JUNE 2023

Forest Wildfires and the Delta

Tricia Lee, Senior Environmental Scientist

Delta Science Program

DELTA STEWARDSHIP COUNCIL

Background

- **Forest wildfire severity and frequency has increased** in recent years as a result of combined effects including:
  - Post-colonial fire management practices
  - Prolonged drought
  - Bark beetle infestation
  - Climate change
- **Forest wildfires often are outside of the legal Delta boundary**
  - Sediment and debris runoff
  - Wildfire retardants on water quality
  - Poor air quality

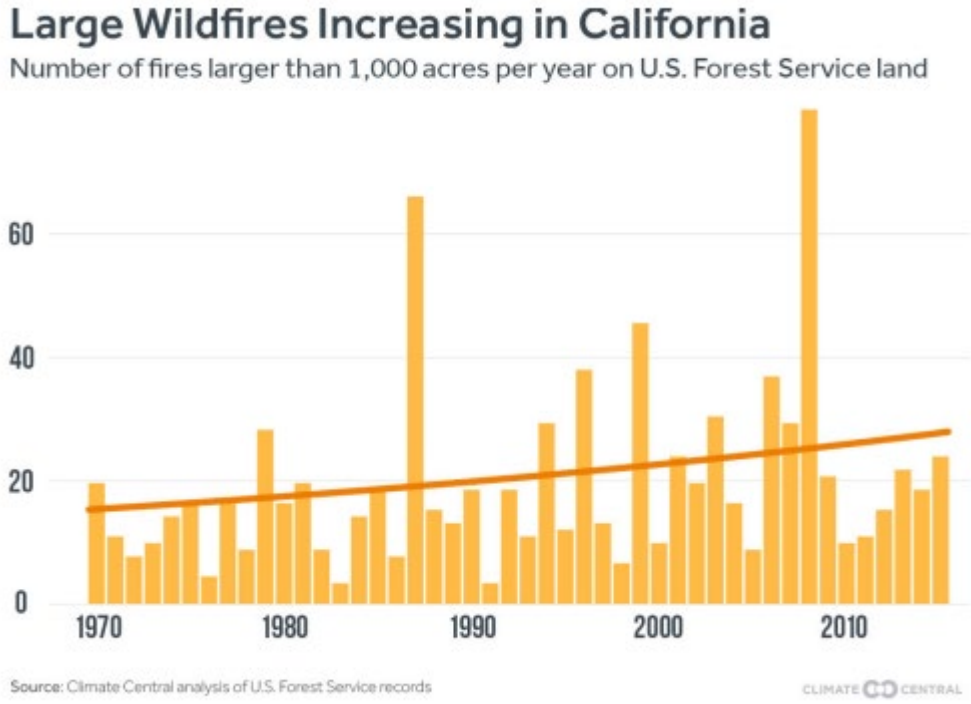


Image from June 2016 Climate Central Report "Western Wildfires: A Fiery Future"

Council Activities and Wildfires

- 2021 Delta Adapts Climate Change Vulnerability Assessment considered forest wildfire threats and smoke impacts to Delta communities
- Advancing Interdisciplinary Research Training (October 14, 2022)
  - Deniss Martinez spoke on indigenous fire stewardship in the state of California and indigenous climate justice
- The Delta Science Program is funding a research study on the impacts of wildfire retardants to early life stages of rainbow trout and Chinook salmon
- The 2024 State of Bay Delta Science will feature a chapter on wildfire impacts

LNU lightning complex burning near Lake Berryessa- August 19, 2020, Associated Press

About the Panel

Dr. Cliff Dahm

- Former Delta Lead Scientist, Professor Emeritus, University of New Mexico
- Water quality

Dr. Teresa Feo

- Senior Science Officer at the California Council on Science and Technology
- Wildfire smoke, public health

Phil Crader

- Assistant Deputy Director for the Division of Water Quality, State Water Resources Control Board
- Water quality and SWRCB's role

Dr. Amelie Segarra

- Assistant Adjunct Professor at UC Davis
- Wildfire retardants on native fish

Water Quality Effects from Recent Wildfires in California, USA

Clifford N. Dahm, University of New Mexico, Albuquerque, NM 87131, USA
Randy A. Dahlgren, University of California Davis, CA 95616, USA

2011 Las Conchas Fire - 63,370 ha

2013 Rim Fire – 104,131 ha

Largest California Wildfires - All in Recent Years

Fire Name and Cause	Date	Hectares
1. August Complex (Lightning)	August 2020	418,000
2. Dixie (Powerlines)	July 2021	389,800
3. Mendocino Complex (Human)	July 2018	186,000
4. SCU Complex (Lightning)	August 2020	160,500
5. Creek (Undetermined)	Sept 2020	154,000
6. LNU Complex (Lightning/Arson)	August 2020	147,000
7. North Complex (Lightning)	August 2020	129,100
8. Thomas (Powerlines)	Dec 2017	114,100

The 2019-2020 wildfire season in Australia was unprecedented with ~5.8 million hectares burned in New South Wales and the Australian Capital Territory (previous high 1.7 million hectares). The 2020 wildfires in the western US burned a record 4.2 million hectares (Robinne et al. 2021 Wildfire and Hydrological Processes).

Wildfire Trends in California
(Today vs 1970s)

- Frequency is increasing (4-fold)
- Area burned is increasing (6-fold)
- Intensity of fires is increasing (hotter fires)

- Fire season is now ~80 days longer than 1970s due to earlier snowmelt

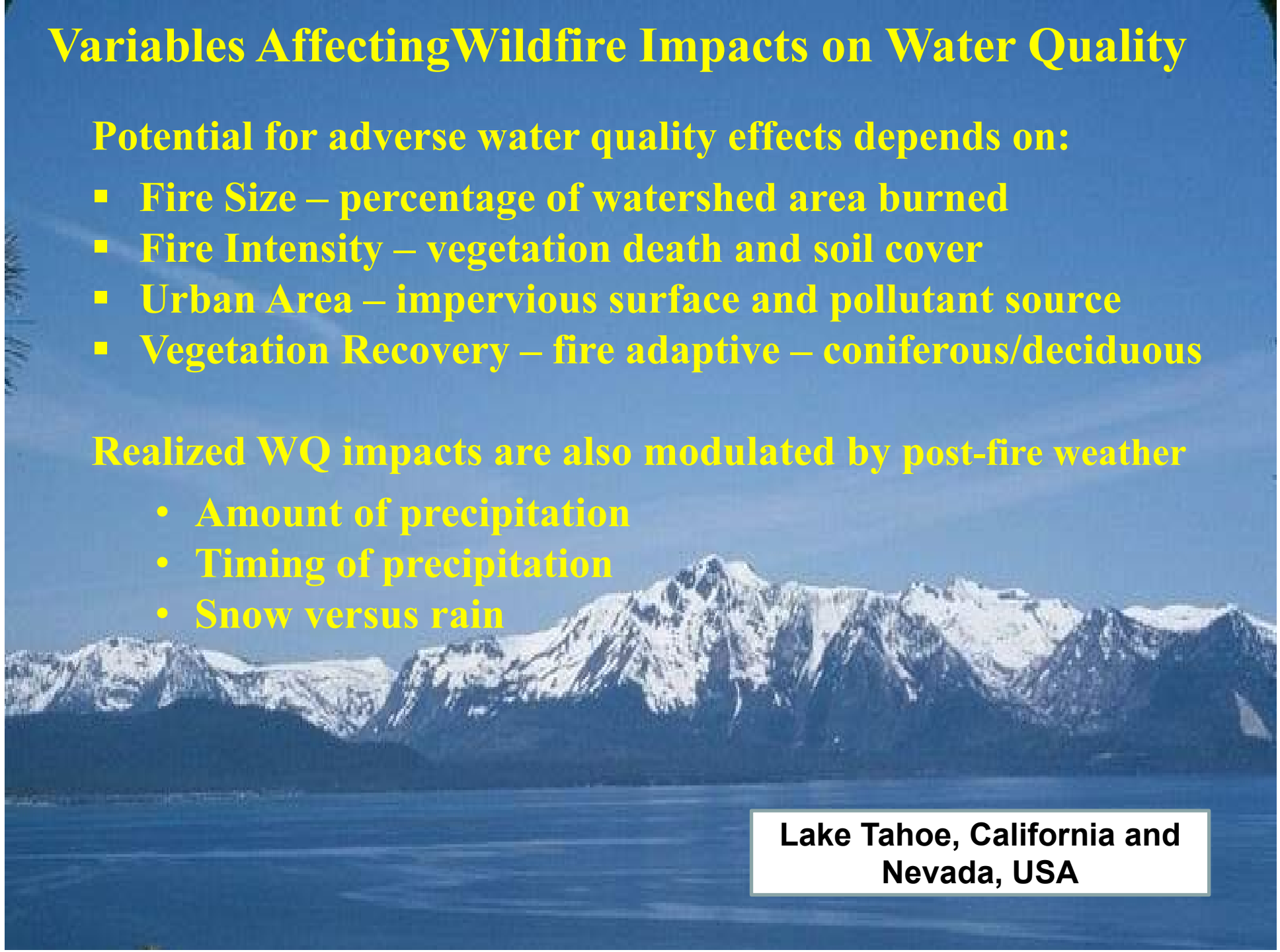
Variables AffectingWildfire Impacts on Water Quality

Potential for adverse water quality effects depends on:

- **Fire Size – percentage of watershed area burned**
- **Fire Intensity – vegetation death and soil cover**
- **Urban Area – impervious surface and pollutant source**
- **Vegetation Recovery – fire adaptive – coniferous/deciduous**

Realized WQ impacts are also modulated by post-fire weather

- **Amount of precipitation**
- **Timing of precipitation**
- **Snow versus rain**



Lake Tahoe, California and Nevada, USA

Severe Wildfires – Water Quality Impacts

- Turbidity, pH, Eh, Dissolved Oxygen, Temperature
- Major cations and anions (conductivity)
- Soluble and particulate organic carbon; black carbon
- Nutrients (N and P)
- Metals (trace and heavy)
- Primary producers

Water quality generally responds linearly with the percentage of the watershed burned and responds exponentially as burn severity increases.
Smith et al. (2011) Journal of Hydrology for a very good review paper on water quality and wildfire

Fire Temperatures Increasing – Higher Intensities

Open-Canopy Forest (Surface Fires)

500 - 800^{o} C – Black Ash

Closed-Canopy Forest (Crown Fires)

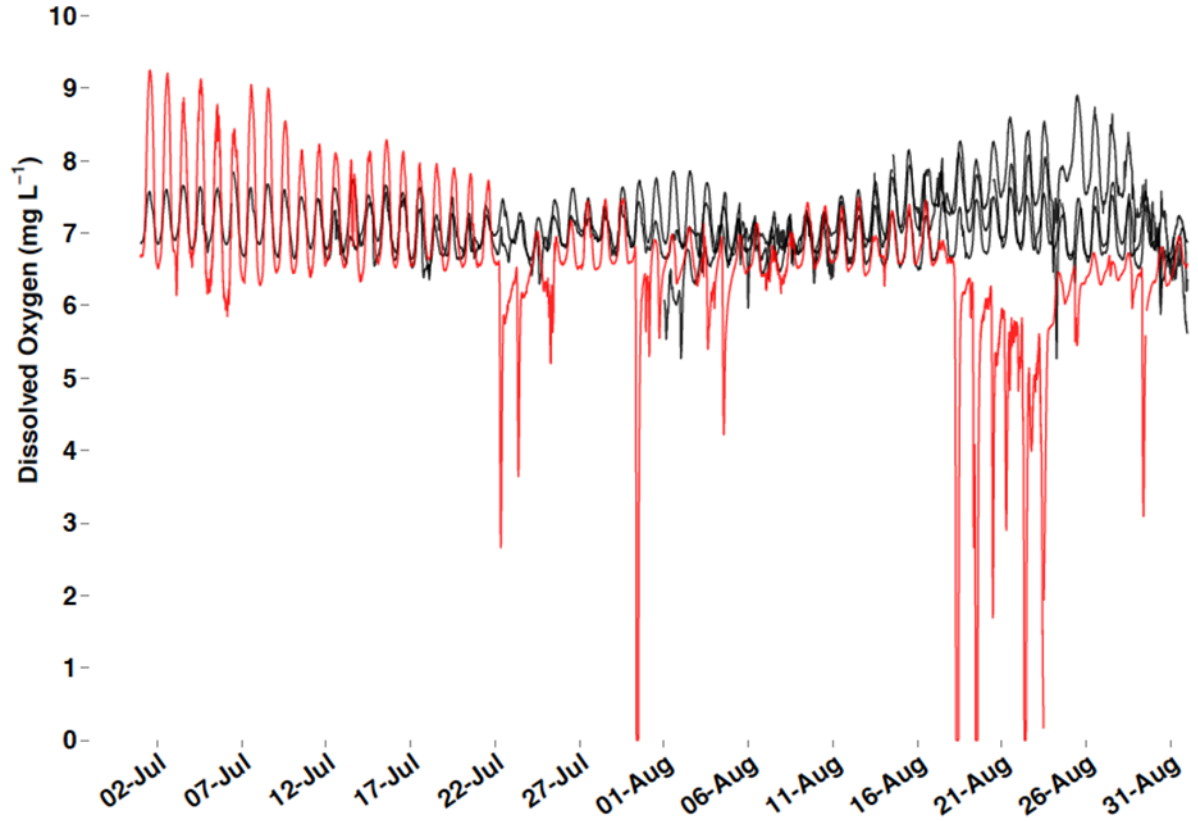
800 - 1200^{o} C – White Ash

First Storm After Catastrophic Wildfire
Importance of continuous sampling

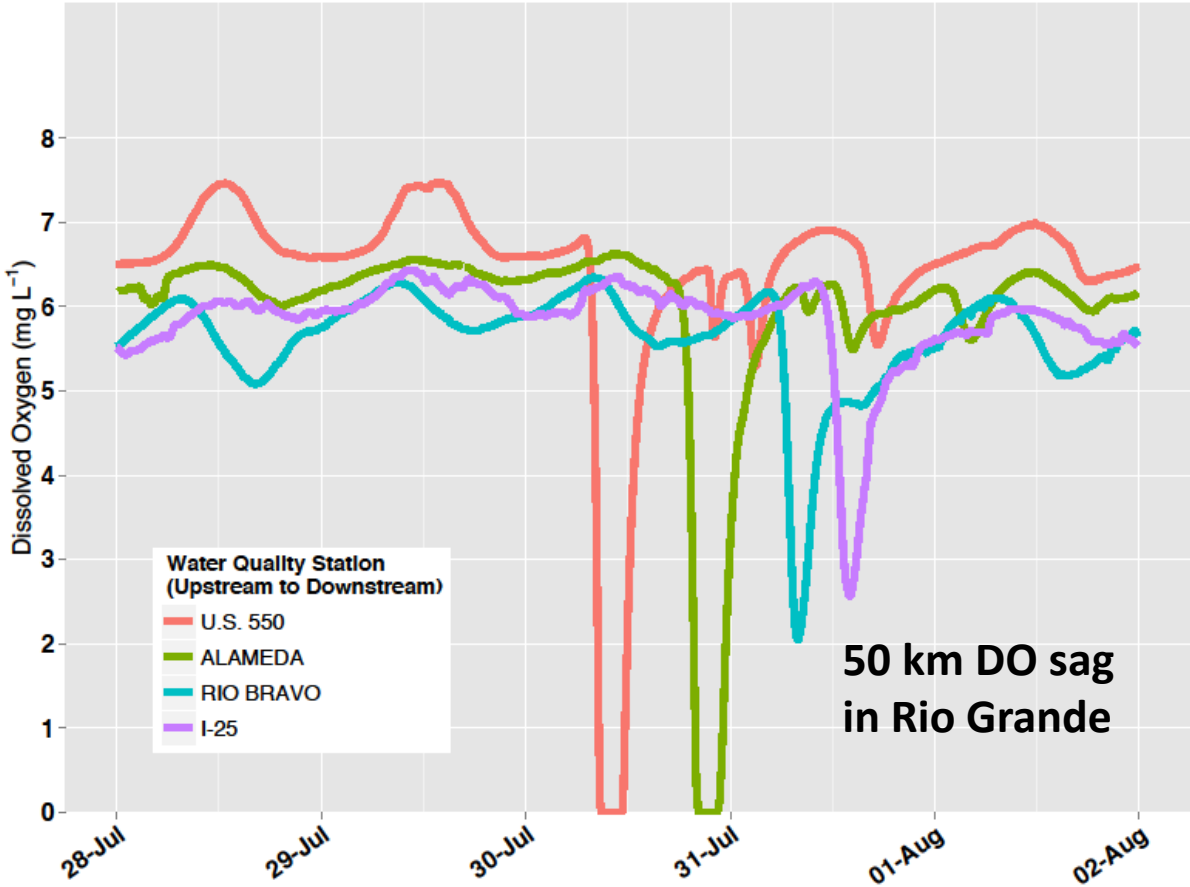
Indios Creek July 29, 2011 – Before and After Samples

Dahm et al. 2015 Freshwater Biology

Dissolved Oxygen (DO) Concentrations
Black Lines – 2007, 2008, and 2010
Red Line – 2011 (Post-Fire)

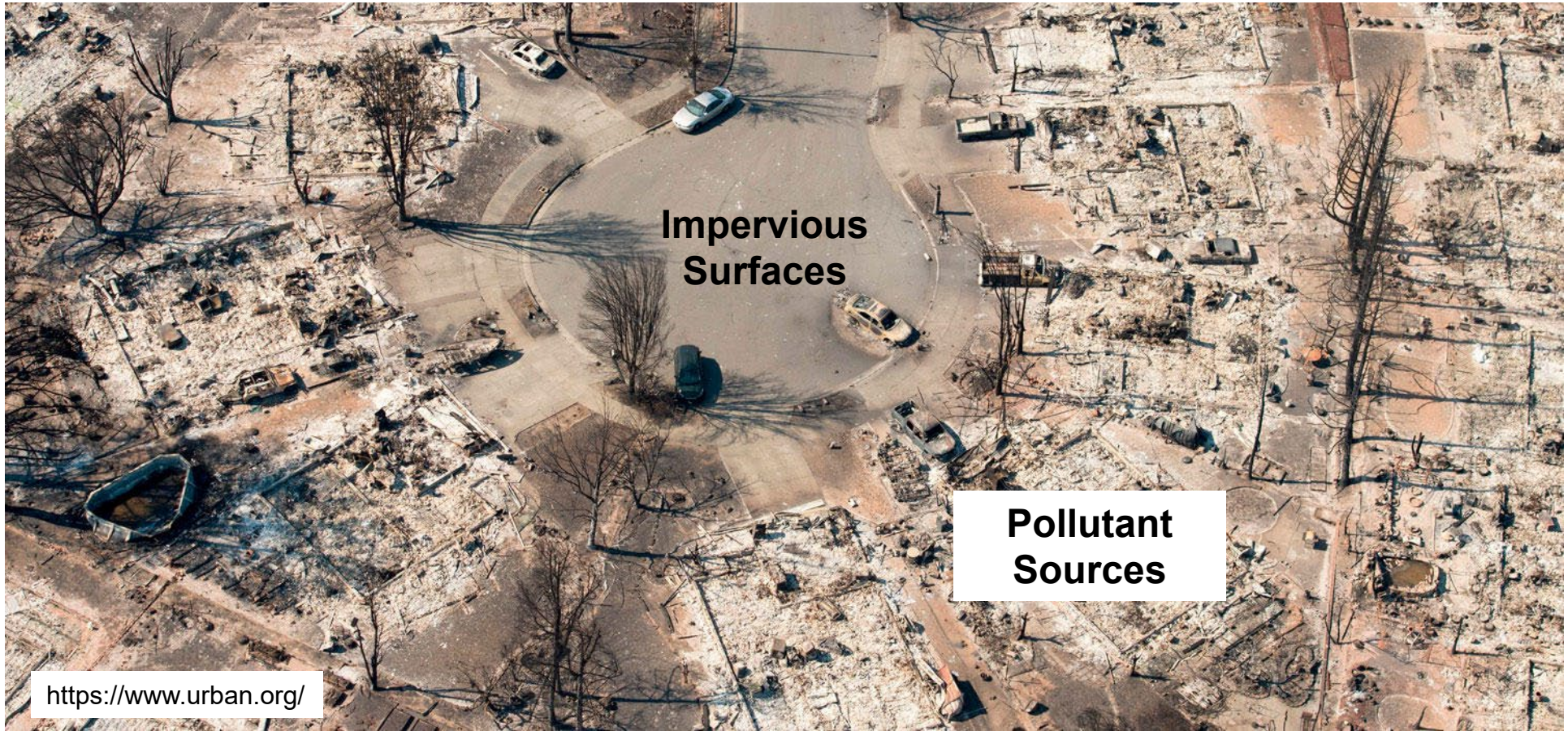


Downstream DO Sags



Urban Wildfire Impacts on Water Quality

- Sediments
- Heavy Metals
- Mercury
- Nutrients
- Toxic Organics – PAHs, Benzene
- Electronic and Plastic Pollutants
- Oil and Grease
- Pesticides and Pharmaceuticals



Lake Tahoe Clarity – An Example of Impacts from Wildfire on Iconic Water Resources

Fine sediments from post-fire erosion
Increased algae from nitrogen and phosphorus

Some Final Thoughts

Wildfires are inevitable in arid and semiarid wildlands; concurrently global climate change is adversely impacting wildfire dynamics at global scales

Reducing the intensity and size of wildfires is key to protecting the water quality of water resources in California

Forest ecosystem recovery in California from wildfire is becoming progressively more difficult

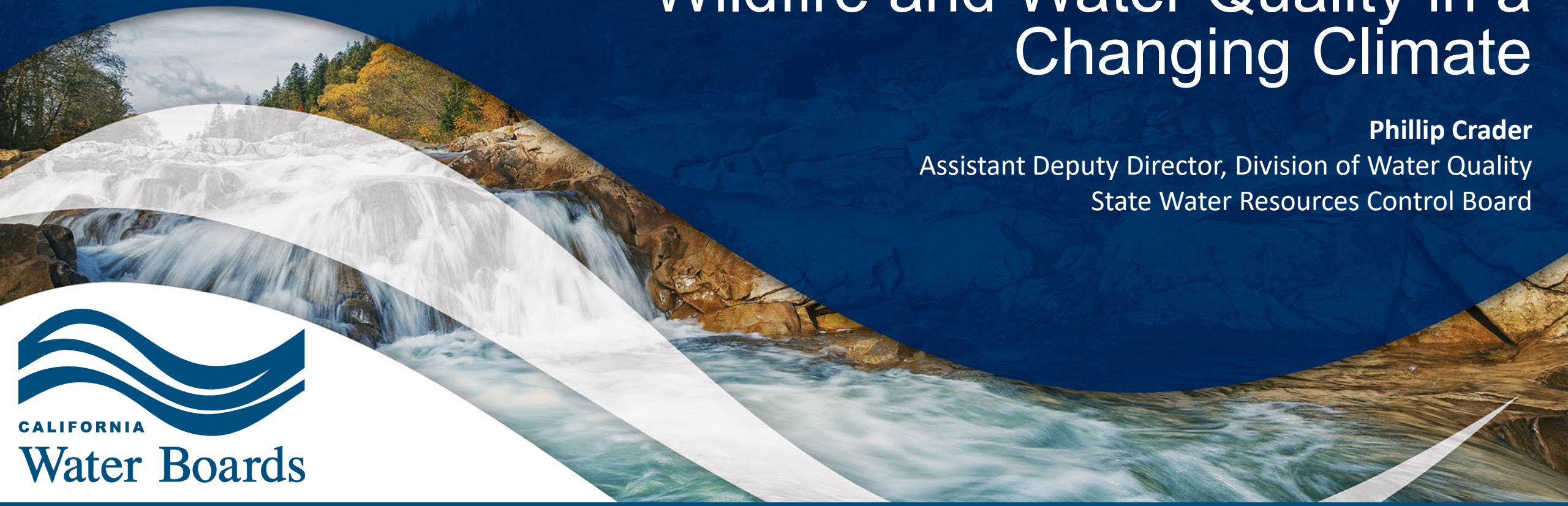
Forest (wildland) management can help reduce potential threats to humans, infrastructure and nature

Reservoirs play a major role in downstream water quality after catastrophic wildfire, but rigorous studies are limited worldwide

State Water Resources Control Board

Wildfire and Water Quality in a Changing Climate

Phillip Crader
Assistant Deputy Director, Division of Water Quality
State Water Resources Control Board



CALIFORNIA
Water Boards

California Water Boards, 06.22.2023

Agenda

- About the Water Boards
- California's Changing Climate
- How wildfire can impact water quality
- How the Water Boards are involved

About the Water Boards

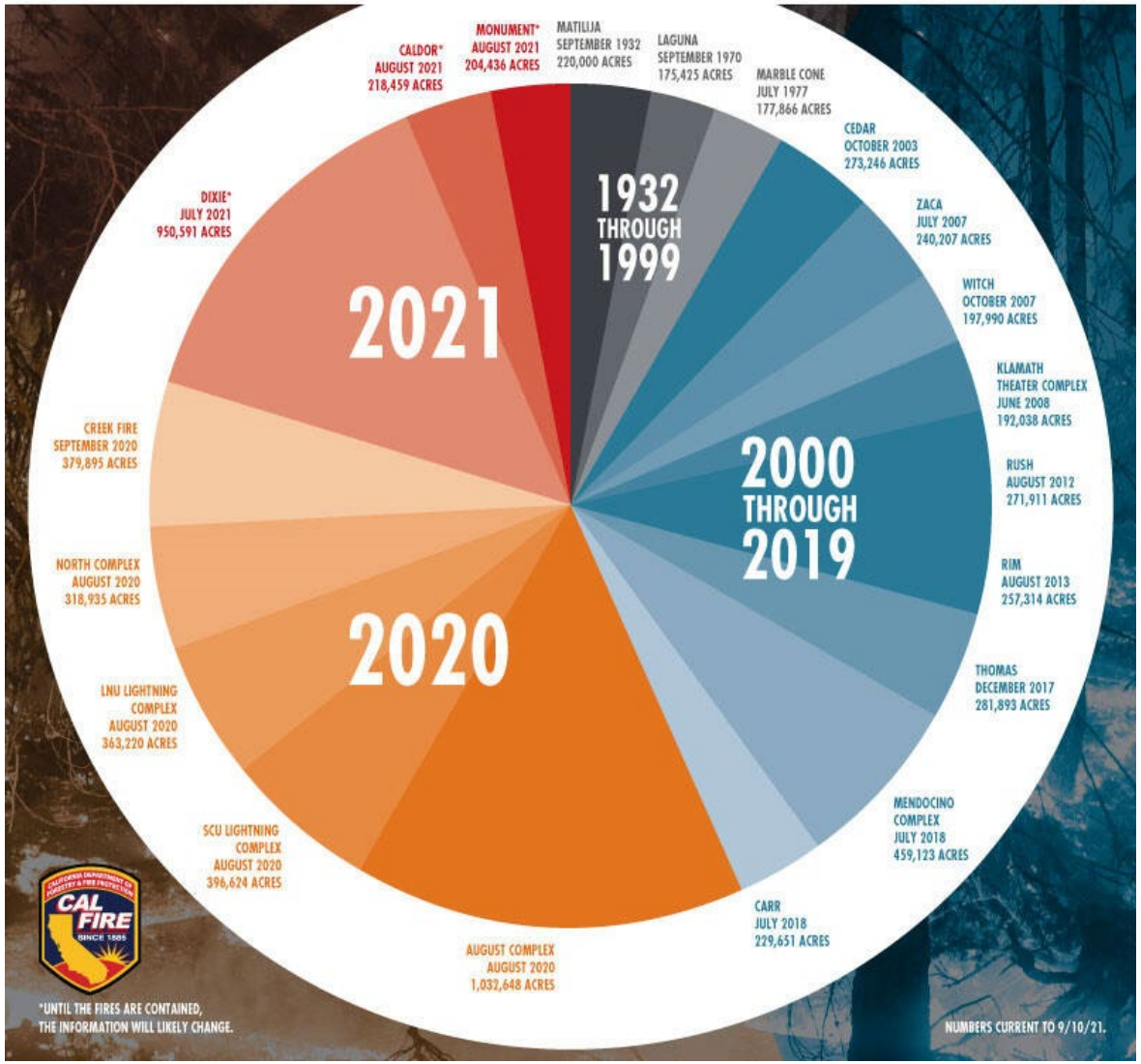
The State Water Board and nine Regional Water Boards (collectively Water Boards), are charged with permitting activities that have the potential to impact water quality and enforcing water quality laws under the federal Clean Water Act and the state's Porter Cologne Water Quality Control Act.

The Water Boards have a statutory obligation to protect all surface and groundwater within the state, including nearly 1.6 million acres of lakes, 1.3 million acres of bays and estuaries, 211,000 miles of rivers and streams, and about 1,100 miles of California coastline.

California's Changing Climate

- More frequent and intense wildfires
- Longer and more severe drought conditions
- Followed by unprecedented winter storms and significant flooding
- Every year experiencing new "records"

TOP 20 LARGEST CALIFORNIA WILDFIRES



Wildfire and Water Quality

- Water quality impacts and watershed response can vary widely depending on multiple factors:
  - Extent of the fire and burn severity
  - Amount of vegetation and organic matter combusted
  - Number and type of facilities, vehicles, and other human-made objects combusted
  - Subsequent precipitation events

Changes in Physical and Chemical Properties of Water

- Increased levels of:
  - Nutrients (nitrates, nitrites, phosphorus, etc.)
  - Metals, both naturally occurring and anthropogenic (copper, zinc, lead, mercury, etc.)
  - Polycyclic Aromatic Hydrocarbons (PAHs)
  - Temperature pollution from loss of vegetative cover
  - Turbidity
- Changes in:
  - Taste and odor
  - Dissolved oxygen levels
  - pH
  - Conductivity

Photo courtesy of Central Valley Water Board

Changes in Hydrology and Channel Morphology

- Loss of vegetative uptake of nutrients in soils; these nutrients can transport into nearby surface waters
- Loss of vegetative uptake of water can alter instream flows and/or create new springs in the area
- Higher risk for debris flows and slope failures; these can transport sediment, ash, and debris into surface waters
- Disconnection of channels from floodplains, alteration of bed and banks, and other morphological changes can impact habitat

Wildfires in the Wildland-Urban Interface (WUI) versus Purely Forested Environment

- Purely Forested Wildfires:
  - Increases in turbidity and temperature
  - Changes in pH, dissolved oxygen
  - Increases in nutrients such as phosphorus, nitrates, and nitrites
  - Increases in naturally occurring metals and organic matter
- WUI Wildfires:
  - All the impacts in purely forested environments
  - Presence of PAHs
  - Larger increases in metals, nutrients, and organic matter
  - Greater potential for water toxicity for human and aquatic life

9

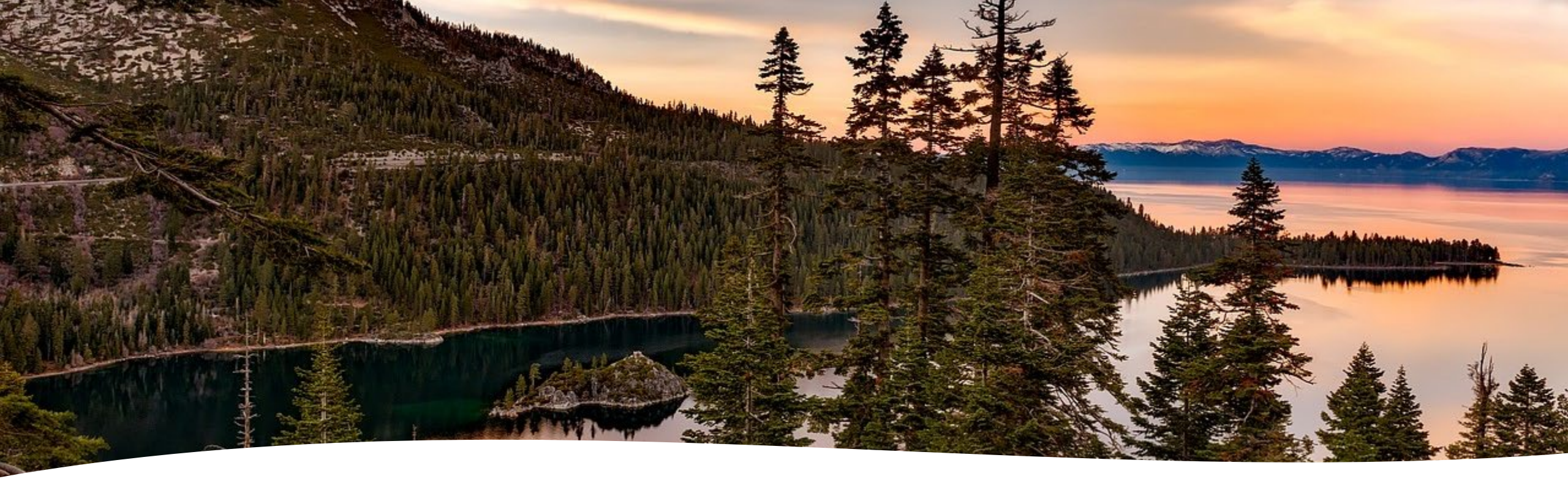
What does this mean for downstream ecosystems?

- Higher treatment costs for downstream drinking water systems
- Changes in water quality due to sediment/pollutant transport, and deposition in downstream systems
- Debris transported from upper watersheds can settle in reservoirs and downstream ecosystems
- Overall changes in hydrology in upper watershed can impact downstream hydrology
- Impacts to salmonid habitat depending on timing of wildfire and precipitation events
- Excess nutrient loading in upper watershed can lead to harmful algal blooms downstream

How are the Water Boards Involved?

- **Pre-Fire:**
  - Streamlined permitting for vegetation management and forest health projects
  - Work with electric utilities and Caltrans doing right-of-way clearing
  - Governor's Wildfire and Forest Resilience Task Force
- **Active Fire:**
  - Water Boards' Emergency Management Program
- **Post-Fire:**
  - Emergency BMP deployments
  - Post-fire water quality monitoring
  - Oversight of recovery activities (debris/hazard tree removal)
  - Coordinate and streamline permitting for post-fire restoration projects
  - Multi-agency task force meetings and working groups

Photo courtesy of Central Valley Water Board



Questions

Phillip Crader

Assistant Deputy Director

Division of Water Quality, Surface Water/Regulatory Branch

State Water Resources Control Board

Phillip.Crader@waterboards.ca.gov

Tel: 916.341.5500

Connecting researchers and policymakers to address the wildfire crisis

Teresa Feo, PhD

Senior Science Officer
California Council on Science & Technology

Delta Stewardship Council Meeting, June 22, 2023

CCST's **Mission**

To engage leading experts in **science and technology** to advise State policymakers—ensuring that California policy is **strengthened and informed by scientific knowledge, research, and innovation**.

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California Community Colleges

Ames Research Center

JPL Jet Propulsion Laboratory California Institute of Technology

Berkeley Lab

Caltech

Stanford

USC University of Southern California

Lawrence Livermore National Laboratory

Sandia National Laboratories

SLAC National Accelerator Laboratory

Our **Impact**

We amplify knowledge and expertise from our **Partners Institutions** toward science informed policy through our science services.

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California Community Colleges
California Institute of Technology
Stanford University
University of California
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
NASA Ames Research Center
NASA Jet Propulsion Laboratory
Sandia National Laboratories
SLAC National Accelerator Laboratory

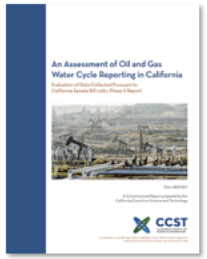
Our **Services**

Peer-reviewed Reports

CALIFORNIA POLICY ACTIONS FOR PANDEMIC PREPARATION, RESPONSE, AND RECOVERY

Publication

August 1, 2022



AN ASSESSMENT OF OIL AND GAS WATER CYCLE REPORTING IN CALIFORNIA

Publication

November 12, 2021

Workshops & Convenings

Science Day Symposium
In partnership with the
California Natural Resources Agency

Presented in partnership with the Delta Stewardship Council!!!

Expert Briefings

THE MANY IMPACTS OF DROUGHT IN THE CALIFORNIA DELTA

Dec. 3, 2021

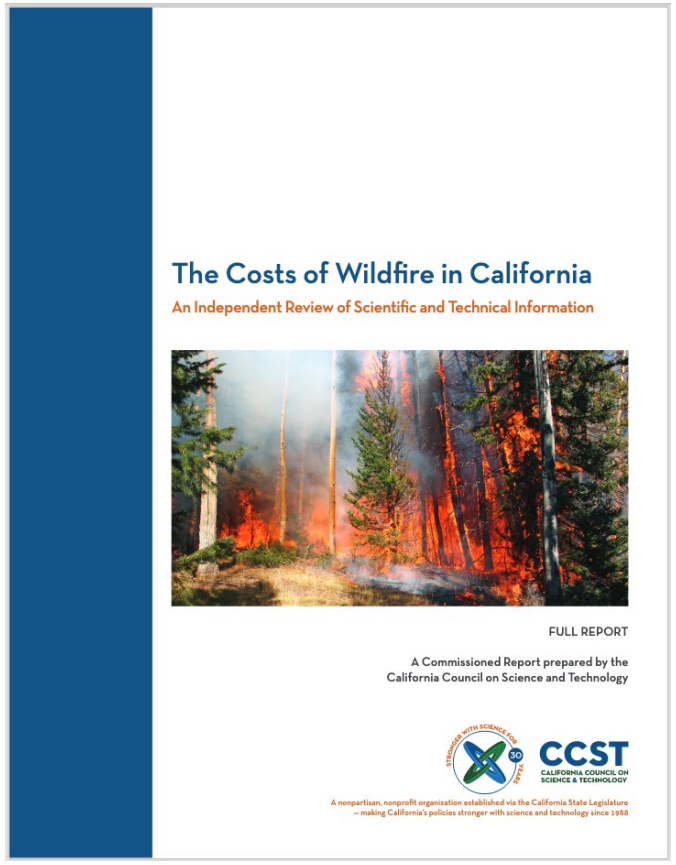
MANAGING SALINITY IN THE CALIFORNIA DELTA IN A CHANGING CLIMATE

May 16, 2022

Wildfire **Projects**

The Costs of Wildfire in California

October 2020



Authors

- **Teresa J. Feo**, PhD, CCST
- **Samuel Evans**, PhD, Mills College

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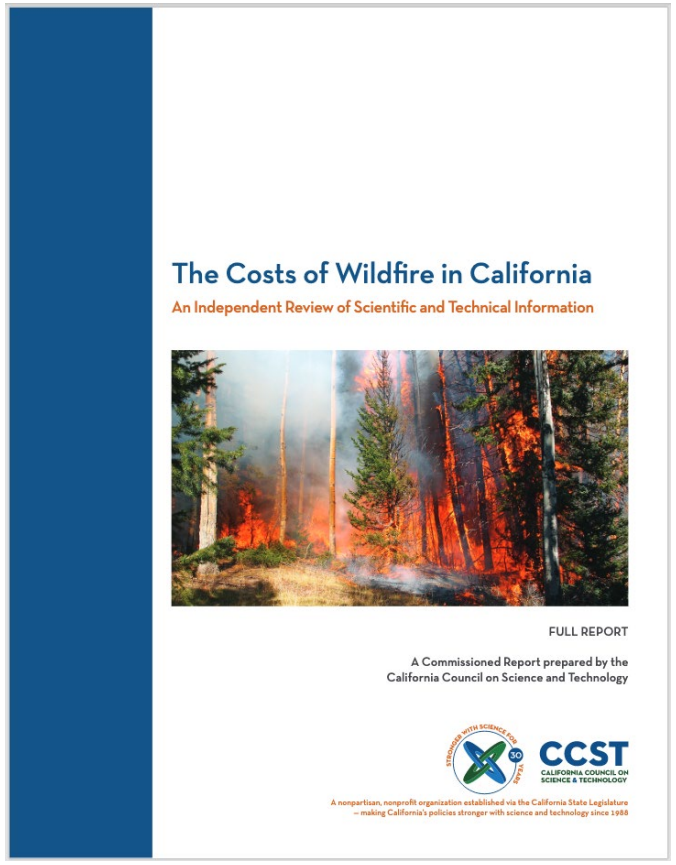
- **Alexandra D. Syphard**, PhD, Vertus Wildfire Insurance Services, LLC, San Diego State University, and Conservation Biology Institute

Wildfire **Projects**

The Costs of Wildfire in California

October 2020



Key Takeaway 1: A comprehensive statewide calculation of wildfire costs is ***not*** possible with currently available data.

Key Takeaway 2: The costs associated with unquantified categories of wildfire loss (e.g., health impacts, loss of ecosystem services) likely exceed the billions of dollars in reported costs.

Wildfire **Projects**

The Costs of Wildfire in California

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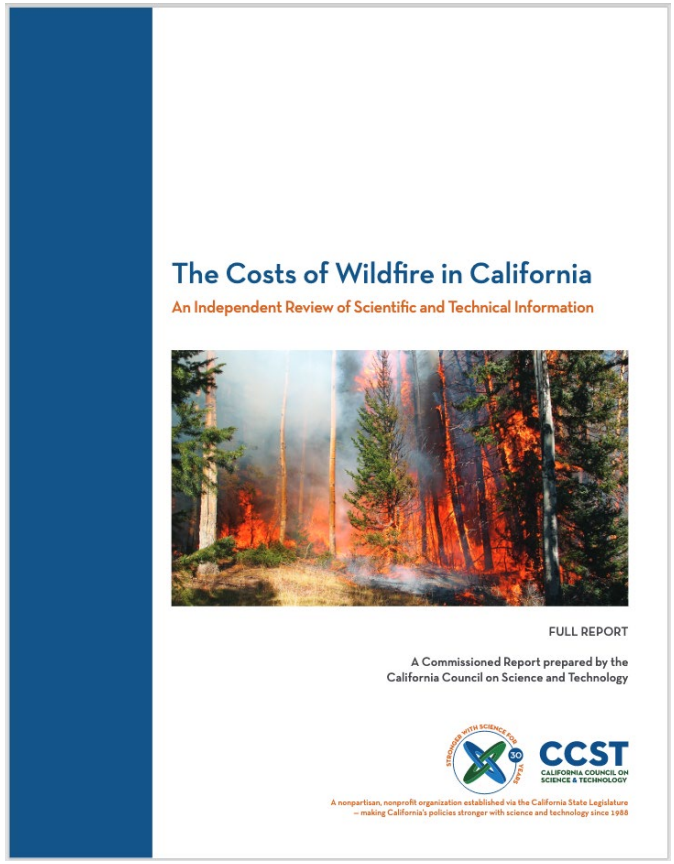
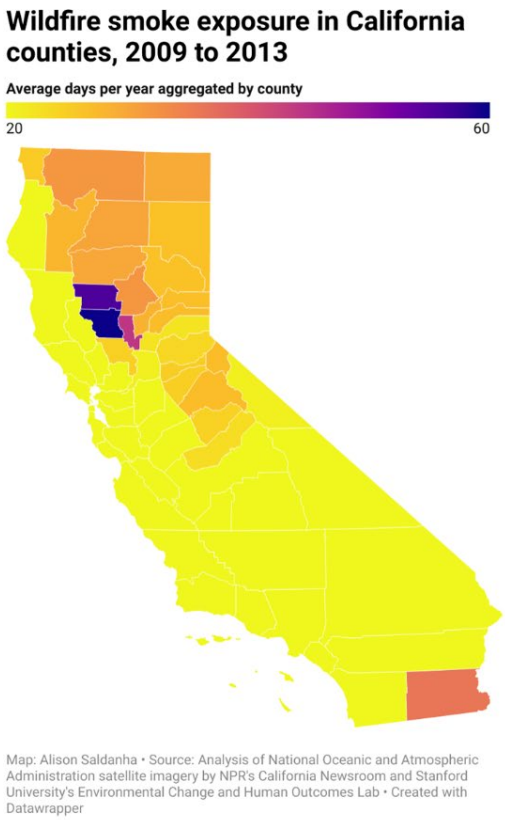


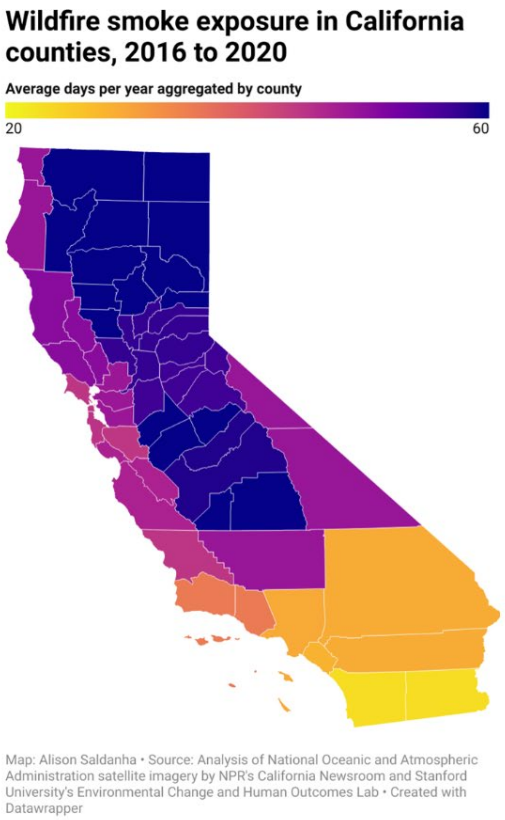
Impacts can be far from the fire!!!

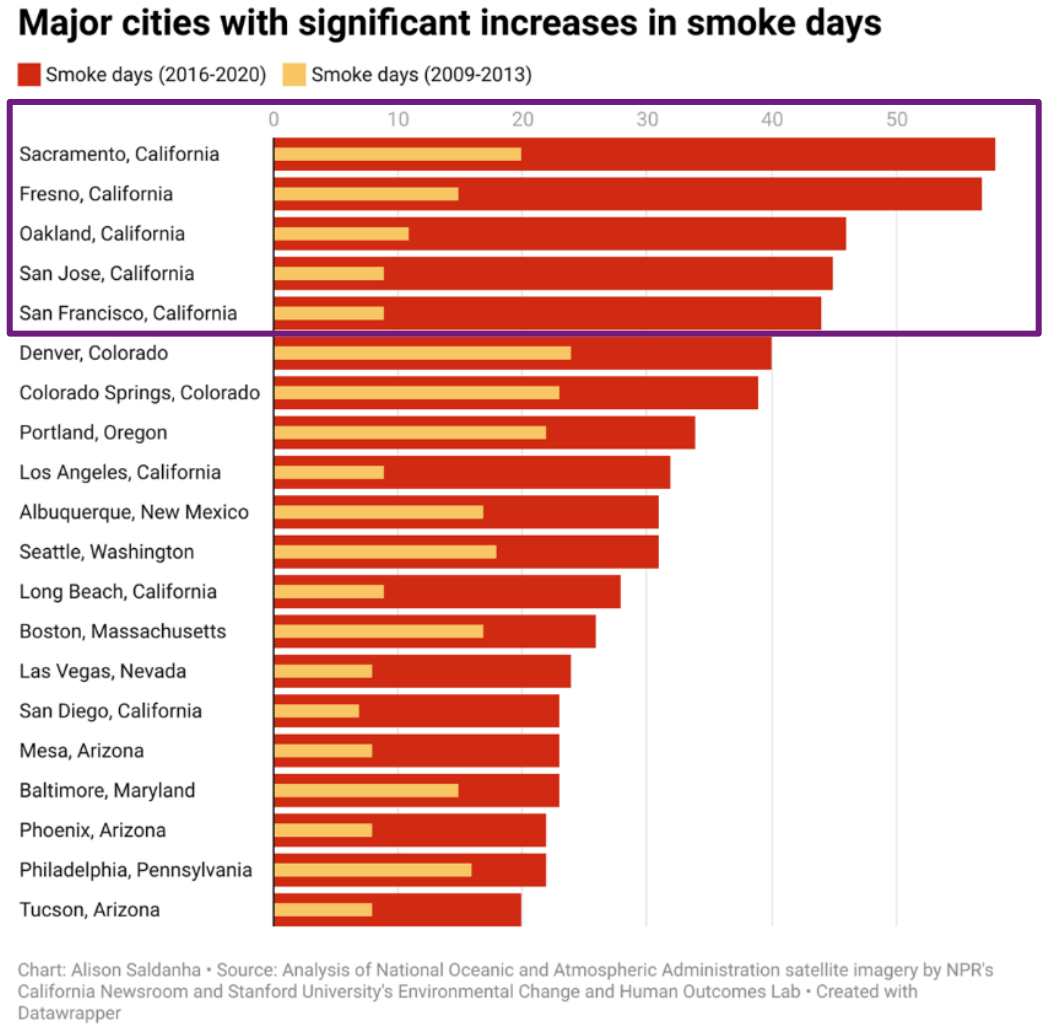
Key Takeaway 1: A comprehensive statewide calculation of wildfire costs is ***not*** possible with currently available data.

Key Takeaway 2: The costs associated with unquantified categories of wildfire loss (e.g., health impacts, loss of ecosystem services) likely exceed the billions of dollars in reported costs.

Wildfire smoke is increasing and projected to get even worse







Credit: Capital Public Radio, https://www.capradio.org/articles/2021/09/28/dangerous-air-as-california-burns-america-breathes-toxic-smoke/

Wildfire **Projects**

Wildfire Policy Accelerator

Federation of American Scientists, in partnership with CCST, COMPASS, and Conservation X Labs

23 Actionable Recommendations For Improving Wildland Fire Policy to support the Wildland Fire Mitigation and Management Commission https://fas.org/publication/wildland-fire-policy-recommendations/

2 Roundtable events in Sacramento, CA and Washington DC to foster conversations between accelerator participants, wildfire commission members, and state and federal policymakers.

Wildfire **Projects**

CCST peer-reviewed study (*in progress*)
expected release Fall 2023

In partnership with
Blue Forest Conservation

CCST
CALIFORNIA COUNCIL ON SCIENCE & TECHNOLOGY

BLUE FOREST
Financial Innovation for Sustainable Solutions

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Authors

- **Teresa Feo, PhD,** *CCST*
- **Kim Seipp, PhD,** Blue Forest Conservation
- **Signe Stroming,** Blue Forest Conservation

CONNECT
WITH US

teresa.feo@ccst.us
Sarah.brady@ccst.us

@CCSTorg

@CCSTfellows

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Post-drought wildfire retardant effects on salmonids, comparing across Phos-Chek formulations to better understand potential environmental impacts

Susanne Brander, Richard E. Connon, Amelie Segarra

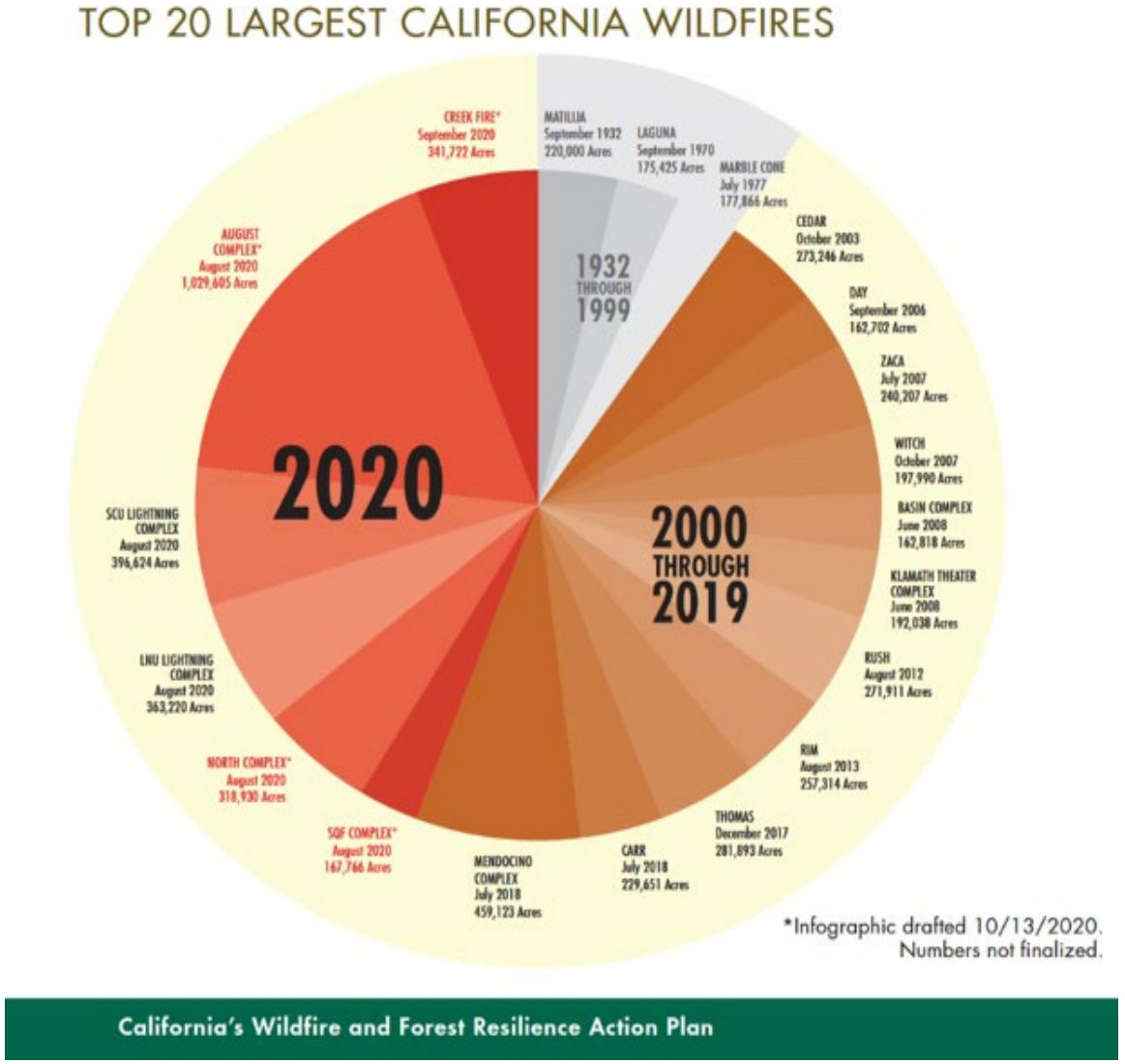
University of California Davis

Delta Stewardship Council – June 22th, 2023

UC DAVIS UNIVERSITY OF CALIFORNIA

Delta Stewardship Council
A CALIFORNIA STATE AGENCY

The New Normal



Prevent & contain fires

Long-term Fire retardants

Aerial volumes of retardants applied in California have increased from 3.3 million gallons (2012) to 15.3 million (2017). (USDA 2017).

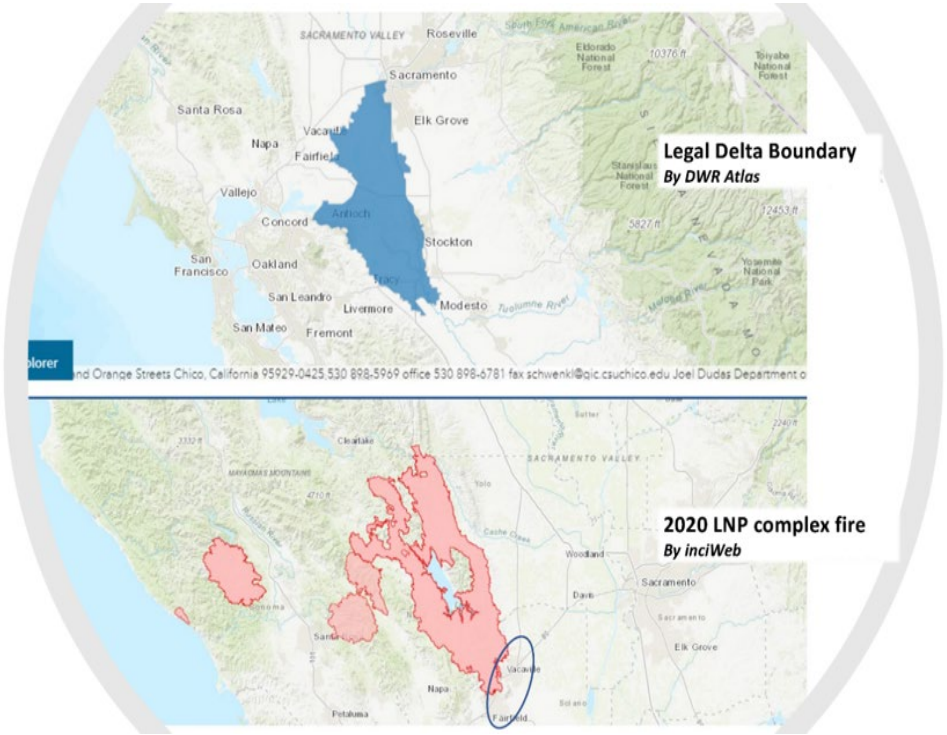
These retardants enter aquatic ecosystems via discharge, run-off with each fire or when manually cleaned (groundwater)

LA Times


David McNew / Getty Images


Watchara Phomicinda, The Press-Enterprise/SCNG

Fire Location and periods



A. the legal boundary of the Delta,

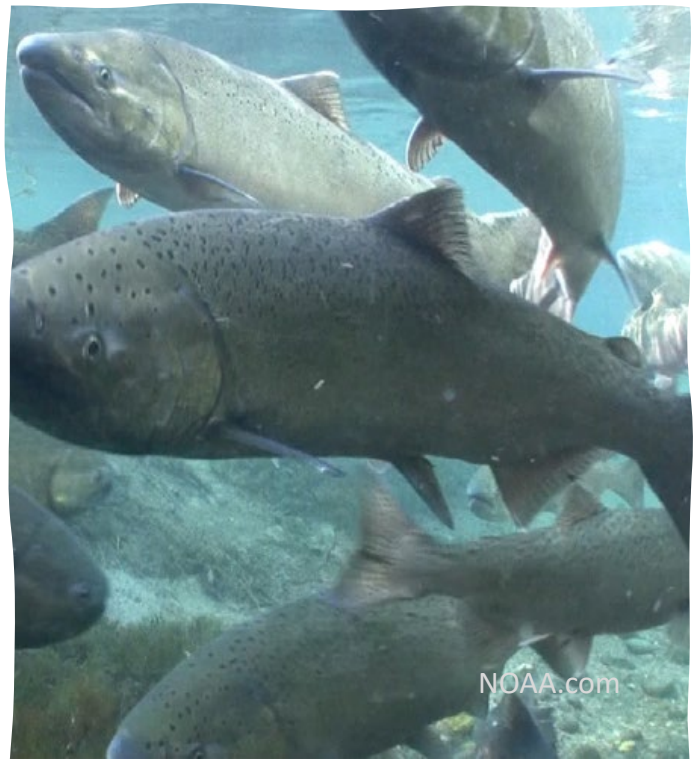
B. extent of the 2020 LNU complex fire, circle indicates potential overlap with the legal Delta.

Risk of Fire retardants into our aquatic systems increases with fire location

In 2020 & 2022, fires almost overlapped the legal delta's boundary.

Concern 1 - firestorms occur near the San Francisco Bay-Delta, home to a number of threatened and endangered native fishes and serving as a migration route for sensitive salmonids

Concern 2 - Fires occurrences overlap with the Chinook Salmon spawning period, which runs from July until October in California



What is the risk of the potential environmental impacts on early-life stage of Salmonids?

AIM

Understand the effects of different fire retardants with relevance to first flush events on early life stages of Fall Run Chinook salmon and Rainbow Trout, a related bioindicator species

Better inform management tradeoffs for fire retardant use prior to the introduction of a new fire retardant method in California.


Sespe Creek /Peter Deneen


Peter Deneen

Objective 1

Lethal and Sublethal effects Assessment

Select fire retardants based on their use and compositions (list from US Forest Service)

- Direct application vs Pretreatment
- Ammonium phosphate (Phos-Check) vs magnesium chloride (Fortress)

Dose determination on embryos & alevins

A B C

8 concentrations + control

→

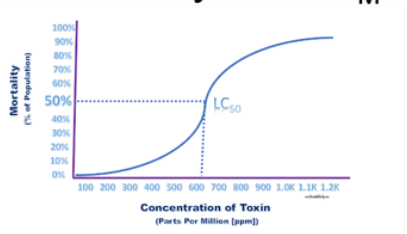
C. Salmon

+

Rainbow Trout

→

Mortality – $LC50_M$



https://www.warrenphotographic.co.uk/11503-rainbow-trout-fry

Objective 1

Lethal and Sublethal effects Assessment

Sublethal effect - EC50

A B C

3 sublethal concentrations + control

→

C. Salmon

+

Rainbow Trout

→

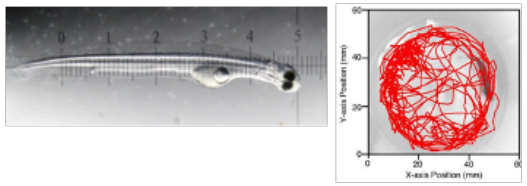
Short term effects

at 96h

Long term effects

After 2-4 weeks

Morphometrics Behavior

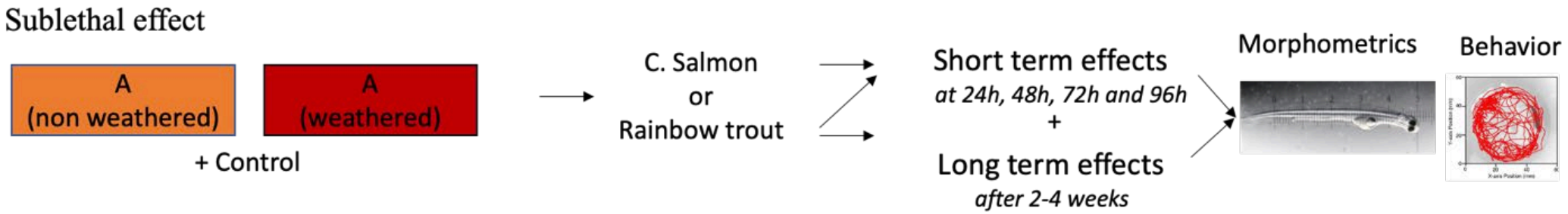


Sublethal endpoints: Behavioral alterations, yolkc sac, latent effects on growth and swim-up

Objective 2

Evaluate effects of weathered fire retardant on early life stage of Chinook Salmon or Rainbow Trout to simulate exposure in the environment

Stock solutions weathered on a substrate, using high temperature or UV light (UV A, B, and C) over a few days to simulate summer conditions prior to first flush event



Thank you very much

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