

Technical Estimation of GHG Emissions of Wildfire and Forest Management Activities

**PUBLIC WEBINAR ON CARB STAFF'S
IMPLEMENTATION OF SECTION 4 OF SB 901**

DECEMBER 1, 2020

Objectives of This Meeting

1. Present CARB staff's work on:
 - a) Greenhouse gas (GHG) emissions of contemporary wildfire and prescribed fire ("Rx fire")
 - b) Ecosystem carbon transformed due to forest management activities
 - c) Scientific literature review of quantitative data needed for modeling historical fire emissions
 - d) Current scientific understanding of California fire activity before fire suppression
2. Provide an opportunity to solicit public input and answer questions

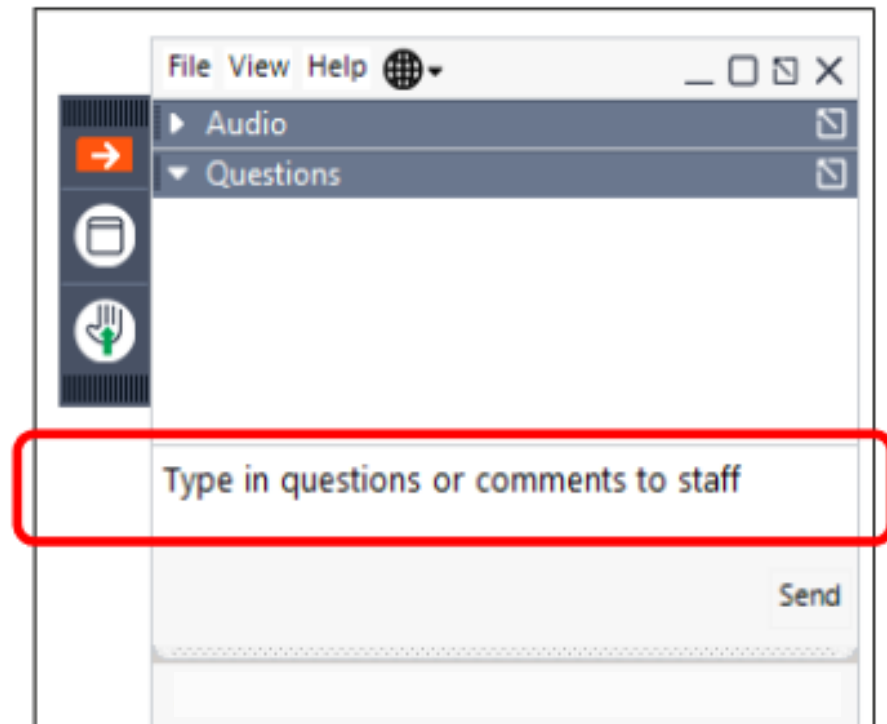
Agenda

- 2:00** Welcome and Introduction (Michael Benjamin and Anny Huang)
- 2:05** **Part 1. GHG Emissions of Wildfire and Forest Management Activities**
- 1a. Contemporary Wildfire (Klaus Scott)
 - 1b. Prescribed Fire (Klaus Scott)
 - 1c. Non-Fire Forest Management Activities (Adam Moreno)
 - 1d. Q&A (*approx. at 2:40*)
- 3:00** **Part 2. Historical Fire Activity Before Modern Fire Suppression**
- 2a. Acknowledgments (Michael Benjamin)
 - 2b. Presentation (Adam Moreno)
 - 2c. Q&A (*approx. at 3:40*)
- 3:55** Closing & Next Steps (Anny Huang)



Webinar Tools

- Comments and Questions
 - GoToWebinar Question Box
 - Please include your affiliation



Introduction



SB 901 (Dodd, 2018 statutes) Section 4

“Health & Safety Code, Sec. 38535. The state board, in consultation with the California Department of Forestry and Fire Protection, shall develop all of the following: ...

(b) In consultation with academic experts, a historic baseline of greenhouse gas emissions from California’s natural fire regime reflecting conditions before modern fire suppression. This shall be completed on or before December 31, 2020. The baseline may be included within the state board’s natural working lands inventory.

(c) On or before December 31, 2020, and every five years thereafter, a report that assesses greenhouse gas emissions associated with wildfire and forest management activities.”



Planned Deliverables

1. A report with estimates of carbon and GHG emissions from contemporary wildfire, prescribed fire, and forest management activities.
2. A literature review report summarizing our current scientific understanding of pre-1910 historical fire activity in California.

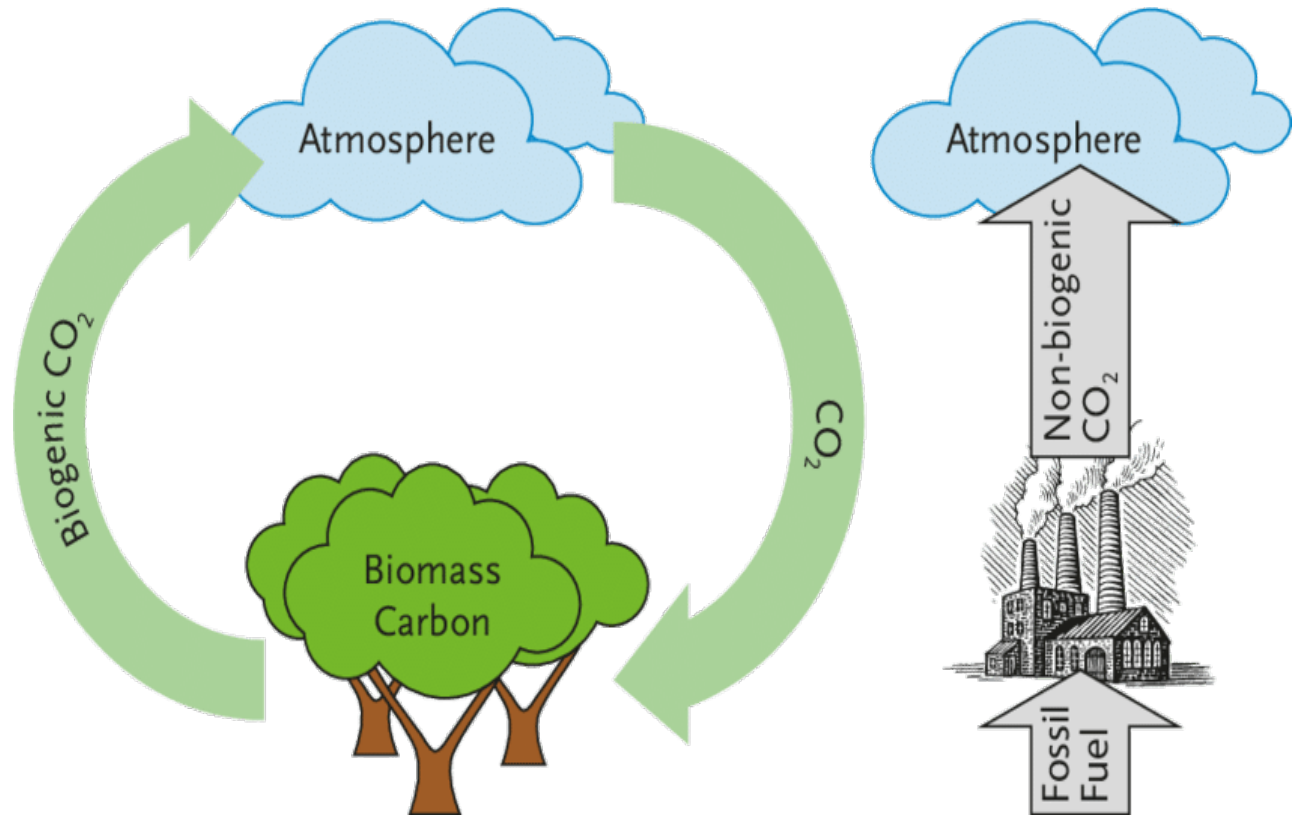
Timeline

- **Late December:** Release public comment draft reports
- **January–February:** Public comment period
- **Mid-2021:** Finalize the two reports



Biomass Carbon, Fossil Carbon, and Climate Change

- Earth's carbon cycle: transfers carbon between land, ocean, and the atmosphere.
- Fire, plant respiration and decomposition are balanced by plant growth and other processes.
- Fossil fuels: ancient carbon stored underground for millions of years.
- Fossil fuel combustion releases carbon that the atmosphere has not seen in recent carbon cycle
→ contributes to climate change



Graphic Source: National Council for Air and Stream Improvement

Part 1a

GHG Emissions of Contemporary Wildfire



Data Sources & Methods

1. Fire perimeters, 2015-2019

- CAL FIRE – Fire and Resource Assessment Program (FRAP) geodatabase

2. Fuels

- Vegetation fuel maps by year (developed for CARB by UC Berkeley)
- Vegetation moisture maps by year, month

3. Burn severity maps

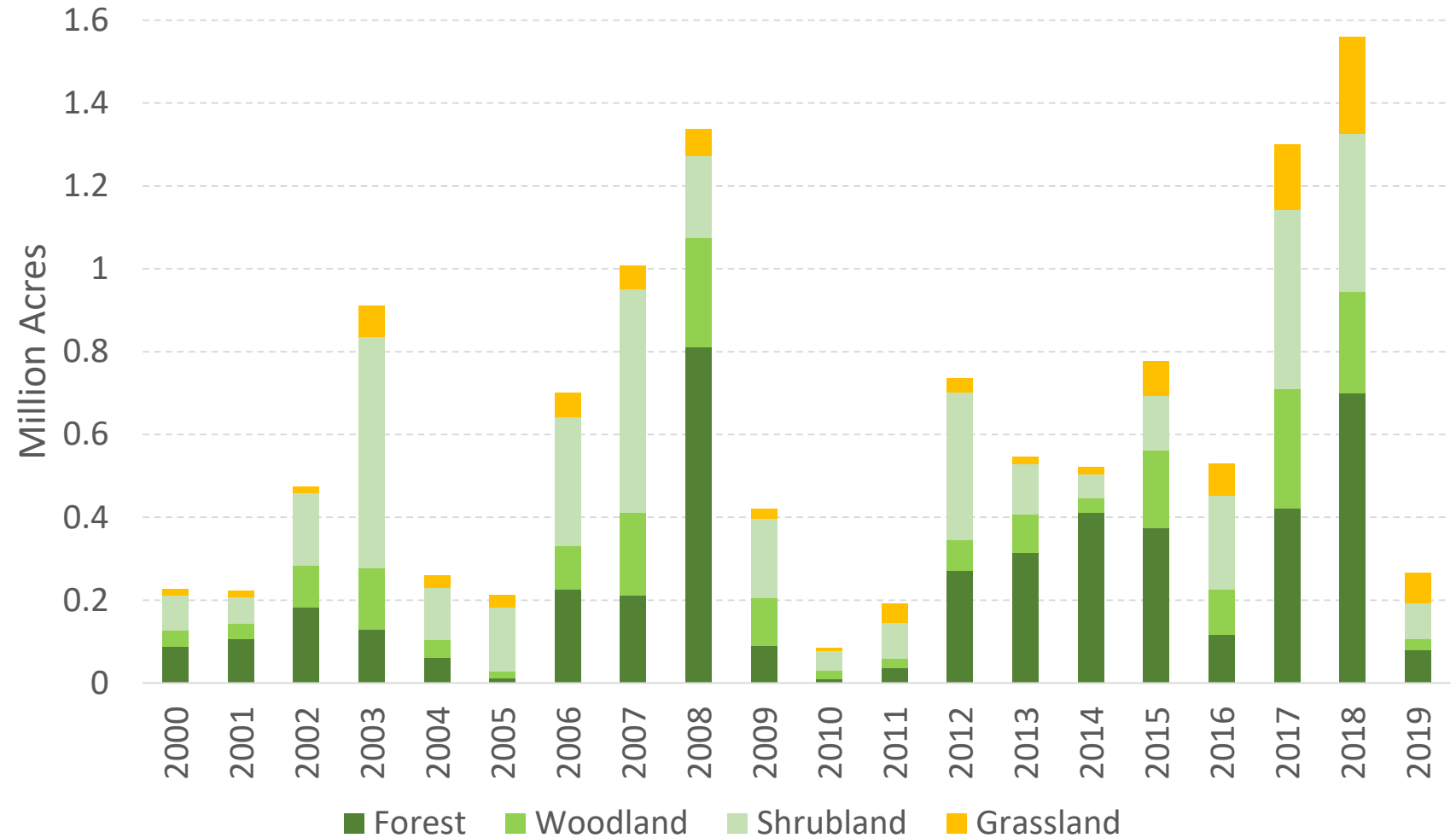
- Geodatabase from US Forest Service Region 5 Remote Sensing Lab

4. Emissions: First Order Fire Effects Model (FOFEM) v 6.7



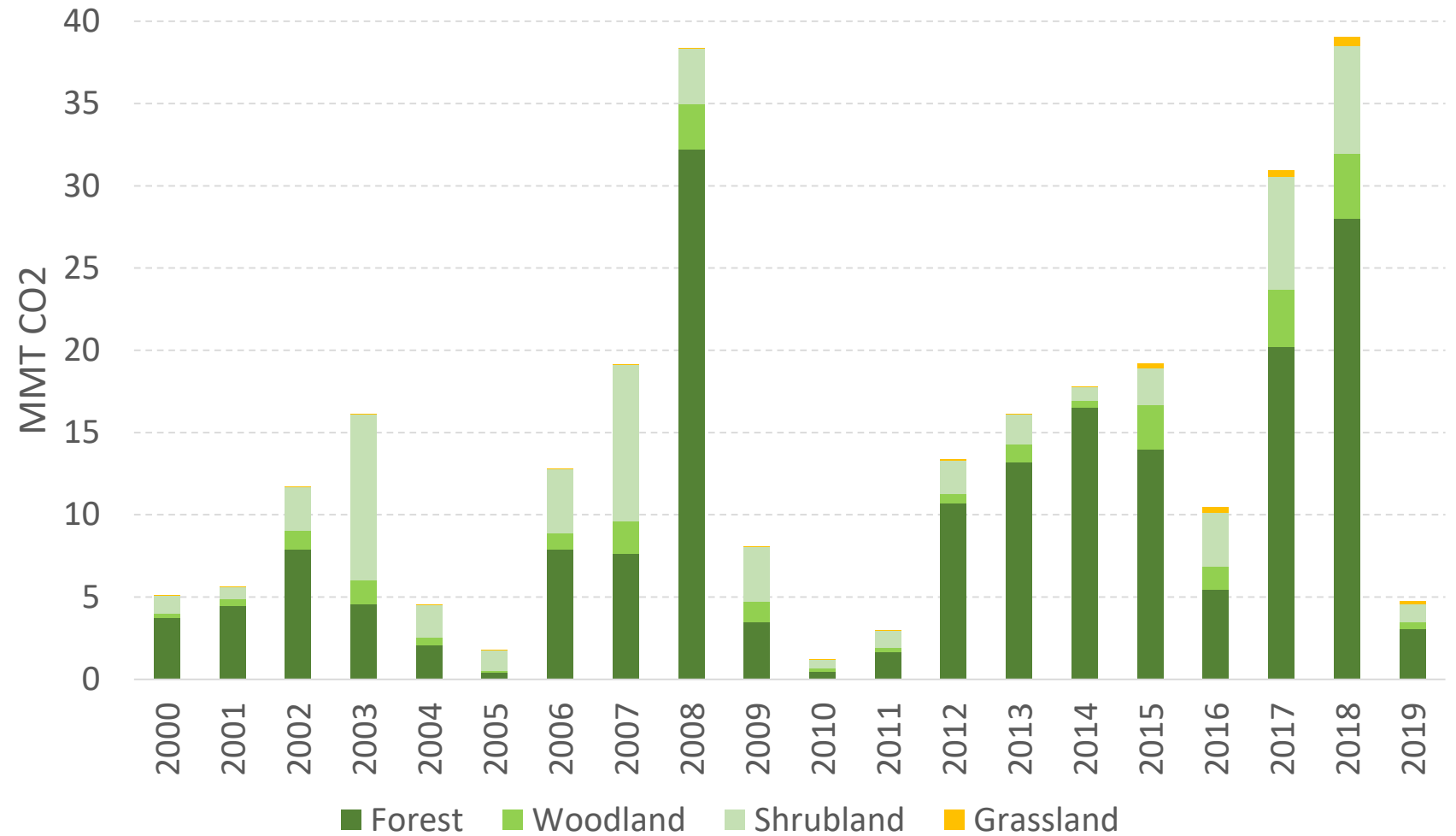
Wildfire: Acreage by Vegetation Type

- Forests, Woodlands, Shrublands dominate acreage
- Grasslands minor contributor



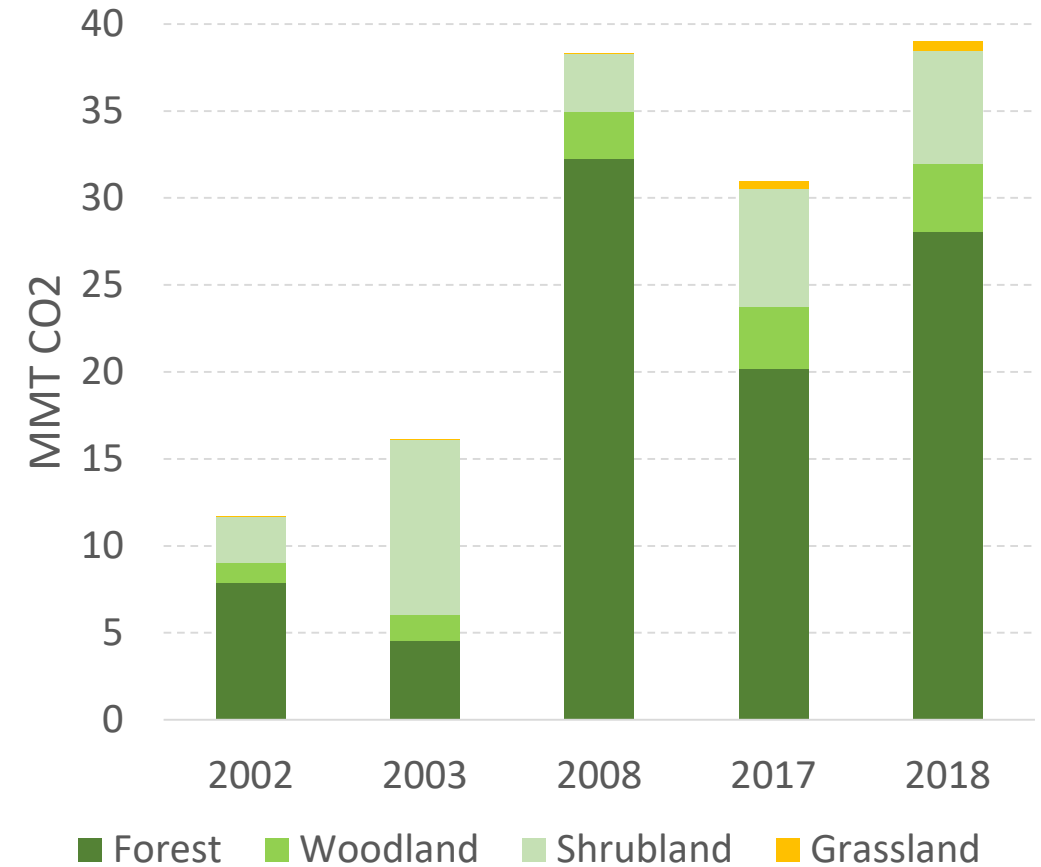
Wildfire: Emissions by Vegetation Type

- Forests have high fuel loads, dominate emissions
- Shrublands, Woodlands intermediate
- Grasslands minor contributor



MMT CO₂ = million metric tons of CO₂

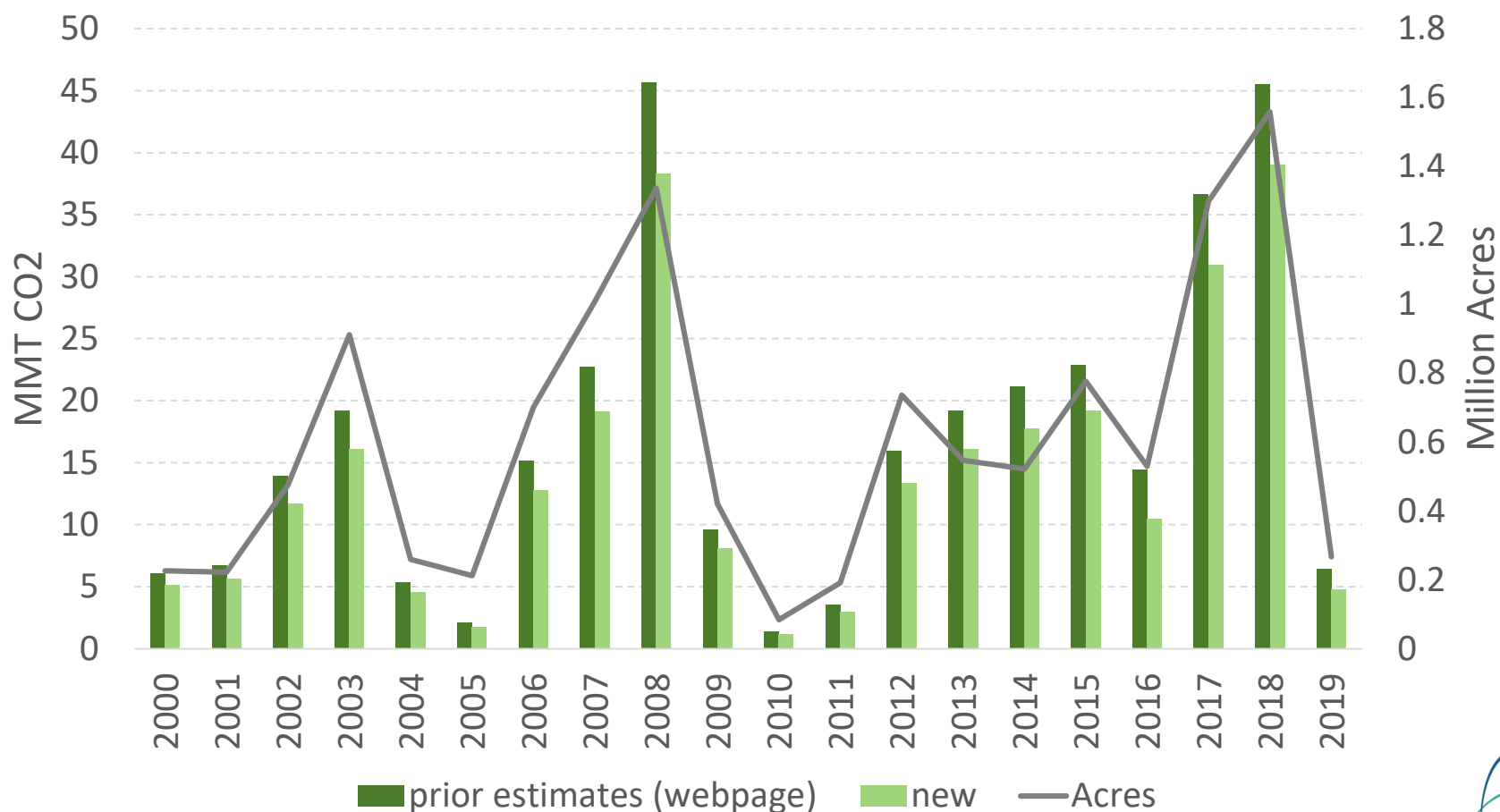
Wildfire: Compare Acreage & Emissions



MMT CO₂ = million metric tons of CO₂

Wildfire Emissions Update

- New emission estimates are lower than previous estimates
- Fuel loadings for forest types are lower in FOFEM v 6.7



Prior estimates available at: <https://ww2.arb.ca.gov/wildfire-emissions>

Part 1b

GHG Emissions of Prescribed Fire



Data Sources & Methods

1. Prescribed burn project perimeters, 2015-2019

- CAL FIRE - FRAP geodatabase (public lands, some private lands)

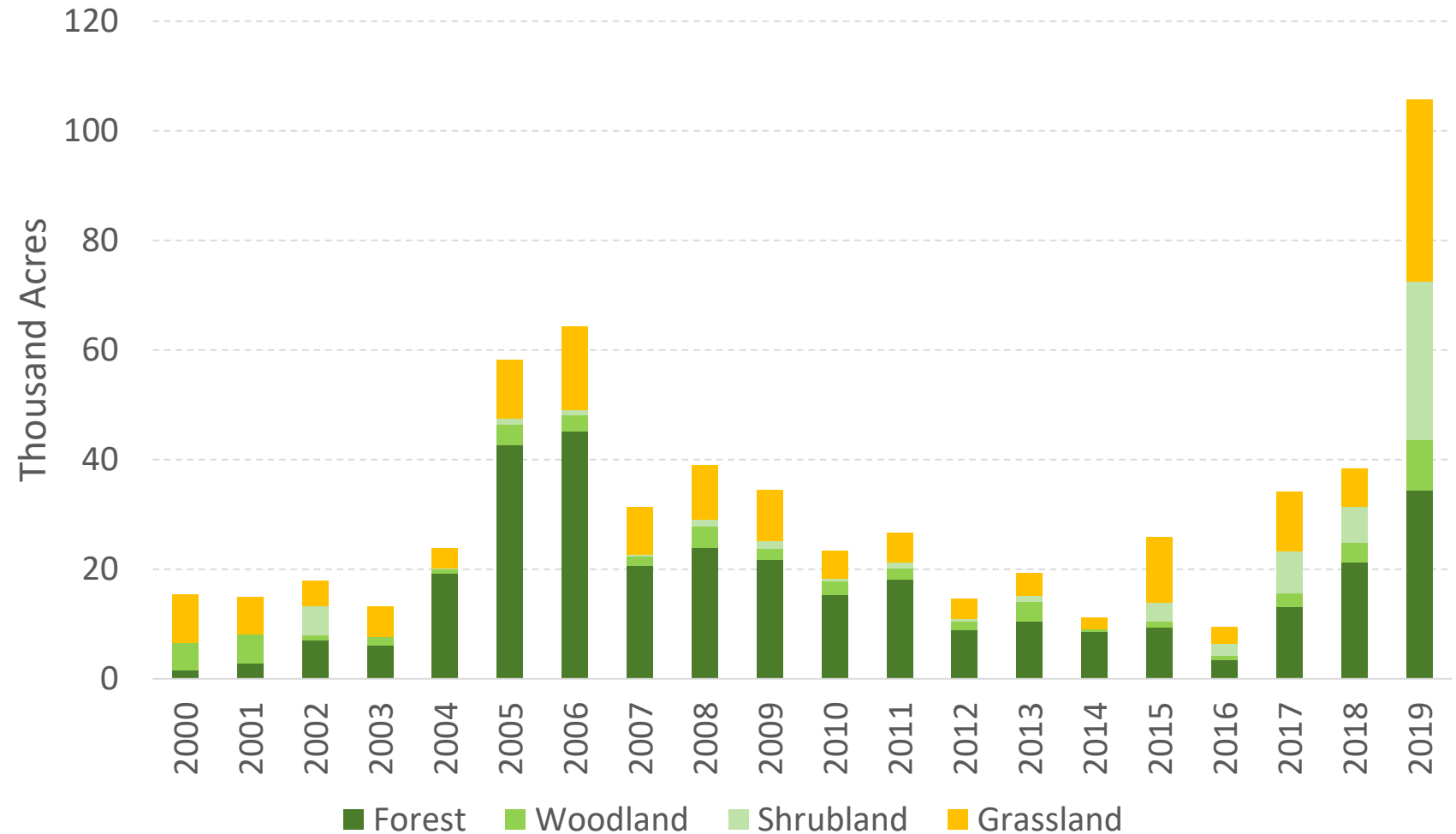
2. Fuels

- Vegetation fuel maps by year (developed by UC Berkeley for CARB)
- Vegetation moisture maps by year, month

3. Emissions: FOFEM v 6.7

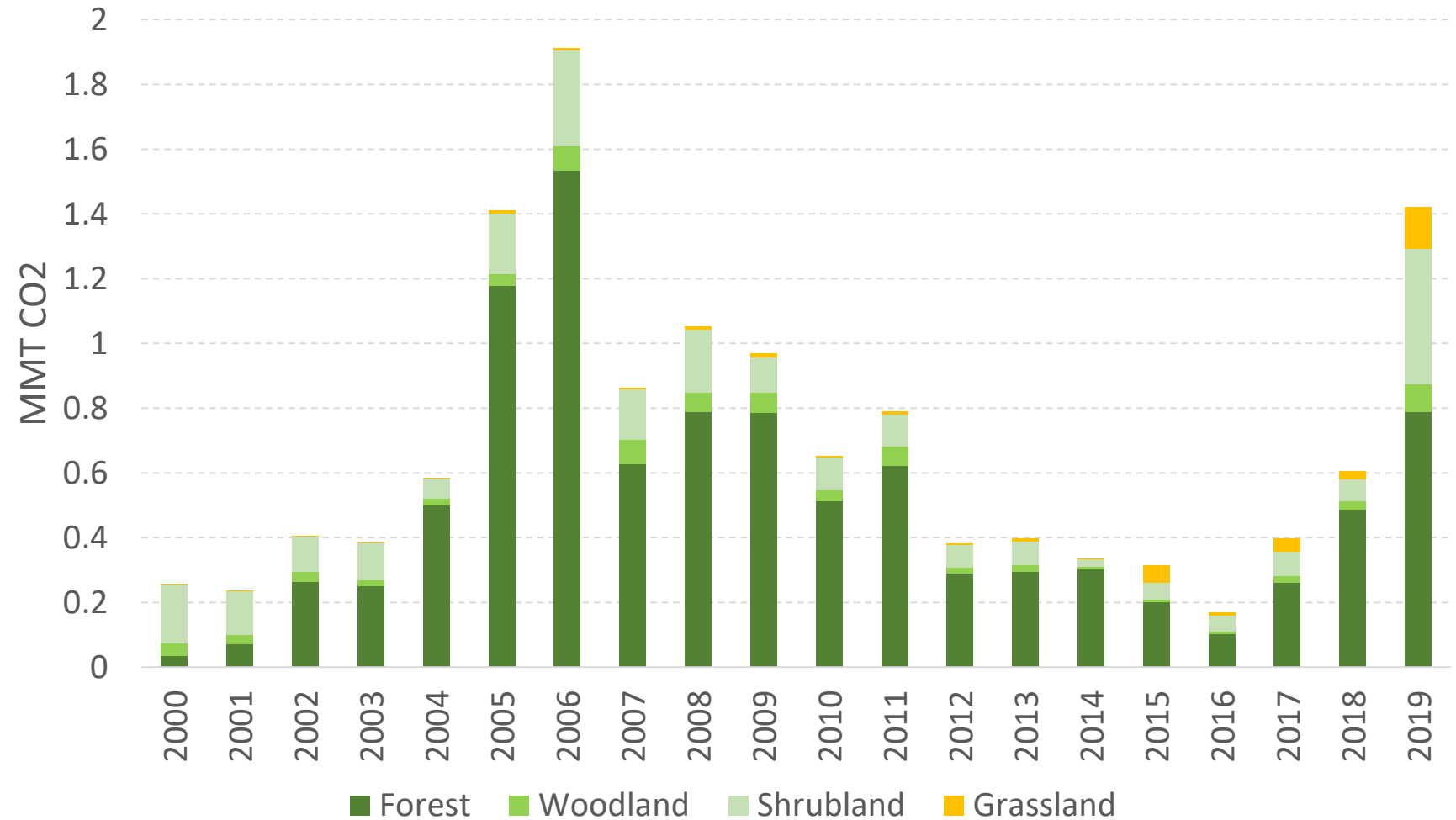
Prescribed Fire: Acreage by Vegetation Type

- Most activity is in forests and woodlands
- Followed by grasslands
- Recent increase in activity in shrublands



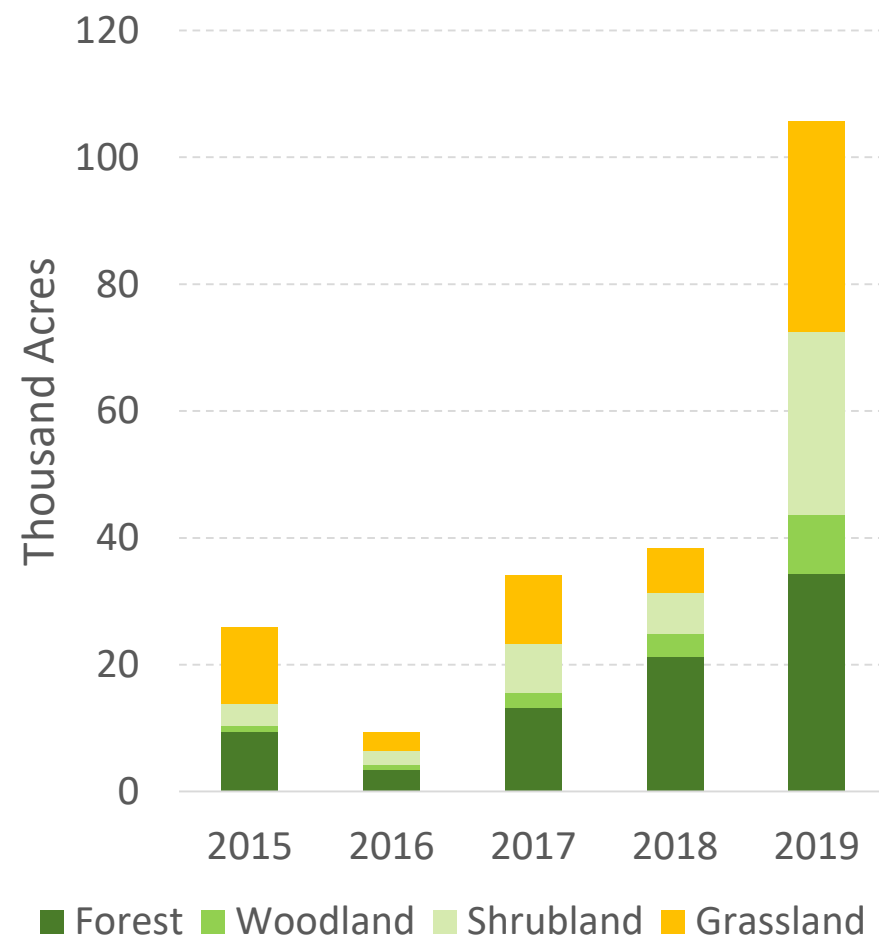
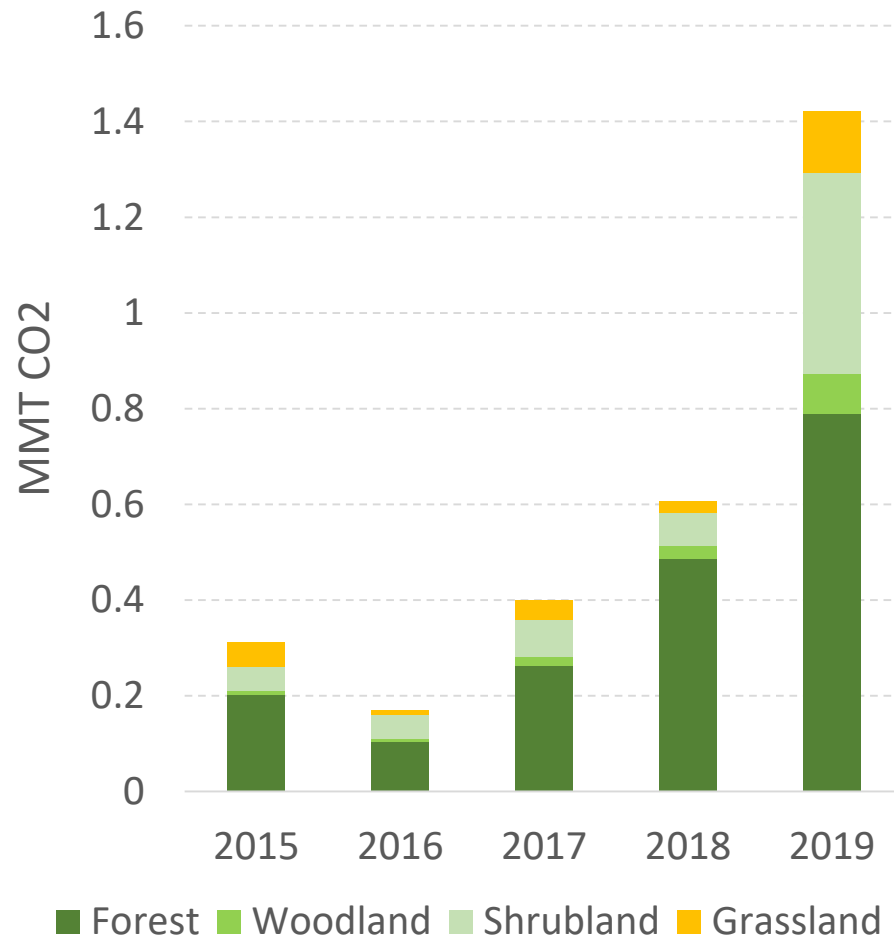
Prescribed Fire: Emissions by Vegetation Type

- Forests have high fuel loads, dominate emissions
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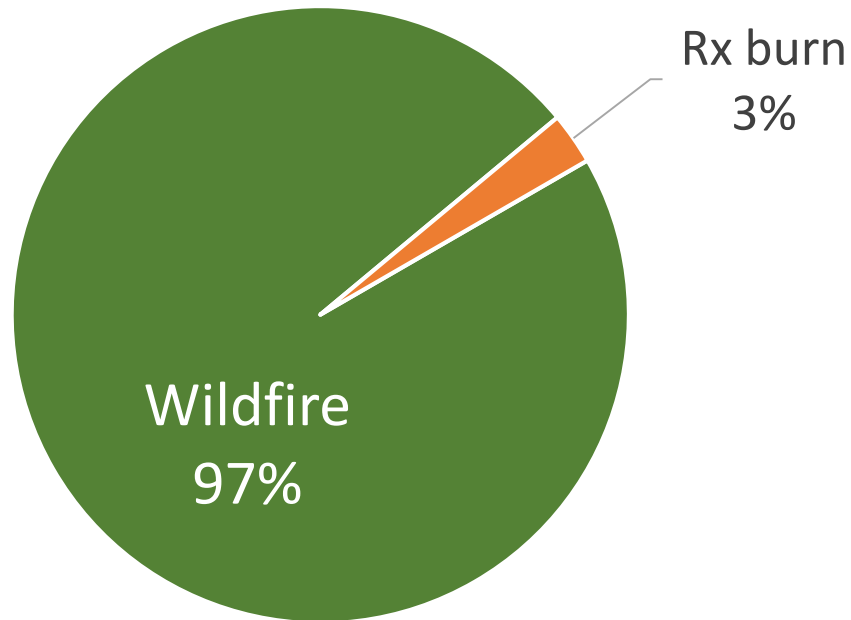
Rx Fire: Compare Emissions & Acreage



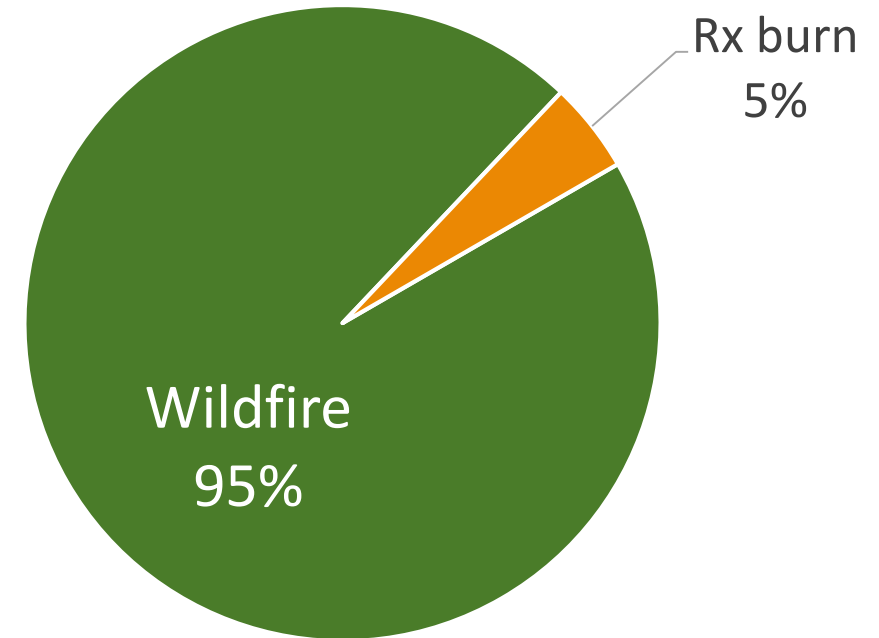
MMT CO₂ = million metric tons of CO₂

Wildfire vs Prescribed Burn Emissions

CO₂ emissions, Sum of 2015-2019



Million Acres, Sum of 2015-2019



- Wildfires dominate emissions
- Prescribed fire minor contributor

Part 1c

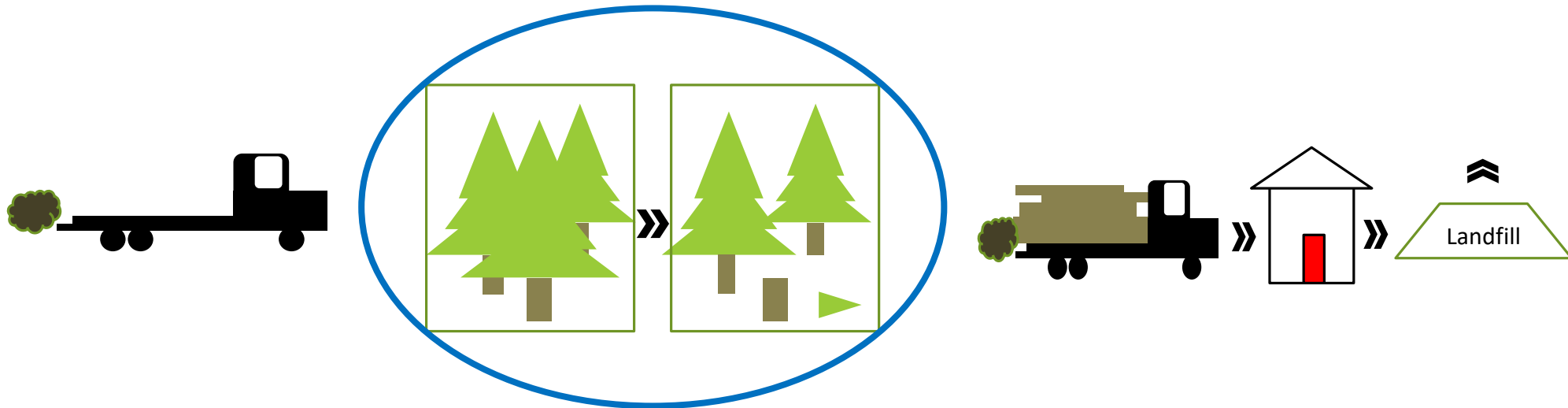
Non-Fire Forest

Management Activities



Scope of This Analysis

- This analysis focuses on the **ecosystem carbon impacted from cutting of forests**:
 - Thinning, clearcutting, mastication, harvesting, other mechanical
- This analysis does NOT quantify:
 - The emissions associated with machinery or transport
 - The life cycle of the wood after cutting
 - Ecosystem process change associated with forest management (growth, fire, etc.)



Data and Methods

Data that includes: spatial, temporal, and activity-type information

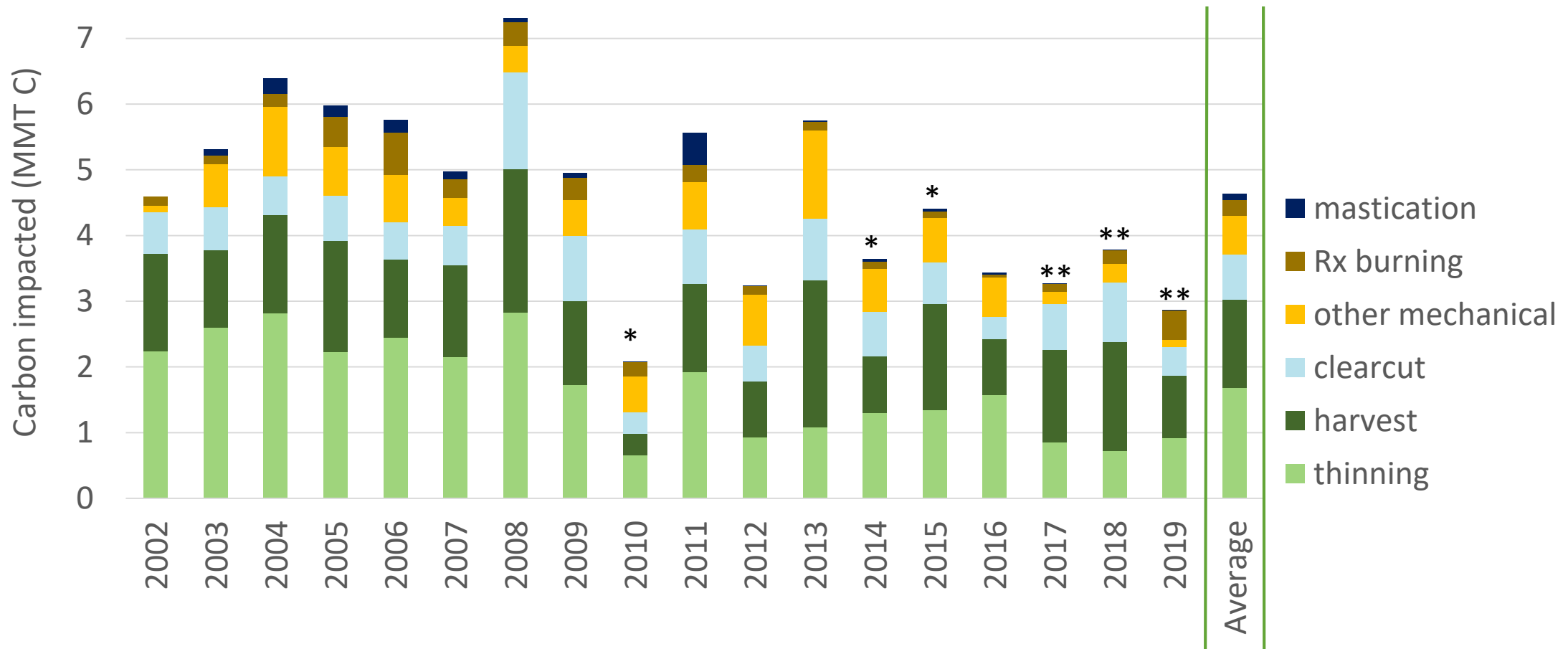
- CARB's Natural and Working Lands (NWL) Carbon Inventory
 - LANDFIRE disturbance layers
 - 2002-2016 (annual)
- Forest Activity Tracking System (FACTS) and CA Forest Practice GIS (FPG) perimeters
 - 2010, 2014, 2015, 2017-2019

Carbon Stock Change

- The results represent impacted ecosystem carbon
- Not all of this carbon is emitted into the atmosphere immediately
- This carbon has many different possible fates

Estimation Results

Ecosystem Carbon Stock Change by Forest Management Type



Other mechanical is a catch-all term for a variety of forest and rangeland mechanical activities related to fuels reduction and site preparation including; piling of fuels, chaining, lop and scatter, thinning of fuels, Dixie harrow, etc.

* LANDFIRE disturbance data was modified by incorporating forest practice rules and FACTS data to account for known errors

** 2017 2019 was calculated by summing areas from FPG and FACTS data, and applying a multiplier for carbon/area derived from modeled data

Relating Carbon Stock Change to CO₂ Emissions

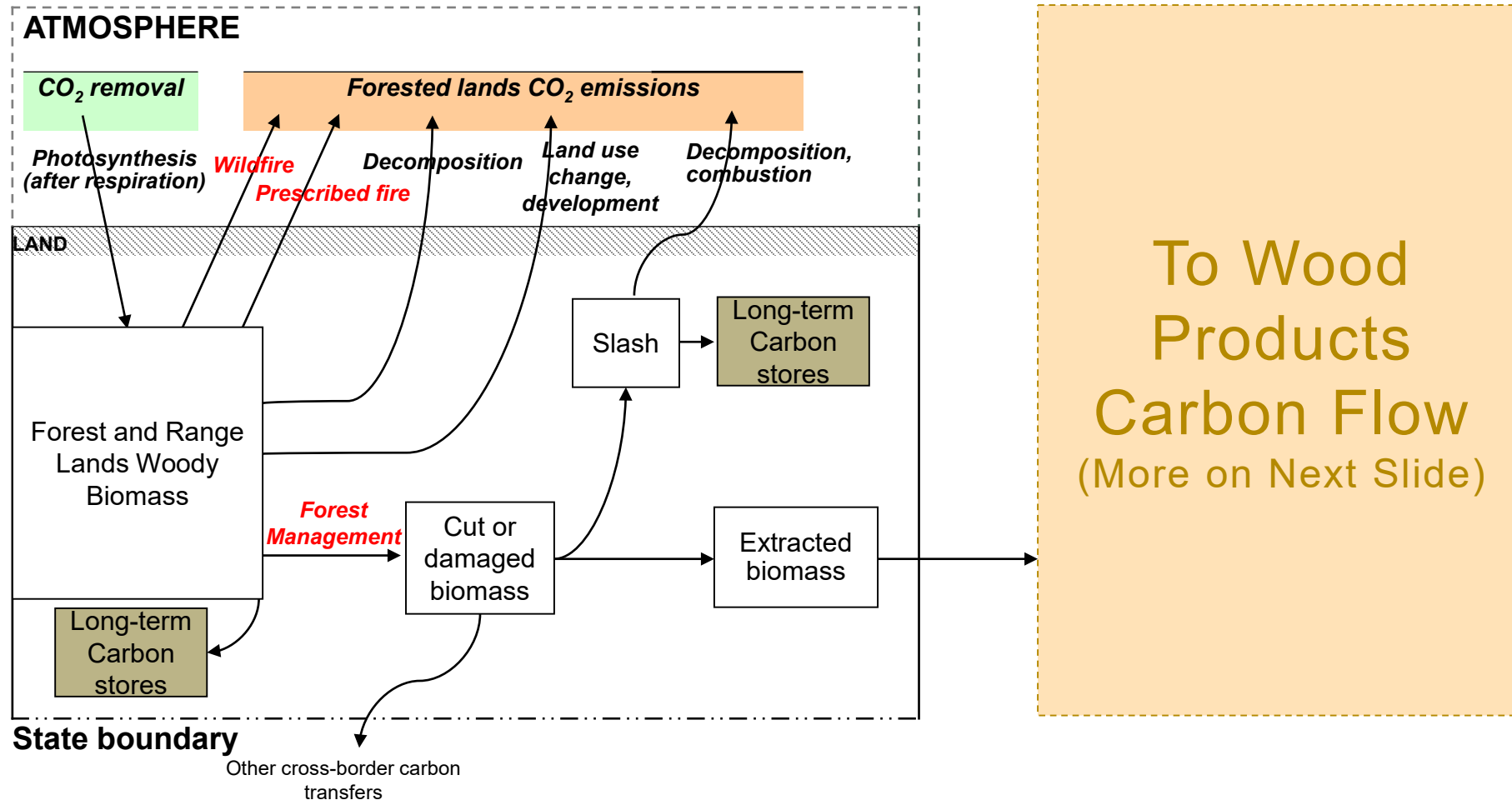
- Impacted carbon stock represents the amount of CO₂ that was previously sequestered in biomass.

Example:

- 4.6 MMT of Carbon is equivalent of 16.8 MMT of CO₂ that was previously sequestered in biomass
- It does not mean that 16.8 MMT of CO₂ have been released into the atmosphere

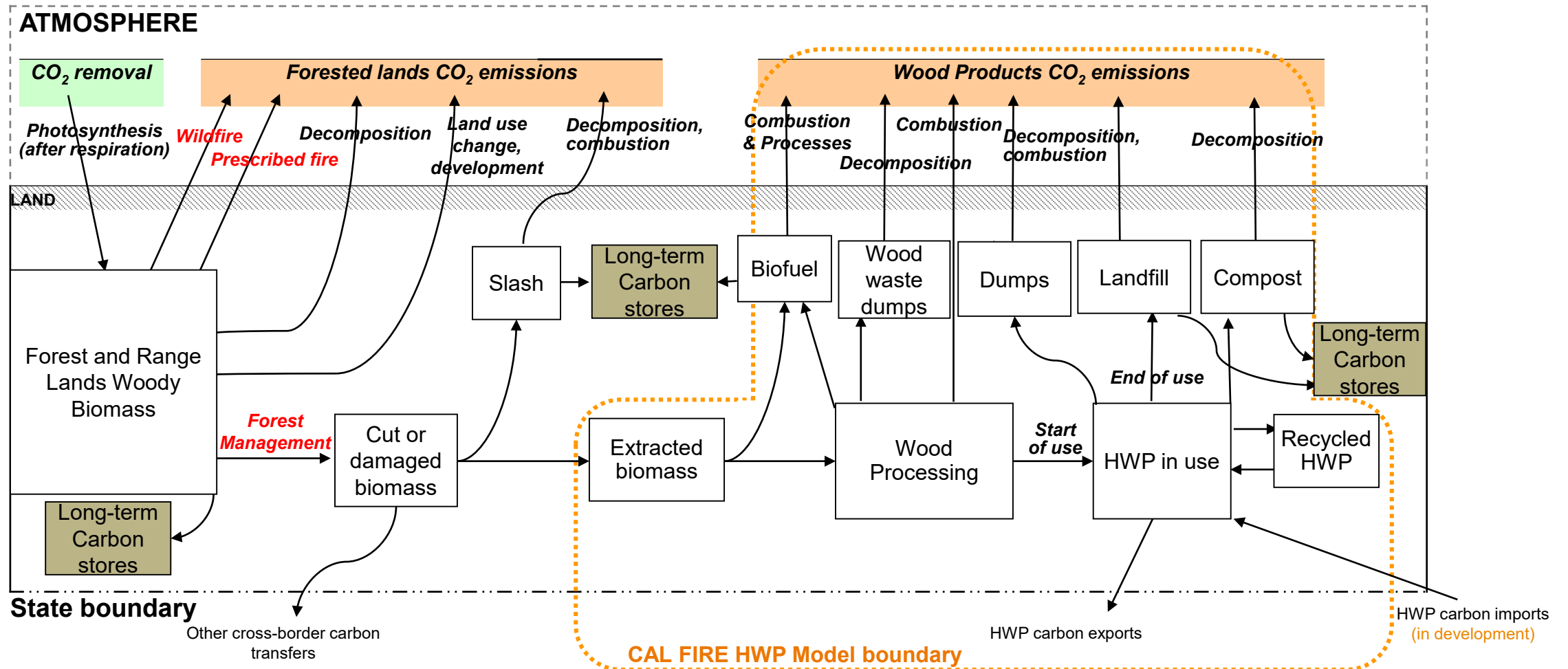
Ecosystem Carbon Flow

Conceptual forest management carbon flow diagram



Ecosystem Carbon Flow

Conceptual forest management carbon flow diagram



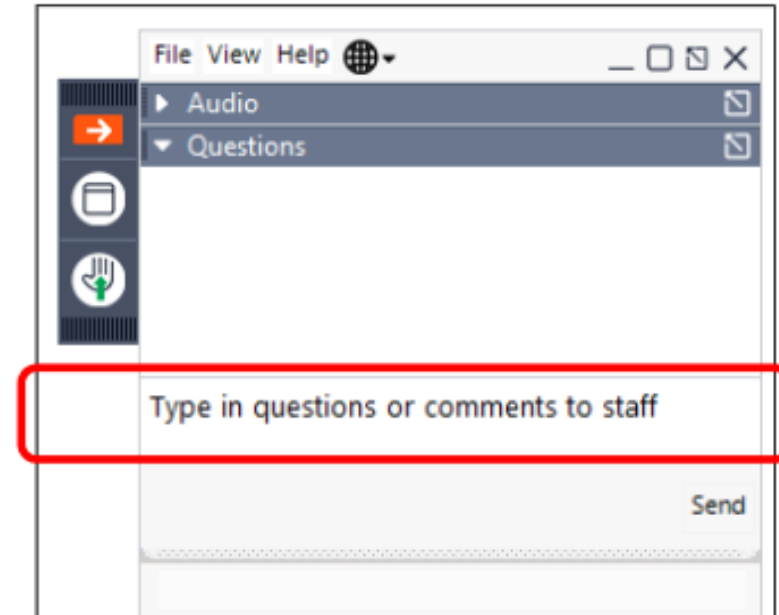
Opportunities for Future Data Development

- Work with other agencies to fill data gaps
 - Refine remote sensing data
 - Work with forest managers to collect more data
 - Piece together datasets from multiple agencies into a complete picture
 - Reconcile the fire and management data between remotely-sensed data, field collected data, and reported information
- Carbon flow estimates

Q&A

Comments and Questions

- GoToWebinar Question Box
- Please include your affiliation



Part 2

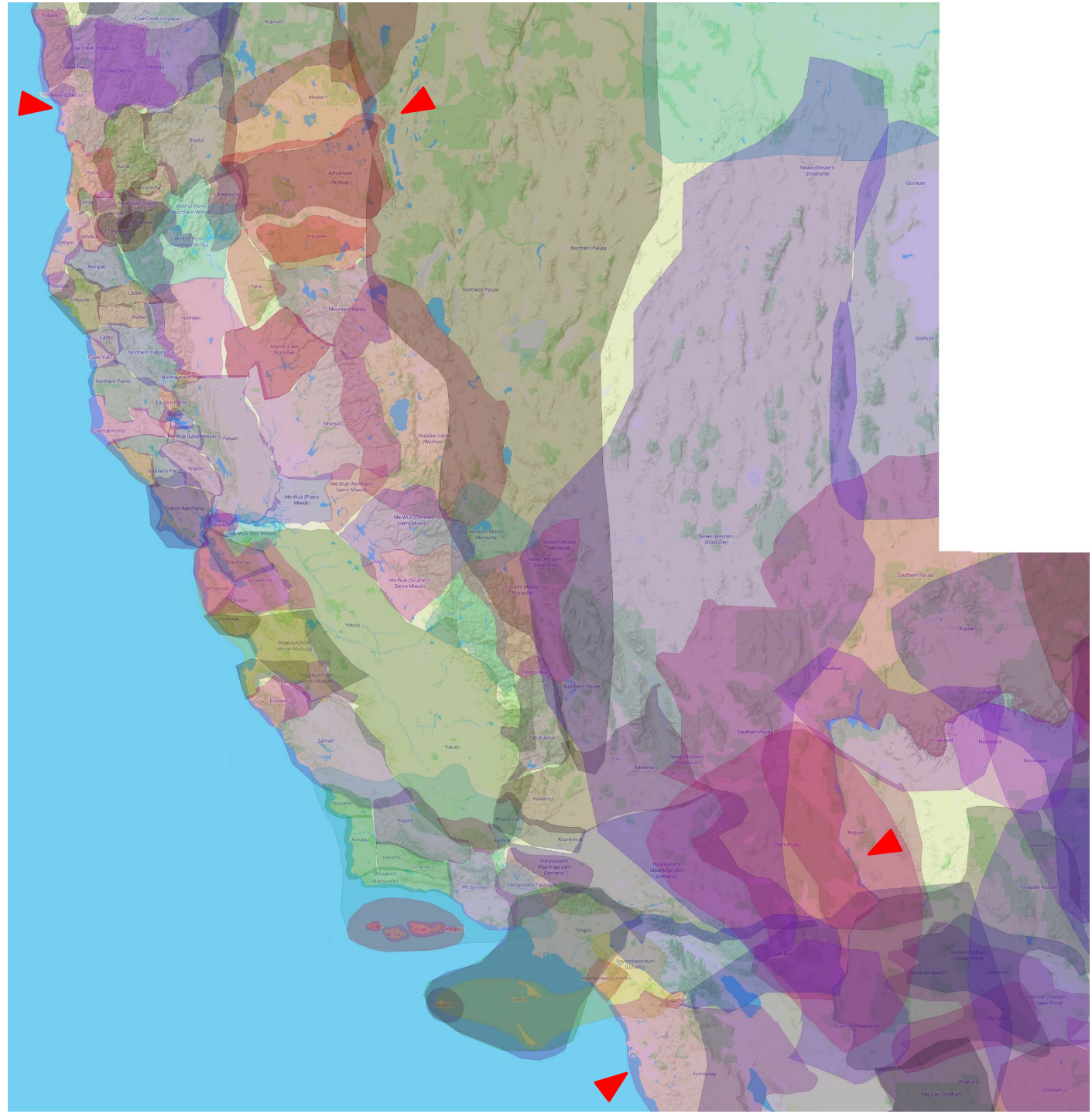
Historical Fire Activity Before Modern Fire Suppression

Acknowledgment of Indigenous People

Map Source: Native Land Digital

(<https://native-land.ca/>)

This map shows a timeless composite of Indigenous homelands. As a point of reference, the 4 triangles indicate the approximate geographical extent of California.



Science Advisors

Alan Taylor, PhD

Pennsylvania State University

- Fire scar dendrochronology
- Fire ecology
- Vegetation change

Don Falk, PhD

University of Arizona

- Fire history
- Fire Ecology
- Ecological resilience

Don Hankins, PhD

California State University, Chico

Miwoko? (Plains Miwok) traditional
cultural practitioner

- Pyrogeography
- Conservation
- Indigenous Stewardship
Practices

Frank Lake, PhD

U.S. Forest Service,
PSW Research Station

Karuk descendant

- Indigenous knowledge
research applications
- Tribal wildland fire and fuels

Glen MacDonald, PhD

University of California, Los Angeles

- Process and impacts of long-term
climate change
- Climate, vegetation, change
relationships
- Long-term climate records

Jennifer Marlon, PhD

Yale University

- Climate Change
- Fire history
- Public opinion

Scott Stephens, PhD

University of California, Berkeley

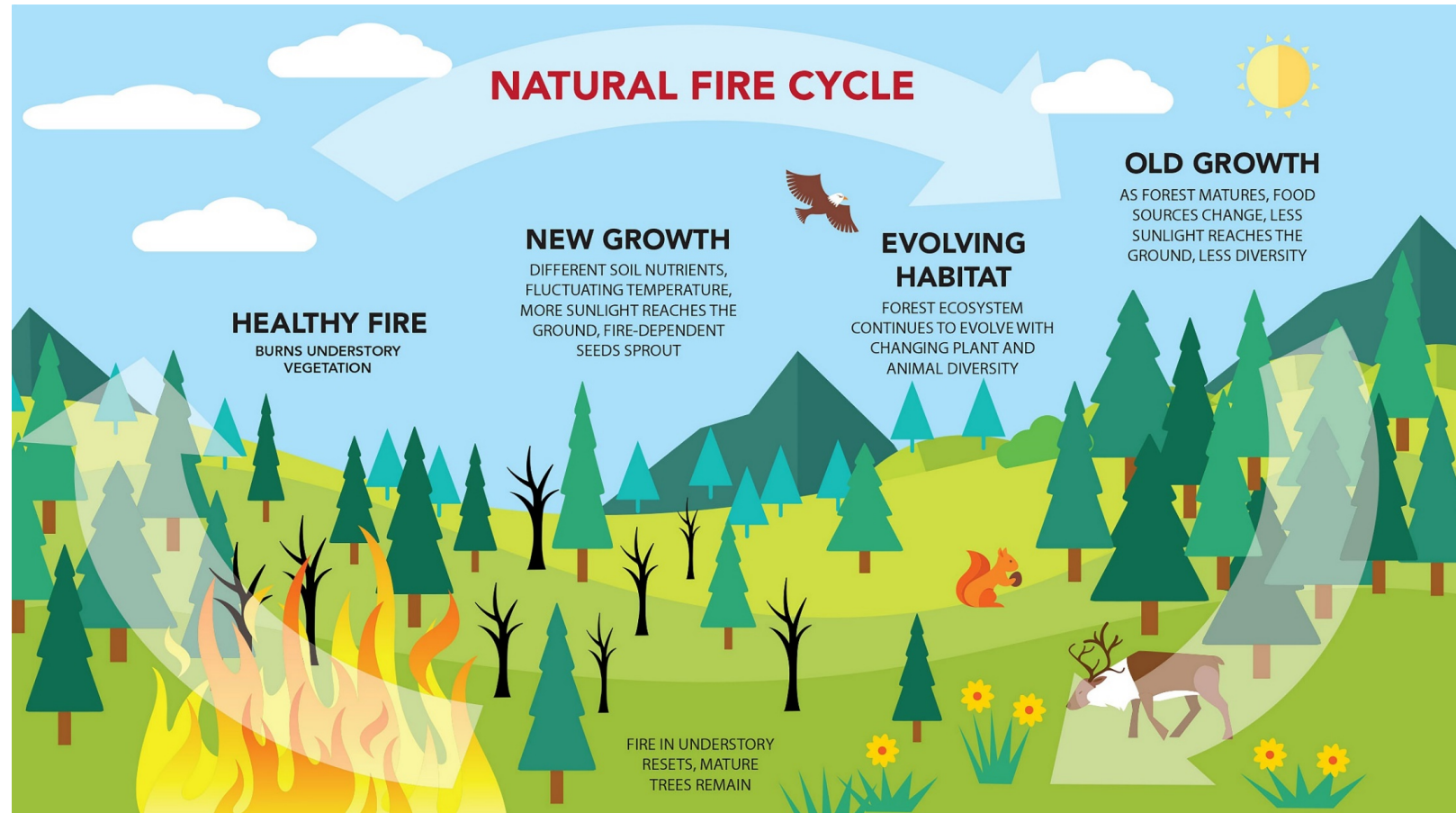
- Fire ecology
- Historical fire
- Fire and forest policy

Overview

- Fundamentals of fire in California landscape
- What historical data are available on pre-1910 fire activity
- Data needed to estimate emissions
- A literature review summary of current scientific understanding of historical fire
- Insights on the use of historical fire as analog of modern fire

Ecosystem Functions of Fire in California Landscapes

- Fire is a natural ecosystem process
- Fire performs several ecosystem functions such as:
 - Facilitating germination of seeds
 - Replenishing soil nutrients
 - Stimulate tree growth
 - Reducing fuels



Factors that Influence Fire Characteristics and Emissions

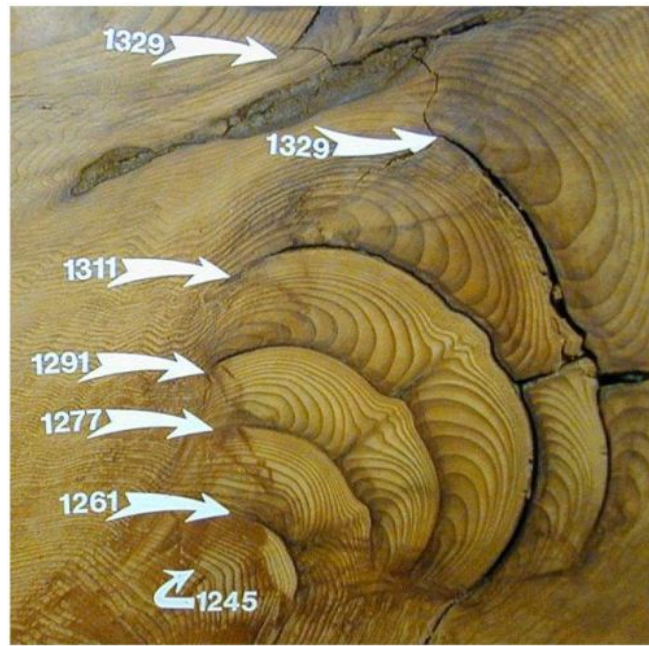
- The type, amount and condition of fuels
- The compartments that burn (forest floor, canopy, etc.)
- Environmental conditions (topography, wind, weather, etc.)
- Climate drivers (temp, precipitation, drought, vegetation cover)
- Ignition sources

Understanding Past Fire Activity

Scientists use proxies to estimate fire activity in the past

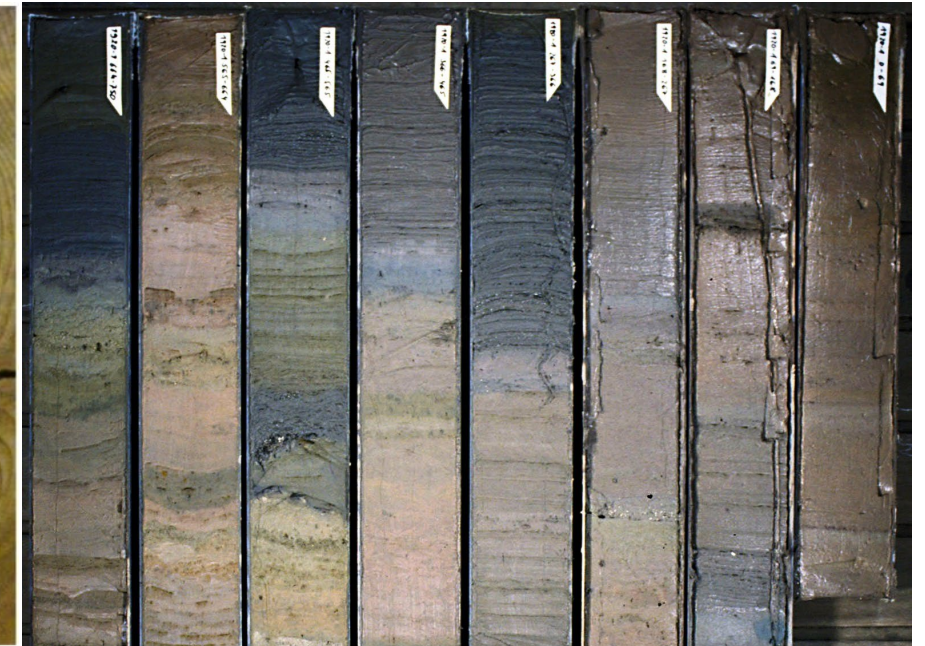
- Trees
- Sediment cores
- Oral histories
- Archeological sites
- Early explorer accounts

Burn Scars



Credit: Tom Swetnam

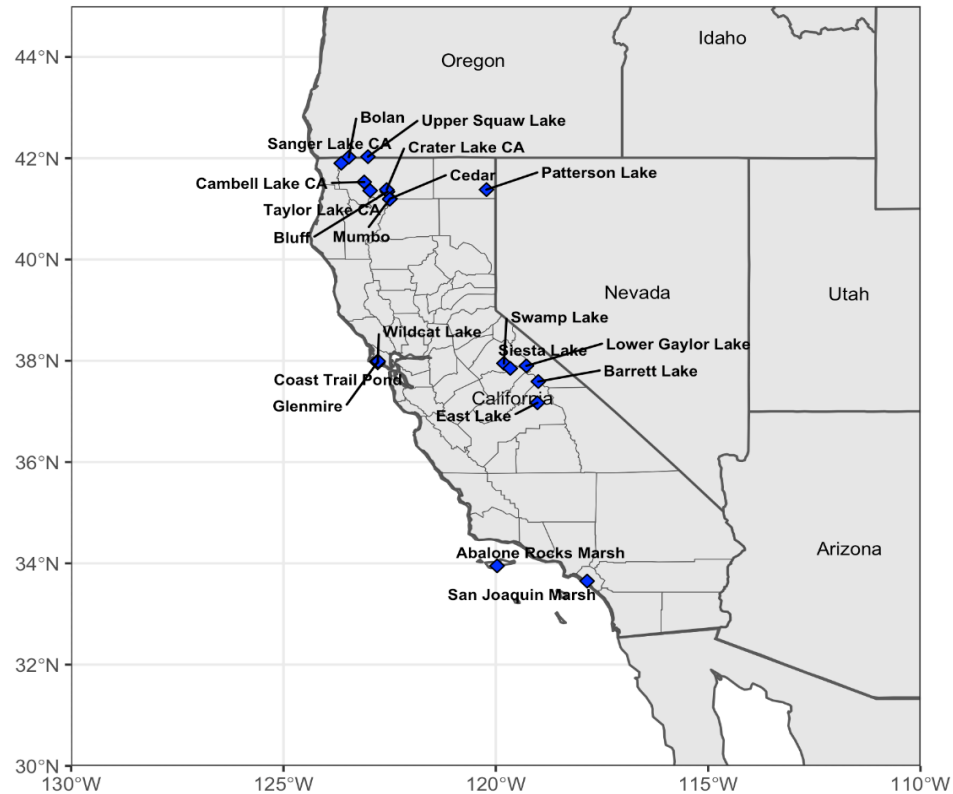
Sediment Cores



Credit: Hannes Grobe

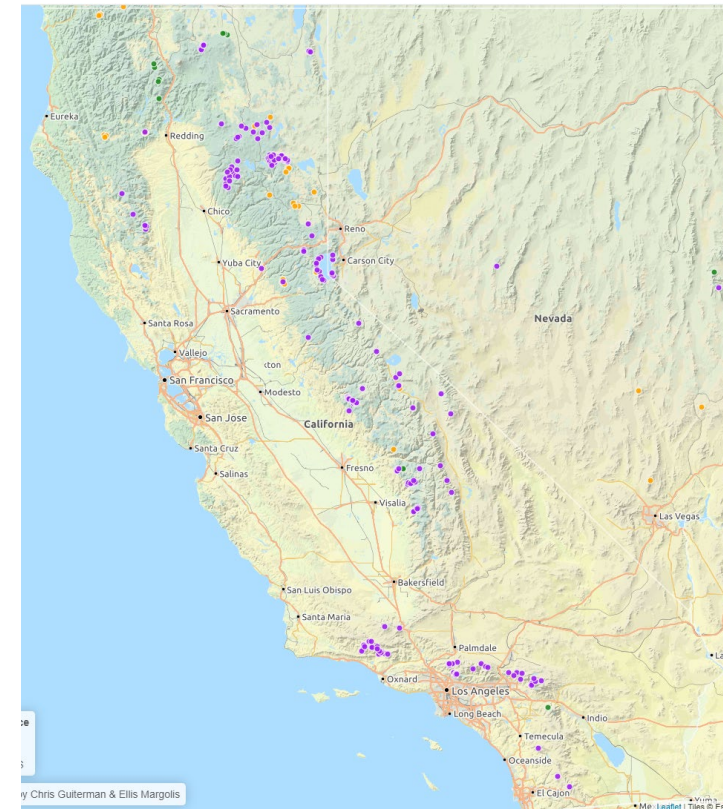
Limited Locations of Proxy Data

Sediment Cores



Marlon (2012)

Burn Scars



The North American Tree-Ring Fire Scar Network
(Guiterman & Margolis)

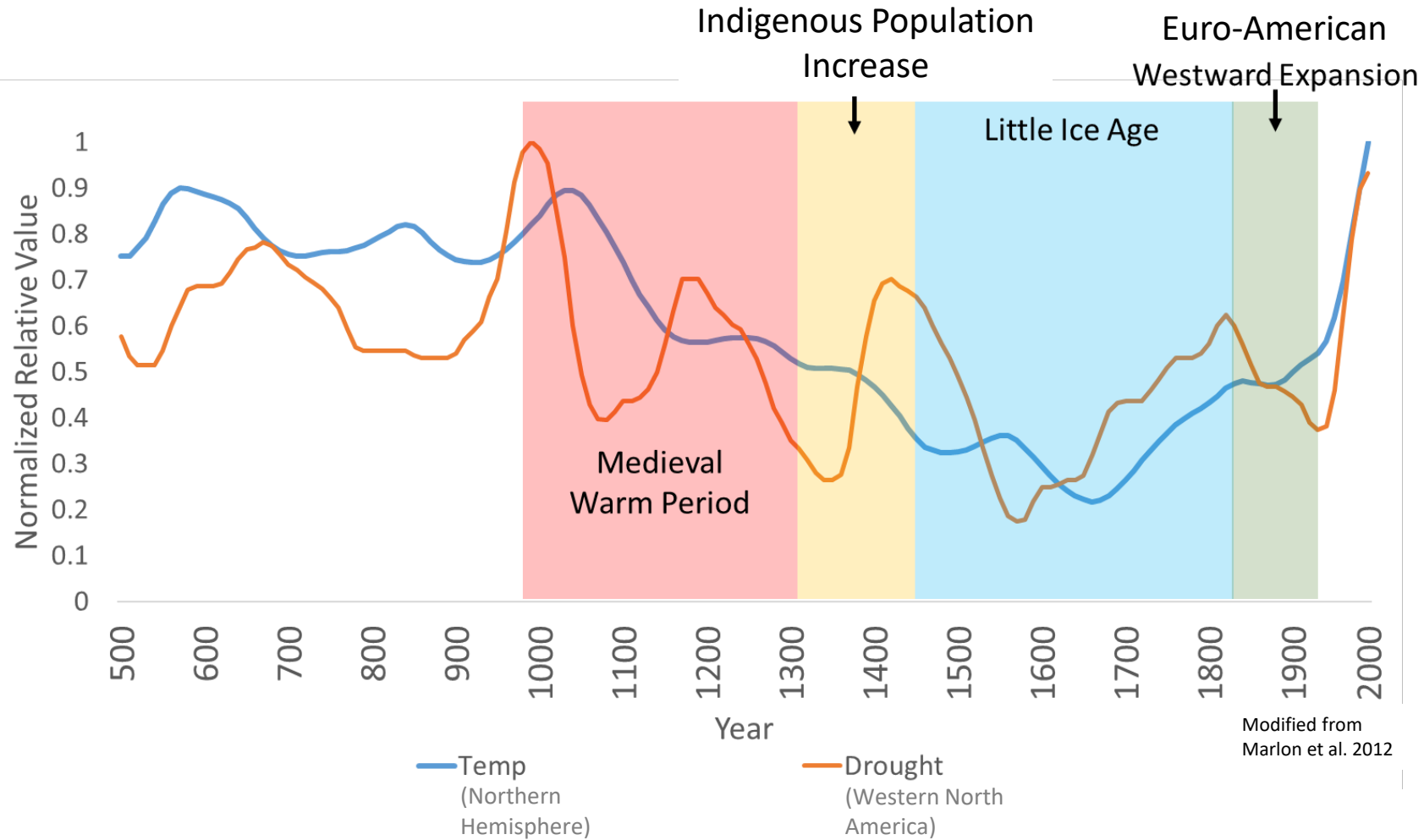
Estimate Historical Fire Emissions

- Quantitative data needed for modeling fire emissions:
 - Area burned per year
 - Emission factors
 - Vegetation type
 - Fuel amount
 - Fuel moisture
 - Fire behavior
- Fire creates a mosaic of intensities, severities, and frequencies, so emissions vary greatly across the landscape and through time

Statewide and Regional Spatial/Temporal Variability

- Fire activity varies across California through time and across regions.
- Every region of California has experienced changes in fire in different ways.
- No one fire regime can represent California's diverse history and ecosystems.

California: A 1500-Year Overview



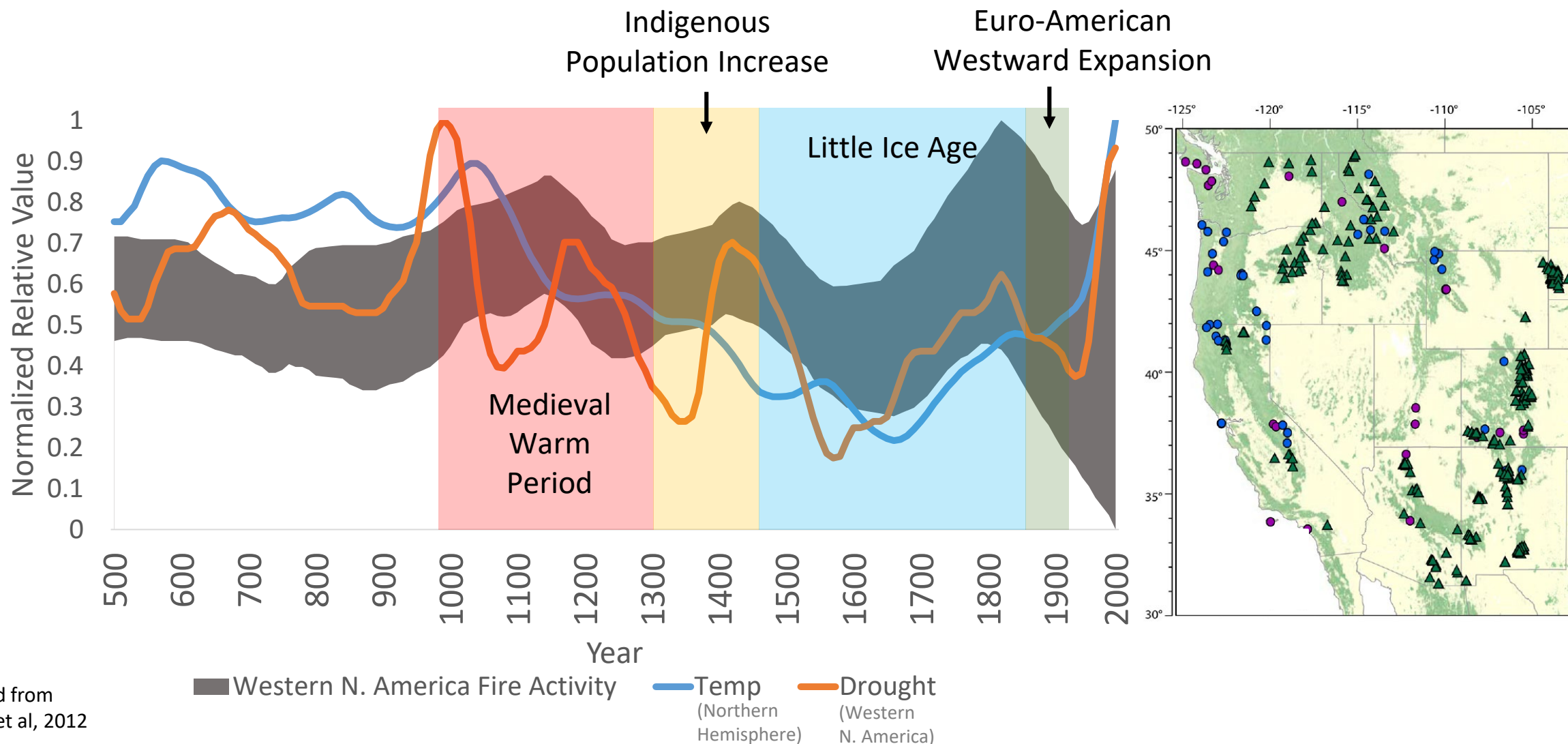
Indigenous Use of Fire

- Physical evidence of humans in North America = 33,000 years ago*
- Cultural burning changes the frequency, seasonality and specificity of a fire regime
- Short to intermediate intervals between burns
- Historically burned large portions of California
- Compared to prescribed burning, cultural burning is more locally specific, has more diverse objectives and requires traditional ecological knowledge
- Evolution of a cultural fire regime - Burning changes with conditions

Changing Climate Impacts on Fire

- Climate drives fires throughout history on local and global scales
 - Temperature
 - Drought
 - Pacific Decadal and El Nino Southern Oscillation (PDO and ENSO)
 - Vegetation type
- Evidence shows fire generally follows climate until fire suppression begins (after 1910)

Changing Climate Impacts on Fire



Modified from
Marlon et al, 2012

Estimation of Historical Fire Emissions

Stephens et al. (2007)¹ estimates and contemporary values

- Stephens et al. (2007) is a modeling exercise to estimate a snapshot in time and does not represent fire through time
- These estimates represent primarily the Little Ice Age (LIA)
- The estimates of area burned per year are derived via burn scar fire frequencies, oral histories, and a vegetation map that does not represent the LIA
- Modeling assumptions:
 - Current fire models can represent historical conditions
 - Vegetation does not change through time
 - Every acre has equal probability of being burned

Statewide Annual Variable	Stephens et al. 2007 Estimates for the LIA	Highest in 2000-2019	Average of 2000-2019 ²
Area burned (Million acres)	4.5 - 12	1.59 (2018)	0.63
CO ₂ fire emissions (MMT CO ₂)	34 – 90	39.0 (2018)	14

1. Stephens, S. L., Martin, R. E., & Clinton, N. E. (2007). Prehistoric fire area and emissions from California's forests, woodlands, shrublands, and grasslands. *Forest Ecology and Management*, 251(3), 205-216.

2. Fire Perimeters: A multi-agency statewide database of fire history. CAL FIRE, Fire and Resource Assessment Program. Sacramento, CA. URL: https://frap.fire.ca.gov/mapping/gis_data/

Historical Fires/Emissions are NOT Good Analogs of Contemporary Fires/Emissions

- Different burning conditions
(1 acre burned then \neq 1 acre burned now)
 - Estimated average for LIA (Stephens et al. 2007) emissions/acre \approx 7.5 MT CO₂/acre
 - Current average emissions/acre \approx 27 MT CO₂/acre
 - Fire deficit resulting in higher fuel loads
- Different environmental and climate conditions not seen in the past
- Different pressures on and needs from ecosystems
- Different population sizes and locations
- Different ignition sources
- Different veg types and fuels (including invasive plants)
- Large variations of fire and emissions throughout history

In Summary (1 of 3)

- Fire emission modeling results can vary significantly depending on vegetation type, fuel characteristics (e.g., quantity and moisture), and fire behavior at the time of burn.
- Contemporaneous field measures and systematic data recording were not done before the modern time. Estimates of historical fire emissions cannot be validated due to lack of data.
- In analyzing tree rings and sediment cores, differentiation between lightning-ignited fire, indigenous fire, and any other ignition source cannot be verified.

In Summary (2 of 3)

- The Earth's climate is not static and has always changed through time.
- Ecosystems respond to changes in climate, environmental conditions, and human activities. In turn, humans adapt with the changing ecosystems.
- There are no historical analogs to the combination of present conditions.

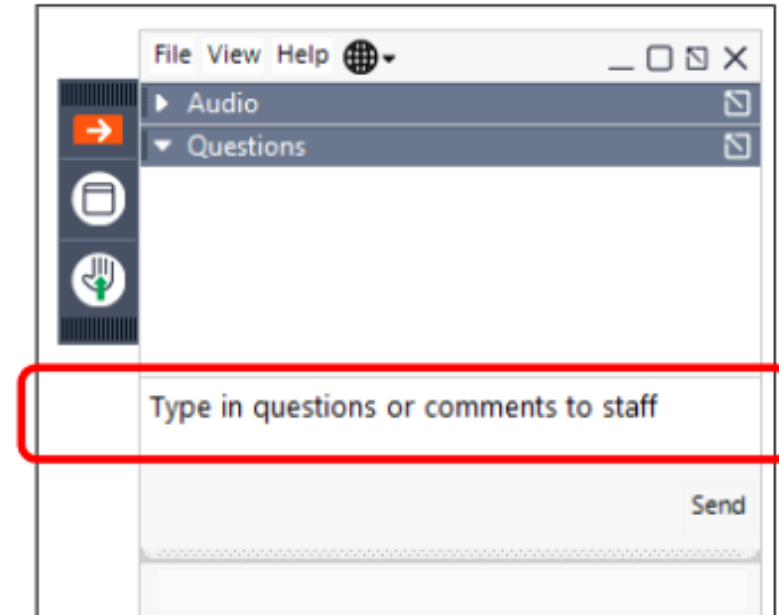
In Summary (3 of 3)

- Long-term trends in fire activity generally followed the changes in the Earth's climate until fire suppression began in the early 20th Century.

Q&A

Comments and Questions

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Closing and Next Steps



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Please feel free to email staff with your comments and questions any time.



Contact Information



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- **Greg Harris** (Greg.Harris@arb.ca.gov)
Chief, Emission Inventory & Economic Analysis Branch
- **California Wildfire Emission Estimates:**
<https://ww2.arb.ca.gov/wildfire-emissions>
- **Natural & Working Lands Ecosystem Carbon Inventory:**
<https://ww2.arb.ca.gov/nwl-inventory>