Reference Library

Teams, tools, terms & technology

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California Forest Observatory

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.

The CFO 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 opportunities for immediate integration, we conducted interviews with advisers and independent stakeholders from a wide range of disciplines. We spoke with experts in land management, emergency services, forest ecology, wildfire, meteorology, hydrology, wildlife biology, user experience & cartography, recording their workflows, pain points & hopes for the CFO.

One key lesson from this process was that it must be developed to work *with* the broad array of available tools and datasets—it shouldn't *replace* them. This required a broad survey of the resources utilized by the wildfire community. In this process of discovery we learned of a vast array of tools, technology platforms, models, and organizations. We've collected these resources into the following reference library. For the most part, descriptions have been copied and pasted from the source websites to allow the original source material to speak for itself.

The CFO Reference Library is a living document that will grow over time.

Table of contents

Organization, agencies & programs

Tools, technologies & resources

LANDIS

Landsat

LiDAR

LUCAS

Mapbox

MATLAB

MTBS

NAIP

NSLRSDA

Open Foris

OpenNRM

OpenStreetMap

PFIRS

Planet Labs

QGIS

R

RAVG

RMLands

Sentinel-2

Sierra Water Work Group

Simtable

Topofire

WFA

WFAS

WFDS

WFDSS

WIFIRE

WIMS

Vega

Programs, governance & standards

CEQA

CWHR

National Preparedness Level

NEPA

NFDRS

NWCG

OGC Standards

Definitions, glossaries & appendix materials

Condition Class

FBAN

Fire Regime

Fire Return Interval

Wildfire Risk

Fire and Forest Glossaries

Studies & Papers

Online Maps

Web Resources

Competitive and Adjacent Markets

Education / R&D Labs

Grants

Land Management Plan Factors

Market Opportunities

Example Datasets

Example API's

Example API Documentation

Organizations, agencies & programs

3DEP

3D Elevation Program

https://www.usgs.gov/core-science-systems/ngp/3dep
To respond to growing needs for high-quality elevation data, the goal of 3DEP is to complete acquisition of nationwide lidar by 2023 to provide the first-ever national baseline of consistent high-resolution elevation data – both bare earth and 3D point clouds – collected in a timeframe of less than a decade.

BLM

Bureau of Land Management

https://www.blm.gov/
In California, the Bureau of Land Management oversees:

- 15 million acres of public lands in California – about 15% of the Golden State's total land mass
- 47 million acres of subsurface mineral estate
- 1.6 million surface acres in northwestern Nevada

These public lands extend across rangelands, forests, high mountains, and deserts, making California one of the most diverse states in the nation. The

abundance of natural resources on public lands managed for multiple use by the BLM throughout California continues to support generations of families and local communities, while providing important economic benefits to Californians and the nation.

While the BLM authorizes renewable energy production, mining, grazing, and timber harvesting, its conservation efforts ensure our natural, recreational, historical, and cultural resources will be available for future generations.

CalEPA

California Environmental Protection Agency

https://calepa.ca.gov
Our mission is to restore, protect and enhance the environment, to ensure public health, environmental quality and economic vitality.

We fulfill our mission by developing, implementing and enforcing environmental laws that regulate air, water and soil quality, pesticide use and waste recycling and reduction. Our departments are at the forefront of environmental science, using the most recent research to shape the state's environmental laws.

The Office of the Secretary heads CalEPA overseeing and coordinating the activities of one office, two boards, and three departments dedicated to improving California's environment.

CALFIRE

California Department of Forestry and Fire Protection

https://fire.ca.gov

The men and women of the California Department of Forestry and Fire Protection (CAL FIRE) are dedicated to the fire protection and stewardship of over 31 million acres of California's privately-owned wildlands. In addition, the Department provides varied emergency services in 36 of the State's 58 counties via contracts with local governments.
While Californians are learning more and more about the good as well as the bad of fire, the prevention of large, damaging fires remains a priority for CAL FIRE. From Captain Cal and Smokey Bear, to the thousands of CAL FIRE Volunteers in Prevention (VIPs), to new alliances with communities, private industry, and government agencies, aggressive action in fire prevention and fire safety is occurring throughout the State.

Beyond its wildland fire fighting role, CAL FIRE is an "all-risk" department. It may very well be a CAL FIRE engine and crew that is dispatched to the scene of an auto accident, or to a home where a child has become the victim of a drowning incident. The Department is always ready to respond - medical aids; hazardous material spills; swiftwater rescues; search and rescue missions; civil disturbances; train wrecks; floods, earthquakes and more.

Because of the Department's size and major incident management experience, it is often asked to assist or take the lead in disasters, including the Northern and Central California floods of 1997, 1998, and 2006; the 1991 Cantara train derailment and toxic spill; 1994 Northridge earthquake; 1989 Loma Prieta earthquake; the 1991 Tunnel Fire in the Oakland/Berkeley Hills; and the 2003 Southern California Fire Siege.

As part of the CAL FIRE team since 1995, the Office of the State Fire Marshal (OSFM) supports the CAL FIRE mission to protect life and property through fire prevention engineering programs, law and code enforcement and education. The OSFM provides for fire prevention by enforcing fire-related laws in state-owned or operated buildings, investigating arson fires in California, licensing those who inspect and service fire protection systems, approving fireworks as safe and sane for use in California, regulating the use of chemical flame retardants, evaluating building materials against fire safety standards,

regulating hazardous liquid pipelines, and tracking incident statistics for local and state government emergency response agencies.

The OSFM, State Fire Training, and CAL FIRE Academy programs provide training education and certification programs for the California Fire Service. Through practical training exercises and classroom courses, every California firefighter is exposed to training standards that have been approved by CAL FIRE and OSFM, each among the best institutions in the nation for fire training education.

CAL FIRE's mission emphasizes the management and protection of California's natural resources; a goal that is accomplished through ongoing assessment and study of the State's natural resources and an extensive CAL FIRE Resource Management Program. CAL FIRE oversees enforcement of California's forest practice regulations, which guide timber harvesting on private lands. Reviews and inspections ensure protection of watershed and wildlife, as well as renewal of timber resources. Department foresters and fire personnel work closely to encourage and implement fuels management projects to reduce the threat of uncontrolled wildfires. CAL FIRE Foresters promote conservation and the importance of our trees and forests to Californians of all ages.

CAL FIRE manages eight Demonstration State Forests that provide for commercial timber production, public recreation, and research and demonstration of good forest management practices. Additional forestry programs include urban forestry, archaeology, pest management, etc.

CARB

California Air Resources Board

https://ww2.arb.ca.gov
The California Air Resources Board (CARB) is charged with protecting the public from the harmful effects of air pollution and developing programs and

actions to fight climate change. From requirements for clean cars and fuels to adopting innovative solutions to reduce greenhouse gas emissions, California has pioneered a range of effective approaches that have set the standard for effective air and climate programs for the nation, and the world.

CCI

California Climate Investments

http://www.caclimateinvestments.ca.gov
California Climate Investments is a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment—particularly in disadvantaged communities.

The Cap-and-Trade program also creates a financial incentive for industries to invest in clean technologies and develop innovative ways to reduce pollution.

California Climate Investments projects include affordable housing, renewable energy, public transportation, zero-emission vehicles, environmental restoration, more sustainable agriculture, recycling and much more. At least 35 percent of these investments are made in disadvantaged communities and low-income communities and households.

https://webmaps.arb.ca.gov/ccimap/
This map shows project level information on California Climate Investments using Cap-and-Trade auction proceeds. These projects are a subset of a larger and coordinated effort to make climate and energy investments throughout California that further the State's climate goals.

CEC

California Energy Commission

https://www.energy.ca.gov/
The California Energy Commission is leading the state to a 100 percent clean energy future. As the state's primary energy policy and planning agency, the Energy Commission is committed to reducing energy costs and environmental impacts of energy use while ensuring a safe, resilient, and reliable supply of energy.

(also see Appendix: Grants)

CTC

California Tahoe Conservancy

https://tahoe.ca.gov/
The California Tahoe Conservancy (Conservancy) is a State agency, established in 1985, with a mission to lead California's efforts to restore and enhance the extraordinary natural and recreational resources of the Lake Tahoe Basin.
California's ten State conservancies play an integral role in conserving, protecting, and restoring natural resources and providing public recreational opportunities. Together, the conservancies comprise a coordinated effort, bringing government resources to designated regions of State and national significance.
The Conservancy owns and manages nearly 4,700 parcels of land, totaling around 6,500 acres, for the purpose of protecting the natural environment and promoting public recreation and access to Lake Tahoe.
The Conservancy has also provided over 170 grants to local governments and nonprofit organizations for projects under the Lake Tahoe Environmental

Improvement Program to restore the Lake Tahoe watershed, provide public recreation and access, protect ecologically important lands, improve forest health and reduce the threat of wildfire.
The Conservancy's Tahoe Livable Communities Program helps reduce greenhouse gas emissions, restore sensitive lands, and revitalize the Basin's town centers through the acquisition of environmentally sensitive lands, the transfer of development rights, and the sale, lease, or exchange of the Conservancy's developable parcels in town centers.
The Conservancy collaboratively leads large-scale watershed and landscape restoration initiatives with over 50 public agencies to reduce wildfire threat, and plays a lead role in enhancing the Basin's resilience and ability to adapt to climate change.
In all, the Conservancy has funded hundreds of environmental improvement projects, and has played a major role in the restoration of the Basin's most environmentally sensitive areas, addressing the threat of climate change, and the reduction of wildfire risk within the Basin. In its first thirty years, these activities totaled over $450 million.

CWCG

California Wildland Fire Coordinating Group

https://gacc.nifc.gov/oscc/cwcg/
The California Wildland Fire Coordinating Group is established to provide an interagency approach to wildland fire management and all-risk support on all land ownerships within the State of California. The purpose of CWCG is to further interagency cooperation, communications, coordination, and to provide interagency fire management direction and all-risk support for the Northern and Southern California Geographical Areas.

CWSF

Council of Western State Foresters

https://www.westernforesters.org
The Council of Western State Foresters (CWSF) is a nonpartisan, nonprofit membership organization comprised of state, territorial and commonwealth foresters whose role is to protect, conserve and enhance Western and Pacific Island forests.

CWSF's membership is comprised of 17 Western U.S. State Foresters and six U.S.-Affiliated Pacific Island foresters.

Unlike other organizations focused on just one aspect of forestry, CWSF takes a broad and comprehensive approach to forest management and provides expertise on the many complex and interrelated factors at play in Western forestry.

Click here to learn more about our key strategies to ensure healthy trees and forests today and in the future.

Though there is great diversity across Western and Pacific Island forests, there are key forest management issues shared across forests types and jurisdictions. Addressing these pressing issues in forest management and conservation is the focus of CWSF's work.
Click here to learn more about key issues in Western forestry.

An important part of CWSF's work is fulfilled through our relationship with the western leadership of the USDA Forest Service. This relationship is realized through the Western Forestry Leadership Coalition (WFLC). The CWSF members comprise half of the WFLC members and CWSF staff are tasked with delivering the important work of this coalition. For more information on the WFLC, please visit https://www.thewflc.org/.

DOC

Department of Conservation

https://www.conservation.ca.gov
The Department of Conservation balances today's needs with tomorrow's challenges and fosters intelligent, sustainable, and efficient use of California's energy, land, and mineral resources.

DOI - Office of Wildland Fire

Department of the Interior

https://www.doi.gov/wildlandfire
https://www.doi.gov/wildlandfire/technology
The Office of Wildland Fire makes sure that nearly one billion dollars is strategically invested to reduce wildfire risk, rehabilitate burned landscapes, promote a better understanding of wildfire, and support firefighters by providing the tools and training they need to work safely and effectively.

FAM-IT

Fire and Aviation Management Information Technology

https://famit.nwcg.gov
The Department of Agriculture (USDA) United States Forest Service (USFS) Fire and Aviation Management (FAM) Information Technology (IT) Branch, located in Boise, Idaho, manages the FAM applications. The applications and their products are designed for use by the interagency fire community, which includes USFS, Department of the Interior (DOI) Bureau of Land Management (BLM), National Park Service (NPS), Bureau of Indian Affairs (BIA), US Fish and Wildlife Service (USFWS), Department of Homeland Security – Federal

Emergency Management Administration (DHS-FEMA), State Forestry Agencies (in all 50 states), and Municipal Agencies. The USFS is the managing agency for the FAMIT applications. The number of organizations across, federal, state, and local boundaries using the FAMIT applications adds complexity for USFS and its contractor in management, design, access, and communications regarding the applications.

FAM applications are used to collect, maintain, and disseminate fire, weather and all-hazard data (current and historical) in support of fire operations, budgeting, fire resource planning, firefighter safety, public affairs information dissemination, and public and private research and development. FAMIT applications directly support the USFS mission by collecting, maintaining, and providing access to current and historical fire and weather data.

FFS

Fire, Fuel, and Smoke Science Program and the Missoula Fire Sciences Laboratory

https://www.firelab.org/

The Fire, Fuel, and Smoke Science Program (FFS) of the Rocky Mountain Research Station is located primarily at the Missoula Fire Sciences Laboratory in Missoula, Montana. The Program's scientists, technicians, and support staff conduct national and international, cutting-edge work in wildland fire research. They conduct research and develop management tools and applications designed to improve understanding of wildland fire and increase the safety and effectiveness of fire, fuel, and smoke management. Specific research activities are focused on physical fire processes, fuel dynamics, smoke emissions and dispersion, fire ecology, fire and fuel management strategies, and science synthesis and delivery.

FIA

Forest Inventory and Analysis Program of the U.S. Forest Service

https://www.fia.fs.fed.us/
The Forest Inventory and Analysis (FIA) Program of the U.S. Forest Service provides the information needed to assess America's forests.

FIA reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership.

FIA is managed by the Research and Development organization within the USDA Forest Service in cooperation with State and Private Forestry and National Forest Systems.

FIA traces its origin back to the McSweeney - McNary Forest Research Act of 1928 (P.L. 70-466). This law initiated the first inventories starting in 1930.

FIA Data and Tools
https://www.fia.fs.fed.us/tools-data/

FMTF

Forest Management Task Force

https://fmtf.fire.ca.gov/
California's Forest Management Task Force was organized to protect the environmental quality, public health, and economic benefits that healthy forests provide to California. The Task Force aims to increase the rate of forest treatments and expand state wood product markets through innovation, assistance, and investment. Advancing forest health project capacity, readiness, and completion statewide aligns with the California Forest Carbon

Plan, the goal of which is to establish healthy and resilient forests that can withstand and adapt to wildfire, drought, and a changing climate.

FRAP

CALFIRE **Fire and Resource Assessment Program**

https://frap.fire.ca.gov/
FRAP assesses the amount and extent of California's forests and rangelands, analyzes their conditions and identifies alternative management and policy guidelines.

NCAR & UCAR

National Center for Atmospheric Research & **University Corporation for Atmospheric Research**

https://ncar.ucar.edu
https://www.ucar.edu

UCAR is a nonprofit consortium of more than 115 North American colleges and universities focused on research and training in the Earth system sciences. We are the experienced managers of the National Center for Atmospheric Research on behalf of the National Science Foundation. Founded in 1960 to fulfill this role, we are trusted administrators of the financial, human resources, facilities, and information technology functions that are essential to NCAR's success.

UCAR's community programs — from encouraging diverse students to pursue science careers, to providing online professional training, data delivery, and other valued services — extend and enhance the world-class research done at the national center. Our work promotes and accelerates access to these and other resources needed to push the boundaries of Earth system science.

We bring together the Earth system science community to exchange ideas, discuss challenges, and share what we've learned. By connecting researchers and educators with each other, with cutting-edge resources, and with the private sector, we take research out of the lab into the real world for the benefit of society.

UCAR members constitute a self-governing body representing nearly all the academic programs in Earth system science in North America. We provide a clear voice for our membership, in collaboration with the broader community, to convey the value of our research, education, and partnerships to policymakers and decision makers.

GTAC

Geospatial Technology and Applications Center

https://www.fs.fed.us/gstc/
The Geospatial Technology and Applications Center (GTAC) provides leadership to geospatial science implementation in the USDA Forest Service by exploring and developing emerging technologies, working with partners to demonstrate their application in land and resource management, providing solutions to inform decision making, and building capacity to support the Agency Mission.
GTAC advances the Forest Service mission through the application of new geospatial science, technology, and methods to meet business requirements. Our efforts result in:

- Better land management decisions,
- More effective work processes, and
- Improved communication with our publics, interests, and partners.

Forest Service National Remote Sensing Program and Geospatial Technology and Applications Center Update (2017 PPT) - includes organizational structure

MRLC

Multi-Resolution Land Characteristics Consortium

https://www.mrlc.gov/
The Multi-Resolution Land Characteristics (MRLC) consortium is a group of federal agencies who coordinate and generate consistent and relevant land cover information at the national scale for a wide variety of environmental, land management, and modeling applications. The creation of this consortium has resulted in the mapping of the lower 48 United States, Hawaii, Alaska and Puerto Rico into a comprehensive land cover product—the National Land Cover Database (NLCD)—from decadal Landsat satellite imagery and other supplementary datasets.

NASF

National Association of State Foresters

https://www.stateforesters.org
Established in 1920, the National Association of State Foresters is a non-profit organization composed of the directors of forestry agencies in the states, U.S. territories, and the District of Columbia.

State foresters manage and protect state and private forests, which encompass nearly two-thirds of the nation's forests. Our members are valued for their leadership, expertise, and public-trust commitment to managing and conserving non-federal trees and forests. Learn more about NASF's membership in the latest state forestry agency statistics survey.
NASF is a leading authority on forest policy. We advocate for federal legislation and national policies that promote the health, resilience, and productivity of forests across the country, as well as for the professionals that

conserve, enhance, and protect our forest resources. Learn more about NASF's policies.

NCALM

National Center for Airborne Laser Mapping

http://ncalm.cive.uh.edu

The National Science Foundation created a research center to support the use of airborne laser mapping technology for the scientific community. The NSF supported National Center for Airborne Laser Mapping (NCALM) is operated jointly by the Department of Civil & Environmental Engineering, Cullen College of Engineering, University of Houston, and the Department of Earth & Planetary Science, University of California, Berkeley. NCALM uses an Airborne Laser Swath Mapping (ALSM) system based at the UH Geosensing Imaging & Mapping Laboratory. The state-of-the-art laser surveying instrumentation and GPS systems collect data in areas selected through the competitive NSF grant review process.

The ALSM observations are analyzed at both Houston and UC Berkeley and then made available to the Principal Investigator through an archiving and distribution center at UCB – building upon the Berkeley Seismological Laboratory's Northern California Earthquake Data Center system. Both the UH and UC Berkeley groups contribute to software development that increase the processing speed and data accuracy. NSF supported researchers must contact NCALM during proposal preparation to obtain guidance on cost estimates, scheduling, and related issues. Once funded, PIs and their students will be able to participate in all phases of the work.

Research-grade ALSM data can be used to produce highly accurate, three-dimensional, digital topographic maps of large areas of land surface. The major component of a mapping system is a laser that emits tens of

thousands of short pulses of light per second. The laser is mounted in a twin-engine aircraft, and the laser pulses are directed toward the ground by a scanning mirror. Each pulse illuminates an area, or footprint, of about one foot in diameter, and the light is scattered back to a sensor in the aircraft. The round-trip travel time of the laser light allows researchers to compute the precise three-dimensional locations of points on the ground. The resulting set of latitudes, longitudes, and heights of many millions of points is then transformed into a highly accurate map.

Airborne Laser Swath Mapping has proven to be a powerful tool for accurately and densely mapping large areas of land. Researchers have used ALSM data to explore geological and geomorphological processes such as faulting and channelization. The power of laser mapping lies not only in quantifying what is immediately visible, but in revealing the landforms that lie below natural and man-made obstructions. Researchers can now gain a clear glimpse of terrain features more rapidly than before.

Continuous advances are being made in improving the quality of the data to meet the needs of scientific research. Researchers are exploiting the use of high-resolution and accurate ALSM data not available before. Height accuracy of less than 10 cm is providing researchers new opportunities and means to make scientific discoveries never realized in the past.

NEON

National Science Foundation's **National Ecological Observatory Network**

https://www.neonscience.org
https://data.neonscience.org/home
https://www.youtube.com/channel/UCNodgIxpGyEjhV3XXMxFO5g

NEON is a continental-scale ecological observation facility, fully funded by NSF and operated by Battelle. NEON collects and provides open data from 81 field sites across the United States that characterize and quantify how our nation's ecosystems are changing. The comprehensive data, spatial extent and remote sensing technology provided by the NEON project will contribute to a

better understanding and more accurate forecasting of how human activities impact ecology and how our society can more effectively address critical ecological questions and issues.

NICC

National Interagency Coordination Center

https://www.nifc.gov/nicc/
The National Interagency Coordination Center is the focal point for overseeing all interagency coordination activities throughout the United States.
Wildfire suppression is built on a three-tiered system of support - the local area, one of the 10 geographic areas, and finally, the national level. When a fire is reported, the local agency and its firefighting partners respond. If the fire continues to grow, the agency can ask for help from its geographic area. When a geographic area has exhausted all its resources, it can turn to NICC at the National Interagency Fire Center (NIFC) for help in locating what is needed, from air tankers to radios to firefighting crews to incident management teams.

NMAC

National Multi-Agency Coordination Group

NMAC is comprised of representatives from the Bureau of Land Management, Bureau of Indian Affairs, National Park Service, Forest Service, U.S. Fish and Wildlife Service, Federal Emergency Management Administration, and the National Association of State Foresters (charter).

The NMAC group at NIFC prioritizes and allocates resources When there are critical shortages of national resources such as smokejumpers, airtankers, or Type 1 Incident Management Teams (IMTs).

NOAA

National Oceanic and Atmospheric Administration

https://www.noaa.gov
NOAA is an agency that enriches life through science. Our reach goes from the surface of the sun to the depths of the ocean floor as we work to keep the public informed of the changing environment around them.

From daily weather forecasts, severe storm warnings, and climate monitoring to fisheries management, coastal restoration and supporting marine commerce, NOAA's products and services support economic vitality and affect more than one-third of America's gross domestic product. NOAA's dedicated scientists use cutting-edge research and high-tech instrumentation to provide citizens, planners, emergency managers and other decision makers with reliable information they need when they need it.

NWCG

National Wildfire Coordinating Group

https://www.nwcg.gov
https://fam.nwcg.gov/fam-web/
The National Wildfire Coordinating Group provides national leadership to enable interoperable wildland fire operations among federal, state, local, tribal, and territorial partners. Primary objectives include:

- Establish national interagency wildland fire operations standards. Recognize that the decision to adopt standards is made independently by the NWCG members and communicated through their respective directives systems.
- Establish wildland fire position standards, qualification requirements, and performance support capabilities (e.g. training courses, job aids) that enable implementation of NWCG standards.

- Support the National Cohesive Wildland Fire Management Strategy goals: to restore and maintain resilient landscapes; create fire adapted communities; and respond to wildfires safely and effectively.
- Establish information technology (IT) capability requirements for wildland fire.
- Ensure that all NWCG activities contribute to safe, effective, and coordinated national interagency wildland fire operations.

OGC

Open Geospatial Consortium

https://www.opengeospatial.org/
The Open Geospatial Consortium (OGC) is an international consortium of more than 530 businesses, government agencies, research organizations, and universities driven to make geospatial (location) information and services FAIR - Findable, Accessible, Interoperable, and Reusable.

OGC's member-driven consensus process creates royalty free, publicly available, open geospatial standards. Existing at the cutting edge, OGC actively analyzes and anticipates emerging tech trends, and runs an agile, collaborative Research and Development (R&D) lab - the OGC Innovation Program - that builds and tests innovative prototype solutions to members' use cases.

ONCC

Northern California Geographic Area Coordination Center

https://gacc.nifc.gov/oncc/index.php
The Northern California Geographic Area Coordination Center (ONCC) is the focal point for coordinating the mobilization of resources for wildland fire and

other incidents throughout the Geographic Area. Located in Redding, CA, the Center also provides Intelligence and Predictive Services related-products designed to be use by the internal wildland fire community for purposes of wildland fire and incident management decision-making.

The ONCC is a fully functional cooperative organization that includes agency representation from the US Forest Service, the Bureau of Land Management, the National Park Service and the California Department of Forestry and Fire Protection.

OPR

Office of Planning and Research

http://opr.ca.gov/
http://opr.ca.gov/wildfire/

The Office of Planning and Research (OPR), created by statute in 1970, is part of the Office of the Governor. OPR serves the Governor and his Cabinet as staff for long-range planning and research, and constitutes the comprehensive state planning agency. (Government Code §65040). In addition, the Government and Public Resources Codes set forth multiple functions for OPR, including:

- Formulation of long-range land use goals and policies
- Conflict resolution among state agencies
- Coordination of federal grants for environmental goals
- Coordination of statewide environmental monitoring
- Coordination of research on growth and development
- Management of state planning grants, and encouragement of local and regional planning
- Creation and adoption of General Plan Guidelines

- Drafting of CEQA Guidelines (for adoption by the Secretary of Natural Resources)
- Creation of a State Environmental Goals and Policy Report, every four years
- Operation of the State Clearinghouse for distribution and review of CEQA documents
- Operation of the Integrated Climate Adaptation and Resiliency Program
- Coordination of environmental justice activities
- Coordination with US military for land use and other issues in the state

RCRC

Rural County Representatives of California

https://www.rcrcnet.org/
The Rural County Representatives of California (RCRC) is a thirty-seven member county strong service organization that champions policies on behalf of California's rural counties.

The term "rural" may be defined in various ways: population density, population size, demographics or economic data. However you define it, rural counties face unique challenges when putting federal and state policies into effect. The greater distances, lower population densities, and geographic diversity of RCRC's thirty-seven member counties create obstacles not faced by their more urban or suburban counterparts. For those reasons, "one-size-fits-all" policies don't work, especially when the "size" typically is a more metropolitan model.

Founded in 1972, RCRC works with its membership to advocate on behalf of rural issues at the state and federal levels. RCRC provides the rural county perspective on a myriad of issues during the legislative and regulatory process, including land use, water and natural resources, housing,

transportation, wildfire protection policies, and health and human services. The core of RCRC's mission is to improve the ability of small, rural California county government to provide services by reducing the burden of state and federal mandates, and promoting a greater understanding among policy makers about the unique challenges that face California's small population counties.

The RCRC Board of Directors is comprised of a member of the Board of Supervisors from each of its thirty-seven member counties. RCRC staff work in partnership with the Board of Directors to deliver a rural perspective when legislation and regulations are being formulated in Sacramento, and Washington, D.C. Our efforts help enhance and protect the quality of life in California's small and rural counties.

RSAC

Remote Sensing Applications Center

The Geospatial Service and Technology Center (GSTC) and the Remote Sensing Applications Center (RSAC) have joined as one Center! Geospatial Technology and Applications Center (GTAC)

Previously:
The Remote Sensing Applications Center (RSAC) is located in Salt Lake City, Utah as a detached technical center of the Washington Office (WO) Engineering. RSAC is collocated with the Geospatial Service and Technology Center (GSTC), also a detached technical center.

RSAC is organized into five program areas:

- Integration of Remote Sensing
- Liaison & Special Projects
- Training & Technology Awareness
- Inventory-Analysis-Accuracy Assessment

- Operations

These programs provide technology evaluation and development and training support in the use of remote sensing, GIS, image processing, and GPS for all resource applications with primary emphasis on ecosystem management.

RSL

Remote Sensing Lab US Forest Service Region 5

The Pacific Southwest Region of the US Forest Service (Region 5) manages 20 million acres of National Forest land in California and assists the State and Private forest landowners in California, Hawaii and the U.S. Affiliated Pacific Islands. Eighteen national forests are located in this region. RSL generates, curates and manages remote sensing and geospatial data for Region 5.

SGC

Strategic Growth Council

http://sgc.ca.gov/
The Strategic Growth Council (SGC) was established in 2008 to coordinate state agency activities in supporting the planning and development of sustainable communities. The SGC also administers a suite of grant programs funded through the California Climate Investments - a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions while providing a variety of other impactful benefits - particularly in disadvantaged communities. To date, the SGC has invested over $775 million in projects that strengthen the economy, ensure social equity, and enhance environmental stewardship across the state.

TCSI

Tahoe-Central Sierra Initiative

https://tahoe.ca.gov/tahoe-central-sierra-initiative/
Building upon several large-scale regional efforts and best available science, a partnership of state, federal, environmental, industry, and research representatives have established the Tahoe-Central Sierra Initiative to accelerate regional scale forest and watershed restoration through ecologically based management actions while creating the opportunities to support a forest restoration economy and explore innovative process, investment, and governance tools

USFS

US Forest Service

https://www.fs.fed.us
To sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations.

At the heart of our agency's mission is our purpose—the ultimate answer to why we do what we do. Everything we do—across our broad and diverse agency—is intended to help sustain forests and grasslands for present and future generations. Why? Because our stewardship work supports nature in sustaining life. This is the purpose that drives our agency's mission and motivates our work across the agency. It's been there from our agency's very beginning, and it still drives us.

To advance our mission and serve our purpose, we balance the short and long-term needs of people and nature by—

- Working in collaboration with communities and our partners;
- Providing access to resources and experiences that promote economic, ecological, and social vitality; and

- Connecting people to the land and one another.
- Delivering world-class science, technology and land management.

WFLC

Wildland Fire Leadership Council

https://www.thewflc.org
The Wildland Fire Leadership Council (WFLC) was originally established in April 2002 by the Secretaries of Agriculture and the Interior to provide an intergovernmental committee to support the implementation and coordination of Federal Fire Management Policy. An updated Memorandum of Understanding (PDF, 1 MB) was signed in 2016 by the Secretary of the Interior, Secretary of Agriculture, Secretary of Defense, and Secretary of Homeland Security to authorize the continuation of the WFLC. The Council meets regularly to provide oversight and coordination of Federal Wildland Fire Management Policy.

The Wildland Fire Leadership Council is an intergovernmental committee of Federal, state, tribal, county, and municipal government officials convened by the Secretaries of the Interior, Agriculture, Defense, and Homeland Security dedicated to consistent implementation of wildland fire policies, goals, and management activities. The Council provides strategic recommendations to help ensure policy coordination, accountability and effective implementation of Federal wildland fire management policy and related long-term strategies through a collaborative environment to help ensure effective and efficient wildfire management, promote fire-adapted communities and create resilient landscapes to achieve long-range benefits for society and nature.

In addition to supporting the mission of the WFLC, Forests and Rangelands provides a portal to information for other interdepartmental and interagency land management efforts including the National Cohesive Wildland Fire Management Strategy process; Rangeland Fire Prevention, Management, and

Restoration; Quadrennial Fire Review (QFR); Wildland Fire Information and Technology (WFIT); the Woody Biomass Utilization Strategic Plan; stewardship contracting; and land management tools.

WFM RD&A

Wildland Fire Management Research, Development, and Application

The Wildland Fire Management Research, Development, and Application (WFM RD&A) program was created to promote application of wildland fire scientific knowledge; develop decision support tools; and provide science application services to the interagency wildland fire community. The WFM RD&A serves as a primary point of contact for communication between scientists and participating field fire managers, as a liaison between research, wildland fire planning and operations, interagency wildland fire IT groups, and as an advisor to program administrators at local, regional, and national levels.

The WFM RD&A was initially chartered in 2006 and re-chartered in 2011 for a five year period. The charter is recommended by the Directors of the Rocky Mountain Research Station, Forest Management Sciences, and Fire and Aviation Management and signed by the Deputy Chief of Research and Development, the Deputy Chief of State & Private Forestry as well and the Chief of the US Forest Service. The charter defines the areas the WFM RD&A will work and focus their attention. The focus areas are:

- Coordinate relevant and timely fire science applications.
- Develop and support a Wildland Fire Decision Support System (WFDSS).
- Coordinate technology and development efforts for hazardous fuels and vegetation management and support interagency training in this area.
- Develop applications, disseminate information and conduct training for existing and emergent research priorities.

- Participate in and manage the National Fire Decision Support Center (NFDSC).

Tools, technologies & resources

AFM (FSAPPS)

Active Fire Mapping Program

https://fsapps.nwcg.gov/afm/index.php
The Active Fire Mapping Program is an operational, satellite-based fire detection and monitoring program managed by the USDA Forest Service Geospatial Technology and Applications Center (RSAC) located in Salt Lake City, Utah. The Active Fire Mapping program provides near real-time detection and characterization of wildland fire conditions in a geospatial context for the continental United States, Alaska, Hawaii and Canada. Detectable fire activity across all administrative ownerships in the United States and Canada are mapped and characterized by the program.

High temporal image data collected by the NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) are currently the primary remote sensing data source of this program. MODIS provides multiple daily observations of the United States and Canada, which is ideal for continuous operational monitoring and characterization of wildland fire activity. To minimize product latency and deliver fire geospatial products as quickly as possible to the user community, the program leverages state of the art technologies to acquire image data directly from orbiting spacecraft. The

program leverages these technologies and partnerships with other collectors of MODIS satellite data to facilitate near real-time data coverage for the entire United States and Canada.

Satellite image data are continually relayed to RSAC, integrated, and processed to produce imagery and science data products. These products are processed and analyzed with current fire intelligence information and other key geographic strata provided by U.S. and Canadian fire management agencies. The results are a suite of "value-added" geospatial products that provide an accurate and current assessment of current fire activity, fire intensity, burned area extent and smoke conditions throughout the U.S. and Canada. Products provided by the program include fire mapping and visualization products, fire detection GIS datasets and live data services, multi-spectral image subsets, and analytical products/summaries.

The near real-time fire products provided by the Active Fire Mapping program provide critical, timely and comprehensive fire data and information, are highly integrated into the daily fire management business of the interagency fire community, and support several interagency fire management objectives and decision support applications. Additionally, the program also generates and distributes several additional MODIS land and atmosphere products to support multi-disciplinary uses.

ArcFuels

https://www.fs.fed.us/wwetac/tools/arcfuels/
Vegetation and fuel management planning is a complex problem that requires advanced vegetation and fire behavior modeling and intensive spatial data analyses. Both the benefits and potential impacts of proposed treatments must be clearly demonstrated in the context of land management goals and public expectations. Potential fire behavior metrics, including fire spread, intensity, likelihood, and ecological risk need to be

analyzed for proposed treatment alternatives. ArcFuels was built to streamline the fuel management planning process, and provide tools for quantitative wildfire risk assessment. 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. The ArcMap framework helps users incorporate data from a variety of sources to address project-specific issues that typify many fuel treatment projects. ArcFuels was built to accommodate ArcGIS raster data (such as LANDFIRE data) and/or forest inventory data. ArcFuels provides a logical flow from stand to landscape analyses of vegetation, fuel, and fire behavior, using a number of different models in a simple user interface within ArcMap.

ArcGIS

http://www.arcgis.com/home/index.html
Esri, the global market leader in geographic information system (GIS) software, location intelligence, and mapping, offers the most powerful geospatial cloud available, to help customers unlock the full potential of data to improve operational and business results. Founded in 1969, Esri software is deployed in more than 350,000 organizations including 90 of the Fortune 100 companies, all 50 state governments, more than half of all counties (large and small), and 87 of the Forbes Top 100 Colleges in the U.S., as well as all 15 Executive Departments of the U.S. Government and dozens of independent agencies. With its pioneering commitment to geospatial information technology, Esri engineers the most advanced solutions for digital transformation, the Internet of Things (IoT), and advanced analytics.

ArcGIS Online
Part of the Esri Geospatial Cloud, ArcGIS Online enables you to connect people, locations, and data using interactive maps. Work with smart,

data-driven styles and intuitive analysis tools that deliver location intelligence. Share your insights with the world or specific groups.

ESRI Collector
Part of the ESRI Geospatial Cloud, Collector for ArcGIS, a mobile data collection app, makes it easy to capture accurate data and return it to the office. Fieldworkers use web maps on mobile devices to capture and edit data. Collector for ArcGIS works even when disconnected from the internet and integrates seamlessly into ArcGIS. (Note: there is a USFS mandate to use collector)

BAER

Burned Area Emergency Response

https://fsapps.nwcg.gov/baer/
The Burned Area Emergency Response (BAER) program assesses damage to both infrastructure and the environment. Forest lands often provide ecosystem services such as providing clean drinking water for municipal watersheds. BAER teams, assisted by burn severity datasets, identify areas where clean water supplies might be threatened and prescribe treatments to ensure that large volumes of soil and debris do not contaminate the water supply.

Within 7 days of fire containment, the BAER Imagery Support Program provides satellite images, burn area severity classifications, and other critical data to BAER teams. One of the team's first tasks in the field is to create a soil burn severity map using BARC data provided by the BAER Imagery Support Program.

BehavePlus

https://www.frames.gov/behaveplus/home

The BehavePlus fire modeling system is a Windows® based computer program that can be used for any fire management application that involves modeling fire behavior and some fire effects. 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.

Some applications include:

- Predicting the behavior of an ongoing fire. Historically, this was the original use for Behave as described by Rothermel (1983) in "How to Predict the Spread and Intensity of Forest and Range Fires." Today, the modern version of Behave, BehavePlus Version 6.0.0 Beta, is even more powerful for predicting fire behavior during wildfires and prescribed fires in the United States and other countries because of its expanded features and capabilities.
- Planning fire treatments. Contingency planning depends on a number of fire variables, such as spotting distance, probability of ignition, spot fire growth, and probability of containment. All of these are modeled within BehavePlus to facilitate planning of prescribed fires for ecological restoration or fuel reduction programs.
- Assessing fuel hazard. BehavePlus allows for easy manipulation of fuel moistures and wind conditions. Variations in these factors affect fire behavior in surface and crown fuels so understanding the sensitivity of fuels to moisture and wind is essential to assessing whether fuel has the potential to burn or whether planned treatments may be dangerous to fire fighters or the public.
- Understanding fire behavior. Modeling systems are excellent sources for educating and training personnel on the subtleties of fire behavior. The complex interactions among fire, fuel, moisture, and wind can be easily explored in BehavePlus by changing input variables and fuel conditions for each model run. This makes BehavePlus well suited to learning about fire behavior, while preparing personnel to better understand and

apply outputs from spatial fire behavior modeling systems based on similar equations.

BehavePlus development history:
The DOS BEHAVE fire behavior prediction and fuel modeling system was first available to the field in 1984. Joint Fire Science Program (JFSP) funded a much-needed redesign and update to the BehavePlus fire modeling system version 1.0 in 2002. Each version update has offered additional features and fire modeling capabilities. Version 2 was released in 2003, Version 3 in 2005, Version 4 in 2008, Version 5 in 2009, and Version 6 in 2018. The Fire Characteristics Chart was released in 2011 and updated in 2013. A description of changes from the old BEHAVE system through each version of BehavePlus is available as a PDF.

Fire modeling capabilities:
Many fire models are available, organized according to modules. Following is a summary of some of the fire modeling capabilities in BehavePlus, by module.

- SURFACE module
  - o Surface fire behavior, including rate of spread and flame length
  - o Includes the standard fuel models (13 + 40)
  - o Allows for custom fuel model development and use
  - o Special case fuel models including palmetto-gallberry, western aspen, and chaparral
- CROWN module
  - o Crown fire behavior, including rate of spread and flame length
  - o Transition from surface to crown fire
  - o Fire type - surface, torching, conditional crown, crowning
  - o Flame length and intensity
- SIZE module
  - o Assumes a point source fire with steady-state spread
  - o Perimeter
  - o Shape (length-to-width ratio)
  - o Area

- CONTAIN module
  - o Fire containment of a point source fire
  - o Containment success based on available resources (single or multiple)
  - o Final size, fireline constructed
- SPOT module
  - o Maximum spotting distance
  - o Torching trees
  - o Active crown fire
  - o Burning pile
  - o Wind-driven surface fire
- SCORCH module
  - o Crown scorch height from surface fire flame length and flame tilt
- MORTALITY module
  - o Tree mortality
  - o Probability of mortality from crown scorch
- IGNITE module
  - o Probability of ignition from a firebrand
  - o Probability of ignition from lightning
- Fire Characteristics Chart
  - o Graphical representation of modeled or observed fire behavior for
    - Surface Fire Behavior
    - Crown Fire Behavior
    - Fire Danger Rating

Bluesky

https://sites.google.com/firenet.gov/wfaqrp-airfire/data/bluesky?authuser=0
BlueSky is a modeling framework. BlueSky modularly links a variety of independent models of fire information, fuel loading, fire consumption, fire emissions, and smoke dispersion. At each modeling step, BlueSky has several different specific models from which to choose. BlueSky is not a model per se

because many different modeling pathways are possible within BlueSky. BlueSky wraps models into modular software objects and provides a structure that connects these objects together and enables information to be passed between objects. The wrapper code is written in Python, but many of the models themselves are in other languages with the Python code simply creating the necessary input files and then running the model code.

BlueSky connects models together and makes them easy to run in combination. Therefore BlueSky can enable:

- the lookup of fuels information from fuel maps
- the calculation of total and hourly fire consumption based on fuel loadings and weather information
- the calculation of speciated emissions (such as CO2 or PM2.5) from a fire
- the calculation of vertical plume profiles produced by a fire
- the calculation of likely trajectories of smoke parcels given off by a fire
- the calculation of downstream smoke concentrations.

CAWFE

Coupled Atmospheric Wildland Fire Environment

http://www2.mmm.ucar.edu/people/coen/files/newpage_c.html

The CAWFE modeling system combines a numerical weather prediction (NWP) model that predicts how weather varies in time and space even in complex terrain with wildland fire behavior modules. These components are connected in two directions such that the evolving wind, along with fuel properties and terrain slope, directs where the fire grows and how fast, while heat released by the fire modifies its atmospheric environment thereby creating its own weather (e.g., fire-induced winds). CAWFE was developed recognizing that fires interact with the atmosphere surrounding them and that this produces many fundamental fire behaviors. Research applying CAWFE showed that fire-atmosphere interactions produce numerous

wildland fire phenomena, including the commonly-observed bowed shape; the heading, flanks, and backing regions; fire whirls; horizontal roll vortices.

CAWFE has been applied to many landscape-scale wildland fire events in varying fuel, terrain, and weather conditions. Provided that a coupled model can reproduce fine-scale (100s of meters) circulations and include fire feedbacks on atmospheric motions, models such as CAWFE can simulate overall rate and direction of spread, distinguishing characteristics of fire events, and transitions in fire behavior. CAWFE has reproduced other fire phenomena and illuminated the conditions in which they form, such as distinctive shapes of the fire perimeter, pyrocumulus, firenadoes, horizontal roll vortices, flank runs, rotating plumes, and the splitting or merging of fire lines.

D3

https://d3js.org/
D3.js is a JavaScript library for manipulating documents based on data. D3 helps you bring data to life using HTML, SVG, and CSS. D3's emphasis on web standards gives you the full capabilities of modern browsers without tying yourself to a proprietary framework, combining powerful visualization components and a data-driven approach to DOM manipulation.

Data Basin

https://databasin.org

As environmental conservation problems become more serious and the demand to solve them grows more urgent, it is critical that science, practice, policy, and people are integrated in stronger ways. A team of scientists, software engineers, and educators at the Conservation Biology Institute (CBI) built Data Basin with the strong conviction that we can expand our individual

and collective ability to develop sustainable solutions by empowering more people through access to spatial data, non-technical tools, and collaborative networks.

The core of Data Basin is free and provides open access to thousands of **scientifically-grounded, biological, physical, and socio-economic datasets**. This user-friendly platform enables people with varying levels of technical expertise to:

- **Explore and organize data & information**
- **Create custom visualizations, drawings, & analyses**
- **Utilize collaborative tools in groups**
- **Publish datasets, maps, & galleries**
- **Develop decision-support and custom tools**

Data Basin supports researchers, natural resource managers, advocates, teachers, students, and members of the engaged public. Members create and participate in working groups where they can visualize, draw, comment, and discuss relevant topics or geographies. Data Basin breaks down barriers to **collaboration** and negotiation for users affiliated with universities, non-profits, tribes, companies, and local, state, federal, and national governments.

Example Data Basin Mapping Tool
http://ceipa.databasin.org/

DATIM

Design and Analysis Toolkit for Inventory and Monitoring

https://www.fs.fed.us/emc/rig/DATIM/index.shtml
The Design and Analysis Toolkit for Inventory and Monitoring (DATIM) project is a collaborative effort between the National Forest System (NFS) and Forest Service (FS) Research and Development (R&D), Forest Inventory and Analysis

(FIA), and Ecosystem Management Coordination (EMC) staff. The DATIM core team comprises both R&D and NFS staff from resource inventory and forest planning programs. The DATIM project has four modules:

- Design Tool for Inventory and Monitoring (DTIM) assists national forests and grasslands and other users in determining objectives, questions, and metrics for monitoring plans.
- Analysis Tool for Inventory and Monitoring (ATIM) enables users to analyze vegetation data to derive estimates of current conditions and trends on the Forest and surrounding landscapes.
- Spatial Intersection Tool (SIT) enables users to add spatial attributes to DATIM datasets for use in ATIM.
- DATIM Compilation System (DCS) enables users to add supplemental Forest Vegetation Simulator (FVS) attributes to DATIM datasets for use in ATIM.

EcObject

Ecological Object Based Vegetation Mapping

Derived from aerial-based Light Detection and Ranging (LiDAR) data, EcObject is created from LiDAR-derived tree approximate objects and then aggregated by stand and tree-level ecological relationships. The resulting segments are then populated with a collection of traditional and contemporary metrics at scales that benefit both project-level planning and large-landscape analysis.

eDaRT

http://www.cstarsd3s.ucdavis.edu/systems#a-sys-drt
http://www.cstarsd3s.ucdavis.edu/portfolio/edart-sosierra-mortality16/
eDaRT is an automated system for satellite image processing, including a suite of advanced algorithms and a software toolbox that detects and categorizes changes in

forested, shrubland, and herbaceous ecosystems. Currently, the primary input data source for eDaRT is Landsat imagery. All available Landsat images can be processed, providing frequent and robust monitoring.

EMDS

Ecosystem Management Decision Support

https://www.fs.usda.gov/pnw/tools/ecosystem-management-decision-support-system
EMDS is a state-of-the-art modeling framework for decision support of environmental analysis and planning at multiple geographic scales. The system integrates geographic information system data, logic-based reasoning, and a variety of decision-modeling technologies to provide explicit, practical decision support for strategic and tactical planning as well as adaptive management. Because the EMDS is a generic solution framework, it can be applied to an extremely broad array of problems at all spatial scales.

Typical applications include landscape restoration, watershed analysis, and fish and wildlife management. All inputs are user defined and based on the data requirements of the various modeling systems employed in the EMDS analyses. Each of the EMDS analytical tools (see description) output maps that display the evaluated state of the landscape units.

FF+

FireFamilyPlus

https://www.firelab.org/project/firefamilyplus
FireFamily+ (FF+) is a software package used to calculate fuel moistures and indices from the US National Fire Danger Rating System (NFDRS) using hourly or daily fire weather observations primarily from Remote Automated Weather

Stations (RAWS). NFDRS use is mandated for fire preparedness and response decisions by all Federal and most State agencies and is operationally run with USFS FAM Weather Information Management System (WIMS).

FF+ has several subsystems. First, it provides all the necessary model calculations to produce fuel moistures and fire danger indices for the NFDRS 1978, 1988 and the newly added NFDRS2016 and well as the Canadian Forest Fire Danger Rating System and the Fosberg Fire Weather Index. When using appropriate hourly fire weather data, usually provided in an FW13 text format, the system can calculate hourly Nelson dead fuel moistures, daily Growing Season Index-based live fuel moistures and all associated fire danger indices such as the Energy Release Component, Burning Index, Spread Component and Ignition Component as part of the new NFDRS2016. Second, the system includes the ability to compare fire danger indices to agency fire reports and use this information to establish breakpoints for decision making on local units. Finally, FF+ includes a suite of climatological tools to explore and display seasonal variations in fire danger to better assess and communicate conditions as they change throughout a fire season or from year-to-year.

FlamMap

https://www.firelab.org/project/flammap

FlamMap is a fire analysis desktop application that runs in a 64-bit Windows Operating System environment. 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). With the inclusion of FARSITE it can now compute wildfire growth and behavior for longer time periods under heterogeneous conditions of terrain, fuels, fuel moistures and weather.)

FORSEE

Forest and Stand Evaluation Environment

http://forsee.iefc.net/
http://courses.washington.edu/fe341/projects/settings_98/report/forsee/forsee.html

FVS

Forest Vegetation Simulator

https://www.fs.fed.us/fvs/
The Forest Vegetation Simulator (FVS) is a forest growth simulation model. It simulates forest vegetation change in response to natural succession, disturbances, and management. It recognizes all major tree species and can simulate nearly any type of management or disturbance at any time during the simulation. Outputs include tree volumes, biomass, density, canopy cover, harvest yields, fire effects, and much, much more.

Google Earth Engine

https://earthengine.google.com/
Google Earth Engine combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities and makes it available for scientists, researchers, and developers to **detect changes, map trends, and quantify differences** on the Earth's surface.

Google Earth Engine is a computing platform that allows users to run geospatial analysis on Google's infrastructure. There are several ways to interact with the platform. The Code Editor is a web-based IDE for writing and running scripts. The Explorer is a lightweight web app for exploring our data catalog and running simple analyses. The client libraries provide Python and JavaScript wrappers around our web API.

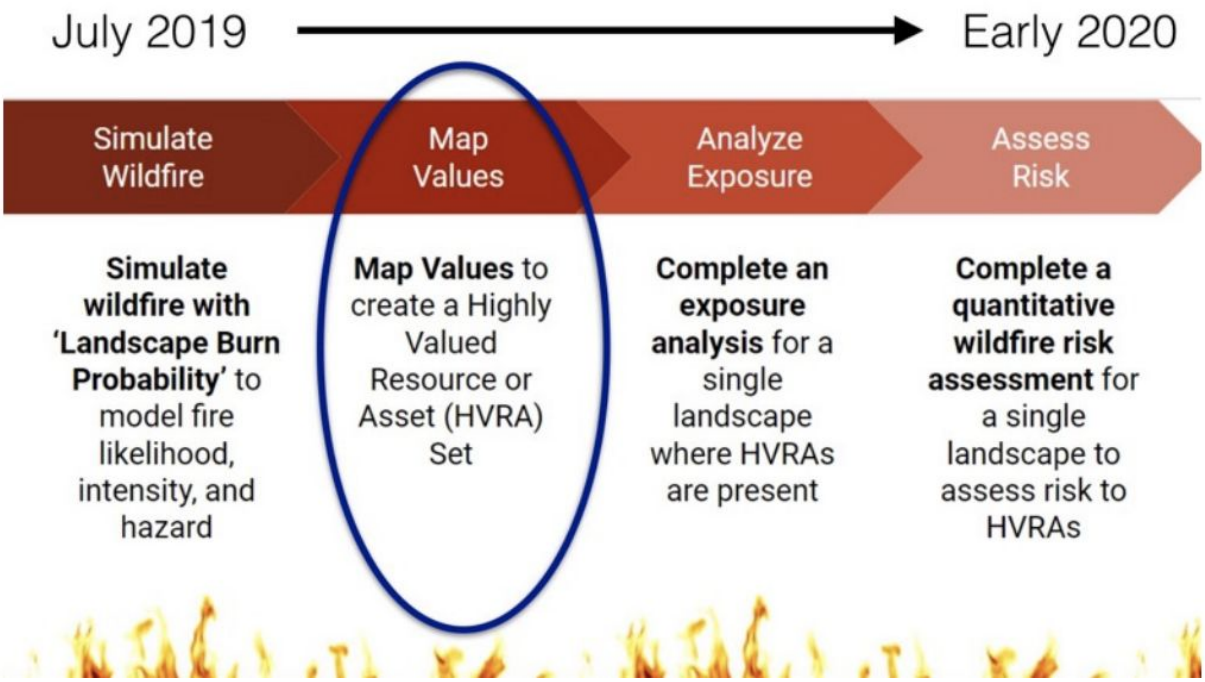
IFTDSS

Interagency Fuel Treatment Decision Support System

https://iftdss.firenet.gov/landing_page
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. It is available to all interested users, regardless of agency or organizational affiliation.

IFTDSS is designed to address the planning needs of users with a variety of skills, backgrounds, and needs. A simple and intuitive interface provides the ability to model fire behavior across an area of interest under a variety of weather conditions and easily generate downloadable maps, graphs, and tables of model results. Additionally, the application provides a step by step process for testing a variety of fuels treatment impacts (thin, clear cut, prescribed burn) on fire behavior and comparing results to determine which modeled treatment best achieves desired results in terms of reduced fire behavior potential. It can be used at a variety of scales from local to landscape level.

IFTDSS hosts a complete set of reference data available for the entire US including LANDFIRE fuels information, SILVIS Wildland Urban Interface, Agency Ownership, as well as a modern map interface allowing users to create or upload their own data.



HIGRAD/FIRETEC

https://www.frames.gov/firetec/home
https://www.fs.fed.us/rm/forest-woodland/higrad-firetec/
HIGRAD/FIRETEC is a physics-based, 3-D computer code designed to simulate the constantly changing, interactive relationship between fire and its environment. It does so by representing the coupled interaction between fire, fuels, atmosphere, and topography on a landscape scale (100s or 1000s of meters).

HIGRAD is a computational fluid-dynamics model that represents airflow and its adjustments to terrain, different types of fuel (vegetation), and the fire itself.
FIRETEC combines physics models that represent combustion, heat transfer, aerodynamic drag and turbulence.

How is HIGRAD/FIRETEC used?

Unlike the empirically based models currently used in the field, FIRETEC simulates the dynamic processes that occur within a fire and the way those processes feed off and alter each other. FIRETEC takes the huge computational resources at the Los Alamos National Laboratory to run, so it is currently a research tool only.

APPLICATIONS
FIRETEC provides a sophisticated analytical tool for fire, fuel, and land managers

- Predicting wildfire behavior in rugged terrain under different atmospheric conditions.
- Optimizing fuel-management strategies (thinning, controlled burns, etc.)
- Investigating how fire interacts with various fuels
- Determining the causes of dangerous changes in a wildfire's behavior
- Providing realistic simulations for training inexperienced fire fighters, and
- Complementing and enhancing existing empirical fire models to make them more reliable.

LANDFIRE

https://landfire.gov
The LF Program provides 20+ national geo-spatial layers (e.g. vegetation, fuel, disturbance, etc.), databases, and ecological models that are available to the public for the US and insular areas.

LANDIS

Landscape Disturbance and Succession

https://www.nrs.fs.fed.us/tools/landis/

http://www.landis-ii.org/home

LANDIS is a forest landscape model designed to simulate forest growth, competition, seed dispersal succession, and disturbances (including fire, wind, harvesting, insects, global change), across large (>1 million ha) landscapes. LANDIS represents landscapes as a grid of cells and tracks age cohorts of each species (presence/absence or biomass) rather than individual trees. LANDIS simulates distinct ecological processes, allowing complex interactions to play out as emergent properties of the simulation.

Landsat

https://landsat.gsfc.nasa.gov/

Landsat 8 is an American Earth observation satellite launched on February 11, 2013. It is the eighth satellite in the Landsat program; the seventh to reach orbit successfully. Originally called the Landsat Data Continuity Mission (LDCM), it is a collaboration between NASA and the United States Geological Survey (USGS). NASA Goddard Space Flight Center in Greenbelt, Maryland, provided development, mission systems engineering, and acquisition of the launch vehicle while the USGS provided for development of the ground systems and will conduct on-going mission operations.

The satellite was built by Orbital Sciences Corporation, who served as prime contractor for the mission. The spacecraft's instruments were constructed by Ball Aerospace and NASA's Goddard Space Flight Center, and its launch was contracted to United Launch Alliance. During the first 108 days in orbit, LDCM underwent checkout and verification by NASA and on 30 May 2013 operations were transferred from NASA to the USGS when LDCM was officially renamed to Landsat 8. It is collecting valuable data and imagery used in agriculture, education, business, science, and government.

The Landsat Program provides repetitive acquisition of high resolution multispectral data of the Earth's surface on a global basis. The data from Landsat spacecraft constitute the longest record of the Earth's continental surfaces as seen from space. It is a record unmatched in quality, detail, coverage, and value.

LiDAR

Light Detection and Ranging

LiDAR is a surveying method that measures distance to a target by illuminating the target with laser light and measuring the reflected light with a sensor. Differences in laser return times and wavelengths can then be used to make digital 3-D representations of the target. The name *lidar*, now used as an acronym of *light detection and ranging*[1] (sometimes, *light imaging, detection, and ranging*), was originally a portmanteau of *light* and *radar*.[2][3] Lidar sometimes is called **3D laser scanning**, a special combination of a 3D scanning and laser scanning. It has terrestrial, airborne, and mobile applications.

LUCAS

Land Use and Carbon Scenario Simulator

https://www.usgs.gov/centers/wgsc/science/lucas-model?qt-science_center_objects=0#qt-science_center_objects

The Land Use and Carbon Scenario Simulator (LUCAS) tracks changes in land use, land cover, land management, and disturbance, and their impacts on ecosystem carbon storage and flux.
The LUCAS model combines:

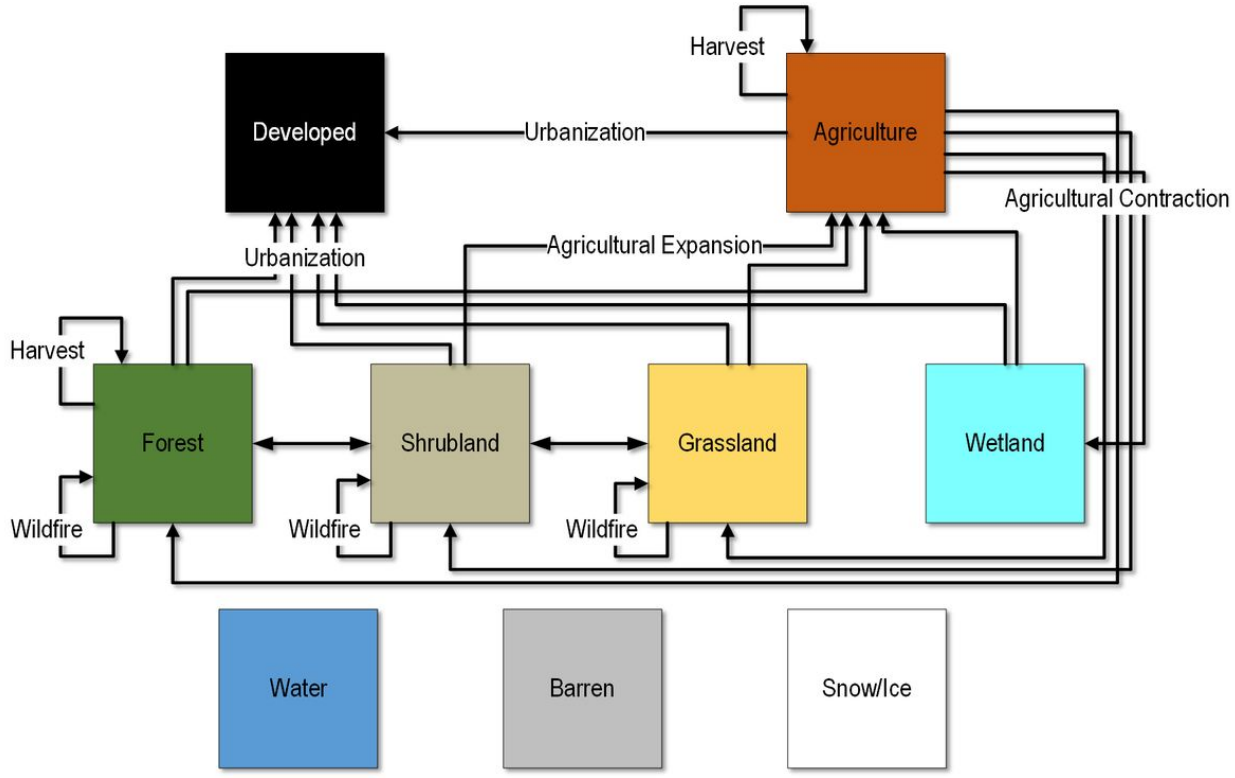
- State-and-Transition Simulation Model to simulate changes in land-use across a range of geographic scales.

- Stock and Flow Model to track the movement of carbon between different “pools” including interactions between land and atmosphere.
- Linkage to the Integrated Biosphere Simulator (IBIS) dynamic global vegetation model.

State-and-Transition Simulation Models (STSM)
The STSM model is used to simulate changes in land use and land cover classes resulting from changes due to:

- Urbanization
- Agricultural expansion and contraction
- Forest harvest, wildfire
- Wildfire and other processes.

We use Monte Carlo methods to capture and reflect model and data uncertainties. We use an ecological framework known as ecoregions to stratify the United States into discrete units.

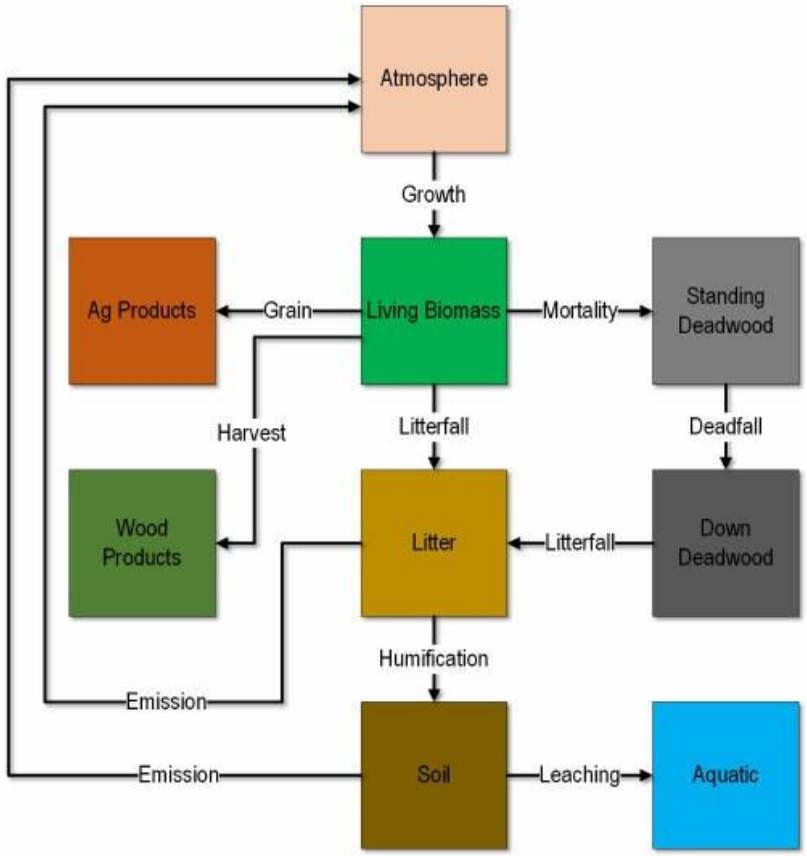


A diagram of the state and transition model for LUCAS (Public domain)

The LUCAS model was developed within ST-Sim , a free software tool built by ApexRMS, for developing and running STSMs. The SyncroSim wiki page provides more information on STSMs and getting started with ST-Sim. Also, check out this video on incorporating uncertainty into land-change projections with STSMs.

Stock and Flow Model

LUCAS carbon modeling is done using a simple stock-flow approach. Carbon pools are defined as a set of stocks, and flows are used to move carbon between stocks over time. We define two primary types of flows; automatic flows occur every year and include transfers of carbon from growth, mortality, and emission. Event-based flows are used to move carbon between stocks when a change in the land system occurs, such as removal of biomass from logging or urbanization. To parameterize the stock-flow model we use biogeochemical models, such as the Integrated Biosphere Simulator (IBIS) to derive regional carbon flux rates.



A diagram of stock and flux for IBIS carbon pools (Public domain)

Mapbox

https://www.mapbox.com
We craft beautiful maps and developer-friendly location data, APIs, and SDKs so that you're free to focus on designing, building, and developing your application. Our open-source tools let analytics companies understand big geo data, drone companies publish flyovers, real estate sites visualize properties, satellite companies process cloud-free imagery, and insurance companies track assets.

MATLAB

https://www.mathworks.com/products/matlab.html
MATLAB® combines a desktop environment tuned for iterative analysis and design processes with a programming language that expresses matrix and array mathematics directly. It includes the Live Editor for creating scripts that combine code, output, and formatted text in an executable notebook.

MTBS

Monitoring Trends in Burn Severity

https://www.mtbs.gov/
https://www.mtbs.gov/viewer/index.html
Monitoring Trends in Burn Severity (MTBS) is an interagency program whose goal is to consistently map the burn severity and extent of large fires across all lands of the United States from 1984 to present. This includes all fires 1000 acres or greater in the western United States and 500 acres or greater in the

eastern United States. The extent of coverage includes the continental U.S., Alaska, Hawaii and Puerto Rico.

The program is conducted by the U.S. Geological Survey Center for Earth Resources Observation and Science (EROS) and the USDA Forest Service Geospatial Technology and Applications Center (GTAC). MTBS was first enacted in 2005, primarily to meet the information needs of the Wildland Fire Leadership Council (WFLC). The primary objective at that time was to provide data to the WFLC for monitoring the effectiveness of the ten-year National Fire Plan. The scope of the program has grown since inception and provides data to a wide range of users. These include national policy-makers such as WFLC and others who are focused on implementing and monitoring national fire management strategies; field management units such as national forests, parks and other federal and tribal lands that benefit from the availability of GIS-ready maps and data; other federal land cover mapping programs such as LANDFIRE which utilizes burn severity data in their own efforts; and academic and agency research entities interested in fire severity data over significant geographic and temporal extents.

NAIP

National Agriculture Imagery Program

https://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/
The National Agriculture Imagery Program (NAIP) acquires aerial imagery during the agricultural growing seasons in the continental U.S. A primary goal of the NAIP program is to make digital ortho photography available to governmental agencies and the public within a year of acquisition.

NAIP is administered by the USDA's Farm Service Agency (FSA) through the Aerial Photography Field Office in Salt Lake City. This "leaf-on" imagery is used

as a base layer for GIS programs in FSA's County Service Centers, and is used to maintain the Common Land Unit (CLU) boundaries.

NSLRSDA

National Satellite Land Remote Sensing Data Archive

https://www.usgs.gov/centers/eros/science/national-satellite-land-remote-sensing-data-archive?qt-science_center_objects=0#qt-science_center_objects

The National Satellite Land Remote Sensing Data Archive (NSLRSDA) resides at the U.S. Geological Survey's (USGS) Earth Resources Observation and Science (EROS) Center. Through the Land Remote Sensing Policy Act of 1992, the U.S. Congress directed the Department of the Interior (DOI) to establish a permanent Government archive containing satellite remote sensing data of the Earth's land surface and to make this data easily accessible and readily available. This unique DOI/USGS archive provides a comprehensive, permanent, and impartial observational record of the planet's land surface obtained throughout more than five decades of satellite remote sensing. Satellite-derived data and information products are primary sources used to detect and understand changes such as deforestation, desertification, agricultural crop vigor, water quality, invasive plant species, and certain natural hazards such as flood extent and wildfire scars.

Open Foris

http://www.openforis.org

What is Open Foris?

Open Foris is a set of free and open-source software tools that facilitates flexible and efficient data collection, analysis and reporting.

Government, research institutions and NGOs use these tools for a wide range of monitoring purposes such as:

- Forest Inventories
- Climate Change reporting
- Socio-economic surveys
- Biodiversity assessment
- Land Use, Land Use Change and Forestry measurement
- Deforestation monitoring with remote sensing
- Detecting desertification and trees outside of forest

The initiative is a collaborative effort of numerous public and private institutions and it is hosted by the Forestry Department of the Food and Agriculture Organization of the United Nations.

Collect
Easy and flexible survey design and data management

Collect Mobile
Intuitive data collection and validation in the field

Calc
Efficient and collaborative data analysis and results dissemination

Collect Earth
Innovative land assessment through freely available satellite imagery

Collect Earth Online
Online Land Monitoring tool for crowd-sourcing of augmented visually interpreted data

SEPAL
System for earth observation, data access, processing, analysis for land monitoring

OpenNRM

http://www.34north.com/opennrm/overview/
OpenNRM is a collaborative resource management platform for data and information collection, analysis, reporting, and visualization. Since 1999, 34 North has been an innovator in collaborative natural resource management technologies and data solutions. Our unique software platform, OpenNRM , and data service offerings help our clients to turn data into valuable real time information.

OpenNRM applications include:

- Collaborative Natural Resource Management and Planning
- Ecosystem Restoration Project Management
- Collaborative Data Management and Access, Open Data
- Collaborative Science
- Water Operations
- Monitoring Programs
- Watershed and Estuary Management
- Regulatory Compliance and Reporting
- Fisheries Management
- Inter-agency Collaboration
- Climate Adaptation
- Conservation
- Policy and Public Outreach

OpenStreetMap

https://www.openstreetmap.org/
OpenStreetMap is built by a community of mappers that contribute and maintain data about roads, trails, cafés, railway stations, and much more, all over the world.

OpenStreetMap emphasizes local knowledge. Contributors use aerial imagery, GPS devices, and low-tech field maps to verify that OSM is accurate and up to date.

OpenStreetMap's community is diverse, passionate, and growing every day. Our contributors include enthusiast mappers, GIS professionals, engineers running the OSM servers, humanitarians mapping disaster-affected areas, and many more.

OpenStreetMap is open data: you are free to use it for any purpose as long as you credit OpenStreetMap and its contributors. If you alter or build upon the data in certain ways, you may distribute the result only under the same licence.

PFIRS

Prescribed Fire Information Reporting System

https://ssl.arb.ca.gov/pfirs/
PFIRS ("P-furs") serves as an interface between air quality managers, land management agencies, and individuals that conduct prescribed burning in California. It is intended to facilitate communications on planned burns and approvals. PFIRS enables individuals involved in prescribed burning the ability to view this information on a statewide level.

PFIRS is a joint project of the California Air Resources Board, federal land management agencies, local air districts, and various fire agencies.

Planet Labs

https://planet.com

Planet Labs, Inc. (formerly Cosmogia, Inc.) is an American private Earth imaging company based in San Francisco, CA. Their goal is to image the entirety of the planet daily to monitor changes and pinpoint trends. The company designs and manufactures Triple-CubeSat miniature satellites called Doves that are then delivered into orbit as secondary payloads on other rocket launch missions. Each Dove is equipped with a high-powered telescope and camera programmed to capture different swaths of Earth. Each Dove Earth observation satellite continuously scans Earth, sending data once it passes over a ground station. Together, Doves form the largest satellite constellation in the world that provides a complete image of Earth once per day at 3–5 m optical resolution. This is accomplished through a technique called a line scan, which allows for continuous, high resolution imagery due to the fact that this type of camera is not restricted to specific vertical resolution.

The images gathered by Doves, which can be accessed online and some of which is available under an open data access policy, provide up-to-date information relevant to climate monitoring, crop yield prediction, urban planning, and disaster response. With acquisition of BlackBridge in July 2015, Planet Labs had 87 Dove and 5 RapidEye satellites launched into orbit. In 2017, Planet launched an additional 88 Dove satellites, and Google sold its subsidiary Terra Bella and its SkySat satellite constellation to Planet Labs. The combined batches of Doves form the largest constellation ever put into orbit. By September 2018 the company had launched nearly 300 satellites, 150 of which are active.

QGIS

Quantum Geographic Information System

https://qgis.org
A Free and Open Source Geographic Information System

QGIS is a professional GIS application that is built on top of and proud to be itself Free and Open Source Software (FOSS).

Create, edit, visualise, analyse and publish geospatial information on Windows, Mac, Linux, BSD (Android coming soon)

R

https://www.r-project.org
R is a language and environment for statistical computing and graphics. It is a GNU project which is similar to the S language and environment which was developed at Bell Laboratories (formerly AT&T, now Lucent Technologies) by John Chambers and colleagues. R can be considered as a different implementation of S. There are some important differences, but much code written for S runs unaltered under R.

R provides a wide variety of statistical (linear and nonlinear modelling, classical statistical tests, time-series analysis, classification, clustering, ...) and graphical techniques, and is highly extensible. The S language is often the vehicle of choice for research in statistical methodology, and R provides an Open Source route to participation in that activity.

One of R's strengths is the ease with which well-designed publication-quality plots can be produced, including mathematical symbols and formulae where needed. Great care has been taken over the defaults for the minor design choices in graphics, but the user retains full control.

RAVG

Rapid Assessment of Vegetation Characteristics after Wildfire

https://fsapps.nwcg.gov/ravg/

The RAVG program, managed by the USDA Forest Service Geospatial Technology and Applications Center (GTAC), provides a rapid initial assessment of post-fire vegetation condition following large wildfires on National Forests. This website provides general information about RAVG, as well as access to RAVG data for individual fires, data summaries based on user-defined queries, and annual data compilations.

RMLands

Rocky Mountain Landscape Simulator

https://www.umass.edu/landeco/research/rmlands/rmlands.html
During the past several years, a small team of scientists at the University of Massachusetts, Amherst (UMass) and Colorado State University (CSU) has developed RMLands: Rocky Mountain Landscape Simulator. RMLands is a computer software program designed to simulate natural (e.g., fire) and anthropogenic (e.g., logging) disturbances and succession processes in the Rocky Mountains. The software is being developed to aid Forest Service planners evaluate the historic range of variation in landscape structure and wildlife habitat, and to evaluate the potential consequences of alternative future land management scenarios.

Sentinel-2

https://sentinel.esa.int/web/sentinel/home
Sentinel-2 is an Earth observation mission from the Copernicus Programme that systematically acquires optical imagery at high spatial resolution (10 m to 60 m) over land and coastal waters. The mission is a constellation with two twin satellites, Sentinel-2A and Sentinel-2B.

The mission supports a broad range of services and applications such as agricultural monitoring, emergency management, land cover classification or water quality.

Sierra Water Work Group - localized GIS apps

Sierra Water Workgroup has launched a series of watershed management GIS apps with and for Sierra Nevada IRWM regions and their stakeholders.

Tahoe-Sierra IRWM App
Yosemite-Mariposa IRWM App
CABY IRWM App
Upper Sacramento River IRWM App
The Inyo-Mono IRWM App & Lahontan Basin IRWM App coming soon!

Simtable

https://www.simtable.com/
Simtable provides digital sandtables and customized agent-based models to the wildland fire, emergency management, defense and urban security communities and colleges and universities. Based in Santa Fe, NM, Simtable is a world leader in agent-based modeling, data visualization and human computer interaction.

Combining existing GIS data with next generation agent-based modeling and ambient computing, Simtable provides a straightforward easy to use approach in incident response and training. Customized models of communities and populations provide a truly interactive experience in all-hazards simulations.

Topofire

https://topofire.dbs.umt.edu/topofire_v3/index.php

A topographically resolved drought and wildfire danger monitoring system for the conterminous US

Topofire Layers

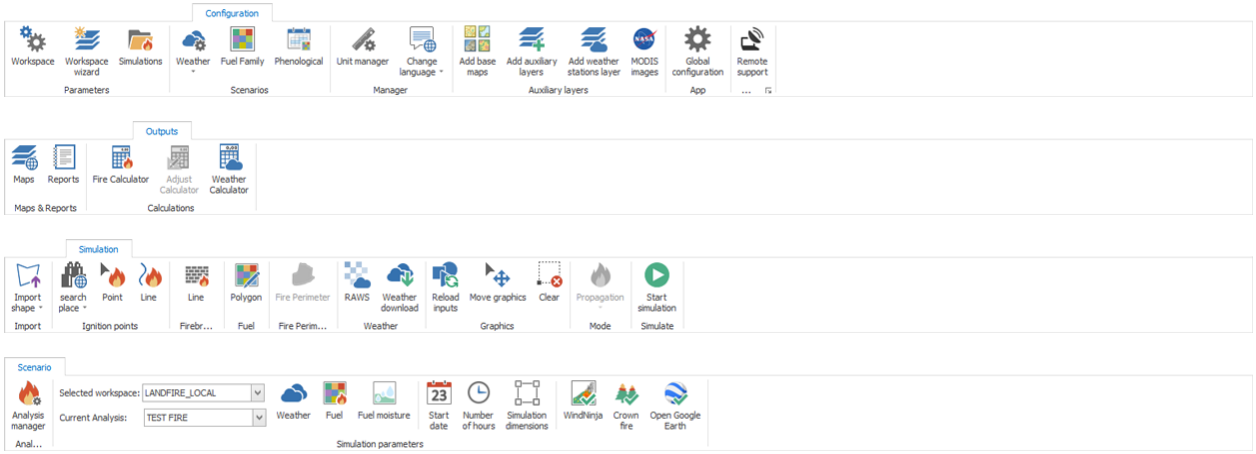
- Ground and Fuel Moisture
- Fire Danger
- Fire Activity
- MTBS Fire Severity
- Daily Weather
- Precipitation and Snow
- Vegetation
- Mountain Pine Beetle

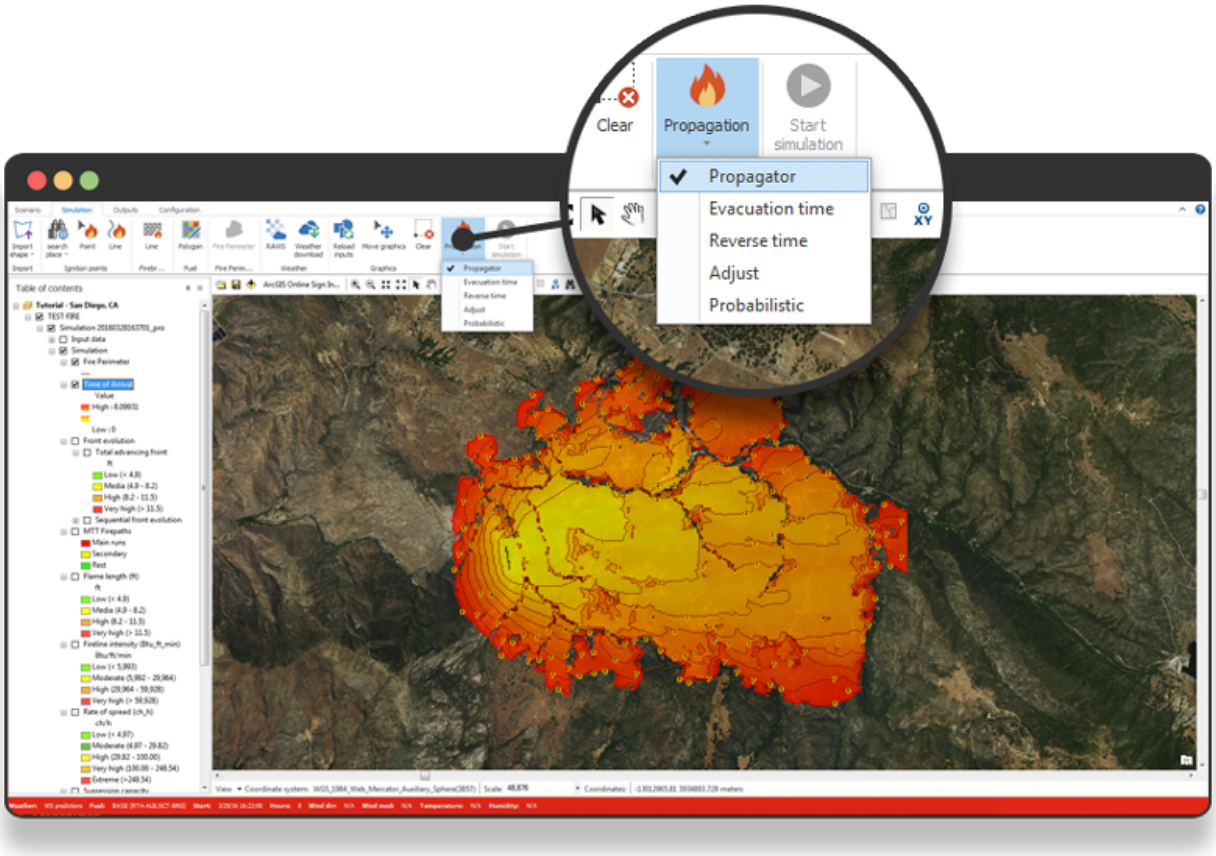
WFA

Wildfire Analyst

https://www.wildfireanalyst.com/

Real-time wildfire modeling that provides stakeholders the information they need to make more informed decisions.





Wildfire Analyst is software that provides real-time analysis of wildfire behavior and simulates the spread of wildfires. Behavior analysis and simulations are completed in seconds, providing results that afford timely decision making.

For wildland fire, time is of the essence, and Wildfire Analyst was specifically architected to support initial attack situations, giving the Fire Chief and Incident Commander the critical intelligence needed to support suppression and resource allocation.

Wildfire Analyst provides a range of analytical outputs, available as GIS maps, charts, and reports, that empower more accurate and timely decision making. Whether through the desktop platform, or web and mobile enabled applications, capabilities and results are deployed to those who need it, when they need it, without delay.

WFAS

Wildland Fire Assessment System

http://www.wfas.net/
The Wildland Fire Assessment System (WFAS) is an integrated, web-based resource to support fire management decisions. It serves as the primary distribution platform for spatial fire danger data to a nationwide user base of federal, state, and local land managers. This web-based platform saw over 41,100 users with nearly 200,000 page views during 2014. The system provides multi-temporal and multi-spatial views of fire weather and fire potential, including fuel moistures and fire danger classes from the NFDRS, as well as Keetch-Byram and Palmer drought indices, lower atmospheric stability indicators, and satellite-derived vegetation conditions. It also provides fire potential forecasts from 24 hours to 30 days.

WFDS

Wildland-Urban Interface Fire Dynamics Simulator

https://sites.google.com/site/wuifiresfiremodels/
https://www.fs.fed.us/pnw/fera/wfds/#4b
The Wildland-Urban Interface Fire Dynamics Simulator (WFDS) is an extension of NIST's structural Fire Dynamics Simulator (FDS) to fuels that include vegetation. WFDS uses computational fluid dynamics methods to solve the governing equations for buoyant flow, heat transfer, combustion, and the thermal degradation of vegetative fuels. The solution method makes use of large eddy simulation techniques to solve the gas-phase equations on computational grids that are too coarse to directly resolve the detailed physical phenomena.

This model suite is developed under a U.S. Forest Service and National Institute of Standards and Technology (NIST) partnership with past funding from the Joint Fire Science Program.

The WFDS model suite currently consists of two models:
WFDS-PB is a physics based model that explicitly accounts for the interactions between wind, fuel, terrain, and fire using the methods of computational fluid mechanics and numerical combustion.

WFDS-LS is a level set based fire front propagation model that requires user specified spread rates for the head, back, and flank fire. This model is commensurate with the U.S. Forest Service model FARSITE.

The results of both WFDS models can be viewed with the visualization Smokeview, developed by NIST. Input files for both models are similar.

Interra: Enterprise Geospatial Portal
https://egp.nwcg.gov/egp/default.aspx?ReturnUrl=%2fegp%2f

Intterra is used to protect our nation's forests. Over 6,000 firefighters access Intterra to monitor, cooperate, support, and protect the lands governed by the United States Forest Service.

WFDSS

Wildland Fire Decision Support System

https://wfdss.usgs.gov/wfdss/WFDSS_Home.shtml
This system assists fire managers and analysts in making strategic and tactical decisions for fire incidents. It has replaced the WFSA (Wildland Fire Situation Analysis), Wildland Fire Implementation Plan (WFIP), and Long-Term Implementation Plan (LTIP) processes with a single process that is easier to

use, more intuitive, linear, scalable, and progressively responsive to changing fire complexity.

WFDSS integrates the various applications used to manage incidents into a single system, which streamlines the analysis and reporting processes.

WFDSS provides the following advantages over previous systems:

- Combines desktop applications for fire modeling into a web-based system for easier data acquisition.
- Provides an easy way for fire managers and analysts to accurately document their decision-making process by allowing results of analyses to be attached to the decision point and included in the final incident report.
- Provides one decision process and documentation system for all types of wildland fires.
- Is a web-based application for easier sharing of analyses and reports across all levels of the federal wildland fire organization.
- Introduces economic principles into the fire decision process.

WIFIRE

https://wifire.ucsd.edu/
The WIFIRE Lab develops integrated systems for natural hazards monitoring, simulation, and response. Our mission is to conduct research and development towards infrastructure, services and tools for artificial intelligence integrated fire science.

WIFIRE Lab grew out of an NSF-funded project called WIFIRE, where we grew our passion for integrated wildfire modeling and response.

Although, the WIFIRE Cyberinfrastructure is built with a primary goal of enhancing fire science, it has been impactful in operational fire response and

public situational awareness settings. As an example for the system's public impact, through word-of-mouth and social media the Firemap tool was accessed by 800,000 public users over 8 million times to view information related to the devastating wildfires in California throughout the fall of 2017.

WIMS

Weather Information Management System

https://famit.nwcg.gov/applications/WIMS
WIMS is a mission critical, national system, managed and maintained by USDA, Forest Service's Fire and Aviation Management (F&AM) branch for interagency use. WIMS serves as the processor for the National Fire Danger Rating System (NFDRS), using weather observations and NWS forecast to generate indices, including Burning Index (BI), Energy Release component (ERC), Staffing Level (SL) and the Adjective Rating.

Vega

https://vega.github.io/vega/
Vega is a visualization grammar, a declarative language for creating, saving, and sharing interactive visualization designs. With Vega, you can describe the visual appearance and interactive behavior of a visualization in a JSON format, and generate web-based views using Canvas or SVG.

Programs, governance, standards & frameworks

CEQA

The California Environmental Quality Act

http://opr.ca.gov/ceqa/

The California Environmental Quality Act (CEQA) generally requires state and local government agencies to inform decision makers and the public about the potential environmental impacts of proposed projects, and to reduce those environmental impacts to the extent feasible. If a project subject to CEQA will not cause any adverse environmental impacts, a public agency may adopt a brief document known as a Negative Declaration. If the project may cause adverse environmental impacts, the public agency must prepare a more detailed study called an Environmental Impact Report (EIR). An EIR contains in-depth studies of potential impacts, measures to reduce or avoid those impacts, and an analysis of alternatives to the project. A key feature of the CEQA process is the opportunity for the public to review and provide input on both Negative Declarations and EIRs.

The laws and rules governing the CEQA process are contained in the CEQA statute (Public Resources Code Section 21000 and following), the CEQA Guidelines (California Code of Regulations, Title 14, Section 15000 and following), published court decisions interpreting CEQA, and locally adopted CEQA procedures.

The Governor's Office of Planning and Research (OPR) serves several important functions in the administration of CEQA. First, together with the Natural Resources Agency, OPR develops the CEQA Guidelines. The CEQA Guidelines are administrative regulations interpreting the CEQA statute and published court decisions. Second, OPR runs the State Clearinghouse which coordinates state level review of CEQA documents. Third, in certain circumstances, OPR may designate a lead agency. Finally, OPR provides technical assistance to state and local government agencies, including the development of technical advisories on selected CEQA topics.

CWHR

California Wildlife Habitat Relationships

https://www.wildlife.ca.gov/Data/CWHR
California Wildlife Habitat Relationships (CWHR) is a state-of-the-art information system for California's wildlife. CWHR contains life history, geographic range, habitat relationships, and management information on 712 species of amphibians, reptiles, birds, and mammals known to occur in the state. CWHR products aid in understanding, conserving, and managing California's wildlife.

- CWHR Life History Accounts and Range Maps (online): Life history information and geographic range data by season on 712 regularly-occurring species. Species range GIS data are available below under GIS data downloads.
- A complete species list (PDF) of California's 1000+ terrestrial vertebrates.
- Guide to Wildlife Habitats of California: a standardized habitat classification scheme for California containing 59 habitats, structural stages for most habitats, and 124 special habitat elements.

- CWHR Model and BIOVIEW (CWHR Version 9.0): A community-level matrix model associating 712 wildlife species to these standard habitats and stages - rating suitability for reproduction, cover, and feeding.

National Preparedness Level

The National Multi-Agency Coordination Group (MAC) establishes National Preparedness Levels throughout the calendar year to help assure that wildland firefighting resources are ready to respond to new incidents. Preparedness Levels are dictated by burning conditions, fire activity, and especially resource availability.

The five Preparedness Levels range from I to V, with V being the highest level. Each Preparedness Level has specific management directions. As the Preparedness Levels rise, more federal and state employees become available for fire mobilization if needed.

NEPA

National Environmental Policy Act

The National Environmental Policy Act (NEPA) is a United States environmental law that promotes the enhancement of the environment and established the President's Council on Environmental Quality (CEQ). The law was enacted on January 1, 1970. To date, more than 100 nations around the world have enacted national environmental policies modeled after NEPA.

Prior to NEPA, Federal agencies were mission oriented. An example of mission orientation was to select highway routes as the shortest route between two points. NEPA was necessary to require Federal agencies to evaluate the environmental effects of their actions. 2–3 NEPA's most significant outcome was the requirement that all executive Federal agencies prepare

environmental assessments (EAs) and environmental impact statements (EISs). These reports state the potential environmental effects of proposed Federal agency actions. Further the U.S. Congress recognizes that each person has a responsibility to preserve and enhance the environment as trustees for succeeding generations. NEPA's procedural requirements do not apply to the President, Congress, or the Federal courts since they are not a "Federal agency" by definition. However, a Federal agency taking action under authority ordered by the President may be a final agency action subject to NEPA's procedural requirements.

NFDRS

National Fire Danger Rating System

https://sites.google.com/firenet.gov/nfdrs

The National Fire Danger Rating System (NFDRS) has offered a consistent interagency decision-support framework since its inception in 1972. The System was first updated in 1978; and again in 1988. Although the original developers intended for periodic improvements to be incorporated as science and technology improved, the System has remained fundamentally unchanged the past 40 years. Today, there is an even greater need for state-of-the-art tools to assist the wildland fire community sort through the daunting complexities and conflicting priorities which can confound decision-makers.

In 2013, research scientists from the USDA Forest Service's Rocky Mountain Research Station (RMRS) proposed updates to the National Wildfire Coordinating Group (NWCG) Fire Danger Subcommittee. In September 2014, the NWCG Executive Board issued Memorandum 14-018, approving a revision to the US National Fire Danger Rating System. Three significant changes were addressed:

1. Incorporate the Growing Season Index (GSI) to compute live fuel moisture;

2. Incorporate the Nelson Model to compute fine dead fuel moisture; and
3. Reduce the number of fuel models in the NFDRS.

In September 2016, the NWCG Executive Board Issued Memorandum 16-019 providing an update of the transition to the 2016 version of NFDRS; otherwise known as NFDRS2016. The primary objective is to provide a stable NFDRS2016 system along with updates to the Weather Information Management System (WIMS) and FireFamilyPlus (FF+) to assure end-users are comfortable with the new model outputs and associated applications.

NFDRS2016 is a next-generation system which aligns with common interagency goals to use the best available science and technology to provide decision-makers with improved efficiencies, increased accuracy, and a much clearer understanding of the associated risks. Since interagency cooperation and collaboration (at every level) is essential for a successful transition to NFDRS2016, all agencies (State and Federal) with responsibility to make and implement risk-based wildfire management decisions are encouraged to participate in the roll-out process.
On July 24, 2019, the NWCG Executive Board approved a proposal from the Fire Danger Subcommittee to update the initial NFDRS2016 Rollout Plan. All units will be fully transitioned to NFDRS2016 by January 2021.

NWCG

National Wildfire Coordinating Group

https://www.nwcg.gov/data-standards-approved
NWCG data standards (data element and geospatial data layer) provide specifications that enable the common usage of data across wildland fire information systems. For more information click on one of the following lists:

- Requested Data Standards
- Assigned Data Standards
- Proposed Data Standards

OGC Standards

Open Geospatial Consortium

https://www.opengeospatial.org/docs/is

The OGC is a collaborative, global voluntary consensus standards organization focused on the discussion and resolution of interoperability issues in the geospatial domain. The key words are “collaboration” and “consensus”. Every member has the opportunity to participate, contribute, and have a voice in the development and approval of OGC standards.

Definitions, glossaries & appendices

Condition Class

Depiction of the degree of departure from historical fire regimes, possibly resulting in alterations of key ecosystem components. These classes categorize and describe vegetation composition and structure conditions that currently exist inside the Fire Regime Groups. Based on the coarse-scale national data, they serve as generalized wildfire rankings. The risk of loss of key ecosystem components from wildfires increases from Condition Class 1 (lowest risk) to Condition Class 3 (highest risk).

FBAN

Fire Behavior Analyst

FBAN is responsible for collecting weather data, developing strategic and tactical fire behavior information, predicting fire growth, and interpreting fire characteristics for use by incident overhead.

Fire Regime

A fire regime is the pattern, frequency, and intensity of the bushfires and wildfires that prevail in an area over long periods of time. It is an integral part of fire ecology, and renewal for certain types of ecosystems. A fire regime describes the spatial and temporal patterns and ecosystem impacts of fire on the landscape, and provides an integrative approach to identifying the impacts of fire at an ecosystem or landscape level. If fires are too frequent, plants may be killed before they have matured, or before they have set sufficient seed to ensure population recovery. If fires are too infrequent, plants may mature, senesce, and die without ever releasing their seed.

Fire regimes can change with the spatial and temporal variations in topography, climate, and fuel. Understanding the historic fire regime is important for understanding and predicting future fire regime changes and the interactions between fire and climates.

Fire Return Interval

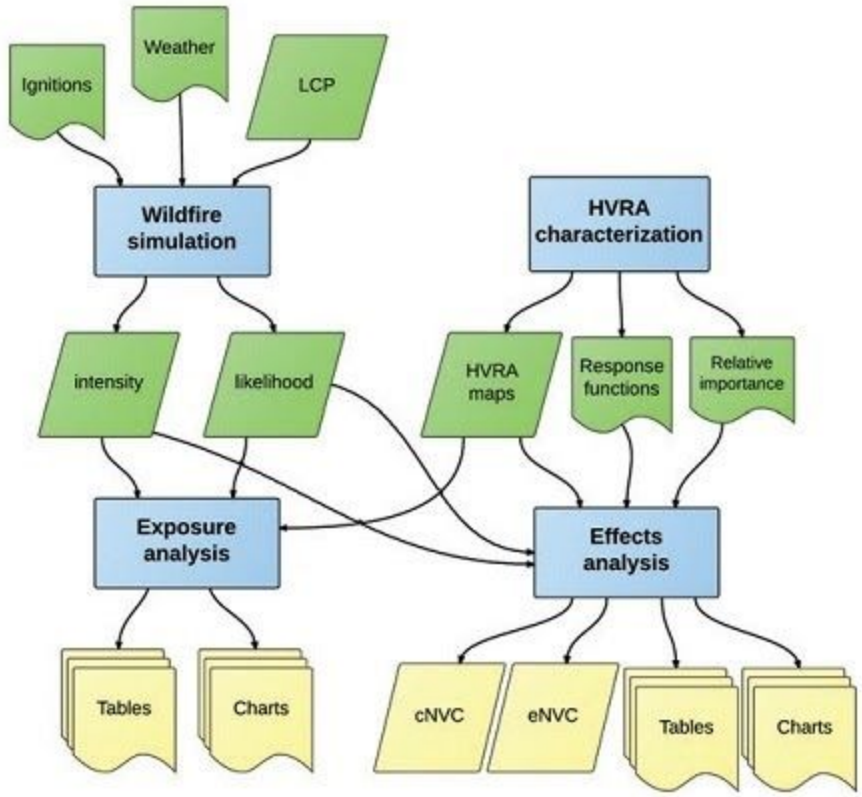
Fire return interval (or fire interval): The time between fires in a defined area, usually at the scale of a point, stand or relatively small landscape area.

Wildfire Risk

Wildfire risk is the product of the likelihood of a fire occurring (likelihood), the associated fire behavior when a fire occurs (intensity), and the effects of the fire (susceptibility) on highly valued resources and assets (Calkin et al. 2010, Finney 2005, Scott 2006, Scott et al. 2013). Wildfire risk mitigation is achieved when any of the three aspects are reduced.

Wildfire risk triangle. Figure 1 from [Scott et al. 2013](#).

The wildfire risk assessment framework is comprised of four primary components: 1) wildfire simulation, 2) highly valued resource and asset (HVRA) characterization, 3) exposure analysis, and 4) effects analysis. In this tutorial we give a brief overview of the process and highlight how ArcFuels can be leveraged to complete the exposure analysis and effects analysis steps. For detailed information we suggest you read [A wildfire risk assessment framework for land and resource management](#).



A wildfire risk assessment is comprised of four primary steps: 1) wildfire simulation, 2) highly valued resource and asset (HVRA) characterization, 3) exposure analysis, and 4) effects analysis. Cover figure from Scott et al. 2013.

Appendix: Fire and Forest Glossaries

Glossary of Forest Engineering Terms
https://www.srs.fs.usda.gov/forestops/glossary/

Forest Service Glossary and List of Acronyms
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5260256.pdf

(Basic) Glossary of Forestry Terminology
http://cemendocino.ucanr.edu/files/17302.pdf

Glossary of Wildland Fire
https://www.nwcg.gov/glossary/a-z

National Wildfire Coordinating Group
https://fam.nwcg.gov/fam-web/help/glossary.htm

FIRESCOPE Glossary of Terms
https://firescope.caloes.ca.gov/ICS%20Documents/ICS%20010-1.pdf

Smokepedia
http://smokeapp.serppas.org/smokepedia.html

Appendix: Studies & Papers

https://www.fs.fed.us/psw/publications/documents/psw_gtr237/psw_gtr237_089.pdf

WFDSS Spatial Fire Planning Guide
https://wfdss.usgs.gov/wfdss/pdfs/WFDSS_SFP_Guide.pdf

State and Private Forestry Fact Sheet California 2019
https://apps.fs.usda.gov/nicportal/temppdf/sfs/naweb/CA_std.pdf

Landscape LiDAR and Managing Forests at Multiple Scales
https://ww3.arb.ca.gov/smp/progdev/iasc/2017/condensed.pdf

Wildland Fire Potential: A Tool for Assessing Wildfire Risk and Fuels Management Needs
https://www.fs.fed.us/rm/pubs/rmrs_p073/rmrs_p073_060_076.pdf

How CalFire Is Spending Recent Forest Health Funds
https://lao.ca.gov/Publications/Report/3902

Improving California's Forest and Watershed Management
https://lao.ca.gov/Publications/Report/3798

A tree-based approach to biomass estimation from remote sensing data in a tropical agricultural landscape
https://www.sciencedirect.com/science/article/abs/pii/S0034425718304206

Threshold System Structure: Forest Health Example (includes workflow)
http://www.trpa.org/wp-content/uploads/2018_8_22_TUISWG_StaffPresentation.pdf

Land Management Plan - Lake Tahoe Basin Management Unit
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd507523.pdf

Cost savings and risk management through precision silviculture

https://www.luke.fi/en/news/cost-savings-and-risk-management-through-precision-silviculture/

McKinsey & Company - Precision forestry: A revolution in the woods
https://www.mckinsey.com/industries/paper-forest-products-and-packaging/our-insights/precision-forestry-a-revolution-in-the-woods

A Wildfire Risk Assessment Framework for Land and Resource Management
https://www.fs.fed.us/rm/pubs/rmrs_gtr315.pdf

Lake Tahoe West Landscape Resilience Assessment
https://www.nationalforests.org/assets/files/Lake-Tahoe-West-Landscape-Resilience-Assessment-V1-FINAL-11Dec2017.pdf

Appendix: Online Maps

CALFIRE Viewers
https://frap.fire.ca.gov/mapping/viewers/

FHSZ Viewer

Forest Practice Watershed Mapper

[SRA Viewer]

[Emergency Declaration Drought-Caused Tree Mortality Viewer]

[2018 Priority Landscapes]

CalFire - Incidents Overview
https://www.fire.ca.gov/incidents/

SF Chronicle CA Fire Tracker
https://projects.sfchronicle.com/trackers/california-fire-map/

Firebuster
https://fwxfcst.us/firebuster/

ONCC: Fire Activity
https://gacc.nifc.gov/oncc/index.php

Topofire - Topographically resolved drought and wildfire danger monitoring system for the conterminous US
https://topofire.dbs.umt.edu/topofire_v3/index.php

MRLC: Land Characteristics
https://www.mrlc.gov/viewer/

MTBS - Monitoring Trends in Burn Severity
https://www.mtbs.gov/viewer/index.html

NOAA - Hazard Mapping System Fire and Smoke Product
https://www.ospo.noaa.gov/Products/land/hms.html

Global Forest Watch
https://www.globalforestwatch.org

Prep Data
https://www.prepdata.org/

BLM - Geospatial
https://www.blm.gov/services/geospatial
https://navigator.blm.gov/map

NASA - Earthdata

https://earthdata.nasa.gov/

Data Basin - science-based mapping and analysis platform that supports learning, research, and sustainable environmental stewardship
https://databasin.org

GEOMAC - Wildland Fire Support
https://www.geomac.gov/viewer/viewer.shtml

USDA Forest Service - PSW district (possibly out of maintenance)
https://www.fireimaging.com

Landfire
https://www.landfire.gov/viewer/viewer.html?extent=-124.459318868889,37.4490776022576,-122.086281160658,42.0270285914843

WFDS - Wildland-Urban Interface Fire Dynamics Simulator
https://www.fs.fed.us/pnw/fera/wfds/simulation_models.shtml

Trust for Public Land Forest Carbon Mapping tool
https://dev.tplgis.org/carbonmap/

Appendix: Web Resources

https://www.fs.fed.us/wwetac/tools/arcfuels/help/Content/02Toolbar/05-04%20-Wildfire%20Models.htm

Wildfire Models link page

Fire Behavior Model	Description	Linkage within ArcFuels10
NEXUS (Scott 1999)	Stand-level spreadsheet that links surface and crown fire prediction models	Calls the program, creates input data
Fire Area Simulator (FARSITE, Finney 1998)	Landscape-level fire spread simulator	Calls the program, creates input data, processes output data
FlamMap (Finney 2006)	Landscape-level fire behavior mapping and analysis program	Calls the program, creates input data, processes output data
BehavePlus (Heinsch and Andrews 2010)	Stand-level fire behavior, fire effects, and fire environment modeling system	Calls the program; SURFACE module fully integrated in the Behave Calculator
First Order Fire Effects Model (FOFEM, Reinhardt et al. 1997)	Stand-level first order fire effects modeling system	Calls the program
Fire Family Plus (Main et al. 1990)	Analysis of fire danger indices and weather	Calls the program

https://ww3.arb.ca.gov/smp/techtool/techtool.htm

Smoke Management Program Technical Tools

https://gacc.nifc.gov/oncc/predictive/weather/index.htm

Northern California Geographic Area Coordination Center: Very deep list of links and resources for weather, smoke and fire

https://gacc.nifc.gov/oncc/analysis.php

Northern California Geographic Area Coordination Center: Very deep list of links and resources for Fire Analysis

https://gacc.nifc.gov/oncc/intel.php
Northern California Geographic Area Coordination Center:
ONCC Intel links to products and resources
The Intelligence Section provides fire management personnel, incident managers, firefighters and support staff with access to current intelligence on preparedness levels, fire situation, resources, mapping and satellite imagery, climatology, preparedness levels, resource availability and rotations, and fire potential information.

https://tahoe.livingwithfire.info/
Helping Lake Tahoe Residents and Visitors Prepare for Wildfire

https://www.neonscience.org/
The National Ecological Observatory Network:
Open data to understand how our aquatic and terrestrial ecosystems are changing

Appendix: Competitive and Adjacent Market – Tools and Companies

Openforis
http://www.openforis.org

Open Foris is a set of free and open-source software tools that facilitates flexible and efficient data collection, analysis and reporting.

Government, research institutions and NGOs use these tools for a wide range of monitoring purposes such as:

- Forest Inventories
- Climate Change reporting
- Socio-economic surveys
- Biodiversity assessment
- Land Use, Land Use Change and Forestry measurement
- Deforestation monitoring with remote sensing
- Detecting desertification and trees outside of forests

The initiative is a collaborative effort of numerous public and private institutions and it is hosted by the Forestry Department of the Food and Agriculture Organization of the United Nations.

Pyrologix
http://pyrologix.com/
Pyrologix LLC was formed to provide specialized fuel characterization and wildfire modeling services to the United States Forest Service. Our client roster has since expanded to include non-governmental organizations, businesses, local and state government entities, and federal agencies in the Departments of Defense, Homeland Security and Interior.

Pyrologix is based in Missoula, Montana, a small city in the northern Rocky Mountains. Missoula is home to premier wildfire and risk science research organizations like the Missoula Fire Sciences Lab, Aldo Leopold Wilderness Research Institute, and Human Dimensions Program of the USFS Rocky Mountain Research Station, the National Center for Landscape Fire Analysis, and the SAF-accredited School of Forestry at the University of Montana.

ESRI / ArcGIS
https://www.esri.com

Intterra
https://www.intterragroup.com
https://www.intterragroup.com/case-study-enterprise-geospatial-portal/
Intterra started on fire. Our team, our tech, and our spirit formed around the need to get reliable information to the fireline faster than was possible back in the day. We had each been challenged, frustrated, even heartbroken by the need for critical intel to save homes, lives, communities, watersheds, wildlife, and firefighters.

When firefighters are racing against disaster – and every emergency is someone's personal disaster – they need to know what's around the corner, what's likely to happen next, where the hazards are located, who's next to them in the dark, and how to get out safely. That's our mission, our vision, our strategy, our tech, our metric, and our bottom line: helping get information to the people who put their lives on the line to save others, as fast as technologically possible.

Silviaterra
https://www.silviaterra.com/bark/index.html

Landfire
https://www.landfire.gov
https://www.youtube.com/playlist?list=PL90B8F1B49D94B2C0 (Landfire on YouTube)

Landscape Fire and Resource Management Planning Tools is a shared program between the wildland fire management programs of the U.S. Department of Agriculture Forest Service and U.S. Department of the Interior, providing landscape scale geo-spatial products to support cross-boundary planning, management, and operations.

What We Do
This multi-partner program produces consistent, comprehensive, geospatial data and databases that describe vegetation, wildland fuel, and fire regimes across the United States and insular areas.

Our Vision
LF is a cornerstone of a fully integrated national data information framework developing and improving vegetation and fuels data products based on the best available authoritative data and science in an all lands landscape conservation approach based on inter-agency/inter-organizational collaboration and cooperation. LF is acknowledged for management excellence and effective mission delivery.

Our Mission
LF's mission is to provide agency leaders and managers with a common "all-lands" data set of vegetation and wildland fire/fuels information for strategic fire and resource management planning and analysis.

34North / OpenNRM
http://34north.com/
http://34north.com/opennrm/opennrm-forest-management-and-project-prioritization-data-platform/

34 North is an innovator in collaborative natural resource management technologies and data solutions. Our unique software platform, OpenNRM, is designed to help our clients turn data into valuable information.

OpenNRM is a collaborative resource management platform for data and information collection, analysis, reporting, and visualization. Since 1999, 34 North has been an innovator in collaborative natural resource management technologies and data solutions. Our unique software platform, OpenNRM , and data service offerings help our clients to turn data into valuable real time information. OpenNRM applications include:

Collaborative Natural Resource Management and Planning
Ecosystem Restoration Project Management
Collaborative Data Management and Access, Open Data
Collaborative Science
Water Operations
Monitoring Programs
Watershed and Estuary Management
Regulatory Compliance and Reporting
Fisheries Management
Inter-agency Collaboration
Climate Adaptation
Conservation
Policy and Public Outreach

Forest Management Data Platform

OpenNRM Forest Management and Project Prioritization

Forest restoration and management must be implemented strategically at the landscape scale to effectively yield multiple watershed benefits. Working with stakeholders, 34 North has customized our OpenNRM data platform to support fuels reduction and forest restoration planning to reduce the risks associated with wildfire. The platform facilitates a more robust collaborative planning process and addresses the challenges facing our forests and the need to increase the “pace and scale of restoration”.

Data and information exist for various purposes in many different forms. To efficiently plan and restore at a landscape level, data and information needs to be accessible, useful, and accurate. The successful implementation of landscape level planning requires the cooperation and coordination of

various agencies, community groups, and individual landowners. Our data platform supports regional stakeholders with collaborative planning tools and base line information allowing stakeholders to view and assess project area conditions and implementation challenges.
The OpenNRM Forest Management Data Platform significantly increases the capacity for forest restoration and fuel reduction project planning.

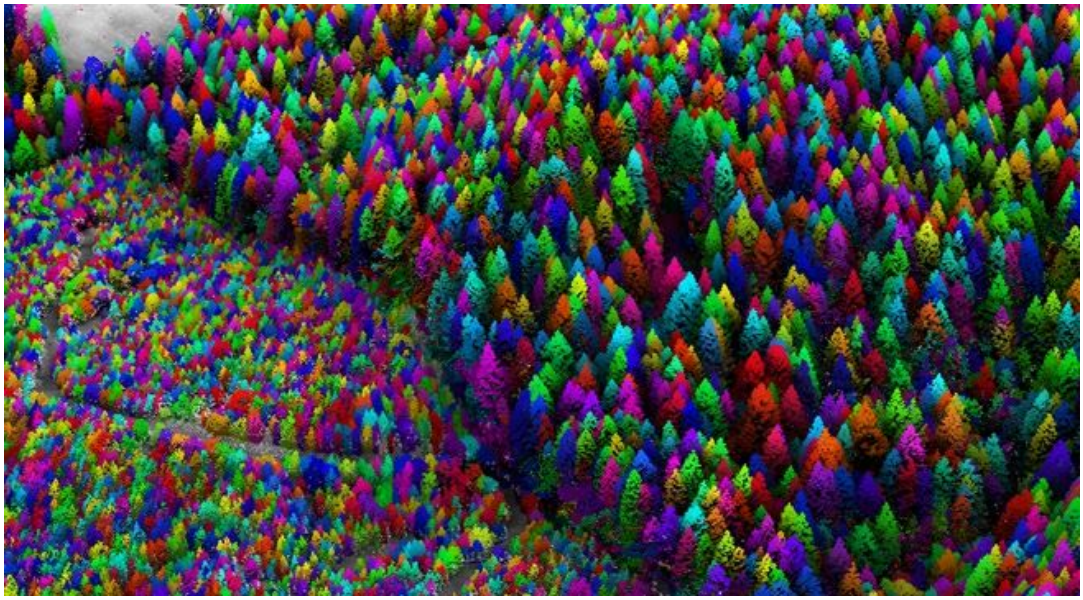
Quantum Spatial
https://quantumspatial.com/
http://quantumspatial.com/about-us/what-we-do
http://quantumspatial.com/our-solutions/forestry
https://vimeo.com/quantumspatial

Quantum Spatial does it all. We go well beyond data acquisition. We excel at transforming data into usable information tailored to meet your needs. We carefully consider technology choices and survey design to optimize data quality, and then we transform pixels and points into meaningful analytics based on the questions you want to answer.

We invest in and deploy the latest and most advanced sensor, platform and satellite technologies on the market to acquire geospatial data. And our acquisition team is the best, bar none.

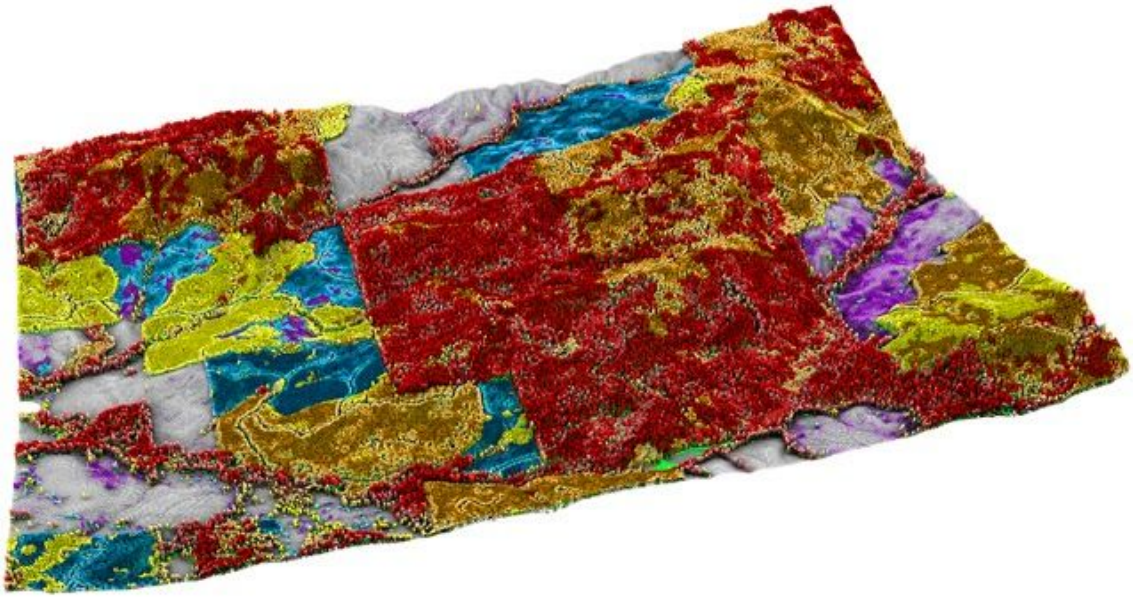
FORESTRY

Individual Tree Delineation & Attribution
Calculate and catalog valuable forest metrics such as tree height, canopy cover, stem density, and crown area for individual trees in both forest and urban settings. Quantum Spatial has developed cutting-edge methodology that generates forest metrics directly from LiDAR points, which produces an accurate, detailed tree databases for entire study areas.



Forest Stratification

Model forest structure and use the results to make management decisions. When aggregated, individual tree metrics produce nuanced analysis of forest characterization. Incorporating Quantum Spatial's forest models aids timber management practices, supports habitat conservation efforts, and improves efficiency of ground surveys and research plot placement.

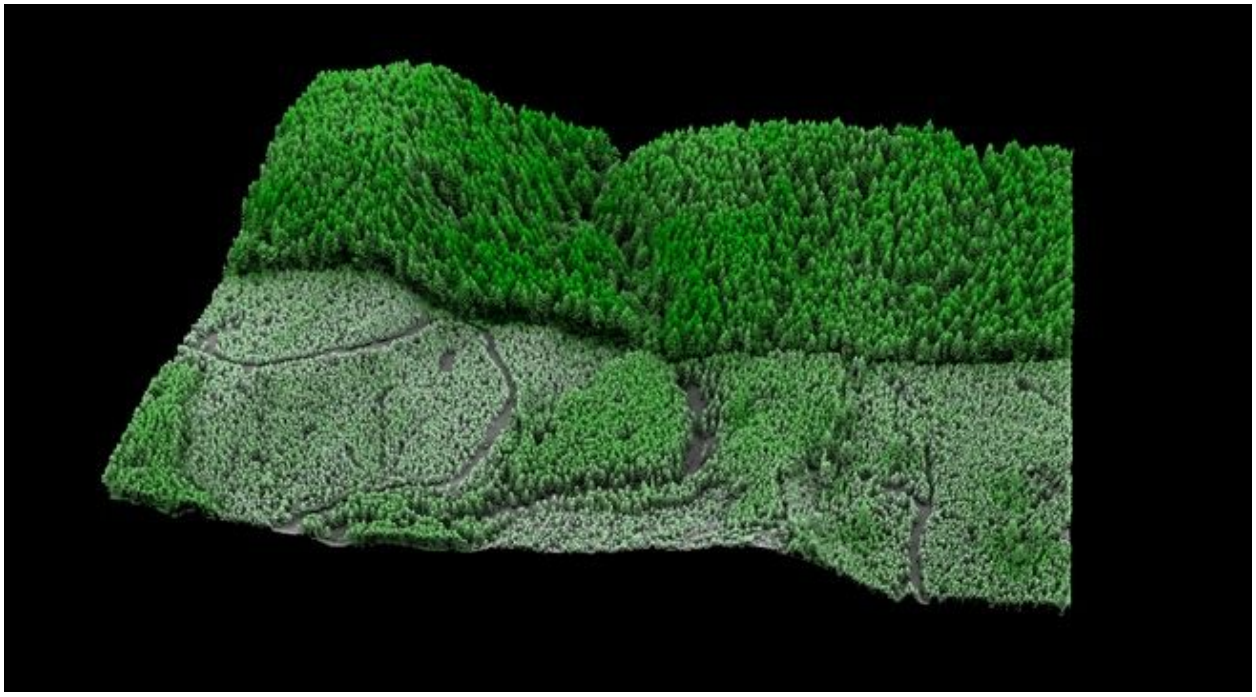


Hardwood - Softwood Classification

Enhance forest structure modeling by distinguishing hardwoods from softwoods. In conjunction with Quantum Spatial's LiDAR-derived physical tree measurements and density calculations, our hardwood/softwood classification further defines forest characterization over vast areas

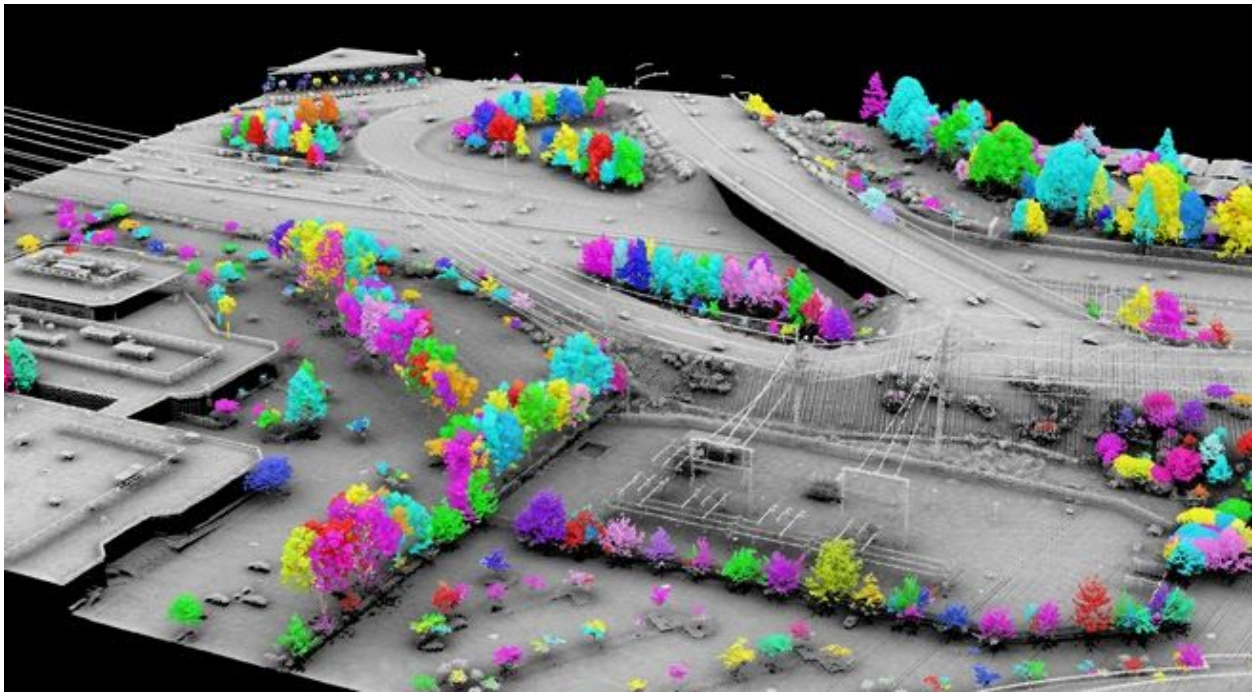
Carbon & Biomass Estimation

Quantify complex bio-relationships using our LiDAR data and analytics. In tandem with onsite measurements, we create linear regression models to calculate carbon, biomass, and related forest inventory parameters.



Urban Forest Inventories

Maintain urban forest health through Quantum Spatial's efficient and accurate approach that identify iIndividual trees are assigned a unique tree ID, and additional metrics relating to tree height, canopy height, canopy cover, stem density, and crown area are calculated directly from our LiDAR data, resulting in precise calculations.



Wildfire Modeling

Forest metrics from LiDAR provide valuable information in the application of land use and management practices, fire suppression planning and fuel loading calculations. High resolution LiDAR also provides detailed terrain models for the determination of slope and aspect, as well as the identification of access roads delineation.

Change Detection

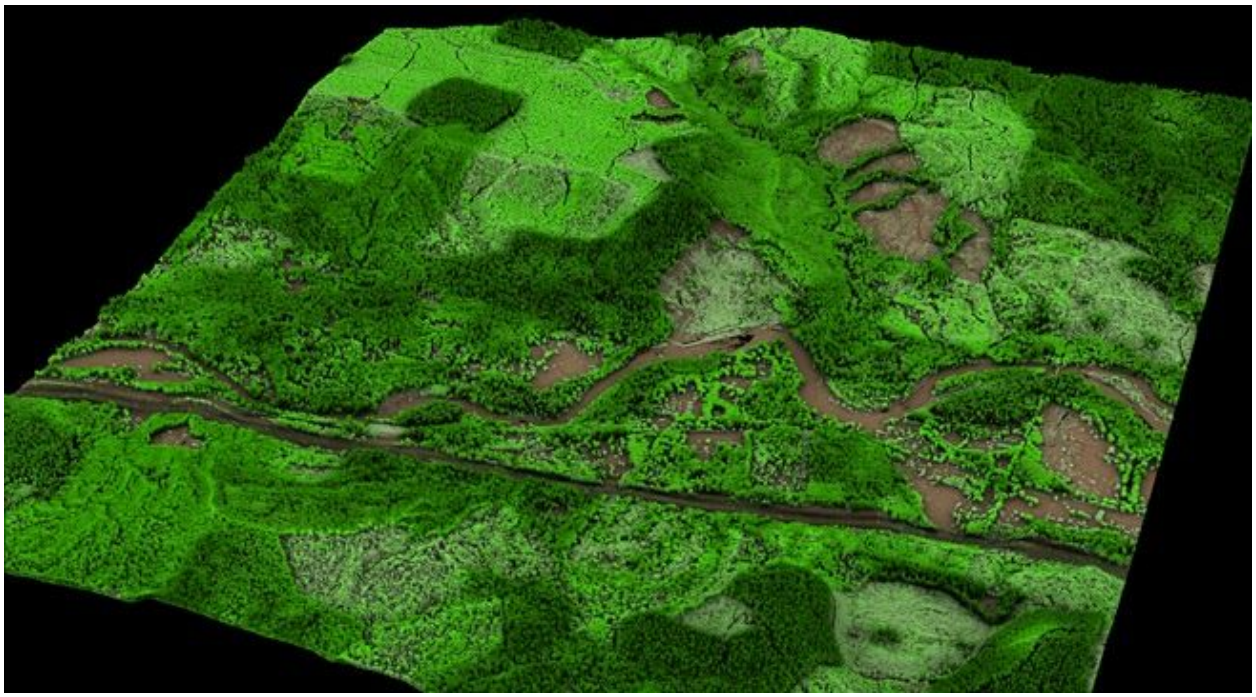
Monitor forest dynamics, including tree growth and vegetation removal with recurring surveys and our temporal analysis and modeling.

Watershed Drainage & Overland Flow Analysis

Combine hydrological mechanics with forest structure modeling to understand the impacts of terrain surface and water movement on forest composition.

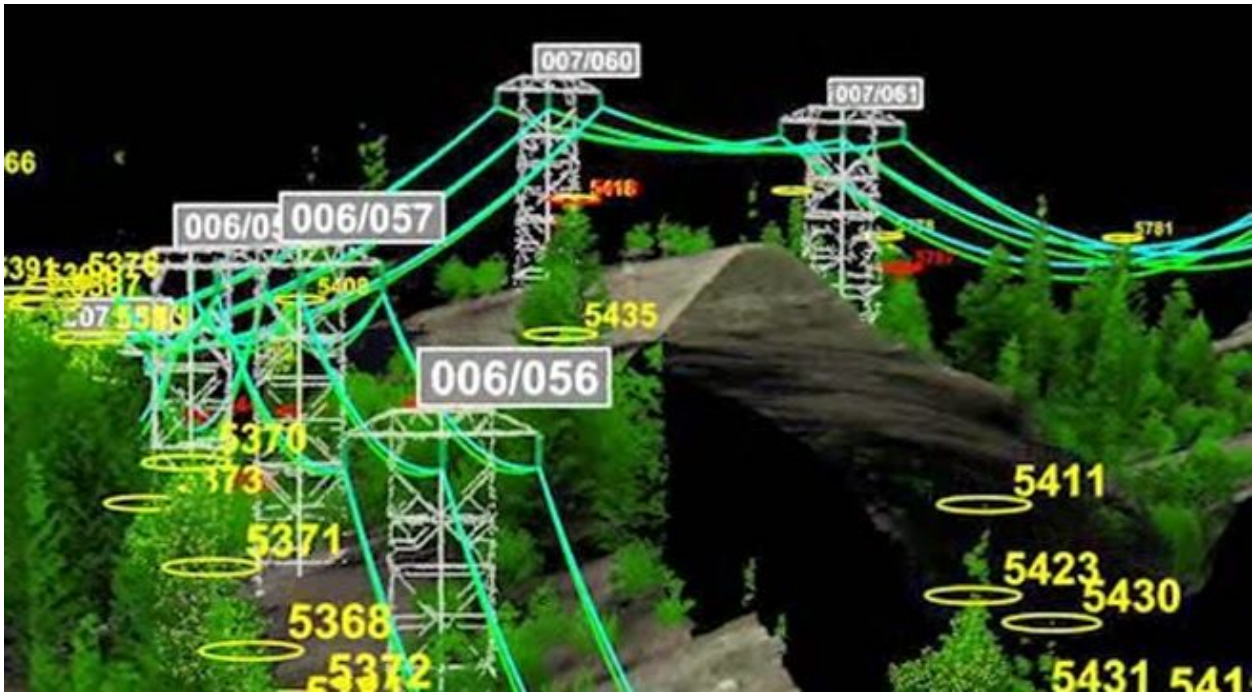
Landslide Analysis

Mitigate forest management risks associated with Landslides. With our high-resolution datasets and analytics, we identify terrain instability beneath dense forest canopy. Find out more about Quantum Spatial's terrain analysis HERE



Vegetation Management Applications

Apply Quantum Spatial's tree analysis to vegetation management practices. We have developed comprehensive programs for electrical utility corridors, oil and gas pipelines, and airport operations. LiDAR based vegetation management provides a fast, safe, and cost competitive approach that increases efficiency of management efforts, decreases underlisting of potential risks, and reduces the amount of time and money spent on mitigation efforts.



Urban Footprint

https://urbanfootprint.com/

Create beautiful maps in a snap. Enhance proposals, reports, and more.

Step up your proposal game, engage your community, or simply craft stunning maps with UrbanFootprint's best-in-class data visualization. Search any U.S. location to create a map in seconds. Choose from hundreds of curated datasets for quick location insights.

Plan Safe, Strong, and Resilient Cities with UrbanFootprint. UrbanFootprint's Risk and Resilience Module is designed to help planners and communities better prepare for the projected impacts of:

- Sea level rise
- Flood risk
- Fire hazard

Vizzuality
https://www.vizzuality.com
Beautiful data design for a better world. We are trusted by the world's most important organisations to create unique tools and applications with a lasting benefit to society and the environment

Technosylva
https://technosylva.com/
Technosylva provides advanced GIS-enabled software solutions for wildfire protection planning, operational response & firefighter and public safety. Our solutions encapsulate years of forestry and wildfire experience into efficient, timely and responsive applications – on desktop, web & mobile platforms.

Technosylva offers a range of subject matter expertise, consulting services and software development capabilities unparalleled for Wildfire Risk Analysis, Fire Protection Planning and Fire Incident Operations. This expertise is encapsulated in our fiResponse™, Wildfire Analyst™ and Wildfire Risk Atlas products.

Appendix: Education / R&D Labs

Forest Resilience Lab - University of Washington
https://sites.uw.edu/vkane

The Forest Resilience Lab in the School of Environmental and Forest Sciences, within the Precision Forestry Collaborative, conducts applied precision forest ecology research to promote forest resilience in the face of climate change. We apply the full suite of technical innovations in active and passive sensing (i.e., lidar, spectral remote sensing, and structure from motion) along with field assessments to investigate what forest structure patterns are resistant to changing ecological processes such as wildfire and drought across multiple spatial scales from the project to ecoregion. We conduct our research in forests located in the western United States, and we collaborate with researchers and land managers to assist in forest planning; evaluating wildlife habitat; and forest management efforts. Our lab is led by Dr. Van R. Kane, a research professor at the University of Washington, College of the Environment, School of Environmental and Forest Sciences . Our lab includes undergraduate, master's and doctoral graduate students, analysts, and faculty. We frequently partner with other labs in our School as well as outside of the University of Washington.

GEARS
Global Environmental Analysis and Remote Sensing Laboratory
https://naes.unr.edu/gears/

The Global Environmental Analysis and Remote Sensing (GEARS) Laboratory, led by Dr. Jonathan A. Greenberg, focuses on addressing questions of the impacts of climate change and land use/land cover change on vegetated ecosystems using remote sensing data. Our research ranges across scales from individual plants to the globe, across many terrestrial and aquatic

ecosystems, and utilizes state-of-the-art remote sensing imagery including hyperspectral, hyperspatial, multitemporal, thermal, and LiDAR data, collected from spaceborne, airborne, and terrestrial sensors.

Berkeley Ecosystem Management and Forestry (EMF)
https://nature.berkeley.edu/advising/majors/forestry-and-natural-resources

Ecosystem Management and Forestry (EMF) focuses on the conservation and restoration of the earth's natural resources through hands-on study of the ecology, stewardship, and management of forest, woodland, and grassland ecosystems. The program offers two specializations to choose from, and if the student chooses a specialization in Forestry, they can qualify to take the Registered Professional Foresters licensing exam in California. Topics studied include wildlife and conservation biology, ecosystem restoration, rangeland management, water policy, fire science, GIS and remote sensing, environmental justice, and rural sociology. Students can participate in an 8-week summer field program in the Sierra Nevada. Offered by the Department of Environmental Science, Policy, and Management (ESPM).

Yale's School of Forestry & Environmental Studies
https://environment.yale.edu/

Yale's School of Forestry & Environmental Studies aspires to lead the world toward a sustainable future with cutting-edge research, teaching, and public engagement on society's evolving and urgent environmental challenges.

Appendix: Grants

https://www.forestrygrants.org/westernLSR/

https://www.forestrygrants.org/cwsfWUI/

https://www.thewflc.org/landscape-scale-restoration-competitive-grant-program
The Landscape Scale Restoration (LSR) Competitive Grant Program prioritizes landscapes of national importance, using the Forest Action Plans and the national themes (specifically the National Themes/Priorities identified in the Farm Bill consistent with P.L. 110-246 Section 8001).
The objective is to focus competitive LSR funds on activities that address priority areas, challenges and opportunities facing Western lands. Funding for the LSR Competitive Process is made possible through the USDA Forest Service.
WFLC is charged with delivering the LSR competitive grant process in the West. Our LSR grants team reviews, scores and makes recommendations on project proposals from Western states and island territories, which are passed along to the WFLC membership for approval. Proposed projects recommended for funding are then sent to the Forest Service.

CA Energy Commission
https://www.energy.ca.gov/funding-opportunities
https://www.energy.ca.gov/programs-and-topics/programs/electric-program-investment-charge-epic-program

CalFire
https://www.fire.ca.gov/grants/

Forest Health Grant Program
https://www.fire.ca.gov/grants/forest-health-grants/

Microsoft AI for Earth
https://www.microsoft.com/en-us/ai/ai-for-earth-grants

Appendix: Land Management Plan Factors

Air Quality
Noise
Recreation
Roads
Scenic Quality
Socio-Economics (Social and Economic Systems)
Soil Conservation
Stream Environment Zones (SEZ)
Smoke
Transportation
Vegetation
Water Quality
Wildlife and Fisheries

Natural Hazards: flooding, mass wasting (landslides, etc.), earthquakes, liquefaction, seiches, avalanches and volcanic hazards

Climate change: expected to bring rising air temperatures and changes in precipitation patterns, leading to an increased risk of high severity fire and shifts in species ranges, presenting complex challenges for management. Perhaps chief among these challenges is how to sustainably balance restoration of fire-adapted ecosystems and fuels reduction projects to protect public and private assets, with the legal and biological necessity of preserving habitat for species that require dense canopy, late seral conditions.

Appendix: Market Opportunities

Individual Tree Delineation & Attribution
Forest Stratification
Hardwood - Softwood Classification
Carbon & Biomass Estimation
Urban Forest Inventories
Wildfire Modeling
Change Detection
Watershed Drainage & Overland Flow Analysis
Landslide Analysis
Vegetation Management Applications
Collaborative Natural Resource Management and Planning
Ecosystem Restoration Project Management
Collaborative Data Management and Access, Open Data
Collaborative Science
Water Operations
Monitoring Programs
Watershed and Estuary Management
Regulatory Compliance and Reporting
Fisheries Management
Inter-agency Collaboration
Climate Adaptation
Conservation
Policy and Public Outreach

Appendix: Example Datasets

NEON
https://data.neonscience.org/browse-data

NOAA
https://www.ospo.noaa.gov/Products/imagery/gis.html

MTBS
https://www.mtbs.gov/direct-download

BAER
https://fsapps.nwcg.gov/baer/data-request

BAER Imagery Support Data Download
https://fsapps.nwcg.gov/baer/baer-imagery-support-data-download

RAVG
https://fsapps.nwcg.gov/ravg/data-access

BLM
https://landscape.blm.gov/geoportal/catalog/main/home.page
https://landscape.blm.gov/geoportal/catalog/main/portal.page

Appendix: Example API's

NEON API
https://data.neonscience.org/data-api
The NEON API (Application Programming Interface) can be used to quickly access NEON data and information about our data products and sampling locations. This API provides a simple means of constructing URLs or CURL statements that return information in a common machine-readable format, JSON (JavaScript Object Notation).

The API provides numerous endpoints, each delivering different types of data or information. Some endpoints provide the option to enter values for specific parameters that allow you to refine your search. Click on the interactive table below to discover and try out the various endpoints. Below the table, read more details about each endpoint. If you need more information, try visiting our FAQ, GitHub repository, or Using the NEON API tutorial. We also provide an R package that you can use to download and reformat the data.

Research Watch
https://api.resourcewatch.org/
https://resource-watch.github.io/doc-api/index-rw.html

NASA - Earth Data
https://earthdata.nasa.gov/collaborate/open-data-services-and-software/api
https://earthdata.nasa.gov/eosdis/science-system-description/eosdis-components/gibs

Appendix: Example API Documentation

- Introduction
- Authentication
- Dataset
- Widget
- Layer
- Query
- Fields
- Metadata
- Vocabulary (and Tags)
- Geostore
- Subscriptions
- Favorites
- Graph
- Areas
- Webshot
- Topic
- Dashboard
- Tasks
- User Management
- Microservices
- Errors
- API attribution requirements