Spring 5-21-2022

Assessing the Efficacy of California's Wildfire and Forest Resilience Action Plan

Chloe Nelson
cnelson9@dons.usfca.edu

This Master's Project

Assessing the Efficacy of California's Wildfire and Forest Resilience Action Plan

By

Chloe Nelson

is submitted in partial fulfillment of the requirements
for the degree of:

**Master of Science
in
Environmental Management**

at the

University of San Francisco

Submitted: Received:

_____   _____
Chloe Nelson   Date   Stephanie Siehr, Ph.D.   Date

Table of Contents

List of Tables

List of Figures

List of Appendices

Acknowledgements

Abstract

California's wildfire threat eclipses current forestry management and wildfire mitigation strategies in place to protect people, infrastructure, and the natural environment. Climate change escalates wildfire risks with declining water supply coupled with hotter, drier conditions. *California's Wildfire and Forest Resilience Action Plan* attempts to integrate and build upon previously successful wildfire resilience plans to amplify the scale and pace of the state's land management and community protections. This research assesses the plan's efficacy to respond to the growing wildfire threat. This study investigates if there is equitable planning for the needs of high-wildfire risk groups living in the WUI and on tribal lands. It also compares the plan structure and initial implementation against a wildfire & forestry management planning framework to determine its potential for success. Lastly, this study reviews the forestry-, community-, economy-, and technology-focused actions against the Arup City Resilience Framework to identify strengths and opportunities for a resilient wildfire management approach. Land treatment and resident outreach and education efforts planned for WUI areas target the key protective needs for those communities. Most work to improve training, grant funding, and partnership opportunities for Native American Indigenous communities is structured through federal and state approval systems. To make wildfire management practices more equitable, more authoritative power should be given to Tribal leadership and traditional ecological knowledge (TEK) should be meaningfully integrated into prescribed fire training and goals. The structure of the *Action Plan* satisfies all planning criteria, but the development of the proposed Forest & Wildland Stewardship Interagency Tracking System will enhance consistency, transparency, and accountability of progress reporting and accessibility. The key actions fulfill Arup's twelve resilience dimensions, but a gap analysis identifies opportunity for future planning to build upon safeguards to human health. State facilitation of county-level emergency plan sharing will strengthen multi-jurisdictional coordination and instill a shared sense of ownership in building California's wildfire resilience.

1. Introduction

California is heralded as a national leader in proactive climate change policy but adverse impacts from climate change and buildup of dead biomass from years of fire suppression endanger the state to devastating wildfire events (Little Hoover Commission, 2018). Significant climate impacts include higher temperatures, more frequent droughts, and decreased water availability from snowpacks and precipitation events (CNRA, 2018). The combination of these climate conditions with years of restrictions on prescribed fires, and the spread of invasive forest insects and pathogens exacerbate the intensity and frequency of wildfires (Auer, 2021).

In 2020, California experienced five of its six largest wildfires to date (Figure 1) (Auer, 2021). Those fires doubled the previous state annual record of burned acreage after consuming over four million total acres (FMTF, 2021). The wildfires in the first seven months of 2021 outpaced the previous year when 4,599 fires burned through 73,472 acres compared to 2020's 3,847 fires across 31,104 acres, respectively (Auer, 2021). Four decades of California wildfire data show that wildfire events are increasing in size and pace in both forested spaces and in populated wildland-urban interface (WUI) zones (Buechi et. al, 2021). Instead of isolated destructive events, California fires are now a growing trend for which previous management strategies are insufficient.
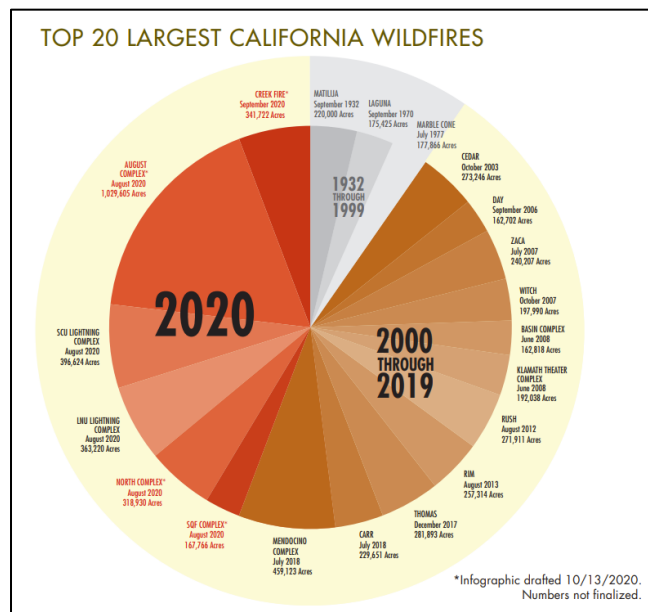
Figure 1 (from FMTF, 2021). California's 20 largest wildfires by acreage burned.

Historically, California's wildfire protection plans have focused primarily on fire suppression (FMTF, 2021). While this strategy along with forest thinning are important tools that benefit forest health, decades of these practices have resulted in accumulations of woody biomass that pose hazards as fuel for wildfires. The strategies in most state and agency level wildfire plans range from building fire resilience to documenting ongoing wildfire management efforts and recommending climate change protections (State Board of Forestry and Fire Protection, 2018; Natural Resources Agency, 2018). While various plans have been published, none have adequately implemented prevention, mitigation, and response actions large enough to meet the scale of the current wildfire crisis.

Landcare management in California requires different approaches tailored to the state's varied topography, diversity of natural landscapes, and distributions of growing populations in urban, rural, and WUI areas. California's vegetative terrain is divided into three main categories: forest, grassland & woodland, and chaparral & shrublands (Little Hoover Commission, 2018; Bohlman et. al, 2018). Tools like mechanical thinning impact the wildfire resilience of a conifer forest ecosystem differently than shrubland, also influenced by historical land care management in each location and ongoing maintenance. Many of California's larger wildfires occurred in the Sierra headwater forests where tree distribution is dense and prone to higher intensity fires but competing wildfire risks are increasing with more people moving to and building in WUI zones (Auer, 2021). Over the past decade, population growth and rising costs of living in cities like San Francisco and Los Angeles influenced the expansion of people out of urban areas. In more recent years, job loss and economic struggles resultant from the Covid-19 pandemic forced further migration out of cities and for others, the global pandemic provided more flexible remote working privileges which supported relocation into more rural and WUI areas (Auer, 2021). The proximity of infrastructure built close to denser vegetation WUI zones than in urban environments poses greater wildfire hazards. Housing growth adds this stressor to California's wildfire management and emphasizes the importance of resilience building strategies like early community preparedness and home hardening (Kramer et. al, 2019).

Another challenge to the implementation of wildfire mitigation of California's vast terrains and demographics is the distribution of land ownership and governance. Federal

agencies own 57% of the 33 million acres of forested land in California, followed by 40% private ownership, and only 3% by the state (Figure 2) (Little Hoover Commission, 2018). State agencies work to protect roughly 13.3 million acres of forested land, but only own 1.1 million of them (FMTF, 2021). While forestry management is critical at all land stewardship levels, it usually falls to city, county, and local stakeholder involvement to education and adapt community developments (Kramer et. al, 2019). Effective wildfire prevention and mitigation requires strong institutional connections acting at multiple levels. To facilitate coordination of efforts, the "Agreement for Shared Stewardship of California's Forest and Rangelands" was created by the State of California and the U.S. Forest Service (USFS) in August of 2020. A core action in this agreement is the shared commitment to expand vegetation treatment of forested land to a total of one million acres per year by 2025 (USFS, 2020b). In order to accomplish this goal, assistance must be extended past current levels to private landowners to incorporate more of their distribution of forested land treated. The state is responsible for half of the Shared Stewardship Agreement goal and currently private landowners contribute only 250,000-300,000 acres to the 500,000-treatment goal (FMTF, 2021). State assistance programs like the California Forest Improvement Program (CFIP) and the Wildfire Resilience Program have provided some funding for private landowners, but state funding is limited (FMTF, 2021).

Figure 2 (from Little Hoover Commission, 2018). Federal, state, private, and tribal ownership distributions of forested land.

Horizontal governance is crucial to scale up California's wildfire defenses and stewardship action at every level must be considered through an equitable lens. Strategies like prescribed burning are being incorporated into forestry management after decades of harmful fire suppression by the USFS and the California Department of Forestry and Fire Prevention (CAL FIRE). USFS banned controlled burning in 1850 as part of European colonization restricting the movements and traditions of Indigenous communities (Brown et al. 2020). Controlled burns are traditional governance practices aimed to preserve and protect native ecosystems. California has a long history of environmental injustices against Indigenous communities, and it was not until the 1990s that fire policies and restrictions started to shift (Marks-Block and Tripp, 2021). As recently as January 1st, 2021, California passed Senate Bill 332 into effect to provide liability protections from damages for public agencies and private landowners when facilitating lawfully prescribed burns (SB-332, 2021). California government's forestry management policies disrupted traditional land care management practices in place. Current and future partnerships, programs, and management strategies must put equity at the forefront.

To attempt to scale up and quicken the response to California's complex climate change and wildfire problems, the California Forest Management Task Force combined previous state and federal recommendations and expanded upon them to create *California's Wildfire*

and Forest Resilience Action Plan. The *Action Plan* provides a collaborative approach to building forest and community resilience amidst increased frequency of high-intensity wildfires (FMTF, 2021). This integrative framework identifies 99 Key Actions that address forest health projects, community protections, and progress and partnerships (Appendix A). The *Action Plan* provides a roadmap for mitigation and resilience building strategies for federal, state, private, and tribal ownership throughout the state.

1.1. Wildfire Resilience and Mitigation

The main goal of the *Action Plan* is to amplify the scale and pace of wildfire resilience and mitigation strategies in California. Resilience building requires the overlap of preventative action on multiple levels as opposed to emergency responses and adaptation. One definition states that resilience "determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling, 1973). In the context of this research, wildfire resilience for California requires an understanding of vulnerability to known climate risks and the ability to anticipate future risks and implement strategies that minimize and mitigate harm to natural environments and socio-economic standings of vulnerable communities. Existing progress has been made through investments of hiring more seasonal firefighters, updating supplies and fire fighting vehicles, and dedicating budgetary resources for future fire seasons (FMTF, 2021). These actions dominantly support wildfire response and adaptation to the problem whereas the newly proposed actions focus on implementing longer term solutions to diminish the problem. Successful wildfire resilience must holistically address ecological, social, and economic needs to meets its target objectives.

1.2. Research Questions

The main objective of this research is to examine the strategies proposed in the *Wildfire and Forest Resilience Action Plan* and assess whether the framework adequately and equitably addresses critical components necessary to build California's wildfire resilience and respond to current wildfire problems. Key categories of focus are on forestry management projects, community protections and preparations, and economic opportunities. This assessment reviews proposed partnerships and actions taken to protect infrastructure, vulnerable and marginalized communities, and natural ecosystems from the impacts of wildfires, assesses whether those strategies adequately address the scale of the climate and wildfire problems, and provides

recommendations on what additional approaches are needed. To achieve these objectives, the main research question of this study is:

To what degree do the key actions in California's Wildfire and Forest Resilience Action Plan reduce wildfire risks, improve forest health, and build climate resilience?

The scope of this action plan considers California's landscape diversity, tribal land assistance, and fire hazards increasing in WUI zones. Billions of dollars are currently being allocated for wildfire management distribution across these areas of focus. The USDA Forest Service spends the most of its budget on annual wildfire management (USFS, 2020a). The FY 2021 budget justification allocated $2.4 billion for wildfire management out of a total budget of $5.3 billion (USFS, 2020a). Additional consideration is needed to ensure equitable allocation of funding for community preparedness of Indigenous communities and populations in high-risk areas. These groups are disproportionately impacted by the shocks and stressors of wildfires. Land care management and community preparedness needs change from urban cities to communities living in WUI or on tribal lands. To better understand the needs of these higher risk groups and whether the *Action Plan* includes sufficient resilience features for them, the sub-question in chapter 4 of this study examines:

Does the Action Plan present equitable protections for the most vulnerable communities affected by wildfires, people in the WUI and on Tribal lands?

To evaluate the potential for success, the analysis in chapter 5 compares the outlined wildfire and forestry management goals, implementation, and monitoring in the *Action Plan* against an evaluative management planning framework to determine the following sub-question:

Does the Action Plan fulfill the nine criteria elements of an effective wildfire and forestry management plan?

The comparison of the *Action Plan* against the Arup Resilience Framework in chapter 6's analysis investigates:

Which resilience drivers are the most robustly addressed in the Action Plan? Are all twelve drivers designed for?

And finally, in the chapter 7 gap analysis the last sub-question assesses:

What gaps exist in the proposed wildfire resilience strategies?

The sub-questions from each chapter of analysis investigate different facets critical to the overall efficacy of the *Action Plan*. The results of these sections tie back into the main research question of this research and identify potential areas for further governance, resource allocation, or other considerations.

1.3. Report Overview

From here, chapter 2 of this report reviews current climate change impacts that influence wildfire needs and response strategies. Changes in air pollution, temperature, available water supply, and the cumulative effects of wildfires impact both natural and human environments. Then it details the distinct types of territory distributions throughout California. Section 2.2 describes California's varied landscapes, population demographics, and land ownership divisions. Characteristics such as terrain diversity, population migration, and built infrastructure influence wildfire conditions. Wildfire risks vary between terrains depending on vegetation types, built infrastructure, and the relative intersection between urban and natural environments.

The third chapter summarizes methodology used to analyze the *Action Plan*. The methods section outlines the goals of the four chapters of analysis starting with an environmental justice (EJ) narrative analysis, a descriptive case study evaluation against a planning framework, a qualitative assessment comparison to twelve drivers of resilience in the Arup City Resilience Framework, and a gap analysis against Arup's seven qualities of a resilient system. In the EJ chapter (Ch.4), this research discusses equity needs for vulnerable groups in the WUI and restorative justice considerations for Indigenous communities on tribal lands. The descriptive case study analysis (Ch. 5) outlines the main components of *California's Wildfire and Forest Resilience Action Plan* and assesses them against a modified planning framework. The Arup Framework is used for the last two chapters of analysis for the resilience assessment (Ch. 6) and the gap analysis (Ch.7). These chapters of analysis highlight gaps in proposed resilience strategies that drive the

recommendations of this research. This research proposes actionable recommendations from the analysis and ends with suggested next steps from the author and from the guidance documents.

2. Literature Review

2.1. Climate Change Impacts

Climate change amplifies the risk of intense wildfires in California. Climate impacts are already evident in California and projections predict increases in impacts moving forward. A resilient California can respond to changing climate conditions and maintain critical ecosystem and essential services (CNRA, 2019). Climate change is a global disturbance and its impacts related to air quality, heat, drought, water, and wildfires are evident in human and natural systems in California.

2.1.1 Air Quality

Air pollution is one of the most serious indirect health effects of climate change. Greenhouse gas emissions (GHGs) including carbon dioxide, methane, nitrous oxides (N_2O), along with volatile organic compounds (VOCs), nitrogen oxides (NO_x), and particulate matter (PM) interact to make potentially dangerous compounds that pose public health risks (Watts et. al, 2015). While climate impacts are not directly due to GHG emissions, hotter conditions and changed wind patterns from climate change have a synergistic relationship with GHG emissions and favor formation of ground-level ozone (EPA, 2022).

Particulate matter and ground-level ozone are two of the six "criteria air pollutants" listed in the Clean Air Act (CAA) with national ambient air quality standards (NAAQS) to control outdoor air levels due to their adverse health impacts (Samet & Krewski, 2006). Particulate matter pollution poses a significant health risk due to its ability to be inhaled past natural filtration processes and settle deep into the lungs, posing cancerous, cardiovascular, and respiratory threats (Kinney, 2008). Exposure to ground-level ozone, produced from photochemical oxidation of VOCs and NO_x gases, can cause respiratory distress by causing airway muscles to constrict (Samet & Krewski, 2006; Jacob and Winner, 2009). Population growth and migration into WUI zones in California increased air pollutant emissions from industrial facilities and transportation exhaust (Hurteau et. al, 2014). Air pollution impacts disproportionately affect disadvantaged communities and individuals with pre-existing

respiratory and cardiovascular conditions. Over 90% of Californians are exposed to unhealthy levels of one or more air pollutants annually (CARB, 2021).

To curb GHG emissions, the California Global Warming Solutions Act (AB-32) was passed in 2006 to aim to reduce state emissions to 1990 levels by 2020 and 80% below 1990 levels by 2050 (CARB, 2021). Wildfires complicate these emissions reduction efforts through a positive feedback loop from emissions exacerbating wildfire impacts and resultant wildfires adding to air pollution when they burn. Cumulative CO_2 emissions increase the total burned acreage in wildfires (Franco et. al, 2018). Each burn event contributes concentrations of particulate matter into the atmosphere. During the Northern California Camp Fire in 2018, ultrafine PM with 2.5 micrometer or smaller diameters exceeded three times the average levels measured from 2010-2017 (CARB, 2021; Rooney et. al, 2020).

Wildfire emissions models for California project increased particulate releases over the 21st century. Integrating wildfire records, population trends, hydrological research, and other land-use data for six future climate scenario models, all outcomes predict wildfire emission increases of total particulate matter (TPM) (Figure 3). The greatest emissions are likely to occur in Sierra Nevada and other dominantly forested parts of northern California with carbon-dense fuels (Hurteau et. al, 2014). TPM increases are expected to increase 19-101% above baseline levels, depending on the climate scenario model, regardless of wildfire low, mid, or high wildfire severity classification (Figure 3).
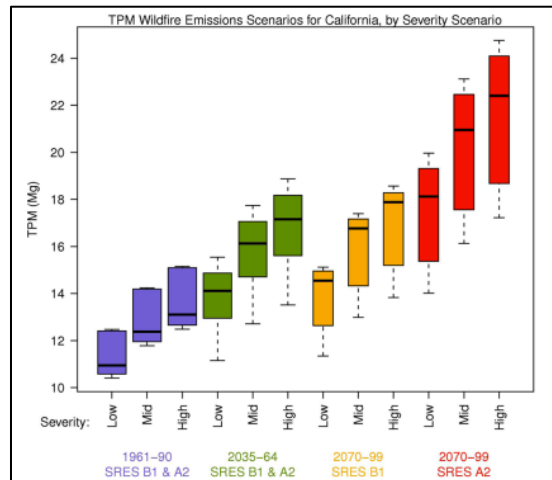

Figure 3 (from Hurteau et. al, 2014). Total wildfire particulate matter emission projections by burn severity.

GHG emissions also play a cyclical role in rising temperatures by trapping heat in the atmosphere. This warming leads to increased ground-level ozone pollution which influence the duration of pollen seasons and resultant ambient allergen concentrations (Jacob and Winner, 2009). Current day temperatures are higher throughout California, with most regions exceeding 1ºF and southern areas exceeding 2ºF compared to average temperatures from 1901-1960 (Figure 4).
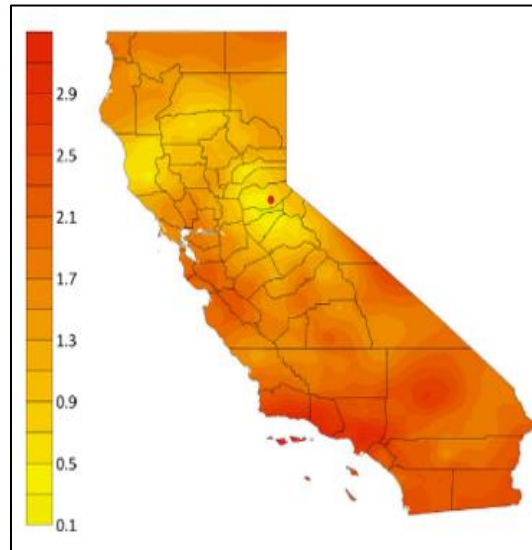
Figure 4 (Bedsworth et. al, 2018). Annual temperature increases (ºF) across California comparing present day averages from 1986-2016 to averages from 1901-1960.

The transient climate response to cumulative carbon emissions (TCRE) quantifies the correlation between global CO_2 emissions and temperature change. Modeling projections using historical state temperature averages estimate a positive trend between the two over time (Figure 5). The representative concentration pathway (RCP) 8.5 for a high emission scenario and RCP 4.5 for long-term global emissions reduction scenario both project temperature increases of 4°C and 2°C, respectively, for California over the rest of the 21st century (Figure 5).
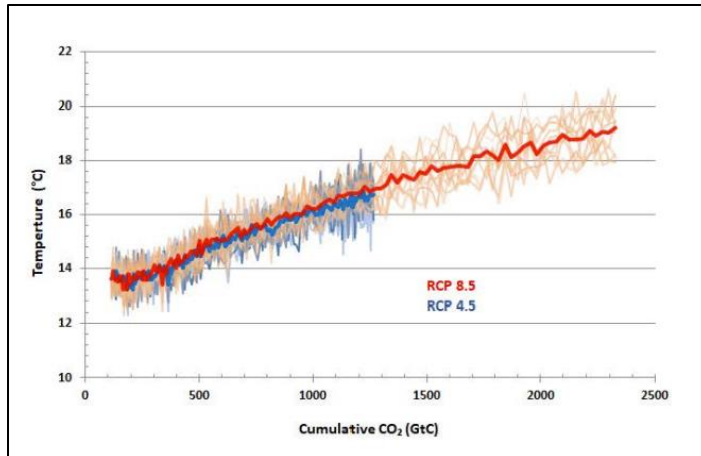
Figure 5 (from Franco et. al, 2018). RCP 4.5 and 8.5
model projections of average annual temperature increases
in California.

Warming temperatures have significant climate impacts on humans and the natural
environment. California suffers from a combination of increasing average annual temperatures
and increasing intermittent extreme heat events that pose public health risks and affect drought
conditions throughout the state.

2.1.2 Heat & Drought

2.1.2.1 Health Hazards

California is affected by the cumulative impacts of rising temperatures and reduced
annual precipitation. The combination of these effects intensifies heat events and prolongs multi-
year drought conditions. 2014-2018 and 2020 were California's six warmest years since 1895,
which also broke the record for the highest number of extremely hot days at 100°F or higher
(Frankson et. al, 2022). Exposure to extreme heat events adversely affects public health.
Heatwaves are the leading cause of weather-related death in the United States (Luber and
McGeehin, 2008). Extreme temperatures contribute to urban heat islands which trap hot air in
densely built city environments and can differ in temperature up to 5°C hotter in Californian
cities (Taha, 2017). These conditions perpetuate heat related emissions and air quality decline.

2.1.2.2 Precipitation

California's seasonality naturally has a wet winter and dry summer. Climatic warming
impacts annual precipitation levels. Hotter temperatures increase the rate of moisture evaporation
into the air. Warmer air can hold more water, leading to heavier precipitation events during the
wet season (Davenport et. al, 2019). Rising temperatures affect the amount and form of

precipitation as rainfall or snowfall. Warming raises the lowest elevation where snow falls, reducing the size of snowpack and resultant amount of water it can store. This also shifts the likelihood to more precipitation falling as rain (Change and Bonnette, 2016; Liu et. al, 2021). Heavier rainfall events can overwhelm soil absorption, surface water capacity, and cause extreme flooding (Liu et. al, 2021).

Hotter weather also causes faster snowmelt. Increased runoff from snowmelt adds to winter flood risks and reduces available water supply for reservoir refill during dry summer months (Liu et. al, 2021). California experienced its hottest drought from 2012-2016 during which the snow water equivalent (SWE) in the Sierra Nevada snowpack reached a low of 5% its historical average (Belmecheri et. al, 2016). While atmospheric river events helped restore snow cover in subsequent post-drought years, 2/3 of snowpack runoff is projected to decline by 2100 due to reduced snowfall and continued heat stress (Berg and Hall, 2017).

California relies on snowpack melt for roughly 30% of the state's fresh water supply (Dettinger & Anderson, 2015). This water is relied upon for wildlife and urban needs, but the greatest demand comes from agriculture. California uses 80% of its annual water supply to produce two thirds of the country's fruit and nut produce and one third of its vegetables (Pathak et. al, 2018). Reduced water availability coupled with drier soil conditions threaten production yields for this national supply. 2022 is the driest year to date of the past 128 years with drought frequency projected to increase (Chang and Bonnette, 2016; NOAA, 2022). Every county is currently experiencing some level of drought ranging from moderate to extreme (Figure 6). All of California is impacted by moderate drought conditions which include lower water levels in stock ponds and creeks, stunted dryland pasture growth, and the need for earlier irrigation in landscaped areas including the need for earlier irrigation interventions for landscaped areas (NOAA, 2022). The next level of severe drought covers most of the state, involving a prolonged and higher intensity fire season, stressed trees, insufficient grazing land, and more wildlife disease (Figure 6) (NOAA, 2022). 40.3% of California is currently categorized by extreme drought conditions (Figure 6). These areas experience a year-long fire season with fires occurring in historically wet regions and water scarcity issues coupled with early agricultural irrigation intervention needs (NOAA, 2022).
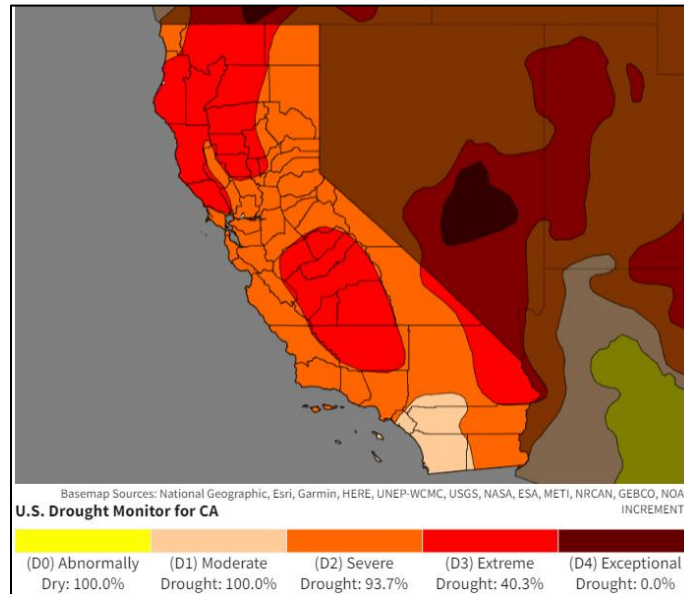
Figure 6 (from NOAA, 2022). U.S. Drought Monitor
conditions for California as of 4/4/22.

California's 2012-2015 drought resulted in mass pine tree mortality. Drought stress impacts a tree's ability to produce the sap that emits a protective barrier to bark beetle infestation (Robbins et. al, 2021). During drought conditions, 48.9% of ponderosa pine trees died in the central and southern Sierra Nevada because of bark beetles burrowing into bark, sapping out nutrients, and laying eggs (Fettig et. al, 2018). The aftermath of bark beetle outbreaks transforms healthy mixed-conifer forests into swaths of dead wildfire fuels.

2.1.3 Wildfire

Concurrent with climate change factors amplifying wildfire conditions, recent years of peak catastrophic burning heighten the current and future wildfire threat. Half of California's 10 largest wildfires occurred in 2020 (Table 1). In 2021 the Dixie Fire, the state's largest single fire, burned almost one million acres (Table 1). The largest fire in state history was the August Complex Fire in 2020, made up of thirty-eight individual fires which cumulatively burned over one million acres (Table 1). These megafires are more destructive to people and property and burn at higher severities than historical wildfires (Keeley and Syphard, 2021).

Table 1 (from CAL FIRE, 2022a). California's top 20 largest wildfires.

	FIRE NAME (CAUSE)	DATE	COUNTY	ACRES	STRUCTURES	DEATHS
1	AUGUST COMPLEX (Lightning)	August 2020	Mendocino, Humboldt, Trinity, Tehama, Glenn, & Colusa	1,032,648	935	1
2	DIXIE (Powerlines)	July 2021	Butte, Plumas, Lassen, Shasta & Tehama	963,309	1,329	1
3	MENDOCINO COMPLEX (Human Related)	July 2018	Colusa, Lake, Mendocino & Glenn	459,123	280	1
4	SCU LIGHTNING COMPLEX (Lightning)	August 2020	Stanislaus, Santa Clara, Alameda, Contra Costa, & San Joaquin	396,624	222	0
5	CREEK (Undetermined)	September 2020	Fresno & Madera	379,895	853	0
6	LNU LIGHTNING COMPLEX (Lightning/Arson)	August 2020	Napa, Solano, Sonoma, Yolo, Lake, & Colusa	363,220	1,491	6
7	NORTH COMPLEX (Lightning)	August 2020	Butte, Plumas & Yuba	318,935	2,352	15
8	THOMAS (Powerlines)	December 2017	Ventura & Santa Barbara	281,893	1,063	2
9	CEDAR (Human Related)	October 2003	San Diego	273,246	2,820	15
10	RUSH (Lightning)	August 2012	Lassen	271,911 CA / 43,666 NV	0	0
11	RIM (Human Related)	August 2013	Tuolumne	257,314	112	0
12	ZACA (Human Related)	July 2007	Santa Barbara	240,207	1	0
13	CARR (Human Related)	July 2018	Shasta County & Trinity	229,651	1,614	8
14	MONUMENT (Lightning)	July 2021	Trinity	223,124	50	0
15	CALDOR (Human Releated)	August 2021	Alpine, Amador, & El Dorado	221,835	1,003	1
16	MATILIJA (Undetermined)	September 1932	Ventura	220,000	0	0
17	RIVER COMPLEX (Lightning)	July 2021	Siskiyou & Trinity	199,343	122	0
18	WITCH (Powerlines)	October 2007	San Diego	197,990	1,650	2
19	KLAMATH THEATER COMPLEX (Lightning)	June 2008	Siskiyou	192,038	0	2
20	MARBLE CONE (Lightning)	July 1977	Monterey	177,866	0	0

Fire season is starting earlier and ending later with more frequent and severe burning, reducing recovery time, and disturbing the capacity for ecosystem regeneration (Westerling et. al, 2006). "Good fire" burns at low or moderate severity levels which help forest systems clear out underbrush and help trees thrive, but current wildfires are burning at high severity levels resulting larger overstory tree kill (Stephens et. al, 2013). Faster regrowth of shrubs and grasses combined with downed post-fire trees generate new quick-burning fuel loads which increase the chances of successive re-burn (Stephens et. al, 2013; Keane et. al, 2008). 85% of California's wildfires are ignited by human activity and once an area burns, the landscape regeneration characteristics increase the likelihood of a re-burn happening through the same area (Short, 2021; Brown and Johnstone, 2011).

2.2. California Territory Distributions

2.2.1 Landscape Diversity

A combination of forests, valleys, mountains, deserts, and coastal regions comprise California's natural landscape. The state can be generally categorized into four areas: Coastal Inland, Sierra-Cascade-Inyo, Northern, and Southern (Figure 7).
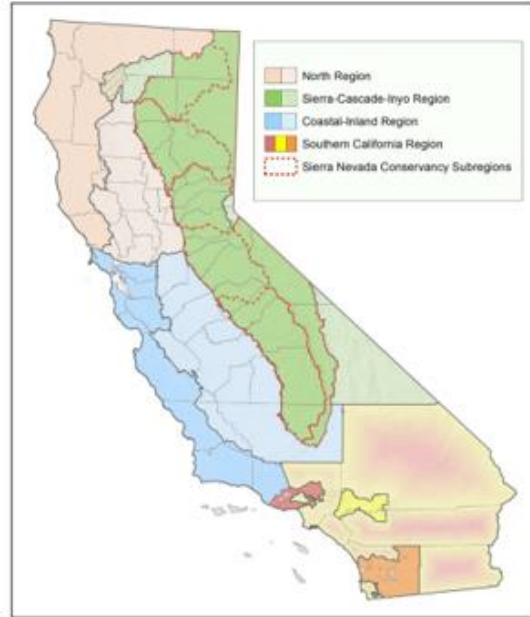
Figure 7 (from FTM, 2021). Location map of
California's four dominant regions.

Factors like vegetation type, human habitation and infrastructure development,
microclimate, and ecosystem biodiversity influence respective wildfire susceptibility and burn
severity levels. The variation in regional characteristics require location-specific land care
management strategies to mitigate wildfire risks.

2.2.1.1 Coastal Inland

The coastal inland encompasses twenty-one counties which cover California's Central
Valley and central coastal bioregions (Figure 8). 13.4 million Californian's live in this region
with greater population densities in San Francisco, Alameda, San Mateo, and San Joaquin
(FMTF, 2021). The flat inland valley acts as a main agricultural hub for the state and includes
the Bay-Delta estuary system (Parker and Boyer, 2019). The Delta provides water to more than
twenty-five million people and three million acres of agricultural land in addition to being home
to various plant and wildlife ecosystems (Kimmerer, 2019). These resources are critical to
protect as almost 90% of California's wetlands and riparian habitats have been vitiated (Lenihan
et. al, 2003).

Figure 8 (from FMTF, 2021). California's Coastal Inland region.

The coastal territory is vegetated with grassland and scrub-covered chaparral ecosystems, with conifer forests further outland (FMTF, 2021). Chaparral regions are naturally adapted to seasonal drought conditions and require intermittent fires for health, but the increased frequency and severity of recent wildfires threaten species regeneration and recovery (Syphard et. al, 2018; Underwood et. al, 2021). Chaparral is the predominant ecosystem throughout the state, but increased wildfire disturbances occurring more frequently than the natural chaparral regime frequency of 30-130 years is driving vegetation type conversion from woody shrubland to ephemeral plants and invasive grasses (Syphard et. al, 2018). Grass and forb cover have higher flammability than chaparral. Vegetation type conversion alters the regional fire regime and threatens native biodiversity.

Targeted management needs in this region include community protections for more densely populated areas and vegetation management treatments to maintain fire-adapted ecosystems. Community protections include plans for evacuation routes, coordinating regional fire action plans, and predesignating emergency shelters (FMTF, 2021). Landcare management strategies range from monitoring activities like vegetation mapping and landowner forest management plans to applied treatments of fuel breaks and managed wildfire (FMTF, 2021). These actions help to build resilience in fire-adapted ecosystems.

2.2.1.2 Sierra-Cascade-Inyo

A trio of mountain ranges characterize the eastern Sierra-Cascade-Inyo region (Figure Y). While home to only 4.1 million Californians, thirty million rely on its headwaters (FMTF, 2021). The forests across this area accounts for 44.6% of California's carbon sinks (Glenn et. al, 208). The Sierra Nevada Mountains, spanning ~400 miles in the southern part of this section, ranges in land cover type depending on elevation level. Vegetation starts as grasses and woodlands in low valleys to sloped chaparral terrain into conifer forests and alpine meadows at snow line altitudes (Boisramé et. al, 2017). The northern area of the Sierra-Cascade-Inyo region also ranges in elevation with flat basins and mountains, but the Southern Cascade Range and Modoc Plateau bioregion differs with majority coverage of pine forest and desert flora (Miller and Safford, 2012).

Figure 9 (from FMTF, 2021). California's Sierra-Cascade-Inyo region.

The Sierra Nevada region alone makes up 44% of California's high fire risk, contains 60% of animal species, and covers 25% of the state (Sierra Nevada Conservancy, n.d.). In the past century of wildfire seasons in Sierra Nevada, only six fires burned more than 200,000 acres. All six fires occurred in the last decade, four of which happened 2020-2021 (Sierra Nevada Conservancy, n.d.). Fire severity shifted from low to moderate in the 1800's when First Nations practiced prescribed burning and other land stewardship practices in Sierra Nevada to higher after decades of small tree and undergrowth fuel build up. The lack of ongoing forest

management was reflected in 2021's fire season with over eighteen times the expected average of high-severity wildfire including the Dixie and Caldor fires burning across the east, top ridge, and west sides of Sierra Nevada forests for the first time (Wise, 2021; CAL FIRE, 2022b).

High-severity burns combined with the increasing impacts of climate change destroy ecosystems and threaten the integrity of snowpack and watershed storage in the Sierra-Cascade-Inyo area. The change in burn intensity is resulting in vegetation type conversion throughout this region where natural reforestation is hindered and beginning to transition from forest to shrubs (Stephens et. al, 2020). Vegetation management practices including tree thinning, prescribed burning, grazing, and mitigation of tree death are critical to protect and preserve this region. Broadcast seeding in high severity burned areas promote forest regeneration and reduce likelihood of vegetation conversion (Paudel et. al, 2022; North et. al, 2019)..

2.2.1.3 Northern

The Northern region starts at the northern Stateline and extend south as far as Solano, Sonoma, and Sacramento counties (Figure 10). This region is dominated by a combination of forest types which comprise 41.8% of the state's total forest carbon sinks (FMTF, 2021). This area only contains 4.5 million in human population, but it contains immense biodiversity with coastal redwood and Douglas fir forests along the coast that transition into a mix of chaparral, oak-woodland savanna, conifer, and evergreen forests (FMTF, 2021). Freshwater ecosystems run through these forests and provide habitat for threatened and endangered species of steelhead trout and coho salmon (Deitch et. al, 2018).

Figure 10 (from FMTF, 2021). California's
Northern region.

This region receives over 90% of annual rainfall in winter months followed by drought conditions in the summer with corresponding higher wildfire risk levels during the dry season (Deitch et. al, 2018). This region historically experienced wildfire in varied intervals depending terrestrial ecosystem type, with intervals of five years or less in woodland savanna and larger periods up to 250 years in evergreen and subalpine forests (FMTF, 2021). Indigenous burning before European colonization throughout this region helped maintain forest health resulting in lower intensity fires. Cultural burning allowed for broader ecosystem diversity development (FMTF, 2021; Long et. al, 2021).

Reinstating prescribed burning throughout this region with additional vegetation management practices of forest thinning and biomass removal support forest health. Watershed restoration and invasive species eradication promote ecosystem biodiversity and help protect water quality (Reilly et. al, 2020; Rhoades et. al, 2019).

2.2.1.4 Southern

The Southern region covers the southern cap of California (Figure 11). Almost a quarter of this region's more than twenty-two million people live in the state's first and second most populous cities, Los Angeles and San Diego (Jin et. al, 2015). These heavily developed urban environments experience semi-arid and desert climates with territories spanning the Sonoran, Mojave, and Colorado deserts (FMTF, 2021).

Figure 11 (from FMTF, 2021). California's
Southern region.

Southern California's fire regime fluctuates between hot, dry summers with high fire risk and the onset of warm Santa Ana winds (SAWs) in winter months which warm airmass over the San Gabriel mountains and fan out wildfires that burn in the WUI (Jin et. al, 2015; Aguilera et. al, 2021). The northeastern movement of offshore SAWs drive wildfire spread along the coastal plains and across mountainous microclimates while fire patterns further inland are more heavily influenced by vegetation distribution and type (Aguilera et. al, 2021). Most Southern California fuel types are quick burning grasses, shrubs, and chaparral fuels (FMTF, 2021). SAW fires have shorter and more intense impacts to densely populated coastal cities than the longer burning wildfires further inland in less populated areas, but these fire regimes may shift with eastern WUI expansion (Jin et. al, 2015).

Community protective measures are critical to building wildfire resilience in the Southern region. Proactive ignition preventions in developed areas and home hardening build community preparedness and resilience (FMTF, 2021). Targeted vegetation management to control canopy loss, reduce invasive species, and restore conifer and chaparral populations influence wildfire burn severity and spread patterns (Mathews and Kinoshita, 2021). Performed concurrently, these preventative and ongoing maintenance strategies reduce wildfire risks.

2.2.2 Land Ownership

While California can be divided into the North, Sierra-Cascade-Inyo, Coastal-Inland, and Southern regions, ownership of those lands follow different boundary designations. California

lands are owned and managed by federal, state, and private entities. Figure 12 identifies the distribution of land owned by federal and state agencies throughout California. Non-highlighted areas represent private ownership (Figure 12).
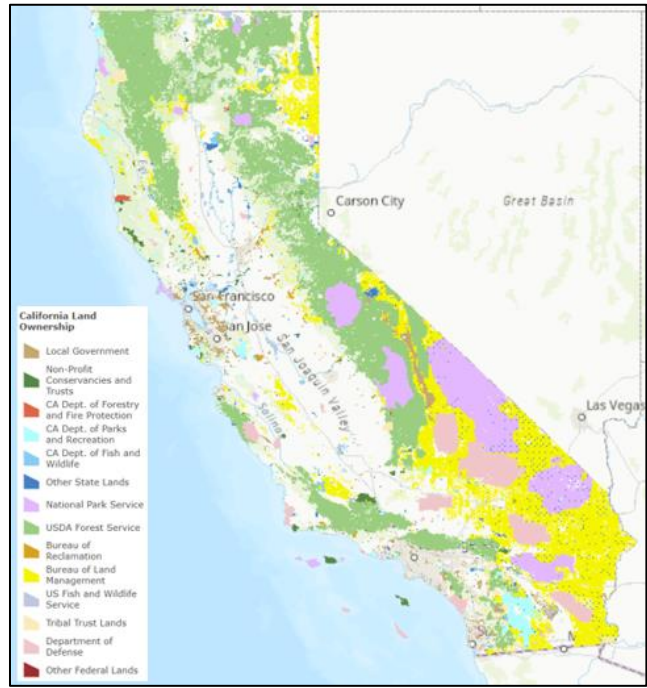
Figure 12 (from CAL FIRE, 2021a). Multi-source land ownership in California.

Roughly one third of California's over 104 million acres are forested. Of those 33 million forested acres, federal agencies own 57%, state agencies own 3%, and private ownership accounts for the remaining 40% (FMTF, 2021). Despite vast differences in the amounts of land owned by federal, state, and private entities, all three share the responsibilities of forest management and work together in cross-boundary collaborations for wildland fire protection (Figure 13).

Figure 13 (CAL FIRE, 2021b). Statewide responsibility areas for fire protection.

CAL FIRE leads state efforts and holds responsibility for fire protection within State Responsibility Areas (SRAs) which cover 56 of 58 state counties across more than 31 million acres (CAL FIRE, 2022c). Collective governance accomplished through variations of federal, state, and private partnerships coordinate statewide action and strengthen wildfire resilience.

2.2.1.1 Federal

The United States Forest Service (USFS) and the Department of the Interior lead federal forestry management for the 19 million acres of national forests in California (USFS, 2022). DOI is comprised of four agencies: the Bureau of Land Management (BLM), the Bureau of Indian Affairs (BIA), the National Park Service (NPS), and the U.S. Fish and Wildlife Service (FWS). USFS owns and manages the largest percentage of national forests at 20%, followed by the BLM with 14% land ownership, NPS at 7.3%, and the Department of Defense (DOD) covering 3.7% (CRS, 2020). These agencies work on land treatments like fuels reductions projects and work with agencies from other sector agencies to update tracking efforts like the California Air Resources Board (CARB) Prescribed Fire Information Reporting System (PFIRS) (WFRTF, 2022d). Other agencies like the Natural Resource Conservation Service (NRCS) provide opportunities like the Environmental Quality Incentives Program (EQIP) which provides technical and financial assistance to participants to plan and execute controlled burns (WFRTF, 2022d; Ferranto et. al, 2011). USFS works with CAL FIRE at the state level in a substantial

collaboration to match each other's 500,000-acre goal of treated forest land by 2025 through the Shared Stewardship Agreement (FMTF, 2021).

2.2.1.2 State

Although the state owns just over one million acres of California's forests, it must provide fire protection for more than thirteen million acres of total forested land. California's Department of Parks and Recreation (State parks) 1.3% of the state's total 3% ownership, the most of any individual state level agency (CAL FIRE, 2021a). CAL FIRE leads state wildfire prevention and forestry management efforts through treating lands, developing grant programs for forest managers, and partnering with federal and private owners. One million of state-owned forests are located in areas designated as high risk for uncontrolled wildfire (CAL FIRE, 2022c). CAL FIRE and state agencies like the California Natural Resources Agency plan and regulate land care management through programs like the Regional Forest and Fire Capacity Program (RFFC) and the California Vegetation Treatment Program (CalVTP) (FMTF, 2021). CAL FIRE increased prescribed fire and forest thinning treatments by 20,000 acres in 2020 compared to 2016 levels (FMTF, 2021).

Wildfire prevention at the state level has more direct engagement with local communities and private landowners. In addition to land treatments, CAL FIRE's fire-related education and prevention programs build community preparedness and reduce fire risks. This work includes inspecting defensible spaces, providing fire prevention education, and mapping and planning emergency evacuations and fire hazard severity zones (FMTF, 2021).

2.2.1.3 Private

Of the 40% of privately owned forested land in California, 14% is owned by timber companies and the other two thirds by non-industrial private forest landowners (NIPFs) (USDA, n.d.). Private landowners currently manage up to 300,000 acres of California's forests which contribute acreage towards the state's half of the Shared Stewardship treatment goal of a net one million acres by 2025 (FMTF, 2021). Federal and state agencies have partnered with private timber companies to work towards restoration goals, especially in regions where decades of fire suppression resulted in overgrown forests. Certified foresters submit timber harvesting plans (THPs) through a permitting process to obtain private timberland management approval in

California (Kelly and Kusel, 2015). Timber harvesting is one strategy that can aid in wildfire risk reduction through targeted species removal and fuels reduction practices.

Family-owned private forests cover roughly seven million acres in California (USDA, n.d.). State governance assistance programs like the California Forest Improvement Program (CFIP) and Wildfire Resilience Program are available for NIPFs to implement projects that improve forest health and reduce fire risks (Ferranto et. al, 2011). These programs provide the technical and financial assistance for private landowners to improve community wildfire preparedness and reduce megafire risks at the local level.

2.2.1.4 Tribal

Tribal lands are categorized as "trust lands" owned by the federal government and subject to federal laws in addition to tribal laws (Baldy, 2013). The nearly 100 reservations on which the 109 federally recognized tribes in California are situated on account for less than 1% of California's total land (Figure 14) (EPA, 2021). Historically, Indigenous communities shaped California's fire regimes with land management applications derived from Traditional Ecological Knowledge (TEK) and Traditional Fire Knowledge (TFK) (Huffman, 2013). Colonizers forced Native people off their lands, which created barriers to ancestral lands that still exist today. Fire exclusion policies were implemented in 1850, resulting in a century of fire suppression in place of fuels regulation, resource management, and habitation protections throughout most of the state's forested areas (Marks-Block and Tripp, 2021; Long et. al, 2021). NPS was the first agency to re-introduce prescribed fire into California's forestry management in 1968, concurrent with the beginning of megafires (Fillmore et. al, 2021; Agee and Skinner, 2005). It was not until the 2000's that policies started reflecting these changes, starting with federal wildland fire policy listing both "planned fire" and fire suppression as main management tools on federal lands in 2001 (Fillmore et. al, 2021). Despite current day agreement that prescribed fire is needed, its application is constrained for all levels of fire managers.

Figure 14 (from EPA, 2021). California tribal lands and reservations.

On federally owned reservations, the BIA requires tribes to have certified fire practitioner training and approved written burn plans before any practices can be implemented (BIA, 2021). Despite regulatory hurdles including burn permits, air quality permits, and NEPA/CEQA environmental review compliance, cultural fire practitioners are working to expand prescribed burning to revitalize their culture and sovereignty (Russell et. al, 2021). The Yurok and Karuk Tribes in northwestern California started developing Climate Adaptation plans which include tribal history and cultural connections to land to impart TEK to non-native people. Since 2013, they lead annual Prescribed Fire Training Exchanges (TREX) in their territories in collaboration with The Nature Conservancy and government agencies (Marks-Block et. al, 2021; Spencer et. al, 2015). This burning reduces Douglas Fir encroachment on oak woodlands and prairies which reduces fuel loads and reduces wildfire risks to nearby homes and infrastructure (Marks-Block et. al, 2021).

The Karuk Tribe and USFS have cooperated in planning and conducting cultural burns on federal lands, including combining fire crews for the first time in 2016 with a Memorandum

of Understanding (MOU) (FMTF, 2021). The MOU served as an agreement between Karuk and federal governments that allowed the Tribe to burn in ancestral land, but it took multiple years to establish. Despite these examples of successful partnerships, the successive burdens placed on Native people to accommodate federal requirements threatens Tribal sovereignty. To distribute authoritative power, grassroots initiatives like the Indigenous Peoples Burning Network (IPBN) were created, originally formed in 2015 between the Yurok, Karuk, and Hoopa Tribes, to prioritize Indigenous leadership, provide community support network, and decentralize burning practices (IPBN, 2021). IPBN has found greater success in Yurok territory where some parts of reservation are retained by Tribal members over others with more land dispossession.

3. Methodology

This research includes four types of analysis: an environmental justice focused narrative analysis, a descriptive case study of *California's Wildfire and Forest Resilience Action Plan* compared against a modified evaluative planning framework, a resiliency assessment assessing the *Action Plan* against the twelve drivers identified in the Arup City Resilience framework, and a gap analysis also utilizing the ARUP framework. The *Action Plan* attempts to integrate and improve upon resilience qualities from previous state and federal plans to help achieve resilience goals, address acute shocks and chronic stresses, and establish a robust system that will not break down. This research assesses the efficacy of the *Action Plan* by using four methods of analysis to identify areas where additional planning, governance, or resources are warranted. This research determines whether the combined strategies adequately compensate for what they previously individually lacked in both land care management and equitable community protections.

3.1. Environmental Justice Narrative Analysis

The first area of focus for this research is a narrative analysis of environmental justice considerations for two groups most vulnerable to wildfire threats, those in wilderness-urban interface areas and Indigenous communities. Narrative analysis is qualitative methodology that focuses on a topic and researches its background and current day contexts from case studies, interviews, surveys, or observations (Webster & Mertova, 2007). This chapter of analysis (Ch. 4) reviews the background and current day context to evaluate why there are higher risks for these

two groups, what the community protection needs are for these at-risk groups, and whether there are equitable protections proposed for each in the *Action Plan*.

3.2. Descriptive Case Study & Plan Evaluation

The second chapter of analysis (Ch. 5) outlines the proposed goals listed in the four main divisions of the *Action Plan* as a descriptive case study and evaluates its composition against a modified evaluative framework derived from the EPA's *Handbook for Developing Watershed Plans to Restore and Protect our Waters*. A descriptive case study in this evaluative research describes the various management interventions laid out in the *Action Plan* ranging from land treatments, educational outreach, monitoring technologies, and collaborative partnerships. This content addresses how the Task Force plans to address the key drivers of devastating fires, enhance the speed and extent of forest management, and build resilience for vulnerable communities. Since this document is still in the planning and initial implementation stages since its date of publication in January 2021, there are limited measurable outcomes for the plan's proposed actions. To assess the likelihood of success of the *Action Plan*, criteria from the EPA's watershed planning handbook were adapted for utilization as an evaluative framework for effective wildfire and forestry management.

The EPA's *Handbook* was published this handbook in 2008 to provide an analytic framework for the development and implementation of watershed plans. The handbook identifies nine minimum elements considered most critical to the preparation of effective management plans. The nine elements are intended to provide an analytic framework for efforts that both restore water quality and protect overall watershed health (USEPA, 2008). The first three *Handbook* elements are designed specifically for watershed management and were augmented for tailored applicability to wildfire and forestry management (Figure 15). The *Action Plan* is sectioned into parts that address forest health, community protections, economic goals, and innovative monitoring. Elements (a) through (c) evaluate the content in those sources and whether the sources creating the wildfire problem and goals set to respond to it are laid out. The final six *Handbook* elements, (d) through (i), address implementation, education, and monitoring components of successful planning that are employable across the *Action Plan*'s four categories without further wildfire specific modification (Figure 15).

Nine Minimum Elements to Effective Watershed Management	Nine Minimum Elements to Effective Wildfire & Forestry Management
a. Identify causes and sources of pollution	a. Identify causes and sources of *wildfires*
b. Estimate pollutant loading into the watershed and the expected load reductions	b. Estimate *wildfire risks* and the expected *risk reductions from forestry management and wildfire mitigation actions*
c. Describe management measures that will achieve load reductions and target critical areas	c. Describe management measures that will achieve *risk reductions* and target critical areas
d. Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the plan	d. Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the plan
e. Develop an information/education component	e. Develop an information/education component
f. Develop a project schedule	f. Develop a project schedule
g. Describe the interim, measurable milestones	g. Develop the interim, measurable milestones
h. Identify indicators to measure progress	h. Identify indicators to measure progress
i. Develop a monitoring component	i. Develop a monitoring component

Figure 15 (Left: from USEPA, 2008). Modification of EPA's nine minimum elements to effective watershed management for wildfire and forestry management application.

3.3. Arup Resilience Framework Analysis

The third chapter of analysis (Ch. 6) uses qualitative methods to identify which key actions of the *Action Plan* correspond to each of the twelve fundamental drivers in the Arup City Resilience Index. A driving component of the *Action Plan* focuses on resilience building methods, so the Arup Framework is used as a comparative guidance document to evaluate resilience efficacy.

The Arup framework uses four dimensions, twelve drivers, and fifty sub-drivers that identify the most critical aspects of resilience and the actions that governance can take to overcome the effects of climate change while maintaining critical services (Arup, 2017). This framework was initially created by Arup International Development to provide a comprehensive framework for cities to evaluate and modify urban resilience. The Arup framework utilizes acute, low-frequency events known as shocks, and longer-term, chronic stresses to define different types of climate impacts (Arup, 2017).

The twelve drivers in the Arup Framework provide comprehensive resilience building guidelines that range from reducing ecosystem fragility and exposure to minimizing human vulnerability and building community support (Figure 16). The *Wildfire and Forest Resilience Action Plan* is structured around four overarching goals that encompass ecological management, community health, economic opportunities, and monitoring progress with clear partnerships and objectives. This analysis chapter assesses

whether the key actions in the *Action Plan* meet Arup's defined range of resilience needs in both natural spaces and urban communities.
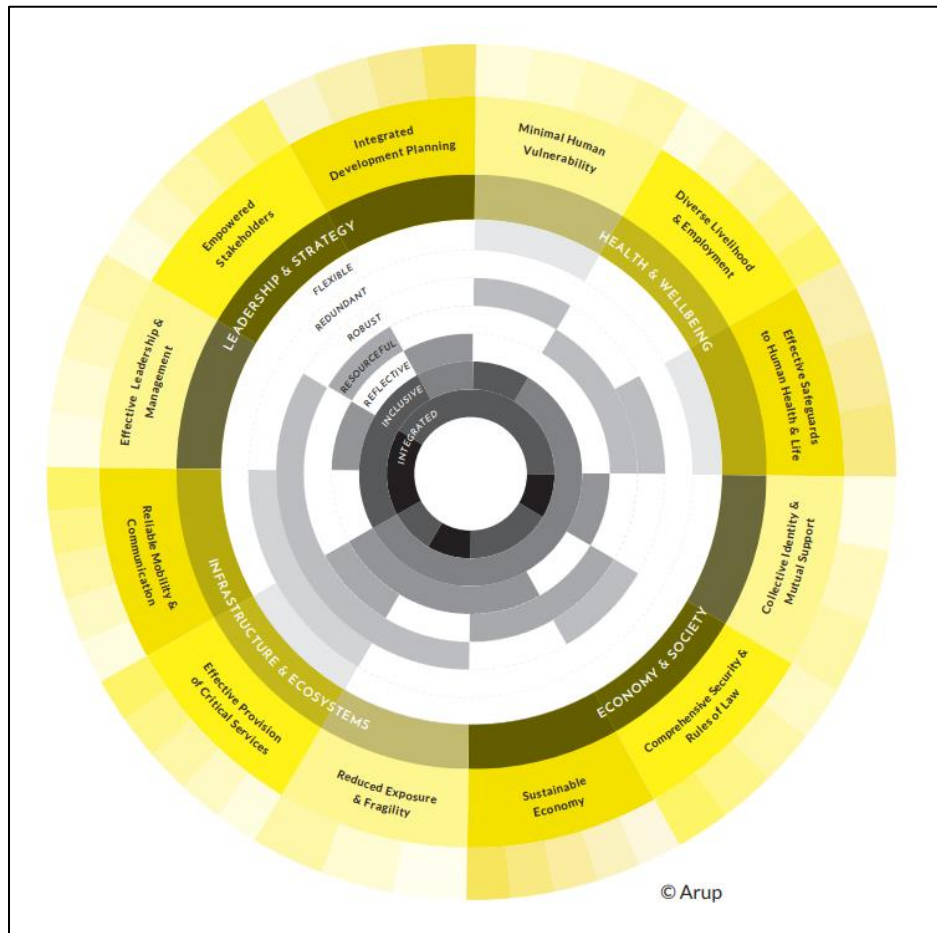
Figure 16 (From Arup, 2017). Arup Resilience Framework's 12 drivers and 7 characteristics of a resilient system.

3.4. Gap Analysis

The final analysis (Ch. 7) conducts a gap analysis which compares the ninety-nine key actions in the *Action Plan's* content against Arup's twelve drivers of a resilient system. The gap analysis identifies which qualities of resilience are most robustly planned for and which drivers could benefit from future planning and development for a more resourceful and flexible wildfire management strategy.

4. Environmental Justice Narrative Analysis

The most vulnerable groups in a community are those that do not have sufficient resources to adequately respond to shocks and stresses and are in high-risk zones. Additional regard is needed

to ensure equitable education and protections for these groups in response to an intensifying threat. These communities require different resilience strategies, and a range of tailored approaches is needed instead of a one-size-fits-all management solution. Environmental justice is the principle that different communities deserve equitable treatment, protection from hazards, social recognition, and economic and political rights (Schlosberg, 2013). Two communities most at risk to wildfires in California are those living in the WUI and Native people on tribal lands. Respective environmental justice needs in terms of recognition, protections, and participation differ to ensure equitable distribution of wildfire impacts and sustainable policies and practices for long-term land management.

4.1. Wildland-Urban Interface

The WUI is defined as "the area where houses meet or intermingle with undeveloped wildland vegetation (Radeloff et. al, 2005). WUI zones are categorized into two types of areas where houses are interspersed amongst native vegetation and zones where urbanization settles adjacent to wildland ecosystems. These are termed intermix WUI and interface WUI, respectively (Radeloff et. al, 2018). Housing built in interface WUI is often spaced closer together, allowing for a greater amount of built infrastructure in one region (Figure 17(a)). Although more flammable vegetation intermingles with housing in intermix WUI, housing developments tend to be distanced farther apart from one another (Figure 17(b)). Both types of WUI heighten wildfire risk due to the proximity of housing to vegetation, the increased probability of human-related ignition, and added fuel of built infrastructure in wildfire prone regions.
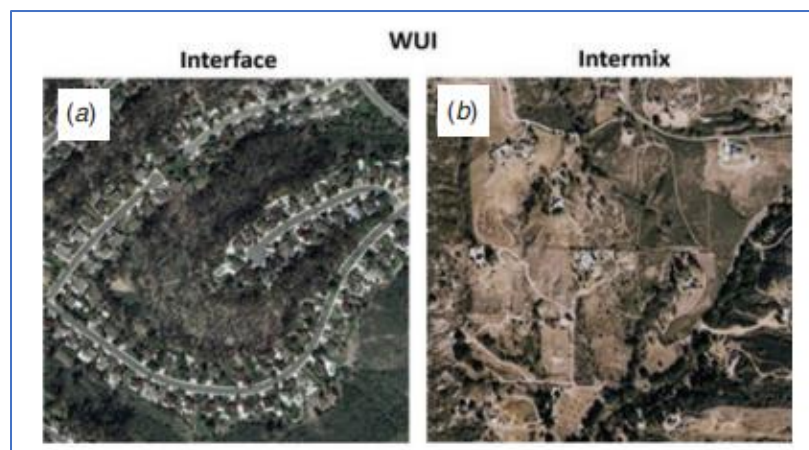
Figure 17 (from Anu Kramer et. al, 2019). San Diego county aerial images of (*a*) the distribution of housing adjacent to native vegetation

in an interface WUI and (*b*) distribution of housing amidst wildland
vegetation in an intermix WUI.

Looking at wildfire damage between 1985-2013, half of destroyed buildings were in interface WUI and 32% in intermix WUI across California (Anu Kramer et. al, 2019). The desire to live closer to nature takes on higher wildfire risk because people are moving into high-risk wildfire areas and the resulting urban sprawl exacerbates the risk. From 1990-2010, WUI zones in California expanded at a rate of 3.8%, reaching over 4.46 million Li et. al, 2021). Intermix WUI regions are found throughout northern California with main clusters following the edge of the Sierra Nevada Mountain range into the southeastern part of the state (Figure 18). Interface WUI are prominently found in the central coast and southeast California (Figure 18). WUI areas have more severe wildfire risks due to the combination of fuel loads. As a result, the highest-risk fire zones align with the distribution of WUI (Figure 19). As more homes and infrastructure are built closer to forests and vegetation, more protections are needed.
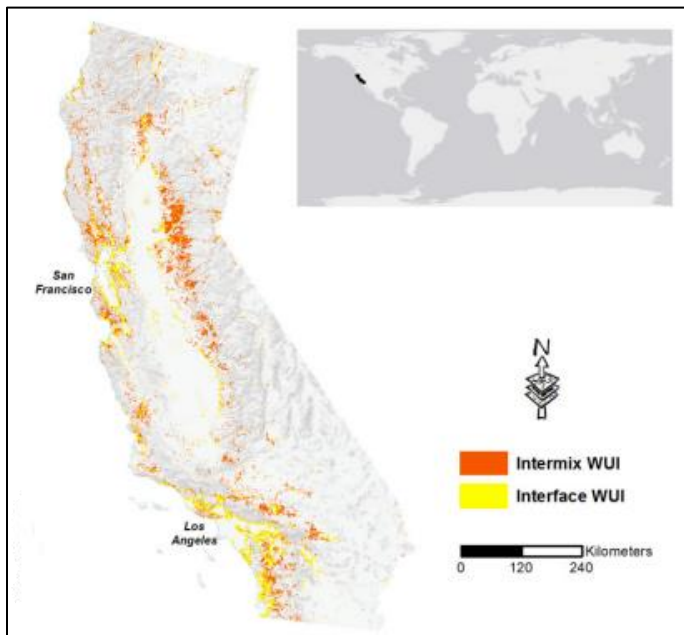
Figure 18 (from Bar-Massada, 2021). Distribution of human settlements in California's WUI.
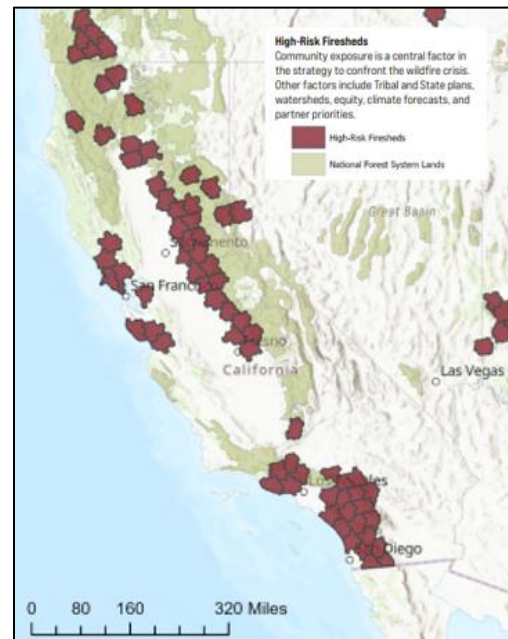
Figure 19 (from USFS, 2022). High-risk firesheds in California.

Private landowners in the WUI take on higher wildfire risk but under-protect themselves when it comes to applying fuel treatments or engaging in other land management practices (Ager, 2019; Busby and Albers, 2010). Increasing community level inclusion in federal and state fire-risk mitigation activities can help lessen liability concerns, educate landowners, and reduce

the management burden on public land managers (Busby and Albers, 2010). Increasing private landowner involvement in land treatments could make the difference between fighting a crown fire burning at all levels or a surface fire burning small biomass close to the ground (Seto et. al, 2022; Dewhirst et. al, 2020). A fuel treated area saved the Arizona Alpine WUI community in 2011 this way by reducing the fire level which allowed firefighters the ability to safely gain control over the blaze (USFS, 2022). CAL FIRE is shifting its fuel break project model to maintain an ongoing list of over five hundred active projects throughout California to slow fire spread in and near the WUI (FMTF, 2021).

One of the goals of the *Action Plan*'s key action 2.5 is to develop a best practices inventory for the WUI which will assist government planning for codes, zoning, and other development related standards relative to wildfire risks (FMTF, 2021). Targeted efforts done by various Task Force workgroups including Fire-Adapted Communities and the CA Wildfire Home Hardening Program to protect wildfire-prone homes once fire reaches the WUI. Residents can work with governments and local organizations to improve home-hardening for increased fire resistance and write community wildfire protection plans (USFS, 2022). Outreach and educational tools to inform WUI communities of human-caused ignition risks and plan for potential evacuations are critical components of a community's ability to respond to changing emergency circumstances.

4.2. Tribal Land

When Indigenous communities were forced from their lands, tribal movement became restricted to their allotted reservations while forest health was left unmanaged and wildfire intensities increased. Currently, Native people bear a disproportionate share of exposure to wildfire hazards as a result of land dispossession, and they face additional barriers to practicing traditional land stewardship strategies on both federally owned reservations and on inaccessible ancestral grounds. Environmental justice is needed for Native American Indigenous communities in protections against the growing wildfire threat, fair recognition of Indigenous fire practitioners as equal partners in wildland fire management, and restoration of access to ancestral lands to revitalize traditional fire practices.

Federal and state planning frameworks state goals to support and enable increased application of cultural burning and improve the integration of Native American tribes, related organizations, and cultural fire practitioners into other applications of planned fire across

California (WFRTF, 2022d; EPA, 2019). Despite these intentions, regulatory and governance barriers interfere with tribal sovereignty and reduce the capacity for cultural burning application. Otherwise beneficial environmental policies like the Clean Air Act impede cultural burning by requiring air quality permits and if any state or local agencies are involved through funding, planning or use of public land, additional environmental review must be completed (Marks-Block and Tripp, 2021). Often these requirements serve no substantive purpose and are procedural, consuming time and financial resources (Marks-Block and Tripp, 2021). Cultural fire practitioners must complete training certifications, acquire burn permits, and obtain federal approval before being permitted for cultural burns on reservation lands. Although the federal and state authorities identify TEK as valuable expertise, there is ample burden place on Native people to fulfill a separate set of criteria than their own in order to apply traditional land stewardship practices. Overseeing federal and state agents operate from an outcome-focused perspective for prescribed burning which intentionally uses fire on lands for wildland management goals in contrast to cultural burning which utilizes controlled burning to achieve cultural objectives that include ecological benefits (Long et. al, 2021; Marks-Block et. al, 2019). Cultural burning and other applications of TEK have interconnected relationships with the ecosystem. To clarify these differences and emphasize the importance of traditional land management practices, Indigenous fire practitioners co-created state legislature SB 1260 to permit prescribed burning as a wildfire mitigation tool and AB 642 to formally define "cultural fire practitioner" and "cultural burning" (AB 642, 2021; SB 1260, 2018). These bills establish liaisons for cultural burning and create liability protections for fire cultural fire practitioners.

To address additional barriers of limited access to workforce training and financial resources, the *Action Plan* lists multiple proposals to incorporate tribal leadership and develop funding and training opportunities for prescribed burn practitioners. CAL FIRE will establish a cultural burning grant program under Goal 1.20 (FMTF, 2021). Goal 1.21 seeks to establish a National Prescribed Fire Training Center, formed under collaborations between USFS, CAL FIRE, and tribal and local governments (FMTF, 2021). Both goals are currently in progress. In March 2022, the Task Force published *California's Strategic Plan for Expanding the Use of Beneficial Fire* to provide a roadmap for the beneficial fire goals established in the *Action Plan.* Key elements focus on streamlining permitting processing and developing a state-financed program that enables tribes and cultural fire practitioners to revitalize cultural burning practices

(WFRTF, 2022d). The acknowledgement of the importance of cultural burning and returning stewardship roles to California Native communities in these documents are significant, but it will be imperative that TEK and tribal expertise are integrated into these changes and that authoritative space is made for tribal leadership if these programs are meant to have equitable power dynamics. Creation of new federal and state government-issued permitting and funding systems for cultural burning without shifting final oversight governance to tribal authorities perpetuates the existing power imbalances.

In efforts to decentralize management and build better relationships with federal and state land management agencies, the Amah Mutsun Tribal Band formed a land trust and created the Native Stewards Core (NSC), which employs tribal members to learn traditional land management practices (AMLT, 2014). TREX trainings hosted by the Yurok and Karuk tribes teach land stewards how to holistically use prescribed fire through experiential training (Spencer et. al, 2015). Another Indigenous-led initiative is the Intertribal Indigenous Stewardship Project which provides training in cultural traditions and policy initiatives to prepare future land stewards (WFRTF, 2022d). These trainings uphold Indigenous expertise in fire stewardship practices. The IPBN model provides an Indigenous-led support network for Native American communities working to revitalize TEK and cultural burning to reduce wildfire hazards and retain autonomy (IPBN, 2021).

Cooperative interagency partnerships can be effective. Federal agencies can authorize co-management of federal lands for federally recognized tribes (Karuk Tribe, 2019). The Good Neighbor Authority permits Native American Indigenous communities to apply cultural burns and related restoration practices on federal lands within a set of specified conditions (Karuk Tribe, 2019). The Tribal Forest Protection Act provides tribes the opportunity to submit fire hazard reduction project proposals for reservation adjacent federal lands to the BLM or USFS (Karuk Tribe, 2019). These avenues provide opportunities for tribal-led projects outside of reservation jurisdiction but negate Indigenous decision-making power by requiring federal approval. This structure cedes the repeated goal to respect tribal sovereignty listed throughout federal and state evaluative regulatory plans and mechanisms. The colonial power structure perseveres throughout current land management governance structures and systems that equally prioritize Indigenous knowledge systems are needed to ensure environmental justice for California's Native American Indigenous communities.

5. Descriptive Case Study & Plan Evaluation

5.1. Case Study: California's Wildfire and Forest Resilience Action Plan

To improve the state's response to wildfire and forest health crisis, on January 8, 2021, Governor Newsom's California Forest Management Task Force, comprised of representatives from the California Natural Resources Agency (CNRA), California Environmental Protection Agency (CAEPA), and the California Department of Forestry and Fire Protection (CAL FIRE), published *California's Wildfire and Forest Resilience Action Plan,* with additional contributions from other federal, state, non-government, and local agencies. This plan incorporates recommendations from previous federal and state plans to scale up and advance forest health and wildfire resilience amongst federal, state, tribal, community, and private groups. The *Action Plan* provides a collaborative approach to building forest and community resilience amidst increased frequency of high-intensity wildfires (FMTF, 2021). This integrative framework provides a roadmap for statewide mitigation strategies that address needs including forest health projects, community protections, industry opportunities, and progress and partnerships (FMTF, 2021). The goals of the *Action Plan* intend to support the range of necessary action in wildfire and forestry management while avoiding duplication of efforts.

This chapter of analysis first overviews the content within the four overarching goals in the *Action Plan.* Second, it utilizes an adapted evaluative framework of nine minimum elements for effective wildfire & forestry management to assess the deliverables and their current stages in implementation planning for each section.

5.1.1 Goal 1: Increase the Pace and Scale of Forest Health Projects

The first goal focuses on scaling and speeding up projects that improve forest heath. This section lists forty key actions out of the total ninety-nine in the *Action Plan* which provide a range of land care management strategies and stewardship outreach across federal, state, and private lands (Appendix A). Healthy forests require management strategies tailored to different vegetation types. Forests benefit from fuel reduction efforts while chaparral needs intermittent fires to remain healthy. Land treatment efforts under this goal work towards accomplishing the 1-million-acre annual restoration target first set by the Shared Stewardship Agreement in 2020.

This agreement established coordination between state and federal agencies to each treat 500,000-acreages annually by 2025 (Shared Stewardship Agreement, 2020). The first key actions in the *Action Plan* focus on doubling USFS' current forest treatment levels from 250,000 acres to 500,000 acres and for CAL FIRE to scale up fuels management crews, available funding opportunities and related partnerships to meet their respective 500,000 annual acreage targets (FMTF, 2021). Key action 1.6 sets out to expand Bureau of Land Management (BLM) treated acreage from 9,000 to 10-15,000 acres per year and 1.5 draws upon mechanical and prescribed fire and managed wildfire methods to treat an additional 175,000 acres for ecological and wildfire resilience benefits (FMTF, 2021).

When used safely, prescribed fire is one of the most cost-effective practices available to reduce fuel buildup. Key actions 1.18-1.27 aim to expand fuels reduction and prescribed fire programs to increase treated acres, but also to create a prescribed fire training center and strategic action plan, extend professional training opportunities for burn practitioners, and develop new automated permits (FMTF, 2021). An important key action is 1.20: to establish a new tribal grants program to support and expand California Tribes' ability to conduct cultural burns and other TEK practices (FMTF, 2021). Controlled burns are currently used throughout California, but factors including seasonality, damage liability, and limited access to training affect its widespread adoptability.

Additional objectives under this goal work on building and maintaining regional action plans. Increased outreach, assistance, funding, and training opportunities from state and federal actors to small private landowners are critical components to adequately increasing treated acreage, improving forest resilience, and building regional networks. Key action 1.28 aims to expand the 2019 Regional Fire and Forestry Capacity (RFFC) program. The RFFC program uses local forest and community resilience plans to support community level alliances, but its scope currently omits some high-risk regions (DOC, 2021). This key action expansion would incorporate all high-risk areas under the program guidelines.

Other key actions work to build out sustainable timber harvest, conserve working forests, reforest damaged lands, and improve the effectiveness of existing regulations. The forest service has worked with states, tribes, and local communities for decades to minimize harm and improve forest health with limited success. Better coordination of actions and access to information help reduce the duplication of forestry improvement efforts. Key actions 1.35-1.40 strive to assist

landowners through the creation of timber harvesting guidance documents, advancing CalTREES and CalVTP programs, and updating information reporting systems (FMTF, 2021).

5.1.2 Goal 2: Strengthen Protection of Communities

The second goal in the plan centers around community risk reduction and preparedness. The thirty-two key actions listed in this section include physical improvements such as increasing fuel breaks and defensible space around and hardening homes in vulnerable areas, as well as developing new or updated risk reduction and hazard measures to share with local communities (Appendix A). Key action 2.5 in this section targets the WUI with a goal for the Governor's Office of Planning and Research (OPR) to generate a WUI best practices inventory with CAL FIRE and the Water Board that outlines guidelines for infrastructure development with minimal wildfire threats (FMTF, 2021). WUI specific fire safety training development comes up again in deliverable 2.19 to create a building standards compliance manual (FMTF, 2021). This objective aligns with Senate Bill No. 190's fire safety requirements to make model defensible space standards for local government zoning use (SB-190, 2019). Roadways also require defensible zones to reduce wildfire ignition risk and safeguard designated routes for emergency evacuations. Key actions 2.24-2.26 target the creation and of fire-safe roadways and outreach efforts for public awareness campaigns (FMTF, 2021).

Community resilience hinges upon information sharing and preparedness. CAL FIRE leads key actions 2.13-2.20 to expand home protection guidance, compliance, and implementation programs, including key action 2.20 which connects the California Department of Insurance with CAL FIRE and the California Office of Emergency Services (Cal OES) to develop a state of emergency insurance memorandum of understanding (MOU) (FMTF, 2021). The MOU supports the implementation of Senate Bill No. 824 which prohibits insurance companies from refusing to renew homeowner policies up to one year after the declaration of a state of emergency like a wildfire (SB-824, 2018). Key actions under this goal also focus on public health protections to increase community awareness of the impacts of wildfire smoke exposure and to improve air quality monitoring. These efforts build community adaptive capacity and make prescribed fire and resultant smoke reporting more efficient (FMTF, 2021).

Objectives 2.21-2.23 in this goal aim to reduce risks from utility-related wildfires. This section requires new review of wildfire mitigation plans, coordination between the Office of Energy Infrastructure Safety (OEIS) and the Utility Wildfire Mitigation Steering Committee to

improve compliance management of electrical company commitments, and implementation of USFS 30-year master special use utility permits throughout more of the state (FMTF, 2021). Utility-ignited wildfires resulted in over one hundred deaths and the destruction of 20,000 building between 2017-2018 (FMTF, 2021). This work seeks to mitigate utility-related ignitions and build out related maintenance planning.

5.1.3 Goal 3: Manage Forests to Achieve the State's Economic and Environmental Goals

The third goal integrates economic development opportunities and forest management strategies into seventeen key actions (Appendix A). This goal promotes strategies pursuant to state climate goals established in Executive Order N-82-20, which requires action to increase carbon removal, extend statewide land conservation coverage to 30% by 2030, and develop a Natural and Working Lands Climate Smart Strategy (Exec. Order N-82-20, 2020). To achieve the 30% by 2030 goal, a mix of land care management strategies are needed from federal, state, and local levels. The first key actions under this goal highlight collaborative agency efforts towards new climate change and biodiversity related conservation strategies including. These actions include developing a 2022 Climate Change Scoping Plan Update and launching a new multi-agency biodiversity collaborative (FMTF, 2021).

A core contingent of key actions under this goal target creating a sustainable wood products market for California. Forest thinning and fuel reduction actions generate woody feedstock with limited disposal methods. Over half of wood collected from forest management projects gets burned which contributes to the carbon emission problem. Key actions 3.5-3.12 develop new frameworks, roadmaps, metrics, and pilot projects to instead utilize wood products in a new sustainable wood products market (FMTF, 2021). Key action 3.8 includes CAL FIRE and other agencies partnering with iBank to provide business loans for companies to repurpose wood and forest biomass (FMTF, 2021). These actions generate economic opportunities out of what is currently wood waste from forest management practices. Two additional key actions highlight the need for updated outdoor recreation planning, another significant economic sector to capitalize on in California (FMTF, 2021).

The last focus in this goal is the protection and expansion of urban forests to improve urban resilience. The final three key actions assign CAL FIRE to increase urban canopy in marginalized communities, create regional goals for local tree canopy coverage, and assist local

governments identify best possible areas for green infrastructure and canopy expansion (FMTF, 2021).

5.1.4 Goal 4: Drive Innovation and Measure Progress

Goal 4 emphasizes the importance of continued investments in forest ecosystem and wildfire research and in the development of comprehensive monitoring and reporting tools. The ten key actions in the final goal address making use of the best available science and innovating technology to better inform forestry management efforts (Appendix A). This includes coordination between the USFS, CAL FIRE, the USDA California Climate Hub, the California Air Resources Board (CARB), and other agencies to create a Forest Data Hub (Hub) to hold current and future forestry management monitoring and reporting data (FMTF, 2021). The Hub would integrate forestry management progress from federal, state, and local organizations and help minimize duplication of work. Additional tool development deliverables include establishing an ecological planning tool and forest ecosystem monitoring system (FMTF, 2021).

The objectives in this section strive to improve current data gathering methods, streamline and expand technological capacity for centralized information storing and sharing, and innovate how that information is used. Key action 4.7 to develop "state-of-the-science models" capitalizes on available field-based forest carbon inventory data (FMTF, 2021). These models inform our understandings of factors like wildfire characteristics and climate change impacts. Future projections from modelling influence risk assessments, land care management planning, and how funding gets allocated. These key actions drive how projects are monitored, progress is documented, and decisions are made to reduce wildfire risks and improve forest health.

5.2. Plan Evaluation

5.2.1 Critical Elements in an Effective Plan

The *Action Plan* describes multi-sector strategies to reduce wildfire risk, protect communities, and improve forest health. To ensure that the *Action Plan* progressed further than a comprehensive proposal, Senate Bill 456, filed on September 18, 2021, required that the Forest Management Task Force develop an implementation strategy to designate lead agency and work group responsibilities and implementation timelines for each of the 99 key actions identified in the plan (SB-456, 2021). In April 2021, the Forest

Management Task Force published an *Organizational Charter* which renamed the group as the Wildfire & Forest Management Task Force (Task Force) and specified the organizational structure of each lead agency and work group that focuses on coordinating, facilitating, and tracking progress of the *Action Plan's* forest management and wildfire resilience building deliverables. The Task Force contains an Executive Committee with a support staff, interagency and stakeholder workgroups, a Science Advisory Panel, and an Interagency Planning and Integration Team with state and federal agency representation (Figure 20). Then in January of 2022 the Task Force released a formal *Implementation Strategy* to fulfill Senate Bill 456's requirement. Each of the ninety-nine key actions identified in the *Action Plan* was assigned to one or more lead agencies and work groups.
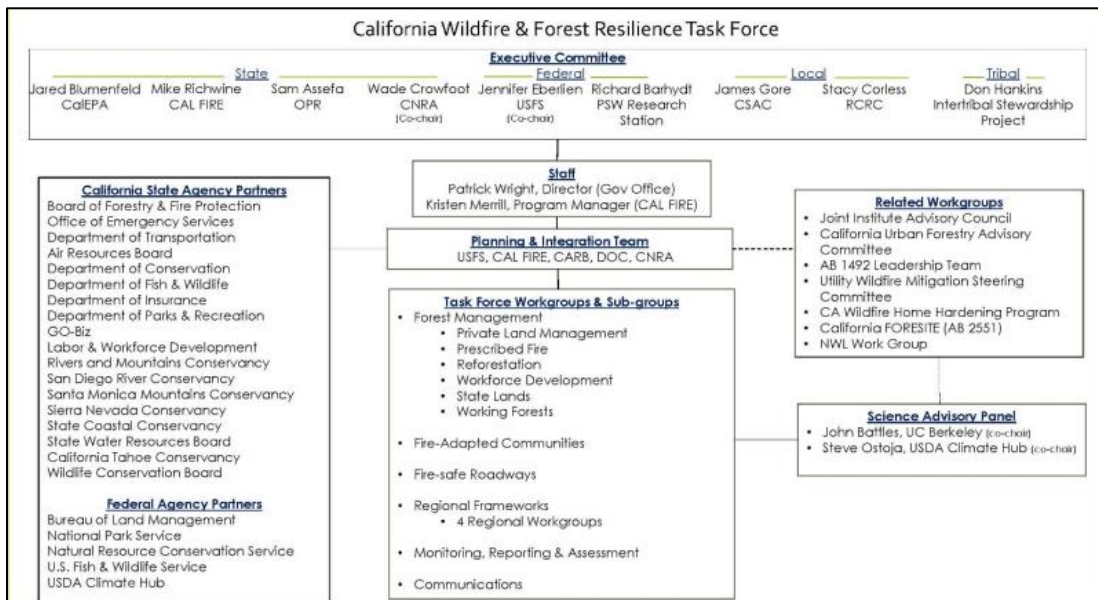
Figure 20 (from WFRTF, 2022). Organizational structure of the 2022 Task Force.

The *Implementation Strategy* outlines direct leadership and targeted deadlines for each of the plan's ninety-nine key actions. Figure 21 lists modified criteria for effective wildfire and forestry management. This list provides the framework to evaluate whether the content in the *Action Plan* and *Implementation Strategy* meets all nine minimum elements required for a successful plan (Figure 21).

Nine Minimum Elements to Effective Wildfire & Forestry Management

a. Identify causes and sources of *wildfires*

b. Estimate *wildfire risks* and the expected *risk reductions from forestry management and wildfire mitigation actions*

c. Describe management measures that will achieve *risk reductions* and target critical areas

d. Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the plan

e. Develop an information/education component

f. Develop a project schedule

g. Develop the interim, measurable milestones

h. Identify indicators to measure progress

i. Develop a monitoring component

Figure 21 (modified from USEPA, 2008). Nine critical elements of a successful plan for effective wildfire and forestry management.

5.3. Implementation Strategy

The *Action Plan* addresses criteria (a) through the identification of direct ignition sources of wildfire and factors that influence wildfire risks. Human-induced fires dominate as the leading ignition source for California wildfires. The WUI heightens ignition risks due to the intersection of increased population distribution and built infrastructure with vegetation fuel sources. Lighting also lights fires in the northern most region of the state, but human-caused or infrastructure-related ignitions such as powerlines overwhelmingly account for the initial causes of California's wildfires (Keeley & Syphard, 2018).

The plan also identifies landscape diversity, climate conditions, and forest health as factors that impact the severity and frequency of devastating wildfires when they occur. Additional considerations including community preparedness tailored to regional needs and collaborative multi-sector leadership help to minimize vulnerabilities and create a unified response to the large-scale wildfire problem. While not direct ignition sparks, these areas create the baseline conditions that when unmanaged, expedite wildfires to catastrophic levels.

The second criteria for effective wildfire and forestry management requires risk identification and corresponding proposed risk reductions. To fulfill the second criteria, the *Action Plan* identifies high risk zones for wildfires to occur, the most at-risk communities in the

WUI, public health risks related to smoke exposure, emissions resulting from wildfires, and related damages to natural ecosystems and build infrastructure.

The estimated risk reductions from forestry management and wildfire mitigation actions encompass targeted priority fuel reduction projects, increasing the acreage of treated lands, increase assistance and outreach to private landowners and local communities, improve protections for vulnerable communities, and innovate current technologies for improved monitoring and reporting. The four overarching goals in the *Action Plan* identify the risk reduction objectives of criteria (b) and the specific key actions specify the how each sub-goal will be achieved for element (c).

Key actions 1.1, 1.5, and 1.6 set specific annual acreage treatment and management coverage targets of 500,000 for USFS, 175,000 for NPS, and 10-15,000 for BLM by 2025 to reduce fuel loads and improve forest health while other deliverables like key actions 1.24, 1.37, 2.3, 2.7, 2.23, 3.7, 4.4, 4.5, and others aim to develop new permitting, reporting, and hazard planning systems to expand existing treatment practices, improve information sharing, and mitigation severe risks (FMTF, 2021). Some risk reduction strategies have specific parameters to satisfy such as key action 2.27 which employs CAL FIRE and Caltrans to work with landowners to establish defensible spaces around 2,600 miles of high-risk highway (FMTF, 2021). A "defensible fuel profile zone" can range between 150-528' of cleared space between the road and adjacent vegetation depending on the width of the roadway, but the distinct condition requirements to create fire control lines are clear (FMTF, 2021). Other key actions work to assess vulnerabilities an create new metrics for future risk reduction work. Key action 2.1 assigns state and federal assessment to enhance qualitative wildfire risk assessments for vulnerable communities across California (FMTF, 2021). The outcomes from this action will supplement OPR's work to integrate resilience building and climate mitigation efforts into state risk-reduction program planning.

To meet criteria (d), the *Implementation Strategy* outlines the Task Force's organizational structure, and the *Action Plan* details which agency collaboration and stakeholder involvement are intended for each respective key action (Figure 20) (FMTF, 2021). The Task Force utilizes an online Airtable online database to organize which lead agency and work group(s) are assigned to each key action (WFRTF, 2022b). These relevant authority assignments are listed at the end of

this section in Tables 2-5, which also include current progress statuses and target dates for key action completion (Appendix B. 1-4).

The other component of this fourth element is an estimate of financial assistance needed to implement the plan (Figure 21). Pursuant to SB-456, the Task Force is obligated to annually report on state costs, policy changes, and other resources needed to implement key actions (SB-456, 2021). To fulfill this requirement, the Task Force created a *Wildfire & Forest Resilience Expenditure Plan* via the Airtable platform which lists proposed costs and enacted state budget allocations to key actions (WFRTF, 2022c). Some programs received funding for individual program use. The RFFC program received an additional $50 million in early action funding in 2021 to expand regional grants across areas not included with its initial funding (FMTF, 2021). The Great American Outdoors Act (GAOA) provides up to $285 million annually to states for five years through the Shared Stewardship framework to implement through local, tribal, and state government partnerships (FMTF, 2021). The *Expenditure Plan* attributes which department each key action is funded by how much funding was attributed from the "Early Action 2020-21 Budget," the current fiscal year sums, and proposed funding totals for 2022-23 and 2023-24 (WFRTF, 2022c).

Element (e) requires an information sharing and educational component to promote transparency and to encourage early engagement between the public and project partners (Figure 10). Given the large amount of private land ownership and partnerships needed to increase treatments to those lands, information and education components play critical parts in the success of the *Action Plan*. This element also encompasses the role of community and stakeholder participation in designing and implementing wildfire mitigation measures that support long term plan objectives.

The *Action Plan* itself contains the full summary of proposed actions. The Task Force hosts meetings every other month in different regions of California with a hybrid webinar and in-person format which allows for broader stakeholder attendance. The Task Force additionally created an interim website which provides access to past meeting recordings and posts updated "essential information" on work group actions as new draft and final documents are published such as the *Comprehensive Implementation Strategy* and the *Strategic Plan for Expanding the Use of Beneficial Fire* (WFRTF, 2022e). The Prescribed Fire work group additionally held a public workshop on October 25, 2021, with video recordings of the four meeting sections

available on the interim website for viewing (WFRTF, 2022e). Supplemental information on work group implementation updates is posted subject to its ongoing availability.

Outside of posted documents and work group updates from Task Force meetings, the progress status for each key action posted on the Airtable platform provides another resource for project status updates. This platform does not contain any additional information detailing specific management measures that will be implemented past the key action descriptions already listed in the *Action Plan.*

Also listed in the Airtable platform are target completion dates for key action execution. The sixth element to effective wildfire and forestry management necessitates a project schedule. Only seventy-six of the ninety-nine key actions are currently assigned a target achievement date (WFRTF, 2022c). On the interim website, each work group has a work plan posted that contains a schedule of met deliverables for each of the key actions they are assigned. Some of the Airtable target dates have lapsed and not all key actions have interim deliverable dates listed in the work plans, so it is unclear how accountability is upheld for project progress and whether those key actions are on track for completion.

This overlaps with elements (g), the development of provisional, measurable milestones and (h), indicators to measure progress (Figure 10). The work group work plans posted to the interim Task Force website list a section to fill in a final deliverable date with the final deliverable outcome and space to list the completion dates and content of interim deliverables (WFRTF, 2022c). Some key actions list future interim deliverables such as key action 3.17 managed by the Urban Forestry Committee which lists June 15, 2023, as a future interim deliverable deadline by which they intend to publish an Urban Tree Canopy report (WFRTF, 2022c). Other work groups like the Regional Frameworks Committee solely list ongoing completed accomplishments as they occur so that existing progress can be reviewed, but it is unclear what the next steps are between current day and the final deliverable date (WFRTF, 2022c). The Airtable platform also provides status updates for each key action in a ranking of 0: status unknown through 6: completed (Appendix B. 1-4). Given the varied objectives of each of the ninety-nine key actions, it is unrealistic for the same benchmarks to be used to track progress, but information sharing through these work plans could benefit from standardization of how progress is reported.

The final element is a monitoring component to track progress (Figure 10). As stated, key action progress is updated via listing completed milestones in website work plans and reflected when the Airtable status' change ratings, but it is unclear how each work group is held accountable to make progress outside of presenting a progress report on bi-monthly Task Force meetings.

6. Arup Resilience Framework Analysis

The Arup Resilience Framework identifies four dimensions to categorize essential characteristics of resilient systems: Leadership & Strategy; Infrastructure & Ecosystems; Economy & Society; and Health & Wellbeing (Arup, 2017).

6.1. Leadership & Strategy

Leadership and Strategy actions are driven by knowledge, partnerships, and planning. This section encompasses three sub-groups: Effective Leadership & Management, using iterative and evidence-based decision making; Empowered Stakeholders, relying upon updated information available to enable action from all invested people and organizations; and Integrated Development Planning, supported by inclusive partnerships to develop regularly updated strategies (Arup, 2017). Key actions under this dimension fulfill the need for informed, inclusive, integrated, and iterative decision making.

Most key actions under Goal 1's forest health and Goal 2's community protection focuses fall within sub-group components of Leadership & Strategy. The multi-stakeholder collaboration necessary to develop the land treatment plans and programs listed throughout Goal 1 align with the planning, approval, and horizontal governance aspects of this resilience dimension. Key action 1.17 joins State Parks, CNRA, CDFW, the Tahoe Conservancy, and others to execute an expanded forest management strategy to build forest resilience across state lands (FMTF, 2021). Actions include increasing community outreach for improved awareness, preparedness, education on best forest-management practices in addition to expanding prescribed fire and fuel reduction programs (FMTF, 2021).

Goal 2 objectives that build on existing mechanisms for communities to engage with local organizations and governments are 2.6 and 2.7, which coordinate multi-agency efforts in the development of Community Wildfire Protection Plans (CWPP's) and facilitate more information sharing, respectively (FMTF, 2021). CWPPs can be integrated with existing plans at the

45

community or state level and will provide best practices to protect communities. Targeted information sharing through recurring virtual forums provide opportunities to share wildfire-mitigation information and management planning for the community, fire practitioners, and government partners (FMTF, 2021).

Key action 1.4 to expand Shared Stewardship and Good Neighbor Authority Agreements increase partnership opportunities by extending federal land management power to tribal, state, and local governments (FMTF, 2021). Having more land stewards authorized to implement fuels reduction projects and cultural burns on neighboring federal lands will reduce red-tape delays to wildland management and work towards achieving land treatment goals.

6.2. Infrastructure & Ecosystems

Infrastructure and Ecosystems relates to the robustness of man-made and natural system that provide critical cervices. This section encompasses: Reduced Exposure and Fragility, includes well managed protective ecosystems and an in-depth understanding of hazards and risks to a system; Effective Provision of Critical Services, generated from strong environmental stewardship, maintenance of critical assets, and robust contingency planning; and Reliable Mobility and Communications, maintained through reliable technology networks, reliable communication technology, and diverse transportation systems (Arup, 2017). Resilience building actions under this dimension include innovative developments that help effectively manage forests, maintain records of stewardship actions, and ensure appropriate standards are enforced.

Most of the key actions under the *Action Plan*'s 4th goal focus on technological innovation and measuring progress which satisfy the technology networks and communication elements of this dimension. Developing a statewide forest ecosystem monitoring system for key action 4.5 and establishing an information clearinghouse through 4.9 will consolidate interagency data to streamline forest condition monitoring and make forest management projects more efficient over time (FMTF, 2021).

Another component to Infrastructure and Ecosystems considers stewardship of ecosystems and building spare capacity for protections. Key action 1.13 assigns CAL FIRE to provide funding for NIPF implemented fuel treatments and related maintenance (FMTF, 2021). This funding creates capacity for landowners and local organizations to take on a larger stewardship role in wildfire mitigation and post-burn restoration efforts on privately owned lands.

One portion of critical hazard and exposure mapping technology was accomplished with the May 2021 launch of the California Smoke Spotter app, the objective of key action 2.3. CARB was the lead agency in the development of this app which integrates air monitor data and informational wildfire content to provide users with live updates on nearby fire smoke, the current Air Quality Index (AQI) rating, a 24-hour smoke forecast, and has the functionality to set personalized alerts (FMTF, 2021). This technology helps inform local communities of potential smoke exposure events resultant from neighboring prescribed fires and seasonal wildfires. The additional information available through the app also provides access to wildfire education on the benefits of planned fire and strategies to reduce impacts of smoke exposure (CARB, 2021).

Another key action related to hazard mapping is the development and implementation of new fire hazard severity zones. This work requires CAL FIRE and the Fire-Adapted Communities work group to assess updated data on local climate conditions and fire spread models to revise hazard severity rating criteria (FMTF, 2021). Having an updated fire hazard rating system will provide a more comprehensive understanding of the fire risks in different regions and strengthen management infrastructure.

6.3. Economy & Society

Economy and Society relates to the organization of law and order within a system. This section includes Collective Identity and Community Support, citizen engagement and local community support networks; Comprehensive Security and Rules of Law, this includes policy enforcement, prevention of crime, and fair justice; and Sustainable Economy, this considers social and financial systems, support for local economies, and a system's ability to develop new investments (Arup, 2017). This dimension dominantly overlaps with key actions from the *Action Plan*'s third and economically driven goal. Key actions that provide assistance to community members, uphold rules of law, and expand economic investment opportunities relate to Economy and Society.

One of the broader targeted key actions is for the state and other forestry professionals to increase technical assistance to local landowners with various forestry management, field work, surveys, or environmentally related projects (FMTF, 2021). This reflects a community investment by providing support to land managers working on Burn and Forest Management Plans. Other key actions address making permitting systems more efficient, such as key action 1.24 to automate prescribed burn permits (FMTF, 2021). Automation of this permitting process is currently in final

stages (WFRTF, 2022b). This change affirms the regulatory system in place while also supporting fire practitioners through a streamlined application system.

Also in final stages is the development of a market roadmap (WFRTF, 2022b). Under key action 3.6, the Governor's Office of Business and Economic Development (GoBiz) sets out to work with other state agencies and stakeholders to build on OPR's state wood utilization framework to develop a market roadmap that guides private investment in the use of woody biomass (FMTF, 2021). This helps generate more economic opportunities for the use of the biomass by-product being produced from expanding fuels reduction and forest management projects.

6.4. Health and Wellbeing

Health and Wellbeing is based on protections for people and encompasses three sectors: Minimal Human Vulnerability, or the extent to which basic needs are met and threats to wellbeing are minimized; Diverse Livelihoods and Employment, the access to resources, education, business investments, and social welfare; and Effective Safeguards to Human Health and Life, protecting public health systems and access to emergency response services (Arup, 2017). Key objectives that fall under this dimension address provisions of public health protections, skills training, and financing mechanisms.

Multiple key actions deal with maintaining and developing grant programs for various wildfire mitigation and forestry management. CAL FIRE works at the state level to distribute fire prevention grants to high-risk and high-priority areas through key action 2.11 and aims to expand forest research grant opportunities under 4.2 to improve applied management practices (FMTF, 2021). Ongoing funding for fire practitioner, conservation, and related fire service trainings is addressed under key action 1.25, calling on local governments, nonprofits, and state agencies to support new workforce creation (FMTF, 2021).

Other key actions creating training opportunities include expansion of lumber certifiers and creation a national prescribed fire training center (FMTF, 2021). These objectives improve access to different types of fire-related certifications and address the needs for a larger workforce that can treat more areas. The *Action Plan* proposes various key actions that build upon needs for more training and technical assistance which when applied to land management would result in risk reduction, ultimately helping to minimize human vulnerabilities to wildfires.

7.

7. Gap Analysis

Table 2 shows the distribution of the *Action Plan*'s key actions grouped by goal category across Arup's twelve drivers of resilience. There is at least one key action attributed to all twelve drivers, indicating that all qualities of a resilient system are included at a minimum. The dominant distribution of key actions falls under the Leadership & Strategy resilience dimension with a total of 44/99 key actions categorized across its three drivers (Table 2). The key actions from the *Action Plan*'s Technology & Tracking goal are the least distributed across the Arup drivers of resilience with 8/10 attributed to Mobility & Communication (Table 2). Safeguards to Human Health is the least represented dimension with a single key action assigned: 2.24, to identify subdivision secondary emergency access (Table 2) (FMTF, 2021).

While many key actions from the *Action Plan*'s Community Protection goal may have secondary outcomes that relate to the Safeguards to Human Health dimension, their primary objectives better fit the criteria of other drivers of resilience. Objectives like the development of defensible space and home hardening curriculum under key action 2.8 or the creation of a WUI best practices inventory under key action 2.5 will increase community protections, but these plans relate more to the accessibility to updated information components of the Empowered Stakeholders resilience driver rather than public health system protections and access to emergency response services elements of Safeguards to Human Health. This gap in key actions for Safeguards to Human Health identifies an opportunity area to plan for in ongoing and future developments.

Table 2. Gap Analysis attributing the Action Plan's 99 key actions to Arup's 12 drivers of resilience.

		Forest Health	Community Protection	Economy & Policy	Technology & Tracking
		Key Actions			
Leadership & Strategy	Leadership & Management	1.4; 1.7; 1.8; 1.9; 1.29; 1.32; 1.34; 1.40	2.10; 2.22; 2.28	3.1; 3.2; 3.3; 3.17	
	Empowered Stakeholders	1.10; 1.12; 1.38	2.5; 2.6; 2.7; 2.8; 2.18; 2.19; 2.29; 2.30		
	Integrated Development Planning	1.1; 1.2; 1.3; 1.5; 1.6; 1.17; 1.18; 1.19; 1.28; 1.30; 1.31; 1.33	2.4; 2.16; 2.21; 2.25	3.10	4.1

Infrastructure & Ecosystems	Mobility & Communication	1.36; 1.37; 1.39	2.31; 2.32		4.3; 4.4; 4.5; 4.6; 4.7; 4.8; 4.9; 4.10
	Critical Services	1.13; 1.14; 1.15	2.27	3.4	
	Reduced Exposure	1.23; 1.27; 1.35	2.1; 2.3; 2.9		
Economy & Society	Sustainable Economy			3.6; 3.7; 3.8; 3.9; 3.11; 3.12	
	Security & Rule of Law	1.24	2.14; 2.23	3.5	
	Community Support	1.11	2.2; 2.20; 2.26	3.13; 3.14	
Health & Wellbeing	Minimal Human Vulnerability	1.20; 1.22	2.12; 2.13; 2.15; 2.17	3.15; 3.16	
	Diverse Livelihoods	1.16; 1.21; 1.25; 1.26	2.11		4.2
	Safeguards to Human Health		2.24		

CAL FIRE and the Department of Conservation (DOC) lead the initiative for key action 2.7, the development of a Community Wildfire Protection Plan (CWPP) Best Practices Guide (FMTF, 2021). While this key action does not directly influence Safeguards to Human Health, the recommendations from a CWPP would inform community emergency plans. A community's emergency response starts with advance planning and Safeguards to Human Health encompasses access to emergency response services. CWPPs provide an opportunity for community-level involvement in the consideration of hazard mitigation strategies and risk reduction priorities tailored to regional needs (Mockrin et. al, 2018). The majority of non-government stakeholder participation in CWPPs in California is from community fire organizations (Palsa et. al, 2022). Most CWPPs are developed through vertical policy coordination, with stakeholders working with federal and state representatives to develop plans for each jurisdiction. Since fire hazard severity zones and other wildfire risk indicators do not follow jurisdictional boundaries, improving coordination of local planning on a peer-to-peer regional level in addition to the top-down coordination could improve emergency planning efficiency via increased information sharing. Expanding the current top-down planning structure to include more horizontal governance with linked communication and coordinated efforts across jurisdictions could make access to emergency services more robust and build resilience for Safeguards to Human Health.

8. Conclusions and Recommendations

This research conducted three different methods of analysis to assess the efficacy of the proposed actions of the *Action Plan*. The EJ analysis in chapter 4 examined whether the *Action Plan* included equitable protections for communities at higher wildfire risks living in the WUI and on Tribal lands.

In the WUI, the core issues that need attention are increased land treatments and targeted community education and engagement campaigns. The *Action Plan* identified these goals and established key actions designed to expand fuels reductions and prescribed burning projects, expand training opportunities to integrate more private owners into land stewardship, and create targeted documents and programs like the Smoke Spotter app to educate residents about wildfire related risks and hazards. These proposed efforts suggest that equitable consideration has been made to build flexible and inclusive protections to reduce the wildfire threat for these high-risk WUI areas.

For Indigenous communities on Tribal lands, while there are some opportunities to collaborate on decisions through multi-agency partnerships, most of the proposed key actions is structured through state and federal management frameworks. While those efforts contribute to valued efforts that provide funding opportunities and prescribed fire training for fire practitioners, the systems that these programs are structured in self-perpetuate an imbalance of power instead of the intended increase in respect of tribal sovereignty. Many of the key actions in the *Action Plan* propose inclusion of TEK into agency strategies but it is not clear that Indigenous knowledge frameworks are being equally prioritized. It is not evident that the *Action Plan* presents equitable protections for Native American Indigenous communities on tribal lands. The first recommendation targets this disparity to enhance protections of Indigenous culture and their autonomy.

8.1. Recommendation 1: Increase tribal sovereignty and integrate TEK practices into non-tribal trainings.

Implementation of this recommendation could involve including Indigenous leadership in authority positions, expanding Indigenous land jurisdiction, and integrating TEK practices into the training materials, restoration strategies, implementation strategies, education programs, strategic action plans, and other wildfire resilience key actions listed in the *Action Plan*. If

permitting and training certification under BIA authority are necessary, new approval systems could be developed adjacent to or outside of existing government systems that give decision-making power and authority back to tribal leadership. Indigenous community-managed permitting systems would allow for better consideration of TEK objectives and cultural burning conditions that meet different criteria such as including year-round or extended seasons for performing low intensity burns rotated on different patches of lands.

Redistributing approval power back to Native people would help reset some of the existing imbalance of power by reducing the requirement of requesting final federal approval and oversight for land management practices. The *Action Plan* does present new and improved protections to fund and expand opportunities for Indigenous communities, but they are not truly equitable until meaningful freedoms are granted for tribal sovereignty and access to ancestral lands is restored. There is a net benefit to publish plans for the state to expand jurisdiction for cultural burning and increase coordinated governance with tribal communities, but these efforts will fall short in application if ancestral land restrictions are still in place.

Chapter 5 evaluated the *Action Plan* to determine if the nine critical elements to an effective plan were fulfilled. The results from the case study comparison against the wildfire and forestry management framework revealed that all nine criteria elements are addressed in some capacity, but there is inconsistency in the how information is getting updated for public access and it is unclear what progress is being accounted for. Some target dates of key action completion have lapsed without updates to the Airtable and interim Task Force website platforms, generating uncertainty surrounding what work is being done and what the next steps are for each work group. The *Action Plan* would benefit from clearer benchmarks to measure both completed and anticipated milestones.

On April 21, 2022, the Task Force published the *Draft Plan for a Forest & Wildland Stewardship Interagency Tracking System.* This proposal addresses the need for the Task Force to report progress of ongoing wildfire and forest resilience projects which would help provide the transparency and accountability missing from the current reporting systems. The Monitoring, Reporting, and Assessment (MRA) Work Group is tasked with the tracking system's development (WFRTF, 2022e). This leads to the second recommendation.

8.2. Recommendation 2: Create the proposed Forest & Wildland Stewardship Interagency Tracking System.

The proposed tracking system would provide transparency and accountability for ongoing wildfire and forest resilience projects. Development of this system would more effectively fulfill the nine criteria elements of effective wildfire & forestry management, specifically improving consistency for project progress reporting and accessibility of information to the public. This proposed tracking system would additionally provide useful data for other reporting system related key actions listed in the *Action Plan.*

Finally, chapters 6 and 7 utilized the Arup Resilience framework to assess whether all twelve resilience drivers are planned for in the *Action Plan*, which drivers are most robustly planned for, and whether there are any gaps. When assessing the key actions against Arup's twelve dimensions of a resilient system, this study showed that all twelve drivers are designed for to varying levels of robustness. The most key actions were attributed to the Leadership & Strategy dimension with 15/99 to the Leadership & Management resilience driver, 11/99 to Empowered Stakeholders, and 18/99 to Integrated Development Planning. These forty-four key actions feature qualities of leadership, multi-stakeholder planning, and project development. The Mobility & Communication driver of resilience was also abundantly planned for with thirteen assigned key actions, eight of which from the Technology & Tracking goal of *Action Plan*. Similarly, many of the Economy & Policy Goal objectives in the *Action Plan* directly tie into themes of the Sustainable Economy driver of Economy & Society.

While all twelve drivers were designed for in the *Action Plan*, a gap was identified from only one key action attributed to the Safeguards for Human Health driver. This highlights a resilience building opportunity for ongoing and future planning. The third recommendation focuses on improving emergency protections to help fill this gap and strengthen the Safeguards for Human Health driver of resilience.

8.3. Recommendation 3: Employ state facilitation of county-level emergency plan sharing.

The *Action Plan* lists state-led actions as priorities for objectives like implementing new fire hazard severity zones and developing a WUI best practices inventory (FMTF, 2021). These actions link state leadership with community protections. One way to improve upon these efforts

is through more peer-to-peer information sharing to reduce duplication of work, share emergency planning strategies, and coordinate jurisdictional efforts at local levels. Local emergency plans are tailored more specifically to regional circumstances and community needs than state and federal guidelines. Since there are already state-led efforts to develop wildfire mitigation resources for the community through top-down policy coordination, lead agencies like DOC, CAL FIRE, and OPR could additionally provide support for more horizontal policy coordination of emergency plan sharing at the county level. Peer-to-peer emergency plan and information sharing has the potential to generate a coordinated sense of ownership in building wildfire resilience and responding to threats.

In conclusion, there are many compounding factors that influence wildfire risks in California. The primary investigation of this study is whether the key actions in the *Action Plan* have the ability to accomplish the plan's goals to reduce wildfire risks, improve forest health, and build climate resilience. The *Action Plan* systematically plans for improvements to forest health through land treatments that integrate the benefits of fire suppression, fuels reduction, prescribed fire, and other management practices. This is reflected in planned key actions to expand application of modified treatment respective to spatial regions and community types. These strategies will improve California's ability to withstand the impacts of future fires without critical asset losses.

Overall, this research indicates that the strategies proposed in the *Action Plan* provide the roadmap to meet land treatment goals, enhance most of California's critical community protections, and build resilience into long-term management strategies. The EJ analysis, plan evaluation, and resilience analysis provide different lenses of assessment that identify opportunities to improve upon in ongoing and future planning. The suggested recommendations to ensure equitable Indigenous community protections, improve consistency and accessibility of plan implementation reporting, and employ state facilitation of county-level peer-to-peer emergency plan sharing would help strengthen the plan's efficacy to achieve its goals.

While the scope of this study reviewed all available information regarding Work Group implementation of the *Action Plan*, there are new and ongoing project developments occurring in real time. New advancements in *Action Plan* execution might be addressed in future studies.

Works Cited

AB-642 Wildfires, AB-642, 2019-2020 Reg. Sess. (Cal. 2021)(enacted).
   https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220AB642

Agee, J.K., and Skinner, C.N. (2005). Basic Principles of Forest Fuel Reduction Treatments. *Forest Ecology and Management, 211*(1-2): 83-96. DOI:10.1016/j.foreco.2005.01.034

Ager, A.A., Palaiologou, P., Evers, C.R., Day, M.A., Ringo, C., and Short, K. (2019). Wildfire Exposure to the Wildland Urban Interface in the Western US. *Applied Geography, 111*. https://doi.org/10.1016/j.apgeog.2019.102059

Aguilera, R., Corringham, T., Gershunov, A., and Benmarhnia, T. (2021). Wildfire Smoke Impacts Respiratory Health More Than Fine Particles From Other Sources: Observational Evidence from Southern California. *Nature Communications, 12*. https://doi.org/10.1038/s41467-021-21708-0

Amah Mutsun Tribal Band. (2014). Amah Mutsun Land Trust Five-Year Strategic Plan: 2014-2019. *Amah Mutsun Tribal Band.* https://static1.squarespace.com/static/59b09b1cf43b55e92c25343e/t/5a4beb80e4966bb3081398f5/1514924937350/AMLT_Strategic_Plan_Draft_v11.compressed.pdf

Anu Kramer, H., Mockrin, M.H., Alexandrew, P.M., and Radeloff, V.C. (2019). High Wildfire Damage in Interface Communities in California. *International Journal of Wildland Fire, 28*(9), 641-650. https://doi.org/10.1071/WF18108

Arup & The Rockefeller Foundation. (2017). *City Resilience Framework.*

Auer, M. R. (2021). Considering equity in wildfire protection. *Sustainability Science*. https://doi.org/10.1007/s11625-021-01024-8

Baldy, C.R. (2013). Why We Gather: Traditional Gathering in Native Northwest California and the Future of Bio-Cultural Sovereignty. *Ecological Processes, 2*. https://doi.org/10.1186/2192-1709-2-17

Bar-Massada, A. (2021). A Comparative Analysis of Two Major Approaches for Mapping the Wildland-Urban Interface: A Case Study in California. *Land, 10,* 679. https://doi.org/10.3390/land10070679

Bedsworth, L., Cayan, D., Franco, G., Fisher, L., and Ziaja, S. (2018). *Statewide Summary Report. California's Fourth Climate Change Assessment* (Publication number: SUMCCCA4-2018-013). California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission. https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf

Belmecheri, S., Babst, F., Wahl, E., Stahle, D.W., and Trouet, V. (2016). Multi-Century Evaluation of Sierra Nevada Snowpack. *Nature Climate Change*. *6*, 2–3. https://doi.org/10.1038/nclimate2809

Bento-Gonçalves, A., and Vieira, A. (2020). Wildfires in the Wildland-Urban Interface: Key Concepts and Evaluation Methodologies. *Science of the Total Environment*, *707*, https://doi.org/10.1016/j.scitotenv.2019.135592

Berg, N., and Hall, A. (2017). Anthropogenic Warming Impacts on California Snowpack During Drought. *Geophysical Research Letters*. *44*(5), 2511-2518. https://doi.org/10.1002/2016GL072104

Boisramé, G.F.S., Thompson, S.E., Kelly, M., Cavalli, J., Wilkin, K.M., and Stephens, S.L. (2017). Vegetation Change During 40 Years of Repeated Managed Wildfires in the Sierra Nevada, California. *Forest Ecology and Management, 402*, 241-252. https://doi.org/10.1016/j.foreco.2017.07.034

Bohlman, G.N., Underwood, E.C., and Safford, H.D. (2018). Estimating Biomass in California's Chaparral and Coastal Scrub Shrublands. *Madroño*. *65*(1): 28-46. https://www.jstor.org/stable/44841117

Brown, T., S. Leach, B. Wachter, and B. Gardunio. 2020. The Extreme 2018 Northern California Fire Season. Bulletin of the American Meteorological Society 101:S1-S4. https://doi.org/10.1175/BAMS-D-19-0275.1

Brown, C.D., and Johnstone, J.F. (2011). Once Burned, Twice Shy: Repeat Fires Reduce Seed Availability and Alter Substrate Constraints on *Picea Mariana* Regeneration. *Forest Ecology and Management, 266*: 34-41. https://doi.org/10.1016/j.foreco.2011.11.006

Buechi, H., Weber, P., Heard, S., Cameron, D., & Plantinga, A. J. (2021). Long-term trends in wildfire damages in California. *International Journal of Wildland Fire*. https://doi.org/10.1071/WF21024

Bureau of Indian Affairs. (2021) *Branch of Wildland Fire Management.* https://www.bia.gov/bia/ots/dfwfm/bwfm

Busby, G., and Albers, H.J. (2010). Wildfire Risk Management on a Landscape with Public and Private Ownership: Who Pays for Protection? *Environmental Management, 45*: 296-310. https://doi.org/10.1007/s00267-009-9381-x

California Department of Conservation. (2021). *2021 Regional Forest and Fire Capacity Program Grant Guidelines*. https://www.conservation.ca.gov/dlrp/grant-programs/Documents/2021%20Regional%20Forest%20and%20Fire%20Capacity%20Program%20Guidelines.pdf

California Air Resources Board. (2021). California's Greenhouse Gas Emissions for 2000 to 2019. https://ww2.arb.ca.gov/sites/default/files/classic/cc/ca_ghg_inventory_trends_2000-2019.pdf

CAL FIRE. (2022a, April 4). *Top 20 Largest California Wildfires.* https://www.fire.ca.gov/media/4jandlhh/top20_acres.pdf

CAL FIRE. (2022b, April 17). *Caldor Fire Incident.* https://www.fire.ca.gov/incidents/2021/8/14/caldor-fire/

CAL FIRE. (2022c, April 25). *Fire Hazard Area.* https://osfm.fire.ca.gov/divisions/community-wildfire-preparedness-and-mitigation/wildfire-preparedness/fire-hazard-severity-zones/?lang=zh-CN

CAL FIRE. (2021a, April 12). *California Land Ownership.*
https://gis.data.ca.gov/datasets/CALFIRE-Forestry::california-land-ownership/about

CAL FIRE. (2021b, April 12). *California State Responsibility Area*. https://calfire-forestry.maps.arcgis.com/home/webmap/viewer.html?layers=5bc422648cf045f38d1 0e1630fb71a71

California Natural Resources Agency. (2019). *California's Fourth Climate Change Assessment Statewide Summary Report* (Report # SUM-CCCA4-2018-013) . *https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf*

California Air Resources Board. (2021). *California Air Resources Board Launches California Smoke Spotter App* (Press release). https://ww2.arb.ca.gov/news/california-air-resources-board-launches-california-smoke-spotter-app#:~:text=The%20California%20Smoke%20Spotter%20app,from%20a%20local%20p rescribed%20fire.

Civil liability: prescribed burning operations: gross negligence, SB-332, 117. (2021). https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB332

Chang, H. and Bonnette, M.R. (2016). Climate Change and Water-Related Ecosystem Services: Impacts of Drought in California, USA. *Ecosystem Health and Sustainability*. *2*(12). https://doi.org/10.1002/ehs2.1254

Congressional Research Service. (2020). *Federal Land Ownership: Overview and Data*. https://sgp.fas.org/crs/misc/R42346.pdf

Davenport, F.V., Herrera-Estrads, J.E., Burke, M. and Diffenbaugh, N.S. (2019). Flood Size Increases Nonlinearly Across the Western United States in Response to Lower Snow-Precipitation Ratios. *Water Resources Research*. *56*(1). https://doi.org/10.1029/2019WR025571

Debats Garrison, J. and Huxman, T.E. (2020). A Tale of Two Suburbias: Turning Up the Heat In Southern California's Flammable Wildland-Urban Interface. *Cities, 104*. https://doi.org/10.1016/j.cities.2020.102725

Deitch, M.J., Van Docto, M., Obedzinski, M., Nossaman, S.P., and Bartshire, A. (2018). Impact of Multi-Annual Drought on Streamflow and Habitat in Coastal California Salmonid Streams. *Hydrological Sciences Journal*. *63*(8), 1219-1235. https://doi.org/10.1080/02626667.2018.1492722

Dettinger, M. (2016). Historical and future relations between large storms and droughts in California. San Francisco Estuary and Watershed Science, *14*(2). https://doi.org/10.15447/sfews.2016v14iss2art1

Dewhirst, R., Smirnoff, N., and Belcher, C.M. (2020). Pine Species That Support Crown Fire Regimes Have Lower Leaf-Level Terpene Contents Than Those Native to Surface Fire Regimes. *Fire, 3*(2). https://doi.org/10.3390/fire3020017

EPA. (2022). *Air Quality and Climate Change Research.* https://www.epa.gov/air-research/air-quality-and-climate-change-research

EPA. (2021). *California Tribal Lands and Reservations.* U.S. Environmental Protection Agency Pacific Southwest. https://www3.epa.gov/region9/air/maps/ca_tribe.html

EPA. (2019). *Wildland Fire Research Framework 2019-2022.* U.S. Environmental Protection Agency Office of Research and Development. https://www.epa.gov/sites/default/files/2019-04/documents/wildland_fire_research_framework_final-tagged.pdf

Executive Order N-82-20. (2020). https://www.gov.ca.gov/wp-content/uploads/2020/10/10.07.2020-EO-N-82-20-signed.pdf

Ferranto, S., Huntsinger, L., Getz, C.M., Nakamura, G.M., Stewart, W.C., Drill, S.L., Valachovic, Y., DeLasaux, M. and Kelly, N.M. (2011). Forest and Rangeland Owners Value Land for Natural Amenities and as Financial Investment. *California Agriculture, 65*(4), 184-191. https://doi.org/10.3733/ca.v065n04p184

Fettig, C.J., Mortenson, L.A., Bulaon, B.M., and Foulk, P.B., (2018). Tree Mortality Following Drought in the Central and Southern Sierra Nevada, California, U.S. *Forest Ecology and Management, 432*: 164-178. https://doi.org/10.1016/j.foreco.2018.09.006

Fillmore, S.D., McCaffrey, S.M., and Smith, A.M.S. (2021). A Mixed Methods Literature Review and Framework for Decision Factors That May Influence the Utilization of Managed Wildfire on Federal Lands, USA. *Fire, 4*(3). https://doi.org/10.3390/fire4030062

Fire Prevention and Protection: Prescribed Burns, SB-1260, 117 (2018) http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB1260

Fire Prevention: Wildfire and Forest Resilience: Action Plan: Reports, SB-456, 117. (2021). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB456

Fire Safety: Building Standards: Defensible Space Program, SB-190, 117. (2019). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201920200SB190

Forest Management Task Force. (2021). California's Wildfire and Forest Resilience Action Plan. *California Department of Water Resources, Public Affairs Office, Creative Services Branch.* https://www.fire.ca.gov/media/ps4p2vck/californiawildfireandforestresilienceactionplan.pdf

Franco, G.F., Cayan, D.R., Pierce, D.W., Westerling, A.L., and Thorne, J.H. (2018). *Cumulative Global CO_2 Emissions And Their Climate Impact From Local Regional Scales* (Publication number: CCCA4-EXT-2018-007). California Energy Commission. https://www.energy.ca.gov/sites/default/files/2019-11/Projections_CCCA4-EXT-2018-007_ADA.pdf

Frankson, R. Stevens, L.E., Kunkel, K.E. (2022). *California State Climate Summaries 2022 150-CA*. NOAA National Centers for Environmental Information. https://statesummaries.ncics.org/chapter/ca/

Glenn, C., Gray, A., Kuegler, O., Tase, N., and Rosneberg, M. (2018). *AB 1504 California Forest Ecosystem and Harvested Wood Product Carbon Inventory: 2006-2015*.California Forest and Harvested Wood Product Carbo Inventory. DOI: 10.13140/RG.2.2.19051.46884

Holling, C.S. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecological Systems.* 4:1-23. https://doi.org/10.1146/annurev.es.04.110173.000245

Huffman, M.R. (2013). The Many Elements of Traditional Fire Knowledge: Synthesis, Classification, and Aids to Cross-Cultural Problem Solving in Fire-Dependent Systems Around the World. *Ecology and Society, 18*(4): 3. http://dx.doi.org/10.5751/ES-05843-180403

Hurteau, M.D., Westerling, A.L., Wiedinmyer, C., and Bryant, B.P. (2014). Projected Effects of Climate and Development on California Wildfire Emissions Through 2100. *Environmental Science & Technology. 48*(4), 2298-2304. https://doi.org/10.1021/es4050133

Insurers: declared disaster: homeowners' insurance policies, SB-824, 117. (2018). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB824

IPBN. (2021). *Indigenous Peoples Burning Network* [Fact sheet]. http://www.conservationgateway.org/ConservationPractices/FireLandscapes/FireLearningNetwork/Documents/FactSheet_IPBN.pdf

Jacob, D.J. and Winner, D.A. (2009). Effect of Climate Change on Air Quality. *Atmospheric Environment. 43*(1), 51-63. https://doi.org/10.1016/j.atmosenv.2008.09.051

Jin, Y., Goulden, M.L., Faivre, N., Veraverbeke, S., Sun, F., Hall, A., Hand, M.S., Hook, S., and Randerson, J.T. (2015). Identification of Two Distinct Fire Regimes in Southern California: Implications for Economic Impacts and Future Change. *Environmental Research Letters, 10*(9), 94005. https://doi.org/10.1088/1748-9326/10/9/094005

Karuk Tribe. (2019). *Karuk Climate Adaptation Plan.* Karuk Department of Natural Resources. https://karuktribeclimatechangeprojects.files.wordpress.com/2019/10/reduced-size_final-karuk-climate-adaptation-plan.pdf

Keane, R.E., J.K. Agee, P. Fule, J.E. Keeley, C. Key, S.G. Kitchen, R. Miller, and L.A. Schulte. (2008). Ecological Effects of Large Fires on US Landscapes: Benefit or Catastrophe? *International Journal of Wildland Fire, 17*(6): 696-712. https://doi.org/10.1071/WF07148

Keeley, J.E., and Syphard, A.D. (2021). Large California Wildfires: 2020 Fires in Historical Context. *Fire Ecology, 17*(22). https://doi.org/10.1186/s42408-021-00110-7

Keeley, J.E., and Syphard, A.D. (2018). Historical Patterns of Wildfire Ignition Sources in California Ecosystems. *International Journal of Wildland Fire, 27*(12), 781-799. https://doi.org/10.1071/WF18026

Kelly, E., and Kusel, J., (2015). Cooperative, Cross-Boundary Management Facilities Large-Scale Ecosystem Restoration Efforts. *California Agriculture, 69*(1), 50-56. https://doi.org/10.3733/ca.v069n01p50

Kimmerer, W., Wilkerson, F., Downing, B., Dugdale, R., Gross, E.S., Kayfetz, K, Khanna, S., Parker, A.E., and Thompson, J. (2019). Effects of Drought and the Emergency Drought Barrier on the Ecosystem of the California Delta. *San Francisco Estuary and Watershed Science, 17*(3). https://doi.org/10.15447/sfews.2019v17iss3art2

Kinney, P.L. (2008). Climate Change, Air Quality, and Human Health. *American Journal of Preventative Medicine, 35*(5), 459-467. https://doi.org/10.1016/j.amepre.2008.08.025

Kramer, H.A., Mockrin, M.H., Alexandre, P.M., and Radeloff, V.C., (2019). High Wildfire Damage in Interface Communities in California. *International Journal of Wildland Fire*. 28: 641-650. https://doi.org/10.1071/WF18108

Lenihan, J.M., Drapek, R., Bachelet, D., and Neilson, R.P. (2003). Climate Change Effects on Vegetation Distribution, Carbon, and Fire in California. *Ecological Applications*, *13*(6), 1667-1681. https://doi.org/10.1890/025295

Little Hoover Commission. (2018). Fire on the Mountain: Rethinking Forest Management in the Sierra Nevada (Report #242). *Milton Marks Commission.* *https://lhc.ca.gov/sites/lhc.ca.gov/files/Reports/242/Report242.pdf*

Liu, Z. Herman, J.D., Huang, G., Kadir, T. and Dahlke, H.E. (2021). Identifying Climate Change Impacts on Surface Water Supply in the Southern Central Valley, California. *Science of the Total Environment*. *759*(10) https://doi.org/10.1016/j.scitotenv.2020.143429

Long, J.W., Lake, F.K., and Goode, R.W. (2021). The Importance of Indigenous Cultural Burning in Forested Regions of the Pacific West, USA. *Forest Ecology and Management, 500*. https://doi.org/10.1016/j.foreco.2021.119597

Luber G., and McGeehin, M. (2008). Climate Change and Extreme Heat Events. *American Journal of Preventive Medicine*. *35*(5), 429-435. https://doi.org/10.1016/j.amepre.2008.08.021

Marks-Block, T., and Tripp, W. (2021). Facilitating Prescribed Fire in Northern California Through Indigenous Governance and Interagency Partnerships. *Fire, 4*(3): 37. https://doi.org/10.3390/fire4030037

Marks-Block, T., Lake, F.K., Bliege Bird, R., and Curran, L.M. (2021). Revitalized Karuk and Yurok Cultural Burning to Enhance California Hazelnut for Basketweaving in Northwestern California, USA. *Fire Ecology, 17*. https://doi.org/10.1186/s42408-021-00092-6

Marks-Block, T., Lake, F.K., and Curran, L.M. (2019). Effects of Understory Fire Management Treatments on California Hazelnut, an Ecocultural Resource of the Karuk and Yurok

Indians in the Pacific Northwest. *Forest Ecology and Management, 450*. https://doi.org/10.1016/j.foreco.2019.117517

Mathews, L.E.H., and Kinoshita, A.M. (2021). Urban Fire Severity and Vegetation Dynamics in Southern California. *Remote Sensing, 13*(1), 19. https://doi.org/10.3390/rs13010019

Miller, J.D., and Safford, H. (2012). Trends in Wildfire Severity: 1984 to 2010 in the Sierra Nevada, Modoc Plateau, and Southern Cascades, California, USA. *Fire Ecology. 8,* 41-57. https://doi.org/10.4996/fireecology.0803041

Mockrin, M.H., Fishler, H.K., and Stewart, S.I. (2018) Does Wildfire Open a Policy Window? Local Government and Community Adaptation After Fire in the United States. *Environmental Management, 62*, 210-228. https://doi.org/10.1007/s00267-018-1030-9

Natural Resources Agency. (2018). 2018 Update of the Safeguarding California Plan. *California Natural Resources Agency.* https://resources.ca.gov/CNRALegacyFiles/docs/climate/safeguarding/update2018/safeguarding-california-plan-2018-update.pdf

National Oceanic and Atmospheric Administration. (2022, April 4) *National Integrated Drought Information System.* https://www.drought.gov/states/california

North, M.P., Stevens, J.T., Greene, D.F., Coppoletta, M., Knapp, E.E., Latimer, A.M., Restaino, C.M., Tompkins, R.E., Welch, K.R., York, R.A., Young, D.J.N., Axelson, J.N., Buckley, T.N., Estes, B.L., Hager, R.N., Long, J.W., Meyer, M.D., Ostoja, S.M., Safford, H.D., Shive, K.L., Tubbesing, C.L., Vice, H., Walsh, D., Werner, C.M., and Wyrsch, P. (2019). Tamm Review: Reforestation for Resilience in Dry Western U.S. Forests. *Forest Ecology and Management*, *432*, 209-224. https://doi.org/10.1016/j.foreco.2018.09.007

Palsa, E., Bauer, M., Evers, C., Hamilton, M., and Nielsen-Pincus, M. (2022). Engagement in Local and Collaborative Wildfire Risk Mitigation Planning Across the Western U.S.-Evaluating Participation and Diversity in Community Wildfire Protection Plans. *PLoS ONE, 17*(2). https://doi.org/10.1371/journal.pone.0263757

Parker, V.T., and Boyer, K.E. (2019). Sea-Level Rise and Climate Change Impacts on an Urbanized Pacific Coast Estuary. *Wetlands*, *39*, 1219-1232. https://doi.org/10.1007/s13157-017-0980-7

Pathak, T.B., Maskey, Maskey, M.L., Dahlberg, J.A., Kearns, F., Bali, K.M., and Zaccaria, D. (2018). Climate Change Trends and Impacts on California Agriculture: A Detailed Review. *Agronomy. 8*(3), 25. https://doi.org/10.3390/agronomy8030025

Paudel, A., Coppoletta, M., Merriam, K., and Markwith, S.H. (2022). Persistent Composition Legacy and Rapid Structural Change Following Successive Fires in Sierra Nevada Mixed Conifer Forests. *Forest Ecology and Management*, *509*. https://doi.org/10.1016/j.foreco.2022.120079

Radeloff, V.C., Helmers, D.P., Kramer, H.A., Mockrin, M.H., Alexandre, P.M. Bar-Massada, A., Butsic, V., Hawbaker, T.J., Martinuzzi, S. Syphard, A.D., and Steward, S. I. (2018). Rapid Growth of the US Wildland-Urban Interface Raises Wildfire Risk. *PNAS, 115*(13). https://doi.org/10.1073/pnas.1718850115

Radeloff, V.C., Hammer, R.B., Steward, S.I., Fried, J.S., Holcomb, S.S, and McKeefry, J.F. (2005). The Wildland-Urban Interface in the United States. *Ecological Applications, 15*(3), 799-805. https://doi.org/10.1890/04-1413

Reilly, M.J., McCord, M.G., Brandt, S.M., Linowksi, K.P., Butz, R.J., and Jules E.S. (2020). Repeated, High-Severity Wildfire Catalyzes Invasion of Non-Native Plant Species in Forests of the Klamath Mountains, Norther California, USA. *Biological Invasions, 22,* 1821-1828. https://doi.org/10.1007/s10530-020-02227-3

Rhoades, C.C., Nunes, J.P., Silins, U., and Doerr, S.H. (2019). The Influence of Wildfire on Water Quality and Watershed Processes: New Insights and Remaining Challenges. *International Journal of Wildland Fire, 28*(10), 721-725. https://doi.org/10.1071/WFv28n10_FO

Robbins, Z.J., Xu, C., Aukema, B.H., Buotte, P.C., Chitra-Tarak, R., Fettig, C.J., Goulden, M.L., Goodsman, D.W., Koven, C.D., Kueppers, L.M., Madakumbura, G..D., Mortenson, L.A., Powell, J.A., and Scheller, R.M. (2021). Warming Increased Bark Beetle-Induced Tree Mortality by 30% During an Extreme Drought in California. *Global Change Biology*, *28*(2): 509-523. https://doi.org/10.1111/gcb.15927

Rooney, B., Wang, Y., Jiang, J.H., Zhao, B., Zeng, Z., and Seinfeld, J.H. (2020). Air Quality Impact of the Northern California Camp Fire of November 2018. *Atmospheric Chemistry and Physics. 20*, 14597-14616. https://doi.org/10.5194/acp-20-14597-2020

Russel, G., Champ, J.G., Flores, D., Martinez, M., Hatch, A.M., Morgan, E., and Clarke, P. (2021). Doing Work on the Land of Our Ancestors: Reserved Treaty Rights Lands Collaborations in the American Southwest. *Fire, 4*(1). https://doi.org/10.3390/fire4010007

Samet, J. & Krewski, D. (2006). Health Effects Associated with Exposure to Ambient Air Pollution. *Journal of Toxicology and Environmental Health, Part A*. *70*, 3-4. https://doi.org/10.1080/15287390600884644

Schlosberg, D. (2013). Theorising Environmental Justice: The Expanding Sphere of a Discourse. *Environmental Politics, 22*(1): 37-55, https://doi.org/10.1080/09644016.2013.755387

Seto, D. Jones, C., Trugman, A.T., Varga, K., Plantinga, A.J., Carvalho, L.M.V., Thompson, C., Gellman, J., and Daum, K. (2022). Simulating Potential Impacts of Fuel Treatments on Fire Behavior and Evacuation Time of the 2018 Camp Fire in Northern California. *Fire, 5*(2). https://doi.org/10.3390/fire5020037

Sierra Nevada Conservancy (n.d.). *Spotlight on the Sierra Nevada*. Sierra Nevada Conservancy. Retrieved April 11, 2022, from https://sierranevada.ca.gov/

Short, Karen C. (2021). Spatial Wildfire Occurrence Data for the United States, 1992-2018 [FPA_FOD_20210617]. 5th Edition. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2013-0009.5

State Board of Forestry and Fire Protection. (2018). 2018 Strategic Fire Plan for California. *California Department of Forestry and Fire Protection.* https://osfm.fire.ca.gov/media/5590/2018-strategic-fire-plan-approved-08_22_18.pdf

Spencer, A.G., Schultz, C.A., and Hoffman, C.M. (2015). Enhancing Adaptive Capacity for Restoring Fire-Dependent Ecosystems: The Fire Learning Network's Prescribed Fire Training Exchanges. *Ecology and Society, 20*(3). http://www.jstor.org/stable/26270249

Stephens, C.W., Collins, B.M., and Rogan, J. (2020). Land Ownership Impacts Post-Wildfire Forest Regeneration in Sierra Nevada Mixed-Conifer Forests. *Forest Ecology and Management*, *468*. https://doi.org/10.1016/j.foreco.2020.118161

Stephens, S.L., Agee, J.K., Fulé, P.Z., North, M.P, Romme, W.H., Swetnam, T.W., and Turner, M.G., (2013). Managing Forests and Fire in Changing Climates. *Science, 342.* DOI: 10.1126/science.1240294

Syphard, A.D., Brennan, T.J., and Keeley, J.E. (2018). Drivers of Chaparral Type Conversion to Herbaceous Vegetation in Coastal Southern California. *Diversity and Distributions*, *25*(1), 90-101. https://doi.org/10.1111/ddi.12827

Taha, H. (2017). Characterization of Urban Heat and Exacerbation: Development of a Heat Island Index for California. *Climate. 5*(3), 59. https://doi.org/10.3390/cli5030059

Underwood, E.C., Hollander, A.D., Molinario, N.A., Larios, L., and Safford, H.D. (2021). Identifying Priorities for Post-fire Restoration in California Chaparral Shrublands. *Restoration Ecology, 30*(3). https://doi.org/10.1111/rec.13513

USDA Forest Service. (2022). *Confronting the Wildfire Crisis.* https://www.fs.usda.gov/sites/default/files/Confronting-Wildfire-Crisis.pdf

USDA Forest Service. (2020a). Fiscal year 2021 budget justification. https://www.fs.usda.gov/sites/default/files/2020-02/usfs-fy-2021-budget-justification.pdf

USDA Forest Service. *Agreement for Shared Stewardship of California's Forest and Rangelands*. (2020b). Retrieved February 16, 2022, from https://www.gov.ca.gov/wp-content/uploads/2020/08/8.12.20-CA-Shared-Stewardship-MOU.pdf

USDA. (n.d.) *Focus on Forestlands in California.* https://www.climatehubs.usda.gov/hubs/california/topic/focus-forestlands-california

U.S. Environmental Protection Agency. 2008. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. Washington, DC: U.S. Environmental Protection Agency. EPA-841- B-08-002.

Watts, N., Adger, W. N., Agnolucci, P., Blackstock, J., Byass, P., Cai, W., Chaytor, S., Colbourn, T., Collins, M., Cooper, A., Cox, P. M., Depledge, J., Drummond, P., Ekins, P., Galaz, V., Grace, D., Graham, H., Grubb, M., Haines, A., Hamilton, I., … Costello, A. (2015). Health and climate change: policy responses to protect public health. *Lancet (London, England)*, *386*(10006), 1861–1914. https://doi.org/10.1016/S0140-6736(15)60854-6

Webster, L., & Mertova, P. (2007). Using Narrative Inquiry as a Research Method: An Introduction to Using Critical Event Narrative Analysis in Research on Learning and Teaching (1st ed.). Routledge. https://doi.org/10.4324/9780203946268

Westerling, A.L., Hidalgo, H.G., and Swetnam, T.W. (2006). Warming and Earlier Spring increase Western U.S. Forest Wildfire Activity. *Science, 313*: 940-943. DOI: 10.1126/science.1128834

Wildfire & Forest Resilience Task Force. (2022a). *California's Wildfire and Forest Resilience Action Plan Implementation Strategy.* California Department of Water Resources, Public Affairs Office, Creative Services Branch. https://fmtf.fire.ca.gov/media/fblpd4el/wfr-task-force-implementation-strategy_2022.pdf

Wildfire & Forest Resilience Task Force. (2022b). *Progress on Key Actions*. AirTable. https://airtable.com/shrC89E7DQx8TgzcT/tbl2ikpAGWBEVULBj

Wildfire & Forest Resilience Task Force. (2022c). *Wildfire & Forest Resilience Expenditure Plan*. AirTable. https://airtable.com/shrp2DRbtl7vENWeU/tblDBPOzYeHbWnfnY

Wildfire & Forest Resilience Task Force. (2022d). *California's Strategic Plan for Expanding the Use of Beneficial Fire*. https://fmtf.fire.ca.gov/media/wmnj23l2/californias-strategic-plan-for-expanding-the-use-of-beneficial-fire.pdf

Wildfire & Forest Resilience Task Force. (2022e). *California Wildfire & Forest Resilience Task Force.* State of California. https://fmtf.fire.ca.gov/

Wise, C.R. (2022). Accountability in Collaborative Federal Programs – Multidimensional and Multilevel Performance Measures Needed: The Case of Wildland Fire Prevention. *American Review of Public Administration, 52*(2), 95-108. https://doi.org/10.1177/02750740211050367

Appendix A

Table A-1. The 99 key actions in the *Action Plan* ordered by goal number 1-4.

No.	Key Action
1.1	Treat 500,000 Acres of USFS Land Annually by 2025
1.2	Increase Sustainable Timber Harvest
1.3	Identify Strategic Fire Management Zones
1.4	Expand Agreements
1.5	Manage 175,000 Acres of NPS Lands by 2025
1.6	Treat 10,000 to 15,000 acres of BLM Land Annually by 2025
1.7	Increase Incentives for Timber Harvests that Improve Forest Resilience
1.8	Implement Fuels Reduction MOU
1.9	Develop Implementation Strategy
1.10	Maintain Forest Stewardship Education Program
1.11	Increase Technical Assistance
1.12	Improve Outreach
1.13	Support Forest Health and Maintenance Treatments
1.14	Establish Emergency Forest Restoration Teams
1.15	Provide Seedlings for Restoration
1.16	Expand Lumber Certifiers
1.17	Execute Strategy for Forested State Lands
1.18	Develop Prescribed Fire Strategic Action Plan
1.19	Utilize All Fuels Reduction Methods to Treat up to 100,000 Acres by 2025
1.20	Establish a Grant Program to Support Cultural Burning
1.21	Establish a National Prescribed Fire Training Center
1.22	Explore Strategies to Address Liability Issues
1.23	Modify Suppression Tactics on State Lands
1.24	Develop an Automated Prescribed Burn Permit
1.25	Provide Training and Technical Assistance
1.26	Improve Workforce Development
1.27	Develop an Annual Reporting System
1.28	Expand RFFC Program
1.29	Develop Network of Regional Forest and Community Fire Resilience Plans
1.30	Develop Pipeline of Local and Regional Shovel-Ready Projects
1.31	Develop Consolidated Forest Conservation Program
1.32	Align Forest Conservation Programs with Climate, Biodiversity, and Outdoor Access Programs
1.33	Develop Restoration Strategy for Federal Lands
1.34	Develop Coordinated State Restoration Strategy
1.35	Complete Permit Synchronization Workplan
1.36	Complete Timber Harvesting Plan Guidance Documents
1.37	Improve and Expand CalTREES
1.38	Enhance CalVTP Implementation
1.39	Update Prescribed Fire Information Reporting System
1.40	Help Landowners Conserve Northern Spotted Owls

2.1	Assess Statewide Risk to Vulnerable Communities
2.2	Develop Performance Measures
2.3	Develop and Implement New Fire Hazard Severity Zones
2.4	Update the Fire Hazard Planning Technical Advisory
2.5	Develop WUI Best Practices Inventory
2.6	Develop CWPP Best Practices Guide
2.7	Increase Information Sharing
2.8	Develop Defensible Space and Home Hardening Curriculum
2.9	Develop and Maintain 500 Fuels Management Projects
2.10	Link with Landscape Scale Projects
2.11	Maintain Fire Prevention Grants
2.12	Extend Defensible Space Programs
2.13	Expand Assistance Programs
2.14	Increase Defensible Space Inspections
2.15	Improve Defensible Space Compliance
2.16	Create a Model Defensible Space Program
2.17	Expand Home Hardening Programs
2.18	Develop Home Hardening Guidance
2.19	Develop WUI Fire Safety Training Material
2.20	Develop Insurance MOU
2.21	Review Wildfire Mitigation Plans
2.22	Coordinate Utility-Related Wildfire Mitigation Initiatives
2.23	Expand USFS Master Special Use Permits
2.24	Identify Subdivision Secondary Emergency Access
2.25	Develop Framework for Safe Road Corridors
2.26	Assist with General Plans
2.27	Expand Highway Treatments
2.28	Develop Good Neighbor Agreements
2.29	Expand Messaging Campaign
2.30	Launch Smoke Ready California Campaign
2.31	Release California Smoke Spotter App
2.32	Enhance Prescribed Fire Reporting
3.1	Develop Natural and Working Lands Climate Smart Strategy
3.2	Develop2022 Climate Change Scoping Plan Update
3.3	Establish Biodiversity Collaborative
3.4	Develop Biodiversity Strategy
3.5	Complete State Framework
3.6	Develop Market Roadmap
3.7	Establish Metrics
3.8	Launch Catalyst Fund Forest Investments
3.9	Develop X-Prize for Wood Product Innovation
3.10	Address Feedstock Barriers through Pilot Projects
3.11	Develop Statewide Forest and Wood Products Workforce Assessment
3.12	Maintain and Develop Removal Incentives
3.13	Update Statewide Comprehensive Outdoor Recreation Plan (SCORP)

3.14	Develop Joint Strategy to Improve Access to Sustainable Recreation
3.15	Increase Urban Canopy
3.16	Establish Regional Targets
3.17	Identify High Priorities
4.1	Complete Applied Research Plans
4.2	Forest Research Grants
4.3	Establish Forest Data Hub
4.4	Establish Ecological Planning Tool
4.5	Develop Statewide Forest Ecosystem Monitoring System
4.6	Integrate and Expand Forest Carbon Initiatives
4.7	Develop State-of-the-Science Models
4.8	Develop Consistent Reporting Tools
4.9	Establish Clearinghouse
4.10	Improve Coordination of Climate and Fire Research

Appendix B

Assigned authorities for the 99 key goals of the *Action Plan* and target dates for completion. Progress is measured by status level, current as of 3/21/22, which range from unknown→not started→in progress→ongoing→need feedback →final states→completed.

Table B-1. Status of the 40 key actions under Goal 1 of the *Action Plan.*

Goal 1: Increase Pace & Scale of Forest Health Projects					
No.	Key Action	Status	Lead Agency	Assigned Work Group	Target Date
1.1	Treat 500,000 Acres of USFS Land Annually by 2025	In Progress	USFS	Forest Management	1/1/25
1.2	Increase Sustainable Timber Harvest	In Progress	USFS	Forest Management	1/1/25
1.3	Identify Strategic Fire Management Zones	Completed	USFS	Forest Management	-
1.4	Expand Agreements	In Progress	USFS	Forest Management	-
1.5	Manage 175,000 Acres of NPS Lands by 2025	In Progress	NPS	Forest Management	1/1/25
1.6	Treat 10,000 to 15,000 acres of BLM Land Annually by 2025	In Progress	BLM	Forest Management	1/1/25
1.7	Increase Incentives for Timber Harvests that Improve Forest Resilience	Not Started	CAL FIRE	Forest Management	-
1.8	Implement Fuels Reduction MOU	Ongoing	CAL FIRE; USFS	Forest Management	-
1.9	Develop Implementation Strategy	Final Stages	CAL FIRE	Forest Management; Private Landowner Assistance	5/31/22
1.10	Maintain Forest Stewardship Education Program	Ongoing	UCANR	Forest Management; Private Landowner Assistance	-
1.11	Increase Technical Assistance	In Progress	CAL FIRE; NRCS	Forest Management; Private Landowner Assistance	7/1/22
1.12	Improve Outreach	Ongoing	CAL FIRE; NRCS	Forest Management; Private Landowner Assistance	-
1.13	Support Forest Health and Maintenance Treatments	In Progress	CAL FIRE; NRCS	Forest Management; Private Landowner Assistance	7/1/22
1.14	Establish Emergency Forest Restoration Teams	In Progress	CAL FIRE; NRCS; Cal OES; RCRC	Forest Management; Private Landowner Assistance	2/1/22
1.15	Provide Seedlings for Restoration	Ongoing	CAL FIRE; USFS	Forest Management; Private Landowner Assistance	-
1.16	Expand Lumber Certifiers	Completed	BOF	Forest Management	7/1/21
1.17	Execute Strategy for Forested State Lands	In Progress	CNRA; CDFW; State Parks; Tahoe Conservancy; CAL FIRE	Forest Management; State Lands Committee	12/31/22
1.18	Develop Prescribed Fire Strategic Action Plan	Final Stages	CAL FIRE; CalEPA/CARB; USFS	Forest Management; Prescribed	3/31/22

1.19	Utilize All Fuels Reduction Methods to Treat up to 100,000 Acres by 2025	In Progress	CAL FIRE	Forest Management; Prescribed Fire	1/1/25
1.20	Establish a Grant Program to Support Cultural Burning	Ongoing	CAL FIRE	Forest Management; Prescribed Fire	9/1/22
1.21	Establish a National Prescribed Fire Training Center	In Progress	USFS; CAL FIRE; Inter-tribal Indigenous Stewardship Project	Forest Management; Prescribed Fire	1/1/25
1.22	Explore Strategies to Address Liability Issues	In Progress	CAL FIRE	Forest Management; Prescribed Fire	12/31/21
1.23	Modify Suppression Tactics on State Lands	Ongoing	CAL FIRE	Forest Management; Prescribed Fire	1/10/22
1.24	Develop an Automated Prescribed Burn Permit	Final Stages	CAL FIRE	Forest Management; Prescribed Fire	5/1/22
1.25	Provide Training and Technical Assistance	Ongoing	CAL FIRE; BOF	Forest Management; Prescribed Fire	5/1/22
1.26	Improve Workforce Development	Final Stages	CAL FIRE	Forest Management; Workforce Development	3/24/22
1.27	Develop an Annual Reporting System	In Progress	CAL FIRE	Forest Management; Prescribed Fire	11/1/22
1.28	Expand RFFC Program	In Progress	DOC	Regional Frameworks	7/29/22
1.29	Develop Network of Regional Forest and Community Fire Resilience Plans	In Progress	DOC; USFS	Regional Frameworks	7/31/22
1.30	Develop Pipeline of Local and Regional Shovel-Ready Projects	Ongoing	DOC; USFS; CAL FIRE	Regional Frameworks	11/30/22
1.31	Develop Consolidated Forest Conservation Program	In Progress	CAL FIRE; WCB	Forest Management	6/30/22
1.32	Align Forest Conservation Programs with Climate, Biodiversity, and Outdoor Access Programs	In Progress	CAL FIRE; WCB	Forest Management	6/30/22
1.33	Develop Restoration Strategy for Federal Lands	In Progress	USFS	Forest Management; Reforestation	3/24/22
1.34	Develop Coordinated State Restoration Strategy	In Progress	Cal OES; OPR; CNRA	Forest Management; Reforestation	11/30/21
1.35	Complete Permit Synchronization Workplan	Final Stages	BOF; CDFW; SWRCB	Forest Management; AB 1492 Leadership Team	2/15/22
1.36	Complete Timber Harvesting Plan Guidance Documents	In Progress	CAL FIRE; SWRCB; CGS; CDFW	Forest Management; AB 1492 Lead	11/17/22
1.37	Improve and Expand CalTREES	Ongoing	CNRA; CDFW; SWRCB	Forest Management; AB 1492 Leadership Team	12/31/24
1.38	Enhance CalVTP Implementation	Final Stages	SWRCB; BOF	Forest Management; AB 1492 Leadership Team	3/31/22
1.39	Update Prescribed Fire Information Reporting System	In Progress	CNRA; CalEPA/CARB	Forest Management; Prescribed Fire	12/1/21
1.40	Help Landowners Conserve Northern Spotted Owls	Completed	CAL FIRE; CDFW; USFWS	Forest Management	3/1/21

Table B-2. Status of the 32 key actions under Goal 2 of the *Action Plan*.

No.	Key Action	Status	Lead Agency	Assigned Work Group	Target Date
Goal 2: Strengthen Protection of Communities					
2.1	Assess Statewide Risk to Vulnerable Communities	In Progress	CAL FIRE; OPR	Fire-Adapted Communities	-
2.2	Develop Performance Measures	Final Stages	CAL FIRE; OPR; The Watershed Center	Fire-Adapted Communities	12/31/22
2.3	Develop and Implement New Fire Hazard Severity Zones	In Progress	CAL FIRE	Fire-Adapted Communities	6/30/22
2.4	Update the Fire Hazard Planning Technical Advisory	Final Stages	OPR	Fire-Adapted Communities	4/1/22
2.5	Develop WUI Best Practices Inventory	Final Stages	OPR	Fire-Adapted Communities	3/1/22
2.6	Develop CWPP Best Practices Guide	Not Started	The Watershed Center; CAL FIRE	Fire-Adapted Communities	12/30/22
2.7	Increase Information Sharing	Ongoing	DOC	Fire-Adapted Communities	-
2.8	Develop Defensible Space and Home Hardening Curriculum	Final Stages	CAL FIRE	Fire-Adapted Communities	12/31/21
2.9	Develop and Maintain 500 Fuels Management Projects	Ongoing	CAL FIRE	Fire-Adapted Communities	-
2.10	Link with Landscape Scale Projects	Ongoing	CAL FIRE	Fire-Adapted Communities	-
2.11	Maintain Fire Prevention Grants	Ongoing	CAL FIRE	Fire-Adapted Communities	-
2.12	Extend Defensible Space Programs	In Progress	CAL FIRE; BOF	Fire-Adapted Communities	12/31/22
2.13	Expand Assistance Programs	In Progress	CAL FIRE	Fire-Adapted Communities	12/31/22
2.14	Increase Defensible Space Inspections	Completed	CAL FIRE	Fire-Adapted Communities	7/1/21
2.15	Improve Defensible Space Compliance	In Progress	CAL FIRE	Fire-Adapted Communities	12/31/22
2.16	Create a Model Defensible Space Program	In Progress	CAL FIRE	Fire-Adapted Communities	6/30/22
2.17	Expand Home Hardening Programs	In Progress	CAL OES	Fire-Adapted Communities	1/1/23
2.18	Develop Home Hardening Guidance	In Progress	CAL FIRE	Fire-Adapted Communities	6/30/22
2.19	Develop WUI Fire Safety Training Material	In Progress	CAL FIRE	Fire-Adapted Communities	12/31/22
2.20	Develop Insurance MOU	In Progress	CAL FIRE; CAL OES; Dept. of Insurance	Fire-Adapted Communities	3/1/22
2.21	Review Wildfire Mitigation Plans	Completed	CNRA; CAL FIRE	Utility Wildfire Mitigation Steering Committee; Fire-Adapted Communities	9/23/21
2.22	Coordinate Utility-Related Wildfire Mitigation Initiatives	Ongoing	CAL FIRE; Energy Safety	Utility Wildfire Mitigation Steering Committee; Fire-Adapted Communities	3/31/22

2.23	Expand USFS Master Special Use Permits	Unknown	USFS	Fire-Adapted Communities	
2.24	Identify Subdivision Secondary Emergency Access	Ongoing	BOF; CAL FIRE	Fire-Adapted Communities; Fire-safe Roadways	-
2.25	Develop Framework for Safe Road Corridors	Completed	Caltrans	Fire-safe Roadways; Fire-Adapted Communities	6/1/21
2.26	Assist with General Plans	In Progress	Caltrans; OPR	Fire-Adapted Communities; Fire-safe Roadways	12/31/22
2.27	Expand Highway Treatments	In Progress	CAL FIRE, Caltrans	Fire-Adapted Communities; Fire-safe Roadways	-
2.28	Develop Good Neighbor Agreements	Final Stages	Caltrans; USFS	Fire-safe Roadways; Fire-Adapted Communities	6/30/22
2.29	Expand Messaging Campaign	In Progress	CAL FIRE, Caltrans	Fire-Adapted Communities; Fire-safe Roadways	12/31/22
2.30	Launch Smoke Ready California Campaign	Completed	CalEPA/CARB	Fire-Adapted Communities	7/1/21
2.31	Release California Smoke Spotter App	Completed	CalEPA/CARB	Fire-Adapted Communities	7/1/21
2.32	Enhance Prescribed Fire Reporting	In Progress	CalEPA/CARB	Prescribed Fire; Fire-Adapted Communities	9/1/23

Table B-3. Status of the 17 key actions under Goal 3 of the *Action Plan.*

No.	Key Goal	Status	Lead Agency	Assigned Work Group	Target Date
Goal 3: Manage Forests to Achieve the State's Economic and Environmental Goals					
3.1	Develop Natural and Working Lands Climate Smart Strategy	Final Stages	CNRA	-	3/31/22
3.2	Develop2022 Climate Change Scoping Plan Update	In Progress	CalEPA/CARB; CNRA	-	11/1/22
3.3	Establish Biodiversity Collaborative	Ongoing	CNRA; CDFA; CalEPA/CARB	-	2/28/22
3.4	Develop Biodiversity Strategy	Final Stages	CNRA	-	10/1/22
3.5	Complete State Framework	Completed	OPR	Joint Institute Advisory Council	5/1/21
3.6	Develop Market Roadmap	Final Stages	OPR; GO-Biz	Joint Institute Advisory Council	1/31/22
3.7	Establish Metrics	Not Started	OPR; GO-Biz	Joint Institute Advisory Council	-
3.8	Launch Catalyst Fund Forest Investments	Completed	iBank; GO-Biz	Joint Institute Advisory Council	12/31/21
3.9	Develop X-Prize for Wood Product Innovation	In Progress	OPR; GO-Biz	Joint Institute Advisory Council	9/30/21
3.10	Address Feedstock Barriers through Pilot Projects	Final Stages	OPR; GO-Biz; Joint Institute for Wood Products Innovation	Joint Institute Advisory Council	6/30/22
3.11	Develop Statewide Forest and Wood Products Workforce Assessment	Final Stages	OPR; Labor & Workforce Development Agency; CAL FIRE	Workforce Development; Joint Institute Advisory Council	3/24/22
3.12	Maintain and Develop Removal Incentives	Not Started	CAL FIRE	Joint Institute Advisory Council	-
3.13	Update Statewide Comprehensive Outdoor Recreation Plan (SCORP)	Completed	CNRA; State Parks	CALREC Vision	12/31/21
3.14	Develop Joint Strategy to Improve Access to Sustainable Recreation	In Progress	USFS; State Parks	CALREC Vision	7/29/22
3.15	Increase Urban Canopy	Ongoing	CAL FIRE	Urban Forestry Committee	1/1/30
3.16	Establish Regional Targets	In Progress	CAL FIRE	Urban Forestry Committee	6/15/23
3.17	Identify High Priorities	In Progress	CAL FIRE	Urban Forestry Committee	1/1/24

Table B-4. Status of the 10 key actions under Goal 4 of the *Action Plan.*

No.	Key Goal	Status	Dated	Assigned Work Group	Target Date
Goal 4: Drive Innovation and Measure Progress					
4.1	Complete Applied Research Plans	Completed	BOF; CAL FIRE	Science Advisory Panel	6/1/21
4.2	Forest Research Grants	Ongoing	CAL FIRE	Monitoring, Reporting & Assessment	-
4.3	Establish Forest Data Hub	In Progress	CAL FIRE; USFS; CNRA; USDA Climate Hub	Science Advisory Panel; Monitoring, Reporting & Assessment	-
4.4	Establish Ecological Planning Tool	In Progress	CalEPA/CARB; CNRA	Science Advisory Panel; Monitoring, Reporting & Assessment	6/1/25
4.5	Develop Statewide Forest Ecosystem Monitoring System	In Progress	CNRA	Science Advisory Panel; Monitoring, Reporting & Assessment	6/1/25
4.6	Integrate and Expand Forest Carbon Initiatives	Ongoing	CAL FIRE; CalEPA/CARB	Science Advisory Panel; Monitoring, Reporting & Assessment	6/1/25
4.7	Develop State-of-the-Science Models	Ongoing	CAL FIRE; CalEPA/CARB	Science Advisory Panel; Monitoring, Reporting & Assessment	-
4.8	Develop Consistent Reporting Tools	In Progress	CalEPA/CARB; CNRA; CAL FIRE; USFS	Science Advisory Panel; Monitoring, Reporting & Assessment	-
4.9	Establish Clearinghouse	In Progress	-	Science Advisory Panel; Monitoring, Reporting & Assessment	-
4.10	Improve Coordination of Climate and Fire Research	Ongoing	CAL FIRE	Science Advisory Panel; Monitoring, Reporting & Assessment	-