FEBRUARY 2024

CALIFORNIA'S YEAR IN FIRE *2021 Report*

An assessment of the social and ecological impacts of wildfire in California in 2021

Berkeley Law | Center for Law, Energy, & the Environment
CLIMATE & WILDFIRE INSTITUTE
GORDON AND BETTY MOORE FOUNDATION

ABOUT THIS REPORT

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The Center for Law, Energy & the Environment (CLEE) channels the expertise and creativity of the Berkeley Law community into pragmatic policy solutions to environmental and energy challenges. CLEE works with government, business, and the nonprofit sector to help solve urgent problems requiring innovative, often interdisciplinary approaches. Drawing on the combined expertise of faculty, staff, and students across the University of California, Berkeley, CLEE strives to translate empirical findings into smart public policy solutions to better environmental and energy governance systems.

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How are wildfires impacting California, and how are those impacts evolving? This question is central to our social response to wildfire—including how we live with it, restore it to the landscape, and mitigate its worst effects. The problem, however, is that we do not yet have clear answers to this question.

A wide variety of wildfire impacts are either not tracked or not reported, limiting our ability to make informed decisions in wildfire mitigation and recovery efforts. Furthermore, this truncated access to essential information and data has the potential to lead us to unsustainable solutions. For example, if wildfire impacts are judged solely by the area burned each year, a rational approach to reducing annual acreage might be to bolster fire suppression. However, such a narrow view of the problem and potential solutions both minimizes the opportunity to produce a range of social and ecological benefits, and could result in unintended consequences.

In an era of increasingly catastrophic wildfire impacts, with wildland fires that raze human communities, causing destruction, loss, and trauma, a broader-based evaluation of impacts is essential. The broader set of metrics also benefits evaluation and decision-making related to the critical need to restore functional fire to landscapes and build a greater understanding of positive aspects of wildfire. The California's Year in Fire project advances a framework for a more complete picture of evolving impacts and consequences, and provides more robust data points to inform meaningful solutions.

One thing that the California's Year in Fire project does not do: establish specific causal connections between management or policy interventions and wildfire impacts. Rather, the goal is to establish reliable and consistent baseline information against which investments and actions may be compared. Over time, we anticipate that the framework and metrics will be iteratively improved and the utility increased, including in the following ways:

- Add and report metrics within local and regional areas of interest
- Expand the scope of metrics, especially to better reflect social impacts

- Conduct statistical analysis to pare down metrics that are statistically related, and to produce more explanatory findings
- Garner and incorporate feedback from data stewards and subject matter experts, as well as potential end-users
- Update annually through a public-facing website with a map interface, increasing accessibility and allowing users to easily explore and compare impacts across scales

Wildfire statistics are often characterized by significant interannual variability; a single year provides a snapshot of a range of conditions which exist along a continuum, are likely to change, and may not produce neat trends. For this reason, the California's Year in Fire project presents annual data in the context of the entire period of record for each impact, and further contextualizes annual figures with benchmarks where appropriate. This report presents key figures and findings from the first iteration of the California's Year in Fire project, which focused on state-level summaries for calendar year 2021.

Interannual variability also highlights the need for more comprehensive assessments of wildfire impacts, and the need to update these assessments annually. For some metrics in this report, we highlight a comparison of 2021 to 2022 figures. 2022 was chosen as a point of comparison due to its recency, but also because 2021 and 2022 are popularly regarded as drastically different in terms of wildfire outcomes, primarily when considering acres burned. However, by evaluating a broader set of data, we can see that, while some impacts trended positively between 2021 and 2022, others remained relatively unchanged. This is especially true when we consider proportional impacts, and highlights the need to consider both the magnitude and the intensity of wildfire impacts. Note that, while values from these two years are highlighted, the entire period of record for each metric is incorporated into the annual values; that is to say, the metric values for these two years are contextualized so as not to be evaluated within a vacuum.

2021 BY THE NUMBERS

The California's Year in Fire framework focuses on five related questions as a way to better understand annual wildfire impacts. For each question, a group of identified metrics collectively help build a measurable "answer" or response. Metric selection is dependent on data availability and suitability; the metrics here are not an exhaustive list of relevant factors and considerations. Metrics are accompanied by benchmarks that provide context to aid in the interpretation of annual metric values. Benchmarks either: (a) reflect how closely aligned a metric is with pre-fire suppression and/or pre-Euro American settlement era conditions; (b) propose an ideal condition based on available data and literature; or (c) constitute a summary figure from the available period of record. Benchmarks may be derived from the scientific literature, modeling, or a trend analysis of available data. To the extent that certain metrics are not associated with legislative or other state goals, these proposed benchmark figures can spur further conversation about desirable and feasible target values.

- **Question 1:** How is wildfire impacting landscapes?
- **Question 2:** How is wildfire impacting ecological resilience?
- **Question 3:** What are the social impacts of wildfire?
- **Question 4:** What is the cost of wildfire response and recovery
- **Question 5:** How are we addressing wildfire risk?

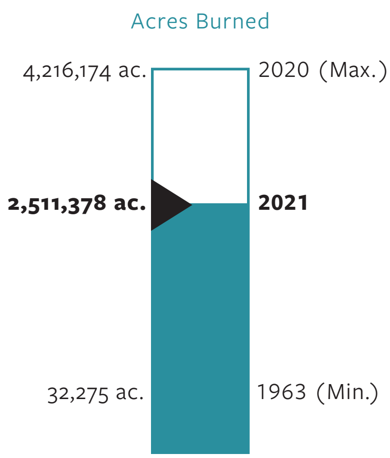
QUESTION 1: HOW IS WILDFIRE IMPACTING LANDSCAPES?

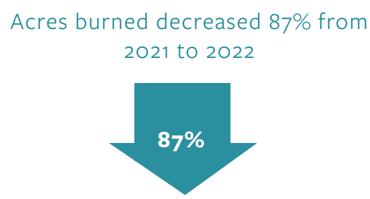
This question reflects on landscape impacts including acres burned, estimated emissions, and debris-flow hazard. Here, the term “landscape” encompasses both natural and engineered features, rather than ecological systems alone (Question 2).

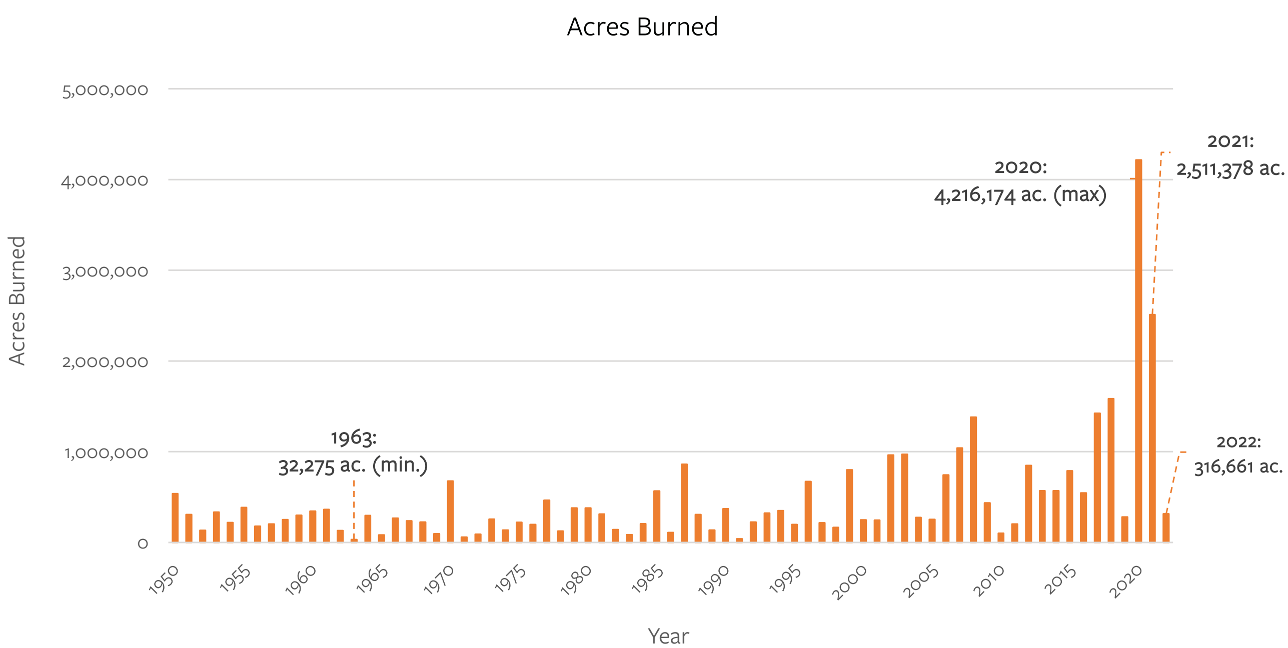
Acres

Many of the summary figures in this report are presented using the type of graphic shown at left, representing the minimum and maximum values per metric for the period of record. These are shown at the top and bottom of the graphic, respectively, and correspond with years 1963 and 2020, respectively, for acres burned. The graphic visually indicates where the 2021 value sits within the range of values. Note that these data points are also labeled on the graph below.

Over the period of record, 2021 had the second highest number of acres burned, exceeded only by 2020. Acres burned significantly the following year in 2022, the result of several factors including favorable weather, suppression response, and management.



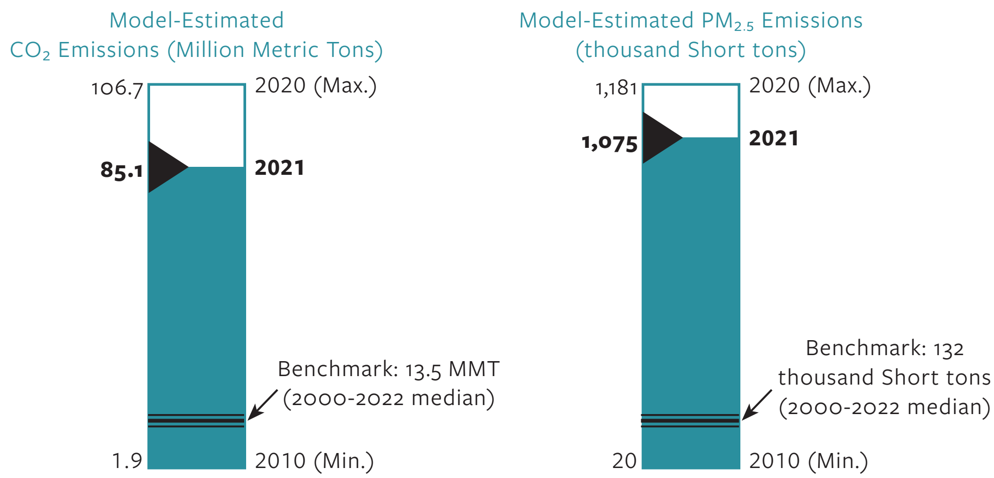


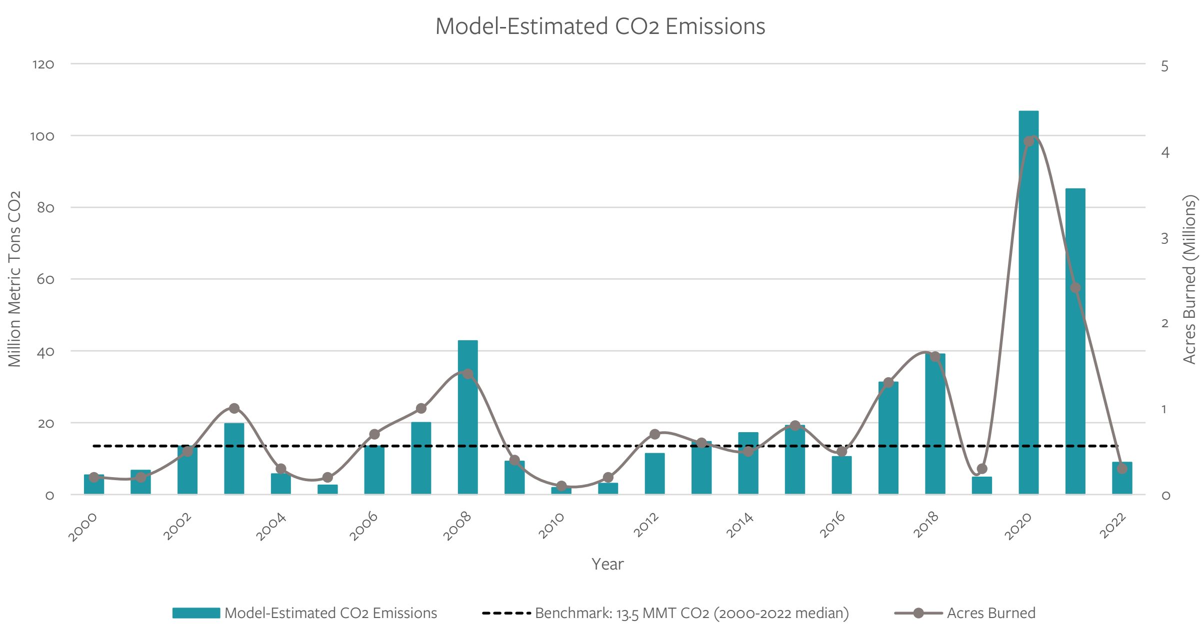


Model Estimated Emissions

2021 model-estimated emission levels approached the maximum for the period of record (both CO_2 and $PM_{2.5}$), though these estimates have high magnitudes of uncertainty.

Model-estimated emission metrics are benchmarked by the median value for the period of record. Benchmarks are shown using the triple black line and are represented at scale as they relate to the minimum and maximum values for the metric in question.





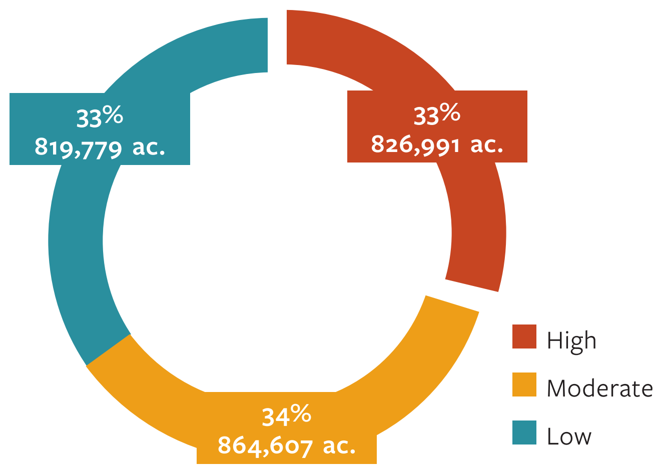
QUESTION 2: HOW IS WILDFIRE IMPACTING ECOLOGICAL RESILIENCE?

This question asks *how* acres burn in any given year, centering largely on ecological impacts. Negative impacts can be considered the result of wildfire behavior and effects that are either: too intense; too homogeneous; occurring more or less frequently than historic fire (depending on the ecosystem type); or a combination thereof.

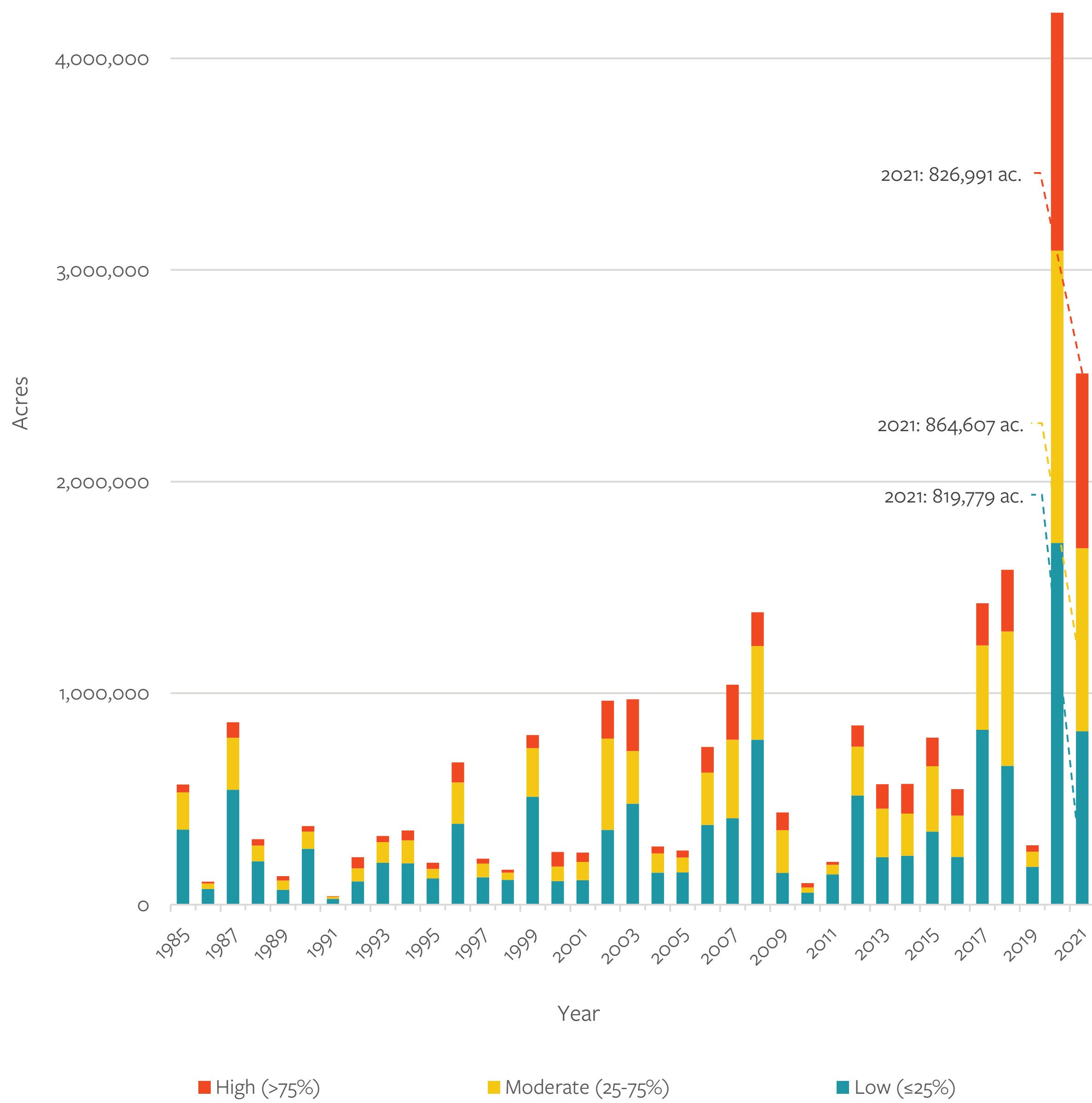
Fire Severity

Areas burning at high severity are increasing, and reached their highest proportion of total area burned in 2021 (33%).

Fire Severity, Area by Severity Class 2021



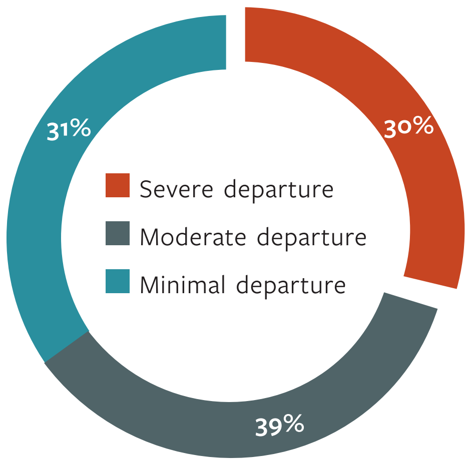
Fire Severity, Area by Severity Class



Degree of Departure from Historic Fire Frequency

Most acres are departed from historical fire frequencies. Whether fire is occurring too frequently, or not frequently enough, post-fire ecosystem recovery may be negatively affected.

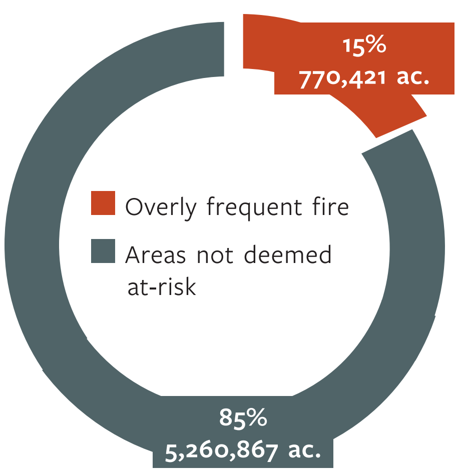
Degree of Departure from Historic Fire Frequency



Low-Lying Shrubland Resilience

This metric reflects the impacts of wildfire occurrence on low-lying shrublands in the South Coast ecoregion. Though wildfire occurs too infrequently in some of California's ecosystems, wildfire occurs much too frequently in low-lying shrublands. Overly frequent fire in these systems can impede regeneration of native species and increase the likelihood of vegetation-type conversion. Here, overly frequent fire is defined as the occurrence of one or more fires per 15-year interval since 1950. In 2021, 15% of the acres analyzed in this ecosystem were deemed "at-risk," based on fire frequency alone.

At-Risk Shrublands 2021



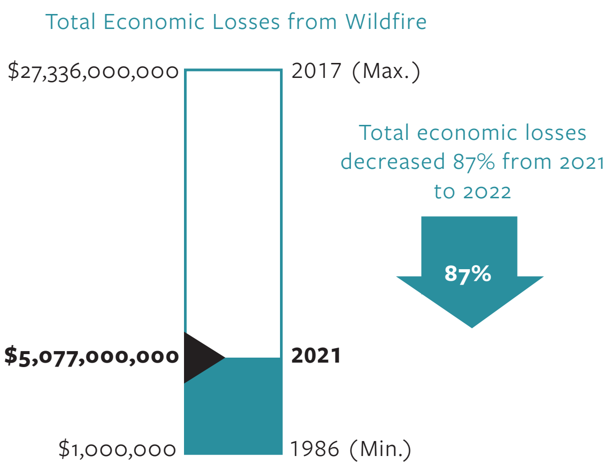
CALVEG Mapping Zones

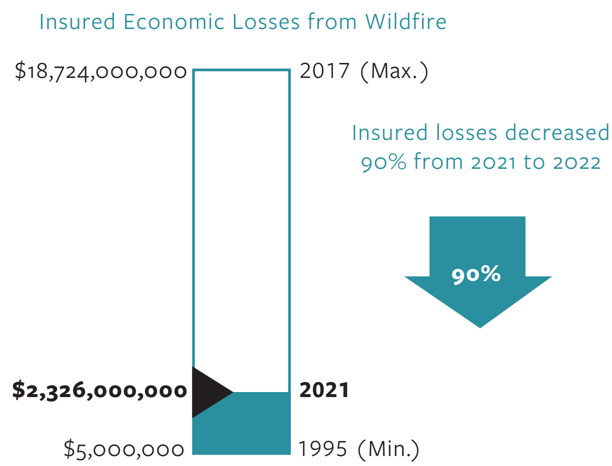
QUESTION 3: WHAT ARE THE SOCIAL IMPACTS OF WILDFIRE?

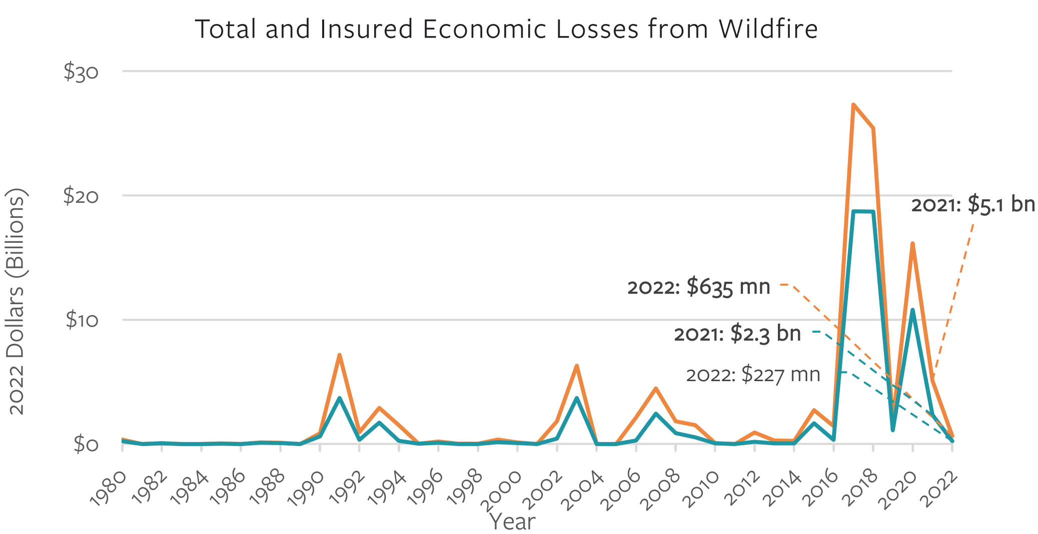
The social impacts of wildfire are extensive and, in many ways, inextricably linked to ecological impacts. Here, social impacts refer to "acute" human impacts, the most dire of which is loss of life. Other question 3 metrics help reflect the capacity of wildfire to interrupt and upend lives and livelihoods—either temporarily in the case of evacuations and power loss, or more permanently in the case of structure loss and associated monetary costs. Additional proposed metrics will examine public health impacts from smoke exposure, and impacts within human communities.

Total and Insured Losses from Wildfire

Total and insured losses fell between 2021 and 2022. But the ratio of insured to total losses also decreased between these years - from about 46% to 36% - indicating lower relative levels of insurance-covered losses. In both years, less than 50% of economic losses were insured. The gap between insured and total losses in any given year was largest in 2017 at $8.6 billion dollars (68%).



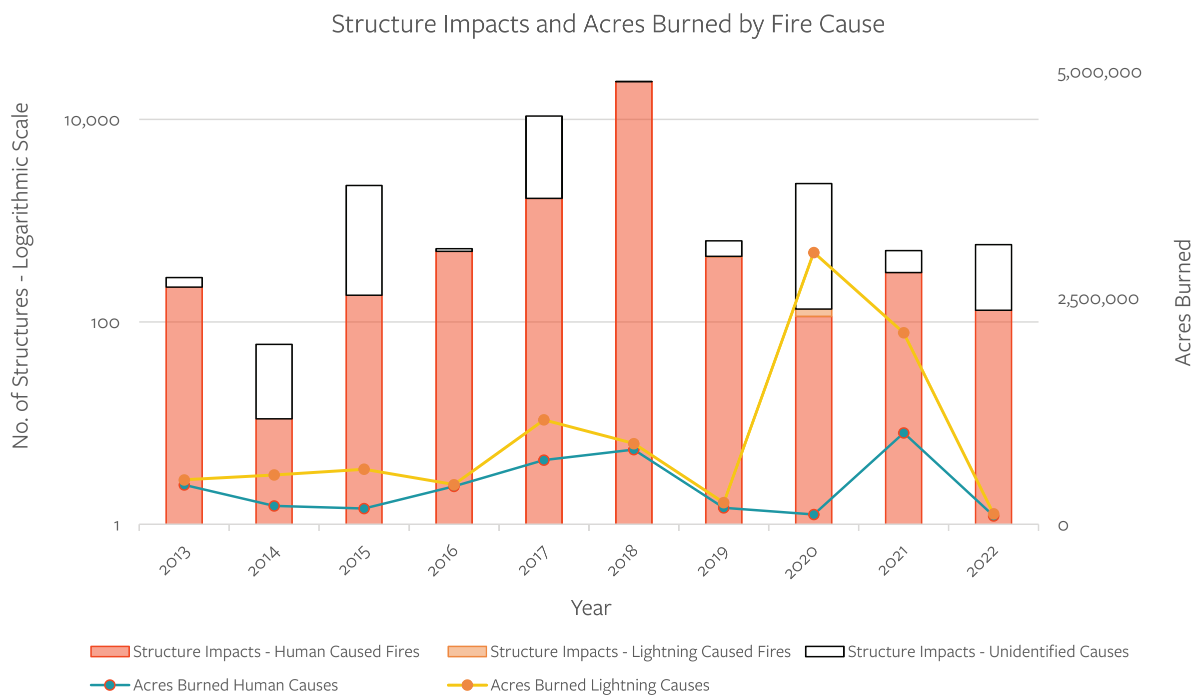




Structure Impacts by Fire Cause

Human-caused fires account for the majority of structure impacts over the period of record, even though they result in fewer acres burned. This is in keeping with findings from an analysis across the western U.S.

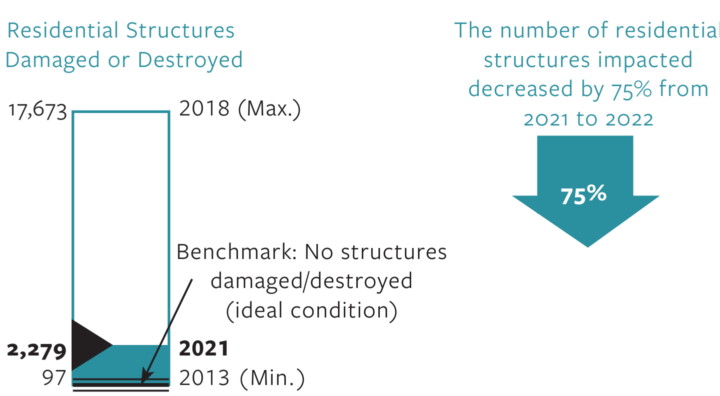
This data is considered preliminary. Some of California's largest lightning-caused incidents from recent years are excluded from this data due to formatting and analysis methods.

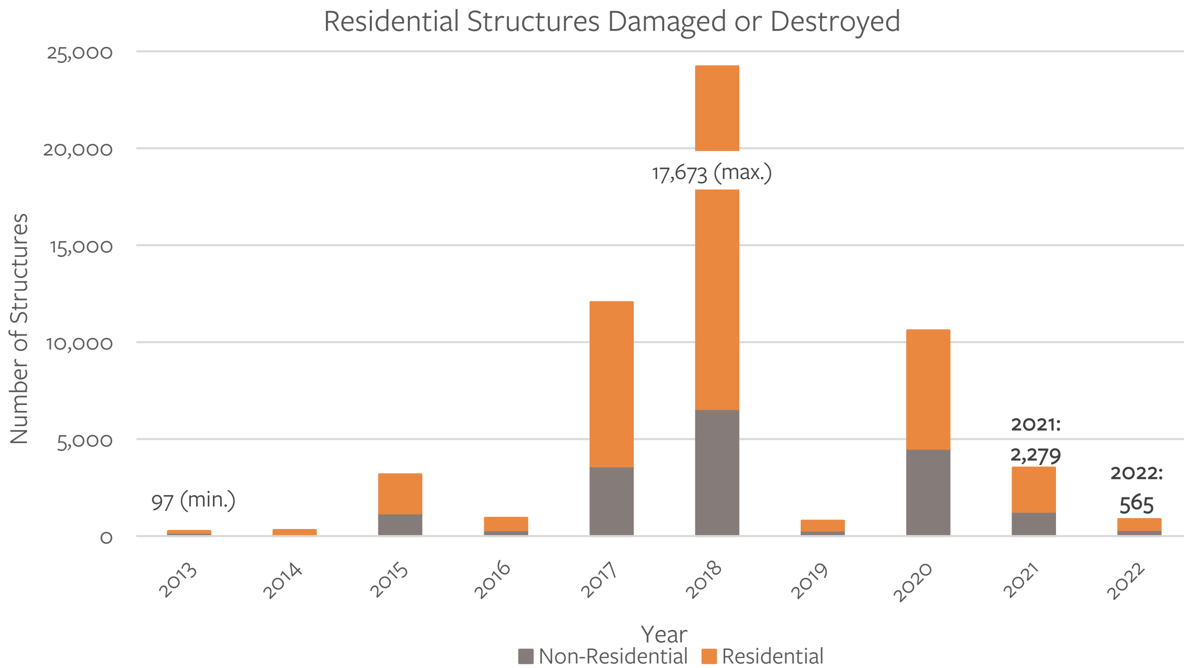


Residential Structure Impacts

The majority of structures damaged or destroyed in the last 10 years have been residential (63% on average).

From 2021 to 2022, the *total number* of residential structures damaged or destroyed decreased significantly. However, the *proportion* of damaged or destroyed structures that are residential remained the same (65%).



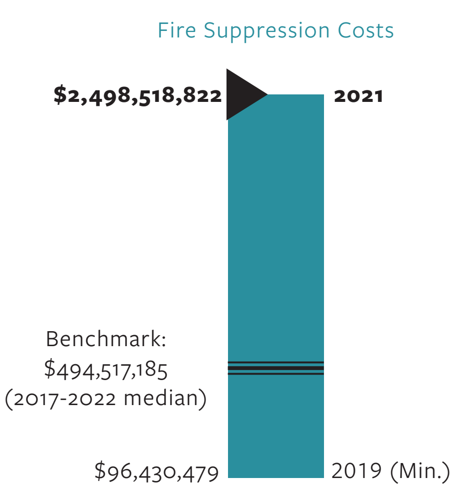


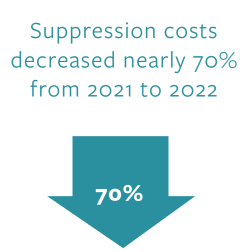
QUESTION 4: WHAT IS THE COST OF WILDFIRE RESPONSE AND RECOVERY?

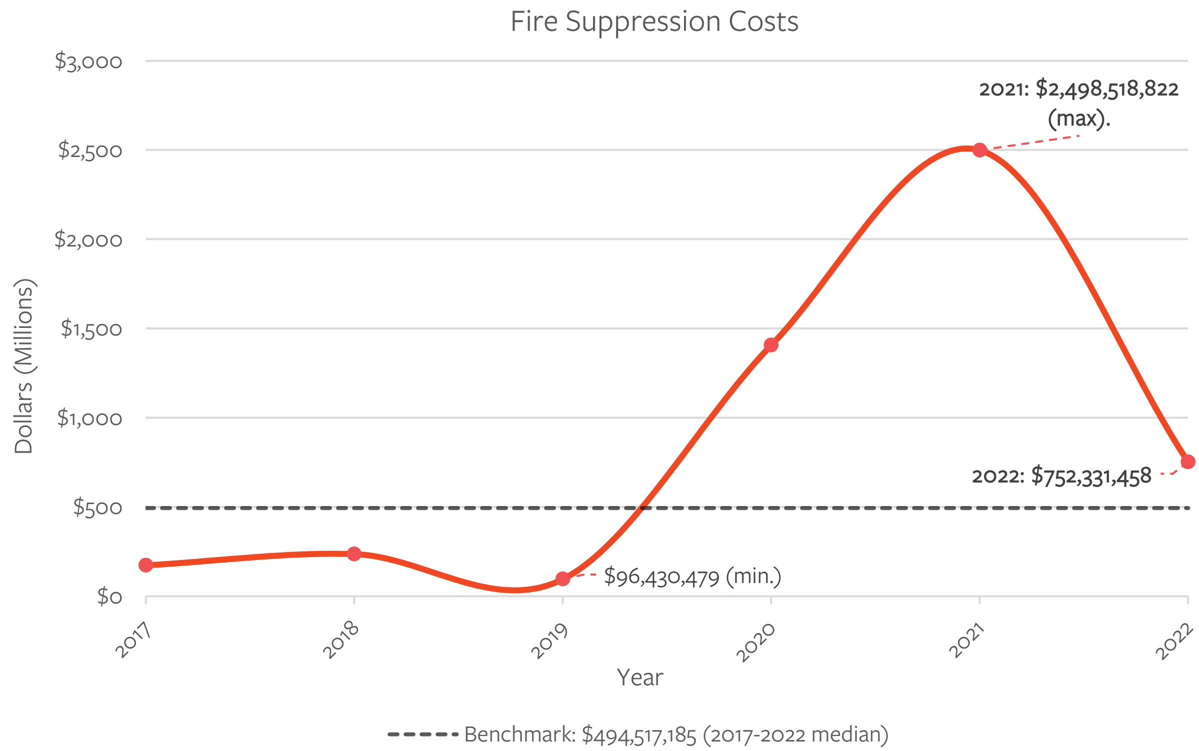
This question examines the costs and burdens of wildfire, borne both by agencies and society at-large. Metrics are associated with both wildfire response and recovery, though there is ample opportunity to improve accounting and representation of both.

Fire Suppression Costs

Fire suppression costs peaked in 2021 at nearly $2.5 billion (considering the years 2017-2022). At $752 million, 2022 fire suppression costs were nearly 70% less than in 2021, and much closer to the benchmark - the median value of the period of record.

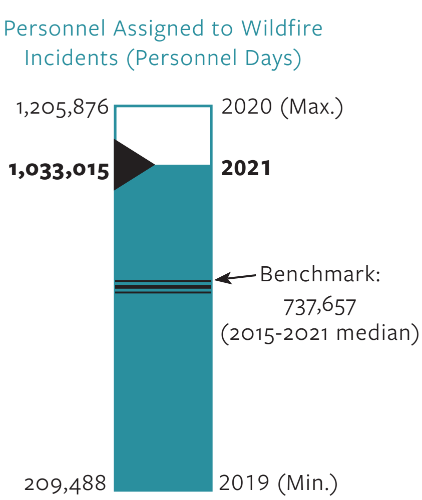


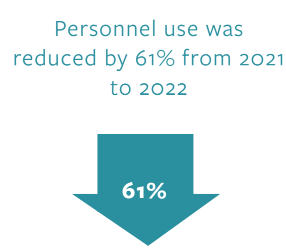




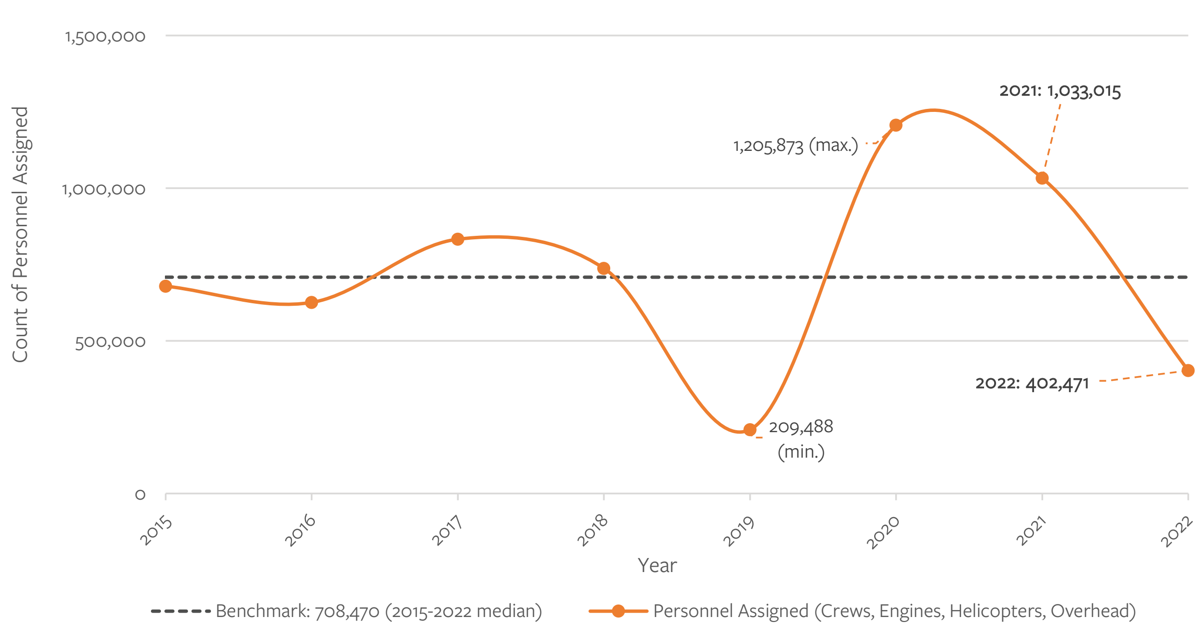
Personnel Assigned to Wildfire Incidents

The demand for fire personnel was high in 2021: both the number of "personnel days," and the number of days requiring the highest complexity of incident management, were exceeded only by 2020. Both values decreased significantly in 2022, below the benchmark values for each data set.





Personnel Assigned to Wildfire Incidents

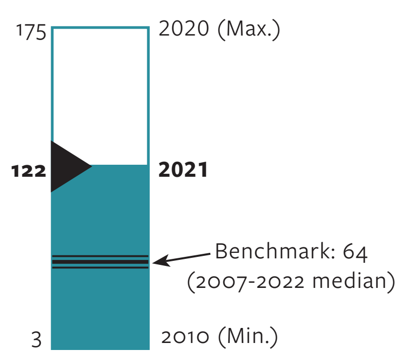


As used in this metric, "personnel days" is a measure of the number of personnel associated with crews, engines, helicopters, and overhead who were assigned to a wildfire incident on any given day, summarized for each calendar year. It is *not* a measure of how many *individual people* were assigned to wildfire incidents in that year.

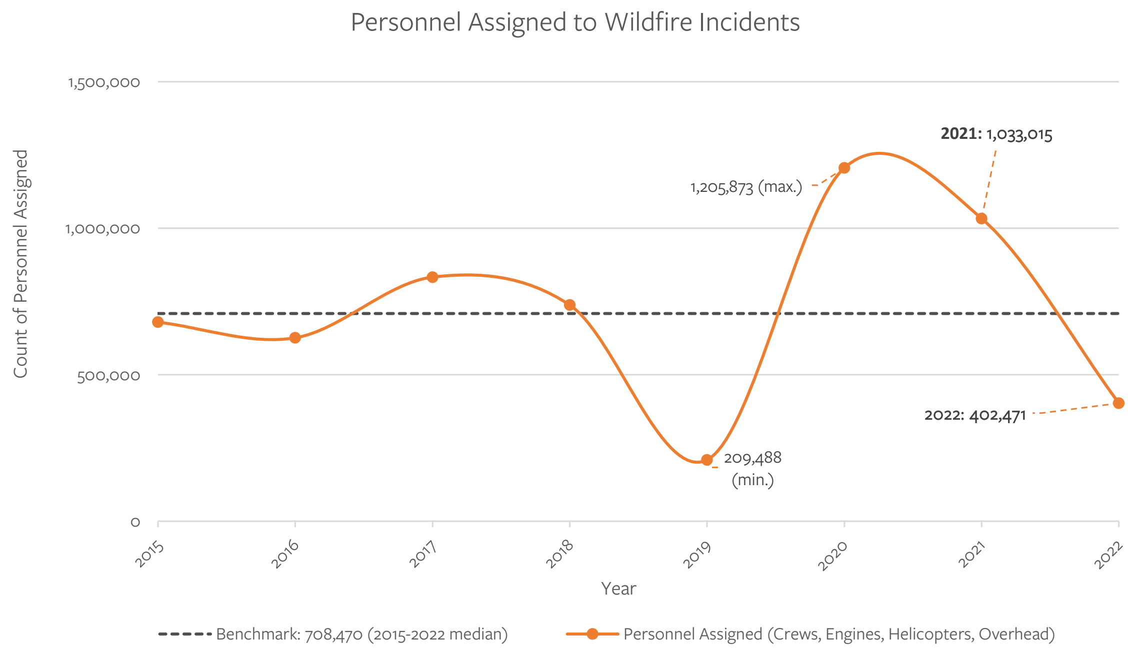
Days Requiring Type 1 and Type 2 Incident Management Teams

Type 1 and Type 2 Incident Management Teams (IMTs) manage operations, logistics, planning, finances, safety, and additional factors in connection with complex wildland fire (and other) incidents. Type 1 and Type 2 IMTs respond to major wildland fire incidents with the highest levels of complexity, and which are beyond the capabilities of local control. Complexity is defined in part by the type and number of resources required, and the need to draw on regional and/or national resources to manage the incident. Incident Complexity levels are defined by the U.S. Fire Administration.

Days Requiring Type 1 and Type 2 Incident Management Teams



Days with Type 1 and Type 2 IMTs was reduced by nearly 60% from 2021 to 2022

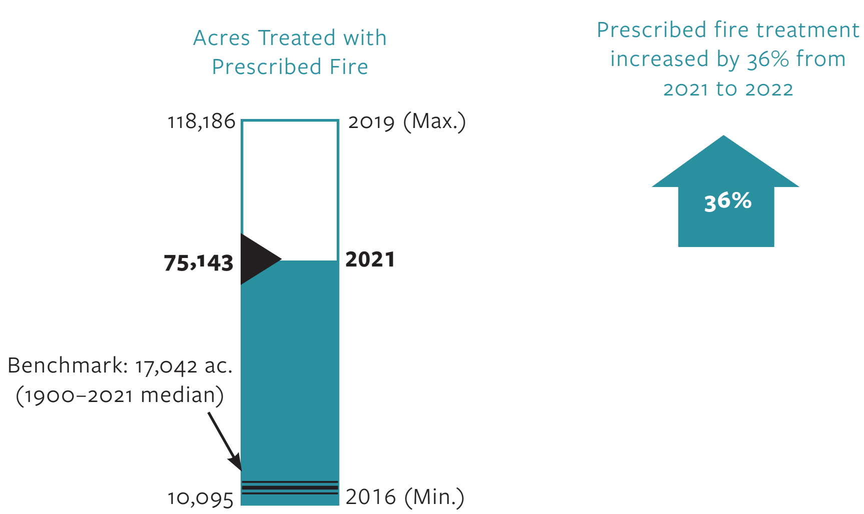


QUESTION 5: HOW ARE WE ADDRESSING WILDFIRE RISK?

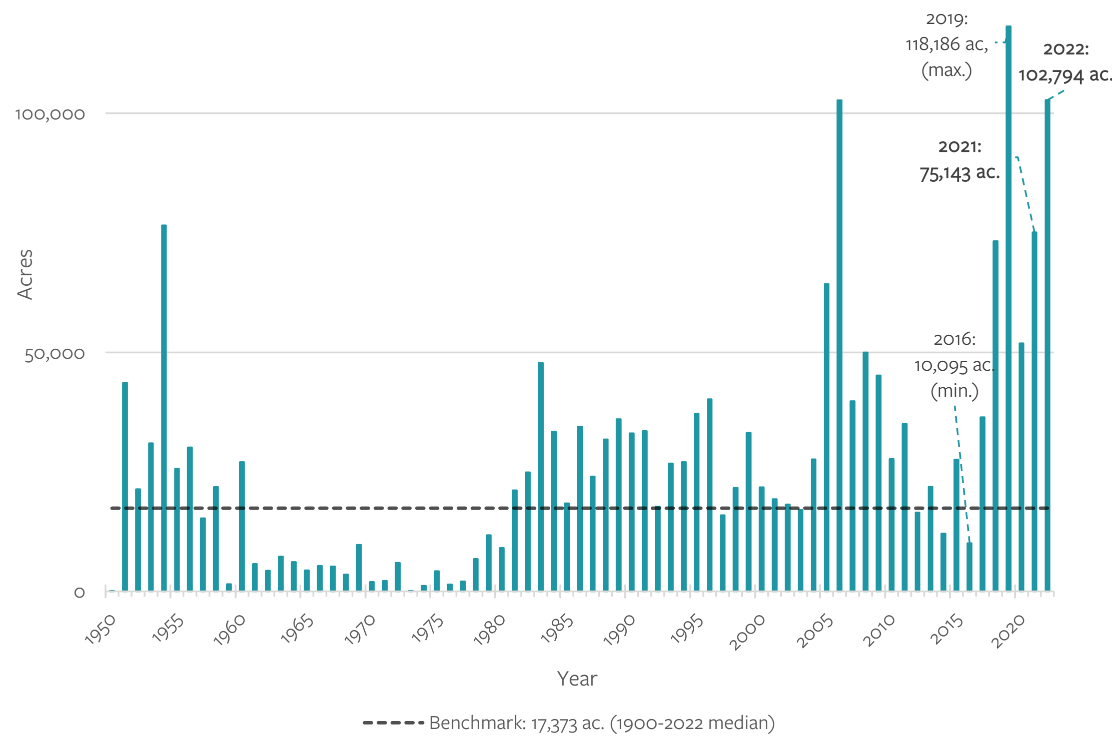
This question examines proactive measures taken across spatial scales and spheres of responsibility to address wildfire risk. We acknowledge that much of the available information relating to mitigation treatments are limited to prescribed fire, which is not an appropriate management tool in all ecosystems or contexts.

Acres Treated with Prescribed Fire

In 2021, the number of acres treated with prescribed fire fell behind recent years at fewer than 100,000 acres statewide. Acres treated with prescribed fire increased 36% between 2021 and 2022.



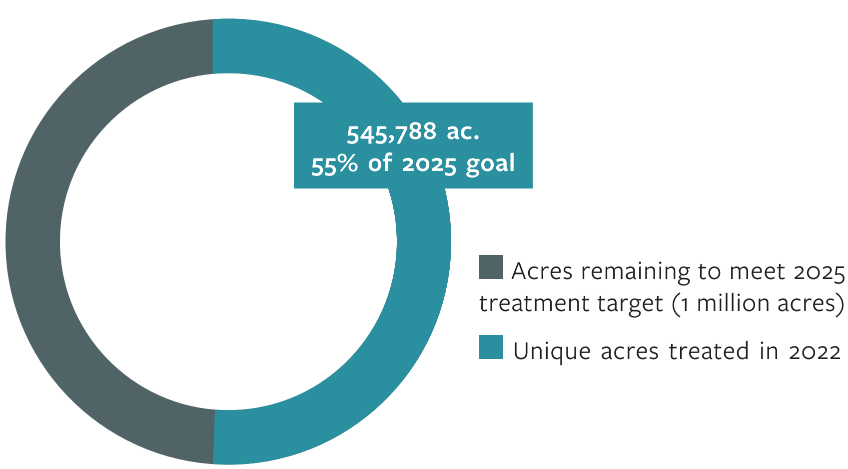
Acres Treated with Prescribed Fire



Unique Acres Treated - All Treatment Types

In 2023, the California Wildfire & Forest Resilience Task Force released a beta version of the Interagency Treatment Dashboard, reporting unique acres treated statewide and across ownerships in the calendar year 2022. Treatments include manual and mechanical fuels reduction, prescribed fire, targeted grazing, tree planting, and timber harvest. As available, the California's Year in Fire project will include previous years for analysis of treatment trends. Unique acres treated in 2022 constitute 55% of the state's *previous* goal to reach a combined 1 million treated acres on state and federal lands by 2025. State treatment goals will be updated in 2024.

Unique Acres Treated - All Treatment Types



CONCLUSION

The metrics included in this report are a subset of those identified in the first iteration of the California's Year in Fire project. Through outreach and engagement, we hope to iteratively improve the metrics included, and their ability to reflect the complex range and interplay of wildfire impacts in California. We acknowledge that there are several impacts of great social import - including public and mental health outcomes, and effects within vulnerable communities - which are not included here. We hope to improve our ability to reflect on these impacts in future iterations by growing our capacity for data analytics, and by incorporating stakeholder feedback. For questions regarding this report, please contact Ken Alex.

DATA DISCLAIMERS

Most values presented in this report were calculated on a preliminary basis by UC Berkeley staff using publicly available data and data provided upon request.

The State of California and the Department of Forestry and Fire Protection make no representations or warranties regarding the accuracy of data or maps. Neither the State nor the Department shall be liable under any circumstances for any direct, special, incidental, or consequential damages with respect to any claim by any user or third party on account of, or arising from, the use of data or maps. For more information about this product, date or terms of use, contact calfire.egis@fire.ca.gov.

APPENDIX A

I. INTRODUCTION

The California's Year in Fire project aims to provide a more nuanced and complete assessment of the social and ecological impacts of wildland fire (wildfire) in the state of California on an annual basis. Some wildfire statistics are currently reported by agencies. However, metrics critical to fully understanding the impacts of wildfire - including those related to fire severity, resource use, and community impacts - are not widely or systematically reported. Concentrating socially and ecologically relevant metrics in one reporting mechanism would allow policy makers, practitioners, and the general public to assess the state of wildfire in California. Our approach is to garner and incorporate feedback from experts and potential end users, increasing the utility of the California's Year in Fire project over time.

This document outlines the California's Year in Fire framework. The framework is comprised of a variety of metrics; metric values for the 2021 calendar year are reported (Section 2). At the time of report preparation, much of the metric data is not yet available for calendar year 2022. This document also contains reflections on metrics which require more sophisticated data analysis or methodological approaches (Section 3), expected features of future iterations (Section 5), and metrics for which data is not currently available (Section 6). Section 7 contains details for all data sets cited in this report. This report was prepared in May 2023; unless otherwise noted, data availability and details were last verified at this time.

The California's Year in Fire project may be adapted into a public-facing webpage. This format would allow for the representation of summary figures, trend analyses, and interactive maps of metric values at both the state summary level and within areas of interest. It is anticipated that this type of data delivery would facilitate interpretation for a variety of audiences. This future development is dependent upon funding.

The California's Year in Fire project is produced by the Climate & Wildfire Institute in cooperation with the Center for Law, Energy & the Environment at the University of California (UC) Berkeley, and funded in part by the Gordon and Betty Moore Foundation.

II. METRICS, BENCHMARKS, AND DATA SOURCES

The following section provides an overview of the questions, metrics, and benchmarks included, or designated for inclusion, in the California's Year in Fire project. Values corresponding to the 2021 calendar year are also reported. Four contextual metrics broadly set the social and ecological stage, including information such as statewide acres by vegetation type, or number of housing units in the Wildland-Urban Interface (Table 1). The underlying data sets for these values are typically refreshed on time intervals longer than one year. The remaining metrics are organized by five overarching questions related to wildfire impacts (Tables 2-6). These questions are proposed for their relevance to policy makers and practitioners alike. For each question, a group of metrics is identified that collectively help build a measurable "response," which could be revisited with annually updated data. These metrics are not considered an exhaustive list of factors relevant to each question; metric selection is contingent upon data availability and suitability.

Most metrics, aside from the contextual metrics in Table 1, are accompanied by a benchmark figure. Benchmark figures provide context to aid in the interpretation of metric values. Benchmark figures either reflect how closely aligned a metric is with pre-fire suppression and/or pre-Euroamerican settlement era conditions, posit an ideal condition based on available data and literature, or constitute a summary figure from the available period of record. Benchmarks may be derived from the scientific literature, modeling, or a trend analysis of available data. The questions, metrics, and benchmarks in this document are subject to revision per changes in data availability and feedback.

To improve legibility, most figures in the tables below have been rounded to the nearest whole number. Unless stated otherwise, benchmarks constituting summary statistics (i.e., means, medians) are for the entire period of record, stated in parentheses. Data sources are identified; additional information is in Section 7. ***Fields which are not yet finalized, or for which a value has not been calculated, are italicized in purple.*** Example figures accompany each table for visualization purposes; metrics for which a value has not yet been calculated are not displayed. Where applicable, these figures include the minimum and maximum values for the period of record per metric. Maps and graphs of certain metrics are also included, both for visualization purposes, and as examples of the type of data representation facilitated by a public-facing website. For additional information on the data below - including suggestions for improvement per metric - please reference Appendix B.

Table 1. 2021 contextual metrics.

METRIC	VALUE(S)	DATA SOURCE(S) (AGENCY/ ORGANIZATION)
Days at Preparedness Levels (PL) 4 and 5 (national) *The highest of 5 PLs (1-5) indicate challenging conditions and constrained firefighting resources.*	99 days	Wildland Fire Summary and Statistics Annual Report Ch. 2 (National Interagency Coordination Center, NICC)1
State acres by Direct Protection Area (DPA)	**Federal:** 51,464,603 (50% of 103,710,619) **State:** 30,785,506 (29%) **Local:** 21,460,510 (21%)	Direct Protection Areas for Wildland Fire Protection Geodatabase (California Department of Forestry and Fire Protection, CAL FIRE)[2]

METRIC	VALUE(S)	DATA SOURCE(S) (AGENCY/ ORGANIZATION)
State acres by vegetation type	**Shrub dominated:** 18,195,971 (24% of 74,829,037)	Existing Vegetation Geodatabases (U.S. Forest Service, USFS)[3]
	Conifer forest/woodland: 18,091,484 (24%)	
	Herbaceous dominated: 15,617,041 (21%)	
	Non- & sparsely vegetated: 10,380,831 (14%)	
	Hardwood: 9,739,754 (13%)	
	Mixed conifer/hardwood: 2,813,956 (4%)	
Number of housing units in the Wildland-Urban Interface (WUI)	5,102,948	1990-2020 WUI of the conterminous U.S. – geospatial data, 3rd ed. (USFS)[4]

Figure 1. 2021 contextual metrics.

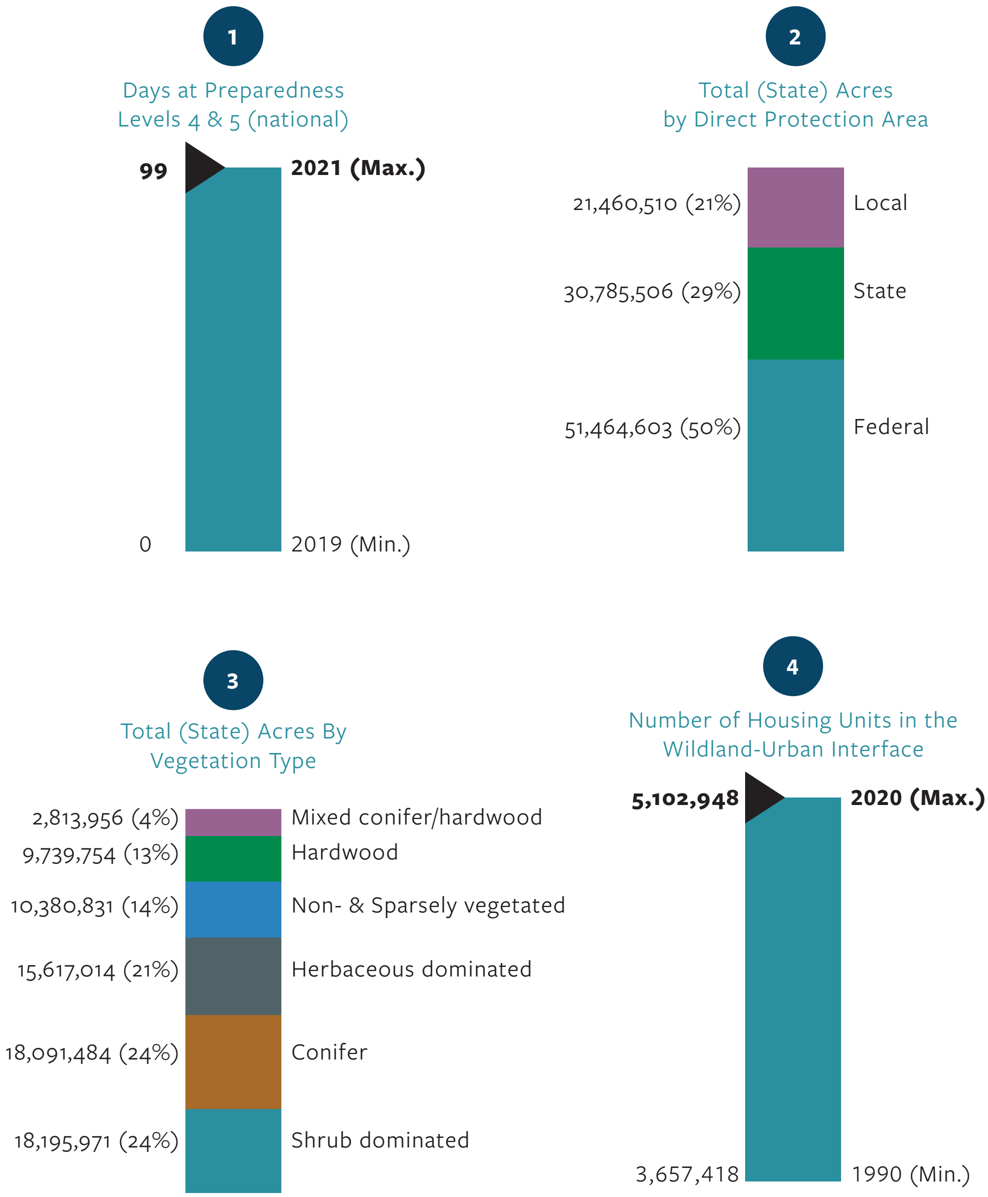


Table 2. 2021 metric and benchmark values responsive to *Question 1: How is wildfire impacting landscapes?*

METRIC	VALUE(S)	BENCHMARK	DATA SOURCE(S) (AGENCY/ ORGANIZATION)
Acres burned* **Note that the figures for total acres burned and acres burned by cause are both derived solely from the CAL FIRE Fire Perimeters Database. Acres burned by DPA and by vegetation type make use of the CAL FIRE data in combination with other data sources. As such, there are discrepancies in total acres burned by category. The percent of total displayed relates to the total acreage for that category as in italics at right.*	**Total:** 2,511,378	***Not yet developed; composite benchmark should take fire severity patterns into consideration.***	Fire Perimeters Database for total acreage (CAL FIRE)[5]
	Acres burned by fire cause: Lightning: 1,105,484 acres (*44% of 2,511,378*) Powerline: 964,206 acres (38%) Other: 441,688 acres (18%)		Acres by fire cause: Fire Perimeters Database (CAL FIRE)[5]
	Acres burned by Direct Protection Area: Federal: 2,202,950.1 (*88.26% of 2,495,936*) State: 288,781.6 (11.57%) Local: 4,204.7 (0.17%)		Acres by DPA: Direct Protection Areas for Wildland Fire Protection Geodatabase (CAL FIRE)[2]
	Acres burned by vegetation type: Conifer: 1,646,585 ac. (*66% of 2,494,387*) Shrub: 471,414 acres (19%) Hardwood: 150,253 acres (6%) Other: 226,135 (9%)		Acres by vegetation type: Existing Vegetation geodatabases (USFS)[3]
Model-estimated emissions (CO_2 and $PM_{2.5}$)	**CO_2:** 85.1 million metric tons (MMT)	Median model-estimated **CO_2** emissions (2000-2021): 13.5 MMT	Wildfire Emission Estimates (California Air Resources Board, CARB)[6]
	$PM_{2.5}$: 1,075 thousand Short tons	Median model-estimated **$PM_{2.5}$** emissions (2000-2021): 135 thousand Short tons	
Modeled debris-flow hazard risk (low vs. moderate-high) *Reflects probability of debris-flow and predicted volume; see Appendix B for details.*	1,204,852 acres (71% of analysis area) has a moderate or high combined hazard rating	Ideal condition in which most acres analyzed have a low combined hazard rating (low probability of debris-flow *and* minimal predicted volume).	Emergency Assessment of Post-Fire Debris-Flow Hazards (U.S. Geological Survey, USGS)[7]
Number of reportable incidents	***Not yet calculated***	***Not yet determined***	***Not yet determined***

Figure 2. 2021 metric and benchmark values responsive to *Question 1: How is wildfire impacting landscapes?*

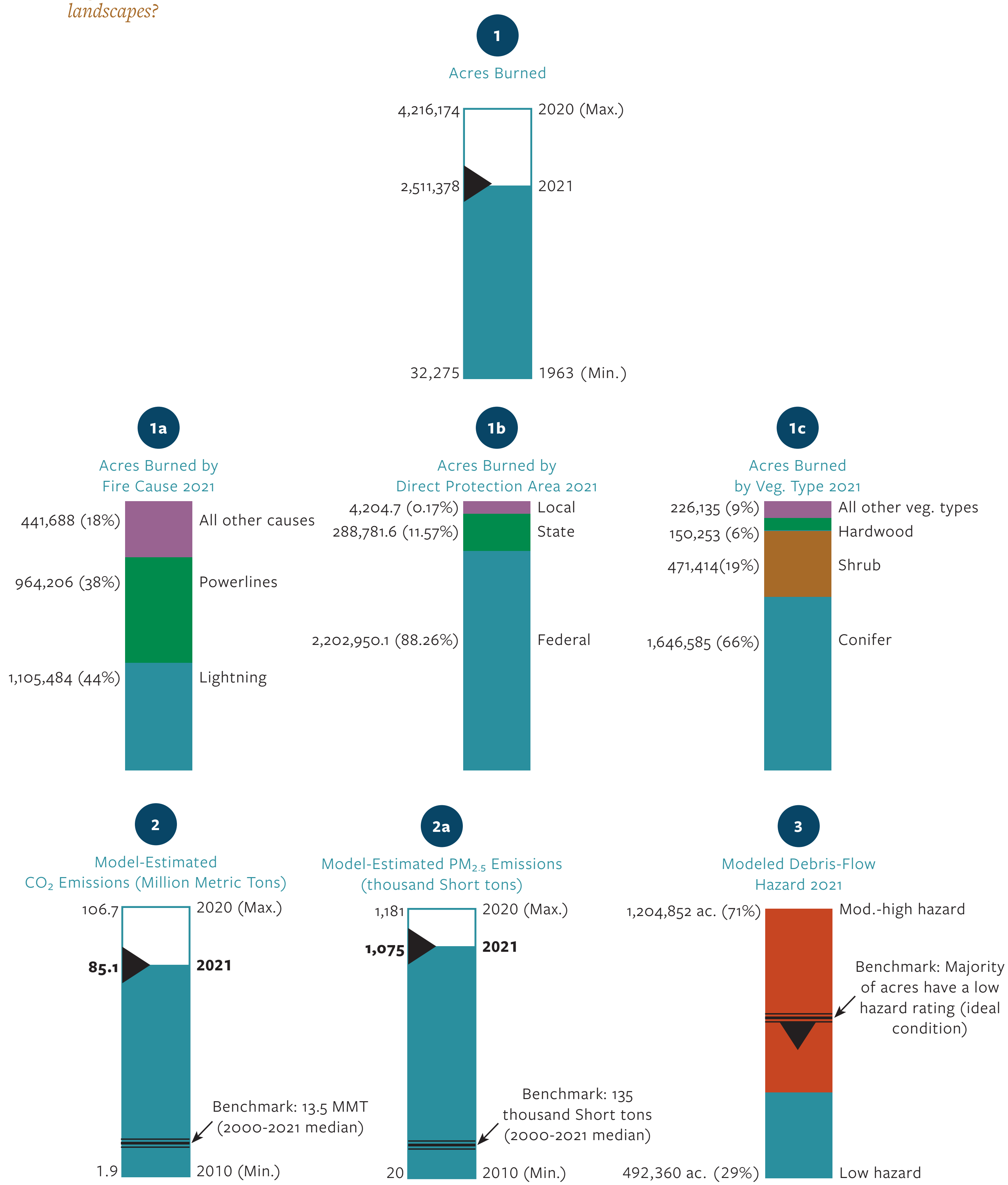


Table 3. 2021 metric and benchmark values responsive to *Question 2: How is wildfire impacting ecological resilience?*

METRIC	VALUE(S)	BENCHMARK	DATA SOURCE(S) (AGENCY/ ORGANIZATION)
Fire severity, area by severity class (basal area loss) **Low:** ≤25% basal area (BA) loss Moderate: 25-75% BA loss High: >75% BA loss	Low severity: 819,779 acres (33%) Moderate severity: 864,607 acres (34%) High severity: 826,991 acres (33%)	***Proportion high severity by Fire Regime Group (FRG) and Fire Return Interval (FRI).*** ***FRG I-A: percent replacement fire (PRS) <66.7%, FRI 0-5 yrs.*** ***FRG I-B: PRS <66.7%, FRI 6-15 yrs.*** ***FRG I-C: PRS <66.7%, FRI 16-35 yrs.*** ***FRG II-A: PRS >66.7%, FRI 0-5 yrs.*** ***FRG II-B: PRS >66.7%, FRI 6-15 yrs.*** ***FRG II-C: PRS >66.7%, FRI 16-35 yrs.*** ***FRG III-A: PRS <80%, FRI 36-100 yrs.*** ***FRG III-B: PRS <66.7%, FRI 101-200 yrs.*** ***FRG IV-A: PRS >80%, FRI 36-100 yrs.*** ***FRG IV-B: PRS >66.7%, FRI 101-200 yrs.*** ***FRG V-A: Any severity, FRI 201-500 yrs.*** ***FRG V-B: Any severity, FRI 501+ yrs.*** Note that the benchmark source defines "replacement fire" as >75% average top-kill and would require calibration of fire severity data to canopy cover loss.	Basal Area Loss 30m raster data (Joseph Stewart, UC Davis); Biophysical Settings (LANDFIRE)[8]
Area in large high severity patches	292,531 acres (12% of analysis area)	Median (1985-2021): 10,394 acres	High severity patch edge raster data (Joseph Stewart, UC Davis)
High priority acres for post-fire reforestation:[9] ***High priority*** *acres have ≤60% probability (P) of natural conifer regeneration 5 yr. post-fire* ***Lesser priority*** *acres have >60% P of natural conifer regen 5 yr. post-fire*	High priority: 55% (1,373,777 acres) Lesser priority: 45% (1,119,060 acres)	Ideal condition in which <50% of the analyzed acres in a given year are "high priority."	Postfire Conifer Reforestation Planning Tool (PostCRPT) batch processed estimates (Joseph Stewart, UC Davis)

METRIC	VALUE(S)	BENCHMARK	DATA SOURCE(S) (AGENCY/ ORGANIZATION)
Fire return interval departure (FRID): Mean condition class (CC) FRI	**CC1, CC-1:** 31% (minimal departure) **CC2, CC-2:** 39% (moderate departure) **CC3, CC-3:** 30% (severe departure)	Ideal condition in which the largest proportion of acres are in CC1 & -1, indicating minimal departure from historic FRI	FRID Geodatabases (USFS)[10]
Low-lying shrubland resilience (acres potentially at risk in the South Coast ecoregion)	770,421 of 5,260,867 acres (15% of the analyzed area)	Areas designated potentially at risk if >0 disturbances have occurred per 15-year interval since 1950	Shrub resiliency data (San Diego State University Connecting Wildlands and Communities Project Team);[11] Ecoregion boundaries (USFS CALVEG)[12]

Figure 3. 2021 metric and benchmark values responsive to *Question 2: How is wildfire impacting ecological resilience?*

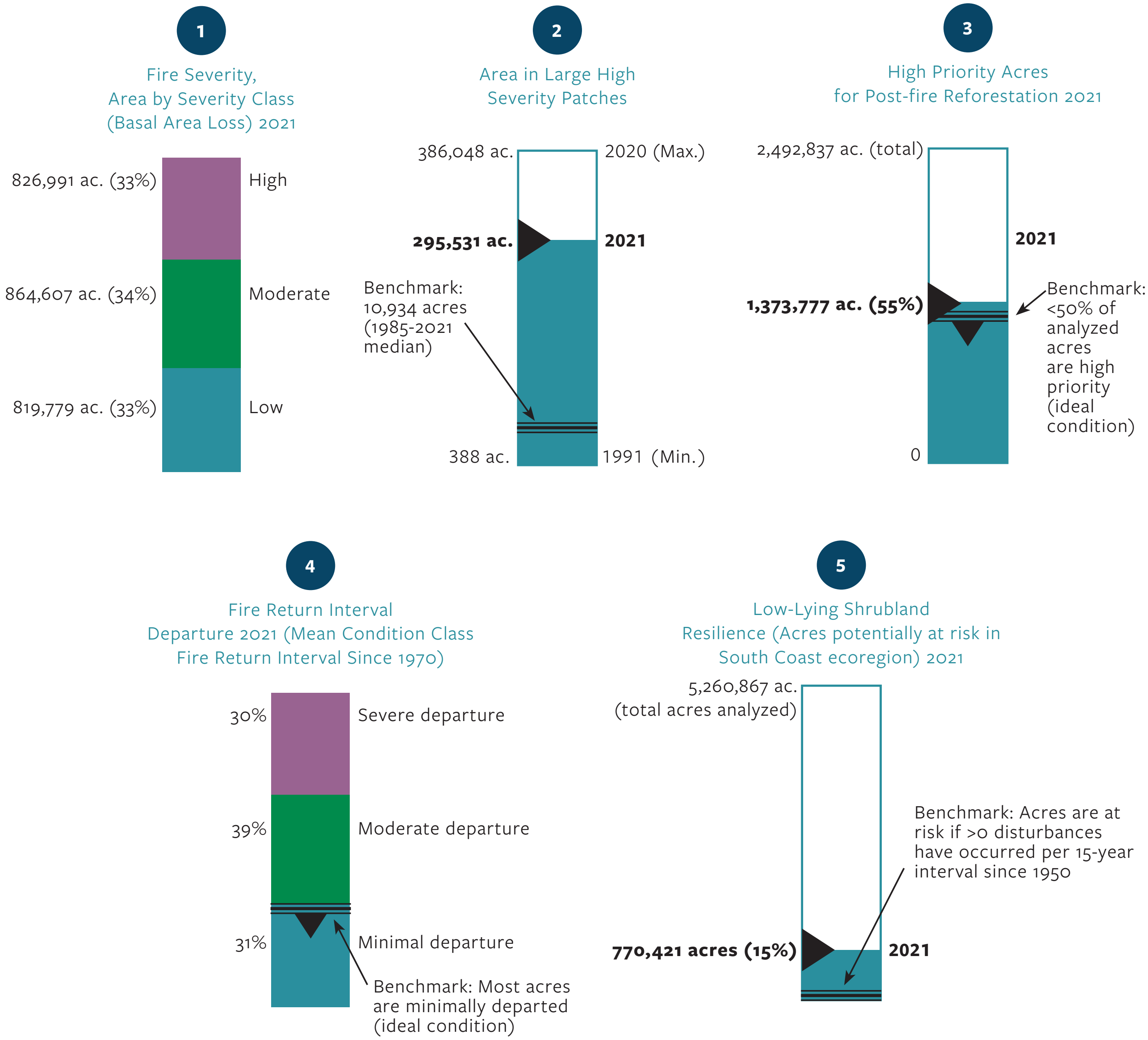
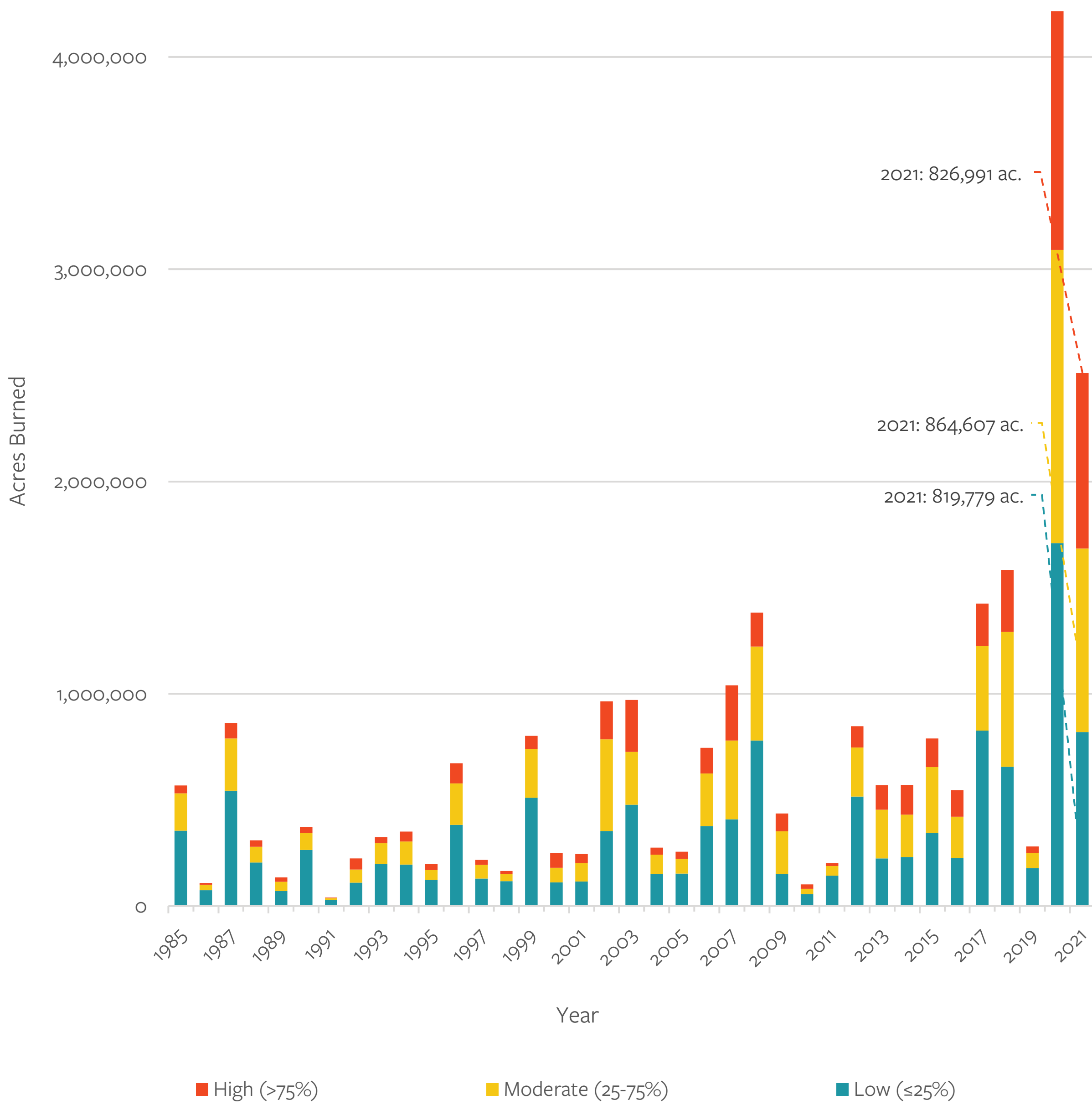


Figure 4. *Question 2* **metric example: Fire severity, area by severity class (basal area loss).**

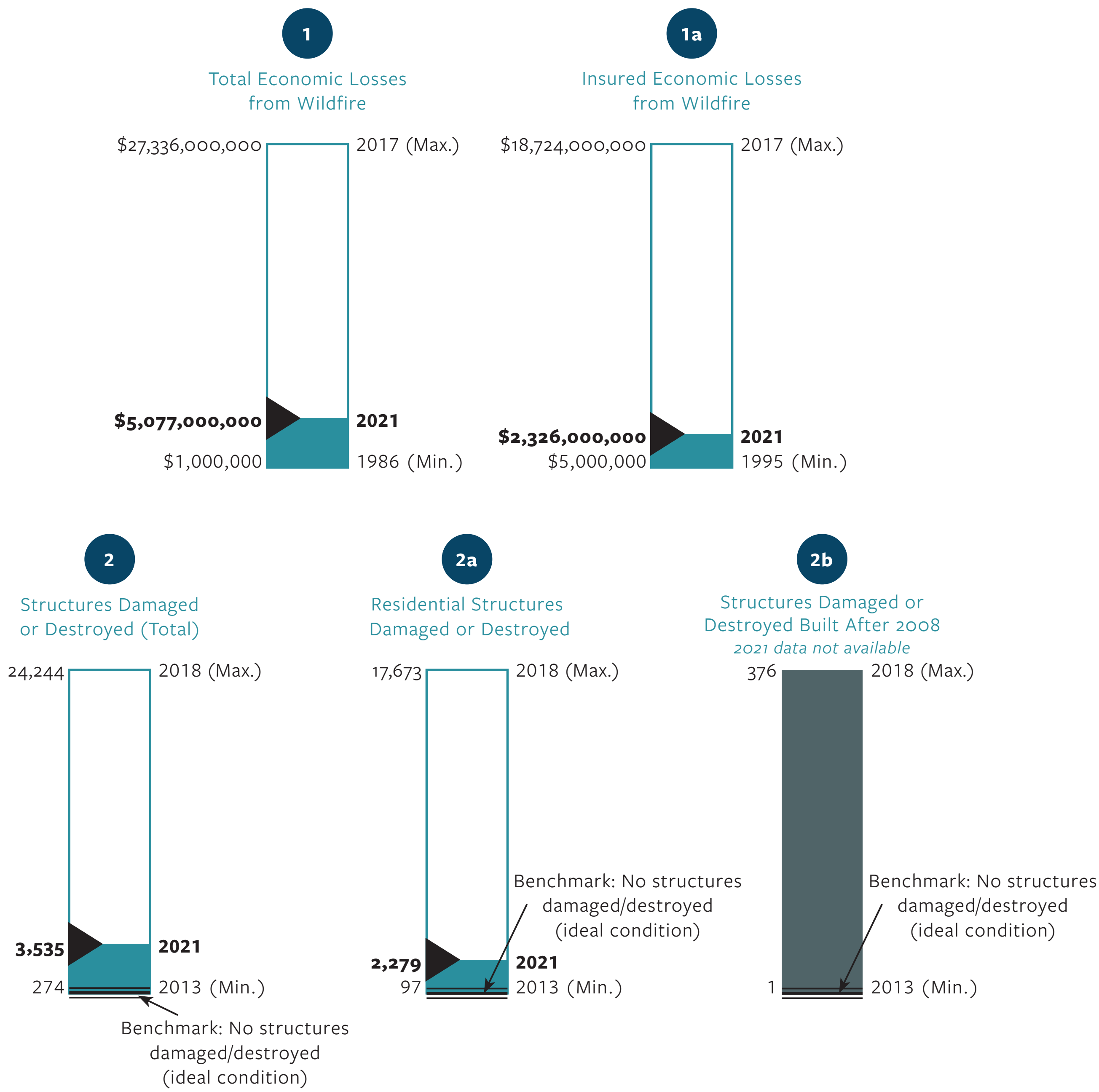


Data Source: Joseph Stewart, UC Davis

Table 4. 2021 metric and benchmark values responsive to *Question 3: What are the social impacts of wildfire?*

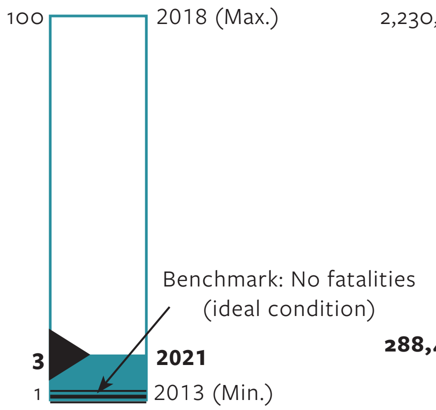
METRIC	VALUE(S)	BENCHMARK	DATA SOURCE(S) (AGENCY/ ORGANIZATION)
Total and insured economic losses from wildfire	Total Losses (2022 $): $5,077,000,000 Insured Losses (2022 $): $2,326,000,000	N/A; data highly skewed by major disaster years	Catastrophe Insight Database (Aon)
Structures damaged or destroyed (total); by structure type (residential/ non-residential) and construction year (pre- and post- 2008)	Total: 3,535 Residential structures: 2,279 (64%) No 2021 data on construction year	Zero (ideal condition)	Damage Inspection (DINS) Geodatabase (CAL FIRE)[13]
Fatalities	3	Zero (ideal condition)	Incident Archives (CAL FIRE)[14] Firefighter Fatalities (U.S. Fire Administration, USFA)[15]
Number of customers impacted by Public Safety Power Shutoff events (PSPS), total customers and medical baseline	Total customers de-energized: 288,492 Medical baseline customers de-energized: 12,218	Median (2013–2021): 84,565 Median (2017–2021): 12,218	PSPS Event Rollup (California Public Utilities Commission, CPUC)[16]
Evacuations (state total and by incident)	State total: 105,119 Incident max.: 60,663 (Caldor Fire)	*Not yet developed*	Data request (California Governor's Office of Emergency Services, CalOES)
Acres burned in (buffered) in communities (total and in vulnerable communities)	*Not yet calculated*	*Not yet developed*	Fire Perimeters Database (CAL FIRE);[5] human communities with 1.5-mile buffer (First Street Foundation) *Vulnerable community identification: See Section 3 for discussion*
Structures damaged or destroyed in (buffered) communities (total and in vulnerable communities)	*Not yet calculated*	*Not yet developed*	DINS Geodatabase (CAL FIRE);[13] First Street Foundation *Vulnerable community identification: See Section 3 for discussion*
Modeled public health impacts from smoke (total and in vulnerable communities)	*Not yet calculated*	*Not yet developed*	*See Section 3 for discussion*

Figure 5. 2021 metric and benchmark values responsive to *Question 3: What are the social impacts of wildfire?*



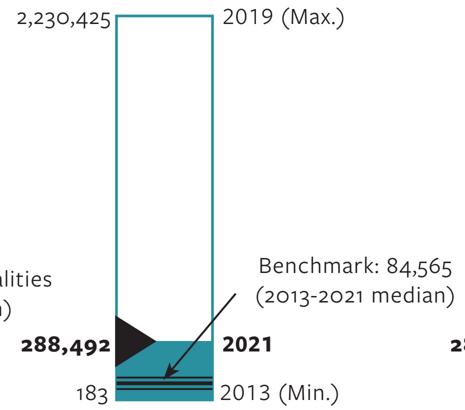
3

Fatalities



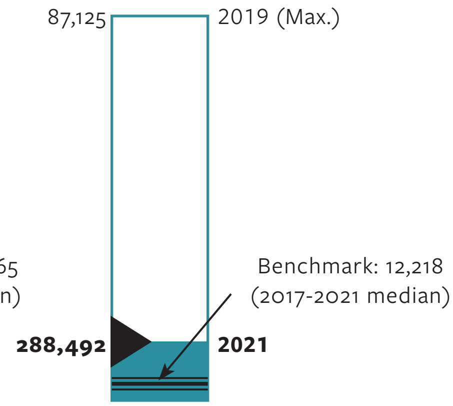
4

Number of Customers Impacted by PSPS Events



4a

Medical Baseline Customers Impacted by PSPS Events



5

Evacuations (Total and Top 3 Incidents) 2021

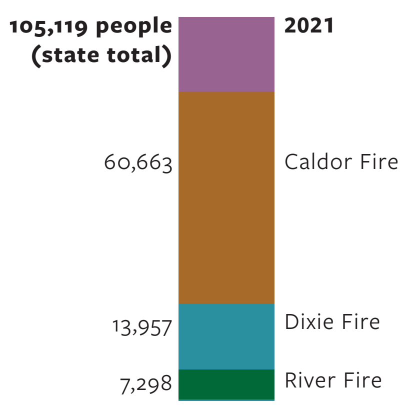
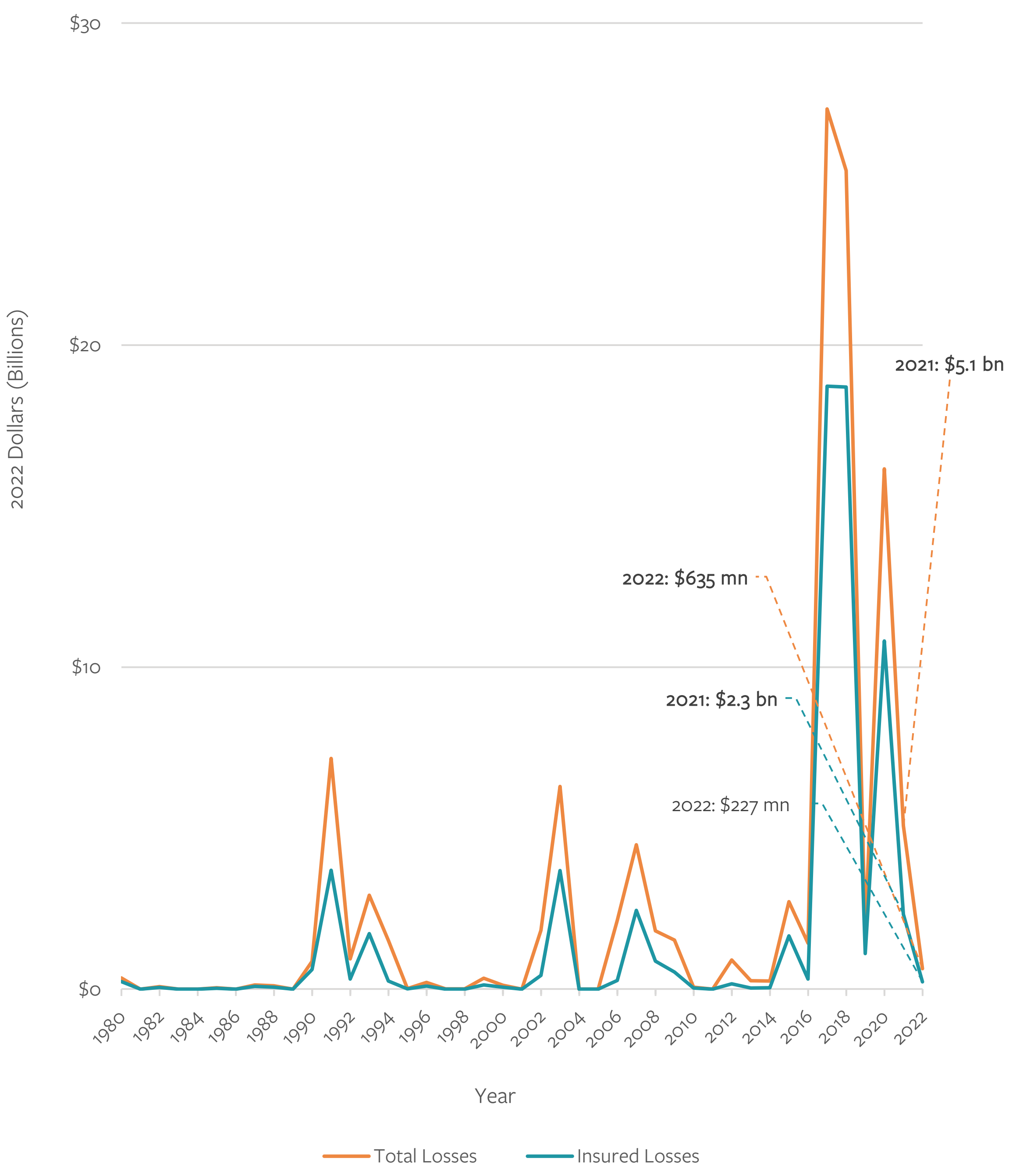
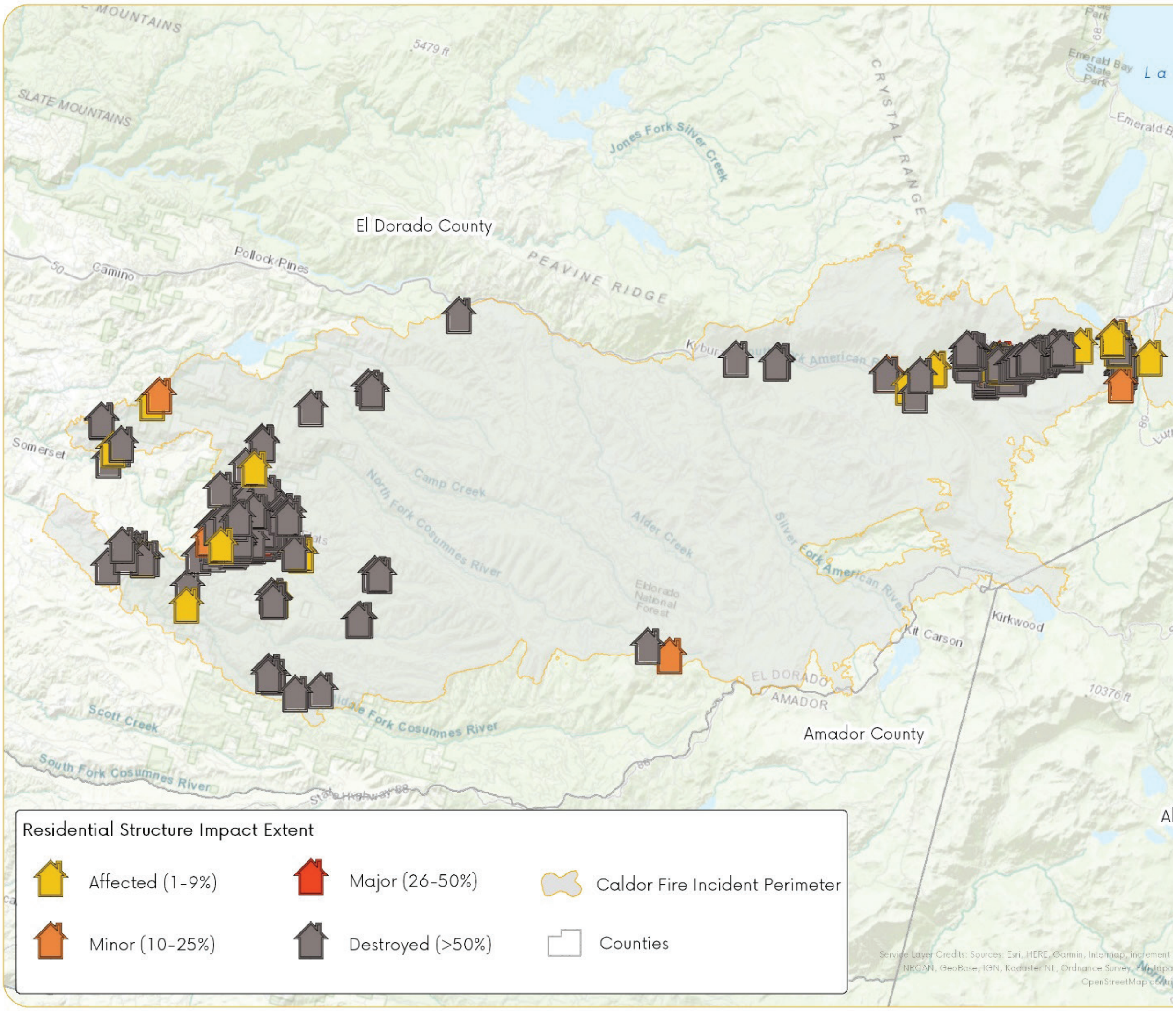


Figure 6. *Question 3* **metric example: Total and insured economic losses from wildfire.**



Data Source: Aon Catastrophe Insight Database

Figure 7. ***Question 3*** **metric example: Residential structures damaged or destroyed within the Caldor Fire.**



Of all 2021 fires in the CAL FIRE DINS database, the largest number of residential structures damaged or destroyed occurred within the Caldor Fire.

Table 5. 2021 metric and benchmark values responsive to *Question 4: What is the cost of wildfire response and recovery?*

METRIC	VALUE(S)	BENCHMARK	DATA SOURCE(S) (AGENCY/ ORGANIZATION)
Fire suppression costs	$2,498,518,822	Median (2017–2021): $236,702,912	Year-to-date large incident report (National Interagency Fire Center, NIFC)
Personnel assigned to wildfire incidents (personnel days)	Total personnel days: 1,033,015	Median (2015-2021): 737,657	2015-2021 Incident Management Situation Reports (IMSR) Data (USFS Rocky Mountain Research Station, RMRS)
Number of days requiring Type 1 and Type 2 Incident Management Teams (IMT)	122	Median (2007–2021): 64	2007 – 2021 IMSR Data (USFS RMRS)
State Emergency Proclamations (count)	9	Median (2016–2021): 7	Emergency Proclamations archives (Office of the Governor of California)
Federal disaster declarations (count)	12	Median (2016–2021): 14.5	Region 9 Declared Disasters archive (Federal Emergency Management Agency, FEMA)
State clean-up costs eligible for FEMA reimbursement	$46,778,216 (total DTSC and Caltrans including estimated figures)	Median (2017–2021): $38,375,242	Estimated and actual contract costs (Department of Toxic Substances Control; DTSC); FEMA Public Assistance Fact Sheet (California Department of Transportation, Caltrans)

Figure 8. 2021 metric and benchmark values responsive to *Question 4: What is the cost of wildfire response and recovery?*

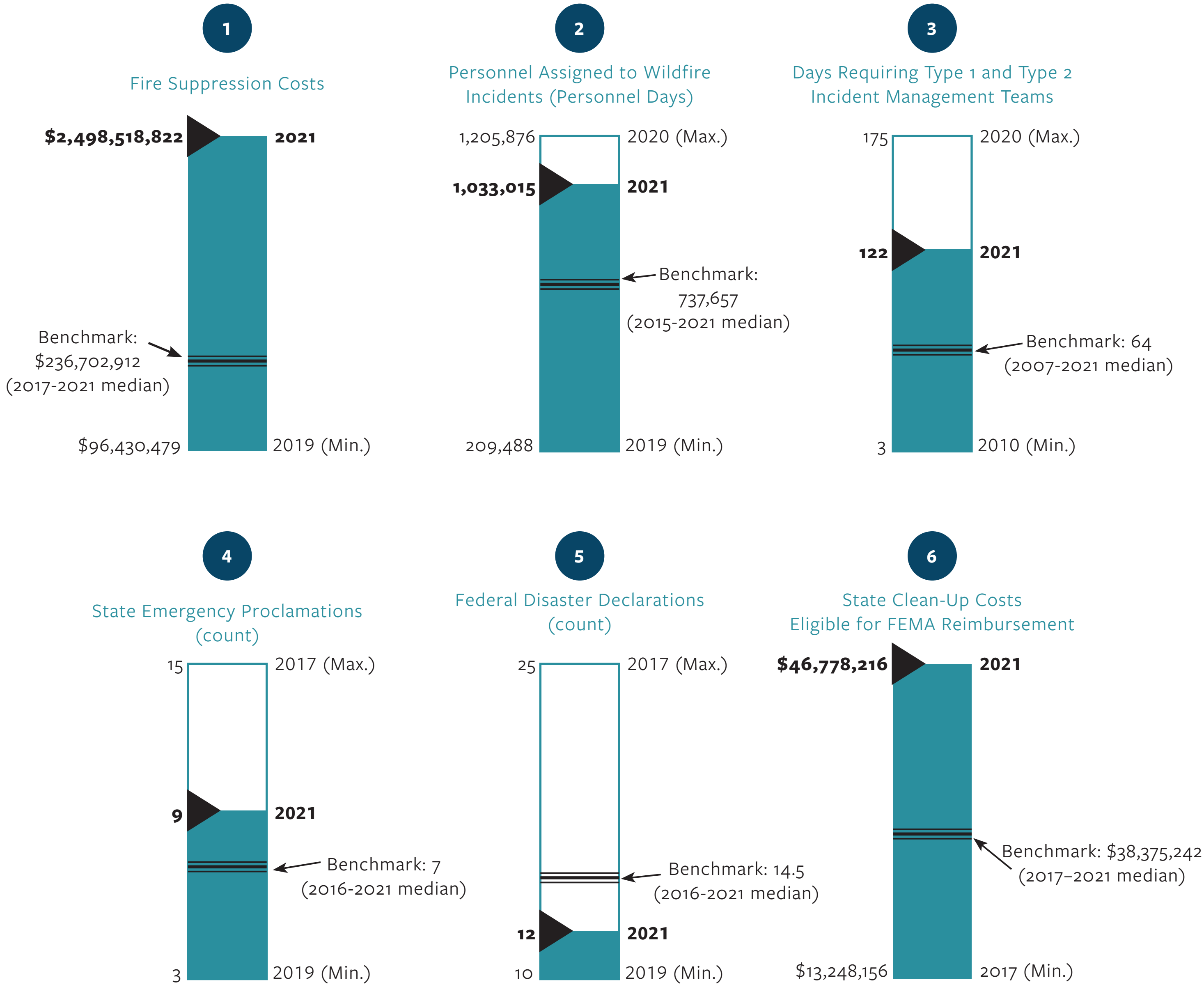
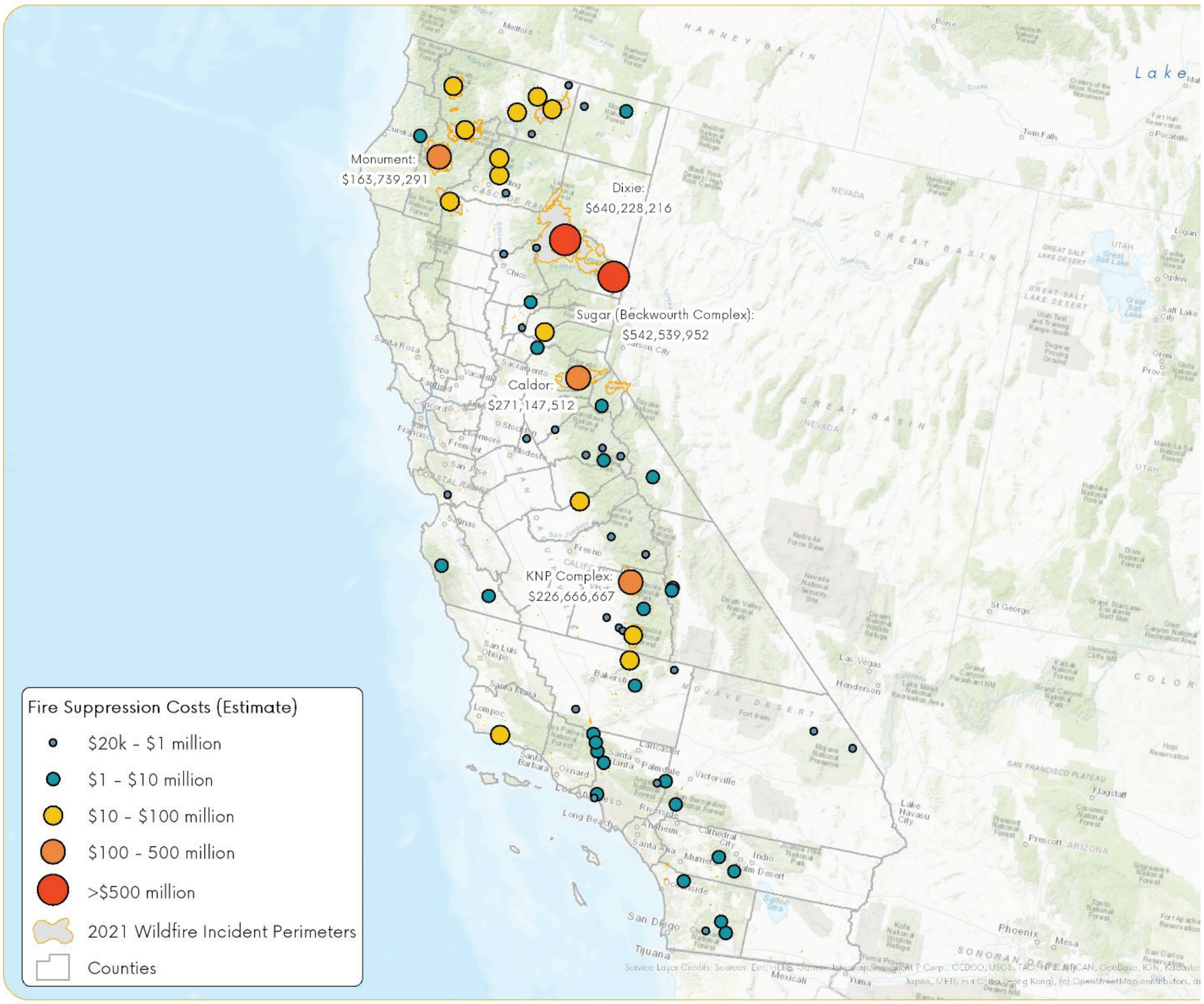


Figure 9. *Question 4* metric example: Fire suppression costs per incident in 2021.

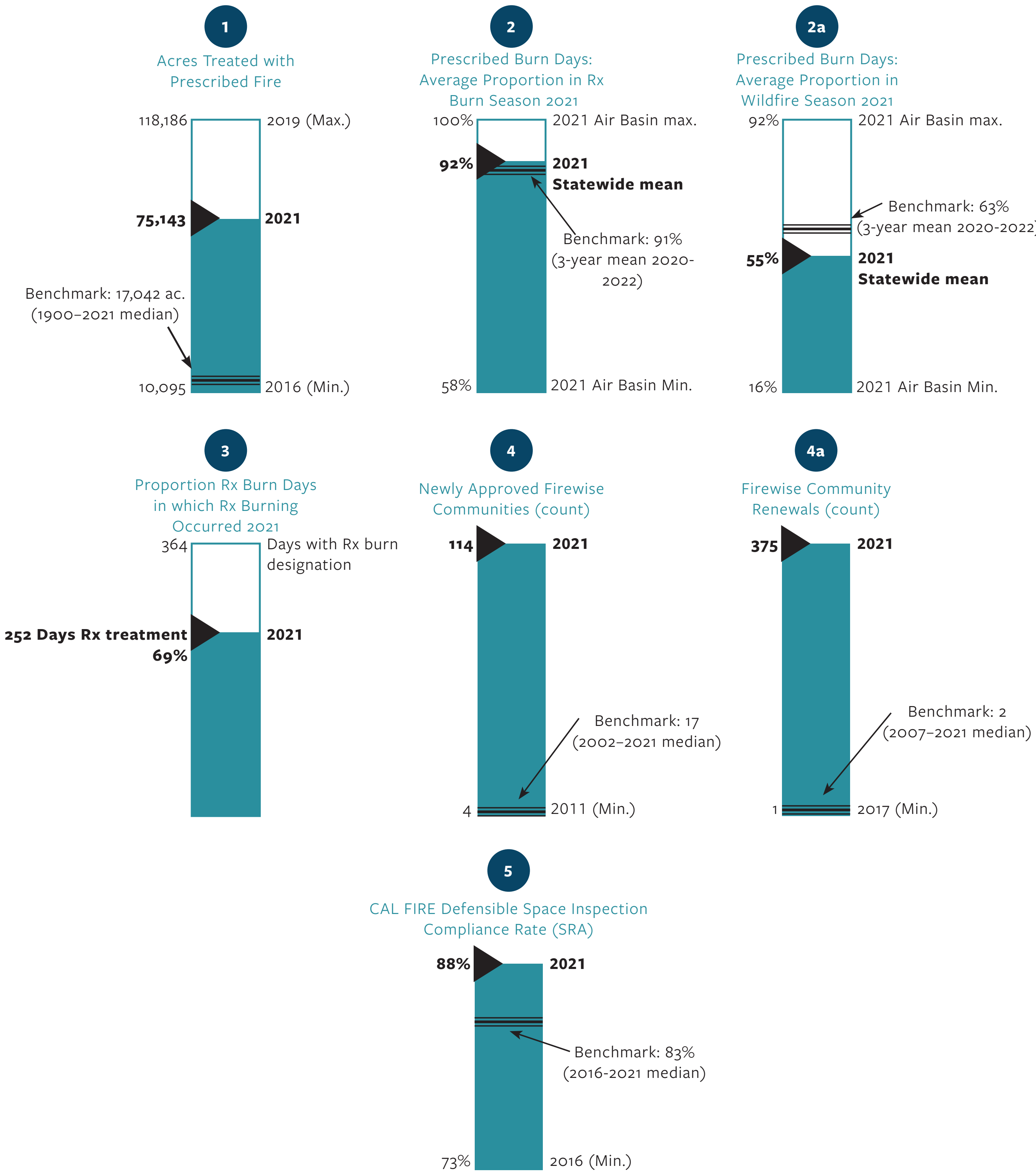


The year's five costliest incidents are labeled in the figure above. Costs are derived from the NIFC Year-to-date large incident report with adjustments based on comparisons with the CAL FIRE Fire Perimeters Database. See Appendix B for details.

Table 6. 2021 metric and benchmark values responsive to *Question 5: How are we addressing wildfire risk?*

METRIC	VALUE(S)	BENCHMARK	DATA SOURCE(S) (AGENCY/ ORGANIZATION)
Acres treated with prescribed fire	75,143	Median (1900-2021): 17,042	Fire Perimeters Database (CAL FIRE)[5]
Prescribed burn days: average proportion by season	Mean proportion, Rx burn season (11/1-4/30): 92%	3-year mean (2020-2022), Rx burn season: 91%	Summary report per agricultural and prescribed fire burn day decisions (CARB)
	Mean proportion, wildfire season (5/1- 10/31): 55%	3-year mean (2020-2022), wildfire season: 63%	
Proportion of prescribed burn days in which prescribed burning occurred	Burning occurred on 252 of 364 days in which one or more Air Basins had burn day designations (69%)	Not yet developed	Ag & Rx Burn Monthly Decisions (CARB), Prescribed Fire Incident Reporting System (CARB)
Count of newly approved and renewed Firewise Communities	Newly approved: 114	Median newly approved (2002-2021): 17	Data request (National Fire Protection Association)
	Renewals: 375	Median renewals (2007-2021): 2	
CAL FIRE Defensible Space inspection compliance rate, State Responsibility Area only	88% compliance rate	Median (2016-2021): 83% compliance rate	Data request (CAL FIRE)
Acres treated		***California Wildfire & Forest Resilience Task Force (Task Force) interim goals (as applicable) OR maximum from period of record***	Interagency Treatment Dashboard

Figure 10. 2021 metric and benchmark values responsive to ***Question 5: How are we addressing wildfire risk?***



III. APPROACHES TO SELECT METRICS DESIGNATED FOR FUTURE INCLUSION

Certain of the metrics designated for inclusion, but for which a value has not yet been calculated, are relatively complex in terms of data source selection or methodology. These include vulnerable community designation and estimated public health impacts from smoke. Potential approaches to both are outlined in this section.

Vulnerable Community Designation

Question 3 contains several metrics which seek to examine wildfire impacts on vulnerable communities specifically, in addition to characterizing impacts on human communities at-large. The intention is to evaluate and track the ways in which wildfire disproportionately impacts communities with limited adaptive capacity to prepare for, respond to, and recover from wildfire. There are a variety of methods and approaches to designating vulnerable communities. A single approach has not yet been determined for the California's Year in Fire project. The implications and drawbacks of "standard" approaches within the state are discussed below.

The California Climate Investments Priority Population 4.0 data set displays "priority populations" in the context of the state's greenhouse gas cap-and-trade auction program, California Climate Investments (CCI). At least 35% of CCI funds must benefit populations which are particularly vulnerable to climate change, including disadvantaged and low-income communities, and low-income households.[17] CCI Priority Population Investments 4.0 is informed by CalEnviroScreen 4.0 (CES), which is developed and maintained by the Office of Environmental Health Hazard Assessment (OEHHA). CES identifies disadvantaged communities at the Census tract scale. A relative score is calculated for each Census tract using indicators in two categories: population characteristics and pollution burden.[18] CCI Priority Population Investments 4.0 includes: Census tracts receiving the highest 25% of CES scores; Census tracts for which no score can be calculated (due to data gaps), but which receive the highest 5% of composite scores related to pollution burden; lands controlled by federally recognized Tribes; and Census tracts identified as disadvantaged in 2017, regardless of their current status. CCI Priority Population Investments 4.0 also includes low-income communities and households as defined by California Assembly Bill 1550.[19,20]

Several organizations have provided official comment to OEHHA regarding CES. These comments highlight the challenges of adequately representing disadvantaged rural communities within CES. This is partly due to the fact that CES assesses vulnerability at the scale of U.S. Census tracts within which small, and often unincorporated, rural communities may be difficult to identify. Additionally, Census tracts may contain pockets of wealth which obscure disadvantaged communities therein. Finally, environmental threats disproportionately experienced in rural communities may not be fully integrated into the CES framework, including wildfire impacts (e.g., community infrastructure damage in addition to air and water quality impacts), and limited access to infrastructure and services (e.g., healthcare), due to geographic isolation.[21,22]

In light of the potential shortcomings of the CCI Priority Population Investments 4.0 data set, several data sources have been identified that may be used to supplement or supplant this data layer. These data sources are summarized in the following table. This does not constitute an exhaustive list; data sets are included if they are or have had accepted use for vulnerable community designation, and/or if they have broad coverage in California. Details pertaining to each data set is found in Section 7. These data sets should be further analyzed for their suitability, in isolation or in combination, in making equitable determinations of the location of communities vulnerable to wildfire impacts throughout the state. Said suitability analysis should also consider additional data sets identified by reviewers and potential end users which are not listed here.

Table 7. Sources identified as potential supplements or alternatives to the CCI Priority Population Investments 4.0 data set

DATA SET	DESCRIPTION/NOTES	SCALE/SCOPE
Community Wildfire Vulnerability Tool (OEHHA)	• Incorporates structure exposure and Fire Hazard Safety Zones (FHSZs), and 9 socioeconomic variables standardized to create a Community Vulnerability Index (CVI) • The CVI percentile is mapped for all areas in the geographic scope (see "Scale/ Scope" column) • The tool is not yet available for public use (as of May 2023)	Census block groups within California in High or Very High FHSZs. Urban areas (and other portions of the state) do not receive scores due to FHSZ designations. Portions of the unscored areas may still be vulnerable to public health impacts from smoke exposure.
California and Justice40 Disadvantaged or Low-Income Communities (California Natural Resources Agency)	• Displays disadvantaged and/or low-income communities designated by both California (per CARB) and Justice40 • Justice40-designations of disadvantaged communities are per U.S. Departments of Transportation and Energy joint interim definition for the National Electric Vehicle Infrastructure Formula Program and include data on vulnerable populations, health, transportation (access and burden), energy burden, fossil fuel dependence, resilience, and hazards (environmental and climate-related).[23]	Census tracts in California. Excludes some tracts identified as disadvantaged or partially disadvantaged in Justice40.

DATA SET	DESCRIPTION/NOTES	SCALE/SCOPE
Disadvantaged Unincorporated Communities, DUC (California Association of Local Agency Formation Commissions, CALAFCO)	• Captures small rural communities that may be obscured due to their occurrence in large Census tracts containing wealthy communities • The majority of DUCs are low- and extremely low-income and are disproportionately overburdened by environmental pollutants, especially because they are governed by under-resourced counties[21] • CALAFCO's DUC map uses 2020 U.S. Census household income data	DUCs in all California counties
Health Professional Shortage Areas, HPSA (California Department of Health and Human Services)	• HPSAs are a type of shortage area designation made by the Health Resources & Services Administration identifying limited access to primary, dental, or mental health providers.[24] Compared with urban residents, rural residents spend more on health care as a percentage of their household income and experience greater barriers (financial and temporal) to health care access.[22] Limited access to medical care increases vulnerability to existing pollution burdens.[21] • HPSAs consider population-to-provider ratio; percent of population below 100% of the Federal Poverty Level; and travel time to the nearest source of care outside the designated area[24]	Census tracts (California/national)
Select socioeconomic factors included in CAL FIRE/CalOES California Wildfire Mitigation Program (CalOES)[25]	• Families in poverty; people with disabilities; people that have difficulty speaking English; people over 65 and under 5; households without a car • Data is sourced from the U.S. Census Bureau American Community Survey (ACS)	Census tract (national)
Social Vulnerability Index (Agency for Toxic Substances and Disease Registry, ATSDR)	• Themes include: socioeconomic status, household characteristics, racial and ethnic minority status, housing type and transportation • Updated every two years using ACS data	Census tract (national)

DATA SET	DESCRIPTION/NOTES	SCALE/SCOPE
Neighborhoods at Risk Tool (Headwaters Economics)	• Includes 9 socioeconomic and 4 climate exposure variables • Incorporates climate projections (changes in temperature and precipitation) • Updated 90 days after each ACS release • Headwaters Economics states that the tool works best for communities >1,000 people	Census tract (national)
National School Lunch Program (National Center for Education Statistics)	• Commonly used as a proxy for poverty among school-age children; ACS child poverty data is also available as a substitute • Employs a more conservative poverty threshold than ACS	Public and non-profit private schools (national); only includes information for students who apply for the program and are eligible

Modeled public health impacts

Future iterations of the California's Year in Fire project would include modeled estimations of public health impacts from smoke. Neither CARB nor the California Department of Public Health (CDPH) produces such an estimate. Only a few jurisdictions in California currently have the requisite syndromic surveillance capacity to produce these estimates (S. Hoshiko, personal communication January 25, 2023). Estimation of public health impacts would likely be performed using BenMAP-CE, described below. Alternative approaches are also summarized.

BenMAP-CE is an open-source computer program which estimates the economic value associated with changes in air quality (PM2.5) changes. Values can be researcher defined or derived from the literature and valuate air quality changes in two separate ways: cost-of-illness (COI) or willingness to pay (WTP). COI monetizes the direct and indirect resource costs of smoke-related illnesses (i.e., medical expenses, opportunity costs of time spent receiving medical care, and value of lost wages). WTP reflects the dollar value to an individual of avoiding health impacts from smoke.[26] BenMAP-CE makes use of air quality and population data, health impact functions, and incident data sets (if estimating impacts for specific population subgroups).[27] Though BenMap-CE is targeted toward evaluations of public health impacts from urban air pollution sources, the program has been used at least once to estimate wildfire smoke costs as a result of a single wildfire incident. However, the estimated impacts have been shown to vary depending on whether the underlying calculations utilize data specific to the relationship between wildfire smoke and health impacts.[26]

Alternative approaches to estimating public health impacts include:

- The extent and demographics of impacted populations can be estimated by mapping wildfire plumes using the National Oceanic and Atmospheric Administration's Hazard Mapping System (HMS). The population impacted by those plumes is then estimated using U.S.

Census data. A similar approach utilizes modeled plumes produced by the National Weather Service via the HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) model. HYSPLIT modeled data can also be verified with the observational HMS data. The plume modeling approach could also potentially make use of data gathered and modeled by the Interagency Wildland Fire Air Quality Response Program, which deploys air quality monitoring equipment during large smoke events. These data are combined with satellite fire detections and other data sets to model daily smoke predictions at various spatial scales. The availability of past data has not yet been determined. The plume mapping approach can be paired with emergency department admissions data to estimate excess public health impacts related to wildfire smoke exposure.[28]

- An estimate could be generated for the number of minor restricted activity days (MRADs) within the state. MRADs are defined as "any day on which an individual was forced to alter his or her normal activities due to minor illnesses, including both respiratory and non-respiratory conditions."[26] Jones et al. estimated MRAD incidence, which was well-matched with their wildfire-specific WTP measure. "MRADs capture most symptoms and illnesses associated with smoke exposure, including those requiring physician or hospital treatment. Thus, it is a broad-based measure of health effects."[26]

CDPH recently released the California Wildfire Smoke and Air Pollution Health Burden Mapping Dashboard, displaying excess respiratory and cardiovascular emergency department visits attributed to particle pollution exposure in years 2008-2016. Depending on the approach employed, CDPH's dashboard data may be useful as a baseline for public health impact estimations.

IV. REGIONAL DATA AND TREND EXPLORATION

In addition to statewide summary statistics, the California's Year in Fire project would ideally reflect data and trends within pre-defined areas of interest (AOI) for a subset of metrics. This section broadly describes such an approach in the context of a public-facing website.

AOIs would be displayed on a scalable map of the state of California which would include the following base layers: land ownership (Tribal, Federal, State, local, private), administrative units (i.e., National Forests), California Wildfire & Forest Resilience Task Force regions, perimeters of wildfire incidents, 8-digit hydrologic unit code (HUC) watersheds, counties, and human communities. Potential additional map layers include: perimeters of prescribed fire incidents, fireshed boundaries, the CPUC High Fire Threat District layer (2018) and CAL FIRE's FHSZ layers (2022). Proposed source data for most base layers are included in Section 7.

Pre-defined AOIs could include wildfire incident perimeters, counties, 8-digit HUC watersheds, and firesheds. The user would be able to make multiple AOI selections. A table would then be generated comparing all relevant metrics at the state summary level and at the level of the AOI(s) for the relevant year. Each distinct AOI would be represented as its own column. The metrics included in the table would be summary only, without reference to benchmarks. Some AOI metrics may need to be normalized by land area and/or population to allow comparison with state totals. AOI summary details would be displayed in the AOI column header as outlined below. Table 8 provides an overview of included metrics and representations. Note that metric values have not yet been calculated for AOIs.

If the AOI is a wildfire incident, the following information would be summarized as relevant:

- Acreage of wildfire incident
- Incident start and end dates
- Managing agency(ies)
- Management objective (i.e., suppression vs. managed wildfire)
- County(ies) within which wildfire incident occurred
- Dominant FRG(s) and high-level summary of "typical" wildfire burn severity patterns

If the AOI is a county or community, the following information would be summarized:

- Most recent population counts
- Counties: Number and populations of vulnerable communities
- Communities: Vulnerable community designation as applicable
- Dominant FRG(s) and high-level summary of "typical" wildfire burn severity patterns

If the AOI is an 8-digit HUC watershed or fireshed, the following information would be summarized:

- County(ies) occurring within the watershed
- Most recent population counts by county
- Number and populations of vulnerable communities
- Dominant FRG(s) and high-level summary of "typical" wildfire burn severity patterns

Table 8. Included fields for state/area of interest comparison.

STATE SUMMARY	AOI [NAME/IDENTIFIER SUMMARY AOI SUMMARY DETAILS]
Acres burned (total)	Acres burned (total, % of state total, rank [i.e., 4th largest incident])
Acres burned by fire cause	Acres burned by fire cause (total, % of state total)
Acres burned by DPA	Acres burned by DPA (total, % of state total)
Acres burned by vegetation type	Acres burned by vegetation type (total, % of state total)
Modeled debris-flow hazard	Modeled debris-flow hazard (total acres, % of state total acres, rank)
Number of reportable incidents	Number of reportable incidents (total, % of state total)
Fire severity, area by severity class	Fire severity, area by severity class (total, % of state total by severity class)
Area in large high severity patches (total acres)	Area in large high severity patches (total acres, % of state total, rank)
High priority acres for post-fire reforestation (total)	High priority acres for post-fire reforestation (total, % of state total, rank)
Fire return interval departure, mean CC FRI (% area in each class)	Fire return interval departure, mean CC FRI (% area in each class)
Low-lying shrubland resilience (total ac. with >0 disturbance events per 15-years)	Low-lying shrubland resilience (total ac. >0 disturbance per 15-year interval, % of total)
Structures damaged or destroyed by construction year and structure type (total)	Structures damaged or destroyed by construction year and type (total, % of state total)
Evacuations (total)	Evacuations (County or incident total, % of state total, rank)
Acres burned in communities (total)	Acres burned in communities (total, % of state total)
Acres burned in vulnerable communities (total)	Acres burned in vulnerable communities (total, % of state total)
Structures damaged or destroyed in communities (total)	Structures damaged or destroyed in communities (total, % of state total)
Structures damaged or destroyed in vulnerable communities (total)	Structures damaged or destroyed in vulnerable communities (total, % of state total)
Fire suppression costs (total)	Fire suppression costs (total, % of state total, rank)
Acres treated with prescribed fire (total)	Acres treated with prescribed fire (total, % of state total)
Acres treated (total)	Acres treated (total, % of state total)

V. UNAVAILABLE OR NOT YET INCLUDED DATA

Available information not yet incorporated:

Adjustments to mean condition class fire return interval:

The Mean CC FRI metric reflects on fire frequency, which is only one aspect of fire regimes. In recent years, portions of the state have seen repeat fires occurring in short intervals with overlapping patches of high severity fire. In ecosystems with short historic fire return intervals, the mean CC FRI metric may depict these areas as minimally departed from the historic norm, since fire intensity (i.e., severity) is not taken into consideration. To help account for potential misinterpretation of the data, future mean CC FRI calculations would exclude areas which have burned in the last ten years in conifer forests and woodlands.[29]

Number of incidents requiring Type 1 and Type 2 IMTs:

This can be a companion measure to number of days requiring Type 1 and Type 2 IMTs. This would require cross-referencing the IMSR data with historical Incident Status Summary (ICS-209) data.

Pre-fire ecological characterization and/or predicted probabilities of high severity fire:

Select data layers from the Task Force Regional Resource Kits (RRK) could be used to compare predicted high-risk areas with observed fire effects (i.e., fire severity; large, high severity patches) in areas where wildfire (and prescribed fire) occurred. Relevant RRK data layers include: estimated maximum stand density index (Sierra Nevada bioregion), and probability of high severity fire (statewide). In the Sierra Nevada, the stand density index could be benchmarked using values from recent, regionally-specific research.[30] These factors could be represented as their own metrics, or could bring additional nuance to metrics related to the ecological impacts of wildfire.

Water Quality Impacts (regional):

The State Water Resources Control Board (SWRCB), Division of Water Quality (DWQ), maintains water quality monitoring data conducted after individual wildfire incidents. These are not part of a broader monitoring effort to ascertain post-fire impacts on water quality. Since around 2018, wildfire incidents are selected for monitoring based on their proximity and impacts to populated areas (G. Low, personal communication, January 19, 2023). DWQ has provided monitoring information for the following wildfire incidents: Carr (2018), Camp (2018), North Complex (2020), and Dixie (2021).

Data not currently available:

Collaborative/partnership footprints:

According to a University of Oregon pilot Climate-Change Adaptation Index on USFS lands (Regions 1 and 6), one of the most important variables which contributes to a USFS unit incorporating climate change considerations into planning and implementation is the "integration of climate change activities into work being done in the context of partnerships."[31] Collaborative groups and natural resource partnerships more broadly have the potential to increase public participation in land management processes, mediate potential resource conflicts, and increase planning and implementation coordination among landowners. The Department of Conservation's Regional Forest and Fire Capacity program has been asked by the Task Force to spatially represent partnership groups throughout the state. Should a website be created for the California's Year in Fire, this data could be incorporated as a "base layer" in the map selection component.

Number of new Community Wildfire Protection Plans (CWPP):

The Office of Planning & Research conducts an Annual Planning Survey identifying counties and cities which have developed new CWPPs. Data is not yet available for 2021 (as of May 11, 2023). The survey is distributed to all cities and counties within California. In 2020, 59% of cities and counties responded. Approximately 71% of California's population is represented by responding jurisdictions.[32]

Reforestation activity compared with PostCRPT predictions of high priority areas for reforestation:

Reforestation activities from the Interagency Treatment Dashboard could be compared against PostCRPT predictions of high priority areas for reforestation. Note that this would be a retrospective measure and should account for planting in addition to site preparation and release treatments associated with planting. For example, each year's publication could consider reforestation related activities in the 5 years prior to publication. As of September 2023, the Beta Interagency Treatment Dashboard does not include pre-2022 data.

Schools impacted by wildfire:

The California Department of Education Emergency Services (CDEES) maintains information on the number of schools included in J-13A requests submitted for wildfire. These records are organized by fiscal year. J-13A requests are submitted when learning loss occurs due to disasters. It is unclear from CDEES's response whether "learning loss" includes only school closures, material decreases in attendance, or both. CDEES does not maintain information on the duration of school closures. Data from Fiscal Year 2020-21 and 2021-22 are still being compiled; there is no estimated availability date for this data.

State clean-up costs (complete):

> CalRecycle is currently drafting reports summarizing 2021 wildfire-related clean-up costs, with an anticipated release in 2023. Due to inconsistencies in reporting methods between state agencies, it may also be preferable to characterize state clean-up costs in terms of money allocated by FEMA using their publicly accessible records. However, there are several incidents with potential data discrepancies; FEMA is preparing an official response to questions posed regarding these records.

Data availability or suitability not determined:

Clean air shelter use:

> This metric could be reported with public health impacts to reflect the level of impact abatement provided by public infrastructure. The CARB Research Division has been contacted to determine data availability.

Drinking water impacts:

> Many water systems post their water quality data publicly on their website. These are real-time reports updated routinely throughout the post- fire investigation and recovery phases (Y. Heaney, personal communication, January 19, 2023). The System Area Boundary Layer depicts water systems and their service areas. The SWRCB, Division of Drinking Water also maintains a water system look-up tool which can be used to generate a list of state-wide water systems. There are 7,775 records in this database.

Evacuation shelter use:

> In order to refine estimates of community displacement impacts represented by evacuation counts, attempts are being made to locate data on the use of evacuation shelters during wildfire incidents. The California Department of Social Services, Disaster Services Branch is determining the availability of such data.

Utility company treatments:

> The California Office of Energy Infrastructure Safety maintains treatment data conducted by utilities on a per mile or per utility pole basis. This data is slated for inclusion in the Interagency Treatment Dashboard.[33]

Several metrics have been suggested for inclusion which have not been thoroughly vetted to determine data availability and suitability. These include: Burned Area Emergency Stabilization and Rehabilitation (U.S. Department of Interior) and Emergency Response (USFS) costs; agricultural insurance claims relating to wildfire damage (Risk Management Agency); tax base decreases; acres of rangeland burned; timber loss (board feet); impacts to transmission lines and other utility infrastructure; and private property impacts, accounting for the percentage of uninsured homeowners or renters. These metrics would be evaluated for potential inclusion in a future iteration.

VI. DATA DISCLAIMERS

With the exception of data provided as summary figures, all calculations were performed on a preliminary basis by UC Berkeley staff using publicly available data and data provided upon request. Appendix B contains details on data analysis for each metric.

CAL FIRE: The State of California and the Department of Forestry and Fire Protection make no representations or warranties regarding the accuracy of data or maps. Neither the State nor the Department shall be liable under any circumstances for any direct, special, incidental, or consequential damages with respect to any claim by any user or third party on account of, or arising from, the use of data or maps. For more information about [this product], date or terms of use, contact calfire.egis@fire.ca.gov.

VII. COMPLETE LIST OF METRICS AND DATA SOURCES

Table 9. Data source details.

Data details are current as of May 2023 and were selectively updated in September 2023. Links are current as of September 2023.

METRIC	DATA SOURCE (AGENCY)	UPDATE FREQUENCY	TEMPORAL COVERAGE	SPATIAL COVERAGE	PUBLIC (Y/N)	DATA FORMAT
Days at preparedness levels 4/5	Wildland Fire Summary and Statistics Annual Report Ch. 2 (NICC)	Annually	2001–2021	National	Y	Tabular summaries (graphic)
State summary acres by Direct Protection Area and acres burned by DPA	Direct Protection Areas for Wildland Fire Protection Geodatabase (CAL FIRE) and Fire Perimeters Database (CAL FIRE)	Last updated May 2022		California	Y	Geodatabases
State summary acres by vegetation type and acres burned by vegetation type	Existing Vegetation Geodatabases (USFS) and Fire Perimeters Database (CAL FIRE)	Periodic	Dates of source imagery vary	CALVEG Zones	Y	Geodatabases
Number of housing units in the WUI	1990-2020 WUI of the conterminous U.S. – geospatial data, 3rd ed. (USFS)		1990-2020	Continental U.S. (CONUS)	Y	Geodatabase

METRIC	DATA SOURCE (AGENCY)	UPDATE FREQUENCY	TEMPORAL COVERAGE	SPATIAL COVERAGE	PUBLIC (Y/N)	DATA FORMAT
Acres burned (total and by fire cause)	Fire Perimeters Database (CAL FIRE)	Annually	Complete 2002-2022; often used for period 1908-present	10 – 300-acre minimum, per fuel type. ≥3 habitable/ commercial structures destroyed.	Y	Geodatabase
Model-estimated emissions (CO_2, $PM_{2.5}$)	Wildfire Emission Estimates (CARB)	Annually	2000–2021	Incidents in the CAL FIRE Fire Perimeters Database	Y	Summary document
Modeled debris-flow hazard	Emergency Assessment of Post-Fire Debris-Flow Hazards (USGS)	Annually	2013-2021 (methods changed in 2016)	Recently burned areas in the western U.S. per direct request from Federal, State, Local agencies or private organizations	Y	Geodatabase
Fire severity, area by severity class (basal area loss)	Basal Area Loss 30m raster data (Joseph Stewart, UC Davis)	Annually per CAL FIRE Fire Perimeters Database	1985-2021	All fires within the CAL FIRE Fire Perimeters Database	Y by request	30-m resolution rasters
Fire Regime Groups	Biophysical Settings (LANDFIRE)	Last updated 2016		CONUS	Y	30-m resolution rasters
Area in large high severity patches	High severity patch edge raster data (Joseph Stewart, UC Davis)	Annually per CAL FIRE Fire Perimeters Database	1985-2021	All fires within the CAL FIRE Fire Perimeters Database	Y by request	30-m resolution rasters
High priority acres for reforestation	PostCRPT batch-processed predictions (Joseph Stewart, UC Davis)	Annually	2012-2021	California yellow pine and mixed conifer (moist and dry) forests. Geographic domain is depicted in web application.	Application is publicly available	Raster files
Fire Return Interval Departure (Mean condition class fire return interval 1970)	FRID Geodatabases (USFS Region 5)	Annually	1908–present (fires >40ha before 1950 and >4ha after)	All fires in CAL FIRE Fire Perimeters Database. All major vegetation types (CALVEG) on National Forests and adjacent lands.	Y	Geodatabases

METRIC	DATA SOURCE (AGENCY)	UPDATE FREQUENCY	TEMPORAL COVERAGE	SPATIAL COVERAGE	PUBLIC (Y/N)	DATA FORMAT
Low-lying shrubland resilience (acres potentially at risk in the South Coast ecoregion)	Data request (San Diego State University Connecting Wildlands and Communities Project Team)[11]		1950-2021	Low-lying shrublands within California (excludes shrublands in montane chaparral and riparian habitats).	Y by request	Raster files
Total and insured economic losses from wildfire	Catastrophe Insight Database (Aon)	Annually	1980-2022		N	Spreadsheet
Structures damaged or destroyed (total), by structure type and construction year	DINS Geodatabases (CAL FIRE) information request	Annually	2013–2021	Permanent structures > 120 ft2 and within 100m of fire perimeter impacted by wildfire (pre-2018: only those damaged or destroyed). May not include fires in Local or Federal Responsibility Areas.	Y by request	Geodatabase
Fatalities (all)	Incident archives (CAL FIRE)	Annually	2013–2022	California	View only	Website
Firefighter fatalities (all causes)	Firefighter Fatalities in the U.S. (USFA)	Annually	2000–2022	California	Y	Website
Number of customers impacted by PSPS events (total and medical baseline)	PSPS Event Data Rollup (CPUC)	Utilities must submit a report within 10 days of each event	2013-2014, 2017-2022 (no reporting 2015-2016)	Circuits de-energized by PSPS events	Y	Spreadsheet
Evacuations	Data request (CalOES)		2021	All reporting counties	Y by request	Spreadsheet
Community boundaries	First Street Foundation community data				Y by request	
Fire suppression costs	Year-to-date large incident report (NIFC)	Annually	2017–2021	All incidents requiring an ICS-209 submission	Y by request	Spreadsheet
Personnel assigned to wildfire incidents (personnel days)	2007 – 2021 IMSR Data Pre-Release Version 1.0.4 (csv)34	Annually	2015–2021	All incidents requiring an ICS-209 submission	Y, now available online	CSV / desktop tool

METRIC	DATA SOURCE (AGENCY)	UPDATE FREQUENCY	TEMPORAL COVERAGE	SPATIAL COVERAGE	PUBLIC (Y/N)	DATA FORMAT
Number of incidents and number of days requiring Type 1 and Type 2 Incident Management Teams	Same as above	Same as above	2007-2021	Same as above	Y, now available online	CSV / desktop tool
State Emergency Proclamations (count)	Proclamations (Office of Governor) And Gov. Brown Proclamations (Office of Governor)	Not specified	2011–2023	California	Y	Website
Federal disaster declarations (count)	Declared Disasters Archive (FEMA)	Hourly	1956–2022	California	Y	Website
State clean-up costs eligible for FEMA reimbursement	Data request (CalRecycle, DTSC)	Annually	2017-2021	California	Y	Spreadsheet (DTSC), PDF (Caltrans)
Acres treated with prescribed fire	Fire Perimeters Database (CAL FIRE)	Annually	1900–2021	Rx fire, fire use, machine/ hand piles, and jackpot burns as small as <1 ac.	Y	Geodatabase
Prescribed burn days (average proportion) by season	Ag & Rx Burn Monthly Decisions (CARB)	Annually	2010-2021	All Air Basins	Y	Spreadsheet
Proportion of prescribed burn days in which prescribed fire occurred	Ag & Rx Burn Monthly Decisions (CARB) and Prescribed Fire Incident Reporting System (PFIRS)	Annually	Ag & Rx Burn: 2010-2021 PFIRS: 2015–2021 (complete)	All Air Basins	Y	Spreadsheet
Count of newly approved and renewed Firewise Communities	Data request (National Fire Protection Association)	Annually	Approvals: 2002-2022 Renewals: 2007-2022	California by community or affiliated city	Y	Spreadsheet
CAL FIRE Defensible Space inspection compliance rate (SRA only)	Data request (CAL FIRE)	Annually	2016-2021	Data set includes some Local and Federal Responsibility Area lands	Y	Spreadsheet

METRIC	DATA SOURCE (AGENCY)	UPDATE FREQUENCY	TEMPORAL COVERAGE	SPATIAL COVERAGE	PUBLIC (Y/N)	DATA FORMAT
Acres treated	Beta Interagency Treatment Dashboard	Periodic updates until official launch (Spring 2024)	2022	Vegetation management projects conducted by large private timber operations, and state and federal agencies in CA	Y	Website
Vulnerable community identification	CCI Priority Population Investments 4.0 (CARB)	Periodic (last update May 2022)		All Census tracts in California	Y	Geodatabase
Vulnerable community identification (potential alternative)	California and Justice40 Disadvantaged or Low-Income Communities (hosted by California Natural Resources Agency)			All Census tracts identified as disadvantaged or low-income using CCI Priority Population Investments 4.0 and interim Justice40 definition developed by U.S. Departments of Transportation and Energy	Y	
Vulnerable community identification (potential alternative)	Disadvantaged Unincorporated Communities (California Association of Local Agency Formation Commissions)		Uses 2020 ACS data	DUCs in all California counties	Y by request	Geodatabase
Vulnerable community identification (potential alternative)	Health Professional Shortage Areas in California (California Health and Human Services)	Last updated 2018		Sub-County level throughout California	Y	KML/Shapefile
Vulnerable community identification (potential alternative)	Various American Community Survey data (demographics, context for child well- being, poverty status variables)	Every 5 years	2017-2021	National by Census tract, county, and state boundaries	Y	ArcGIS Portal items
Vulnerable community identification (potential alternative)	Neighborhoods at Risk Tool (Headwaters Economics)	Updated within 90 days of ACS 5-year estimate-publication	ACS data 2017-2021	National by Census tract, county, or state	Y	Report summary
Vulnerable community identification (potential alternative)	Social Vulnerability Index (ATSDR)		2000-2020 (incomplete)	CONUS by Census tract or County	Y	Shapefile or csv

METRIC	DATA SOURCE (AGENCY)	UPDATE FREQUENCY	TEMPORAL COVERAGE	SPATIAL COVERAGE	PUBLIC (Y/N)	DATA FORMAT
Vulnerable community identification (potential alternative)	Lunch Program Eligibility (National Center for Education Statistics)		1986-2019	Public and non-profit private schools (national); students who apply for the program and are eligible	Y	Data files (Excel, Statistical Analysis Software, Statistical Package for the Social Sciences)
HUC-8 watersheds (map layer, AOI)	National Hydrography Products (USGS)	Unknown		National	Y	Shapefile or geodatabase
County boundaries	California County Boundaries 2019 (CAL FIRE)	Last updated 2019		California	Y	Geodatabase
Firesheds (map layer, AOI)	Fireshed Registry (USFS)	Unknown		Forested lands in continental U.S.; all ownerships. Average fireshed size is 100k ac.	Access request required	Geodatabase
High fire threat district layer (map layer, AOI)	High Fire Threat District layer (California Public Utilities Commission)	Last updated 2018		Areas with high fire risk and overhead utility power lines or facilities also supporting communication facilities and High-Hazard Zones (tree mortality) with direct proximity to communities, roads, and utility lines	Y	Geodatabase
Fire Hazard Severity Zones	Fire Hazard Severity Zone Layers (CAL FIRE)	Last updated 2022		State Responsibility Areas and Very High Hazard in Local Responsibility Areas	Y	Shapefile

LIST OF ACRONYMS - APPENDIX A

ACS: American Community Survey

AOI: Area of Interest

ATSDR: Agency for Toxic Substances and Disease Registry

BA: Basal Area

CAL FIRE: California Department of Forestry and Fire Protection

CalOES: California Governor's Office of Emergency Services

Caltrans: California Department of Transportation

CARB: California Air Resources Board

CC: Condition Class

CCI: California Climate Investments

CDEES: California Department of Education Emergency Services

CDPH: California Department of Public Health

CES: CalEnviroScreen

COI: Cost-of-illness

CONUS: Continental U.S

CPUC: California Public Utilities Commission

CVI: Community Vulnerability Index

CWPP: Community Wildfire Protection Plan

DINS: Damage Inspection

DPA: Direct Protection Area

DTSC: Department of Toxic Substances Control

DUC: Disadvantaged Unincorporated Community

DWQ: Division of Water Quality

FEMA: Federal Emergency Management Agency

FHSZ: Fire Hazard Severity Zone

FRG: Fire Regime Group

FRI: Fire Return Interval

FRID: Fire Return Interval Departure

HMS: Hazard Mapping System

HPSA: Health Professional Shortage Area

HUC: Hydrologic Unit Code

HYSPLIT: Hybrid Single-Particle Lagrangian Integrated Trajectory

ICS: Incident Status Summary

IMSR: Incident Management Situation Reports

IMT: Incident Management Team

KML: Keyhole Markup Language

LANDFIRE: Landscape Fire and Resource Management Planning Tools

MMT: Million Metric Tons

MRAD: Minor Restricted Activity Days

NICC: National Interagency Coordination Center

NIFC: National Interagency Fire Center

OEHHA: Office of Environmental Health Hazard Assessment

PFIRS: Prescribed Fire Incident Reporting System

PL: Preparedness Levels

PostCRPT: Postfire Conifer Reforestation Planning Tool

PRS: Percent Replacement Fire

PSPS: Public Safety Power Shutoff

RMRS: Rocky Mountain Research Station

RRK: Regional Resource Kit

SWRCB: State Water Resources Control Board

UC: University of California

USFA: U.S. Fire Administration

USFS: U.S. Forest Service

USGS: U.S. Geological Survey

WTP: Willingness to pay

WUI: Wildland-Urban Interface

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APPENDIX B

INTRODUCTION

This document summarizes information for each California's Year in Fire metric for which a preliminary value has been calculated. Metric summaries contain some or all of the following fields:

- A description of the metric
- A description of the data source used, including a link to the source data where applicable
- Calculation methods and the preliminary 2021 figure
- Benchmark values
- Suggestions for improvement

To improve legibility, most figures and/or benchmarks have been rounded to the nearest whole number for reporting.

Note that the terms "wildfire" and "wildland fire" are both used in this document. "Wildland fire" is typically used when quoting a specific source that employs this terminology.

CONTEXTUAL METRICS

Metric 1: Days at Preparedness Levels 4 and 5 (national)

Metric Description

Preparedness Levels (PL) are determined by the National Multi-Agency Coordination Group, based at the National Interagency Fire Center (NIFC). PLs are established throughout the year to ensure availability of suppression resources across the country. The PL is a national figure and does not vary by state. The PL determination takes fuel and weather conditions, fire activity, and the national availability of suppression resources into consideration. PLs range from 1 to 5, with 1 being the lowest and 5 being the highest. Each PL is associated with specific management actions. The need for suppression resources – of all kinds – increases with the PL. At PL 4, geographic areas are competing for wildland fire suppression resources and roughly 60% of the country's Incident Management Teams (IMTs) and firefighting crews are committed to wildland fire incidents. At PL 5, at least 80% of IMTs and firefighting crews are deployed to wildland fire incidents. Additionally, at PL 5, wildland fire assistance and support are requested from all available employees within the Departments of Interior and Agriculture.[1]

Data Source Description

A summary of PL data from 1990-2021 is included in the 2021 Wildland Fire Summary and Statistics Annual Report: Incident Activity Charts and Tables.[2] This report is prepared annually by the National Interagency Coordination Center, a branch of the NIFC.

Calculation Methods and 2021 Figures

Figures were obtained from the "National Preparedness Level Summary" chart, containing the number of days at PL 4/5 from 1990-2021.

In the year 2021, there were a total of 99 days in which the national Preparedness Level was 4 or 5.

Benchmark

The minimum value for the period of record (1990-2021) is included with the annual figure as a point of reference. The period of record minimum is 0 days at PL 4/5. This value occurred in multiple years and most recently in 2019. The 2021 value is the maximum for the period of record.

Metric 2: Total (state) acres by Direct Protection Area

Metric Description

Within the state of California, there are three Direct Protection Area (DPA) groups: Federal, State, and Local. Each DPA group has primary responsibility for providing wildland fire protection within the designated area.[3]

Data Source Description

Total acres by DPA were derived from the California Department of Forestry and Fire Protection (CAL FIRE) Direct Protection Areas for Wildland Fire Protection geodatabase.[4] This dataset was last updated in May 2022.

Calculation Methods and 2021 Figures

The acreage was summarized for each DPA group using the aforementioned geodatabase.

DPA GROUP	ACRES	PERCENT OF TOTAL
Federal	51,464,602.54	49.6%
State	30,785,506.48	29.7%
Local	21,460,510.08	20.7%
Grand Total (Rounded)	**103,710,619**	**100%**

Metric 3: Total (state) acres by vegetation type

Metric Description

This metric summarizes total acres in the state by vegetation type, categorized by "lifeform" (i.e., hardwood, conifer, shrub, herbaceous, etc.). These figures help provide context for estimates of acreage burned by vegetation type (see see Question 1, Metric 1). Additionally, they can help determine if any vegetation types are overrepresented in burned acreage compared to their proportion of the state total.

Data Source Description

Vegetation type was calculated using the California Wildlife Habitat Relationships (CWHR) lifeform field of the U.S. Forest Service (USFS) Existing Vegetation (EVeg) layers.[5] EVeg layers are mapped using automated and systematic processes which are supplemented with onsite field visits when appropriate. Vegetation types are based on the CALVEG ("Classification and Assessment with Landsat of Visible Ecological Groupings") classification system and forest structural characteristics (i.e., canopy cover and stem diameters).[6] The CALVEG classification system is based on satellite imagery.[7] EVeg layers are updated within CALVEG zones and in different years depending on satellite imagery. The most recent updates were made in 2018.[6]

Calculation Methods and 2021 Figures

Vegetation type was summarized by CWHR lifeform field for each EVeg layer, then summed for a statewide total.

CWHR LIFEFORM	ACRES	PROPORTION
Shrub dominated	18,185,971.17	24.30%
Conifer forest/woodland	18,091,484.24	24.18%
Herbaceous dominated	15,617,041.08	20.87%
Non-vegetated	10,380,830.74	13.87%
Hardwood forest/woodland	9,739,753.58	13.02%
Mixed conifer/hardwood	2,813,956.36	3.76%
Grand Total (Rounded)	74,829,037	100%

Metric 4: Number of housing units in the Wildland-Urban Interface

Metric Description

This figure reports the estimated number of housing units within the Wildland-Urban Interface (WUI) in California as of 2020. Wildfire risk to people and property is elevated in WUI areas due to the presence of wildland fuels (i.e., vegetation).[8] Housing units are defined by the U.S. Census in the following manner:

> "a house, an apartment, a mobile home or trailer, a group of rooms, or a single room that is occupied, or, if vacant, is intended for occupancy as separate living quarters. Separate living quarters are those in which the occupants live separately from any other persons in the building and have direct access from the outside of the building or through a common hall. [...] Both occupied and vacant housing units are included in the housing unit inventory, except that recreational vehicles, boats, vans, tents, railroad cars, and the like are included only if they are occupied as someone's usual place of residence. Vacant mobile homes are included provided they are intended for occupancy on the site where they stand."[9]

Estimates of housing units in the WUI are updated every 10 years using decennial Census data.

Data Source Description

This metric was calculated using data produced by the USFS and University of Wisconsin.[10] This dataset delineates WUI communities per the Federal Register definition.[11] WUI classifications are produced using block level data from the decennial U.S. Census and the National Land Cover Database (2019). Changes in WUI community characteristics are tracked at ten-year intervals, beginning in 1990.[10]

WUI communities are defined by the Federal Register as either intermix or interface. Intermix WUI is "dominated" by wildland vegetation. All Census block housing polygons with >50% wildland vegetation and a minimum of ~6.17 housing units per square kilometer were mapped as such. Interface WUI is defined in the Federal Register as developed areas abutting wildland vegetation and was mapped in the following manner: all block housing polygons with ≥75% wildland vegetation were aggregated into larger, connected areas. A 1.5-mile buffer was applied to any aggregated area >500. Any housing polygon falling inside the vegetation buffer and with a minimum of ~6.17 housing units per square kilometer was assigned to the interface WUI category (unless the area was already identified as intermix WUI).

This metric makes use of a housing unit data field, reported by the U.S. Census. Per the metadata, housing units are preserved as reported. Small counts and Census block data should be interpreted with caution owing to errors introduced by Census-employed statistical techniques designed to preserve privacy.[10]

Calculation Methods and 2021 Figures

From the national dataset, all areas within California identified as WUI in the "WUIFLAG2020" field were selected (non-zero values).[12] The number of housing units was then summed from the relevant field ("HU2020," total housing units).

In 2020, there was a total of 5,102,948 housing units in areas designated as WUI – either intermix or interface. Note that this dataset relies on decennial Census data and, as such, the total is not specific to the year 2021.

Benchmark

The minimum and maximum values for the period of record (1990-2020) would be included with the annual figure as points of reference. The period of record minimum is 3,657,418 housing units in areas designated as WUI in the year 1990. The 2020 value is the maximum for the period of record.

QUESTION 1: HOW IS WILDFIRE IMPACTING LANDSCAPES?

Metric 1: Acres burned (Total; Acres by fire cause, Direct Protection Area, and vegetation type)

Metric Description

Acres burned is one of the most commonly reported statistics related to wildfire impacts. Acreages of individual wildfire incidents reflect all land within the final perimeter, which are calculated in a Geographic Information System (GIS). Acres burned captures all burn severity classes, from unburned to high severity.

Data Source Description

Wildfire acreage data is sourced from the CAL FIRE Fire Perimeters Database, considered to be the most comprehensive data source for wildfire perimeters in the state of California.[13] The database includes information on all fires occurring on Bureau of Land Management (BLM), USFS, and National Park Service (NPS) lands which are at least 10 acres in size. The database also reports on incidents occurring on State Responsibility Area (SRA) lands (lands where the State of California has the primary financial responsibility for the prevention and suppression of wildland fires) which are at least 10 acres in timber (forested) fuel types, 50 acres in brush (shrubland) fuel types, and 300 acres in grass fuel types. The database also reports on incidents occurring on SRA lands which destroy 3 or more habitable structures. The database contains information for the majority of CAL FIRE incident perimeters from 1950 onward. The earliest record in the database is from 1878. The database is updated annually.[13]

Calculation Methods and 2021 Figures

The **total reported acreage (2,511,378)** is derived from the 2021 CAL FIRE Fire Perimeters Database layer in ArcGIS. The values on CAL FIRE's 2021 Incident Archive page and the Stats & Events page (2021 Fire Statistics) conflict with this figure.

Acres by fire cause were derived from the CAL FIRE Fire Perimeters Database. As such, the sum of acres by cause is equal to total acres burned. Total acres burned differs for acres burned by DPA and acres burned by vegetation type because they require combinations of datasets with disparate spatial coverage (see below).

Acres by fire cause:

FIRE CAUSE	ACRES	PROPORTION OF ACRES
Lightning	1,105,483.85	44.02%
Powerline	964,205.63	38.39%
Unknown/unidentified	397,090.85	15.81%
Equipment	20,847.97	0.83%
Arson	9,923.35	0.40%
Miscellaneous	7,739.93	0.31%
Debris	2,001.58	0.08%
Escaped prescribed fire	1,504.52	0.06%
Vehicle	1,359.44	0.05%
Campfire	1,042.88	0.04%
Smoking	124.39	0.005%
Playing with fire	32.10	0.001%
Railroad	18.60	0.001%
Structure	2.88	0.0001%
Grand Total (Rounded)	2,511,378	100%

Acres by DPA were derived from the CAL FIRE Fire Perimeters Database and the Direct Protection Areas for Wildland Fire Protection geodatabase. These two datasets were intersected; the intersecting acreage was calculated and summarized per DPA group (State, Federal, Local). The sum of acres by DPA is approximately 15,000 acres fewer than the total acres burned.

Acres by DPA:

DPA GROUP	ACRES	PROPORTION OF ACRES
Federal	2,202,950.12	88.26%
State	288,781.56	11.57%
Local	4,204.73	0.17%
Grand Total (Rounded)	**2,495,936**	**100%**

Acres by vegetation type were derived from the CAL FIRE Fire Perimeters Database and USFS EVeg layers. Vegetation type was categorized using the CWHR lifeform field. Acreages were evaluated to avoid double-counting in the case of incidents occurring in more than one EVeg zone. The sum of acres burned by vegetation type is approximately 17,000 acres fewer than total acres burned.

Acres by vegetation type:

CWHR LIFEFORM	ACRES	PROPORTION OF ACRES
Conifer forest/woodland	1,646,585.32	66.01%
Shrub dominated	471,413.71	18.90%
Hardwood forest/woodland	150,253.16	6.02%
Mixed conifer/hardwood	101,741.26	4.08%
Herbaceous dominated	76,199.68	3.05%
Non-vegetated	48,193.65	1.93%
Grand Total (Rounded)	2,494,387	100%

Benchmark

A benchmark has not yet been specified for this metric and should consider historical fire severity patterns. It may also be appropriate for the benchmark to incorporate the best available estimates for annual acres burned in the pre-suppression era.[14]

Challenges, Opportunities for Improvement, and Recommendations

CAL FIRE reports several figures related to acres burned in a given year. These figures differ in their inclusion criteria. CAL FIRE considers the Redbook the authoritative source for CAL FIRE SRA wildfires and acres (T. Meyer, personal communication, February 8, 2023). The Redbook does not have a geospatial component. If the Fire Perimeters Database will continue to be used for this metric, it may be useful to compare against burned acre figures reported in the Redbook.

Metric 2: Model-estimated emissions (CO2 and PM2.5)

Metric Description

Model-estimated emissions reflect the consumption of vegetative fuels within wildfire incident perimeters, summed at the state level. Ultimately, burned areas with lesser fuel loading (i.e., density of living and/or dead vegetation) will have fewer emissions. However, several factors impact the magnitude of estimated wildfire emissions. Large fires typically contain a variety of vegetation types within the fire perimeter, each with differential contributions to emissions. For example, forest and woodland vegetation exhibit greater fuel loading per unit area than shrubs or herbaceous vegetation. The magnitude of emissions is also determined by fuel moisture and rates of fuel consumption during burning.[15] The emissions type (CO_2 or particle emissions) depends on the stage of combustion; "flaming" occurs at the fire front and is the phase in which combustion is most complete. "Smoldering" is characterized by the absence of flame. Smoldering may also take place along the fire front in the case of a ground fire, when fuels below the surface layer are being consumed.[16] CO_2 emissions are emitted during both the flaming and smoldering phases of combustion. Particle emissions ($PM_{2.5}$) are typically associated with the smoldering phase of combustion.[15]

Considerable uncertainty is associated with model-estimated emissions due to underlying uncertainties in model inputs. The modeled mass of pollutant species emitted per unit mass of fuel consumed (i.e., emission factor) is a primary contributor. For certain pollutants, uncertainty associated with the emission factor is close to a factor of two. Fuel loading, especially over large areas with heterogenous vegetation types, is also a major contributor. Fuel loading uncertainties can approach an order of magnitude.[15] Users should consider these levels of uncertainty when interpreting model-estimated emissions.

Data Source Description

Annual emission estimates for the period 2000-2021 are produced by the California Air Resources Board (CARB).[15] Emissions are estimated for all fires reported in the CAL FIRE Fire Perimeters Database, and are calculated annually upon release of the Database, typically by July of the following year. Emissions estimations are derived using the First Order Fire Effects Model and consider wildfire perimeters, fuel (vegetation), and fuel moisture. The following factors introduce uncertainties in model estimates: vegetation fuel types, fuel loading, fuel moisture, area burned, fuel consumption in various combustion phases (flaming and smoldering), and emission factors.

Calculation Methods and 2021 Figures

Summary figures for CO_2 and $PM_{2.5}$ emissions are calculated and reported by CARB.

In 2021, CO_2 model-estimated emissions totaled 85.1 million metric tons (MMT).

In 2021, $PM_{2.5}$ model-estimated emissions totaled 1,075 thousand Short tons.

Benchmark

The benchmark for this metric is the median value for CO_2 and $PM_{2.5}$, respectively, for the period of record (2000-2021).

For CO_2 model-estimated emissions, the median value is 13.5 MMT.

For $PM_{2.5}$ model-estimated emissions, the median value is 135 thousand Short tons.

Challenges, Opportunities for Improvement, and Recommendations

There are existing open-source platforms which can produce emissions estimates for years prior to 2000, when official CARB reporting begins. The CARB period of record begins in 2000 in part due to the unavailability of sufficiently fine-scaled input data (i.e., vegetation maps, burned area perimeters, satellite data resolution) in preceding years, impacting the ability to produce reliable model-estimated emissions figures (A. Huang, personal communication, March 7, 2023). As such, estimates from open-source tools for years prior to 2000 have not been incorporated.

METRIC 3: MODELED DEBRIS-FLOW HAZARD

Metric Description

This metric communicates the modeled likelihood of post-fire debris-flows. Post-fire debris-flows are becoming more prevalent as wildfire frequency and urbanization increase. Vegetation loss and hydrophobic soils – in the case of high intensity burning – limit water infiltration, leading to higher volumes of surface runoff, and ultimately increasing the risk of debris-flows. California and other Pacific coastal states are particularly at risk due to a pronounced pattern of heavy seasonal rains arriving soon after the end of a fire season.[17] Wildland fire can greatly impact watershed hydrology, producing flash floods and debris-flows in response to even modest rainstorms.[18] Debris-flows can impact private property as well as roadways, resulting in significant road closures and associated repairs.[17]

The combined hazard value reflected in this metric considers both the probability of debris-flow in response to the modeled event, and the estimated volume of debris-flow volume (0 – 1,000 m^3; 1,000 – 10,000 m^3; 10,000 – 100,000 m^3; >100,000 m^3). The combined hazard is classified to values 1 (low), 2 (moderate), and 3 (high). The highest combined hazard values are assigned to basins with a high probability of occurrence and a large estimated volume of material.[19] The below graphic outlines the values within each of the combined hazard classes (provided by U.S. Geological Survey, USGS).

Likelihood	Volume, in m^3: < 1,000	1,000 - 10,000	10,000 - 100,000	> 100,000
0 - 20%	Low	Low	Moderate	Moderate
20 - 40%	Low	Moderate	Moderate	Moderate
40 - 60%	Moderate	Moderate	Moderate	High
60 - 80%	Moderate	Moderate	High	High
80 - 100%	Moderate	High	High	High

Data Source Description

Data layers are produced by the USGS and depict the modeled probability of debris-flow generation and flow magnitude in recently burned areas in the western U.S., beginning in 2013.[18] Assessments are made per direct requests from Federal, State, and Local agencies or private organizations. Predictions are made both at the drainage basin-scale and along the drainage networks within each basin. The most recent version of the model (2016) uses historical debris-flow occurrence and magnitude data, rainfall storm conditions, terrain, soil information, and burn severity data from recent burns to generate predictions. Models are generated for various rainfall intensities and durations.[19] Where possible, the USGS and its partners conduct field-based evaluations of the accuracy of selected hazard assessments. These evaluations are used to test and subsequently improve models. Calculations utilize the basin-wide predictions for a design storm with a 15-minute peak rainfall intensity of 24 mm/h. This was identified by USGS staff as a reasonable catch-all for a storm with a statewide 1-year recurrence interval (J. Kean, personal communication, January 27, 2023).

Calculation Methods and 2021 Figures

Calculations utilize the combined hazard ratings of basin-wide debris-flow using a 15-minute peak rainfall intensity of 24 mm/h for all analyzed fires occurring within California in the year 2021. For each fire, the total and proportional acreage was summarized by combined hazard rating class (1, 2, 3; low, moderate, high).

In 2021, 1,204,852 acres of the 1,697,212 acres analyzed (71%) have a moderate or high combined hazard rating (i.e., scores of 2 or 3).

Benchmark

The benchmark for this metric is an ideal condition in which the majority of acres analyzed have a low combined hazard rating (value of 1).

Challenges, Opportunities for Improvement, and Recommendations

Previous years should be calculated to allow for trend analysis.

QUESTION 2: HOW IS WILDFIRE IMPACTING ECOLOGICAL RESILIENCE?

Metric 1: Fire severity, area by severity class (basal area loss)

Metric Description

In addition to the extent and spatial pattern of wildfires, the intensity of burning is also extremely important in assessing overall impacts. Wildfire intensity is the rate of heat released by fire, and is measured per unit time and length. Since this metric cannot be measured contemporaneously in all areas of an active wildfire, fire severity is often used as a proxy.[20] Fire severity is defined as the "degree to which a site has been altered or disrupted by fire" and can be measured in terms of impacts to soil, overstory vegetation, or to vegetation in both the understory and overstory.[21,22] "High severity" fire can be defined using various thresholds, and is sometimes defined as fire resulting in >95% canopy cover mortality. In this case, high severity fire is defined as fire resulting in >75% basal area loss (i.e., mortality is estimated as the percent reduction in the per acre area occupied by living trees). While high severity fire is a natural component of fire regimes in fire prone/fire adapted ecosystems, many (regional) studies indicate that the frequency, extent, and contiguity of high severity fire on the landscape is increasing compared to the historic norm.[23]

Data Source Description

Fire severity data for the years 1985-2021 are provided by Joseph Stewart, Postdoctoral Scholar at the University of California (UC) Davis. Fire severity estimates are based on difference-adjusted relativized difference normalized burn ratio (RdNBR). There are three NBR measures which produce estimates of wildfire severity by observing changes in vegetative reflectance of infrared light. The RdNBR produces a severity estimate less biased by pre-fire conditions compared with other NBR measures.[22] RdNBR was calculated using methods modified from Parks et al.[24] Fire perimeters were obtained from CAL FIRE's April 2022 Fire Perimeters Database. Fire severity was measured in terms of percent basal area loss. A function for estimating basal area loss from RdNBR values was fit to data from Miller et al. using quasibinomial logistic regression and applied to the fires.[25] This same data source is used in the California Wildfire & Forest Resilience Task Force (Task Force) Regional Resource Kits. In this dataset, low severity fire is defined as <25% basal area loss, moderate severity fire is defined as 25-75% basal area loss, and high severity fire is defined as >75% basal area loss. These thresholds are calibrated to Miller et al. tree basal area loss data. RdNBR and other thresholds may vary for non-conifer dominated vegetation types.

Calculation Methods and 2021 Figures

Fire severity data were reclassified in ArcGIS into the three fire severity classes. The only adjustment to the thresholding above is that values of 1 are ≤25% basal area loss, as opposed to <25%. This is a function of the ArcGIS tool used. Severity classes were assigned values 1, 2, and 3 for low, moderate, and high severity, respectively. Acreages were calculated by multiplying the percentage in each fire severity class by the total number of acres in the CAL FIRE Fire Perimeters Database, which is the spatial extent of the fire severity layers.

Approximately 819,779 acres burned at low severity (33%)

Approximately 864,607 acres burned at moderate severity (34%)

Approximately 826,991 acres burned at high severity (33%)

Benchmark

The proposed benchmark for this figure would involve assessing fire severity patterns for the period of record (1985-2021) in comparison to estimates of pre-settlement era fire severity and fire return intervals. These estimates are derived from the LANDFIRE Biophysical Settings (BpS) layer. Estimates are organized by Fire Regime Group (FRG) and are summarized below. Note that the LANDFIRE BpS data refers to "high severity" as "replacement fire," and defines replacement fire as >75% average top-kill. Benchmarking the fire severity data source in this manner would require calibration to canopy cover instead of basal area loss. Miller et al. data include canopy cover loss estimates for study plots and should allow for this calibration.

LANDFIRE BPS FIRE REGIME GROUP	% REPLACEMENT FIRE	FIRE RETURN INTERVAL (YEARS)
FRG I-A	<66.7%	0-5
FRG I-B	<66.7%	6-15
FRG I-C	<66.7%	16-35
FRG II-A	>66.7%	0-5
FRG II-B	>66.7%	6-15
FRG II-C	>66.7%	16-35
FRG III-A	<80%	36-100
FRG III-B	<66.7%	101-200
FRG IV-A	>80%	36-100
FRG IV-B	>66.7%	101-200
FRG V-A	Any severity	201-500
FRG V-B	Any severity	501+

Challenges, Opportunities for Improvement, and Recommendations

Ideally, severity patterns would be combined with acres burned in a manner which considers current and past fire severity patterns. This may result in adjustments to the data source and/or the proposed benchmark. FRGs listed above with fire return intervals that exceed the period of record will likely be challenging to benchmark based on available fire severity data. The period of record for these data is constrained by the availability of satellite imagery.

Within forested ecosystems in the Sierra Nevada and portions of northwestern California, it has been reported that the majority (typically 85%) of the area within single 30-meter pixels classified as experiencing ≥90% basal area mortality in actuality had no surviving trees. Often, much of the area classified at lower severities (i.e., ≥50% basal area mortality) is also severely burned and contains few surviving trees.[26] Future iterations of the California's Year in Fire project could report on an alternative high severity class, with a threshold at or above 90% basal area mortality (or the corresponding canopy cover loss value depending on the benchmark data source). This may better represent and communicate the likely ecological outcomes of basal area loss exceeding 75%, at least within large portions of the state. A statewide benchmark corresponding to this high severity threshold has not been identified.

Metric 2: Area in large high severity patches

Metric Description

Recent research indicates that contiguous patches of high severity fire are increasing in occurrence, size, and homogeneity.[27,28] While the occurrence of high severity fire, and high severity patches, are a natural component of fire regimes in various ecosystems across California – forested and non-forested – these recently observed shifts have far-reaching implications. The scale and occurrence of high severity patches can inhibit natural regeneration of conifer species, facilitate vegetative type conversion, and decrease both wildlife habitat and carbon storage. Increasingly large high severity patches also homogenize landscapes. This is especially of consequence in areas where historical fire regimes produced highly heterogenous severity effects, thereby increasing ecosystem resilience to biotic and abiotic stressors.[28] Conversely, high severity fire is essential for the survival and propagation of California's chaparral habitats. One of the primary threats to the survival and integrity of these ecosystems is the preponderance of low and moderate severity fire, which facilitates the invasion of non-native annual grasses. Non-native annual grasses can both outcompete native shrub species and alter fire regimes in a manner that perpetuates their dominance.[29]

Data Source Description

Data layers of distance from high severity patch edge for the years 1985-2021 are provided by Joseph Stewart, Postdoctoral Scholar at UC Davis. Estimates are derived using the aforementioned fire severity raster layers. The high severity patch edge layers are coded with four integer values as follows:

1 = low severity (0-25% basal area loss)

2 = moderate severity (25-75% basal area loss)

3 = high severity (75-100% basal area loss)

4 = high severity (75-100%) basal area loss *and* greater than 120 meters from high severity patch edge. The minimum patch size is 900m^2, represented by a single 30m x 30m pixel.

Calculation Methods and 2021 Figures

High severity patch data is already classified into four classes in ArcGIS. Acreages were calculated by multiplying the percentage in each fire severity class by the total number of acres in the CAL FIRE Fire Perimeters Database, which is the spatial extent of the originating raster layers.

Approximately 292,531 of the 2,511,378 acres analyzed (12%) occurred within a high severity patch more than 120 meters from the patch edge.

Benchmark

The benchmark for this metric is the median for the period of record (1985-2021): 10,394 acres.

Challenges, Opportunities for Improvement, and Recommendations

The benchmark value is an interim suggestion which provides a summary of the trend over time. However, there is likely a more appropriate benchmark for this metric. The natural range of variation for high severity patch size and concentration can differ greatly depending on ecosystem type. The USFS Natural Range of Variation publications for yellow pine and mixed-conifer forests, as well as red fir and subalpine forests – both in the Sierra Nevada and Northwestern California – provide relatively specific estimates for historical occurrence and/or size of high severity patches. Some of this information is derived from qualitative sources.[30–33] However, there are many ecosystems for which this information is not readily available and, as stated above, degradation in some vegetation types may be due in part to a *lack* of high severity fire. It may be appropriate to mask such ecosystems from this calculation; additional research and consultation with experts is needed to make this determination. Note that the current data set includes all fires in the CAL FIRE Fire Perimeters Database, without adjustment for ecosystem suitability of the metric.

Metric 3: High priority acres for post-fire reforestation

Metric Description

Shifts in fire frequency, severity, and size, can impact the ability of conifer forests to naturally regenerate. This is in part due to increases in high severity patch size outside the natural range of variation as observed within the Sierra Nevada, northwestern California, and across much of the state more broadly. These high severity patches inhibit natural conifer regeneration due to seed dispersal distances and other reproductive factors. High severity patches can also become self-reinforcing; particularly in portions of California's montane forests, areas with limited natural conifer regeneration may become dominated by continuous shrub-fields with the potential to support high severity reburning. Persistent conifer regeneration challenges can impact long-term carbon storage, snowpack retention, water quality, and habitat integrity. The USFS' Postfire Restoration Framework for National Forests in California, published in 2021, recognizes the need to prioritize reforestation actions and recommends that users of the Postfire Spatial Conifer Regeneration Prediction Tool (PostCRPT) application – from which this metric's data are sourced – focus on areas with <60% probability of seedling presence after fire. These areas were shown to have seedling stocking rates well below stocking guidelines. This threshold accounts for the need to adjust production-oriented seedling stocking densities to guard against a changing climate and fire risk.[23]

Data Source Description

Data layers of batch-processed conifer regeneration estimates are provided by Joseph Stewart, Postdoctoral Scholar at UC Davis. Estimates were generated using the PostCRPT version 0.125 application. This metric indicates the modeled probability of natural regeneration of conifer seedlings 5 years post-fire within 60 m^2 plots from 2012-2021. The model considers seed availability, burn severity, post-fire precipitation, slope, and equinox solar insolation. Batch processed estimates assumed mean levels of seed production. Where available, these estimates considered average species-specific basal area up to 5 years following fire. When these estimates were not available, composite forest structure maps were used in an attempt to account for the impact of subsequent fires. Topographically downscaled post-fire precipitation was used up to the 2022 water year and assumed to be equivalent to historical mean conditions (1984-2010) for future or incomplete water years.[34,35] The PostCRPT tool was developed for yellow pine, dry mixed-conifer, and moist mixed-conifer forests in California.[23]

Calculation Methods and 2021 Figures

Annual PostCRPT predictions were reclassified in ArcGIS into two classes. The first class represents ≤60% probability of natural conifer regeneration presence 5 years post-fire. Corresponding cells were assigned a value of 0 and designated as "high priority acres" per USFS guidance as above. The second class represents >60% probability of natural conifer regeneration presence 5 years post-fire. Corresponding cells were assigned a value of 1 and designated as "lesser priority." Note that the "high priority" class is inclusive of the 60% value; this is a function of the ArcGIS tool used. For the year 2021, the resulting raster was converted to a polygon and the acreage was calculated, necessitating a coordinate system projection. For all other years, only the proportion of area (pixels) in each severity class was calculated.

Note that, when PostCRPT predictions are generated for individual fires using the web application, the user has the option to apply a conifer mask with the same spatial extent. The conifer mask allows the user to quantify only regeneration predictions in areas classified as a conifer forest type according to the CWHR classifications in EVeg. This estimate has not yet been refined with the use of a conifer mask layer due to the lack of availability of a statewide layer. As such, these figures should be considered an overestimate.

Approximately 55% of acres analyzed in 2021 were designated as "high priority" (1,373,777 of 2,492,837).

YEAR	HIGH PRIORITY ACRES (PERCENT OF TOTAL)	LESSER PRIORITY ACRES (PERCENT OF TOTAL)
2012	74%	26%
2013	61%	39%

YEAR	HIGH PRIORITY ACRES (PERCENT OF TOTAL)	LESSER PRIORITY ACRES (PERCENT OF TOTAL)
2014	48%	52%
2015	47%	53%
2016	84%	16%
2017	81%	19%
2018	68%	32%
2019	94%	6%
2020	68%	32%
2021	55%	45%

Benchmark

The benchmark represents an ideal condition in which less than 50% of the analyzed acres are designated as "high priority" for reforestation.

Challenges, Opportunities for Improvement, and Recommendations

This metric could be cross-referenced with reforestation activities implemented in "high priority" areas, once these figures are available from the Task Force Interagency Tracking System. Note that this would be a retrospective measure and should account for planting in addition to site preparation and release treatments associated with planting. For example, in each year, reforestation related activities having occurred in the 5 years prior to publication could be considered.

The 2019 value was flagged as a potential miscalculation, since the proportion of areas identified as high priority appears high in the context of a relatively mild fire season. A preliminary examination of the data indicated that 2019 outputs are consistent with the conditions where fires occurred. 2019 fire footprints had the lowest mean, 0.75 quantile, and maximum historical precipitation [of the years analyzed]. Of the area burned in 2019, a relatively low proportion was classified as coniferous forest prior to analyzed wildfire incidents. A high proportion of wildfire incidents occurring in arid, non-conifer dominated ecosystems, may have contributed to this high figure (J. Stewart, personal communication, February 25, 2023). Applying the aforementioned vegetation mask should positively impact the accuracy of this figure for all years in the period of record.

Metric 4: Fire Return Interval departure (mean condition class fire return interval since 1970)

Metric Description

This metric represents the degree to which modern (since 1908) fire frequencies are departed from historic (pre-1850) fire frequencies, estimated according to the best available science. The base measure is the Fire Return Interval Departure (FRID), a reflection of the difference between the anticipated fire return interval (FRI) for a given area compared with the modern observed FRI. FRID determinations are based on pre-settlement fire regimes (PFR), which represent a likely historic fire regime. PFRs were developed using a variety of sources (including current vegetation mapping) and expert consultation.

From the FRID values, a Percent FRID (PFRID) value is calculated, which represents the degree of departure from historic fire frequencies as a percent. This percent can be either positive – indicating that fire is occurring less frequently than pre-1850 – or negative – indicating that fire is occurring more frequently. PFRID can either be calculated using 1908 as a base year for current fire return intervals, or using 1970. This metric was calculated using PFRID values with 1970 as a base year. Compared to the 1908 PFRID value, this will amplify difference between NPS and other Federal land holdings since NPS began reintroducing fire in this decade.[36] Also, because FRID and PFRID are based on an average of the period of record, measures with a base year of 1970 are more sensitive to year-to-year changes than the alternative (H. Safford, personal communication, September 20, 2022).

Mean condition class (CC) FRI is a simplified representation of PFRID, in which values are classified into six categories (condition classes) ranging from -3 to 3. Condition classes -3 and 3 represent +/- 67-100% departure from historic fire frequencies. Condition classes -2 and 2 represent +/- 33-67% departure from historic fire frequencies. Condition classes -1 and 1 represent +/- 0-33% departure from historic fire frequencies. There is no zero value.[36]

Data Source Description

Calculations make use of the USFS Region 5 FRID geodatabases.[37] These data reflect information on modern and pre-Euroamerican settlement fire return intervals for major vegetation types on California's National Forests and adjacent land jurisdictions. Fire return intervals are calculated using the CAL FIRE Fire Perimeters Database. The FRID dataset is updated annually in accordance with the CAL FIRE database.[38] The FRID dataset dates back to 1908, including fires >40 hectares (ha) before 1950 [approximately 100 acres] and >4 ha [approximately 10 acres] thereafter (C. Fontenot, personal communication, September 13, 2022).

Calculation Methods and 2021 Figures

USFS FRID layers, organized by region, were combined into one layer. The "Mean CC FRI 1970" field was summarized by acreage and the proportion of acres within each pair of condition classes (i.e., 1 and -1, etc.) was calculated.

There are a significant number of acres with null values (-999) which were not included in the calculation. These values are recorded in areas that are not tracked in CALVEG (used to map vegetation types) or for vegetation codes excluded by FRID (i.e., not dominated by woody plants) (C. Fontenot, personal communication, September 13, 2022).

In 2021, the largest proportion of classified acres (39%) were in condition classes 2 and -2.

CONDITION CLASSES (CC)	PERCENT OF TOTAL ACRES
CC1 and CC-1 (minimal departure)	31%
CC2 and CC-2 (moderate departure)	39%
CC3 and CC-3 (severe departure)	30%

Benchmark

The benchmark for this metric reflects an ideal condition in which the largest proportion of acres would occur in condition classes 1 and -1.

Challenges, Opportunities for Improvement, and Recommendations

Frequent, high severity reburns in conifer-dominated ecosystems – where frequent, low to moderate severity fire was the historic norm – may result in these acres being mapped in increasingly favorable condition classes. This is because the mean CC FRI value considers only fire frequency, and not fire intensity, which may be trending unfavorably. To address this potential issue, future calculations of this metric will eliminate from consideration areas within wildfire perimeters having occurred in conifer-dominated ecosystems within a specified time period (i.e., the last 10 years). Additional research and consultation are needed to further define areas that will be excluded from this metric in future iterations.

Metric 5: Low-lying shrubland resilience (acres potentially at risk in the South Coast ecoregion)

Metric Description

This metric identifies areas where low-lying shrublands in the CALVEG South Coast ecoregion may be at risk of type conversion as a result of repeat fire within short fire return intervals (15 years). A single fire event within a 15-year interval represents overly frequent fire that may lead to vegetation type conversion.

Data Source Description

Data were provided by San Diego State University Connecting Wildlands and Communities (CWC) Project Team.[39] The data depict low-lying shrublands where one or more fire disturbance has occurred per 15-year interval for the years 1950-2021. The low-lying shrubland designation is based on CAL FIRE's fveg vegetation map, and is defined as all entries in the WHRNAME field *except* Montane Chaparral and Montane Riparian that are assigned a "SHRUB" lifeform.[40] These two shrub types are excluded from the dataset because they have shorter fire return intervals than most California shrublands. Note that the fveg layer is produced by CAL FIRE and is not the same as the vegetation layers used for acres burned by vegetation type. Summary figures pertain only to acres within the South Coast CALVEG zone as data developers deemed that this is the most appropriate geographic scope for this metric (E. Conlisk, personal communication, April 11, 2023).

Calculation Methods and 2021 Figures

Summary figures were provided by the CWC Project Team. Area was reported in square kilometers and was converted to acres.

As of 2021, approximately 15% of the acres analyzed have experienced at least 1 disturbance per 15-year interval in the period between 1950 and 2021 (770,421 of 5,260,867 acres).

Benchmark

Areas are designated as potentially at risk if they have experienced at least one fire disturbance per 15-year interval since 1950 (i.e., >0).

Challenges, Opportunities for Improvement, and Recommendations

Summary figures for other ecoregions were provided by the CWC team but have not been incorporated at this time. Further conversation is needed to determine if these figures should be benchmarked differently, or if they simply need additional caveats.

QUESTION 3: WHAT ARE THE SOCIAL IMPACTS OF WILDFIRE?

Metric 1: Total and insured economic losses from wildfire

Metric Description

Total economic losses encompass total direct damage on public and private property and infrastructure resulting from wildfire. Estimates of total economic losses are based on various publicly available sources, or from estimates based on insured losses. The proportion of total economic losses which are insured varies by year. Research indicates that individuals who are insured recover "better and faster" compared to those who are uninsured.[41] Those who are insured are also more likely to rebuild than their uninsured counterparts. The trajectory of individual recovery has ripple effects for communities; research indicates that overall economic recovery progresses more quickly when natural disasters are well insured.[41]

Data Source Description

Data were provided by Aon from Aon's Catastrophe Insight Database for the years 1980-2022. These figures are indexed to 2022 dollars but are not indexed in any way to present day exposure using population and wealth growth (M. Loring, personal communication, January 30, 2023).

Calculation Methods and 2021 Figures

Data were provided as an annual summary for each category: total and insured losses. There are several years with a 0 value in one or both fields.

In 2021, total economic losses from wildfire in California were estimated at $5,077,000,000. Insured losses were estimated at $2,326,000,000. These estimates are in 2022 dollars.

Benchmark

Aon's Head of Catastrophe Insight advised against a trend analysis (i.e., benchmark) for these figures "because the statistic is quite skewed by the extreme loss years 2017, 2018, and 2020" (M. Lorinc, personal communication, January 30, 2023).

Challenges, Opportunities for Improvement, and Recommendations

It would be ideal to provide a justification for years with "0" values in the Aon spreadsheet.

The California Department of Insurance (CDOI) releases data regarding insured losses from wildfire in California. As of May 9, 2023, CDOI data are not available for 2021. In the future, CDOI figures could be compared with Aon data.

Metric 2: Structures damaged or destroyed (total and stratified)

Metric Description

CAL FIRE performs damage inspections during and after wildland fire incidents on SRA lands. There are approximately 1 million residential structures on SRA lands.[42] Structure damage and destruction data is collected by field personnel using a systematic search protocol and is reported in categories for all relevant structures. These categories are as follows:

- No Damage
- Inaccessible
- Affected (1-9%)
- Minor (10-25%)
- Major (26-50%)
- Destroyed (>50%)

For the purposes of this calculation, a structure was considered damaged or destroyed if it was assigned any of the above labels other than “No Damage” or “Inaccessible.” In addition to use in public reporting, data collected during damage inspections is used to analyze the efficacy of fire safe regulations, including California Public Resources Code 4290 and 4291 (Fire Safe Development and Defensible Space, respectively), and California Building Code Chapter 7a (WUI Building Standards).[42]

The number of structures damaged or destroyed is also reported using two stratifications: (1) structure type, which distinguishes residential from non-residential structures, and (2) construction year, which separates structures that were built before or after 2008. In the latter case, 2008 was chosen to delineate the two groups because Chapter 7a of the California Building Code went into effect that year. Chapter 7a requires certain exterior construction materials and methods for the purposes of mitigating wildfire- related structure impacts. Chapter 7a applies to new construction in the WUI and all Fire Hazard Severity Zones within the SRA.[43]

Data Source Description

This metric was calculated using data provided by the CAL FIRE Damage Inspection Program (DINS).[44] DINS data is collected for permanent structures greater than 120 ft^2, and within 100 meters of a fire perimeter, that were impacted by wildland fire in California. Prior to 2018, only those structures that were damaged or destroyed were subject to data collection. Beginning in 2018, the DINS program began collecting information on all non-damaged structures as well. Fires in Local and Federal Responsibility Areas may or may not be included in DINS records.[41] Digital records are available from 2013-2021.

Calculation Methods and 2021 Figures

To calculate the total number of structures damaged and destroyed, records for all years were summed by category in the “Damage” field, considering all but “No Damage,” “Inaccessible,” and other erroneous entries. Entries without specified dates, years, incident names or numbers were removed.

In 2021, 3,535 structures were damaged or destroyed due to wildfire impacts (total).

To calculate the stratified figures, all records matching the aforementioned damage and destruction criteria were summarized by construction year using the “YEARBUILT” field in the DINS database. Any structure built in or after 2008 was classified as “Pre-2008 Construction.” A significant number of entries have no specified construction year (~36%). Similarly, the DINS database “STRUCTURECATEGORY” field was used to classify structures as “Residential” or “Non-Residential.” The following structure types were considered residential: “Mixed commercial/Residential,” “Multiple Residence,” and “Single Residence.” Of the 83,550 records, only 55 entries could not be classified as residential or non-residential. Annual totals for each category (construction year: pre-/post-2008, and structure type: residential/non-residential) were then tabulated.

In 2021, 2,279 residential structures were damaged or destroyed (64%). None of the 2021 database entries contain information on the construction year.

Benchmark

The benchmark for this metric (total value and all stratifications) represents an ideal condition in which no structures are damaged or destroyed.

Challenges, Opportunities for Improvement, and Recommendations

The 2021 total reported here does not match the 2021 total reported by CAL FIRE, either in the 2021 Redbook (3,560) or in the Incident Archives (3,846; 3,560 destroyed and 286 damaged). It is unclear how CAL FIRE defines relevant terms. The Redbook offers the following definition (Table 6):

"Structures Damaged = Residence, commercial property, outbuilding, or other structure that its usefulness or value is impaired

Structures Destroyed = Residence, commercial property, outbuilding, or other structure that is declared unusable"[45]

Metric 3: Fatalities

Metric Description

This metric represents the loss of human life due to direct impacts of wildfire incidents. This metric does not reflect fatalities resulting from smoke impacts or other indirect effects. This metric is reported in terms of civilian and firefighter fatalities where it is possible to make this distinction based on publicly available information.

Data Source Description

The 2021 and benchmark figures are from the CAL FIRE Incident Archive page.[46] The Incident Archives are updated annually and are available from 2013-2022. The U.S. Fire Administration's Firefighter Fatalities in the United States website was used to assess whether any of the 2021 fatalities were firefighter fatalities. No relevant fatality records were found.

Calculation Methods and 2021 Figures

The total number of fatalities displayed on each year's Incident Archive page (2013-2021) was recorded.

In 2021, 3 recorded fatalities occurred as a result of wildfire.

Benchmark

The benchmark for this metric represents an ideal condition in which no fatalities occur in any given year.

Challenges, Opportunities for Improvement, and Recommendations

Values from both the CAL FIRE Redbooks (2008-2021) and Incident Archive pages (2013-2021) were considered. The Redbook lists fatalities for fires ≥300 acres on CAL FIRE, Contract Counties, and other Direct Protection Areas, including Federal. Information is from the Incident Status Summary (ICS-209). The Incident Archives page does not specify inclusion criteria. For 2021, these data sources were in conflict, with the Incident Archives page listing 3 fatalities and the Redbook listing none. CAL FIRE has indicated that the Incident Archives fatalities occurred on fires <300 acres in size. The Redbook distinguishes between firefighter and civilian fatalities and is considered authoritative by CAL FIRE (T. Meyer, personal communication, February 8, 2023).

Metric 4: Number of customers impacted by Public Safety Power Shutoff events (total, medical baseline)

Metric Description

Public Safety Power Shutoff (PSPS) events, also referred to as "proactive de-energizations," are employed by electric investor-owned utilities (IOUs) to mitigate catastrophic wildfire risk associated with the IOU infrastructure. PSPS events are considered a "last resort measure" to reduce said risk. The California Public Utilities Commission (CPUC) oversees these events by establishing rules and regulations governing PSPS events. These rules and regulations attempt to balance the need for wildfire risk reduction with the significant impacts represented by de-energization, many of which also have implications for public health and safety.[47]

Data Source Description

Data for this metric are from the CPUC, which provides an Excel summary of PSPS events from 2013-2022 for PacifiCorp, Pacific Gas and Electric, Southern California Edison, and San Diego Gas & Electric.[48] There is no data for the years 2015 and 2016. The CPUC spreadsheet details PSPS events by circuit de-energized. Multiple circuits can comprise one PSPS "event," per the required IOU reporting. Therefore, no annual count of PSPS events was calculated. IOUs are required to submit a report to the CPUC within 10 days of each PSPS event.[49] "Total customers" encompasses residential, commercial, and other customers and, beginning in 2017, medical baseline customers. Medical baseline customers meet certain medical condition requirements and are billed at their IOU's lowest residential rate.[50]

Calculation Methods and 2021 Figures

Entries for the total number of customers and number of baseline customers in CPUC's PSPS event spreadsheet were summed by year. For entries that were missing an outage end date, the relevant PSPS report was consulted to determine that the event did not occur in more than one year.

In 2021, a total of 288,492 customers were impacted by PSPS events. Of those, 12,218 were medical baseline customers.

Benchmark

The benchmark for this metric is the period of record median for both total and medical baseline customers.

Total customers (2013-2021): 84,565

Medical Baseline customers (2017-2021): 12,218

Challenges, Opportunities for Improvement, and Recommendations

There are other means of characterizing this data set as an alternative or supplementary metric, including the number or duration of PSPS events.

Metric 5: Evacuations (total and by incident)

Metric Description

This metric provides an estimate of the number of individuals who may be impacted or displaced by evacuation orders resulting from wildfire incidents. Evacuation orders are issued when there is an immediate threat to life. Evacuation orders constitute a lawful order to leave the area in which it is issued. Areas under evacuation order are lawfully closed to public access. The figures reported may also reflect areas impacted by evacuation warnings. Evacuation warnings are issued when there is a potential threat to life and/or property. Those requiring additional time to evacuate, including those with pets and livestock, are encouraged to evacuate when warnings are issued.[51]

Data Source Description

2021 evacuation data were provided upon request by the California Governor's Office of Emergency Services (CalOES). Evacuation data are provided to CalOES by individual counties, often either to demonstrate a need for a State Emergency Proclamation or, if a Proclamation already exists, to demonstrate a need for sheltering resources. Only evacuation orders are used to substantiate a need for sheltering. However, evacuation counts may include evacuee estimates resulting from evacuation warnings as well. CalOES does not require that counties report these figures, and there are no inclusion criteria for the data provided.

Evacuation counts are based on the number of households within an evacuation area; this number is then extrapolated to estimate the number of individual people evacuated. This number is not an accurate count of the number of people actually evacuated. Counties may report multiple evacuation figures to CalOES daily; a final figure is determined by the CalOES Warning Center at the close of the day. The same figure may be provided for multiple days in a given county; this may indicate either that the estimate of evacuees has not changed, or that the county has not reported any new evacuation data for the period in question (D. Liu, personal communication, April 11, 2023).

Calculation Methods and 2021 Figures

Summary figures per incident and county were provided by CalOES. Additional daily data was also provided but excluded from consideration as they are not believed to provide a more accurate representation of evacuation impacts (D. Liu, personal communication, April 11, 2023). Summary figures are presented on the following page.

Benchmark

A benchmark has not been developed for this figure; past year's data has not been requested from CalOES.

Challenges, Opportunities for Improvement, and Recommendations

As stated above, there are several caveats involved in presenting this data. It would be ideal to reflect the numbers of individuals actually impacted by evacuations. Data on evacuation shelter use is being sought from the California Department of Social Services, Disaster Services Branch. Per the recommendations of CalOES staff, it may also be useful to conduct an evacuation case study in which evacuation data is requested directly from a subset of counties. CalOES staff are not intimately acquainted with county-level data collection and estimation methods; a case study(ies) may help illuminate how these data are collected and what other information should be considered.

WILDFIRE INCIDENTS

Counties	AN*	CA	CAL	CH	DI	FR	GL	MCC	MCF	MO	RI	RIC	SO	TA	WA	Incident Totals
Alpine			3,359											800		4,159
Amador			3,979													3,979
Butte					119											119
Calaveras															6,603	6,603
El Dorado			53,325													53,325
Kern						7,153										7,153
Lake		700														700
Lassen					5,503											5,503
Nevada											4,298					4,298
Placer											3,000					3,000
Plumas					7,785											7,785
San Ber-nardino													1,040			1,040
San Diego				100												100
Shasta									190							190
Siskiyou	410							145				410				965
Tehama					550				100							650
Trinity									200	4,600		250				5,050
Yuba							500									500
County Totals	410	700	60,663	100	13,957	7,153	500	145	490	4,600	7,298	660	1,040	800	6,603	105,119

*Incident Key:

ABBREVIATION	INCIDENT NAME	ABBREVIATION	INCIDENT NAME	ABBREVIATION	INCIDENT NAME
AN	Antelope	FR	French	RI	River
CA	Cache	GL	Glenn	RIC	River Complex
CAL	Caldor	MCC	McCash	SO	South
CH	Chaparral	MCF	McFarland	TA	Tamarack
DI	Dixie	MO	Monument	WA	Washington

QUESTION 4: WHAT IS THE COST OF WILDFIRE RESPONSE AND RECOVERY?

Metric 1: Fire suppression costs

Metric Description

Annual federal fire suppression costs have increased greatly since 1985.[52] In recent years, this trend has triggered legislative action to limit deleterious impacts to other portions of federal budgets.[53] Fire suppression costs typically include "all costs for the response, including all management and support activities per discipline, agency, or organizational guidance or policy," and are calculated beginning with the initial response.[54] Example costs include: pay for firefighting and support personnel; food, shelter, and supplies; heavy equipment used for ground support; and aviation assets.[17] While fire suppression costs capture much of the immediate investment in wildland fire response, they generally do not include suppression repair or long-term recovery spending.[55] Recent case studies in the western U.S. have demonstrated that these "indirect costs," including losses and mitigation investments, can exceed fire suppression costs for individual wildland fire incidents, sometimes by an order of magnitude.[17]

Data Source Description

Fire suppression data are provided by the NIFC from 2017-2021 and are considered unofficial figures (M. Kepahrt, personal communication, September 7, 2022). Fire suppression costs are derived from the ICS-209, used to report large wildland fires on lands under federal protection or federal ownership. Lands administered by states and other federal cooperators may also report using this system. The ICS-209 is submitted by the agency with protection responsibility for the incident, regardless of land ownership or administration. "Large" fires are defined as being 100 acres or larger in timber and slash fuel types, 300 acres or larger in grass or brush fuel types, or when a Type 1 or Type 2 Incident Management Team is assigned (i.e., wildfire incidents with the highest degrees of complexity). The following wildland fires must be reported in ICS-209:

- Wildland fires managed for full suppression (complete perimeter control) meeting the aforementioned "large fire" criteria
- Wildland fires managed under a Monitor, Confine, or Point Zone Protection management strategy[56]

Calculation Methods and 2021 Figures

For each year, fire suppression estimates provided by NIFC were compared to data from the CAL FIRE Fire Perimeters Database, eliminating duplicates and records with other errors (i.e., mismatches in incident numbers). NIFC suppression cost estimates for individual incidents were considered only if an incident number match could be found in the CAL FIRE database.

In 2021, approximately $2,498,518,822 was spent on fire suppression in California.

A map depicting fire suppression costs statewide, and highlighting the five costliest incidents, is included in the California's Year in Fire 2021 report. All cost figures are derived from the NIFC data set described above. However, minor adjustments were made based on comparisons with the CAL FIRE Fire Perimeters database:

- The Evans and Fly fires appear in the NIFC data set (incident numbers CA-PNF-001358 and CA-PNF-001273, respectively). These fires do not appear as individual incidents in the CAL FIRE Fire Perimeters Database. However, the CAL FIRE entry for the Dixie Fire states that it includes the Evans and Fly fires, with incident number matches. As such, the NIFC cost estimates for these two incidents were included in the annual estimate of fire suppression and were added to the NIFC Dixie Fire cost estimate for the purposes of individual incident cost reporting.
- The Beckwourth Complex appears in the NIFC data set (incident number CA-PNF-001064), but does not appear in the CAL FIRE Fire Perimeters Database. However, the CAL FIRE entry for the Sugar Fire includes "Beckwourth" in the comments. Additionally, the CAL FIRE Incident Archive page for the Beckwourth Complex indicates that it includes the Sugar and Dotta Fires.[57] As such, the NIFC cost estimate for the Beckwourth Complex was included in the annual estimate of fire suppression and represents the Sugar Fire/Beckwourth Complex cost estimate for the purposes of individual incident cost reporting. The CAL FIRE Fire Perimeters Database does not include the Dotta Fire. As such, the NIFC cost estimate for this incident was excluded all fire suppression cost reporting.
- The Colony and Paradise fires appear in the NIFC data set (incident numbers CA-KNP-000116 and CA-KNP-000118, respectively). These fires do not appear as individual incidents in the CAL FIRE Fire Perimeters Database. However, the CAL FIRE entry for the KNP Complex states that it includes both the Colony and Paradise fires, with incident number matches. The NIFC cost estimate is the same for both the Colony and Paradise fires. As such, only one of these values was included in the annual estimate of fire suppression and was added to the NIFC KNP Complex cost estimate for the purposes of individual incident cost reporting.

Benchmark

The benchmark for this metric is the median for the period of record (2017-2021): $236,702,912.

Challenges, Opportunities for Improvement, and Recommendations

It may be possible to consider more incidents reported in the NIFC spreadsheet if data discrepancies could be cleared through CAL FIRE, specifically mismatches in incident numbers which may be attributable to data entry errors. Relatedly, some subjective judgment was applied in determining which incidents should or should not be included. For example, no cost data was considered for duplicate entries with mismatching cost estimates. However, it may be desirable to consider an average, for example. It would be ideal to include as many previous years as possible; additional records have not yet been requested from NIFC.

It may also be desirable to directly compare fire suppression cost estimates provided by NIFC with those produced by CAL FIRE. However, comparisons with CAL FIRE suppression cost estimates are complicated by the fact that CAL FIRE figures account only for CAL FIRE managed incidents costing ≥$25,000 (A. Herring, personal communication, August 22, 2022). Additionally, these figures are reported as a Fiscal Year total, and not by incident or calendar year. It would be beneficial to understand the degree to which CAL FIRE expenditures are reflected in the NIFC suppression cost estimates since ICS-209 reporting is used primarily for incidents occurring on lands under federal protection or ownership.

Finally, for the years 2017-2020, NIFC provided suppression estimates on a per incident basis, either organized by state, or aggregated nationally. The latter were then filtered by state. In 2021, NIFC provided first a report of suppression costs by Geographic Area Coordination Center (GACC) – of which there are two in California – and, at a later date, suppression cost estimates for the entire state. The former was used to calculate suppression costs in 2021. However, the "unfiltered" sum (not cross-referenced with the CAL FIRE Fire Perimeters Database) provided in the GACC report exceeds the corresponding total in the state report by nearly $13 million.

Metric 2: Personnel assigned to wildfire incidents (personnel days)

Metric Description

The Active Incident Resource Summary summarizes total personnel assigned to wildfire incidents on a daily basis in California, including crews, engines, helicopters, and overhead. This figure may include an incidental number of prescribed fire personnel (E. Belval, personal communication, February 1 and 8, 2023). This figure does not represent a count of unique individuals. Thus, this figure can be conceived of as the number of "personnel days" in a given calendar year. This metric represents the use of a subset of fire suppression personnel and does not reflect resource availability. Though there are means of estimating resource availability, there is currently no system of record for tracking supply and demand of suppression resources. However, resources managers may utilize what data does exist to determine the composition and scale of suppression resources.[58]

Data Source Description

Data were provided by the USFS Rocky Mountain Research Station (RMRS) Human Dimensions Program. The data are summarized from the publicly available Incident Management Situation Reports (IMSR), which are produced daily at national Preparedness Level 2 and above, or as warranted by wildland fire activity. The IMSR is produced by the National Interagency Coordination Center, a branch of NIFC. All wildland fire activity information comes from the ICS-209.[59] The provided IMSR data reports on interagency wildland fire personnel *use* by wildfire incident, GACC, and nationally. The Active Incident Resource Summary, which forms the basis of this metric, is available from 2015-2021. This table contains data on all fires, regardless of size, with resources committed and which are reported in the ICS-209 program in the preceding week.[59] These data are not a reflection of data *availability*. This data is a "pre-release" version and will be publicly available upon publication of an associated manuscript. RMRS does not anticipate any changes to this dataset prior to publication (E. Belval, personal communication, January 19, 2023).

Calculation Methods and 2021 Figures

Only entries for the Northern and Southern California GACCs were considered (ONCC and OSCC, respectively). The number of personnel assigned to wildfire incidents ("personnel") was summarized by year.

In 2021, 1,033,015 personnel were assigned to wildfire incidents in California.

Benchmark

The benchmark for this figure is the median for the period of record (2015-2021): 737,657 personnel days.

Challenges, Opportunities for Improvement, and Recommendations

As stated, this metric reports on resource use, which is an imperfect reflection of the intensity (used colloquially) of a given fire year. Research has indicated that resource use may not vary significantly with fire year severity (as represented by Preparedness Levels). Furthermore, the relationship between unmet demand and fire year severity may vary depending on the type of resource (i.e., Type 1 hand crews vs. large and very large airtankers) and geographic region.[58] Supplementary data to the IMSR from the Interagency Resource Ordering Capability (IROC) may be released to UC Berkeley via a Joint Venture Agreement with the USFS, which would allow for additional characterizations (i.e., resource point of origin and personnel classification as overhead or grounds). Ultimately, it would be ideal to characterize both resource use *and* availability. Information on resource orders deemed "unable to fill" can be gleaned from the IROC data, though this is also not a perfect measure of resource availability. Finally, various other representations are possible using the existing data, including a graphic of personnel use by day throughout each year and daily year-to-year comparisons.

Metric 3: Number of days requiring Type 1 and Type 2 Incident Management Teams

Metric Description

Type 1 and Type 2 Incident Management Teams (IMT) respond to complex emergency incidents, including wildland fire, for incident command purposes. The IMT manages operational, logistical, informational, planning, fiscal, community, political, and safety issues connected to these incidents. IMTs are comprised of staff from federal, state, local, tribal, and territorial entities. Type 1 IMTs respond nationally to the wildland fire incidents with the highest degree of complexity. Type 2 IMTs may be assigned to major wildland fire incidents with lower degrees of complexity.60 Incident Complexity levels are defined by the U.S. Fire Administration and range from lowest (5) to highest (1) complexity. Type 3 (and less complex) incidents are considered within the capabilities of local control.[61]

Data Source Description

This metric utilizes the same dataset as above, provided by the USFS RMRS Human Dimensions Program. Type 1 and 2 IMT use is available from 2007-2021. This dataset includes IMT assignments on wildland fires, and no other emergency incidents.

Calculation Methods and 2021 Figures

Only entries for the Northern and Southern California GACCs were considered (ONCC and OSCC, respectively). The number of days with values in both the Type 1 and Type 2 teams' columns was summed by year.

In 2021, there were a total of 122 days in which both Type 1 and Type 2 IMTs were assigned to wildfire incidents.

Benchmark

The benchmark for this metric is the median for the period of record (2007-2021): 64 days.

Challenges, Opportunities for Improvement, and Recommendations

As with the previous metric, this measure captures use, and not availability, of Type 1 and 2 IMTs. Using ICS-209 data, this metric could also characterize the number of unique incidents requiring Type 1 and 2 IMTs. Additionally, ICS-209 data could be used to spatially represent the location of IMT assignments and the fire start date. ICS-209 data is publicly available but has not yet been applied to this metric. Data from IROC could also be evaluated to reflect patterns in Type 1 and Type 2 IMT resource ordering.

Metric 4: State Emergency Proclamations (count)

Metric Description

State Emergency Proclamations are made in response to a situation which overwhelms the ability of local agencies to respond. Gubernatorial State of Emergency Proclamations may be made in areas impacted by natural or man-made disasters and in response to a request by the affected local agency, or when the state finds that the local authority is not equipped to respond to the emergency. This Proclamation provides the Governor with powers under the Emergency Services Act including the ability to provide financial relief under the California Disaster Assistance Act (via the California Governor's Office of

Emergency Services). State Emergency Proclamations are a prerequisite for requesting federal major disaster or emergency declarations.[62]

Data Source Description

Emergency Proclamations made during the current administration are available via Office of the Governor of California website and are available from 2019-2023.[63] Records from the Brown administration are available on an archived website and are available from 2011-2019.[64] Emergency Proclamations were recorded from 2016-2021.

Calculation Methods and 2021 Figures

There does not appear to be a publicly available database of State Emergency Proclamations. As such, each of the aforementioned websites was searched for relevant proclamation entries. Each page is organized by year and by month, with multiple webpages for each month. Each proclamation relating to an individual wildfire(s) was counted. In some cases, this may result in the tabulation of a proclamation made for a singular fire and a subsequent proclamation made for a complex or for a larger region, due in part to that wildfire incident's impact on resource availability, for example. Statewide proclamations made for wildfire preparedness or similar purposes not connected to wildfire incident(s) were not counted toward the annual totals.

In 2021, there were a total of 9 State Emergency Proclamations relating to wildfire incidents.

Benchmark

The benchmark for this metric is the median for the period of record (2016-2021): 7 Emergency Proclamations.

Challenges, Opportunities for Improvement, and Recommendations

There are 5 additional years of Proclamation records which could be incorporated into the benchmark. Proclamations could be represented graphically by month. An official dataset or report should be requested from the state to reduce the likelihood of erroneous reporting.

Metric 5: Federal Disaster Declarations (count)

Metric Description

Federal disaster declarations are made by the Federal Emergency Management Agency (FEMA) in response to natural disasters, including wildfires, when local and state response resources are overwhelmed. FEMA's Fire Management Assistance Grant (FMAG) program is the primary vehicle through which FEMA assists states, tribes, and local governments in their wildfire response. FMAG grants require cost sharing, with FEMA providing a 75% federal cost share. Major disaster and/or emergency declarations may be appropriate for fires with significant costs and impacts that cannot be addressed through the FMAG program. These types of assistance require Presidential declarations. FEMA also provides grants for public assistance, individual assistance, and hazard mitigation, which are administered separately from the FMAG program.[65]

Data Source Description

Federal disaster declarations were recorded from FEMA's Declared Disasters archive webpage.[66] Information on declared disasters can be searched by state and by incident type ("fire"). Data are available from 1956-2022. Cost information is available beginning in 1988.

Calculation Methods and 2021 Figures

Relevant incidents were recorded from the Declared Disasters archive for the years 2016-2020. Disaster type (FMAG, Emergency, Major Disaster Declaration) was also recorded.

In 2021, there were a total of 12 Federal disaster declarations relating to wildfire incidents in California.

Benchmark

The benchmark for this metric is the median for the period of record (2016-2021): 14.5 Disaster Declarations.

Challenges, Opportunities for Improvement, and Recommendations

There are many additional years of disaster declarations which could be incorporated into the benchmark. As above, it would be ideal to work with a summarized dataset.

Metric 6: State clean-up costs eligible for FEMA reimbursement

Metric Description

Following wildfire incidents, California state agencies incur costs related to a variety of debris and hazard tree removal efforts. The Department of Toxic Substances Control (DTSC) assesses and removes household hazardous waste and bulk asbestos from commercial properties and private residential lands (A. Palmer, personal communication, October 18, 2022).[67] The California Department of Transportation (Caltrans) conducts disaster related debris removal, emergency protective measures, and repairs to Caltrans owned assets.68 State agencies may seek partial reimbursement from FEMA for eligible costs incurred during wildfire incidents that have received a federal disaster declaration status (A. Palmer, personal communication, October 24, 2022).

Data Source Description

Data was provided by the DTSC detailing actual and estimated contractor costs, as well as the percent and amount of FEMA reimbursement where applicable, for wildfire incidents from 2017-2021. DTSC reimbursement amounts were either 75% or 90% of total costs, depending on the incident. The California Department of Transportation (Caltrans) provided a summary factsheet with annual FEMA reimbursement amounts from 2017-2021. The Caltrans summary indicates that FEMA can provide 75% reimbursement. Caltrans provided only reimbursement amounts and not total costs incurred by the agency.

Calculation Methods and 2021 Figures

The amount of money DTSC and Caltrans received from FEMA – or were eligible to receive – were combined and summed for the years 2017-2021. Estimates which had not yet been finalized were included in the calculation. In one case, a figure was reported by Caltrans for 2017-2018; this was split evenly between the two years.

In 2021, DTSC and Caltrans received, or were eligible for, approximately $46,778,216 in FEMA reimbursement.

Benchmark

The benchmark for this metric is the median for the period of record (2017-2021): $38,375,242.

Challenges, Opportunities for Improvement, and Recommendations

Given the mismatch in reporting format between Caltrans and DTSC, and the preponderance of estimated costs for both agencies, reporting the amount of state costs eligible for FEMA reimbursement was the simplest representation. With additional quality control and consultation with state agencies, this metric could represent the total amount spent on cleanup costs. However, final figures may not be compatible with an ideal reporting timeframe. Similar data has been requested from CalRecycle, which has not yet finalized 2021 figures.

It may be preferable to characterize state clean-up costs in terms of money allocated by FEMA using publicly accessible records (as in Question 4, Metric 5). However, there are several incidents with potential data discrepancies; FEMA is preparing an official response to questions posed regarding these records.

QUESTION 5: HOW ARE WE ADDRESSING WILDFIRE RISK?

Metric 1: Acres treated with prescribed fire

Metric Description

CAL FIRE defines prescribed fire as "the intentional application of fire to land for wildland management goals, including the prevention of high intensity wildland fires, watershed management, range improvement, vegetation management, forest improvement, wildlife habitat improvement, restoring ecological integrity and resilience, community wildfire protection, carbon resilience, enhancement of culturally important resources, and maintenance of air quality." Any prescribed fire activity which is undertaken for these purposes is considered by state law (Public Resources Code 4491(a)) to be a "public purpose" burn.[69] Prescribed fires are generally conducted in accordance with a written burn plan outlining the conditions within which firing can safely occur. Burn plans evaluate and consider weather (temperature, humidity, wind), vegetation moisture, and smoke dispersal conditions.[70]

Data Source Description

This metric was calculated using the CAL FIRE Fire Perimeters Database following the 2021 update; the period of record is 1900-2021. CAL FIRE maintains records on prescribed fire activities managed by CAL FIRE (including contract counties), BLM, California State Parks, NPS, USFS, and other entities. Treatments include prescribed fires, fire use, machine pile burns, hand pile burns, and jackpot burns as small as <1 acre.[13]

Calculation Methods and 2021 Figures

Acres were summarized by year for the period of record in ArcGIS. Summary statistics were calculated from these values.

In 2021, a total of 75,143 acres were treated with prescribed fire.

Benchmark

The benchmark for this metric is the median for the period of record (1900-2021): 17,042 acres.

Challenges, Opportunities for Improvement, and Recommendations

The CAL FIRE layer used for this calculation also contains a "treated acres" field. The acreages between this and the field used for calculations are not in agreement. The "treated acres" field has a significant number of years with zero values, while the field used for calculations has none. CAL FIRE has indicated that reporting for the "treated acres" value is on a per agency basis. Official CAL FIRE prescribed fire activity is available online. CAL FIRE personnel recommend acquiring prescribed fire records from individual agencies (T. Meyer, personal communication, February 8, 2023). Prescribed fire activity will be incorporated into the Interagency Tracking System; it is anticipated that this system will better reflect prescribed fire activities on private lands. Acres treated and acres treated with prescribed fire can be combined into one metric with the availability of this data.

Additionally, it may be desirable to truncate the period of record for the purposes of calculating a benchmark figure in order to ensure that only years with relatively accurate reporting are included. Additional consultation with CAL FIRE, and potentially other land managers, is required.

Metric 2: Prescribed burn days (average proportion), by season

Metric Description

This dataset reflects prescribed burn days as determined by CARB. Prescribed burn days are those with permissive and marginal determinations. "Permissive" burn days are those in which agricultural burning, including prescribed burning, is not prohibited by the state board (CARB). A "marginal" burn day is one in which the state board does not prohibit limited amounts of agricultural burning, including prescribed burning, with restrictions related to the project, location, and time period. In both cases, burning must be authorized by the relevant Air District consistent with state guidelines.[71] Local Air Quality Districts may override CARB burn day designations based on micrometeorological phenomena and/or highly localized forecasts. Additionally, CAL FIRE may override CARB burn day designations based on factors beyond air quality, for example safety concerns and resource availability. As such, these figures should be considered a maximum (J. Avise, personal communication, January 27, 2023). This dataset defines the "wildfire season" as May 1–October 31, and the "prescribed burn season" as November 1–April 30.

Data Source Description

Summary data were provided by CARB from the Prescribed Fire Incident Reporting System. All CARB burn day designations are made based on meteorological conditions being conducive to reduced smoke impacts.[71] Monthly data related to burn day decisions are available online from 2012-2021. The summary report used for this metric provides data from 2020-2022.

Calculation Method and 2021 Figures

Summary data was provided by CARB.

In 2021, the average (mean) proportion of prescribed burn days across all Air Basins during the prescribed burn season was 92%. During the wildfire season, the mean proportion of prescribed burn days across all Air Basins was 55%.

Benchmark

CARB provided a three-year mean from 2020-2022. The mean proportion of prescribed burn days across all Air Basins during the wildfire season was 63%. During the prescribed burn season, the mean proportion of prescribed burn days across all Air Basins was 91%.

Challenges, Opportunities for Improvement, and Recommendations

Per discussion with CARB, it would be ideal to characterize this figure by Air Basin, rather than as an annual total (J. Avise and G. Vlasek, personal communication, February 3, 2023). This would better reflect geographic differences, some of which are relatively persistent anomalies. For example, Lake County frequently overrides CARB burn day designations. Additionally, San Diego, South Coast, San Joaquin Valley, and the Bay Area complete their own daily burn determinations (J. Avise, personal communication, January 26, 2023). Characterization by Air Basin would be relatively easy to achieve if represented graphically and not as a singular annual summary statistic. Data depicting the number of burn days per month is available online dating back to 2012. It may be desirable to adjust the three-year mean benchmark to increase alignment with other metrics.

Metric 3: Proportion of prescribed burn days in which prescribed burning occurred

Metric Description

This metric reflects the degree to which prescribed fire application and burn day designations are aligned. There are many factors that may prevent prescribed fire treatments from occurring on days with burn day designation, potentially making a 1:1 ratio infeasible. These factors include, but are not limited to, local Air Districts overriding CARB burn day designations, limited availability of prescribed fire personnel, changing weather conditions, and individual burn units being out of prescription.

Data Source Description

Summary data for the year 2021 were provided by CARB from the Prescribed Fire Incident Reporting System (PFIRS). These data were used to identify the unique number of days in which burning occurred in that year. Title 17 of the California Code of Regulations (Title 17) requires that Smoke Management Plans be submitted to local Air District(s) for any burn project greater than 10 acres or expected to produce more than 1 ton of particulate matter.[71] However, PFIRS should not be considered a complete accounting of prescribed fire activity (see Challenges, Opportunities for Improvement, Recommendations)

CARB's Ag & Rx Burn Monthly Decision data for the year 2021 were used to determine the total number of days that year in which some or all Air Basins received burn day designations (permissive and marginal) from CARB.[72]

Calculation Methods and 2021 Figures

Using PFIRS data, the number of acres burned was summed by day for each unique date in the record (n = 261). Of these, there were 9 days on which no burning occurred. The number of days on which burning occurred (n = 252) was compared with the number of days on which some or all Air Basins had a Burn Day declaration for the year of 2021 (n = 364).

In 2021, there were a total of 364 days in which one or more Air Basins received a Burn Day declaration from CARB. Of these, burning occurred on a total of 252 unique days (approximately 69%).

Benchmark

A benchmark has not yet been developed for this metric; additional years of PFIRS data are being prepared by CARB.

Challenges, Opportunities for Improvement, Recommendations

For several reasons, PFIRS is not considered a complete record of prescribed fire activity in the state. Firstly, statutory requirements regarding reporting of prescribed fire activity do not specifically mention the use of PFIRS. Title 17 outlines the minimum threshold for reporting prescribed burns to local Air Districts, as well as the requirement that Air Districts report prescribed fire activity to CARB within 45 days of the end of the calendar year. However, Title 17 does not specify that required reporting be done in PFIRS.[71] As a result, reporting using PFIRS is not enforceable by statute. This lack of enforcement may contribute to an incomplete record of burning activity. Secondly, land managers with large jurisdictions (i.e., USFS units) may span multiple Air Districts with differing reporting requirements. This may lead to inaccurate or incomplete reporting (J. Branz, personal communication, April 28, 2023).

As outlined in the Metric Description section above, the number of days in which some or all Air Basins received a burn day designation from CARB should be considered a maximum possible value, which does not account for factors that may decrease the number of days in which burning is feasible or desirable given local conditions.

It may be desirable to report this information on a per Air Basin and/or seasonal basis, with seasons defined as in Question 5, Metric 2 above. In this case, a spatial representation would likely be preferable, as a summary figure pertaining to each Air Basin could be difficult to interpret.

The annual treated acreage reported using PFIRS (69,405) does not match the treated acreage reported in the CAL FIRE Fire Perimeters Database (75,143). It would be ideal to use the same data source for this and Question 5, Metric 1 (Acres treated with prescribed fire). Additional consultation with CARB and CAL FIRE is needed.

Metric 4: Count of newly approved and renewed Firewise Communities

Metric Description

The Firewise USA® program is administered by the National Fire Protection Association (NFPA), the USFS, and National Association of State Foresters. The Firewise USA® program is a collaborative framework aimed at organizing private citizens to make their homes and communities more resistant to ignition, and to reduce wildfire risks locally. Neighborhoods or communities can be recognized as part of the Firewise USA® program provided that they annually meet a set of voluntary criteria and remain "In Good Standing." NFPA maintains data on Firewise Communities nationally.

Data Source Description

Data was provided by the NFPA for the state of California for the years 2002-2022 (partial). The provided spreadsheet details community names, status ("Good Standing," "Archived," and "Inactive"), and approval and renewal dates. Communities move to "Inactive" after one year of not completing the renewal application, then to "Archived" after two years. "Archived" communities also includes those that start, but do not finish, the application process. Participating communities are required to renew annually to remain in "Good Standing" (M. Fitzgerald-McGowan, personal communication, August 25, 2022).

Calculation Methods and 2021 Figures

The NFPA spreadsheet was summarized by count of newly approved and renewed communities by year. Summary figures are only for those communities in "Good Standing." 2022 data was excluded from the calculation. Some years do not have any renewal data (2002, 2005, 2007-2008, 2010, 2012). This is because participating communities were not required to renew at this point in the program (M. Fitzgerald-McGowan, personal communication, January 19, 2023).

In 2021, the Firewise USA® program approved 114 new Firewise Communities. An additional 375 were renewed.

Benchmark

The benchmark for this metric is the median for the period of record for newly approved and renewed communities, respectively.

Median value for newly approved Firewise communities (2002-2021): 17

Median value for Firewise community renewals (2007-2021): 2

Challenges, Opportunities for Improvement, Recommendations

These data could be summarized by County to view trends on a coarser geographic scale and allow for geospatial representation.

Metric 5: CAL FIRE Defensible Space inspection compliance rate (SRA only)

Metric Description

Per Government Code 51182, any person who "leases, controls, operates, or maintains an occupied dwelling or structure in, upon, or adjoining a mountainous area; forest-, shrub-, or grass-covered land, or land that is covered with flammable material; and is within a very high Fire Hazard Severity Zone designated by the local agency" must maintain 100 feet of defensible space from their property line to their dwelling, in each direction. The amount of fuel modification necessary to comply with these restrictions depends on the flammability of the structure as determined by building materials, location, and vegetation. It is required that vegetation be managed "such that a wildfire burning under average weather conditions would be unlikely to ignite the structure."[73]

CAL FIRE enforces state defensible space requirements in the SRA. Within the SRA, 768,000 parcels are subject to defensible space inspections. CAL FIRE's goal is to inspect each of these parcels once every three years. In six contract counties, the local fire agency is responsible for these inspections. There is no centralized collection or reporting of activities undertaken in the Local Responsibility Area or by other agencies in the SRA. Though authorized to enforce defensible space regulations, there is generally no requirement that state and local agencies conduct enforcement or that homeowner compliance be verified (i.e., via inspections).[74]

Data Source Description

Defensible Space inspection data were provided by CAL FIRE for the years 2016-2021. In addition to the compliance status and recorded violations (as applicable), the data indicate the following for each property: the CAL FIRE unit conducting the inspection, the community and county within which the inspection occurred, the Fire Hazard Severity Zone rating for the property in question, and several fields related to home hardening information (i.e., roof construction material, presence or absence of vent screens, exterior siding material, etc.).

State and local agencies vary in their inspection process and inspection rates vary considerably by CAL FIRE unit. Some parcels may be inspected multiple times within a year so inspection rates may overrepresent unique, annual inspection rates.[74] Unique inspections are not identified in the data source used for this metric.

Calculation Methods and 2021 Figures

The number of compliant inspections were summarized by year for each year of data provided by CAL FIRE. In some years, the "Inspection Status" field contains multiple potentially relevant labels (i.e., "Compliant," "1st compliant," "Compliant6mon1year," etc.). All labels indicating some manner of compliance were considered in the calculation of the compliance rate.

In 2021, the compliance rate for CAL FIRE Defensible Space inspections in the SRA was 88% (approximately 149,991 compliant inspections of a total of 170,098).

Benchmark

The benchmark for this metric is the median compliance rate for the period of record (2016-2021): 83%.

Challenges, Opportunities for Improvement, and Recommendations

As previously mentioned, there are multiple labels indicating compliance in the CAL FIRE data. It is unclear whether this is because the same property was inspected more than once in the same year, or whether a serial label (i.e., "2nd compliant") could reflect compliance status from a previous year. It is also unclear whether a property would have a 2nd (or 3rd) inspection only because it was found to be non-compliant during the first inspection, or whether there might be other reasons for repeat inspections (assuming inspections are occurring more than once every three years). CAL FIRE has been contacted for clarity on these topics. Additionally, these figures do not represent defensible space inspections or compliance in Local or Federal Responsibility Areas. Should this metric be included in future iterations of the California's Year in Fire project, relevant agencies would need to be contacted for similar information.

LIST OF ACRONYMS - APPENDIX B

BLM: Bureau of Land Management

BpS: Biophysical Settings

CalOES: California Governor's Office of Emergency Services

CALVEG: Classification and Assessment with Landsat of Visible Groupings

CARB: California Air Resources Board

CC: Condition Class

CDOI: California Department of Insurance

CPUC: California Public Utilities Commission

CWC: Connecting Wildlands and Communities Project Team

CWHR: California Wildlife Habitat Relationships

DINS: Damage Inspection

DPA: Direct Protection Area

DTSC: Department of Toxic Substances Control

FEMA: Federal Emergency Management Agency

FMAG: Fire Management Assistance Grant

FRG: Fire Regime Group

FRI: Fire Return Interval

FRID: Fire Return Interval Departure

GACC: Geographic Area Coordination Center

GIS: Geographic Information System

ICS: Incident Status Summary

IMSR: Incident Management Situation Reports

IMT: Incident Management Team

IOU: Investor-Owned Utilities

IROC: Interagency Resource Ordering Capability

MMT: Million Metric Tons

NBR: Normalized Burn Ratio

NFPA: National Fire Protection Association

NIFC: National Interagency Fire Center

NPS: National Park Service

ONCC: Northern California Geographic Area Coordination Center

OSCC: Southern California Geographic Area Coordination Center

PFIRS: Prescribed Fire Incident Reporting System

PFR: Pre-settlement Fire Regime

PFRID: Percent Fire Return Interval Departure

PL: Preparedness Levels

PostCRPT: Postfire Conifer Reforestation Planning Tool

PSPS: Public Safety Power Shutoff

PSW: Pacific Southwest Research Station

RMRS: Rocky Mountain Research Station

SRA: State Responsibility Area

UC: University of California

USFS: U.S. Forest Service

USGS: U.S. Geological Survey

WUI: Wildland-Urban Interface

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