Chapter 1: Resilient Forests



Mountain Home Demonstration State Forest old-growth giant sequoia. Photo: CAL FIRE.

INDICATORS

- ⓘ 1.1 Net Growth on Timberland
- ⓘ 1.2 Timberland Restoration Needs
- ⓘ 1.3 Silvicultural Methods
- ⓘ 1.4 Timber Harvest
- ⓘ 1.5 Sustainability Initiatives
- ⓘ 1.6 Carbon Offset Projects

INTRODUCTION

From wilderness reserves to productive working forests, California's forests provide a multitude of ecosystem services to the state's 39 million residents and beyond, including scenic and culturally significant landscapes, timber products, medicinal plants, clean air and water, wildlife habitat, soil resources, carbon sequestration and storage, and recreational opportunities. These forests support rural economies and the well-being of the people living in and visiting them, as well as populations well beyond the forested boundaries. However, California's forests are facing major threats. Rising temperatures coupled with droughts are already causing increased wildfire activity and insect and disease outbreaks. Tree mortality is rampant, post-disturbance natural regeneration failure and vegetation type conversion threaten millions of acres, and current tree species ranges are at risk (Coppoletta et al. 2022, Davis et al. 2023, Estes and Bovee 2023, Steel et al. 2023, USFS 2022b, WFR Task Force 2024d). Recent studies project that California's forests will be a carbon emission source under future climate, losing 7–24% of the carbon sink between 2014 and 2045 (CARB 2022b, DeLyser et al. 2025). The combination of increased high severity fire and post-fire regeneration failure could result in the loss of 48% of forest area by 2070 (DeLyser et al. 2025). Further, invasive plants, many of which are not native to California, also are having a major impact on both working forests and other forestlands.

Applying concepts from North et al. (2022) in this chapter, forest resilience refers to its adaptability to a range of stresses and reflects the functional integrity of the ecosystem, such as retaining fundamental forest ecological structure, composition, and processes. While California's Forest Practice Rules (FPRs) and federal policies are in place to ensure sustainable harvesting, managing towards more resilient forests in a changing climate is complex. The overarching goal is to maintain forested landscapes despite more frequent and intense disturbance regimes. While silviculture is applied at the stand level, efforts to overcome a century of fire suppression policy and legacies of past problematic timber operations require strategic landscape-scale management on millions of acres, including areas that have seen very little management in the last century besides fire suppression. These actions include managing for diverse forest stand structure and composition, reducing stand densities substantially in some forest types, conducting post-disturbance salvage harvest to enable safe and successful reforestation, reintroducing beneficial

fire, and exploring the use of assisted gene flow or species migration. A robust research, monitoring, and adaptive management process, enabling Indigenous stewardship, integrating traditional ecological knowledge (TEK), restoring ecological processes, and encouraging collaboration across all lands and various types of sustainability initiatives are all key to forest resilience and minimizing projected carbon losses.

SUMMARY

Building on the 2017 Assessment, this chapter uses six indicators to track California conditions and management trends with emphasis on conifer-dominated forestlands. California's forestland (including woodlands) comprises 32 million acres, almost a third of the state. Approximately 51% of California's forest (16.3 million acres) is characterized as timberland.[1] Over half of California timberland is in public ownership, primarily administered by the U.S. Department of Agriculture (USDA) Forest Service (USFS). About a quarter of timberland is owned by forest industry, including much of the higher site quality lands. The remaining timberland (20%) is owned by a diverse group of smaller private nonindustrial owners and nongovernmental organizations (NGOs).

In California, a robust set of federal, state, and local laws, rules, regulations, and ordinances govern the sustainable harvest of timber from working forests. The Board of Forestry and Fire Protection (BOF) is responsible for developing general forest policy (e.g., FPRs), determining guidance policy for the California Department of Forestry and Fire Protection (CAL FIRE), and representing the state's interest in federal forestland in California. In turn, the BOF's FPRs and other forest policies interact with regulations implemented by other state agencies such as the California Department of Fish and Wildlife (CDFW) and the Regional Water Quality Control Boards (RWQCBs).

A variety of silvicultural methods are employed on California forestlands. Since the late 1990s, the California FPRs have required all non-federal forest landowners to manage on a sustained yield basis under a state regulatory framework for "maximum sustained production (MSP) of high-quality timber products" (California Code of Regulations [CCR] Title 14, §§ 913.11, 933.11, 953.11). Landowners must submit harvest documents to CAL FIRE prior to conducting commercial harvests, many of which undergo a multiagency review. Additional permits to protect aquatic habitats and water quality may be required. The scope of timber harvesting regulations on non-federal lands includes assessing impacts on threatened and endangered species, wildlife habitat, water quality, carbon storage and emissions, archeological sites, and other resources. Together, the FPRs, water quality regulatory systems, fish and wildlife regulatory systems, and interagency review and enforcement provide for broad natural resource sustainability. In the past decade, regulations have been amended to establish more stringent standards, such as those related to forest roads and yarding methods.

Statewide, public and private forests face high risks, as demonstrated by ongoing tree mortality and recent large stand-replacing wildfires. Legacy timber harvest practices, land use development patterns, fire suppression policies, and in some cases minimal management have limited wildfire's natural role across California's landscapes and contributed to an unnatural build-up of fuels throughout California forests. Coupled with novel climate conditions, including rising temperatures and recent severe droughts, California's forests are under stress, making them more susceptible to insects and disease as well as worsening wildfire outcomes. The scope and extent of restorative treatments needed at the landscape scale, including reducing stand densities

1 *Timberland represents the land base that could potentially be managed for forest products and is defined by the USFS as land capable of producing over 20 cubic feet/acre/year of wood with commercial value and not withdrawn from timber utilization by statute or administrative regulation (USFS 2023b).*

in certain forests and conducting post-fire restoration/regeneration, is significant and challenging (ⓘ1.2), with the greatest area of forest in general and of forest in need of treatment on public lands.

There has been a steady decline in the number of harvested acres and volume since the 1990s (ⓘ1.3, ⓘ1.4), with greater declines in volume removed from public lands due to many factors, including increased protections for state and federal listed species, reductions in USFS funding and staffing, and changing public demands for National Forest ecosystem services. These declines in harvest from the state's timberlands have been accompanied by a corresponding decline in the number of wood processing facilities. While timber harvest and lumber production are generally at historically low levels, average output per mill is at a record high. In 2021, average mill production was approximately 2.5 times larger than the average mill in the 1950s, when California lumber production peaked, and many more mills were operating than today. Despite increased efficiencies with fewer mills, there is limited wood processing infrastructure, such as sawmills and biomass plants (ⓘ1.4, ⓘ12.2), particularly for the large quantities of small-diameter and/or low-value material typical of restoration projects (LHC 2018, Porter and Longcor 2020).

Limited infrastructure combined with wood products being a broadly available commodity constrain the volume of material that can be economically removed through restoration treatments. However, these treatments present an opportunity for California to contribute more substantially to meeting its own wood product demand. While increased utilization of in-state material could support forest health and reduce reliance on imports, California's forests will likely never satisfy the state's overall wood product needs. As a result, the majority of wood products consumed in California will continue to be from other states and countries, many of which operate under less restrictive forest practice rules (Evans and Potts 2024).

Recent federal executive orders (U.S. President Trump 2025a, 2025b), followed by further directives from the Secretary of Agriculture and USFS leadership (USDA 2025, USFS 2025a), emphasize the need to increase domestic timber production on National Forest System (NFS) and Bureau of Land Management (BLM) forests immediately and as a matter of national security, while also seeking to relax environmental regulations such as the National Environmental Policy Act (NEPA) and the Endangered Species Act. Notably, a recent study in California indicates that by focusing on ecological restoration, by completing initial thinning treatments within 10 years, timber volumes can double, with 80% of the volume coming from federal lands. For this to occur, both sawmill and bioenergy capacity would need to double to accommodate the increased removals. New infrastructure will require a longer-term green timber supply than evaluated in this study. Where appropriate, consideration of follow-up thinning treatments on a regular cutting cycle intermixed with prescribed fire could help to address timber supply and costs. It would cost up to $2 billion annually in addition to business-as-usual activities, with wood product revenues offsetting 39–50% of costs under moderate pricing assumptions (DeLyser et al. 2025). A similar study indicated an annual cost of $1.8 billion for treatments across forests, shrublands, and grasslands (CARB 2022b).

Constraints extend beyond supply and infrastructure. These additional constraints include a decline in the skilled workforce, high and increasing regulatory and implementation costs, and limited funding (Heard and Franklin 2023, LHC 2018, Porter and Longcor 2020, Riddle 2023). Public sector barriers also inhibit workforce recruitment and retention (e.g., low federal wages, hiring freezes), which are further exacerbated by uncertainty in funding (e.g., operating under continuing budget resolutions) (Heard and Franklin 2023, Riddle 2023). These uncertainties are very significant under the current federal administration through budget cuts, freezes, reduction-in-workforce efforts, and major structural reorganization of federal land management agencies. Additionally, important regulatory oversight and public participation processes such as environmental review at times have the unintended consequence of delaying critical forest health projects. Some projects

on public lands face potential for community opposition and litigation (LHC 2018, Riddle 2023).

Similarly, there are many limitations to the reforestation process, also coined the "reforestation pipeline," preventing a larger planting effort as the need for post-fire reforestation increases (WFR Task Force 2024d). These barriers include project planning processes that can be costly and cause delays, inadequate seed collection and processing, especially from low elevation zones, insufficient seedling nursery capacity, inadequate site preparation, and not enough funding and labor. Each component in the reforestation pipeline faces its own set of challenges—for example, seed collection requires having a skilled workforce and the ability to mobilize resources quickly when a big cone production year occurs. Big cone production years are impacted by disturbance and climate change, which also reduces genetic diversity in the seed stock itself. These barriers are further documented in Dobrowski et al. (2024).

Over the years, the state has made numerous efforts to address barriers that impede active management. The state legislature and subsequent rulemaking by the BOF have expanded permissions to enable commercial harvesting activities primarily for fuels reduction that are exempted from Timber Harvesting Plan (THP) preparation (e.g., Exemption Notices). These changes have prompted more tracking of activities (e.g., CAL FIRE's Forest Practice GIS and California Timber Regulation and Environmental Evaluation System (CalTREES) timber harvest document hubs, Interagency Treatment Tracking System, etc.). Data gaps remain, however, with regard to comprehensive geospatial data for completed work on private lands. These changes have also prompted monitoring and evaluation of both Emergency and Exemption Notice outcomes (see Chapter 13, Institutional Response, for more information). Programmatic management plans and other harvest plan types have been provided by the state to reduce the regulatory burden on non-federal landowners interested in conducting restoration treatments and using uneven-aged silviculture or other lower disturbance practices to reduce environmental impacts. Most recently in 2025, Governor Newsom declared a state of emergency due to catastrophic wildfire risks and directed the state to expedite critical fuels reduction projects by suspending various state statutes, rules, and regulations that might slow the implementation of such projects (Newsom 2025). Protection of air quality, water quality, tribal cultural resources, and wildlife species and their habitat is to be implemented through various protection measures outlined in the Statewide Fuels Reduction and Environmental Protection Plan (CNRA and CAL EPA 2025).

To help reverse declining conditions in California's forests and address barriers to doing so, new strategies and significant investment of public funds have been deployed to more actively manage forests across all landownerships. The California Wildfire and Forest Resilience Task Force's (WFR Task Force) 2021 Action Plan, and several other state efforts aim to address the challenges that impede forest restoration (WFR Task Force 2021, 2024b, 2024d, 2025a). Collaborative state-federal efforts initially set an annual treatment goal of 1 million acres by 2025 to help achieve resilient forest conditions, including 500,000 acres of non-federal lands and 500,000 acres of NFS lands. This represents a near doubling of management from 2020 activities. More ambitious state goals for forests, shrublands, and grasslands of 2.5 million acres per year of wildfire resilience and restoration work by 2045 have been established by the Newsom administration following enactment of Assembly Bill (AB) 1757 (Garcia and Rivas 2022). This legislation required the California Natural Resources Agency (CNRA) to develop an ambitious range of targets for natural carbon sequestration and for nature-based climate solutions that reduce greenhouse gas (GHG) emissions (CNRA 2024). Thus far, the number of acres treated annually has been trending upward. However, it is widely acknowledged that reaching both the annual million-acres goal and the more ambitious nature-based solutions (NBS) goals will require a long-term ramp up of planning and capacity building, including workforce development.

In addition to the WFR Task Force Action Plan and the NBS climate targets, other important recent state

plans that address forests include the California Forest Carbon Plan (FCAT 2018), the California Climate Adaptation Strategy (CNRA 2021), Pathways to 30x30 California (CNRA 2022a), the Natural and Working Lands Climate Smart Strategy (CNRA 2022b), and the Scoping Plan for Achieving Carbon Neutrality (CARB 2022b). The work of individual landowners and landscape-level collaboratives is critical to achieving the goals of the above plans, including improving forest health, reducing fire threat, and contributing to local economic development. Successful collaboratives build trust, have a science-based approach, provide a mechanism outside of litigation to address conflicting stakeholder concerns, and facilitate work across multiple ownerships (LHC 2018).

Financial support for individual landowner and collaborative forest resilience work has increased significantly at the federal and state levels since the 2017 Assessment. This support has been prompted in part due to the series of deadly and catastrophic wildfires that have affected the Western United States in recent years. Federal and state programs are important sources of grant funding to nongovernmental and community organizations, as well as technical and financial assistance to landowners, both large and small, for their forest management planning and projects. Multiple state programs for projects, organizational capacity, wood products and workforce development, forest health research, and other activities have been established and significantly funded in the past half dozen years across a number of state entities (see Chapter 13, Institutional Response). Examples at the federal level include the funds from the federal Inflation Reduction Act and the Bipartisan Infrastructure Law, although the future of these funds is uncertain with the current federal administration. The WFR Task Force estimates that nearly $6 billion of state and federal funds have been invested in forest health and wildfire resilience projects and programs since 2021 (WFR Task Force 2025a). Looking forward, major funding approved in November 2024 by California voters under Proposition 4 and codified in Senate Bill (SB) 867 allocates $1.5 billion of bond funds for wildfire and forest resilience programs and $1.2 billion for biodiversity protection and nature-based climate solution programs (Allen et al. 2024).

Trends by Owner

Overly dense stand conditions from a century of fire suppression and exclusion (ⓘ1.2), legacies of past problematic timber operations, decades of limited or no active management on public lands, and deviation from historic fire regimes (ⓘ4.1) are major issues further exacerbated by climate change. Indicators and key findings illustrate trends that vary by forest ownership and other metrics. Trends presented are not intended to be a causal comparison of management methods, but rather to highlight potential concerns for different landowners. Softwoods (i.e., conifers) comprise just over 98% of commercial timber harvest and come primarily from timberland (Scott et al. 2024). USFS Forest Inventory and Analysis (FIA) data indicate across all ownerships, average softwood growth was 1.3 billion cubic feet (ft^3)/year. Net growth was 0.3 billion ft^3/year, or 18 ft^3/acre/year. Net growth was 54% less than what was reported in the 2017 Assessment. Increased wildfire, insect, and disease-related losses drove reductions in net growth on private corporate,[2] NFS timberlands, and productive NFS land reserved from management for timber production. Considering fires greater than

2 *The USFS FIA program partitions private land into corporate and non-corporate categories. Corporate ownership is defined in the field manual (USFS 2023d) and is typically based on whether an owner name includes Inc. or Corp., while non-corporate ownership includes non-governmental conservation organizations, unincorporated partnerships, associations and clubs, Native American lands within reservation boundaries, and individual and family ownership, including trusts, estates, and family partnerships. This classification is slightly different than CAL FIRE'S private industry GIS layer, which generally consists of landowners that own greater than 2,500 acres and are members of the California Forestry Association. In 2021, definitional differences led to an approximate 1 million acre difference in FIA corporate versus CAL FIRE industrial forestland. FIA corporate generally corresponds to industrial lands, though there are approximately 1.8 million acres of corporate forestland that are not industrial; similarly, there are approximately 360,000 non-corporate acres that are industrial. FIA-based indicators in this chapter refer to private corporate and non-corporate categories. Other indicators in this chapter that refer to industrial lands are based on the CAL FIRE private industry GIS layer or other data from CAL FIRE's Forest Practice reporting. These will be indicated by use of corporate/non-corporate or industrial/nonindustrial terminology. As most timber harvest in California originates on private industrial lands, in general the chapter will refer to industrial and nonindustrial private lands.*

10,000 acres in size in select ecoregions between 2018 to 2021, high severity fire occurred on 41% of the private forest industry area burned, with slightly lower percentages on NFS lands (37%) and private nonindustrial forestlands (33%) (MBG 2023). Between 2012 and 2022, 42% of public lands experienced elevated forest pest and drought-related mortality (>5 trees per acre), with 15% of that mortality in the severe category (>15 trees per acre) (USFS 2022b; see Chapter 5, Forest Pests). Elevated mortality was detected on 19% of private lands, with 6% of the mortality in the severe class. It is possible that some private landowners conduct operations to improve forest health and resilience, thereby reducing mortality, and/or remove dead and dying trees more rapidly, thereby reducing detection of mortality during aerial surveys.

Widespread tree mortality from the 2012–2016 and 2020–2022 droughts, insects and disease, and wildfire have contributed to a continued high number of non-federal acres filed for harvesting under FPR Emergency Conditions (CCR Title 14, §1052.1[b]) (CAL FIRE 2024c). Since 2012, Emergency Notice harvests (e.g., salvage logging on burned areas, similar to clearcut silviculture where high severity fire occurred) comprised a substantial portion of the total harvested area. In 2022, following unprecedented wildfires in 2020 and 2021, these Emergency Notices made up 68% of the total harvested area statewide, 86% of total acres filed for harvest in the Sierra/Cascades, 75% in the Central Coast and Interior Ranges, 69% in the Klamath/Interior Coast Ranges, and 2% in the North Coast ecoregions. Altogether, the response to multiple disturbances is largely driving forest management across land ownerships in California.

Forest Industry

On private corporate lands, FIA data indicate that softwood growth exceeded harvest and mortality (ⓘ1.1), though there is still a need to consider lowering stand densities in some areas for climate change resilience (ⓘ1.2). Considering fires between 2019 and 2021, approximately 184,000 acres were in need of reforestation on private industrial lands (WFR Task Force 2024d). Between 2021 and 2023, an average of 41,965 acres per year of tree planting occurred on private industrial forestlands (WFR Task Force 2024c).

Opportunities exist to improve forest health and/or enhance the levels of certain ecosystem services provided by working forests. Working forest acquisitions by conservation organizations, voluntary participation in carbon offset programs (ⓘ1.6), and use of conservation easements (ⓘ1.5 and 6.2) help to diversify landowner income, promote improved forest management practices, and maintain forests as forests. Carbon offset projects and voluntary third-party forest certification remain important business tools. Since the 2017 Assessment, there has been a 50% acreage increase in industrial land in voluntary carbon offset projects and a 16% increase under voluntary third-party forest certification (ⓘ1.5). There are approximately 221,000 acres of industrial timberland under permanent conservation easements, a portion of which include working forest conservation easements (ⓘ1.5). Lastly, voluntary use of Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs) provide additional protections to fish and wildlife. As of October 2024, there are approximately 2.4 million acres covered under HCPs and 675,600 acres in state SHAs (HCP and SHA acres may overlap), mainly on industrial forestland (A. Stanish, personal communication, November 7, 2024). As a result, uneven-aged management has remained a prominent component of timberland management over the past 25 years (ⓘ1.3).

Nonindustrial Forest

Private nonindustrial forestland owners manage for a range of objectives (Sass et al. 2023). Net softwood growth is highest on these lands (ⓘ1.1), given they have higher gross growth rates compared to private corporate and NFS lands and lower harvest rates compared to private corporate lands. Currently, Nonindustrial Timber Management Plans (NTMPs), which are intended to facilitate active management, are in place on 11% of nonindustrial timberland (ⓘ1.5). With a substantial portion of the landscape potentially in need of treatments to reduce stand density (ⓘ1.2), it is important to support strategies and collaborative projects to assist these landowners with managing their

lands. Additionally, considering fires between 2019 and 2021, there were approximately 158,000 acres of nonindustrial forestland in need of reforestation (WFR Task Force 2024d). Tree planting occurred on an average of 2,534 acres per year on nonindustrial forestland between 2021 and 2023 (WFR Task Force 2024c).

Public Forests

Public forestlands (primarily NFS lands), have been increasingly impacted by large, stand replacing fires and insect outbreaks resulting in substantial areas of standing dead trees. Public lands comprise the greatest area (4.3 million acres) and proportion of the area (57%) in need of stand density reduction treatments (ⓘ1.2). Another study focusing on wildfire hazard potential puts 70% of the 7.3 million operational acres in need of stand density reduction treatments on public lands (DeLyser et al. 2025). Since the 2017 Assessment, across all NFS forestland, tree mortality increased and tree growth decreased, such that losses from mortality and limited tree harvest exceeded gains from live tree growth (ⓘ7.5). Following increases in high severity burned area between 2019–2021, there were 1.1 million acres of public forestland without adequate natural tree seed source at risk of vegetation type conversion (e.g., forest to shrubland) and in need of post-disturbance reforestation. There are an additional 200,000 acres of reforestation backlog from disturbances between 2010–2018. Estimates as of spring 2024 put the operationally feasible reforestation need on public lands at 1.5 million acres (WFR Task Force 2024d). Between 2021 and 2023, tree planting occurred on an average of 14,949 acres per year of federal forestland (WFR Task Force 2024c). One modeling study projects that NFS lands will lose 69% of their forest area (10.3 million acres) and accumulate approximately 9 million acres of post-fire regeneration failure in the next 50 years, contributing 70% of the overall forest area losses during this time (DeLyser et al. 2025).

When looking more narrowly at softwood growth on all NFS timberland, growth exceeded removals and mortality such that net growth was 10 ft^3/acre/year (ⓘ1.1). In contrast, on all productive NFS lands reserved from management for timber production, where fire suppression is the main form of active management, softwood mortality exceeded growth such that there was a net loss of 27 ft^3/acre/year. NFS timberlands experienced the greatest per acre and total reductions in net softwood growth since 2017, compared to other ownerships. These trends may be undermeasured due to the lag in the FIA remeasurement cycle. To mitigate this lag, CAL FIRE has funded a shortening of the remeasurement cycle from 10 to five years beginning in the 2021 data collection year. For example, an unprecedented extent of high severity fire occurred in California forests in 2020 and 2021, but only 10% of plots in the data used in this report have been sampled since 2020. Heightened efforts are underway to coordinate land management across jurisdictional boundaries to reduce mortality impacts and restore fire-adapted landscapes on NFS lands (USFS 2022a).

The key indicators used in this chapter to briefly describe the status and trends in forest conditions in California are found on the following pages. A comprehensive discussion is also included providing detailed information on major forest threats, restoration needs, forest management, and collaborative efforts, as well as opportunities available for addressing forest-related concerns.

Indicator 1.1: Net Growth on Timberland (Softwoods)

Which Montreal Process Criteria does the indicator evaluate?

MPC2: Maintenance of productive capacity of forest ecosystems

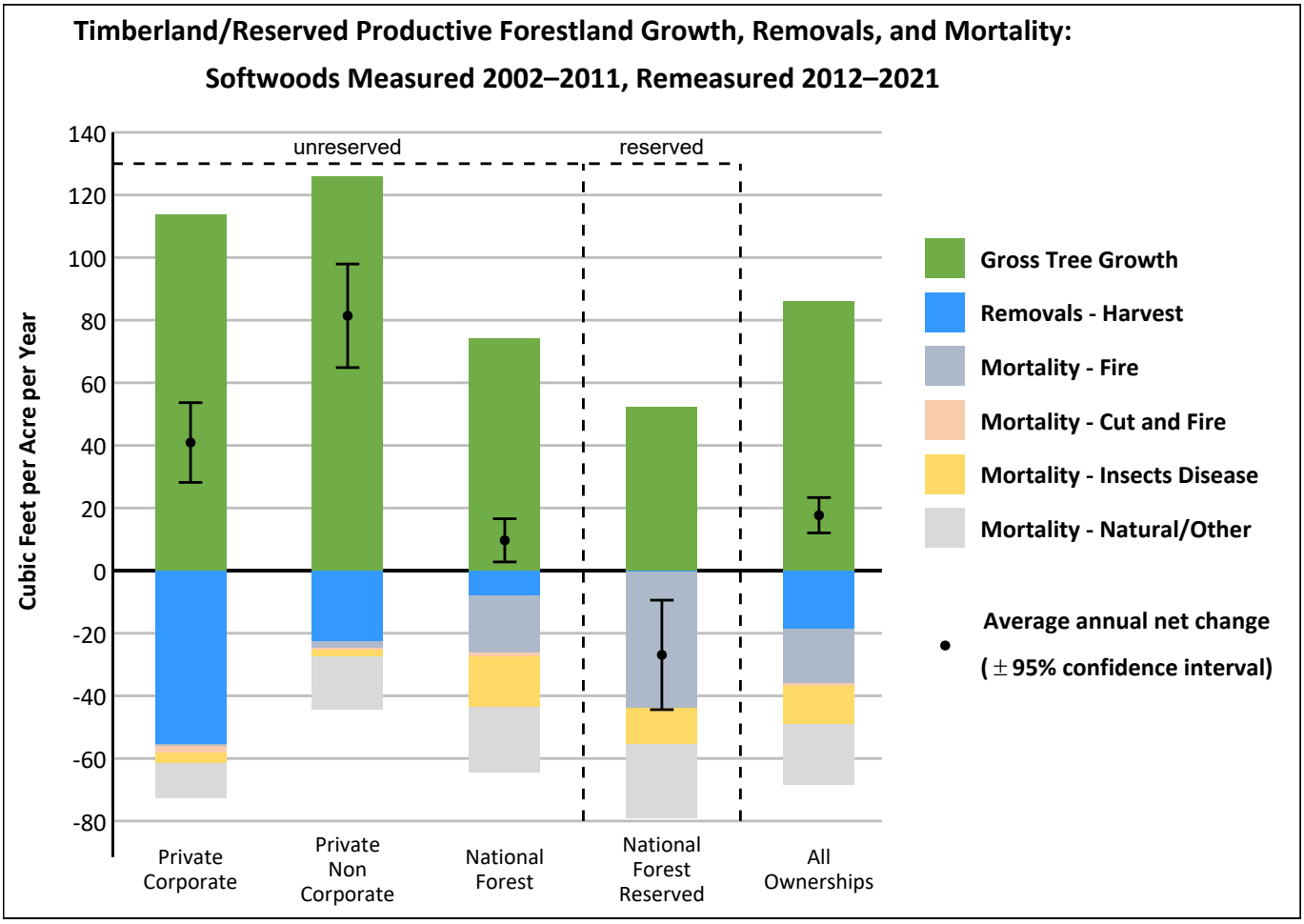
MPC3: Maintenance of forest ecosystem health and vitality

Why is this indicator important?

Net growth indicates whether harvest levels are sustainable (i.e., positive net growth) or if disturbance-related mortality exceeds growth (i.e., negative net growth). In California, private and public timberland managers operate under various federal and state statutory and regulatory mandates requiring long-term sustained yield of timber.

What does the indicator show?

Average annual softwood growth, removals, mortality by cause and net growth of live trees on productive forestland by owner/reserve class over the Forest Inventory and Analysis (FIA) remeasurement period (2002–2011 to 2012–2021). Rapid changes to forests may have a lag before they are reflected in the FIA data. Reserved forestland is unavailable for management for timber production. Trends presented are not intended to be a causal comparison of management methods but rather highlight that different concerns may be present for different landowners.



Key Findings:

- Increased wildfire and insect and disease-related losses drive reductions in net growth on private corporate and National Forest System (NFS) timberlands and productive reserved land compared to the 2017 Assessment.[3]
- Private corporate timberlands are both some of the most productive and the most actively managed lands. Softwood growth exceeded harvest and mortality by an average of 41 ft^3/acre/year, indicating sustained yield is being achieved. Net growth was 14% less than in the 2017 Assessment.[3]
- A portion of private non-corporate timberlands are actively managed. Net softwood growth averaged 81 ft^3/acre/year, which is 2% more than in the 2017 Assessment.[3]
- NFS timberlands are managed for multiple objectives including ecosystem services. Net softwood growth averaged 10 ft^3/acre/year and was 72% less than in the 2017 Assessment.[3]
- Very little active management beyond fire suppression occurs on NFS productive reserved forests. Softwood mortality from natural disturbance exceeded growth for an average net loss of 27 ft^3/acre/year, which was 1055% less than in the 2017 Assessment.[3]
- Across all ownerships, average softwood growth was 1.3 billion ft^3/year. Net growth was 0.3 billion ft^3/year, or 18 ft^3/acre/year. Net growth was 54% less than in the 2017 Assessment.[3]

Data Sources

USDA Forest Service, Forest Inventory and Analysis database (USFS 2024b).

3 *For comparison, 2017 FIA Assessment data were recalculated using new FIA national scale volume-to-biomass equations.*

Indicator 1.2: Timberland Restoration Needs

Which Montreal Process Criteria does the indicator evaluate?

MPC2: Maintenance of productive capacity of forest ecosystems
MPC3: Maintenance of forest ecosystem health and vitality

Why is this indicator important?

For lands managed for timber, over- or understocked timberland is not operating at its potential productivity. Overly dense stands increase risk from disturbances that can lead to catastrophic losses. Understocked stands and certain hardwood-dominated lands represent potential areas for restoration.

What does the indicator show?

Relative density (RD) of timberland and hardwood-dominated productive forestland area compared to a maximum stand density index (max SDI) value by competition class (i.e., free, partial, full competition classes, or zone of imminent mortality). This provides an estimate of acres for which treatments may be warranted to improve stand density.

Indicator 1.2. Statewide area of timberland and area of hardwood-dominated productive forestland by competition class (millions of acres)

Ownership	Commercial Conifer Species				Hardwood-Dominated (Site Class 1–3[1] only)
	<25% (Free)	25–34% (Partial)	35–60% (Full)	≥60% (Imminent Mortality)	
Public	2.2	1.0	2.9	1.4	0.3
Corporate Forest	1.0	0.6	1.1	0.7	0.4
Non-Corporate Forest	0.2	0.2	0.6	0.4	0.5
Total	3.4	1.7	4.6	2.6	1.2

Data Note 1: Site class is an estimated or predicted indicator of site productivity (Hanson 2003). FIA site classes 1–3 represent highly productive sites corresponding to predicted timber productivity of ≥120 cubic feet/acre/year of growth at culmination of mean annual increment (CMAI) (USFS 2024c).

Key Findings:

- A traditional RD threshold greater than 60% indicates there are approximately 2.6 million acres potentially in need of density reduction treatments. Considering a RD greater than 35% as less resilient under future climate in some forests such as in the Sierra Nevada (North et al. 2022), an additional 4.6 million acres increases the total to 7.1 million acres. Overly dense stands are an issue on all ownerships. Lower thresholds may not apply to all forest types (e.g., 628,000 acres of coast redwood with RD >35%), sites (e.g., mesic, north facing slopes), or areas optimizing timber growth with active fuel reduction programs.
- Approximately 19% to 58% of public timberlands are overly dense, using either a RD threshold of 60% or 35% max SDI, respectively.
- Of the 3.4 million acres of stands with RD less than 25%, 2.2 million acres are on public lands. A portion of these lands may represent areas impacted by recent disturbance in need of reforestation.

- After high severity fires between 2019–2021, approximately 0.3 million acres need reforestation on private lands and 1.1 million acres on public lands, with a 200,000 acre reforestation backlog on public lands from fires between 2010–2018 (WFR Task Force 2024d). As of spring 2024, the operationally feasible need is 1.5 million acres on public lands.
- Hardwood-dominated timberlands are a natural component of the landscape, but they have expanded into some previously conifer-dominated areas due to past disturbances or management (e.g., coast redwood shifts to tanoak/laurel on drier inland sites in the North Coast). Restoring conifer dominance is more economically feasible on higher site quality lands, such as the 1.2 million acres in site classes 1–3. About 43% of these acres are in the tanoak/laurel type, the majority of which are in the North Coast region. Conversely, restoration of conifer-encroached woodlands should also be considered (e.g., California black oak).

Data Sources

USDA Forest Service, Forest Inventory and Analysis database (USFS 2024b).

Indicator 1.3: Silvicultural Methods for Non-federal Timberland Harvest

Which Montreal Process Criteria does the indicator evaluate?

MPC2: Maintenance of productive capacity of forest ecosystems

MPC4: Conservation and maintenance of soil and water resources

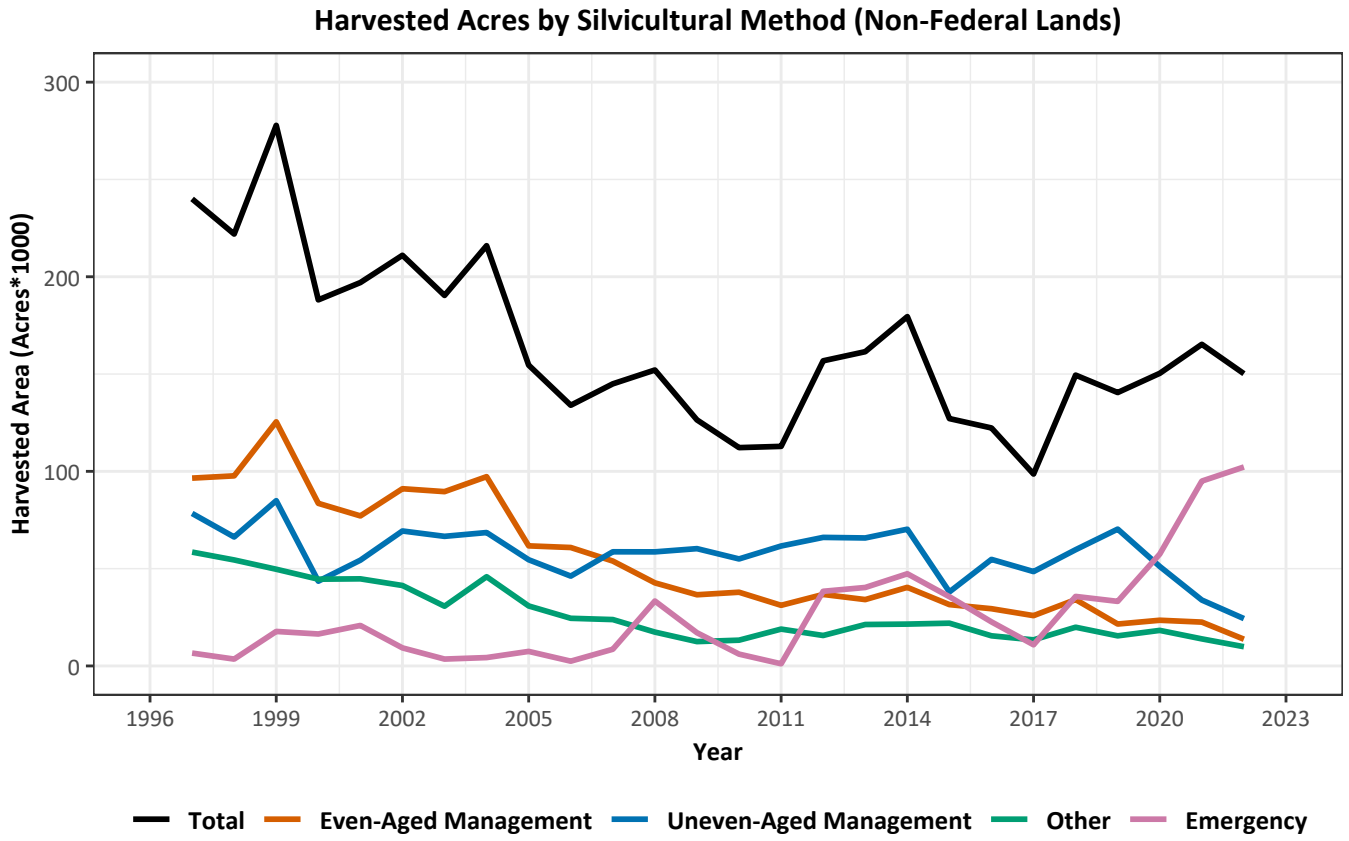
MPC6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies.

Why is this indicator important?

The silvicultural methods applied to timberland for commercial harvest affect productivity, harvest levels, risk from fire and pests, and provision of various ecosystem services.

What does the indicator show?

Non-federal timberland planned for commercial harvest using different silvicultural systems and emergency management actions.



**Note: "Other" includes the 'Intermediate Treatments,' 'Road Right-of-Way,' 'Special Prescriptions & Other Management,' and 'Timberland Conversion' categories from the CAL FIRE harvest data. These categories include silvicultural practices labelled as: Alternative Prescription, Sanitation Salvage, Variable Retention, Road Right-of-Way, Commercial Thin, Non-Standard Practice, Fuel break/Defensible Space, Substantially Damaged Timberland, Rehabilitation of Understocked, Aspen/Meadow/Wet Area Restoration, Conversion, and/or Oak Woodland Management.*

Key Findings:

- Total annual acres harvested declined over the 1997–2022 period but have remained relatively steady from 2008 to 2022. Harvested acres in 2022 were 60% of 1997 harvest acres.
- The number of acres harvested using uneven-aged systems have been fairly constant, despite the decline in total harvest acres. Thus, the percentage of acres harvested using uneven-aged systems increased from an average of 29% of harvested acres between 1997–2001, to 41% between 2011–2015, before returning to 32% for the most recent five-year period of 2018–2022.
- Widespread tree mortality from the 2012–2016 and 2020–2022 droughts, insects and disease, and wildfire have contributed to a continued high number of non-federal acres filed for harvesting under FPR Emergency Conditions (CCR Title 14, §1052.1[b]). Since 2012, Emergency Notice harvests (e.g., salvage logging on burned areas, similar to clearcut silviculture where high severity fire occurred) comprised a substantial portion of the total harvested area. In 2022, following unprecedented wildfires in 2020 and 2021, these Emergency Notices made up 68% of the total harvested area statewide, 86% of total acres filed for harvest in the Sierra/Cascades, 75% in the Central Coast and Interior Ranges, 69% in the Klamath/Interior Coast Ranges, and 2% in the North Coast ecoregions.

Data Sources

CAL FIRE, Forest Practice GIS data, Timber Harvesting Plans (CAL FIRE 2023e, 2023f).
CAL FIRE, Forest Practice GIS data, Emergency Notices (CAL FIRE 2023a, 2023b).

Indicator 1.4: Timber Harvest from Private and Public Lands and Sawmill Infrastructure

Which Montreal Process Criteria does the indicator evaluate?

MPC2: Maintenance of productive capacity of forest ecosystems

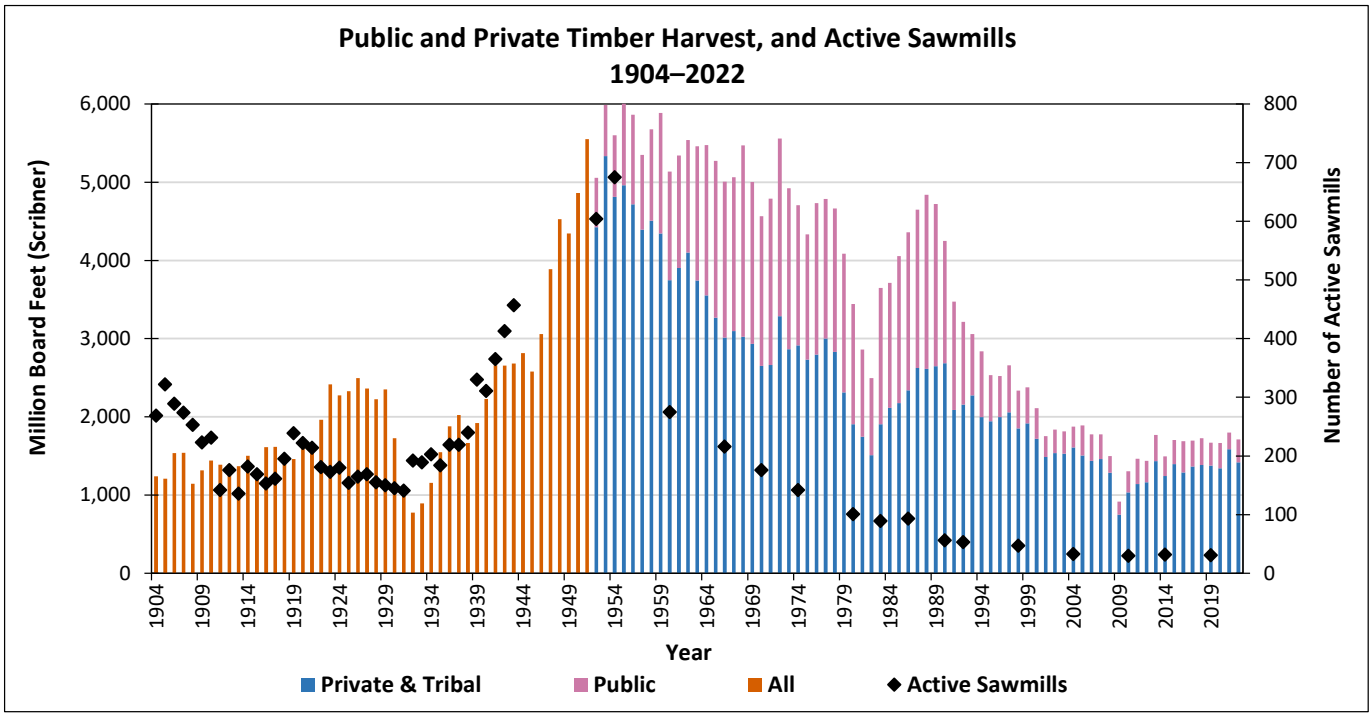
MPC6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies.

Why is this indicator important?

Timber harvest levels are an indicator of sustained yield and related economic activity. Decades ago, there were public concerns about overharvesting. However, since the late 1990s, non-federal forest landowners in California must manage on a sustained yield basis. Existing mill infrastructure is included as it is both affected by harvest trends and affects how much additional harvest can occur.

What does the indicator show?

Harvest volumes on public, private, and tribal lands from 1904–2022 and the number of active sawmills.



Key Findings:

- The total volume harvested in 2022 was 72% lower than peak harvest in 1955. Since 2000, total harvest has generally stabilized around an average of 1,668 million board feet.
- The contribution from public lands to total harvest volume over the 1955–1990 period averaged about 38%. Since 2000, it has averaged only about 18%. On average, total public harvest since 2000 is 83% less than between 1955–1990.
- Since 2000, private harvest (the bulk of which is from forest industry) averaged 1,369 million board feet per year. Annual fluctuations have been as much as 26% over and 45% under this average. On average, total private harvest since 2000 is 55% less than between 1955–1990.

- The number of sawmills declined from a peak of 907 in 1946 to only 31 in 2021. Expanding capacity requires a reliable, long-term, green timber supply from nonindustrial and public forestlands.
- Numerous factors contributed to declining timber harvest, including recovery from the post-WWII housing boom and regulatory changes such as increased protections for state and federal listed species.

Data Sources

Historic timber harvest data compiled from Bolsinger (1976), May (1953), Morgan et al. (2004), Ruderman (1976 –1984), UM BBER (2024), Warren (1986 – 2003), Zhou (2015).

Forest products infrastructure data compiled from Marcille et al. (2020), May (1953), Morgan (2024), Morgan et al. (2004), Oswald (1970).

Indicator 1.5: Timberland Managed for Sustainable Harvest or with Other Sustainable Forestry Standards

Which Montreal Process Criteria does the indicator evaluate?

MPC1: Conservation of biological diversity

MPC2: Maintenance of productive capacity of forest ecosystems

MPC7: Legal, institutional, and economic framework for forest conservation and sustainable management

Why is this indicator important?

Certification and other sustainable forestry standards indicate that land is being managed to achieve defined criteria for sustainable harvest levels and provision of ecosystem services.

What does the indicator show?

Private timberland acres managed under regulatory or voluntary sustainability initiatives. See Table 1.1 for details on regulatory initiatives.

Indicator 1.5. Private timberland managed under regulatory or voluntary sustainability initiatives or certification (thousands of acres)

	Timberland	
Regulatory[1]	**Forest Industry**	**Nonindustrial[5]**
Option "a" or "b" for MSP	3,853	0
Program Timberland Environmental Impact Report (PTEIR)[2]	61	44
Nonindustrial Timber Management Plan (NTMP)	0	355
Working Forest Management Plan (WFMP)	4	0
Voluntary Initiatives or 3rd Party Certification[3]		
Carbon Offset Projects	305	66
Permanent Conservation Easements	221	227
Forest Stewardship Council certification (FSC)[4]	1,596	277
Sustainable Forestry Initiative certification (SFI)[4]	2,517	0
American Tree Farm System certification (ATFS)[4]	123	250

Data Notes:
1. Owners with less than 2,500 acres are nonindustrial by regulatory definition (PRC § 4593.2[b]). In this analysis, owners with more than 2,500 acres are considered industrial. Owners with more than 50,000 acres of timberland are required by law to demonstrate Maximum Sustained Production (MSP) through an Option "a" or "b," or with a PTEIR.
2. PTEIR acres may total more than 2,500 acres and be considered nonindustrial as they cover multiple small landowners. Industrial PTEIR acres overlap with other regulatory initiatives.
3. Acres within each category may overlap with acres covered by regulatory initiatives or other voluntary initiatives.
4. Third party certification acres reported as industrial/nonindustrial by the certifying organizations to their best knowledge.
5. Nonindustrial landowners without PTEIRs or NTMPs typically achieve MSP not through planning or analytical processes but by meeting detailed minimum stocking standards provided in the Forest Practice Rules. These acres are not reflected here.

Key Findings:

- Forest industry landowners have almost 3.9 million acres of planned treatments in mandatory Option "a" or "b" documents, or PTEIRs whereby maximum sustained production (MSP) of timber is indicated.
- As of December 2023, there were 911 approved NTMPs covering about 355,000 acres, representing an 18% increase in approved plans and an 11% increase in total acres since the 2017 Assessment.
- Additional acres of private timberland are under modified management (e.g., WFMP, Carbon Offset Project, permanent conservation easements), giving additional emphasis to ecosystem services.

- Emergency (EM) and Exemption (EX) notices include allowing landowners to remove trees to restore oak woodlands, to remove dead, dying, and diseased trees, and to remove trees to reduce the vertical and horizontal continuity of fuels, including for defensible space and fuel breaks. These are not considered regeneration harvests required to demonstrate MSP and are excluded from this indicator. EMs are included in ⓘ1.3. There were 1.3 million acres filed under EX Notices and allow for removal of dead and dying trees that amount to less than 10% of the total volume. Often, landowners will put their entire ownership in an EX Notice and address dead and dying trees wherever they occur.
- Since the 2017 Assessment, there was a 16% increase in industrial land and a 25% increase in nonindustrial under third party certification; acreage between different certifications may overlap.
- Voluntary use of HCPs and SHAs provide additional protections to fish and wildlife. As of October 2024, there were approximately 2.4 million acres in HCPs and 675,600 acres in state SHAs (acres may overlap), mainly on industrial forestland.

Data Sources

Industrial timberland data from CAL FIRE, Forest Practice GIS data (CAL FIRE 2023b) and USDA Forest Service, Forest Inventory and Analysis database (USFS 2024b).

Regulatory data from CAL FIRE, Forest Practice CalTREES and GIS data (CAL FIRE 2022, 2023c, 2023d, 2023g).

Carbon offset project data from California Air Resources Board, Offset Credits Issued (CARB 2022a) and Voluntary Registry Offsets database (BCTP 2022).

Conservation easements from CA Conservation Easements Database (GreenInfo Network 2024).

Certification data through 2023 from P. Brigman (personal communication, March 20, 2024), T. Kain (personal communication, March 21, 2024), and the Sustainable Forestry Initiative (SFI 2023).

Habitat Conservation Plans and Safe Harbor Agreements from U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, California Department of Fish and Wildlife (A. Stanish, personal communication, November 7, 2024).

Indicator 1.6: Acres of Forestland Being Managed as Carbon Offset Projects

Which Montreal Process Criterion does the indicator evaluate?

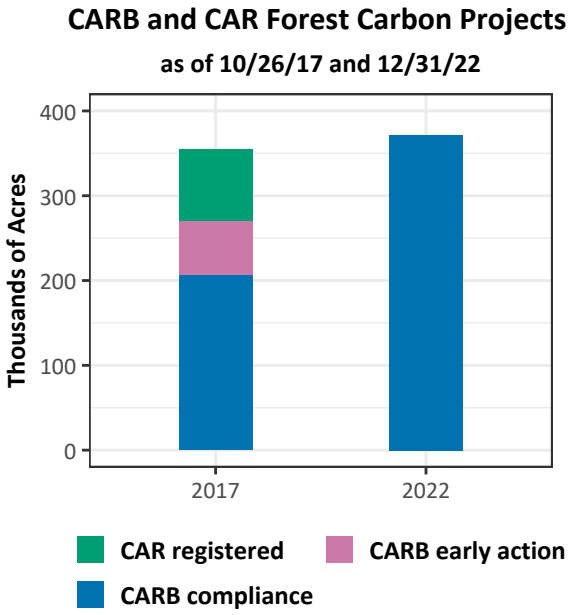
MPC5: Maintenance of forest contribution to global carbon cycles

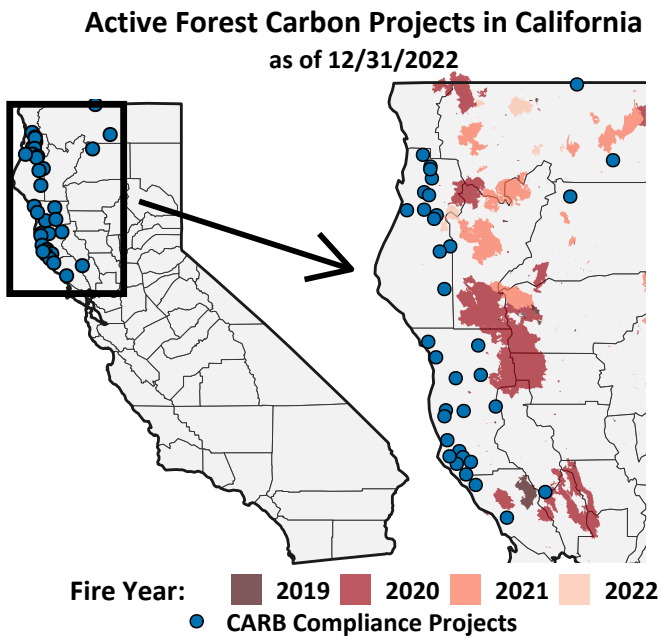
Why is the indicator important?

Through photosynthesis and the carbon cycle, forests can potentially be leveraged for climate mitigation. As part of the California Cap-and-Trade Program (initially authorized under AB 32 (Nunez and Pavley 2006), the California Air Resources Board (CARB) has developed protocols for improved forest management, reforestation, and avoided conversion projects. Forest landowners can be issued compliance carbon offsets by CARB or through the voluntary carbon market by registries such as Climate Action Reserve (CAR). Landowners participating in these projects can sell offsets to increase or diversify income while contributing to GHG emissions reductions. Permanence of GHG benefits is a concern in fire-prone landscapes.

What does the indicator show?

Acres and general locations of compliance and voluntary forest carbon offset projects and their intersection with recent fires.





Key Findings:

- Forested acres enrolled in California's Cap-and-Trade Program increased by 35% between 2017 and 2022 to 371,659 acres, all registered as CARB compliance forest projects. The early action projects have since expired, and project tracking and enrollment has consolidated considerably.

- All California CARB projects fall under "improved forest management," which typically involve combinations of reduced harvest levels, longer rotations, and uneven-aged management.

- Despite very large recent wildfires, in 2022 only three forest carbon offset projects overlapped with wildfires that occurred from 2019–2022, totaling approximately 2,400 acres impacted by the fires. This amounts to ~0.5% of the total forest area enrolled in carbon offset projects. Of the area within the fire perimeters, 13% was unchanged, 35% was low severity fire, 45% was moderate severity fire, and only 7% was high severity fire.

Data Sources

Compliance offsets from California Air Resources Board, Offset Credits Issued (CARB 2022a).
Voluntary offsets from Voluntary Registry Offsets database (BCTP 2022).
CAL FIRE, Historical Fire Perimeters (CAL FIRE 2024f).
Fire severity data produced using methods from Parks et al. (2018).

DISCUSSION

The Resource Base

California's forestland (including woodlands) comprises approximately 32 million acres, almost a third of the state. Forestlands provide a wide range of benefits, many of which extend to all Californians (e.g., water, recreation, wildlife habitat, forest products, grazing, carbon storage and sequestration, and tribal cultural uses). Approximately 51% of California's forestland (16.3 million acres) is characterized as timberland (see Footnote 1 for definition of timberland).

Over half (9.1 million acres) of California timberland is in public ownership (Figure 1.1), primarily administered by the USFS (USFS 2024b). About a quarter of timberland is owned by forest industry (3.9 million acres), including much of the higher site quality lands.[4] The remaining timberland (20% or 3.3 million acres) is owned by a diverse group of smaller nonindustrial owners. There have been no significant changes in the proportions of forestland owned by public agencies and private owners since the 2017 Assessment.

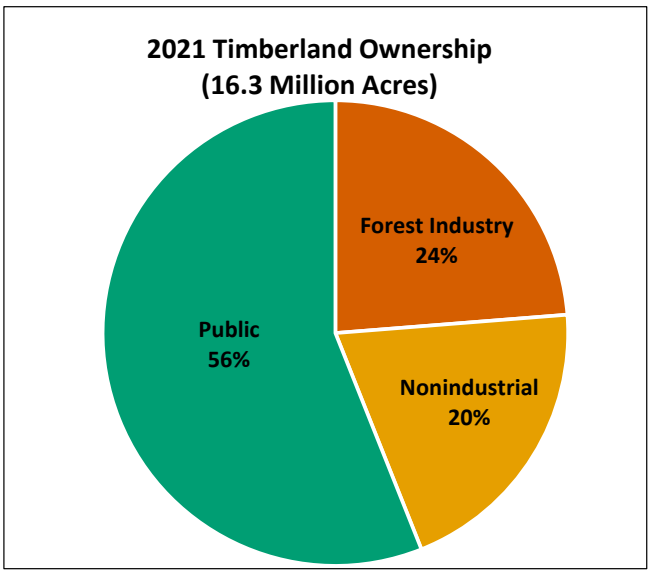


Figure 1.1. California timberland ownership. Data Sources: CAL FIRE (2024e) and USFS (2024b).

According to data from the USFS FIA program, average net softwood growth across all of California's timberland was 1.3 billion ft^3/year. When accounting for harvest removals (-0.3 billion ft^3/year, 23% of gross growth) and mortality (-0.7 billion ft^3/year, 54% of gross growth), the net growth was still positive at 0.3 billion ft^3/year (USFS 2024b).[5] This represents a 54% decrease in net growth compared to 2017 Assessment data (recalculated to enable comparison using the new FIA national scale volume-to-biomass equations). Reductions in total net softwood tree growth, ranging from 5–78% less than in the 2017 Assessment, were observed in all regions except the North Coast, which increased by 6%. These trends were largely driven by increased mortality exacerbated by increasing temperatures, drought, insect infestations and disease, and wildfire.

Across all ownerships, softwoods on timberlands in the North Coast region had the second highest per acre gross softwood tree growth, highest per acre harvest levels, and highest overall net growth at approximately 109 ft^3/acre/year. Mortality losses were just 10% of gross growth mainly due to natural causes, while harvest losses were 33% of gross growth. The Central Coast and Interior Ranges ecoregion had the highest per acre gross softwood tree growth, the second lowest harvest levels, and overall net growth of 104 ft^3/acre/year. Mortality was 42% of gross growth, mainly due to fire, and harvest losses were just 3% of gross growth. Net growth per acre in the Klamath/Interior Coast Ranges and Sierra/Cascades was substantially less at nine and six ft^3/acre/year, with mortality losses of 77% and 69% of gross growth and harvest losses of 13% and 24%, respectively. In the Klamath/Interior Coast Ranges, mortality was driven by fire and natural causes while in the Sierra/Cascades ecoregion, mortality was driven almost equally by fire, insects and disease, and natural causes. In the Eastside ecoregion, net growth was

4 *Industrial timberland acres determined through a spatial join of CAL FIRE's forest industry GIS layer (CAL FIRE 2024e) and FIA plots with site class 1–6 (USFS 2024d).*

5 *Net growth can indicate net gains (positive numbers) or losses (negative numbers).*

19 ft^3/acre/year, with mortality at 33% of gross growth and removals at 25% of gross growth. In the South Coast Mountains and Deserts ecoregion, net growth per acre was approaching zero, driven mainly by mortality losses.

Looking at ownership at the state level, net softwood growth per acre was positive and highest on private non-corporate lands (81 ft^3/acre/year), followed by corporate lands (41 ft^3/acre/year), and then unreserved NFS lands (10 ft^3/acre/year). Reserved NFS system lands were experiencing a net loss in growth (-27 ft^3/acre/year). Across the entire state, NFS lands had the greatest per acre and total reductions in gross growth (due in part to the sheer areal extent of these lands), greatest increases in losses from harvest, fire and insect mortality, and greatest reductions in net growth overall. Mortality losses were 76% of gross growth on NFS unreserved lands and 150% of gross growth on NFS reserved lands (meaning mortality exceeded gross growth), compared to 15% and 18% of gross growth on private corporate and non-corporate lands, respectively. Harvest losses including salvage were 50% of gross growth on private corporate lands, 18% on private non-corporate lands, 13% on NFS unreserved lands, and less than 1% on NFS reserved lands.

Looking at ownership trends at the ecoregion level, reductions in total net softwood tree growth were observed in most ownership classes. Similar to trends at the state level, net softwood growth per acre was positive and highest on private non-corporate lands, followed by corporate lands, and then unreserved NFS lands, with reserved NFS system lands experiencing a net loss in growth in the Central Coast and Interior Ranges, the Klamath/Interior Coast Ranges, the North Coast, and the Sierra/Cascades ecoregions. In the Eastside ecoregion, net change was roughly equal and positive for private corporate, NFS reserved, and NFS unreserved lands, with private non-corporate lands having the lowest net change, which was approaching zero. In the Klamath/Interior Coast Ranges region, net growth on unreserved NFS system lands was approaching zero. Samples sizes were too small for ownership analysis in the Central Valley and South Coast Mountains and Deserts ecoregions.

Threats

Insects, Disease, and Drought

California's forests are under significant threats from various factors, such as wildfire, development, conversion to farmland, insect infestations, diseases, and climate change, with consequences ranging from forest degradation to type conversion (forest becoming non-forest). The severity of these threats is evident after recurring extreme drought events and increases in large wildfire areas in recent decades. According to USFS aerial detection survey data (ADS), the drought from 2012 to 2016 and the subsequent bark beetle epidemic resulted in the death of nearly 96 million trees (USFS 2022b). Of these, almost 62 million trees died in 2016 alone. Another drought period occurred from 2020–2022, resulting in another 107 million dead trees detected between 2017 and 2022, with the highest mortality recorded in 2022—just over 36 million dead trees (USFS 2022b). However, ADS surveys do not occur until three years after wildfire, so these numbers exclude insect and disease-related mortality from the extensive fires in 2020 and 2021.

Between 2012 and 2022, 42% of public lands experienced elevated forest pest and drought-related mortality (>5 trees per acre), with 15% of that mortality in the severe category (>15 trees per acre) (USFS 2022b; see Chapter 5, Forest Pests). Elevated mortality was detected on 19% of private lands, with 6% of the mortality in the severe class. It is possible that some private landowners conduct operations to improve forest health and resilience, thereby reducing mortality, and/or remove dead and dying trees more rapidly, thereby reducing detection of mortality during aerial surveys.

Overall, based on ADS data, an average of 20 million trees died per year between 2012–2022, with an average of 95% of total mortality occurring in softwoods (Figure 1.2). It is important to note that ADS data may overestimate the number of dead trees and underestimate the area affected, with remote-sensing based approaches now aimed to refine these estimates (Cheng et al. 2024).

FIA data for a similar time period (2012–2021) indicates 237 million dead trees per year including all hardwoods and softwoods greater than one inch in diameter at breast height (DBH). This supports the argument that ADS may underestimate total tree mortality. However, when considering only overstory softwood trees, FIA data report 31 million dead trees per year, which aligns more closely with ADS flight detections (USFS 2024b). Additional information on forest insects and disease is found in Chapter 5 of this Assessment.

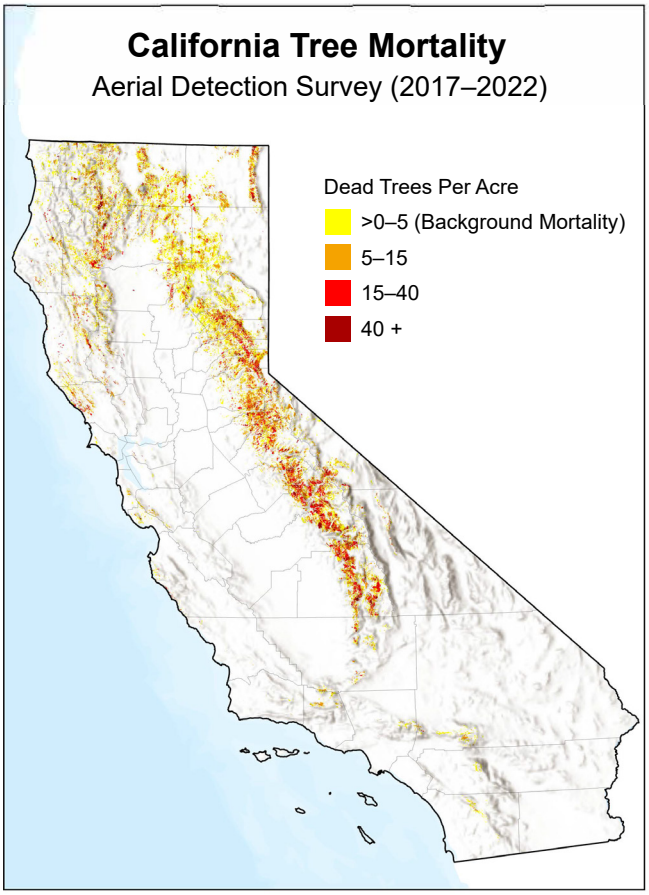


Figure 1.2. Levels of tree mortality from 2017 to 2022. Data Source: Aerial Detection Survey data, USDA Forest Service, 2017–2022. Data Source: USFS (2022b).

Wildfire

Wildfires in California have increased in size, severity, and destructive capacity over the past two decades (see Chapter 4, Wildfire). From 2018–2021, California experienced its most significant (by area) wildfire activity in recorded history, with 5.1 million acres of forestland burned. Nearly all (96%) of the burned area during this time occurred in the Sierra Nevada/Cascade and Klamath/Interior Coast Ranges combined. Moreover, high severity fire accounted for 37% (more than 1.6 million acres) of the burned area across all ownerships (MBG 2023). The proportion of high severity fire within each ownership group was highest for private forest industry lands (41%), with similar proportions of high severity fire on NFS lands (37%), and private nonindustrial forestlands (33%).

Compounding disturbances, such as tree mortality and drought, also exacerbate fire behavior and increase fire severity. In a study of the 2020 Creek Fire, which intersected expansive areas of tree mortality from drought and bark beetle activity during 2012–2016, high fire severity occurred on 41% of the area burned, with one large high severity patch greater than 48,000 acres comprising 14% of the burned area (Stephens et al. 2022). Areas with the highest amounts of dead biomass and live tree densities were positively related to high severity fire patch size, with dead biomass most strongly influencing fire severity. Additionally, as the fire burned, high levels of heat were concentrated in the interior of the fire rather than along the perimeter, as elevated levels of dead biomass continued to fuel the fire. This type of fire behavior is not captured by operational fire models.

Large patches of high severity fire are particularly concerning, as research has shown that natural tree regeneration is unlikely to occur more than 330 feet from potential seed sources (North et al. 2019, Shive et al. 2018, Welch et al. 2016), with high severity patches greater than 40 acres being outside the range of natural variation for certain forest types (Bohlman et al. 2021). Literature is variable on the size of high severity patches within a natural range of variation (NRV) depending on forest type, reference site location, and whether an average or maximum patch size is used (Minnich et al. 2000). In one study of a single reference site, the maximum high fire severity patch size within NRV for yellow pine was approximately 40 acres, while a larger review indicated that high severity patch sizes exceeding 250 acres rarely occurred (Meyer 2015, Minnich et al. 2000, Safford and Stevens 2017).

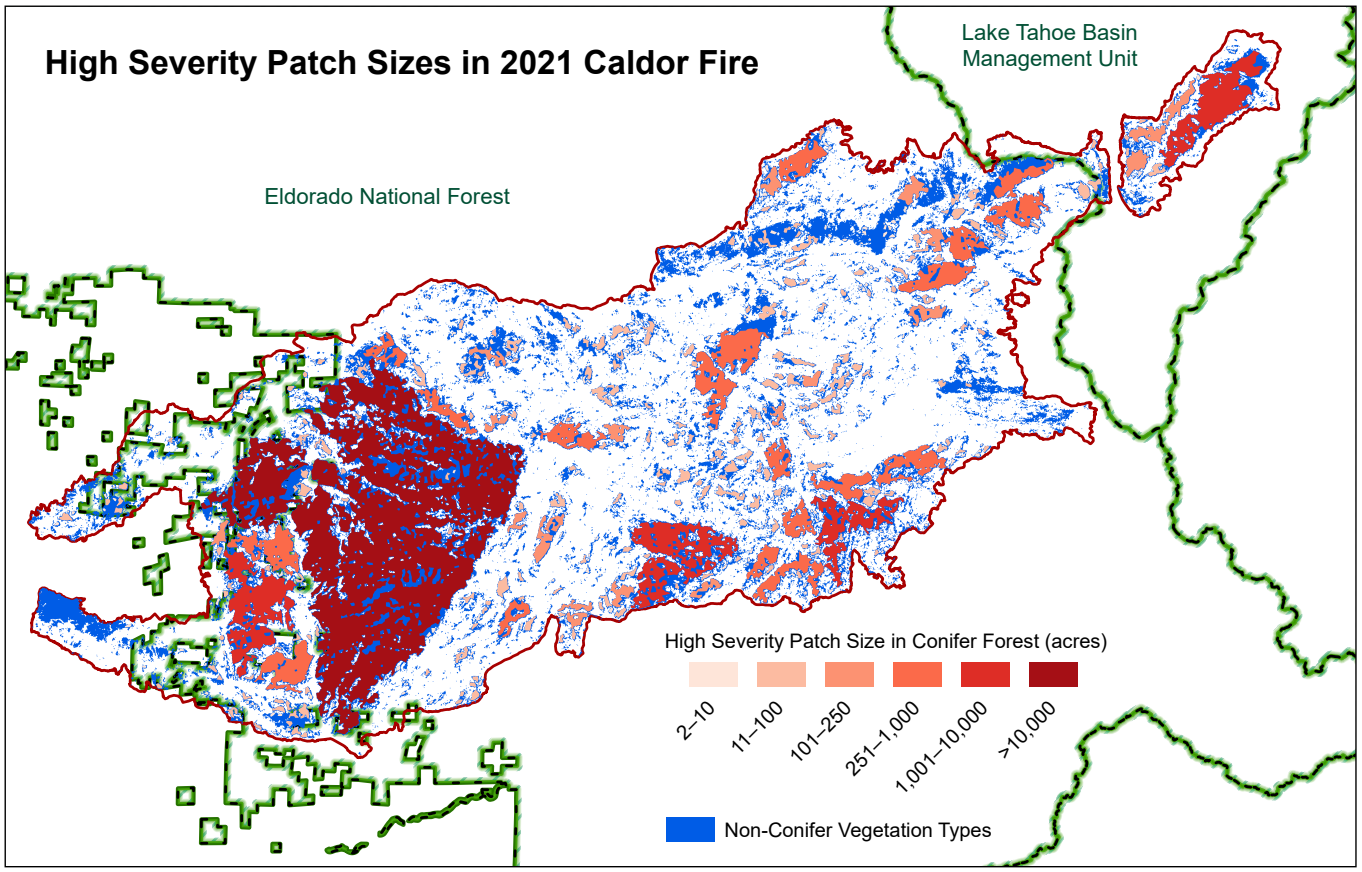


Figure 1.3. Patch sizes of high severity fire (>75% basal area loss) within the 2021 Caldor Fire footprint shown in reddish colors for areas dominated by yellow-pine, mixed conifer, or red fir forests and blueish colors for areas dominated by other vegetation types (e.g., chaparral, oak woodlands) burned at high severity. Data Source: Estes and Bovee (2023).

Between 2018 and 2021, large fires produced 1,494 high severity patches that exceeded 40 acres in size, impacting a total area of 668,000 acres (MBG 2023). Significantly, eight patches were larger than 10,000 acres each, impacting 182,000 acres. The 2021 Caldor Fire resulted in 102,000 acres of high severity patches greater than 100 acres and outside the range of natural variability (Estes and Bovee 2023). Of these, 46,000 acres are unlikely to recover naturally and will require reforestation, while 4,000 acres are at risk of being unable to support softwood (conifer) species under future climate (Figure 1.3). The 2021 Dixie and Sugar fires resulted in 313,000 acres of high severity fire patches greater than 100 acres and outside the range of natural variability. Of these, 289,000 acres outside of wilderness are unlikely to recover without reforestation (Coppoletta et al. 2022).

Without adequate reforestation following large-scale high severity fire, there is a high risk of vegetation type conversion to shrublands or oak woodlands. One study found that disturbances between 2011 and 2020 led to 30% of the southern Sierra Nevada's conifer forest transitioning (temporarily or permanently) into non-forest vegetation (shrublands or sparsely treed landscapes), with particularly high impacts to mature forest habitat and high-density forest (Steel et al. 2023). Another study predicted that increased high severity fire and post-fire regeneration failure could reduce California's forest area by 48% by 2070 (DeLyser et al. 2025). Though federal lands (particularly NFS system lands) experienced the greatest total areas burned (5.7 million acres from 2012–2022), impacts from wildfire on non-federal lands are sizeable. An estimated 1.7 million acres of non-federal forests were within wildfire perimeters from 2012–2022, with 1.2 million acres burned since 2018. This total compares to less than 500,000 acres burned between 2000–2011. Further, 2020 alone saw 365,000 acres of non-federal forests burned at moderate and high severity (Olsen et al. 2025). In total, 7.3

million acres of forestland have burned between 2012 and 2022, approximately 7% of California's land base.

Wildfires and wildfire smoke impacts extend far beyond damage to vegetation itself. Five of the 10 deadliest fires have occurred since 2017 and substantial destruction of property has occurred with billions of dollars in insured losses (Safford et al. 2022). Substantial financial impacts to the timber industry and forestland value are also a result of wildfire (MBG 2023, Wang and Lewis 2024; see Chapter 4, Wildfire). Wildfire and wildfire smoke also have adverse impacts on air quality; public health; water quality, quantity, and storage capacity; recreation; and wildlife species and their habitats. For additional information, see Chapter 11 (Wildfire Risk to Communities); Chapter 9 (Water Resources); and Chapter 10 (Wildlife Habitat).

Climate Change Impact on Species Ranges

Restoration need and effort are exacerbated by climate change. California is already experiencing rising temperatures, with increasing drought impacts and pronounced changes in wildfire, insect, and disease activity. Tree mortality, natural regeneration failures, vegetation type conversions, and species range shifts are already occurring. See Chapter 5 (Forest Pests), Chapter 7 (Climate Change), and Chapter 10 (Wildlife Habitat) for additional information on climate change impacts to California's ecosystems. Changes in growth and mortality are evident in the forest inventory data (see ⓘ1.1, above).

The direct and indirect effects of climate change on California's forests are projected to worsen (CARB 2022b). Modeled scenarios in the 2017 Assessment that considered different future climatic conditions and global GHG emissions scenarios projected that by 2069, between 0.6 million (3%) and 1.4 million acres (8%) of current timberlands will no longer be climatically suitable for growing the tree species that are of primary commercial value in California (Douglas-fir, coast redwood, Jeffrey pine, ponderosa pine, red fir, sugar pine, white fir, incense cedar) (Thorne 2017, Thorne et al. 2017). These former timberlands will likely transition



Plumas National Forest conifer forests burned by the 2000 Storrie Fire. Shrublands are evident today in areas dominated by conifer forest prior to fire. USFS photo.

into oak woodland, shrubland, or grassland, with different ecological and economic values (e.g., for grazing), with most losses in the southern Sierra Nevada. Additionally, future climate may support different tree species in a given forested area, or in newly suitable habitat, but other factors such as soils, competition from other vegetation, and disturbance regimes could prevent these species from occupying these new sites. As stated earlier, high severity fire and post-regeneration failure project 48% loss of California's forests by 2070 (DeLyser et al. 2025).

Given the novel climate conditions facing California, there is a level of uncertainty as to what specific management approaches will work best across the diverse biogeographic conditions found throughout forested systems of the state. Therefore, consideration of a diversified management approach is crucial to build more resilient forests in a changing climate. This underscores the need for ongoing research to better understand how to manage for resilient forests and employ climate-smart reforestation practices. Research using FIA remeasurement data has shown that many tree species are already undergoing distribution shifts in response to climate change, with seedlings tending to establish in relatively cooler parts of their range (Monleon and Lintz 2015), while other work looking at trees greater than 5.0 inches DBH does not find strong evidence of tree species range shifts (Groom and Monleon 2023). Some studies project species range shifts to be a larger issue for some species, such as red fir, than others (Thorne et al. 2016).

To address these issues, assisted migration (human-assisted movement of species or genes in response to climate change) and modified species-mixes or planting densities are available management options (Handler et al. 2023). However, land managers and the public cite a lack of experience and direction as barriers to employing some of these climate-smart reforestation strategies (Palik et al. 2022). The University of Nevada's Sierra Nevada Adaptive Management Experiment (AMEX) utilizes a network of state and federal forestland throughout the mountain range to test seedlings from different seed zones, species-mixes, and residual forest densities to increase resistance, and resilience and adaptation to climate change (AMEX 2024). The Climate Adapted Seed Tool (CAST) provides climate-based seed zone guidelines, and it is currently in use by USFS ecologists working on National Forest reforestation (Stewart et al. 2023). These types of long-term studies and decision-support tools are critical to removing barriers to adopting these strategies. Additionally, recent release of the Superior National Forest Assisted Migration Plan will serve as a pilot for NFS lands and begin to address the barrier around lack of guidance for this practice (Frerker et al. 2023).

Invasive Plants

Invasive plants, many of which are not native to California, are having a major impact on both working forests and other forestlands. They can limit forest productivity, reduce forage for wildlife and livestock alike, increase the threat of wildfire, and lower land values. Invasive plant species are usually pioneer species that invade disturbed sites, including after wildfire, timber harvesting, or road construction. The majority of the invasive species in California are biennial or perennials (46%), winter annuals (25%), and woody plants (22%), with approximately 215 species that are considered threats to California wildlands (DiTomaso et al. 2017). Various invasive plant containment efforts exist throughout the state related to public education, detection, and control.

For private working forests, addressing invasive species is an important part of management plans, for both timber production and protecting environmental values. Green Diamond Resource Company, a large industrial forest owner, has an invasive species program to prevent or control noxious weed species that could negatively impact native flora or fauna (GDRC 2023). The California Invasive Plant Council (Cal-IPC) website provides extensive information to assist small forest landowners (USFWS and CA-IPC 2018). Management of invasive plants must consider potential impacts to sensitive plants and animals, such as threatened or endangered bird species or impacts to culturally important plants. Control activities may be restricted to specific parts of the year.

Invasive plants affect public lands as well, though wildfire and lack of funding and resources are constraints on limiting their introduction and spread (NPS 2024, USFS 2023c). Invasive plants on NFS lands are documented and treated whenever possible with the Early Detection/Rapid Response system, and an Integrated Pest Management (IPM) approach. As of 2022, site-specific NEPA documents approved to control invasive plants as part of an IPM program have been completed on 14 of the 19 National Forests in California (USFS 2023c).

Development Impacts

Data from FIA are indifferent to permitted or unpermitted activities and indicate net conversion of timberland to developed or agricultural uses is less than 2,000 acres per year and for all forestland it is closer to 7,000 acres per year (USFS 2024b). An analysis of CAL FIRE Forest Practice "Less-than-three-acre Timberland Conversion Exemption" requests shows that on average, between 2018 and 2023, CAL FIRE permitted a total of 1,733 acres of these requests, or an average of approximately 300 acres per year (CAL FIRE 2025b). Over 60% of these acres were converted to residential development, with approximately 8% converted to both agriculture and to non-residential development, and just over 3% converted each to cannabis and vineyard uses. Larger than three-acre timberland conversion permits covered approximately 851 acres, averaging 142 acres and six requests per year (CAL FIRE 2025a). Approximately 26% of the acres in these larger requests were in Siskiyou County, 16% in Nevada County, with 12 other counties making up the remainder of the requests. Public, private, and subdivision development comprise approximately half of these larger timberland conversions, with ski area development at 19%, vineyards/agricultural and cannabis at 9%, mines and quarries at 9%, solar at 4%, and re-zoning out of timberland at 10%. Though illegal conversions may occur, there are limited data. An analysis of cannabis cultivation in Humboldt and Mendocino counties indicated that approximately 974 acres of indoor and outdoor cultivation occurred in 2016, with approximately 400 acres occurring in forestland (Butsic et al. 2018). In another study focused on Humboldt County, cannabis grows contributed to forest cover loss on approximately 1,060 acres between 2000 and 2013, or 1.1% of the forest cover loss during that time (Wang et al. 2017).

Working forests are also impacted by subdivision of large parcels, which can result in holdings too small to be effectively managed for timber. When timberland value is diminished, there is increased potential of conversion to other developed or agricultural land uses (Miner et al. 2014, Nepal and Skog 2014). Conservation easements are an increasingly effective tool for preserving timberlands with important environmental or social values and for protecting working forests from conversion or subdivision (ⓘ6.2). There are close to 450,000 acres of timberland under permanent conservation easements (see ⓘ1.5, above), with approximately 287,000 acres under the state and federal Forest Legacy Programs working forest conservation easements (P. Leuzinger, personal communication, May 24, 2024) (D. Walsh, personal communication, March 27, 2024). Across all forestland, there are 592,323 acres under conservation easements (ⓘ6.2). Conversion of oak woodlands is discussed in Chapter 2 (Sustainable Rangelands). Additional discussion on population and development impacts for forests and rangelands occurs in Chapter 6 (Population Growth and Development Impacts).

Restoration Need

Applying concepts from North et al. (2022) in this chapter, forest resilience refers to a forest's adaptability to a range of stresses and reflects the functional integrity of the ecosystem, such as retaining fundamental forest ecological structure, composition, and processes. Maintaining forests as forests with increases in disturbance and climate impacts is a major challenge in California, especially given the very long time spans required to restore forested conditions after a disturbance. With uncertainty in future global emissions, climatic conditions, and ecological response, there is a need for adaptive management. Adaptive management can be considered along a gradient with different tolerances of ecosystem change and mechanisms for coping with climate change (Millar et al. 2007, Nagel et al. 2017). Management actions to promote

forest *resistance* are aimed at maintaining a relatively unchanged forest (e.g., existing stand structure, composition, and densities prior to disturbance). Management actions to promote *resilience* would allow some change in pre-disturbance conditions but would encourage an eventual return to a reference condition (e.g., historic pre-European settlement stand structure, composition, and densities), and recognize that landscape mosaics may shift over time. Management actions to *transition* forests are aimed at actively facilitating change to encourage adaptive responses (e.g., assisted species migration). Maintaining a diverse set of forest species, structures, and compositions; targeting advantageous species adaptations; restoring ecological processes such as beneficial fire; restoring TEK and relationships; and post-disturbance restoration are key elements of adaptive management (Nagel et al. 2017). Robust monitoring programs examining a variety of approaches are critical to provide the feedback loop to adapt management based on current conditions and the effectiveness of treatments.

Forest resilience also extends beyond the trees themselves. The following ten pillars of resilience—addressing both biophysical and social elements—have been developed for forest restoration in California: forest resilience; durable, diversified, and sustainable carbon; fire dynamics; fire-adapted communities; economic diversity; social/cultural well-being; air quality; water security; wetland integrity; and biodiversity conservation (Manley et al. 2023). The 2022 Natural and Working Lands Climate Smart Strategy (CNRA 2022b) discusses "climate smart forest management" as including forest thinning focused on small trees through prescribed fire and mechanical or manual thinning. These treatments are described as leading to healthy and resilient forests that will limit future carbon losses, sequester carbon, and store carbon. These treatments also will support resilient communities, natural systems, and resilient economies.

Given current changes in temperature and precipitation regimes, tree mortality levels and several recent very large stand-replacing wildfires, scientists, land management agencies, and members of the public alike have called into question past forest and fire management policies, and specifically whether the problem has been exacerbated by overly dense forest conditions. In certain forest types across the state, denser forests have higher fuel continuity, making them more susceptible to crown fire, and have more inter-tree competition for water and light, making them more susceptible to drought, insects, and disease. Forest resilience is increasingly challenged by these conditions.



Resilient forest stand after multiple fuel reduction treatments at Blodgett Forest Research Station in the central Sierra Nevada. Photo: CAL FIRE.

Relative Stand Density as a Metric of Conifer Forest Restoration Needs

To explore restoration needs on California's timberlands across forest types comprised of commercial softwood (conifer) species, the relative density (RD) of stands is evaluated as a percentage of the maximum Stand Density Index (SDI). SDI is an expression of relative stand density based on the predictable relationship between average tree size and trees per unit area and varies by forest type, with more productive forests having higher maximum SDI values. SDI is well correlated with stand volume and growth, and it can be used as a relative measure of inter-tree competition (North et al. 2022). By presenting RD with thresholds related to widely accepted management and biological thresholds, the utility of this metric is expanded beyond typical production forestry objectives to address overall forest resilience across different ownership types and objectives (Woodall and Weiskittel 2021).

In the past, RDs greater than 60 to 100% of maximum SDI were considered indicative of overstocked conditions, as these are the lower and upper thresholds for density-induced mortality (Long 1985), although ideal management ranges of anywhere between 20–60% of max SDI have been proposed (Dean and Baldwin 1996, Long and Shaw 2005). However, recent research in the Sierra Nevada indicates that historical stand conditions maintained by frequent low-severity fire were usually below 35% of maximum SDI, and most were below 25% of maximum SDI (North et al. 2022). In contrast, most current stands were found to be at RDs greater than 35%. Similarly, another recent study indicated that treatments that reduced RD to less than 35% were most resilient to modeled wildfire (Stephens et al. 2024). These results suggest that forest treatments for resilience in the Sierra Nevada or potentially other fire adapted areas need to be much more intensive, as well as extensive, than the current standard practices for fuels reduction and production timber stand management. These lower densities are both more resilient to frequent fire and facilitate the reintroduction of beneficial fire.

Relative Density Thresholds

<25% =	Free of Competition
25–35% =	Partial Competition
35–60% =	Full Competition
>60% =	Imminent Mortality, lower threshold of the self-thinning zone, where competition due to tree density begins to induce tree mortality



2021 Caldor Fire salvage and unsalvage logged forest, with Blodgett Forest Research Station in the foreground. Photo: CAL FIRE.

We used both the traditional 60% RD threshold and a 35% threshold to assess need for restoration (see Relative Density Thresholds box insert). Using the more traditional RD threshold of 60%, about 1.4 million acres (19%) of public timberlands are overstocked, while a 35% RD threshold suggests that 4.3 million acres (57%) of public timberland are in need of restoration to improve forest resilience. When including private timberlands, there are 2.6 million acres of public and private timberland that exceed 60% of maximum SDI and an additional 4.6 million acres that exceed 35% of maximum SDI, for a total of 7.1 million acres in need of restoration to improve forest resilience (see ⓘ1.2, above). This equates to 44% of all timberland. Using the upper threshold of the range, approximately 63% of the need is on public land. However, these thresholds may not be appropriate for all forest types, such as coast redwood (approximate RD of 628,000 acres >35%) or sites (e.g., mesic, north-facing slopes). Additionally, in fire adapted areas, some industry forest managers maintain stands at higher densities alongside active fuel reduction programs (G. Gentry, personal communication, October 31, 2024).

Understocked stands and widespread areas that have experienced drought, insect and disease, and wildfire-related mortality are potentially in need of reforestation. There are 3.4 million acres of stands with RD less than 25% considered free from competition (see ⓘ1.2, above). Sixty-four percent of those acres are on public lands. A portion of these productive timberlands likely represents areas that are recovering from disturbance, with some portion in need of post-disturbance reforestation due to a lack of nearby seed trees. While forest industry landowners generally replant promptly after large disturbance events, nonindustrial owners typically do not unless technical and/or financial assistance is available through the state and federal programs discussed later in this chapter. The following box insert further discusses the considerable reforestation challenges on federal lands, many of which spill over into private lands as well.

Post-fire Reforestation Challenges on Federal Lands

Postfire reforestation is a major issue facing western forests[6]—it is estimated that the current reforestation backlog is close to 4 million acres and that is expected to double by 2050 based on future fire frequency, severity, and size (Dobrowski et al. 2024). California's federal interior forests have been subjected to multiple large damaging wildfires over the past 10 years. It is estimated that 0.4 million acres of private forests and at least 1.1 million acres of federal forestlands would benefit from reforestation efforts following fires between 2019–2021, with an additional 200,000 acre backlog of reforestation need on public lands from disturbances between 2010–2018 (WFR Task Force 2024d). Preliminary estimates as of spring 2024 put the operationally feasible reforestation need on public lands at 1.5 million acres. However, an average of only 11,600 acres were planted on public lands annually between 2010–2020, amounting to less than 10% of high severity burned areas between 2015–2020. Between 2021 and 2023, an average of 14,949 acres per year of tree planting occurred on federal forestland and 41,965 acres on private industrial forestlands (WFR Task Force 2024c).

Research conducted in the Sierra Nevada has shown that there have been significant differences in reforestation success by landowner type, due to differing management circumstances (Stephens et al. 2020). For example, following the 2007 Moonlight Fire (65,000 acres), only 1% of publicly owned lands were characterized by young regenerating conifer forests, whereas approximately 70% of privately owned lands were regenerated successfully. In a recent analysis applying data from Davis et al. (2023), it is anticipated that up to 82% of future high severity fire areas in California could have natural regeneration failure (under a high global emissions scenario, RCP [Representative Concentration Pathway] 8.5), resulting in potential modeled losses of 48% of California's forested area by 2070. Approximately 70% of those losses are projected to occur on NFS lands, which may accumulate up to 9 million acres in post-fire reforestation needs during this time (DeLyser et al. 2025). Timely reforestation efforts following high-severity fires, particularly within the first three years, are critical to minimize these losses.

Specific elements of the reforestation process, known as the "reforestation pipeline," include seed collection, project planning, nursery production, site preparation, planting, vegetation management, and monitoring (WFR Task Force 2024d). Numerous limitations in the reforestation process are preventing a larger planting effort across the board, but particularly on federal lands. These barriers include costly and time-intensive project planning processes, inadequate seed collection and processing, especially from low elevation zones, insufficient seedling nursery capacity, and inadequate site preparation, all of which are mostly limited by the same underlying issue—insufficient funding and associated workforce. Each component in the reforestation pipeline faces its own set of challenges. For example, seed collection requires having a skilled workforce and the ability to mobilize resources quickly when a big cone production year occurs. Big cone production years are impacted by disturbance and climate change, which also reduces genetic diversity in the seed stock itself. These barriers are further documented in Dobrowski et al. (2024).

Despite these barriers, federal and state entities are committed to addressing reforestation needs. Within the Infrastructure Investment and Jobs Act (U.S. Congress 2021), the REPLANT Act (Repairing

6 *Western forests in the cited analysis include California, Oregon, Washington, Idaho, Montana, Wyoming, Utah, Nevada, Colorado, New Mexico, and Arizona (Dobrowski et al. 2024).*

Existing Public Land by Adding Necessary Trees) requires the USFS to address its reforestation backlog within 10 years and is accompanied by substantial funding nationally over the next five years (WFR Task Force 2024d). However, the future of federal funding, including some that is currently allocated, is highly uncertain under the current federal administration (see Chapter 13, Institutional Response, for further discussion). In 2022, the California Reforestation Pipeline Partnership, a strategic collaboration among American Forests, the USFS, and CAL FIRE, formed to identify and address limitations in the reforestation pipeline. Some of the approaches identified to address reforestation needs in California include updating reforestation need acres annually, improving the planning and permitting process, increasing funding and staffing, increasing site preparation activities, increasing capacity at existing nurseries, and establishing new forest nurseries with large zone-specific seedling capacities. Addressing these needs will require ongoing commitment, funding, and staff from federal, state, and non-government partners.

Some meaningful progress has been made in addressing the reforestation pipeline needs:

- CAL FIRE and Sierra Pacific Industries collaborated on the establishment of a new tree seedling nursery at Gazelle, CA (Siskiyou County). Ground-breaking occurred in April 2023 for a facility that will be able to produce up to 25 million native conifer seedlings per year when fully functional in 2026. This will nearly double the current seedling production capacity in the state (WFR Task Force 2024d).
- The "California Cone Corps" was established and is a workforce development program to recruit and place new workers into California's reforestation pipeline through on-the-job training.
- Efforts to scale up training and capacity for cone surveys and collection activities have been active. Through Cone Camps held across the state in 2024, 175 individuals were trained on cone surveying and monitoring, and nearly 20 individuals were trained and certified as cone collection climbers (J. Schied, personal communication, July 11, 2025).
- Given increased landowner participation in the new CAL FIRE Reforestation Because of You (RBY) program, when combined with a new cone surveyor web app and other efforts, nearly 2,000 cone surveys were submitted which translated into over 4,300 bushels of cones being collected for CAL FIRE's L.A. Moran Reforestation Center (J. Schied, personal communication, July 11, 2025).
- In 2024, a total of 11,330 bushels of conifer seed-bearing cones made it to a USFS and CAL FIRE seedbank, representing a 275% increase in cone collection from 2023 and a potential 57 million seedlings. The California Reforestation Pipeline Partnership supported 30% of the federal and state bushels collected (CRPP 2024).

In light of the multiple limitations in the reforestation pipeline, there is a need to prioritize treatment locations that are most in need and have the best potential for seedling survival, and to re-evaluate and adapt planting activities, including site preparation, to enhance seedling survival and proliferation in a changing climate. Salvage can be an important site preparation tool to reduce fuels and safety hazards. Recent research on patterns of natural regeneration after wildfire in the Sierra Nevada (Shive et al. 2018, Welch et al. 2016) has shown that uncharacteristically large high severity patch size (e.g., >100 ac) often leads to natural regeneration failure. Using local knowledge and the Postfire Conifer Reforestation Planning Tool (PostCRPT), a model developed from field data to



New SPI nursery in Grazelle, September 2024. Photo: CAL FIRE.

predict natural regeneration, analysts can delineate areas likely to successfully reseed. Postfire and historical precipitation have been found to be good predictors of regeneration success (Stewart et al. 2023). The Postfire Reforestation Success Estimation Tool (PReSET) can identify where postfire reforestation outcomes are most likely to be successful in Sierra Nevada mixed-conifer forests.

Traditional reforestation has specified planting conifer seedlings (mostly ponderosa pine) in interior areas, in a regularly spaced grid at relatively high densities. For areas outside the zone of predicted natural seed fall, new strategies have been developed to prioritize areas to plant conifer seedlings for resilient reforestation, since funding, labor, and seeds are limited (Long et al. 2023, Meyer et al. 2021). This approach includes using a variety of geospatial data and tools to locate areas with high severity patches, and determine microsite water availability, appropriate topographic positioning, and lower potential future fire behavior (Meyer et al. 2021, North et al. 2019). Acceptable areas can be planted with clustered seedlings at low stocking density (e.g., 200 trees/ac). Clustering can help mimic natural heterogeneity associated with fire resilience and actually promote tree establishment and growth (Fertel et al. 2022). Caldor, Dixie, and Sugar fire analyses provide recent examples of applying this planning approach (Coppoletta et al. 2022, Estes and Bovee 2023). While not yet being widely utilized in California National Forests, resilient reforestation approaches are being considered for experimental planting areas.

Hardwood-dominated timberlands are a natural component of the landscape and have expanded into some previously conifer-dominated areas due to past disturbances or management, such as shifts to tanoak/laurel in coast redwood stands on drier inland sites in the North Coast (Berrill and Howe 2019, Cafferata and Yee 1991). Treatments to restore conifer dominance are more economically feasible on higher site quality lands, such as the nearly 1.2 million acres in site classes[7] 1–3 (see ⓘ1.2, above). About 43% of these acres are in the tanoak/laurel type, with the majority in the North Coast region. Careful consideration should be given before implementing conifer restoration treatments in oak-dominated lands. Some hardwood species, such as California black oak, are ecologically and culturally important to many Native American tribes. These woodlands face numerous threats such as extensive wildfire, invasive pests, development, and potential range shifts, and effort must also be made to ensure they persist in certain places. In many cases they are suffering from conifer encroachment due to fire exclusion and require conifer removal and reintroduction of beneficial fire to restore these woodlands (Cocking et al. 2015, Stephens et al. 2023). In recognition of this need, the BOF adopted regulations to allow for conifer removal to restore oak woodlands (CAL FIRE 2024c), with recent revisions through AB 2276 to increase the size of conifers that can be removed (Wood 2024). Moreover, climate modeling suggests less climatic suitability for conifer-dominated forests in some areas—these forests may shift to oak woodlands in the future (Thorne et al. 2016, Thorne et al. 2017).

In sum, the total acres potentially in need of treatment (RD <25%, RD >35% or 60%, site class 1–3 hardwood dominated) to improve stand density and composition ranges from 7.4 to 11.8 million acres, affecting both public and private timberlands (see ⓘ1.2, above).

Management Context

Though California's forests face numerous threats creating substantial need for more active management, work is underway to build more resilient forest stands in areas at high risk of catastrophic wildfire or vulnerable to disease and drought. Sustainable forest management, which includes treatments to enhance forest resilience and reduce fire risk, is the cornerstone for forest policy in California.

Sustainable Harvest

The public interest in maintaining and enhancing sustainable working forests in California is protected through numerous federal, state, and local laws, rules, regulations, and ordinances. The BOF is responsible for developing general forest policy, determining guidance policy for CAL FIRE, and representing the state's interest in federal forestland in California. For non-federal lands, the primary regulatory framework governing commercial timber operations is provided by the 1973 Z'Berg-Nejedly Forest Practice Act, implemented through the FPRs (CAL FIRE 2024c). Since the late 1990s, the FPRs require all non-federal forest landowners to manage on a sustained yield basis under a state regulatory framework for "maximum sustained production (MSP) of high-quality timber products" (CCR Title 14, §§ 913.11, 933.11, 953.11). Except for under Emergency and Exemption Notices, commercial timber harvesting under the FPRs requires landowner preparation and CAL FIRE approval of a Timber Harvesting Plan (THP) or other type of Plan such as a Nonindustrial Timber Management Plan (NTMP), a Modified THP (MTHP), or a Working Forest Management Plan (WFMP) written by a Registered Professional Forester (RPF). These plans, in combination with the state's interagency, interdisciplinary review and approval process, are considered the functional equivalent of a California Environmental Quality Act (CEQA) Environmental Impact Report (EIR) (Table 1.1). NTMPs, MTHPs, and WFMPs provide additional

7 *Site class is an estimated or predicted indicator of site productivity (Hanson 2003). FIA site classes 1–3 represent highly productive sites corresponding to predicted timber productivity of ≥120 cubic feet/acre/year of growth at culmination of mean annual increment.*

Table 1.1. Types of plans or notices for commercial timber harvest on non-federal lands in California				
Plan/Notice Type	**Valid Time Period**	**Main Users**	**Ownership Size Limitations**	**Key Additional Requirements**
Timber Harvesting Plan (THP)	5 years; potential for 2-year extension	Large or small landowner	None	Detailed multi-agency environmental review and approval process. Can use Option "a" or "c" to demonstrate MSP.
Modified THP (MTHP)	5 years; potential for 2-year extension	Small landowner	≤160 acres	Numerous limitations on practices to reduce environmental impacts.
Sustained Yield Plan (SYP)	Effective up to 20 years, or less if environmental conditions substantially change	Large landowner (typically, ≥50,000 acres)	None	Relies on Option "b" to demonstrate MSP. Requires detailed assessments of fish, wildlife, watersheds, timber sustainability. Subject to detailed multi-agency environmental review/ approval.
Program Timberland Environmental Impact Report (PTEIR)	Effective until environmental conditions substantially change	Large landowner or conglomeration of smaller landowners	None	Used to demonstrate MSP. Requires detailed assessments of public-trust resources unique to an ownership. Harvest compliance demonstrated with multi-agency endorsed PTHP "checklist" showing harvest operations are withing the scope of the PTEIR.
Nonindustrial Timber Management Plan (NTMP)	Effective until environmental conditions substantially change	Small landowner	<2,500 acres	Uneven-aged management only; Timber Operations can commence on the same day that the Notice of Operations is submitted to the Department (effective for one year).
Working Forest Management Plan (WFMP)	Effective until environmental conditions substantially change	Small to medium sized landowner	≤10,000 acres	Uneven-aged management only; owner not primarily engaged in the manufacture of forest products; must be included within a single planning watershed unit. Harvest operations may commence in 3-days after submittal of Harvest Notice.
Exemption and Emergency Notices (EX/EM)	One year	Small and large landowners	None	Non-discretionary documents (no formal agency review). Must comply with operational FPRs. Rapid commencement for damaged stands, fuel hazard reduction, other conditions.

Data Source: CAL FIRE.

emphasis on ecosystem services and uneven-aged management.

Programmatic management plans have also been provided in an attempt to reduce the regulatory burden on non-federal landowners interested in conducting commercial forest management, which may include forest restoration or resilience goals. A Programmatic Timberland Environmental Impact Report (PTEIR) can be used, with Programmatic Timber Harvesting Plans (PTHPs) tiering off them to reduce the work needed in preparing a THP. For vegetation treatments in forests and other vegetation types aimed at hazardous fuels reduction, constructing fuel breaks, and promoting ecological restoration without a commercial timber component, the California Vegetation Treatment Program (CalVTP) Environmental Impact Report (EIR) provides a powerful CEQA compliance tool to expedite the implementation of wildfire resilience and community protection projects. Plan review includes multi-agency participation by CAL FIRE, CDFW, RWQCBs, and the California Geological Survey (CGS). Interagency policy coordination is provided by CNRA. Additional permits to protect aquatic habitats and water quality may be required from CDFW and/or the applicable RWQCB. Together, the FPRs, the Water Quality and CDFW regulatory systems, and interagency review and enforcement provide for broader sustainability than just MSP.

A summary of how the FPRs address sustainable forestry is provided below. These rules may vary throughout the state to account for local issues.

Inventory management:

- Timberland preservation: Restrictions on timberland conversion to alternative uses.

- Post-harvest re-stocking: Specific requirements for re-stocking after timber harvest.

- Sustained yield: Owners of over 50,000 acres of timberland in California are required to meet MSP under a Sustained Yield Plan (SYP, via Option "b"), with an Option "a" document, or with a PTEIR. A detailed assessment of timber sustainability sufficiently constrained by general assessments of public-trust resources such as fish, wildlife, and watershed protection is required for these large landowners. Owners of less than 50,000 acres can additionally use the default Option "c," which requires meeting minimum stocking and basal area standards for a given silvicultural system specified in the FPRs.

- Emergency and Exemption Notice rules: Serve as a non-discretionary equivalent to a THP to commence rapid timber harvesting to address stands damaged by fire, insects, disease, etc., and to rapidly implement fuel hazard reduction treatments. The operational FPRs must be followed.

Ecological and environmental protection:

- Water quality protection: Watercourse protection rules related to harvest practices, road construction, and maintenance rules to control erosion and sediment delivery to channels.

- Wildlife habitat protection: Retaining/recruiting late seral habitat in watercourse and lake protection zones (WLPZs) for habitat connectivity, protection for threatened and endangered species, and snag and downed wood considerations.

Community support and socio-economic benefits:

- Formal process for public comment on Plans; the lead agency (CAL FIRE) must respond to comments in the permit record.

- Specific provisions for protection of archaeological, historical, and cultural sites.

- MSP provisions for large landowners that contribute to a sustained level of economic activity and local employment.

The regulatory framework has undergone numerous revisions since its inception, including measures to provide additional protection for water quality, fish and wildlife habitat, archaeological sites, and threatened and endangered species. Regulations have been upgraded in the past decade relating to forest roads, yarding methods, and stocking standards. Changes have also addressed regulatory efficiency and cost of compliance, while maintaining or strengthening environmental protection. Since 2004, a series of Legislative and BOF expansions of allowed activities under Exemption Notices, primarily focused on fuel reduction, have enhanced opportunities for landowners to conduct limited commercial timber harvest without a THP or other type of Plan. Certain changes have also directed more tracking of activities and increased monitoring and evaluation of outcomes, particularly as they relate to Exemption and Emergency Notices (e.g., Olsen et al. 2025; see Chapter 13, Institutional Response, for further discussion).

Further improvements to the regulatory system are provided by AB 1492 (Blumenfield et al. 2012). This bill created the Timber Regulation and Forest Restoration Fund (TRFR Fund) through a 1% tax on retail sales of lumber and engineered wood products in California. AB 1492 goals include improving the state's ability to monitor the economic and environmental consequences of timber regulation, providing for a more efficient regulatory process that takes into account the THP process as a whole, and funding critical restoration activities.

AB 1492 accomplishments include but are not limited to:

- Statewide forest ecosystem monitoring using new remote sensing data including LiDAR and other technologies to obtain post-disturbance condition, emergency public safety information, and to assess progress and effectiveness of vegetation treatments.

- Ongoing monitoring of Emergency and Exemption Notices and funding for BOF FPR Effectiveness Monitoring Committee projects.
- Continued development and implementation of CalTREES, an online timber harvesting permitting system for non-federal lands.
- Funding for over 200 staff positions and improved coordination for the various state agencies responsible for timber harvest document review, inspections, approval, enforcement, and monitoring.

California's FPRs provide numerous resource protections, options for landowners to comply with the regulations, and efforts to improve the regulatory process. However, private family forest landowners have expressed that the regulatory environment is still complex and the high costs to prepare harvest documents, ranging from $12,000 to $50,000, make it difficult to actively manage their forestland (Goldstein et al. 2023).

Trends by Owner

California timberland has a diverse set of biophysical conditions and ownerships with different management objectives. These differences, combined with ongoing threats to forest health, result in distinct outcomes by ownership, described in detail below. Trends presented are not intended to be a causal comparison of management methods but rather highlight that different concerns may be present for different landowners.

It should be noted that due to the FIA remeasurement cycle where 10% of all plots are remeasured 10 years later and 100% of the plots are remeasured over the course of 10 years, rapid changes to forests have a lag before they are reflected in the data. For example, an unprecedented extent of high severity fire occurred in California forests in 2020 and 2021 but only 10% of plots in the data used in this report have been sampled since 2020. As discussed below, CAL FIRE is providing program staff and funding to reduce the remeasurement cycle to five years. To enable a direct comparison between values reported in the current Assessment and the 2017 Assessment, FIA-based metrics from the 2017 Assessment were recalculated using the new national scale volume-to-biomass equations recently employed by FIA. Stand conditions in terms of elevated stand densities (see ⓘ1.2, above) and deviation from historic fire regimes (ⓘ4.1) affect some portion of all ownerships. In general, increased wildfire, insect, and disease-related losses drive reductions in net growth on private corporate, NFS timberlands, and NFS productive reserved land compared to those reported in the 2017 Assessment.

Forest Industry

For forest industry (3.9 million timberland acres throughout northern and central California), timber production is the primary objective, but sustainable forestry practices are required by the California FPRs, and in some cases occur through voluntary participation in third-party certification programs. In this analysis, forest industry includes landowners with more than 2,500 acres that are commercially harvesting trees. Forest industry landowners have demonstrated MSP on almost 3.9 million acres of planned treatments in either mandatory Option "a" or "b" documents, and with 61,000 acres that are additionally covered by a PTEIR (see ⓘ1.5, above). Alternatively, for owners with less than 10,000 acres, there is one WFMP with 4,000 planned acres (see ⓘ1.5, above). Though not considered a long-term, analytical planning approach like the various MSP options and harvest plan types, landowners with 2,500 to 50,000 acres are satisfying MSP requirements on 469,000 planned acres in currently active THPs through use of the default Option "c", which is based on stocking standards.

Softwoods comprise just over 98% of commercial timber harvest and come primarily from industrial timberland (Scott et al. 2024). Management for sustained yield on corporate forestlands as a whole is confirmed by independent FIA data indicating that softwood growth exceeds harvest and mortality by 41 ft^3/acre/year (see ⓘ1.1, above). However, this represents a 14% decline in net growth compared to the recalculated 2017 Assessment data. The multitude of other metrics that are important in evaluating forest sustainability, such as water quality or wildlife, are discussed in other chapters throughout the Assessment.

Carbon offset projects remain a very important tool for industrial forest owners, since profit margins can be thin and adding an economic incentive is valuable. Landowners participating in these projects can sell offsets to increase or diversify income while contributing to GHG emission reductions. There is a 50% acreage increase in industrial land in carbon offset projects since the 2017 Assessment, at 316,000 acres (see ⓘ1.5, above). Similarly, forest certification is a very important business practice for industrial landowners, since it is required by major retailers. Since the 2017 Assessment, there is a 16% increase in industrial land under third party certification, for a current total of 4.2 million acres; however, acreage between different certifications may overlap (see ⓘ1.5, above). Lastly, there are approximately 221,000 acres of industrial timberland under permanent conservation easements, a portion of which include working forest conservation easements (see ⓘ1.5, above).

Industrial owners on the North Coast, with the most productive timberland, are at the forefront of new management initiatives that take multiple resource objectives and ecosystem services into account, though these approaches are being applied in other regions as well. Additionally, many landowners with more than 2,500 acres that are commercially harvesting trees are managing for multiple resource objectives and ecosystem services. For example, Green Diamond Resource Company, which manages approximately 400,000 acres of forestland on the North Coast, is certified for sustainability by the Forest Stewardship Council, has a Habitat Conservation Plan (HCP) to protect the northern spotted owl, an aquatic HCP to protect several fish and amphibian species, a forest HCP, and a Safe Harbor Agreement with CDFW for the conservation and recovery of the Humboldt marten. The company also is active in forest carbon markets on its lands in California and elsewhere in the U.S. (GDRC 2024). The Usal Redwood Forest Company is a subsidiary of the Redwood Forest Foundation, Inc., a private non-profit, Section 501(c)(3) organization. Comprising just under 50,000 acres, the once heavily cut-over forestland that is now dominated by Douglas-fir and tanoak is being managed with a focus on restoration through planting redwoods and practicing sustainable forest management for the purpose of long-term community benefits. Their forest carbon project is one of the largest in the United States (Usal Redwood Forest Co 2020). Additionally, The Conservation Fund, with over 70,000 acres in the North Coast region, is managing with decreased harvest intensities, longer rotation lengths, enhanced wildlife and aquatic habitat measures, and increased carbon sequestration (The Conservation Fund 2023).

Nonindustrial

Owners with less than 2,500 acres are nonindustrial (PRC § 4593.2[b]). Nonindustrial private lands (3.3 million acres of timberland) include a diverse group of owners who own land for a variety of objectives. Through the CAL FIRE Fire and Resource Assessment Program (FRAP) Management Landscape analysis discussed later, there is a total of 4.7 million acres of nonindustrial private forests, which includes some woodlands. An additional 5.4 million acres of less productive nonindustrial woodlands also exist. A separate FIA analysis indicates there are approximately 5.8 million acres of family forestland; however, these numbers are limited to parcels of 10 acres or more, and includes 1.1 million acres of family LLCs (Limited Liability Companies) or LLPs (Limited Liability Partnerships) (Butler et al. 2021). This FIA analysis also indicates that approximately 55% of family forest landowners with parcels greater than 10 acres do not have a primary residence within one mile of their forestland, which can be a proxy for determining absentee owners. Information at the state level is not available for parcels less than 10 acres, as the survey sample size is small with high variance in the estimates.

Based on national and California-specific surveys of small forest landowners, the most common reasons these owners cite for owning forestland in California are enjoyment of scenic beauty; protecting wildlife habitat, water resources, and nature; passing the land to heirs; and investment property (Ingram et al. 2022, Sass et al. 2023). Key concerns include wildfire, keeping land intact for future generations, climate change, drought, and insects and disease (Ingram et al. 2022).

Overall, timber growth on nonindustrial ownerships far exceeds harvest and mortality by an average of 81 ft^3/acre/year, resulting in an accumulation of volume (see ⓘ1.1, above). This represents a 2% increase in net growth compared to the recalculated 2017 Assessment data.

The state has tried to encourage more active sustainable management of these lands, for example by allowing owners of less than 2,500 acres of timberland to streamline the THP process by preparing an NTMP. NTMPs have a core requirement for an assessment of MSP and long-term sustained yield based on an uneven-aged silvicultural prescription. These plans, which do not expire, also must include provisions for protecting environmental and ecological values. As of December 2023, there were 911 approved NTMPs covering about 355,000 planned acres, representing 11% of nonindustrial timberland acres (see ⓘ1.5, above). Since the 2017 Assessment, there is an 18% increase in approved NTMPs and an 11% increase in total acres. In addition to satisfying MSP requirements with an approved NTMP, alternatives for nonindustrial landowners include using a PTEIR, WFMP, submitting an Option "a" document, or through use of Option "c." There are 44,000 planned nonindustrial acres under a PTEIR (see ⓘ1.5, above). Additionally, there are 1,000 planned acres under the shorter-term planning horizon currently in active THPs through use of the default Option "c" FPR standards. Carbon offsets and voluntary third-party certification are important to nonindustrial landowners as well. Since the 2017 Assessment, there has been an 8% decrease in nonindustrial carbon offset acres and a 25% increase in certified acres (see ⓘ1.5, above). Lastly, there are 227,000 acres of nonindustrial timberland under permanent conservation easements, a portion of which include working forest conservation easements.

Public

The USFS administers 8.7 million acres of the 9.1 million acres of publicly owned timberland in California (USFS 2024b). These lands generally have much lower removal from harvest than private corporate and non-corporate lands given the USFS's inherent multi-use mission, extensive landholdings that cover diverse biogeographic conditions, and regulatory environment (see ⓘ1.1, above). In addition to its 8.7 million acres of timberlands, the USFS also administers 2.7 million acres of productive forestland that is reserved from timber harvest and 3.7 million acres of less productive forestland, a portion of which is also reserved from timber harvest.

According to FIA data, elevated stand densities occur on 4.3 million acres, or 57% of public lands, comprising 63% of the area in need of stand density reduction treatments (see ⓘ1.2, above). Based on another study considering wildland fire hazard potential, approximately 70% of operational acres in need of stand density reduction treatments are on federal lands (5.2 million acres) (DeLyser et al. 2025). Across all NFS forestland in the last decade, there have been increases in tree mortality and decreases in tree growth, such that losses from mortality and limited tree harvest exceed gains from live tree growth (ⓘ7.5). The highly disturbed portions of these forests are in the early stages of resetting (density, structure, composition, and extent) to a new equilibrium that is being determined by factors including past management, climate change, wildfires, drought, and insects and disease. Across public lands, there are at least 1.1 million operationally feasible[8] acres without an adequate natural seed source, at risk of vegetation type conversion, and in need of post-disturbance reforestation after increases in high severity burned area between 2019–2021. There is an additional 200,000-acre backlog in reforestation needs from earlier disturbances between 2010–2018. Preliminary estimates as of spring 2024 put the operationally feasible reforestation need on public lands at 1.5 million acres (WFR Task Force 2024d). One study projects that the NFS will lose 69% of its forest area (10.3 million acres) and accumulate approximately 9 million acres of post-fire regeneration failure in the next 50 years, contributing 70% of

8 *Outside of wilderness areas, within one mile of a road, and have a slope of 70 degrees or less (WFR Task Force 2024d).*

the overall forest area losses during this time (DeLyser et al. 2025).

When looking narrowly at only softwood growth on NFS timberland, growth slightly exceeds removals and mortality by an average of 10 ft^3/acre/year (see ⓘ1.1, above). This represents a 72% decrease in net growth compared to recalculated 2017 Assessment data. In contrast, on productive NFS lands reserved from management for timber production (e.g., wilderness areas) where very little active management beyond fire suppression occurs, softwood mortality from extensive wildfire and insect and disease activity exceeds growth for an average net loss of -27 ft^3/acre/year. This represents a 1055% decrease in net growth compared to recalculated FIA data from the 2017 Assessment using the new FIA national scale volume-to-biomass equations. According to the agency, "Growing wildfire risk is due to accumulating fuels, a warming climate, and expanding development in the wildland-urban interface. The risk has reached crisis proportions in the West… It will take a paradigm shift in land management across jurisdictional boundaries to reduce risk and restore fire-adapted landscapes" (USFS 2022a). For further discussion on development in the wildland-urban interface (WUI), see Chapter 11 (Wildfire Risk to Communities).

Other public lands managed for multiple uses including timber production are certain BLM lands, Demonstration State Forests administered by CAL FIRE, and properties owned by local agencies (e.g., the City of Arcata Community Forest). In 2023, the BLM approved the Statewide Wildland-Urban Interface Fuels Treatment Programmatic Environmental Assessment (BLM 2023) for California to "streamline plans to protect communities, reduce wildfire risk and improve forest health." Work will be coordinated across ownerships with local and state agencies to create a landscape-level network of strategic fuels treatments. The BLM anticipates being able to treat an additional 20,000 acres of public land annually through this program. In 2023, the BLM entered into Good Neighbor Authority (GNA) Agreements with CAL FIRE, the California Conservation Corps, and Caltrans to increase coordination for restoration, fuels reduction, and forest health projects on BLM-managed public lands in California. These agreements incorporate approximately $13 million in funding from the federal Bipartisan Infrastructure Law.



California Tree Mortality Data Collection Network plot measured in 2023 in the Stanislaus National Forest showing pine mortality and rapid snag fall following the bark beetle epidemic. Photo provided by the Pacific Southwest Research Station, USFS.

Other public forestlands such as national and state parks are not actively managed for timber but often are managed for old-growth sized tree recruitment (e.g., Redwood National and State Parks [RNSP]) and wildfire hazard reduction (e.g., Yosemite, Kings Canyon, and Sequoia National Parks). In RNSP, restoration thinning, reforestation, and logging road rehabilitation are currently underway as part of the "Redwoods Rising" project in two main areas—Mill Creek and Prairie Creek watersheds. The goal is to rehabilitate over 70,000 acres of second-growth forest in the next 30+ years. Low-retention thinning treatments have been found to be most effective in accomplishing restoration objectives for second-growth stands in RNSP (Teraoka et al. 2017). Management in national roadless

or wilderness areas is even more limited. However, these NFS system lands are experiencing massive levels of mortality and more active management may be needed to maintain the resilience of these ecosystems into the future. Recent research has identified 1.2 to 1.7 million acres of large blocks (greater than 800 acres) of non-WUI federal forestland that could be managed as Strategic Fire Zones where beneficial fire could be reintroduced through natural ignitions and prescribed and cultural burning during favorable fire weather conditions (North et al. 2024).

Tribal Lands

Before European settlement, California supported a diverse population of Native Americans with over one-third of North America's Native peoples living in the region from Oregon to Baja California. Over 100 languages and 300 dialects were spoken and sophisticated tending of the ecosystems they depended on occurred through pruning, coppicing, and maintaining low-intensity fire regimes (FNDI 2020). Indigenous peoples' holistic and spiritual view of the world recognizes that all beings and natural processes are interconnected and interdependent on one another, and that humans are related through kinship to the world that surrounds them (Romero-Briones et al. 2020, Tribal Adaptation Menu Team 2019). There are western analogs to this perspective in deep ecology (Devall and Sessions 2007) and some religious teachings (Stine 2020), however the overarching belief that accompanied European settlement was that nature was to be dominated and controlled. With the arrival of these settlers to North America, Indigenous peoples were systematically removed from their ancestral lands and were victims of genocide and disease. Their land stewardship practices, such as cultural burning, were outlawed in 1911 with the Weeks Act (Elasser 2022), creating lasting negative impacts to ecosystems, biodiversity, and human communities (Hankins 2024).

More recently, warming air, lake, and stream temperatures; decreasing stream flows; harmful algal blooms; drought; variable precipitation; flooding; depleted groundwater; high severity wildfire; degraded air quality; and loss of native plants, fish, animals, and traditional foods are threatening the physical, cultural, and spiritual health and livelihood of California tribes, their habitats, ecosystems, and built environments (CA OEHHA 2022). Restoring opportunities for Indigenous land stewardship, integrating TEK with western science, and restoring traditional fire regimes are important for ecosystem resilience (Karuk Tribe 2019). While the effects are often overlapping, tribal objectives can differ from traditional land management agency objectives. For example, a cultural burn may be aimed at increasing plant diversity for food or medicinal uses, while the land management agency may be focused on fuels reduction within communities. By applying TEK, a wider range of ecosystem and cultural benefits may be provided.

The importance of Indigenous land stewardship and relationships with their ancestral lands is increasingly being recognized by state and federal agencies. In fire-adapted forests, there is increasing understanding of the level of burning by Indigenous peoples that shaped and maintained the forest structure that European settlers saw when they first arrived in the West, as discussed further in Chapter 4 (Wildfire). Though the concept of TEK is a western construct in itself, there are inherent challenges in making space for the intimate, spiritual nature of cultural burning and Indigenous stewardship practices within the secular government agencies that manage and regulate natural landscapes. However, there are newfound government-based efforts to integrate TEK and cultural burning into land stewardship actions, such as through the WFR Task Force's Strategic Plan for Expanding the Use of Beneficial Fire (Blumenfeld et al. 2022). Additionally, there are decades of wrong-doings towards Indigenous peoples that must be repaired. Tribal publications (e.g., Marks-Block and Tripp 2021, Tribal Adaptation Menu Team 2019) can provide guidance on how to build relationships and trust and address barriers to Indigenous land stewardship.

California Native American tribes are seeking to actively manage their ancestral lands, particularly with respect to the use of cultural fire (see box insert in Chapter 4, Wildfire). Indigenous-led efforts are numerous

and critical to increasing resilience in a changing climate (Hankins 2024). One example is the Indigenous Stewardship Network, a recently established 501(c)(3) nonprofit organization created through the Yurok Tribe. The organization works to advance community health and wellbeing, traditions, and cultural values through land stewardship led by Indigenous persons (Indigenous Stewardship Network 2024). Additionally, The Stewardship Project, under the Climate and Wildfire Institute, is "…supporting a partnership of tribes and western science to consider how current federal forest policy can incorporate insights from Indigenous practices to better steward the landscapes of the American West" (CWI 2022). The Stewardship Project works to advance policy proposals that address Indigenous rights to burn and co-manage wildlands; the management of wildfires for resource benefit; and development of a workforce adequate to meet the treatment needs on federal lands.

A number of financial resources are now being made available to enable the collaborations needed to increase opportunities for Indigenous stewardship. For example, CAL FIRE's Tribal Wildfire Resilience grant program supports California Native American tribes in managing ancestral lands, implementing and promoting TEK in wildfire resilience, and establishing wildfire safety for tribal communities (CAL FIRE 2024d). These efforts are discussed further in Chapter 4 (Wildfire).

With respect to timber resources, there are four reservations in California that are actively managed for timber production and other uses in accordance with their forest management plans (Hoopa Valley Tribe, Round Valley Indian Tribe, Tule River Indian Tribe, and Yurok Tribe). These lands are included in the private non-corporate category in the FIA data, though some tribes may be conducting substantial amounts of commercial harvest. The Hoopa Valley Tribe was one of the first properties in California to undergo third-party certification for sustainable management. Both the Yurok Tribe and the Round Valley Tribe have projects that have been approved by CARB for sale of carbon offsets through improved forest management.

Carbon Offset Projects

Through photosynthesis and the carbon cycle, forests can potentially be leveraged for climate mitigation. Additionally, as stated above, carbon offset projects are an important tool for forest landowners to diversify income streams and contribute to GHG reductions. As part of California's Cap-and-Trade Program (initially authorized under AB 32 [Nunez and Pavley 2006]), CARB has developed protocols for improved forest management, reforestation, and avoided conversion projects. Forest landowners can be issued carbon offsets by CARB or through the voluntary carbon market by registries such as Climate Action Reserve (CAR). Forested acres enrolled in this program have increased between 2017 and 2022 (see ⓘ1.6, above). In 2017, CARB issued credits for 207,000 acres of Compliance Offset forest projects and 64,000 acres of Early Action projects in the state, while the CAR had 85,000 acres registered. As of December 31, 2022, 371,659 acres of forestland in California were enrolled in the program, all as CARB compliance forest projects (see ⓘ1.6, above). The early action projects have since expired, and project tracking and enrollment has consolidated considerably so that most CAR projects are now included in the CARB compliance project data.

Permanence of GHG benefits is a concern in wildfire-prone landscapes (Badgley et al. 2022). All but one California project is in or adjacent to Humboldt and Mendocino counties, typically highly productive timberland with relatively low fire and pest threat. All California projects are "improved forest management," involving combinations of reduced harvest levels, longer rotations, and uneven-aged management, with the exception of one CAR project that also includes some even-aged management with actions to maintain stocking for optimal growth. Despite very large areas burned in wildfires in the past several years, only three forest areas being managed for carbon offset projects in 2022 overlapped with wildfires that occurred in 2019–2022, with a total of ~2,400 acres overlapped by the fires (see ⓘ1.6, above). This amounts to ~0.5% of the total forest area enrolled in carbon offset projects. Of the area within the fire perimeters, 13% was unburned,

35% was low severity fire, 45% was moderate severity fire, and only 7% was high severity fire.

The Management Landscape

FRAP has developed the "Management Landscape" layer for forestlands[9] (excluding woodlands) to summarize and simplify how diverse and unique owner objectives translate into broad timber management emphasis categories (e.g., high, medium, low, and no timber commodity emphasis, Figure 1.4) (CAL FIRE 2024b).[10] Management emphasis relates not only to harvest volume, but also to the silvicultural systems and practices used to grow and harvest timber and the level of associated ecosystem services provided.

In the past, industrial forestland was categorized by an acreage threshold (e.g., 50,000 acres or more) and ownership of wood processing technology. However, this definition has become increasingly complex due to changes in timberland ownership and management objectives. Some industrial landowners have downsized their holdings, and wood processing infrastructure has consolidated and decreased. Other landowners with diverse management objectives have amassed timberlands beyond the 50,000-acre mark. With private landowners seeking diverse income through carbon offsets and sustainability certifications, the focus has sometimes moved away from timber products as the primary output. This evolution has increased the complexity of defining and managing industrial forestland.

Statewide, only 15% of forestland (3.9 million acres) is high timber emphasis (Figure 1.4), where timber harvest is the primary objective (typically forest industry owners). In California, high timber emphasis is typically less intensive than in other states or even what was practiced here in the past. This is due to regulatory measures such as California's FPRs that require long-term sustained yield for large owners, initiatives such as voluntary enrollment in third-party certification programs, and other factors. Owners with high timber emphasis use both even and uneven-aged silvicultural systems. Additionally, 2.7% of high timber emphasis area is under permanent conservation easement.[11]

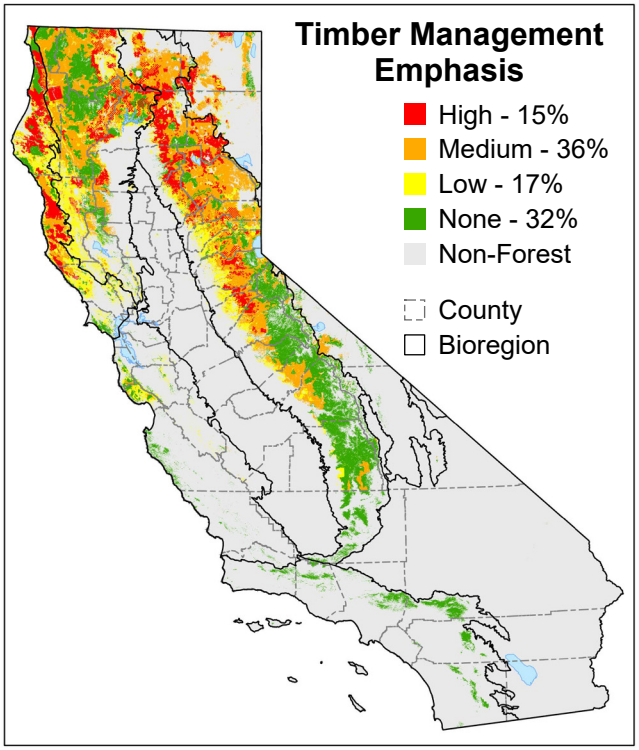


Figure 1.4. Timber management emphasis classes. Data Source: CAL FIRE (2024b).

The prevailing emphasis is medium (36% or 9.1 million acres), which can be characterized as multiple-use management primarily using uneven-aged silvicultural systems. This includes: public timberlands, industrial

9 *Based on 25.6 million acres of forestland, excluding 8.9 million acres of less productive woodlands, from FVeg/CalVeg. This differs from the FIA-based estimate of 32 million acres of forestland which includes all woodlands that have at least 10% canopy cover of trees of any size or has had at least 10% canopy cover of trees in the past.*

10 *Some errors in this analysis may exist due to overlaps, gaps, and misalignments of the different input spatial datasets used. These datasets also vary in how current they are; older data may have been used where more current data could not be obtained (e.g., CalVeg geospatial data for productive forestlands). This may result in outdated results in some areas. Additionally, some datasets used in the 2017 Assessment were not available or complete (e.g., no updated CAL FIRE Forest Industry geospatial dataset available that included certified and uncertified spatial designations. Instead, a Forest Industry owner spatial layer was combined with non-spatial owner certification information; this required all acres for an owner to be set as certified or uncertified in their entirety, which is often, but not always, the case).*

11 *Conservation easement spatial data are not displayed due to landowner confidentiality requirements.*

landowners operating under special California FPRs,[12] nonindustrial owners managing under an NTMP, conservation organizations managing working forests, and any lands enrolled in the CARB carbon offsets program. Approximately 1.3% of medium emphasis area is under permanent conservation easement.

Seventeen percent of forest is in low timber emphasis (4.4 million acres). This area is typically nonindustrial lands where timber is not one of the primary objectives for owning land. Approximately 3.4% of low emphasis is under permanent conservation easements.

Finally, 32% of forest (8.2 million acres) is either legally or administratively withdrawn from timber production (e.g., wilderness, parks), protected conservation organization, or is in areas where timber harvest is not a viable option due to lack of wood processing infrastructure (e.g., southern California). Approximately 0.6% of these lands are under permanent conservation easements.

Figure 1.5 shows a more detailed view of management classes for Mendocino County. New management initiatives are concentrated here and in Humboldt County, typically on highly productive timberland. Forest industry lands here tend to have third-party certification for sustainable management. There are carbon offset projects on timberlands owned by forest industry, numerous nonindustrial private holdings, conservation organizations, and tribal ownerships. Conservation organizations are very active here and in the northern interior in purchasing lands or easements to conserve working forests. For example, Pacific Forest Trust, a nonprofit land trust and conservation organization, has four working forest conservation easement projects in the Klamath-Cascade region of northern California totaling 57,000 acres.

Governor Gavin Newsom's "30x30" initiative, led by CNRA, is aimed at conserving 30% of California's lands and coastal waters by 2030 (CNRA 2022a, Newsom 2020). Lands that count towards the "30x30" goal must be "durably protected and managed areas" and generally encompass:

- Areas under government ownership or control, primarily designated to protect species and their habitats.
- Areas under perpetual easements that protect species and their habitats.
- Areas with species and habitat protection designations that have gone through a formal rulemaking or other enforceable decision-making process not subject to simple reversal (CNRA 2022a).

Additionally, lands that allow beneficial fire or other management techniques that mimic beneficial fire's effects and that limit most other extractive management can count towards "30x30" (e.g., U.S. Geological Survey Gap codes 1 and 2, USGS 2021). Most forest areas that qualify for "30x30" fall in areas classified in FRAP's no timber management emphasis category. Low timber emphasis areas where owners never intend to cut trees may be prime candidates for registration with the initiative if they become durably protected through a mechanism like a conservation easement. However, there are substantial areas in medium and high timber emphasis areas that would not qualify to contribute acreage into the "30x30" initiative. Substantial portions of these productive timberlands are maintained as functioning forests that provide significant ecosystem services, yielding "complementary conservation measures" critical to "30x30" objectives. So, while timber-producing working forests and many NFS lands may not count towards "30x30" acreage because they are managed for multiple resource objectives, these areas are considered buffers that support "30x30" acres and provide net value to California. These forests that offer complementary conservation measures to "30x30" may be evaluated in the future and tracked over time to better understand

12 *All forest industry lands within the Southern Subdistrict of the Coast Forest District, and within the Coastal Zone as defined by the California Coastal Commission, both of which operate under special FPRs.*

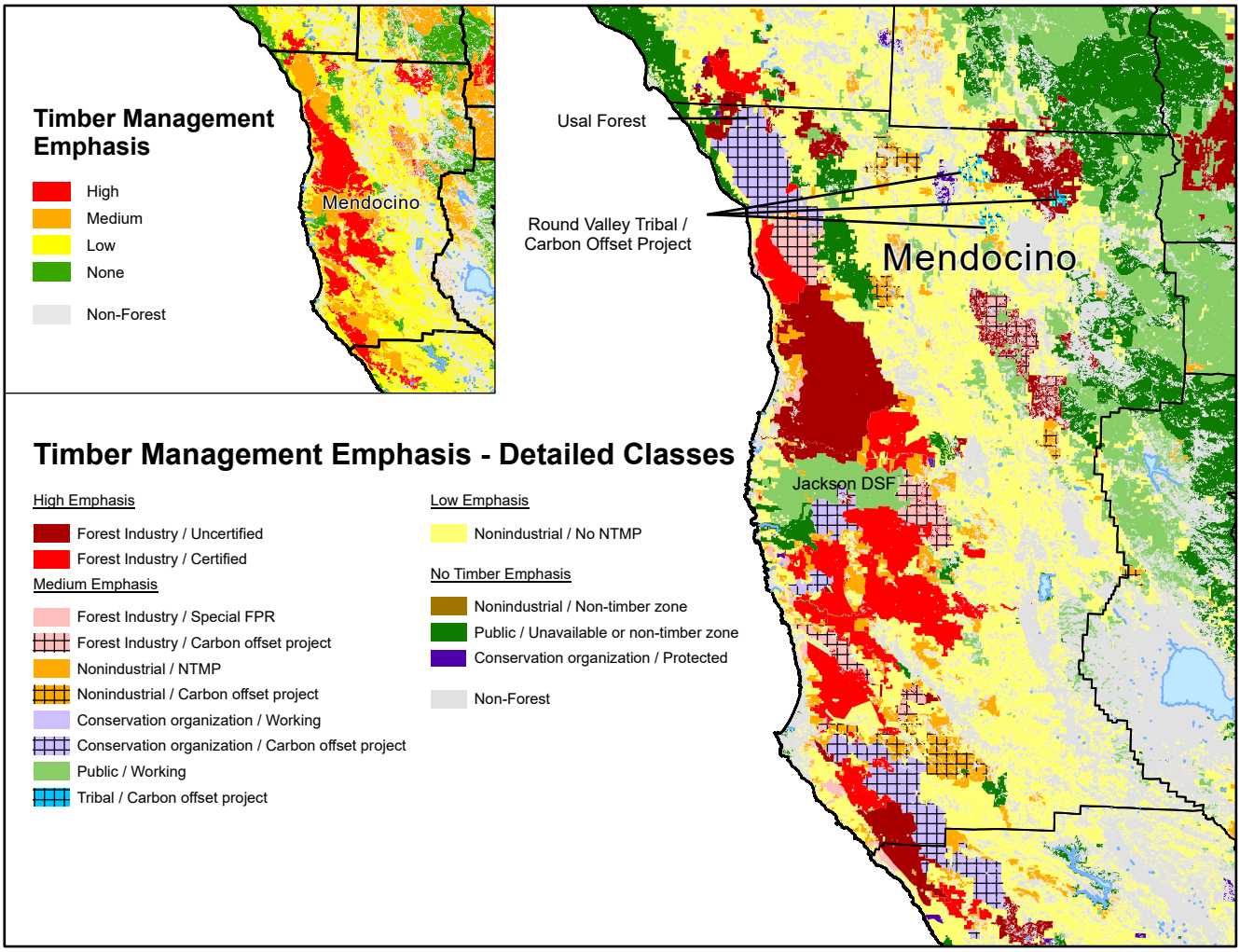


Figure 1.5. Detailed FRAP management landscape classes for Mendocino County as of June 14, 2024. Data Source: CAL FIRE (2024b).

whether they can directly contribute toward "30x30" targets.

Silvicultural Practices and Commercial Harvest

Changes in management emphasis on non-federal lands are also reflected in terms of trends in commercial harvesting activity and associated silvicultural practices (see ⓘ1.3, above). Between 1997 and 2022, there was an average of 165,000 acres of non-federal lands commercially harvested per year, though overall during this time period there has been a steady significant decline in total acres harvested. Harvested acres in 2022 were about 60% of 1997 harvest acres. The number of acres harvested using uneven-aged systems have been fairly constant, despite the decline in total harvest acres (i.e., even-aged acres have declined). Thus, the percentage of acres harvested using uneven-aged systems has increased, from an average of 29% of harvested acres between 1997 and 2001, to 41% between 2011 and 2015, before returning to 32% over the most recent five-year period of 2018–2022. In the CAL FIRE Forest Practice Coast Forest District, 57% of the 2011–2015 period harvest acres were uneven-aged, decreasing to 48% during the 2018–2022 period.

Widespread tree mortality from drought, insects and diseases, and wildfire have contributed to a major increase in non-federal acres filed for harvesting under Emergency Conditions (CCR Title 14, § 1052.1[b]). Emergency (EM) and Exemption (EX) notices include allowing landowners to remove trees to restore oak woodlands, to remove dead, dying, and diseased trees, and to remove trees to reduce the vertical and horizontal continuity of fuels, including for defensible space and

fuel breaks. There are 1.3 million acres filed under EX notices, which allow for removal of dead and dying trees that amount to less than 10% of the total volume. Often, landowners will put their entire ownership in an EX Notice and address dead and dying trees wherever they occur. Most Emergency Notices, regardless of size or ownership, have a one-year permit life. If the landowner is not able to complete the work in one year, they can simply submit a new permit application to continue the work for another year. When harvested, severely burned areas are salvage logged, generally removing all dead trees similar to clearcut silviculture, while mixed-burn severity locations are often salvage logged with single tree or small group silviculture.

In the last decade, Emergency Notice harvests have made up a substantial portion of the total harvested area. There have been over 352,000 reported acres under post-fire Emergency Notices since the 2014 fire season. In 2022, 215,000 harvested acres, or 68% of the total harvested area, were covered by Emergency Notices following unprecedented wildfires in 2020 and 2021. Regionally, Emergency Notices in 2022 comprised 86% of total acres filed for harvest in the Sierra/Cascades ecoregion, 75% in the Central Coast and Interior Ranges ecoregion, 69% in the Klamath/Interior Coast Ranges ecoregion, and 2% in the North Coast ecoregion. Notably, the proportion of uneven and even-aged acres filed through non-emergency timber harvest documents decreased dramatically during these years as Emergency Notice activity increased.

Monitoring work on Emergency Notices on private lands conducted in 2019 and again in 2022–2023 indicated that parameters related to erosion, sedimentation, and watercourse protection have generally reflected greater negative impacts than those reported for THPs, and that water quality-related impacts remained largely unchanged between the two sampling periods (Olsen et al. 2019, Olsen et al. 2025). Burn severity, inadequate best management practices (BMPs), ground-based operations, and project-specific settings (e.g., exposed bare soil, steep burned hillslopes) are primary factors driving these differences between salvage and green tree operations (Olsen et al. 2025). It should be noted that post-fire erosion in unmanaged areas was not evaluated. Generally speaking, salvage logging can have a have a negative, neutral, or positive effect on water quality depending upon site factors and how the logging activities are conducted (Wagenbrenner et al. 2015), discussed further in Chapter 9 (Water Resources). Use of BMPs should be prioritized during the different stages of post-fire salvage logging to reduce the potential for increased sediment delivery to watercourses (Wagenbrenner et al. 2023). Areas where salvage logging occurs may require additional remediation treatments that could further reduce impacts, such as mulching and seeding problematic areas, replacing fire-damaged culverts, repairing fire-impacted roads, rearranging dead fuels to prevent or disrupt sheet flow and erosion, and implementing rapid reforestation that can hasten hydrologic recovery.



2020 Hog Fire salvage logged area in Lassen County. Photo from Olsen et al. (2025).

Harvest on federal lands tends to be much less extensive than on non-federal lands. Using the Forest Activity Tracking System (FACTS) on federal lands, between 2000 and 2021 there was an average of approximately 3,800 acres per year of even-aged management, 68,000 acres per year of uneven-aged management, and 4,600 acres per year of salvage (DeLyser et al. 2025). Available data from the Interagency Treatment Tracking System on accomplishments in 2023 indicates uneven-aged management on federal forestlands totaled 53,146 activity acres (WFR Task Force 2024c). Even-aged management is not included in the tracking system and salvage is indistinguishable in the existing categories.

The Forest Products Sector

In addition to the steady decline in the number of harvested acres since the 1990s (ⓘ1.3), there has also been a steady decline in harvest volumes and wood product manufacturing (ⓘ1.4). These declines are driven by a combination of regulatory, economic, environmental, and market factors discussed in this section. Nevertheless, demand for wood products is high—California produces fewer wood products than it consumes. Based on a 2017 snapshot of trade, approximately two-thirds of the lumber used in the state is imported; approximately three-quarters of the plywood/veneer and nearly all the non-structural panel, oriented strand board, and pulp/paper are also imported (Evans and Potts 2024). Meeting in-state demand requires importing lumber and wood products from other states and countries that often have less restrictive rules on forest practices. Forests in these other locations may also be experiencing substantial impacts, such as from climate change. The majority of lumber imports originate in Oregon, Washington, and British Columbia, in that order. Plywood/veneer is imported from other countries, Oregon, and the Southeastern United States; non-structural panel and oriented strand boards are imported primarily from other countries, British Columbia, and the Southeastern U.S. Paper is mainly imported from U.S. states outside of the Pacific Coast region, Oregon, other countries, and Washington; and pulp, chip, and wood pellet imports are minimal.

Forest inventory data indicate that private corporations with forestland in Oregon and Washington are harvesting nearly all they are growing. Coupled with the additional losses from mortality (approximately 11% and 14% of gross growth in Oregon and Washington, respectively), net growth is close to zero. This means that though harvest is slightly less than gross growth, when combined with mortality, average annual net growth on live trees is reduced and may be approaching zero or net loss when statistical uncertainty is included. In British Columbia, insect, disease, and wildfire mortality are nearly equal to losses due to harvest. Combined impacts on the timber harvesting land base from harvest, wildfire, and insects and disease are causing net carbon losses, which may impact wood supply in the future (Christensen et al. in press). There are many trade dynamics and factors at play, making it difficult to determine whether the extent to which reduced harvest in California may lead to increased harvest in these other places (i.e., leakage). As part of a long-running softwood lumber trade dispute, the U.S. Department of Commerce increased antidumping and countervailing duty rates on Canadian softwood lumber in 2025, alongside additional import tariffs imposed by the Trump Administration.



Aerial view of reforestation on Boggs Mountain Demonstration State Forest following the 2015 Valley Fire and extensive salvage logging. Photo: CAL FIRE.

Beginning in 1904, historic timber harvest volumes in California generally increased until a crash in the early 1930s and then generally increased sharply until peak harvest in 1955 (see ⓘ1.4, above). Since then, timber harvest shows a major decline—total volume harvested in 2022 was 72% lower than peak harvest in 1955, with an all-time low at 85% lower than peak harvest in 2009 due to the Great Recession. Since 2000, total harvest has generally stabilized around an average of 1,668 million board feet. The number of sawmills follows a similar trend—there was a high of 675 sawmills in 1956 and only 31 in 2021 (Scott et al. 2024). Numerous factors are cited as reasons for these declines:

- Historically high timber harvest levels in the 1950s coinciding with the post-WWII housing boom.

- Forest industry transitioning from harvest of old-growth timber to management of second-growth in the latter half of the 20th century.
- Increased regulation of timber harvest on private lands, including the Z'Berg-Nejedly Forest Practice Act (effective 1/1/74).
- Increased protection for state and federally listed species, such as under the Endangered Species Act. For example, harvest from NFS lands declined steeply (see ⓘ1.4, above) after the listing of the northern spotted owl under the federal Endangered Species Act in 1989 and passage of additional federal regulations such as the 1994 Northwest Forest Plan (USFS and BLM 1994), along with changes in federal timber programs to reduce impacts to the California spotted owl (Morgan et al. 2004).
- Other policy and regulatory changes and greater public demand and focus on ecological integrity and ecosystem services that resulted in reduced timber harvest on federal lands.
- Various market forces including concentration of milling capacity into larger, more efficient mills in fewer locations (Marcille et al. 2020, McIver et al. 2015). Total milling capacity has scaled down to what is currently produced off federal and private timberlands.
- Wood products are a broadly available commodity product. Economic and market forces such as global markets, recessions, recovery from recession, price, and competition impact production in California (McIver et al. 2015, Morgan et al. 2012).

The contribution from public lands to total harvest volume over the 1955–1990 period averaged about 38%. It has stabilized at about 18% of total harvest in the state since the year 2000 at (see ⓘ1.4, above). In 2021, federal harvest was 12% of total harvest (Scott et al. 2024). Between 1955–1990, private harvest comprised 66% of total harvest and since 2000 it comprised 82% of total harvest (see ⓘ1.4, above). In 2000, private industrial comprised 48% of total harvest, increasing to 70% of total harvest in 2021. Nonindustrial and tribal comprised 36% of total harvest in 2000 and decreased to 18% in 2021 (Scott et al. 2024). Since 2000, private harvest levels (the bulk of which are forest industry) have averaged 1,369 million board feet (see ⓘ1.4, above). Annual fluctuations have been as much as 26% over this average in 2000 and 45% under in 2009. Future harvest levels are likely to fluctuate around this average based on various economic, regulatory, and environmental factors, as well as the capacity of infrastructure to process harvested materials. In the most recent mill survey, salvage volume rose to 38% compared to 3% in 2016 and just 2% in 2012 (Scott et al. 2024). Dead trees comprise 59% of pine volumes.

While timber harvest and lumber production are generally at historically low levels, average output per mill is at a record high. Prior to 1950, numerous small mills operated in California, producing on average 6.5 million board feet (MMBF) per mill annually. From 1970–1990, average lumber production per sawmill increased steadily from approximately 31 MMBF per mill in the 1970s to 69 MMBF per mill in the 1990s. Since 1990, average mill output has remained relatively stable, increasing slightly in 2021 to 77.2 MMBF per mill (Scott et al. 2024). In 2021, average mill production was approximately 2.5 times larger than the average mill in the 1950s when California lumber production peaked and many more mills were operating than today.

Increasing Pace and Scale of Restoration

Quantifying the Scope of Treatment Needs

The scope and extent of restorative treatments needed at the landscape scale, both in terms of acreage and treatment intensity, is significant and challenging. Estimates of up to 7.1 million acres of timberland in need of stand density reduction treatments (ⓘ1.2) are aligned with other efforts to quantify the state's fire hazard reduction needs. An analysis conducted by American Forests and CAL FIRE of all forested acres on less than 70% slopes at high and very high fire hazard totaled 11 million acres, about a third of all of California's forests (DeLyser et al. 2025). Approximately seven of the 11 million acres are considered more likely to be managed

based on a variety of criteria such as forest type, presence of critical wildlife habit, ownership, reserve status, etc. Approximately 70% of those acres are under federal land management.

While climate change is expected to negatively impact forests, increasing the pace and scale of restoration can reduce losses of forest area while also increasing timber production. Under a high global emissions scenario (RCP 8.5) in the American Forests/CAL FIRE study, California could lose up to 48% of its forest area and 50% of its forest carbon due to future wildfire regimes and potential post-fire regeneration failure by 2070. A portfolio of strategies that includes 1.4 million acres per year of post-fire salvage and reforestation, stand density and fuel reduction treatments, and other actions across forestlands can reduce carbon losses to just 12% (DeLyser et al. 2025). With the focus on ecological restoration, by completing initial thinning treatments on these acres within 10 years followed by prescribed fire for all maintenance treatments, timber harvest volumes could potentially double over a 10-year period, with 80% of the volume coming from federal lands. Removal of lower value, small diameter trees for which there are currently limited markets (Porter and Longcor 2020) would also increase.

New processing capacity would need to increase substantially, perhaps doubling both sawmill and bioenergy capacity to accommodate the increased removals associated with fire resilience and post-fire restoration treatments. For financial feasibility, new infrastructure will require a longer-term green timber supply than evaluated in this study. Where appropriate, consideration of follow-up thinning treatments on a regular cutting cycle intermixed with prescribed fire could help to address timber supply and costs. Restoration treatments are estimated to cost up to $2 billion annually in addition to business-as-usual activities, with wood product revenues offsetting 39–50% of costs under moderate pricing assumptions (DeLyser et al. 2025). A similar study indicated an annual cost of $1.8 billion for treatments across forests, shrublands, and grasslands (CARB 2022b).

A separate study for the California Energy Commission, focused on California mixed conifer, ponderosa pine, true fir, and Douglas-fir forest types, demonstrated a need to treat 400,000 acres per year for 40 years to reduce wildfire hazard, with the overall harvest volume similar to that of the high levels in the 1980s (Fried et al. 2016). As with the American Forests/CAL FIRE study, there is a substantial increase in the amount of low value, small diameter material removed from the landscape. In the CARB 2022 Scoping Plan, under a high global emissions scenario (RCP 8.5) future increases in disturbance could lead to a 7% reduction in forest carbon between 2014 and 2045 under business-as-usual management (CARB 2022b). Levels of vegetation management activities in the preferred scenario of 2.5 million acres of treatments per year across shrublands, grasslands, and forests of California would still yield an 8% reduction in forest and harvested wood product carbon, though losses are reduced in the near-term.

In addition to reducing fire hazard on the landscape, there is some level of treatment needed to maintain landscape resilience whether it is established through natural means, such as through low or moderate severity wildfire, or through active management. For example, for stands at lower RD SDI thresholds as in ⓘ1.2, stands at low or moderate fire hazard potential such as those identified by DeLyser et al. (2025), or stands that have received an initial treatment, management actions will be necessary to maintain such a state, as through prescribed fire or other actions (e.g., every 10–15 years) (North et al. 2021). While these may represent lower priorities because they may currently be in a more resilient state, they may also represent a landscape that is easier and less expensive to treat. Further, in cases where wildfire has already impacted much of the landscape and done the fuel reduction work already, it could be ecologically beneficial and lower cost to actively maintain that condition to prevent further degradation (see the box insert on beneficial fire in Chapter 4, Wildfire).

State and Federal Goals for Forest Treatments

In recognition of the need for treatment across vast areas of California's forests, initial collaborative state-federal

efforts set an annual treatment goal of 1 million acres by 2025 to achieve resilient forest conditions, including 500,000 acres of non-federal lands and 500,000 acres of NFS lands (State of California and USFS PSW 2020). The path to the achievement of this one-million-acre goal was further refined through the WFR Task Force's development of a comprehensive strategy titled the "Roadmap to a Million Acres" (WFR Task Force 2022b).

However, more ambitious state goals have been established more recently. Building in part on CARB's 2022 Scoping Plan, AB 1757 (Garcia and Rivas 2022) required CNRA, in coordination with other agencies, to develop NBS climate targets (CNRA 2024). Created with the guidance of an expert advisory committee, the targets address natural carbon sequestration and nature-based climate solutions that reduce GHG emissions and improve community and ecosystem health and resilience (such as through wildfire risk reduction) on all land types (including forests) and seagrasses.

The wildfire risk reduction targets address forests, shrublands, and grasslands collectively (an area of 71.3 million acres, or about 70% of the state), providing targets for beneficial fire and other fuel reduction activities totaling 2.5 million acres per year by 2045 (Table 1.2). Other targets focused on forests seek to address the current shift of forests from being a net carbon sink to a net carbon source, recognizing this shift results from a century of fire exclusion, historic harvesting that removed large, fire-resilient trees, and climate change impacts. Benchmarked to specific dates, the goals for other forest-specific actions total 735,300 acres in 2038, for example. AB 1757 directs CNRA to biennially publish, via its website, data on progress and expenditures made toward achieving the NBS climate goals, beginning January 2025 (Garcia and Rivas 2022).

Table 1.2. Selected nature-based solutions climate targets

Vegetation Class and Activity	Acres Treated Per Year by Benchmark Dates		
Forest, Shrublands and Chaparral, and Grasslands	**2030**	**2038**	**2045**
Beneficial Fire	800,000	1,200,000	1,500,000
Other Fuel Reduction Activities	700,000	800,000	1,000.000
Total Activity Acres per Year*	**1,500,000**	**2,000,000**	**2,500,000**
Forests			
Afforestation	52,900	52,900	52,900
Conservation	55,100	55,100	55,100
Restoration	322,100	462,100	322,100
Working Forest Conservation	165,200	165,200	165,200
Total Acres per Year	**595,300**	**735,300**	**595,300**

Data Notes:
**The term "Activity acres" assumes that a given acre may receive more than one type of treatment (e.g., mechanical fuels reduction and prescribed fire), so the number does not necessarily reflect the total effective area treated or "footprint acres."*

Data Source: CNRA (2024).

Identifying and Addressing Challenges to Increasing Pace and Scale of Treatments

A variety of challenges impede increasing the pace and scale of forest restoration in California, limit the economic feasibility and amount of wood that can be removed from the landscape in restoration treatments, and limit the state's ability to contribute more significantly to meeting its own demand for wood products. Some constraints include lack of investment in new wood product processing infrastructure (ⓘ1.4) for both traditional and emerging wood products, decline in the skilled forestry and forest product processing workforce, and regulatory and implementation hurdles, especially for new wood processing capacity (Heard and Franklin 2023, LHC 2018, Porter and Longcor 2020, Riddle 2023). Public sector barriers inhibit workforce recruitment and retention (e.g., low federal wages, hiring freezes), which are further exacerbated by uncertainty in funding (e.g., operating under continuing budget resolutions) (Heard and Franklin 2023, Riddle 2023). These uncertainties are very significant under the current federal administration through budget cuts, freezes, reduction-in-workforce efforts, and major structural reorganization of federal land management agencies. Additionally, important regulatory oversight and public participation processes such as environmental review at times have the unintended consequence of delaying critical forest health projects. Some projects on public lands face potential for community opposition and litigation (LHC 2018, Riddle 2023). Even with increases in federal and state funding in recent years,

funding remains an issue. In many instances, while costs from restoration treatments can be offset, either partially or fully, with timber product revenue, overall, treatment costs have been increasing in California.

An analysis of two CAL FIRE datasets illustrates the magnitude of these increases. The California Forest Improvement Program (CFIP) is a cost-sharing program between the state and private landowners. The inflation-adjusted reimbursable costs, referred to as the cap rates, for mechanical treatments increased from $371–$742/acre in fiscal year 2015–16 to $645–$1,290/acre in fiscal year 2023–24, an average real annual cost increase of 8–11% per year. An analysis of planned costs from recipients of California Forest Health grant awards shows similar trends. Average inflation-adjusted treatment costs, across all types of forest health activities, increased from $1,456/acre in fiscal year 2017–18 to $2,669/acre in fiscal year 2022–23, an average increase of 14% per year.

It will be difficult to reach the WFR Task Force's ambitious annual treatment goals to achieve resilient forest conditions given the shortfalls in workforce capacity and mill infrastructure (discussed below), current high levels of natural disturbance, physical (e.g., slopes, site access) and administrative limitations (e.g., wilderness designations) on mechanical operations, and the low value of the biomass to be removed to reduce stand densities. Identifying opportunities to manage wildfire from natural ignitions for resource benefit can contribute to the state's restoration goals (Kreider et al. 2024, North et al. 2024). Pyrosilviculture, which coordinates mechanical thinning, prescribed burning, and managed fire, can be a useful approach to increasing pace and scale (North et al. 2021, York et al. 2021). Leveraging the fuels reduction work achieved through low and moderate intensity wildfire by maintaining those conditions through follow up treatments, particularly prescribed fire, can also help meet larger-scale restoration goals (see Chapter 4, Wildfire).

State and Federal Leadership

Over the years, the state has made numerous efforts to address barriers that impede active management. The state Legislature and subsequent rulemaking by the BOF have expanded permissions to enable commercial harvesting activities primarily for fuels reduction that are exempted from THP preparation (e.g., Exemption Notices). Additionally, programmatic management plans and other harvest plan types have been provided by the state to reduce the regulatory burden on non-federal landowners interested in conducting restoration treatments using uneven-aged silviculture or other lower disturbance practices to reduce environmental impacts.

Created in 2021 by Governor Newsom, the WFR Task Force is the overarching collaborative effort to address barriers and coordinate the efforts of federal, state, local, public, private, and tribal entities (WFR Task Force 2022a). The 2021 WFR Task Force Action Plan lists 99 individual key action items (WFR Task Force 2021). Tracked by an on-line dashboard, as of early July 2025, 40 of the actions were completed, eight were in final stages, 37 were ongoing, and 14 were in progress (WFR Task Force 2025b). In March of 2025, the WFR Task Force released its 2025 Key Deliverables, which include California's top priorities and initiatives underway in 2025 to continue promoting wildfire and community resilience across the state (WFR Task Force 2025a); many of the priorities and initiatives have been highlighted in the draft 2026 update of the Action Plan (WFR Task Force 2026).

The WFR Task Force also has played a key role in advocating for increased funding to address a variety of barriers, and estimates that nearly $6 billion of state and federal funds have been invested for forest health and wildfire resilience projects and programs since 2021 (WFR Task Force 2025a). These funds are disseminated through a number of programs discussed in the "Landowner Assistance" section of this chapter. They also include direct funding to agencies such as California State Parks for project implementation, the State and Regional Water Boards to simplify regulatory requirements, the California Conservation Corps to enhance workforce development, tribes to support forest health on tribal lands and cultural use of fire, the University of California system to increase technical advisory

capacity, and technological investments such as statewide LiDAR and broadened remote sensing-based monitoring efforts. Regional investment strategies involving funding from multiple agencies were developed to finance large bundles of projects (scaling up), rather than support individual projects. Examples include the North Coast Resource Partnership, Healthy Eldorado Landscape Partnership (HELP), and the Southern California Partnership. Additionally, the WFR Task Force published four Regional Resource Kits to provide guidance and decision support tools to help regional and local entities plan, prioritize, and monitor vegetation treatments.



Prescribed fire in a mixed conifer forest at Blodgett Forest Research Station. Photo: CAL FIRE.

Great efforts and expenditures (mostly of public funds thus far) are being made to increase the pace and scale of restoration. In the past, treatment activity tracking has occurred separately among federal and various state land management agencies, with inconsistent publicly available data for activities on private lands (Knight et al. 2022b). This siloed approach makes it difficult to understand business-as-usual levels of activity and increases above this to evaluate progress towards the ambitious goals within the state to increase the pace and scale of forest restoration. The WFR Task Force has developed a Wildfire and Landscape Resilience Interagency Treatment Dashboard for displaying recently completed forest and wildland projects from over a dozen different federal and state agencies (WFR Task Force 2024a). An analysis of available Interagency Treatment Tracking System data on accomplishments in 2023 indicate activity acres[13] total 316,029 acres on non-federal forested lands and 272,834 acres on federal forested lands, for a total of 564,461 acres (WFR Task Force 2024c). Significantly, prescribed fire acres increased from 47,816 acres in 2022 to 149,429 acres in 2023 (combined federal, state, and other landowners). Though progress is being made, it is widely acknowledged that reaching the ambitious state and federal treatment goals will require a long on-ramp of planning and capacity building, including workforce development and broad collaboration. This build-up will require significant, ongoing public funding to be successful.

In recognition of an ongoing need to continue to address barriers to increase pace and scale, most recently in 2025, Governor Newsom declared a state of emergency due to catastrophic wildfire risks and directed the state to expedite critical fuels reduction projects by suspending various state statutes, rules, and regulations that might slow the implementation of such projects (Newsom 2025). Protection of air quality, water quality, tribal cultural resources, and wildlife species and their habitat is still required to be implemented through various protection measures outlined in the Statewide Fuels Reduction and Environmental Protection Plan (CNRA and CAL EPA 2025). By the end of January 2026, 116 projects have been approved with 26 completed and 102 underway for a total of 244 projects (Cal EPA et al. 2026).

At the federal level, in 2025 executive orders (U.S. President Trump 2025a, 2025b), followed by further directives from the Secretary of Agriculture and the USFS leadership (USDA 2025, USFS 2025a), emphasized the need to address catastrophic wildfire risks and increase domestic timber production immediately and as a matter of national security, while also seeking to

13 *Activity acres may occur on the same footprint acres and include beneficial fire, grazing, mechanical hazardous fuel reduction, uneven-aged management, tree planting related actions, and watershed improvement actions.*

relax environmental regulations and permitting processes, such as the National Environmental Policy Act (NEPA) and the Endangered Species Act. Specific direction from the USDA and the USFS indicates a goal of increasing timber production by 25% over the next five years and proclaims an emergency situation determination with regard to fire hazard. These goals are somewhat in contrast with other current federal efforts to reduce workforce and funding.

Though implementation details are yet to emerge at the federal level, additional direction from the USFS emphasizes leveraging partnerships with states, tribes, and industry. This includes using GNA agreements; developing long-term supply assurances such as by using 10+ year contracts and agreements; adopting new technologies to assist with project implementation; prioritizing post-disturbance salvage and reforestation; using programmatic agreements and emergency authorizations to expedite National Historic Preservation Act, Endangered Species Act, and Clean Water Act review; reducing survey and consultation burdens; and changing or eliminating restrictive policies and regulations (USFS 2025b). California's Environmental Protection Plan provides an example of how fast-tracking fuel reduction projects, reducing regulatory burden, and mitigation of adverse impacts can be approached. As stated earlier, a recent study indicates that by focusing on ecological restoration in California, timber harvest volumes can double over a 10-year period, with 80% of the volume coming from federal lands (DeLyser et al. 2025). Though these volumes exceed the 25% increase called for at the federal level over the next five years, a balance is needed between sustaining a longer-term timber supply beyond five or 10 years to support increased infrastructure, achieving restoration goals at a faster pace, and use of thinning or prescribed fire for maintenance treatments in the future.

Public Concerns about Expanded Treatments

As more acreage is treated and removals are increased, particularly through emergency means, public concern may increase. Consequently, special consideration should be given to the resulting stand structure, species composition, and seral stages on the landscape to protect the ecosystem services provided by forests and safely reintroduce beneficial fire (North 2012). With increased levels of treatments occurring with less regulatory oversight on both private and public lands come increased public concerns about the results; thus, it becomes more important to ensure transparency through open project reporting, monitoring, and assessment of outcomes, such as can be provided through on-line dashboards that provide both spatial and descriptive data (see Chapter 13, Institutional Response).

In many fire-adapted forests, spatial variability in stand structure, such as variation in individual trees, clumps of trees, and openings (ICO) throughout the landscape, was both facilitated by frequent fire and promoted the low-severity effects that were characteristic of the fire regime (Churchill et al. 2013, North et al. 2009, North 2012), with Indigenous burning playing a significant role in shaping and maintaining this landscape (Knight et al. 2022a). In some cases, it may be necessary to consider methods such as density reduction treatments and/or prescribed fire to establish, enhance, and maintain mature and old-growth forests, which can further increase public concern (e.g., see giant sequoia box insert in Chapter 4, Wildfire). Recent federal efforts to inventory and analyze threats in mature and old-growth forests can help guide policy to foster resilience (USFS 2023a, USFS and BLM 2024a, 2024b).

Wood Products Processing Capacity, Markets, and Workforce

Though studies indicate that by focusing on ecological restoration there can be an increase in timber volume and biomass (Baker et al. 2020, CARB 2022b, DeLyser et al. 2025), and ambitious targets and efforts are underway to fast-track projects to increase the pace and scale of restoration and timber production, lack of wood processing infrastructure, markets, and workforce remain limiting factors. The massive volumes of dead timber created following large-scale mortality events are also a challenge to existing milling infrastructure and can delay processing of green material. Despite recent increases in mill output, the general decline in the number of sawmills is of concern (see ⓘ1.4, above), particularly to nonindustrial owners left with limited or no

options to market their timber and public land managers looking to increase the pace and scale of restoration. Currently, in the Sierra Nevada, lack of wood processing infrastructure combined with relatively low value material limits the ability of landowners faced with extensive tree mortality and fire salvage to sell their timber and thereby secure funds for reforestation and other work to enhance forest resilience. Though emergency operations can help some landowners with economic recovery, in many cases economic impacts are negative. Many small nonindustrial timberland owners reported only breaking even or experiencing a financial cost to undertake salvage logging operations due to inadequate milling capacity and an inundated timber market following the historic fires of 2020 and 2021, as well as the expense of hiring licensed professionals (Olsen et al. 2019, Olsen et al. 2025). Emergency Notice harvesting on private lands, however, has been valuable to the timber industry, allowing the companies to recapture some value to fund reforestation work.

In addition to fire-killed trees, landowners need a viable method to remove small timber and harvest residues from the landscape in a financially feasible way. Though burning residual material on site is often the most economical and logistically feasible option that serves an ecosystem function, in some circumstances wood utilization can provide local jobs and alternative sources of energy and fuel, and can be performed in areas and at times that mitigate threats to local air quality. Where there is financial value to utilization, it can improve the likelihood that a project occurs, though there may be tradeoffs with the ecological benefits of utilizing fire to dispose of material. Given the high cost of hauling logs relative to their value at the mill gate, having a nearby mill is critical to the economic viability of timber harvest. In 2021, there was one less sawmill than in 2016, one less bark products facility, and five bioenergy facilities in the state that either closed or are not accepting forest biomass feedstocks (Scott et al. 2024). Export markets can be an alternative, as evidenced by California exporting approximately 9% of its harvest between 2010–2018 (Dillon and Morgan 2023). Expanding the capacity to produce both traditional wood products (e.g., lumber, panels, biomass electricity) and innovative wood products (e.g., mass timber, biochar, clean fuels) presents an opportunity to improve the economic viability of forest restoration treatments (Elias et al. 2023, Porter and Longcor 2020), while increasing carbon stored in harvested wood products or offsetting fossil fuels used for energy (Cabiyo et al. 2021).

There are many challenges to increasing capacity in both traditional and innovative wood product markets, such as improving project financing economics, securing long-term wood supply, increasing wood processing infrastructure, and addressing regulatory barriers (Porter and Longcor 2020, Redmore et al. 2021). The WFR Task Force is currently developing a strategy to leverage existing state programs, as well as developing new programs, to increase wood utilization capacity in both the near and long run (WFR Task Force 2024b). The state's plans to increase capacity by improving the economic landscape for developers include supplying low-cost bridge financing (iBank Climate Catalyst Fund), development grants (e.g., CAL FIRE's Wood Products and Bioenergy Business and Workforce Development grants), favorable tax treatment (California Competes Tax Credit), and subsidizing forest restoration treatment costs (e.g., CAL FIRE's Forest Health Grant program).

The California Joint Institute for Wood Products Innovation, initiated in 2020 by the BOF, and CAL FIRE's Wood Products and Bioenergy Program's Business and Workforce Development grants address a number of barriers related to wood processing infrastructure and existing and emerging technologies to diversify wood products and markets. The Joint Institute seeks to provide forest product information, research, and analysis to increase economic drivers for healthy forests. CAL FIRE's grants provide funding for business development and operations, including solid wood and biomass processing, manufacturing facilities, expanding biopower generation and biofuels, and other projects that increase workforce capacity in the fields of logging, fuels treatment, transportation, manufacturing, or other support services that bolster the development of a resilient forest sector workforce (CAL FIRE 2024a).

Since 2022, the program has awarded $105 million to 90 grantees (J. McCarthy, personal communication, March 27, 2024). Bioenergy represents another area of expansion potential (discussed in detail in Chapter 12, Renewable Energy). Though there is an ongoing decline in the number of biomass plants in California (ⓘ12.2), at least five small biomass plants are in various stages of development because of SB 1122 (2012), known as the Bioenergy Market Adjusting Tariff (BioMAT) (Rubio 2012). Additionally, the state offers several bioenergy grants, including one to create carbon-negative fuels from materials resulting from forest vegetation management in the Sierra Nevada (State of California 2024). The USFS has also made substantial grants available to support wood products in California through its Forest Wood Innovations, Community Wood, and Wood Product Infrastructure Assistance programs. The grants are meant to incentivize innovation, build new markets for wood products and renewable wood energy from sustainably sourced wood, and increase the capacity of wood processing facilities. Taken together, the 2023 and 2024 funding cycles supported a total of 55 projects totaling $27 million (USFS 2025c).

Increasing pace and scale of forest restoration is also hampered by the current challenges California's forest sector workforce faces. One study projects the workforce to decline 10.7% by 2028, with smaller declines among logging equipment operators and woodworking machine setters, operators, and tenders (NSPDC 2021). About 58% of forest sector representatives surveyed cited lack of qualified workforce as a primary challenge to expanding and/or staying in business. The study states that the workforce is the smallest it has ever been and the need for qualified personnel is growing faster than the available talent pool, with a current inability to fill critical positions. Lack of available housing near forest sector businesses, high cost of living, negative perceptions of the industry among young people, lack of on-the-job training, and a disproportionately large amount of current personnel reaching retirement age all contribute to this small and declining pool of candidates. Low and stagnant federal wages, mental health crises among our first responders, professional forestry licensing requirements, and barriers to workforce entry for formerly incarcerated firefighters are other challenges that have been identified (Heard and Franklin 2023). Meanwhile, The Nature Conservancy has estimated that the workforce will need to grow by 9,400 jobs for California to meet its restoration goals (Heard and Franklin 2023).

The Governor's WFR Task Force Workforce Development Work Group is developing and promoting training and vocational programs and other efforts to expand the forest sector workforce. A new Forestry Corps branch of the California Conservation Corps (CCC) has been established. The California Reforestation Pipeline Partnership is also establishing the California Cone Corps to recruit and develop the technical skills needed in the workforce to collect seeds, grow nursery stock, plant seedlings, and conduct research (WFR Task Force 2024d). CAL FIRE's Business and Workforce Development grants discussed above are also aimed at developing workforce capacity for in-woods, transportation, and manufacturing jobs (J. McCarthy, personal communication, March 27, 2024). One such grant funds an effort led by the California Forestry Association called the "California Forestry Sector Jobs Initiative" to increase workforce diversity, ensure equitable opportunities, and address the urgent need for proactive forest management through training, outreach and recruitment, community engagement, and promoting resilient forests (CalForests 2024). This grant program also has funded the development of new forestry degree programs, such as the Lake Tahoe Community College Forestry Education and Job Placement Program. The Tahoe Fund provided full scholarships to all forestry students in the inaugural year, with the intention of keeping it going as long as possible (Tahoe Fund 2024). In an integrated fashion, the local CCC crews were enrolled in the program to increase exposure and interest in forestry and provide a meaningful educational experience to the crews. In part through a $3.3 million grant received from the Foundation for California Community Colleges in 2022, Redding-based Shasta College has expanded its forestry and fire-safety training and related student support programs.

Continued investment in workforce development programs; addressing barriers such as housing shortages, wage disparities, and lack of mental health resources; and expanding programs available to disadvantaged communities, inmates, and formerly incarcerated individuals is needed to build up the workforce needed to carry out the forest health and restoration projects at the pace and scale needed within the state. Additionally, the H-1B visa allows migrant workers into the country to fill critical roles in forestry, from reforestation to logging activities. This visa program has experienced inconsistencies through the years and recent significant changes. Improving and expanding the H-1B work visa program is important for providing labor for the workforce (G. Gentry, personal communication, August 30, 2023).



Cone collection on Boggs Mountain Demonstration State Forest, August 2023. Photo: CAL FIRE.

Scientific Knowledge Gaps

Chapter 13 (Institutional Response) documents a significant increase in the publication of peer-reviewed scientific research on forest and wildfire management in California. Yet, there remain many knowledge gaps in wildfire and forest health and resilience. Investment in research helps provide information on forest condition and increases understanding of the effectiveness of management actions. CAL FIRE's Forest Health Research Program (FHRP) began in 2018 and as of August 2025, 116 projects have been awarded funding for a total of $48.6 million. These projects broadly support research on the following overarching themes:

- Disturbance, recovery, and strategies for various types of landowners to increase forest resilience in an altered future climate.
- Implementation, effectiveness, impacts, and tradeoffs of current and alternative management strategies to achieve diverse land management goals.
- Contemporary range of variation and trends in fire regimes, forest conditions, and distributions in California ecosystems.
- Forest products and utilization of forest residues related to fuel reduction and forest health treatments.
- Human dimensions, socio-economic considerations, and environmental justice issues related to forest health and wildfire management.
- Improved prediction of wildland fire spread, behavior, severity, patch size, and potential impacts.

Collaborative Projects

Recognizing that ecosystems do not acknowledge ownership boundaries, effective management requires collaboration across all lands. Collaborative projects for forest resilience take many different forms in California. There are numerous examples of collaborative landscape-level projects designed to improve forest health, reduce fire threat, provide policy and process improvements, increase wood/biomass utilization infrastructure, contribute to local economic development, and provide financial mechanisms for project

implementation. Successful collaboratives build trust, have a science-based approach, provide a mechanism outside of litigation to address conflicting stakeholder concerns, and facilitate work across multiple ownerships (LHC 2018). There are programs that support these collaborative efforts at the federal (e.g., Joint Chiefs' Landscape Restoration Partnership, National Cohesive Wildland Fire Management Strategy, Collaborative Forest Landscape Restoration Program, Wildfire Crisis Strategy) and state levels (e.g., CAL FIRE Forest Health Initiative/Greenhouse Gas Reduction Fund grant program, Sierra Nevada Conservancy Watershed Improvement Program, California Department of Conservation [DOC] Regional Forest and Fire Capacity Program). They are also supported by collaborative agreements such as the Fire MOU Partnership (USFS 2021), which is intended to increase the use of fire to meet ecological and other management objectives.

The use of GNA Agreements and federal stewardship contracts with collaborators such as state agencies can facilitate the work in collaboratives by allowing partners to assist or take the lead on management of NFS lands. Work can include timber harvesting, fuel reduction, timber stand improvement, fuel break construction, and many other restoration actions through manual, mechanical, herbivory, herbicide, and prescribed fire application. The USFS and CNRA signed a 10-year master GNA agreement in 2016. Three of four CAL FIRE supplemental project agreements (SPA) are still active. Approximately 2,500 acres of forest health treatments have been accomplished on NFS lands. Under the active SPAs, work is planned to continue until the sunset of each agreement. Additionally, several projects led by CAL FIRE are set to occur on BLM lands under the 2023 GNA statewide agreement. Another 10-year agreement was recently signed between CAL FIRE and the Klamath National Forest, with other standalone agreements in development (J. Fitch, personal communication, October 23, 2024). Through the use of federal stewardship contracts, local timber supplies can be increased, employment opportunities are created, and revenues are produced by the sale of the timber. These revenues in turn, are retained at the local Forest level rather than sent to the Treasury and are used to fund restoration and management projects. There are dozens of stewardship contract projects in California providing opportunities to local communities (USFS 2024a). In some cases, stewardship contracts serve the purpose of creating relationships to involve local communities in the co-management of federal lands. For example, the Weaverville Community Forest (Trinity County RCD 2021) consists of USFS and BLM lands being managed by the local community to reduce fuel loads and generate timber for supplying the local mill.

The following are examples of collaborative efforts recently underway that fall under programs, leverage agreements, and contracting mechanisms mentioned above.

South Fork American River (SOFAR) Cohesive Strategy Project

The South Fork American River watershed was proposed for implementing the National Cohesive Wildland Fire Management Strategy because of the many values at risk threatened by complex fire issues associated with drought, climate change, fuel loading, insects, and disease (South Fork American River Cohesive Strategy 2024).

A major component of SOFAR is the Fire Adapted 50 Project. Under the terms of the GNA Agreement between CNRA and the USFS, the Eldorado National



Sly Park fuel hazard reduction treatment area near Jenkinson Lake. Photo: CAL FIRE.

Forest (ENF) has helped CAL FIRE and the Sierra Nevada Conservancy (SNC) to fund fuels treatments in the Highway 50 (U.S. 50) corridor between Camino-Pollock Pines and Echo Summit. This project complements major fuel treatments funded by CAL FIRE in the Sly Park area beginning in 2017.

Dinkey Collaborative

The Dinkey Collaborative is a diverse group of stakeholders and California Native American tribes working with the USFS and other public agencies to implement the federal Collaborative Forest Landscape Restoration Project (CFLRP), covering 154,000 acres, including 24,000 acres of private lands, in the Sierra National Forest. Restoration goals were accomplished through the GNA, grants, and agreements. Thinning and prescribed fire activities are complete, making the project a valuable model for successful shared stewardship.

Caples Creek Watershed Ecological Restoration Project (Caples Project)

The Caples Project was funded by the SNC and completed by the ENF to protect the Caples Creek watershed and surrounding communities. It was proposed in 2015 and took place over four years. Two years before the 2021 Caldor Fire, fuels in the Caples Creek watershed were reduced through a mix of prescribed fire (425 acres) and mixed severity wildfire (3,435 acres in the 2019 Caples Fire).

Evidence of the Value of Collaborative Forest Resilience Project Efforts

Several recent large damaging wildfires have provided evidence that fuels treatments implemented as part of collaborative projects have been successful in protecting communities. Examples include:

2021 Caldor Fire

The Fire Adapted 50 Project work was tested during the 2021 Caldor Fire, which burned over 221,000 acres from Grizzly Flats all the way into the Lake Tahoe Basin. The fire initially burned toward the Highway 50 corridor, threatening a huge number of lives and structures. The goals of the project work in the Sly Park area included creating a fuel break to moderate fire behavior. This fuel break provided a safe and effective starting point for firefighters, which was important for protecting Pollock Pines and Sly Park during the fire (SNC 2021). Additionally, the treatment units performed well when subjected to USFS and CAL FIRE backfiring for controlling the fire; none of the units experienced the full force of the Caldor Fire. Similarly, fuel treatments conducted by 21 partner agencies of the Lake Tahoe Basin's Fire and Fuels Team (TFFT) allowed homes to be saved and firefighters to work aggressively in the Christmas Valley area. Fire intensity greatly diminished, with flame lengths dropping from 100–150 feet in untreated areas to 20 feet in fuel treatment areas (Avitt 2021). Additionally, prior low severity wildfire and treatments had a clear beneficial impact on Caldor fire severity in the Caples Creek Ecological Restoration Project area.

2020 Creek Fire

Large scale fuels reduction treatments implemented by the USFS and CAL FIRE took place for many years in the Blue Canyon area south of Shaver Lake prior to the 2020 Creek Fire, which burned approximately 380,000 acres in the southern Sierra Nevada Mountains. The treatments reduced the severity of the fire in the Blue Canyon area, protecting homes and defending the backside of Shaver Lake and Pine Ridge. A fuel break studied near Shaver Lake was found to alter fire behavior and reduce fire intensity, and it proved to be effective at reducing fire burn severity (Baijnath-Rodino et al. 2023). In addition, much of the Dinkey Collaborative Forest Landscape Restoration Project area did not burn at high severity during the 2020 Creek Fire (approximately 15,000 acres did experience severe fire effects). More recently, the severity of the 2025 Garnet Fire was significantly reduced in areas where fuel treatments occurred within the Dinkey Collaborative (CAL FIRE 2026).

Landowner Assistance

Increasing active management on nonindustrial timberland is dependent on factors such as public education on the need for proactive work to achieve forest health and resilience to disturbance, engaging absentee landowners, regulatory costs, availability of technical and financial assistance, ability to market timber based

on access to wood processing infrastructure, and prescribed fire liability insurance. Efforts within the state have been made to streamline regulatory processes to make it more possible for landowners to conduct forest treatments, such as through Emergency and Exemption Notices, NTMPs, the CalVTP, and the 2025 state emergency declaration directing the state to expedite critical fuels reduction projects through the accompanying Environmental Protection Plan process. Voluntary options such as NTMPs that reduce long-term regulatory costs while enhancing environmental protection have had limited success, with about 11% of nonindustrial timberlands enrolled (see ⓘ1.5, above). For landowners with less than 10,000 acres, there is the option to use a WFMP, although there is only one at this point. The Timber Regulation and Forest Restoration Program, established by AB 1492 (Blumenfield et al. 2012), aims to benefit nonindustrial owners through streamlined harvest plan processing via the CalTREES online permit application system and funding for forest restoration projects.

With only 11% of nonindustrial timberlands currently under NTMPs, it is important to consider what mechanisms are in place to assist small nonindustrial landowners given existing barriers to active management (e.g., reduced milling infrastructure). Collaborative projects can help smaller landowners by leveraging a variety of funding sources and reaching across ownership boundaries to accomplish management objectives. Historically, the primary sources of financial and technical assistance to landowners were the Natural Resources Conservation Service (NRCS), through its Environmental Quality Incentives Program (EQIP) and Healthy Forests Reserve Program (HFRP), and CAL FIRE through CFIP. CFIP is intended for landowners whose parcels are between 20 and 5,000 acres and supports activities such as forest management planning, reforestation and restoration activities, fuel hazard reduction, forest thinning, and fish and wildlife habitat improvement. When funds are available, the Timber Regulation and Forest Restoration Program can provide support to programs including CFIP.

CAL FIRE administers the California Forest Legacy Program (FLP) (in partnership with the national program administered by the USFS), which aims to secure the protection of working forests through conservation easements and fee title acquisition. California competes annually for congressionally appropriated funds with other states. As of May 2024, over 168,000 acres of forestland have been permanently conserved, utilizing over $30 million federal dollars and an undetermined amount of state and private funds, representing a 51% increase in conservation easements since the 2017 Assessment. Currently, the FLP is working on 12 projects which will conserve an additional 60,000 acres of forestland following completion of the projects (P. Leuzinger, personal communication, May 24, 2024). The portion of the program in California administered by the USFS Pacific Southwest Region (Region 5) State, Private, and Tribal Forestry (SPTF) branch has provided an additional $122.5 million federal dollars and 118,486 acres of forestland conservation easements (D. Walsh, personal communication, March 27, 2024).

Several new disaster funding sources are also now available. In September 2021, Congress passed Public Law 117–43 (Extending Government Funding and Delivering Emergency Assistance Act), which included supplemental disaster relief funding for California. These funds are also administered by USFS SPTF for (1) the post-disturbance recovery of private lands, and (2) for CAL FIRE to further accomplish actions identified in the 2021 WFR Task Force Action Plan, including increasing technical assistance, improving outreach, supporting forest health and maintenance treatments, establishing emergency forest restoration teams, and providing seedlings for reforestation. As of March 2024, $43.8 million dollars for restoration actions on nonindustrial private forestlands and $32 million dollars on industrial forestlands have been granted to CAL FIRE and partner organizations to develop recovery assistance programs, and to directly implement restoration actions on more than 20,000 acres of private forestlands in the state that experienced disasters between 2019–2022. This funding includes establishment and support of several Emergency Forest Restoration Teams; development of a Reforestation Pipeline Partnership between

CAL FIRE, USFS, and American Forests; and education programs developed by the University of California Cooperative Extension (UCCE) (P. Leuzinger, personal communication, July 15, 2025) (D. Walsh, personal communication, March 27, 2024). The USDA also has the Emergency Forest Restoration Program (EFRP), which provides up to 75% of the cost to implement restoration practices, with a cap of $500,000 for nonindustrial private landowners to restore their forested lands after natural disasters such as wildfire or insect and disease outbreaks (USDA FSA 2025).

Several existing and new CAL FIRE grant programs have been bolstered since the 2017 Assessment. The Wildfire Resilience Block Grants program was initiated in 2020 to provide financial and technical assistance to nonindustrial landowners with parcels of five acres of more, complementing the CFIP program. Between 2020 and 2024, 17 block grants have been awarded totaling over $37 million dollars. The deliverables from these grant awards are estimated at putting 15,837 acres under management and assisting 2,688 private nonindustrial landowners (P. Leuzinger, personal communication, July 15, 2025). The Forest Health Program has funded landscape-scale, regionally-based projects in fuels reduction, prescribed fire, and reforestation to improve forest health and provide measurable GHG emission reduction benefits. Between 2017 and 2023, approximately $520 million dollars have funded projects covering over more than 410,000 unique acres. These projects are anticipated to store nearly 14 million tons of carbon dioxide equivalent (CO_2e) over their lifetimes (M. Sintetos, personal communication, March 27, 2024). The Tribal Wildfire Resilience Program provides California Native American tribes with resources to implement and promote TEK, cultural use of fire, workforce development and training, and environmental planning and permitting. Between 2020 and 2024, $24 million dollars were allocated to fund 16 projects (J. Inzunza, personal communication, July 17, 2025). Additionally, Wildfire Prevention grants fund projects in and near fire threatened communities to improve public health and safety. From 2014 through June 2024, 956 grants have been awarded for a total of $650 million (N. Burke, personal communication, September 8, 2025).

Leveraging the WFR Task Force funding, the DOC's Regional Forest and Fire Capacity (RFFC) Program has provided funding focused on building fire resilient communities by improving ecosystem health, community wildfire preparedness, and fire resilience. In 2023, $72 million was awarded, bringing the program's total investments to $140 million (CA DOC 2023).

Technical assistance and education are also important tools to assist landowners. The UCCE, California Society of American Foresters (CAL SAF), California Licensed Foresters Association (CLFA), Resource Conservation Districts (RCDs), the CAL FIRE Forest Stewardship Program, and other organizations offer technical assistance and educational workshops, trainings, and webinars to resource management professionals and landowners. The number of workshops geared towards nonindustrial landowners affected by wildfires and bark beetle epidemics has increased considerably in the past five years, in part due to increased WFR Task Force funding that has allowed the UCCE program to add 11 additional Wildfire Science Advisors throughout the state.

OPPORTUNITIES

Emphasize a Variety of Approaches to Resilience Treatments that Restore Ecological Processes and Function under a Changing Climate

- Increase use of thinning and prescribed burning to reduce wildfire risk, restore forest health, and restore ecological processes such as beneficial fire in fire-adapted forests.
- Use indicators in this assessment (e.g., ⓘ1.1 and ⓘ1.2) and other analyses (DeLyser et al. 2025) to inform the development of science-based forest management policies and targets, such as the CNRA's NBS natural and working lands targets (CNRA 2024).

- Implement treatments that establish variety in stand density and structure, duly considering forest type (e.g., coast redwood versus Sierra mixed conifer forests) and landscape characteristics such as slope, aspect, and topographical position (e.g., ridgetops vs. valley bottoms) to create a heterogenous landscape that can support beneficial fire while still providing other important ecosystem services such as wildlife habitat (Ng et al. 2020, North 2012). In many fire-adapted forests, spatial variability in stand structure, such as variation in individual trees, clumps of trees, and openings (ICO) throughout the landscape, was both facilitated by frequent fire and promoted the low-severity effects that were characteristic of the pre-European fire regime (Churchill et al. 2013, North et al. 2009, North 2012).

- Treatments should consider resulting tree species composition—targeting advantageous species adaptations can allow forests and their overall function to persist on the landscape (Nagel et al. 2017).

- Use adaptive management aimed at a mixture of goals including resistance, resilience, and facilitating transition in response to change because while historic and contemporary reference conditions are valuable to understand what resilient forest conditions have been, climate change is shifting the targets as to what might be resilient in the future (North 2012, North et al. 2022).

- Continue investment in research to address knowledge gaps in managing forests for resilience in a changing climate, such as through CAL FIRE's FHRP grants.

Support Increased use of Pyrosilviculture, including Managed Wildfire, on Public Lands When and Where Appropriate

- Utilize pyrosilviculture, which coordinates mechanical thinning, prescribed burning, and managed fire, to help increase the pace and scale of fuels reduction treatments (North et al. 2021, York et al. 2021).

- Identify opportunities to manage wildfire from natural ignitions for resource benefit, which can contribute to the state's restoration goals (Kreider et al. 2024, North et al. 2024).

- Leverage the fuels reduction work achieved through low and moderate intensity wildfire by maintaining those conditions through follow up treatments, particularly prescribed fire, to help meet larger-scale restoration goals (see Chapter 4, Wildfire).

Support Climate-Smart Reforestation

- Support a massive reforestation effort that is urgently needed to restore forests in some post-fire landscapes and reduce current and projected forest area and carbon losses in the future (DeLyser et al. 2025, WFR Task Force 2024d). Reforestation to avoid vegetation type conversion is critical and dependent on timely and successful implementation of the various reforestation strategies, as well as continued investments in managing plantations for resilience to future disturbance.

- Address specific elements of the reforestation process, known as the "reforestation pipeline," including seed collection, project planning, nursery production, site preparation, planting, vegetation management, and monitoring (WFR Task Force 2024d), such as through the California Reforestation Pipeline Partnership (see Post-fire Restoration box insert for details).

    - Continue investments being made to expand capacity for seed collection and nursery production (WFR Task Force 2024d).

    - Consider efforts to replace older seedlots in storage at the USFS Placerville Nursery and CAL FIRE L.A. Moran Reforestation Center. Given current limitations in reforestation capacity, prioritize planting locations that are most in need and have the best potential for successful survival, and re-evaluate and adapt planting activities to enhance seedling

survival and future proliferation in a changing climate.

- Utilize adaptive reforestation practices to assure successful regeneration, including adjusting seed zones, utilizing seed orchards that contain broadly adapted selections, and placing greater emphasis on genotype selection for drought avoidance and tolerance traits.

    - Reforestation based on historically established seed zones may not be successful under a changing climate for some species (Thorne et al. 2016). Several tools exist to support planning, prioritization, and seed zone selection decisions (e.g., PostCRPT, PReSET, SST, CAST).

- Fund research to better understand post-fire natural regeneration success and failure for better calibration of reforestation decision-support tools.

- Use adequate BMPs to minimize impacts on forest soils and water quality from salvage operations, which are needed to reduce future reburn potential, prepare the landscape for safely conducting reforestation activities, and improve seedling survival.

- Employ variable planting densities for post-fire reforestation that accounts for site topographic configurations and seeks to establish a forest structure of individual trees, clumps, and openings (ICO) (Meyer et al. 2021, North et al. 2019). Variety in stand structure is a key component for restoring ecological processes and function of forests.

- Conduct follow-up treatments (e.g., prescribed fire or thinning) and survival monitoring to enhance the success of reforestation efforts and adaptive management.

- Maintain conditions to promote resistance of remaining live tree islands within large fire areas to help preserve natural seed sources.



Post-fire reforestation AMEX study, Mountain Home Demonstration State Forest. Photo: CAL FIRE.

- Support research for experimental planting areas to test new approaches for increasing the use of climate-smart reforestation approaches (e.g., AMEX 2024). Given the limitations of tree improvement programs and common garden studies, experiments that test the ability of trees to resist multiple stressors including drought, temperature, insects, and pathogens are critically important.

Maintain the Current High Level of Public Grant Funding for Collaborative Landscape-Level Forest Health, Resilience, and Fire Prevention Activities and Research to Improve Social-Ecological Resilience

Successful collaboration involving state and federal agencies, tribes, local communities, NGOs, and other stakeholders is critical to advancing forest resilience at scale. The primary constraints on collaborative projects are funding and capacity.

- Continue state funding to support wildfire and forest heath and resilience, such as from Cap-and-Trade Program-generated California Climate Investment funds, the California voter-approved 2024 Proposition 4 “Climate Bond” (which provided $1.5 billion in additional funding), and other appropriated dollars.

- Continue funding support for collaborative efforts by federal agencies. Though funding has

historically been strong, such as through the 2021 Bipartisan Infrastructure Law (U.S. Congress 2021) and the 2022 Inflation Reduction Act (USDA 2024a, 2024b), there is major uncertainty about currently allocated and future federal funding under the current federal administration (see Chapter 13, Institutional Response, for further discussion).

- Ensure the state and federal workforce and organization is sufficient to support increasing the pace and scale of restoration, participating in collaborative efforts, and effectively administering grant programs.

Continue to Explore, Implement, and Support Ways to Increase Active Sustainable Management on Nonindustrial Timberlands

- Continue to expand and explore efforts to streamline regulatory requirements and permitting and to reduce costs. For example, use of NTMPs could be expanded to more of the privately owned forested landbase, since the uneven-aged management and ecosystem services emphasis required in NTMPs can improve forest resilience.

- Expand technical and/or financial assistance programs like CAL FIRE's CFIP, NRCS's EQIP, the USFS Disaster Recovery Program, and the USDA EFRP to support fire resilience treatments and reforestation operations after widespread tree mortality and wildfires on nonindustrial lands.

- Increase availability of appropriate reforestation seedlings for small landowners, such as through efforts of the multi-agency Reforestation Pipeline Partnership.

Continue to Support Ways to Maintain Active Sustainable Management on Industrial Timberlands

- Continue to ensure the California FPRs are sufficient to confirm sustained yield is occurring and ecosystems are protected. Efforts to support continued sustainable management on these lands will help maintain the value of timber and preserve these lands as forestland.

- Continue support for the use of sustainability initiatives, such as carbon offset projects and forest certification.

- Address various barriers to increase the pace and scale of forest restoration, such as increasing workforce capacity and mill infrastructure, which will support active management on these lands in general.

- Establish working forest conservation easements on industrial forestlands such as through state and federal forest legacy programs, protecting them from development, establishing high standards for protecting ecological resources, and providing the landowner with significant immediate economic benefits and tax credits.

- Employ relevant opportunities identified throughout this section that address forest resilience, as working forests face many of the same threats as other forests, such as increased drought, wildfire, and insect and disease outbreaks.

Promote More Active Sustainable Management of National Forests to Improve Forest Health, Reduce Wildfire Threat, Support Local Economies, and Facilitate Post-Disturbance Restoration

- Ensure the USFS has adequate staffing, funding, and organization to conduct sustainable active management.[14]

14 *It is a matter of significant concern that at the time of completion of this Assessment, the USFS is experiencing major uncertainty in both funding and staffing levels through budget cuts, reduction-in-workforce efforts, and major organizational restructuring. It is unclear how the needed increases in pace and scale will occur on these lands amid these current challenges.*

  - It is critical for the USFS to increase active management of NFS lands, given the federal acreage potentially in need of stand density reduction treatments, the reforestation backlog, the overall goal of treating 500,000 acres per year on federal lands, projections of disturbance impacts on federal lands in the next 50 years (DeLyser et al. 2025), and the majority of federal forestlands in California being in the NFS.

- Support federal efforts to achieve sustainable timber harvest targets for individual National Forests that also contribute to forest health and resilience.

- Supplement federal funding and resources through state, private, and non-profit resources (e.g., CAL FIRE Forest Health grants).

  - This is particularly important when the main objective is not commercial timber harvest but rather ecological restoration to improve forest health and restore natural fire regimes, which can still require removal of merchantable trees that can partially or fully offset costs and support expansion of mill infrastructure.

- Continue federal collaboration and support to increase active management through efforts and programs such as the Joint Chiefs' Landscape Restoration Partnership, National Cohesive Wildland Fire Management Strategy, Collaborative Forest Landscape Restoration Program, Wildfire Crisis Strategy, and participation in the WFR Task Force.

  - Direction within the agency continues to emphasize coordination and collaboration with state and tribal partners through the use of creative authorities and contracting mechanisms such as the GNA and stewardship contracts. State and local agencies and other stakeholders involved in numerous collaborative projects with the USFS should continue and increase the use of these mechanisms to facilitate forest resilience work on federal lands (USDA 2025, USFS 2025a).

- Maintain previously allocated federal funding tied to several ongoing efforts, such as previous allocations of billions of dollars through the REPLANT Act in the 2021 Bipartisan Infrastructure Law (U.S. Congress 2021) and the 2022 Inflation Reduction Act (USDA 2024a, 2024b).

Restore and Develop Opportunities for Indigenous Land Stewardship and Relationships with Indigenous Peoples of California

- Increase recognition of the importance of revitalizing cultural practices, including promoting cultural burning, engaging tribes, and using TEK in developing management guidelines.

- Integrate TEK and cultural burning into land stewardship actions, such as through the WFR Task Force Strategic Plan for Expanding the Use of Beneficial Fire (Blumenfeld et al. 2022).

- Support Indigenous-led efforts, such as the Indigenous Stewardship Network.

- Acknowledge the decades of wrong-doings towards Indigenous peoples that must be repaired and work to build relationships and trust in collaborative land management efforts.

  - Tribal publications (e.g., Marks-Block and Tripp 2021, Tribal Adaptation Menu Team 2019) can provide guidance on how to build relationships and trust and address barriers to Indigenous land stewardship.

- Continue to provide financial resources, such as through CAL FIRE's Tribal Wildfire Resilience Grants Program, to enable the collaborations needed to increase opportunities for Indigenous stewardship. These efforts are discussed further in Chapter 4 (Wildfire).

- Continue commitment at the federal level to the USFS Region 5 Tribal Relations Strategic Plan (USFS 2023e).

Increase Transparent Monitoring and Assessment to Track Trends in Forest Health and Disturbance Regimes and to Evaluate Management Outcomes and Progress Towards Statewide Goals

Frequent monitoring is needed to track trends in forest health and disturbance regimes and to evaluate management outcomes and progress towards statewide goals, given the rapid changes California's forests are experiencing from natural disturbance and the ambitious restoration targets.

- Continue coordinated interagency tracking of treatment activity through the WFR Task Force Wildfire and Landscape Resilience Interagency Treatment Dashboard to better evaluate progress towards the ambitious goals within the state to increase the pace and scale of forest restoration.
- Continue support for the USFS FIA program, which provides detailed information on the health and condition of public and private forests and the drivers of change.
    - Maintain federal funding and staffing to fully implement the FIA program at the USFS.
    - Maintain funding for CAL FIRE efforts that began in 2021 to increase the frequency of the FIA field plot remeasurements from every 10 to every five years (FIA intensification), which improves the state's ability to evaluate rapid changes to the health and condition of California's forests.
- Continue support for acquisition and processing of remotely sensed data, such as CNRA's investment in new statewide LiDAR and change detection and assessment technologies (NASA 2025).
    - Remote sensing-based methods of monitoring forest conditions can provide important information and sometimes at more frequent intervals than the FIA program. These methods include utilizing high-resolution remotely sensed imagery, such as National Agriculture Imagery Program (NAIP), Sentinel-2, and LiDAR, to track forest health conditions such as climatic water deficit, vegetation changes and disturbances, canopy structure, and management outcomes. Remotely sensed data are often enhanced in conjunction with ground-based FIA data.

Expand Capacity to Produce Traditional and Innovative Wood Products

- Increase capacity to utilize sub-merchantable biomass and small logs, since the restoration treatments envisioned by the state produce these low value products in greater proportion to valuable large sawlogs.
- Expand the capacity to produce both traditional wood products (e.g., lumber, panels, biomass electricity) and innovative wood products (e.g., mass timber, biochar, clean fuels), which presents an opportunity to improve the economic viability of forest restoration treatments (Elias et al. 2023, Porter and Longcor 2020) while increasing carbon stored in harvested wood products (Cabiyo et al. 2021, DeLyser et al. 2025).
- Continue efforts to address barriers related to existing and emerging technologies to diversify wood products and markets, such as through the BOF's Joint Institute for Wood Products Innovation and the WFR Task Force.
- Continue efforts to increase capacity in both the near and long-term, such as the development of a strategy by the WFR Task Force to leverage existing state programs and develop new programs (WFR Task Force 2024b).
- Provide sustainable, long-term wood supply to encourage expansion of new and existing wood processing infrastructure. Recent USFS direction emphasizes the use of 10+ year contracts and

agreements to develop long-term supply assurances (USFS 2025b).

- Continue state efforts to improve the economic landscape for wood product developers by supplying low-cost bridge financing (iBank Climate Catalyst Fund), development grants (e.g., CAL FIRE's Wood Products and Bioenergy Business and Workforce Development grants), and favorable tax treatment (California Competes Tax Credit), and by subsidizing forest restoration treatment costs (e.g., CAL FIRE's Forest Health Program).

Support Development of the Professional, Semi-Skilled, and Labor Workforce Needed for Forest Resilience Work and Wood Products Manufacturing

- Continue WFR Task Force Workforce Development Work Group efforts to develop and promote training and vocational programs and other efforts to expand the forest sector workforce, including the new Forestry Corps branch of the CCC.
- Continue the California Reforestation Pipeline Partnership establishment of the California Cone Corps to recruit and develop the technical skills needed in the workforce to collect seeds, grow nursery stock, plant seedlings, and conduct research (WFR Task Force 2024d).
- Continue CAL FIRE's Business and Workforce Development grants to develop workforce capacity for in-woods, transportation, and manufacturing jobs (J. McCarthy, personal communication, March 27, 2024), such as:
    - Efforts led by partners such as the California Forestry Association called the "California Forestry Sector Jobs Initiative" (CalForests 2024).
    - Development of new forestry degree programs, such as the Lake Tahoe Community College Forestry Education and Job Placement Program.
- Develop ways to address other workforce barriers such as housing shortages, wage disparities, and lack of mental health resources, as well as expanding programs available to disadvantaged communities, inmates, and formerly incarcerated individuals.
- Provide consistent and clear legal pathways for migrant workers that fill critical roles in forestry from reforestation to logging activities, such as the H-1B visa to allow migrant workers into the country.

REFERENCES

Allen; Becker; Garcia; Gonzalez; Limón; Portantino; Stern; Wilson. 2024. SB 867: An act to add Division 50 (commencing with Section 90000) to the Public Resources Code, relating to safe drinking water, wildfire prevention, drought preparedness, and clean air, by providing the funds necessary therefor through an election of the issuance and sale of bonds of the State of California and for the handling and disposition of those funds, and declaring the urgency thereof, to take effect immediately. California State Legislature. Chapter 83. https://leginfo.legislature.ca.gov/faces/billStatusClient.xhtml?bill_id=202320240SB867.

AMEX. 2024. Post fire reforestation trail call for collaborators: Sierra Nevada. Adaptive Management Experiment. https://www.adaptive-forest-management-experiment.com.

Avitt, A. 2021. Caldor Fire: Defending Lake Tahoe Basin. Office of Communication, U.S. Department of Agriculture, Forest Service. https://www.fs.usda.gov/features/caldor-fire-defending-lake-tahoe-basin.

Badgley, G.; Chay, F.; Chegwidden, O.S.; Hamman, J.J.; Freeman, J.; Cullenward, D. 2022. California's forest carbon offsets buffer pool is severely undercapitalized. Frontiers in Forests and Global Change. 5: 930426. https://doi.org/10.3389/ffgc.2022.930426.

Baijnath-Rodino, J.A.; Martinez, A.; York, R.A.; Foufoula-Georgiou, E.; AghaKouchak, A.; Banerjee, T. 2023. Quantifying the effectiveness of shaded fuel breaks from ground-based, aerial, and spaceborne observations. Forest Ecology and Management. 543: 121142. https://doi.org/10.1016/j.foreco.2023.121142https://doi.org/10.1016/j.foreco.2023.121142.

Baker, S.E.; Stolaroff, J.K.; Peridas, G.; Pang, S.H.; Goldstein, H.M.; Lucci, F.R.; Li, W.; Slessarev, E.W.; Pett-Ridge, J.; Ryerson, F.J.; Wagoner, J.L.; Kirkendall, W.; Aines, R.D.; Sanchez, D.L.; Cabiyo, B.; Baker, J.; McCoy, S.; Uden, S.; Runnebaum, R.; Wilcox, J.; Psarras, P.C.; Pilorge, H.; McQueen, N.; Maynard, D.; McCormick, C. 2020. Getting to neutral: Options for negative carbon emissions in California. LLNL-TR-796100. Livermore, CA: Lawrence Livermore National Laboratory. 190 p. 10.2172/1597217.

BCTP. 2022. Voluntary registry offsets [Database]. Berkeley, CA: Berkeley Carbon Trading Project, Richard and Rhoda Goldman School of Public Policy, University of California, Berkeley. https://gspp.berkeley.edu/research-and-impact/centers/cepp/projects/berkeley-carbon-trading-project/offsets-database. (August 21, 2023).

Berrill, J.P.; Howe, R. 2019. Multiaged redwood responds well to partial harvest and herbicide treatments. Canadian Journal of Forest Research. 49(11): 1425–1433. https://doi.org/10.1139/cjfr-2019-0142.

BLM. 2023. BLM announces ambitious approach to reduce wildfire risk in California, NW Nevada. Bureau of Land Management. https://www.blm.gov/press-release/blm-announces-ambitious-approach-reduce-wildfire-risk-california-nw-nevada.

Blumenfeld, J.; Porter, T.; Assefa, S.; Crowfoot, W.; Eberlien, J.; Gore, J.; Coreless, S.; Hankins, D.; Nielson, L.; Noxon, L.; Clark, S.; Grondin, K. 2022. California's strategic plan for expanding the use of beneficial fire. Sacramento, CA: California Natural Resources Agency. 54 p. https://wildfiretaskforce.org/wp-content/uploads/2022/05/californias-strategic-plan-for-expanding-the-use-of-beneficial-fire.pdf.

Blumenfield; Alejo; Bonilla; Brownley; Buchanan; Butler; Cedillo; Chesbro; Dickinson; Feuer; Gordon; Huffman; Mitchell; Monning; Swanson. 2012. AB-1492. California State Legislature. Chapter 289. https://leginfo.legislature.ca.gov/faces/billStatusClient.xhtml?bill_id=201120120AB1492.

Bohlman, G.N.; Safford, H.D.; Skinner, C.N. 2021. Natural range of variation for yellow pine and mixed-conifer forests in northwestern California and southwestern Oregon. Gen. Tech. Rep. PSW-GTR-273. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 146 p. https://www.fs.usda.gov/research/treesearch/63522.

Bolsinger, C.L. 1976. Timber resources of northern interior California, 1970. Res. Bull. PNW-65. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 85 p. https://www.fs.usda.gov/pnw/pubs/pnw_rb065.pdf.

Butler, B.J.; Butler, S.M.; Caputo, J.; Dias, J.; Robillard, A.; Sass, E.M. 2021. Family forest ownerships of the United States, 2018: Results from the USDA Forest Service, National Woodland Owner Survey. Gen. Tech. Rep. NRS-199. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 52 p. https://doi.org/10.2737/nrs-gtr-199.

Butsic, V.; Carah, J.K.; Baumann, M.; Stephens, C.; Brenner, J.C. 2018. The emergence of cannabis agriculture frontiers as environmental threats. Environmental Research Letters. 13(12): 124017. https://doi.org/10.1088/1748-9326/aaeade.

CA DOC. 2023. State awards $72 million to accelerate building fire resilient communities and landscapes across California. California Department of Conservation. https://www.conservation.ca.gov/index/Pages/News/State-Awards-72-Million-Building-Fire-Resilient-Communities-Landscapes.aspx.

CA OEHHA. 2022. North Fork Rancheria of Mono Indians of California indicators of climate change summary report. Sacramento, CA: California Office of Environmental Health Hazard Assessment. 3 p. https://oehha.ca.gov/media/epic/downloads/2-pagernorthfork.pdf.

Cabiyo, B.; Fried, J.S.; Collins, B.M.; Stewart, W.; Wong, J.; Sanchez, D.L. 2021. Innovative wood use can enable carbon-beneficial forest management in California. Proceedings of the National Academy of Sciences of the United States of America. 118(49): e2019073118. https://doi.org/10.1073/pnas.2019073118.

Cafferata, P.H.; Yee, F. 1991. A comparison of techniques to control sprouting hardwoods on harsh sites in western Mendocino County. California Forestry Note No. 105. Sacramento, CA: California Dept. of Forestry and Fire Protection. https://www.cabidigitallibrary.org/doi/full/10.5555/19950616334.

Cal EPA; CNRA; CAL FIRE. 2026. Request to suspend state statutes and regulations fast-tracking critical fuels reduction projects dashboard. California Environmental Protection Agency, California Natural Resources Agency, California Department of Forestry and Fire Protection. https://experience.arcgis.com/experience/44774e7d2cb1438ca901a38793e2fdec/page/Approved-Projects-Dashboard. (January 29, 2026).

CAL FIRE. 2022. CalTREES, PTEIR query [Forest Practice Database]. Sacramento, CA: California Department of Forestry and Fire Protection. https://caltreesplans.resources.ca.gov/caltrees/.

CAL FIRE. 2023a. Forest Practice GIS: CAL FIRE emergency notices TA83. [Shapefile]. California Department of Forestry and Fire Protection. https://forest-practice-calfire-forestry.hub.arcgis.com/datasets/CALFIRE-Forestry::cal-fire-emergency-notices-ta83/about. (June 8, 2023).

CAL FIRE. 2023b. Forest Practice GIS: CAL FIRE emergency notices historical TA83. [Shapefile]. California Department of Forestry and Fire Protection. https://forest-practice-calfire-forestry.hub.arcgis.com/datasets/CALFIRE-Forestry::cal-fire-emergency-notices-historical-ta83/about. (June 8, 2023).

CAL FIRE. 2023c. Forest Practice GIS: CAL FIRE nonindustrial timber management plans and notices TA83. [Shapefile]. California Department of Forestry and Fire Protection. https://forest-practice-calfire-forestry.hub.arcgis.com/maps/0ac2b3b9f8654488825d3d6fa4d76769/about. (May 4, 2024).

CAL FIRE. 2023d. CalTREES, Option a and b query [Forest Practice Database]. Sacramento, CA: California Department of Forestry and Fire Protection. https://caltreesplans.resources.ca.gov/caltrees/.

CAL FIRE. 2023e. Forest Practice GIS: CAL FIRE timber harvesting plans TA83. [Shapefile]. California Department of Forestry and Fire Protection. https://forest-practice-calfire-forestry.hub.arcgis.com/datasets/CALFIRE-Forestry::cal-fire-timber-harvesting-plans-ta83/about. (June 8, 2023).

CAL FIRE. 2023f. Forest Practice GIS: CAL FIRE timber harvesting plans historical TA83. [Shapefile]. California Department of Forestry and Fire Protection. https://forest-practice-calfire-forestry.hub.arcgis.com/datasets/CALFIRE-Forestry::cal-fire-timber-harvesting-plans-historical-ta83/about. (June 8, 2023).

CAL FIRE. 2023g. Forest Practice GIS: CAL FIRE working forest management plans and notices TA83. [Shapefile]. California Department of Forestry and Fire Protection. https://forest-practice-calfire-forestry.hub.arcgis.com/maps/bd5a77052fbb47d0bb4b0c2deee84ab8/about. (May 4, 2024).

CAL FIRE. 2024a. Wood products and bioenergy. California Department of Forestry and Fire Protection. https://www.fire.ca.gov/what-we-do/natural-resource-management/environmental-protection-program/wood-products-and-bioenergy.

CAL FIRE. 2024b. CAL FIRE Fire and Resource Assessment Program (FRAP) management landscape geodatabase. On file with: California Department of Forestry and Fire Protection Headquarters, 715 P St., Sacramento, CA 95814. (June 28, 2024).

CAL FIRE. 2024c. California Forest Practice Rules. Title 14. Sections 895 through 909.1 and 1020 through 1115.3. California Department of Forestry and Fire Protection. 431. https://bof.fire.ca.gov/media/qs5p1yk4/2024-forest-practice-rules-and-act-final.pdf.

CAL FIRE. 2024d. Tribal wildfire resilience grants. California Department of Forestry and Fire Protection. https://www.fire.ca.gov/what-we-do/grants/tribal-wildfire-resilience.

CAL FIRE. 2024e. Forest Practice GIS: Forest Industry Owners 23_1 feature class [Shapefile]. On file with: California Department of Forestry and Fire Protection Headquarters, 715 P St., Sacramento, CA 95814. (January 23, 2024).

CAL FIRE. 2024f. California interagency fire perimeter database. [Shapefile]. California Department of Forestry and Fire Protection. Firep23_1. https://hub-calfire-forestry.hub.arcgis.com/datasets/california-fire-perimeters-all/explore. (March 7, 2025).

CAL FIRE. 2025a. Summary of CAL FIRE forest practice timberland conversion permits, 2018–2023. On file with: California Department of Forestry and Fire Protection Headquarters, 715 P St., Sacramento, CA 95814. (July 22, 2025).

CAL FIRE. 2025b. Summary of CAL FIRE forest practice less-than-3-acre-conversion permits, 2018–2023. On file with: California Department of Forestry and Fire Protection Headquarters, 715 P St., Sacramento, CA 95814. (June 19, 2025).

CAL FIRE. 2026. Fuels treatment effectiveness reporting. California Department of Forestry and Fire Protection. https://experience.arcgis.com/experience/7accd31d00d24d6b9389f25fbee93af8/page/Treatment-Reporting-Overview-Page.

CalForests. 2024. California's future forest health and resilience relies on us all. California Forestry Association. https://www.caforestryworkforce.com/.

CARB. 2022a. CA forest compliance offset project boundaries [Shapefile]. On file with: California Air Resources Board Headquarters, 1001 I St., Sacramento, CA 95814. (28 December 2022).

CARB. 2022b. 2022 Scoping plan for achieving carbon neutrality. Sacramento, CA: California Air Resources Board. 297 p. https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp.pdf.

Cheng, Y.; Oehmcke, S.; Brandt, M.; Rosenthal, L.; Das, A.; Vrieling, A.; Saatchi, S.; Wagner, F.; Mugabowindekwe, M.; Verbruggen, W.; Beier, C.; Horion, S. 2024. Scattered tree death contributes to substantial forest loss in California. Nature Communications. 15(1): 641. https://doi.org/10.1038/s41467-024-44991-z.

Christensen, G.A.; Tase, N.A.; Gray, A.N.; Kuegler, O.; Dymond, C.C.; Drummond, J.; Kurz, W.A.; Dillon, T.; Todd, M.; Evans, S.; Scott, S.; Russell, H. In Press. Pacific Coast region temperate forest carbon dynamics: A regional forest and harvested wood product assessment of British Columbia, California, Oregon, and Washington, 2001–2019. PNW GTR-XXX. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Churchill, D.J.; Larson, A.J.; Dahlgreen, M.C.; Franklin, J.F.; Hessburg, P.F.; Lutz, J.A. 2013. Restoring forest resilience: From reference spatial patterns to silvicultural prescriptions and monitoring. Forest Ecology and Management. 291: 442–457. https://doi.org/10.1016/j.foreco.2012.11.007.

CNRA. 2021. 2021 California climate adaptation strategy: Priorities, goals, and actions. Sacramento, CA: California Natural Resources Agency. 20 p. https://climateresilience.ca.gov/overview/docs/20220404-CAS_Priorities_Goals_Actions.pdf.

CNRA. 2022a. Pathways to 30x30 California: Accelerating conservation of California's nature. Sacramento, CA: California Natural Resources Agency. 72 p. https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/30-by-30/Final_Pathwaysto30x30_042022_508.pdf.

CNRA. 2022b. Natural and working lands climate smart strategy: California's climate smart lands strategy. Sacramento, CA: California Natural Resources Agency. 111 p. https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/CNRA-Report-2022---Final_Accessible.pdf.

CNRA. 2024. California's nature-based solutions: Climate targets. Sacramento, CA: California Natural Resources Agency (CNRA), Administration of Governor Gavin Newsom. 43 p. https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/Californias-NBS-Climate-Targets-2024.pdf.

CNRA; CAL EPA. 2025. Statewide fuels reduction environmental protection plan. Sacramento, CA: California Natural Resources Agency, California Environmental Protection Agency. 8 p. https://wildfiretaskforce.org/wp-content/uploads/2025/05/CA-Fuels-Reduction-Environmental-Protection-Plan.pdf.

Cocking, M.I.; Varner, J.M.; Engber, E.A. 2015. Conifer encroachment in California oak woodlands. In: Standiford, Richard B.; Purcell, Kathryn L., tech. cords. Proceedings of the seventh California oak symposium: Managing oak woodlands in a dynamic world. Gen. Tech. Rep. PSW-GTR-251. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 10 p.

Coppoletta, M.; Brendecke, W.; Bauer, R.; Tompkins, R.; Heide, F. 2022. Post-fire restoration opportunities for conifer forest in the 2021 Dixie and Sugar Fires. Vallejo, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region Ecology Program. 48 p. https://www.fs.usda.gov/detail/r5/plantsanimals/?cid=FSE-PRD1087476.

CRPP. 2024. 2024 California conifer tree seed collection results. Washington, D.C.: American Forests, California Reforestation Pipeline Partnership. https://lp.constantcontactpages.com/cu/u36alsD/2024conecollection?source_id=dac796d5-bef6-439d-81e2-b44340b59197&source_type=em&c=mtgh1pKQi-BiUqVPqW-W9vdM_i1Up_k9moDGXBGMJM-mGxyLIqm15fQ.

CWI. 2022. The stewardship project: Integrating Indigenous and western knowledges. Climate and Wildfire Institute. https://climateandwildfire.org/cwi-projects/the-stewardship-project.

Davis, K.T.; Robles, M.D.; Kemp, K.B.; Higuera, P.E.; Chapman, T.; Metlen, K.L.; Peeler, J.L.; Rodman, K.C.; Woolley, T.; Addington, R.N.; Buma, B.J.; Cansler, C.A.; Case, M.J.; Collins, B.M.; Coop, J.D.; Dobrowski, S.Z.; Gill, N.S.; Haffey, C.; Harris, L.B.; Harvey, B.J.; Haugo, R.D.; Hurteau, M.D.; Kulakowski, D.; Littlefield, C.E.; McCauley, L.A.; Povak, N.; Shive, K.L.; Smith, E.; Stevens, J.T.; Stevens-Rumann, C.S.; Taylor, A.H.; Tepley, A.J.; Young, D.J.N.; Andrus, R.A.; Battaglia, M.A.; Berkey, J.K.; Busby, S.U.; Carlson, A.R.; Chambers, M.E.; Dodson, E.K.; Donato, D.C.; Downing, W.M.; Fornwalt, P.J.; Halofsky, J.S.; Hoffman, A.; Holz, A.; Iniguez, J.M.; Krawchuk, M.A.; Kreider, M.R.; Larson, A.J.; Meigs, G.W.; Roccaforte, J.P.; Rother, M.T.; Safford, H.; Schaedel, M.; Sibold, J.S.; Singleton, M.P.; Turner, M.G.; Urza, A.K.; Clark-Wolf, K.D.; Yocom, L.; Fontaine, J.B.; Campbell, J.L. 2023. Reduced fire severity offers near-term buffer to climate-driven declines in conifer resilience across the western United States. Proceedings of the National Academy of Sciences of the United States of America. 120(11): e2208120120. https://doi.org/10.1073/pnas.2208120120.

Dean, T.J.; Baldwin, V.C. 1996. Crown management and stand density. In: Carter, Mason C., ed., Growing trees in a greener world: Industrial forestry in the 21st century; 35th LSU forestry symposium. Baton Rouge, LA: Louisiana State University Agricultural Center, Louisiana Agricultural Experiment Station. 148–159a–e. https://research.fs.usda.gov/treesearch/717.

DeLyser, K.; Tase, N.; Clay, K.; Magnan, M.; Evans, S.; Keithley, C.; Bartowitz, K.; Gadoth-Goodman, D.; Papa, C.; Ontl, T.; Cooper, L. 2025. Effects of forest management & wood utilization on carbon sequestration & storage in California. Washington, DC.: American Forests. https://d3f9k0n15ckvhe.cloudfront.net/wp-content/uploads/2025/02/CBM_CA_report_FINAL.pdf.

Devall, B.; Sessions, G. 2007. Deep ecology: Living as if nature mattered. Salt Lake City, UT: GibbSmith. 267 p.

Dillon, T.; Morgan, T.A. 2023. Pacific Coast temperate forest regional timber product flow analysis. GTR-1017. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 54 p. https://www.fs.usda.gov/pnw/pubs/pnw_gtr1017.pdf.

DiTomaso, J.M.; Bell, C.E.; Wilen, C.A. 2017. Invasive plants: Pest notes for home and landscape. Doc. no. 74139. Berkeley, CA: University of California Agriculture and Natural Resources Integrated Pest Management Program. 8 p. https://anrcatalog.ucanr.edu/Details.aspx?itemNo=74139.

Dobrowski, S.Z.; Aghai, M.M.; Chichilnisky du Lac, A.; Downer, R.; Fargione, J.; Haase, D.L.; Hoecker, T.; Kildisheva, O.A.; Murdoch, A.; Newman, S.; North, M.; Saksa, P.; Sjoholm, M.; Baribault, T.; Buonanduci, M.S.; Chambers, M.E.; Gonzales-Kramer, L.; Harvey, B.J.; Hurteau, M.D.; Loevner, J.; Safford, H.D.; Sloan, J. 2024. 'Mind the Gap'—reforestation needs vs. reforestation capacity in the western United States. Frontiers in Forests and Global Change. 7: 1402124. https://doi.org/10.3389/ffgc.2024.1402124.

Elasser, A. 2022. California once prohibited Native American fire practices. Now, it's asking tribes to use them to help prevent wildfires. CNN. https://www.cnn.com/2022/04/03/us/california-native-american-fire-practitioners-wildfires-climate/index.html. (August 2, 2024).

Elias, M.; Dees, J.; Cabiyo, B.; Saksa, P.; Sanchez, D.L. 2023. Financial analysis of innovative wood products and carbon finance to support forest restoration in California. Forest Products Journal. 73(1): 31–42. https://doi.org/Artn22-0004910.13073/Fpj-D-22-00049.

Estes, B.; Bovee, K. 2023. Post-fire restoration framework in mixed conifer forests in the 2021 Caldor Fire, Eldorado National Forest and the Lake Tahoe Basin Management Unit. Vallejo, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region Ecology Program. 52 p. https://www.fs.usda.gov/detail/r5/plants-animals/?cid=FSE-PRD1087476.

Evans, S.; Potts, M. 2024. The trade flow of primary wood products in the Pacific Coast region. Res. Pap. PNW-RP-619. Portland, OR: U.S. Department of Agriculture, Pacific Northwest Research Station. 33 p. https://doi.org/10.2737/pnw-rp-619.

FCAT. 2018. California forest carbon plan: Managing our forest landscapes in a changing climate. Sacramento, CA: California Forest Climate Action Team. 186 p. https://ww2.arb.ca.gov/sites/default/files/2019-01/California-Forest-Carbon-Plan-Final-Draft-for-Public-Release-May-2018.pdf.

Fertel, H.M.; North, M.P.; Latimer, A.M.; Ng, J. 2022. Growth and spatial patterns of natural regeneration in Sierra Nevada mixed-conifer forests with a restored fire regime. Forest Ecology and Management. 519: 120270. https://doi.org/10.1016/j.foreco.2022.120270.

Frerker, K.; Bower, A.; Brandt, L.; Gregory, C.; Handler, S.; LaBonte, N.; Layman, C.; McTighe, K.; Miller, K.; Pike, C.; Stover, K.; Theimer, M. 2023. Superior National Forest assisted migration plan. Duluth, MN: U.S. Department of Agriculture, Forest Service. 96 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd1150836.pdf.

Fried, J.; Loreno, S.; Sharma, B.; Starrs, C.; Stewart, W. 2016. Inventory based landscape-scale simulation to assess effectiveness and feasibility of reducing fire hazards and improving forest sustainability in California with BIOSUM. California Energy Commission Agreement No. 600-11-006. Berkeley, CA: University of California. 215 p.

Garcia, C.; Rivas, R. 2022. AB-1757: An act to add section 38561.5 to the health and safety code, relating to greenhouse gases. California State Legislature. Chapter 341. https://leginfo.legislature.ca.gov/faces/billStatusClient.xhtml?bill_id=202120220AB1757.

GDRC. 2023. California timberlands forest management plan. Green Diamond Resource Company. 286 p. https://www.greendiamond.com/downloads/Forest_Management_Plan.pdf.

GDRC. 2024. Green Diamond Resource Company. https://www.greendiamond.com/.

Goldstein, B.A.; Kelly, E.C.; Crandall, M.S. 2023. By the book: Examining California's private forest regulations from the perspectives of family forest landowners. Society & Natural Resources. 37(3): 328–346. https://doi.org/10.1080/08941920.2023.2286652.

GreenInfo Network. 2024. California conservation easements database (CCED) [Database]. GreenInfo Network. https://www.calands.org/cced/. (May 31, 2024).

Groom, J.D.; Monleon, V.J. 2023. West coast U.S. tree species show stronger evidence for shifts in density than range. Forest Ecology and Management. 545: 121262. https://doi.org/10.1016/j.foreco.2023.121262.

Handler, S.; Pike, C.; St. Clair, B.; Abbotts, H.; Janowiak, M.K. 2023. Assisted migration. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. https://www.climatehubs.usda.gov/sites/default/files/Assisted-Migration_Climate-Change-Resource-Center.pdf.

Hankins, D.L. 2024. Climate resilience through ecocultural stewardship. Proceedings of the National Academy of Sciences of the United States of America. 121(32): e2310072121. https://doi.org/10.1073/pnas.2310072121.

Hanson, E.J.A., David L.; Hiserote, Bruce A. 2003. Site index equations and mean annual increment equations for Pacific Northwest Research Station forest inventory and analysis inventories, 1985–2001. Res. Note PNW-RN-533. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 24 p.

Heard, S.; Franklin, B. 2023. Building California's forest resilience workforce: A critical gap in increasing the pace and scale of wildfire prevention. The Nature Conservancy. 20 p. https://www.scienceforconservation.org/products/Forest-Restoration-Workforce-Development.

Indigenous Stewardship Network. 2024. Indigenous Stewardship Network. https://www.indigenousstewardship.org/.

Ingram, K.; Kocher, S.; Tompkins, R.; Jones, M. 2022. California's small forest landowners: Goals and barriers of landowners motivated to manage their forests. Prepared for the California Wildfire and Forest Resilience Task Force. Berkeley, CA: University of California Agriculture and Natural Resources. 13 p. https://ucanr.edu/sites/forestry/files/376603.pdf.

Karuk Tribe. 2019. Karuk climate adaptation plan. Karuk Tribe Department of Natural Resources. 232 p. https://www.karuk.us/images/docs/dnr/FINAL%20KARUK%20CLIMATE%20ADAPTATION%20PLAN_July2019.pdf.

Knight, C.A.; Anderson, L.; Bunting, M.J.; Champagne, M.; Clayburn, R.M.; Crawford, J.N.; Klimaszewski-Patterson, A.; Knapp, E.E.; Lake, F.K.; Mensing, S.A.; Wahl, D.; Wanket, J.; Watts-Tobin, A.; Potts, M.D.; Battles, J.J. 2022a. Land management explains major trends in forest structure and composition over the last millennium in California's Klamath Mountains. Proceedings of the National Academy of Sciences of the United States of America. 119(12): e2116264119. https://doi.org/10.1073/pnas.2116264119.

Knight, C.A.; Tompkins, R.E.; Wang, J.A.; York, R.; Goulden, M.L.; Battles, J.J. 2022b. Accurate tracking of forest activity key to multi-jurisdictional management goals: A case study in California. Journal of Environmental Management. 302(Pt B): 114083. https://doi.org/10.1016/j.jenvman.2021.114083.

Kreider, M.R.; Higuera, P.E.; Parks, S.A.; Rice, W.L.; White, N.; Larson, A.J. 2024. Fire suppression makes wildfires more severe and accentuates impacts of climate change and fuel accumulation. Nature Communications. 15(1): 2412. https://doi.org/10.1038/s41467-024-46702-0.

LHC. 2018. Fire on the mountain: Rethinking forest management in the Sierra Nevada. Sacramento, CA: Little Hoover Commission. 87 p. https://lhc.ca.gov/wp-content/uploads/Reports/242/Report242.pdf.

Long, J.N. 1985. A practical approach to density management. Forestry Chronicle. 61(1): 23–27. https://doi.org/DOI10.5558/tfc61023-1.

Long, J.N.; Shaw, J.D. 2005. A density management diagram for even-aged ponderosa pine stands. Western Journal of Applied Forestry. 20(4): 205–215. https://doi.org/DOI10.1093/wjaf/20.4.205.

Long, J.W.; Walsh, D.; Coppoletta, M.; Tompkins, R.E.; Meyer, M.D.; Isbell, C.; Bohlman, G.N.; North, M.P. 2023. Interventions to restore wildfire-altered forests in California. Gen. Tech. Rep. PSW-GTR-278. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 105 p. https://doi.org/10.2737/psw-gtr-278.

Manley, P.N.; Povak, N.A.; Wilson, K.N.; Fairweather, M.L.; Griffey, V.; Long, L.L. 2023. Blueprint for resilience: The Tahoe-Central Sierra Initiative. Gen. Tech. Rep. PSW-GTR-277. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 94 p. https://doi.org/10.2737/psw-gtr-277.

Marcille, K.C.; Morgan, T.A.; McIver, C.P.; Christensen, G.A. 2020. California's forest products industry and timber harvest, 2016. Gen. Tech. Rep. PNW-GTR-944. Portland, OR: U.S. Department of Agriculture, Forest Service, Northwest Research Station. 58 p. https://www.fs.usda.gov/research/treesearch/61745.

Marks-Block, T.; 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.

May, R. 1953. A century of lumber production in California and Nevada. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Calfornia Forest and Range Experiment Station. 33 p. https://www.google.com/books/edition/A_Century_of_Lumber_Production_in_Califo/DSo6AQAAMAAJ?hl=en&gbpv=1&dq=%22A+Century+of+Lumber+Production+in+California+and+Nevada%22&pg=PA2&printsec=frontcover.

MBG. 2023. Long-term economic impacts of large fires in California from 2018–2021: Losses and opportunities. Portland, OR: Mason, Bruce and Girard, Inc. 69 p. https://masonbruce.com/news/long-term-economic-impacts-of-large-fires-in-california-from-2018-2021-losses-and-opportunities/.

McIver, C.P.; Meek, J.P.; Scudder, M.G.; Sorensen, C.B.; Morgan, T.A.; Christensen, G.A. 2015. California forest products industry and timber harvest, 2012. Gen Tech Rep. PNW-GTR-908. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 49 p. https://doi.org/10.2737/PNW-GTR-908.

Meyer, M.D. 2015. Forest fire severity patterns of resource objective wildfires in the southern Sierra Nevada. Journal of Forestry. 113(1): 49–56. https://doi.org/10.5849/jof.14-084.

Meyer, M.D.; Long, J.W.; Safford, H.D. 2021. Postfire restoration framework for national forests in California. Gen. Tech. Rep. PSW-GTR-270. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 204 p. https://www.fs.usda.gov/psw/publications/documents/psw_gtr270/psw_gtr270.pdf.

Millar, C.I.; Stephenson, N.L.; Stephens, S.L. 2007. Climate change and forests of the future: Managing in the face of uncertainty. Ecological Applications. 17(8): 2145–51. https://doi.org/10.1890/06-1715.1.

Miner, R.A.; Abt, R.C.; Bowyer, J.L.; Buford, M.A.; Malmsheimer, R.W.; O'Laughlin, J.; Oneil, E.E.; Sedjo, R.A.; Skog, K.E. 2014. Forest carbon accounting considerations in US bioenergy policy. Journal of Forestry. 112(6): 591–606. https://doi.org/10.5849/jof.14-009.

Minnich, R.A.; Barbour, M.G.; Burke, J.H.; Sosa-Ramirez, J. 2000. Californian mixed-conifer forests under unmanaged fire regimes in the Sierra San Pedro Martir, Baja California, Mexico. Journal of Biogeography. 27 (1): 105–129. https://www.jstor.org/stable/2655990.

Monleon, V.J.; Lintz, H.E. 2015. Evidence of tree species' range shifts in a complex landscape. Plos One. 10(1): e0118069. https://doi.org/10.1371/journal.pone.0118069.

Morgan, T., Scott, S. 2024. Public western mill list. On file with: Bureau of Business and Economic Research, University of Montana.

Morgan, T.A.; Keegan, C.E.; Dillon, T.; Chase, A.L.; Fried, J.S.; Weber, M.N. 2004. California's forest products industry: A descriptive analysis. Gen. Tech. Rep. PNW-GTR-615. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 55 p. https://www.fs.usda.gov/treesearch/pubs/7067.

Morgan, T.A.; Brandt, J.P.; Songster, I.K.E.; Keegan, C.E.; Christensen, G.A. 2012. California's forest products industry and timber harvest, 2006. Gen. Tech. Rep. PNW-GTR-866. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 48 p. https://research.fs.usda.gov/treesearch/41151.

Nagel, L.M.; Palik, B.J.; Battaglia, M.A.; D'Amato, A.W.; Guldin, J.M.; Swanston, C.W.; Janowiak, M.K.; Powers, M.P.; Joyce, L.A.; Millar, C.I.; Peterson, D.L.; Ganio, L.M.; Kirschbaum, C.; Roske, M.R. 2017. Adaptive silviculture for climate change: A national experiment in manager-scientist partnerships to apply an adaptation framework. Journal of Forestry. 115(3): 167–178. https://doi.org/10.5849/jof.16-039.

NASA. 2025. Wildfire, Ecosystem Resilience, & Risk Assessment Initiative (WERK). National Aeronautics and Space Administration. https://www.nasa.gov/werk/.

Nepal, P.; Skog, K.E. 2014. Estimating net greenhouse gas (GHG) emissions from wood energy use: Issues and the current state of knowledge. In: Wood energy in developed economies: Resource management, economics and policy. First ed. London: Routledge: 30. Chapter 8. https://doi.org/10.4324/9781315884417.

Newsom, G. 2020. Executive Order N-82-20. Executive Office, State of California. https://www.library.ca.gov/wp-content/uploads/GovernmentPublications/executive-order-proclamation/40-N-82-20.pdf.

Newsom, G. 2025. Proclamation of a State of Emergency, 01 March 2025. https://www.caloes.ca.gov/wp-content/uploads/Legal-Affairs/Documents/Proclamations/3.1.2025-fast-track-critical-wildfire-prevention-projects-statewide.pdf.

Ng, J.; North, M.P.; Arditti, A.J.; Cooper, M.R.; Lutz, J.A. 2020. Topographic variation in tree group and gap structure in Sierra Nevada mixed-conifer forests with active fire regimes. Forest Ecology and Management. 472: 118220. https://doi.org/10.1016/j.foreco.2020.118220.

North, M.; Hurteau, M.; Innes, J. 2009. Fire suppression and fuels treatment effects on mixed-conifer carbon stocks and emissions. Ecological Applications. 19(6): 1385–96. https://doi.org/10.1890/08-1173.1.

North, M.P.; Bisbing, S.M.; Hankins, D.L.; Hessburg, P.F.; Hurteau, M.D.; Kobziar, L.N.; Meyer, M.D.; Rhea, A.E.; Stephens, S.L.; Stevens-Rumann, C.S. 2024. Strategic fire zones are essential to wildfire risk reduction in the Western United States. Fire Ecology. 20(1): 50. https://doi.org/10.1186/s42408-024-00282-y.

North, M.P., ed 2012. Managing Sierra Nevada forests. Gen. Tech. Rep. PSW-GTR-237. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 184 p. https://purl.fdlp.gov/GPO/gpo36146.

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.; 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.

North, M.P.; Tompkins, R.E.; Bernal, A.A.; Collins, B.M.; Stephens, S.L.; York, R.A. 2022. Operational resilience in western US frequent-fire forests. Forest Ecology and Management. 507: 120004. https://doi.org/10.1016/j.foreco.2021.120004.

North, M.P.; York, R.A.; Collins, B.M.; Hurteau, M.D.; Jones, G.M.; Knapp, E.E.; Kobziar, L.; McCann, H.; Meyer, M.D.; Stephens, S.L.; Tompkins, R.E.; Tubbesing, C.L. 2021. Pyrosilviculture needed for landscape resilience of dry western United States forests. Journal of Forestry. 119(5): 520–544. https://doi.org/10.1093/jofore/fvab026.

North State Planning and Development Collective (NSPDC). 2021. Forest sector workforce study report. Chico, CA: California State University Chico. 57 p. https://www.valleyvision.org/wp-content/uploads/Forest-Sector-Workforce-Study-Final-Report-1.pdf.

NPS. 2024. Resource management and science - exotic plant management. National Park Service. https://www.nps.gov/redw/learn/nature/exotic-vegetation.htm.

Nunez; Pavley. 2006. AB-32: An act to add division 25.5 (commencing with section 38500) to the health and safety code, relating to air pollution. California State Senate. Chapter 488. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=200520060AB32.

Olsen, W.; Coe, D.; Stanish, S.; Cafferata, P. 2019. Emergency notice of timber operations monitoring and report on exemption usage. Final report prepared for the California State Legislature. Sacramento, CA: California Department of Forestry and Fire Protection and State Board of Forestry and Fire Protection. 52 p. https://www.researchgate.net/publication/345036759_REPORT_ON_EMERGENCY_NOTICE_OF_TIMBER_OPERATIONS_MONITORING_RESULTS_AND_EXEMPTION_NOTICE_USE.

Olsen, W.; D. Coe; J. Oswald; C. Allison; A. Fehrenbach; M. Boone. 2025. Monitoring results of non-federal post-fire salvage logging in California forests: Report on post-fire §1052 notice of emergency timber operations. California Forestry Report No. 8. Sacramento, CA: California Department of Forestry and Fire Protection. 135 p. https://34c031f8-c9fd-4018-8c5a-4159cdff6b0d-cdn-endpoint.azureedge.net/-/media/calfire-website/what-we-do/natural-resource-management/forest-practice/publications/forestryreport8_postfireemergencynotic-emonitoring_final.pdf?rev=38f66de291dc4e178b0d-2f34741a8a41&hash=E70A9B4906FBFB-744D2AE1D00EB8BF55.

Oswald, D.D. 1970. California's forest industries—prospects for the future. Res. Bull. PNW-RB-035. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 55 p. https://www.fs.usda.gov/pnw/pubs/pnw_rb035.pdf.

Palik, B.J.; Clark, P.W.; D'Amato, A.W.; Swanston, C.; Nagel, L. 2022. Operationalizing forest-assisted migration in the context of climate change adaptation: Examples from the eastern USA. Ecosphere. 13(10): e4260. https://doi.org/10.1002/ecs2.4260.

Parks, S.A.; Holsinger, L.M.; Voss, M.A.; Loehman, R.A.; Robinson, N.P. 2018. Mean composite fire severity metrics computed with Google Earth Engine offer improved accuracy and expanded mapping potential. Remote Sensing. 10(6): 879. https://doi.org/10.3390/rs10060879.

Porter, D.; Longcor, R. 2020. Accelerating forest restoration: Stimulating a forest-restoration economic and rebuilding resilience in California's fire-adapted forests. The Nature Conservancy and Bain & Company. 28 p. https://www.scienceforconservation.org/assets/downloads/tnc_AFR_v9.pdf.

Redmore, L.S.; Marshall, J.; Kusel, J.; Kunches, R.; Anderson, Z.; Watson; Wright, A. 2021. Mass timber and other innovative wood products in California: A study of barriers and potential solutions to grow the state's sustainable wood products sector. Taylorsville, CA: Sierra Institute for Community and Environment. 115 p. https://sierrainstitute.us/new/wp-content/uploads/2022/01/Mass-Timber-SIERRA-INSTITUTE-2021-FULL-REPORT-1B-COMPLIANT.pdf.

Riddle, A.A. 2023. National Forest System management: Overview and issues for Congress. R43872, Version 16. Washington, D.C.: Congressional Research Service. 34 p. https://crsreports.congress.gov/product/pdf/R/R43872.

Romero-Briones, A.; Salmon, E.; Renick, H.; Costa, T. 2020. Recognition and support of Indigenous California land stewards practitioners of kincentric ecology. Longmont, CO: First Nations Development Institute and California Foodshed Funders. 20 p. https://www.firstnations.org/wp-content/uploads/2020/08/Indigenous-California-Land-Stewards-Practitioners-of-Kincentric-Ecology-Report-2020.pdf.

Rubio. 2012. SB 1122: An act to amend Section 399.20 of the Public Utilities Code, relating to energy. Chapter 612. Statutes of 2012. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120SB1122.

Ruderman, F.K. 1976–1984. Production, prices, employment, and trade in Northwest forest industries. Resour. Bull. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. Quarterly.

Safford, H.D.; Paulson, A.K.; Steel, Z.L.; Young, D.J.N.; Wayman, R.B. 2022. The 2020 California fire season: A year like no other, a return to the past or a harbinger of the future? Global Ecology and Biogeography. 31(10): 2005–2025. https://doi.org/10.1111/geb.13498.

Safford, H.D.; Stevens, J.T. 2017. Natural range of variation for yellow pine and mixed-conifer forests in the Sierra Nevada, southern Cascades, and Modoc and Inyo National Forests, California, USA. General Technical Report PSW-GTR-256. Albany, CA: U.S. Department of Agricluture, Forest Service, Pacific Southwest Research Station. 229 p. https://research.fs.usda.gov/treesearch/55393.

Sass, E.M.; Butler, B.J.; Caputo, J.; Huff, E.S. 2023. Trends in United States family forest owners' attitudes, behaviors, and general characteristics from 2006 to 2018. Forest Science. 69(6): 689–697. https://doi.org/10.1093/forsci/fxad040.

Scott, S.; Dillion, T.; Morgan, T. 2024. California's forest products industry and timber harvest. Missoula, MT: The University of Montana Bureau of Business and Economic Research. 16 p. https://www.bber.umt.edu/pubs/forest/fidacs/CA2021Tables.pdf.

SFI. 2023. Sustainable Forestry Initiative [Database]. Washington, D.C.: Sustainable Forestry Initiative. https://sfidatabase.org/search/advanced-certificate-search. (June 2, 2023).

Shive, K.L.; Preisler, H.K.; Welch, K.R.; Safford, H.D.; Butz, R.J.; O'Hara, K.L.; Stephens, S.L. 2018. From the stand scale to the landscape scale: Predicting the spatial patterns of forest regeneration after disturbance. Ecological Applications. 28(6): 1626–1639. https://doi.org/10.1002/eap.1756.

SNC. 2021. Fire Adapted 50 project protects communities from Caldor Fire. Sierra Nevada Conservancy. https://sierranevada.ca.gov/fire-adapted-50-project-protects-communities-from-caldor-fire/.

South Fork American River Cohesive Strategy. 2024. What is SOFAR cohesive strategy? https://sofarcohesivestrategy.org/about/#:~:text=The%20SOFAR%20Cohesive%20Strategy%20project.of%20the%20Highway%2050%20corridor.

State of California. 2024. California grants portal: Forest biomass to carbon-negative biofuels project. https://www.grants.ca.gov/grants/forest-biomass-to-carbon-negative-biofuels-pilot-program/.

State of California; USFS PSW. 2020. Agreement for shared stewardship of California's forest and rangelands. U.S. Department of Agriculture Forest Service Pacific Southwest Region, State of California. 9 p. https://www.gov.ca.gov/wp-content/uploads/2020/08/8.12.20-CA-Shared-Stewardship-MOU.pdf.

Steel, Z.L.; Jones, G.M.; Collins, B.M.; Green, R.; Koltunov, A.; Purcell, K.L.; Sawyer, S.C.; Slaton, M.R.; Stephens, S.L.; Stine, P.; Thompson, C. 2023. Mega-disturbances cause rapid decline of mature conifer forest habitat in California. Ecological Applications. 33(2): e2763. https://doi.org/10.1002/eap.2763.

Stephens, C.W.; Collins, B.M.; Rogan, J. 2020. Land ownership impacts post-wildfire forest regeneration in Sierra Nevada mixed-conifer forests. Forest Ecology and Management. 468: 118161. https://doi.org/10.1016/j.foreco.2020.118161.

Stephens, S.L.; Bernal, A.A.; Collins, B.M.; Finney, M.A.; Lautenberger, C.; Saah, D. 2022. Mass fire behavior created by extensive tree mortality and high tree density not predicted by operational fire behavior models in the southern Sierra Nevada. Forest Ecology and Management. 518: 120258. https://doi.org/10.1016/j.foreco.2022.120258.

Stephens, S.L.; Foster, D.E.; Battles, J.J.; Bernal, A.A.; Collins, B.M.; Hedges, R.; Moghaddas, J.J.; Roughton, A.T.; York, R.A. 2024. Forest restoration and fuels reduction work: Different pathways for achieving success in the Sierra Nevada. Ecological Applications. 34(2): e2932. https://doi.org/10.1002/eap.2932.

Stephens, S.L.; Hall, L.; Stephens, C.W.; Bernal, A.A.; Collins, B.M. 2023. Degradation and restoration of Indigenous California black oak (*Quercus kelloggii*) stands in the northern Sierra Nevada. Fire Ecology. 19(1): 12. https://doi.org/10.1186/s42408-023-00172-9.

Stewart, J.A.; Wright, J.W.; Godfrey, J.M.; O'Neil, G.A.; Ostoja, S.M.; Thorne, J.H.; Boynton, R.M. 2023. Climate Adapted Seed Tool: An evidence-based tool to improve reforestation outcomes. https://reforestationtools.org/docs/cast/presentations/LAMRC_open_house_poster_May2023.pdf.

Stine, A.P. 2020. Catholic social teaching and sustainable development: What the church provides for specialists. PhD dissertation. Portland State University. https://doi.org/10.15760/etd.7476.

Tahoe Fund. 2024. Lake Tahoe Community College forestry program. https://www.tahoefund.org/projects/completed-projects/lake-tahoe-community-college-forestry-program/.

Teraoka, J.R.; van Mantgem, P.J.; Keyes, C.R. 2017. Low thinning and crown thinning of two severities as restoration tools at Redwood National Park. In Proceedings of Coast Redwood Science Symposium 2016: Past Successes and Future Direction. PSW-GTR-258. 259–266 p. https://www.fs.usda.gov/psw/publications/documents/psw_gtr258/psw_gtr258_259.pdf.

The Conservation Fund. 2023. Where we work: California. https://www.conservationfund.org/where-we-work/california.

Thorne, J.H. 2017. Climaticaly suitable current and projected vegetation range models. On file with: California Department of Forestry and Fire Protection, Fire and Resource Assessment Program, 715 P St., Sacramento, CA 95814. http://frap.fire.ca.gov/assessment/2017/assessment2017.

Thorne, J.H.; Boynton, R.M.; Holguin, A.J.; Stewart, J.A.; Bjorkman, J. 2016. A climate change vulnerability assessment of California's terrestrial vegetation. Final report to California Department of Fish and Wildlife. Davis, CA: Information Center for the Environment, University of California, Davis. 331 p. https://www.researchgate.net/profile/Joseph_Stewart4/publication/296639897_A_climate_change_vulnerability_assessment_of_California's_terrestrial_vegetation/links/56d72def08aee1aa5f75c693/A-climate-change-vulnerability-assessment-of-Californias-terrestrial-vegetation.pdf.

Thorne, J.H.; Choe, H.; Stewart, J.A.; Boynton, R.M. 2017. Range dynamics of selected tree and shrub species and climate exposure projections for forest and woodland habitats in California under four climate projections. On file with: Information Center for the Environment, University of California Davis, 1 Shields Ave., Davis, CA 95616.

Tribal Adaptation Menu Team. 2019. Dibaginjigaadeg Anishinaabe Ezhitwaad: A Tribal Climate Adaptation Menu. Odanah, WI: Great Lakes Indian Fish and Wildlife Commission. 54 p. https://research.fs.usda.gov/download/treesearch/58352.pdf.

Trinity County Resource Conservation District (RCD). 2021. The Weaverville Community Forest. https://www.tcrcd.net/wcf/index.htm.

U.S. Congress. 2021. H.R.3684 - 117th Congress (2021–2022): Infrastructure Investment and Jobs Act. https://www.congress.gov/bill/117th-congress/house-bill/3684.

U.S. President Trump, D.J. 2025a. United States Executive Order No. 14225: Immediate expansion of American timber production, 01 March 2025. Federal Register, vol. 90, no. 43, pages 11365–11367. https://www.federalregister.gov/documents/2025/03/06/2025-03695/immediate-expansion-of-american-timber-production.

U.S. President Trump, D.J. 2025b. Executive Order No. 14223: Addressing the threat to national security from imports of timber, lumber, 01 March 2025. Federal Register vol. 90, no. 43, pages 11359–11361. United States of America. https://www.federalregister.gov/documents/2025/03/06/2025-03693/addressing-the-threat-to-national-security-from-imports-of-timber-lumber-and-their-derivative.

UM BBER. 2024. Harvest by county tool [Database]. Missoula, MT: University of Montana Bureau of Business and Economic Research. www.bber.umt.edu/FIR/HarvestCA.aspx. (January 2, 2024).

Usal Redwood Forest Co. 2020. Usal Redwood Forest Company. https://www.usalredwoodforestcompany.com/.

USDA. 2024a. Bipartisan Infrastructure Law. U.S. Department of Agriculture. https://www.usda.gov/infrastructure#:~:text=The%20Bipartisan%20Infrastructure%20Investment%20and%20Jobs%20Act%20of%202021%20(PDF,as%20trails%2C%20roads%20and%20bridges.

USDA. 2024b. Inflation Reduction Act. U.S. Department of Agriculture. https://www.usda.gov/ira#:~:text=The%20law%20makes%20%245%20billion,million%20for%20administrative%20costs%20to.

USDA. 2025. Increasing timber production and designating an emergency situation on National Forest System lands. Secretary's memorandum 1078-006. Washington, D.C.: U.S. Department of Agriculture. 6 p. https://www.usda.gov/sites/default/files/documents/sm-1078-006.pdf.

USDA FSA. 2025. Disaster assistance emergency forest restoration program. U.S. Department of Agriculture Farm Service Agency. https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/emergency_forest_restoration_program-fact_sheet.pdf.

USFS. 2021. Memorandum of understanding for the purpose of increasing the use of fire to meet ecological and other management objectives including the protection of public health and community safety. Forest Agreement No. 21-MU-11052012-162. Vallejo, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. 19 p. https://www.sierraforestlegacy.org/Resources/Community/PrescribedFire/Fully%20Signed%2021-MU-11052012-162%20Fire%20MOU%20Partnership%202021-2025--FINAL.pdf. (August 5, 2024).

USFS. 2022a. Confronting the wildfire crisis: A strategy for protecting communities and improving resilience in America's forests. FS-1187a. U.S. Department of Agriculture, Forest Service. https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Confronting-the-Wildfire-Crisis.pdf.

USFS. 2022b. Aerial Detection Survey (ADS). [Geospatial GDB]. U.S. Department of Agriculture, Forest Service, Region 5 Forest Health Protection. https://www.fs.usda.gov/foresthealth/applied-sciences/mapping-reporting/detection-surveys.shtml.

USFS. 2023a. Land management plan direction for old-growth forest conditions across the National Forest System. 88 FR 88042 (proposed December 20, 2023). U.S. Department of Agriculture, Forest Service. 88, 243. https://www.govinfo.gov/content/pkg/FR-2023-12-20/pdf/2023-27875.pdf.

USFS. 2023b. Forest Inventory and Analysis glossary. U.S. Department of Agriculture, Forest Service. 28 p. https://www.fs.usda.gov/research/sites/default/files/2024-01/wo-fia_glossary_standardterms20231211.pdf.

USFS. 2023c. Invasive plants of California. U.S. Department of Agriculture, Forest Service. https://www.fs.usda.gov/detail/r5/forest-grasslandhealth/invasivespecies/?cid=stelprdb5332103.

USFS. 2023d. Field instructions for the annual inventory of California, Oregon and Washington, 2023. Portland, OR: Pacific Northwest Research Station, U.S. Department of Agriculture, Forest Service. 556 p. https://www.fs.usda.gov/research/sites/default/files/2023-04/pnw-2023_or_wa_ca_fia_field_manual.pdf.

USFS. 2023e. Tribal relations strategic plan, FY2023–FY2028. Vallejo, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest Service Region 5. 36 p.

USFS. 2024a. Stewardship contracting projects and activities map viewer. U.S. Department of Agriculture, Forest Service Enterprise Map Services Program, Enterprise Data Warehouse. https://usfs.maps.arcgis.com/apps/webappviewer/index.html?id=cb4c12675334447f824b128d7ef52a89.

USFS. 2024b. 2021 Forest Inventory and Analysis database. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. https://www.fs.usda.gov/research/pnw/products/dataandtools/tools/pnw-fiadb-forest-inventory-and-analysis-databases. (February 22, 2024).

USFS. 2024c. FIADB user guides: Database description (version 9.3). U.S. Department of Agriculture, Forest Service. https://research.fs.usda.gov/understory/forest-inventory-and-analysis-database-user-guide-nfi.

USFS. 2024d. 2021 California confidential FIA plot locations GIS shapefile. On file with: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forest Inventory and Analysis Program, 1220 SW 3rd Ave., Suite 1410, Portland, OR 97204.

USFS. 2025a. Implementation of secretarial memo 1078-006. Washington, D.C.: U.S. Department of Agriculture, Forest Service. 4 p. https://www.usda.gov/sites/default/files/documents/implementation-secretarial-memo-1078-006.pdf.

USFS. 2025b. National active forest management strategy, report no. FS-1268a. Washington, D.C.: U.S. Department of Agriculture, Forest Service. 20 p. https://www.usda.gov/sites/default/files/documents/national-active-forest-management-strategy.pdf. (August 22, 2025).

USFS. 2025c. Wood innovations program grants. U.S. Department of Agriculture, Forest Service. https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovation/grants.

USFS; BLM. 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl. Washington, D.C.: U.S. Department of Agriculture, Forest Service, Bureau of Land Management. 78 p. https://www.fs.usda.gov/sites/nfs/files/r06/mbs/publication/NW%20Forest%20Plan%20-%20Record%20of%20Decision.pdf. (August 22, 2025).

USFS; BLM. 2024a. Mature and old-growth forests: Definition, identification, and initial inventory on lands managed by the Forest Service and Bureau of Land Management. FS-1215a. U.S. Department of Agriculture, Forest Service, Bureau of Land Management. 82 p. https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Mature-and-Old-Growth-Forests.pdf.

USFS; BLM. 2024b. Mature and old-growth forests: Analysis of threats on lands managed by the Forest Service and Bureau of Land Management. FS-1215c. U.S. Department of Agriculture, Forest Service, Bureau of Land Management. 212 p. https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/MOG-threat-analysis.pdf.

USFWS; CA-IPC. 2018. Land manager's guide to developing an invasive plant management plan. Cal-IPC Publication 2018-01. Sacramento and Berkeley, CA: U.S. Fish and Wildlife Service, National Wildlife Refuge System, Pacific Southwest Region, Inventory and Monitoring Initiative and California Invasive Plant Council. 76 p. https://www.cal-ipc.org/.

USGS. 2021. GAP status code assignment assumptions, criteria, and methods. U.S. Geological Survey. 5 p. https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/atoms/files/GAP%20Status%20Code%20Assignment_2021.pdf.

Wagenbrenner, J.; Coe, D.; Olsen, S. 2023. Mitigating potential sediment delivery from post-fire salvage logging. California Forestry Report No. 7. Sacramento, CA: California Department of Forestry and Fire Protection. 32 p. https://www.fs.usda.gov/psw/publications/wagenbrenner/psw_2023_wagenbrenner001.pdf.

Wagenbrenner, J.W.; MacDonald, L.H.; Coats, R.N.; Robichaud, P.R.; Brown, R.E. 2015. Effects of post-fire salvage logging and a skid trail treatment on ground cover, soils, and sediment production in the interior western United States. Forest Ecology and Management. 335: 176–193. https://doi.org/10.1016/j.foreco.2014.09.016.

Wang, I.J.; Brenner, J.C.; Butsic, V. 2017. Cannabis, an emerging agricultural crop, leads to deforestation and fragmentation. Frontiers in Ecology and the Environment. 15(9): 495–501. https://doi.org/10.1002/fee.1634.

Wang, Y.; Lewis, D.J. 2024. Wildfires and climate change have lowered the economic value of western U.S. forests by altering risk expectations. Journal of Environmental Economics and Management. 123 https://doi.org/10.1016/j.jeem.2023.102894.

Warren, D.D. 1986–2003. Production, prices, employment, and trade in Northwest forest industry. Resour. Bull. PNW-RB-247. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. Quarterly. 171 p. https://doi.org/10.2737/PNW-RB-247.

Welch, K.R.; Safford, H.D.; Young, T.P. 2016. Predicting conifer establishment post wildfire in mixed conifer forests of the North American Mediterranean-climate zone. Ecosphere. 7(12): e01609. https://doi.org/10.1002/ecs2.1609.

WFR Task Force. 2021. California's wildfire and forest resilience action plan: Recommendations of the Governor's forest management task force. Sacramento, CA: California Wildfire and Forest Resilience Task Force. 84 p. https://fmtf.fire.ca.gov/media/cjwfpckz/californiawildfireandforestresilienceactionplan.pdf.

WFR Task Force. 2022a. California's Wildfire and Forest Resilience Task Force. California Wildfire and Forest Resilience Task Force, State of California. https://wildfiretaskforce.org.

WFR Task Force. 2022b. Roadmap to a million acres. California Wildfire and Forest Resilience Task Force. https://wildfiretaskforce.org/roadmap-to-a-milllion-acres/.

WFR Task Force. 2024a. California wildfire and landscape resilience interagency treatment dashboard. California Wildfire and Forest Resilience Task Force. https://wildfiretaskforce.org/treatment-dashboard/.

WFR Task Force. 2024b. Draft Wood Utilization Strategy. Sacramento, CA: California Wildfire and Forest Resilience Task Force.

WFR Task Force. 2024c. California wildfire and landscape resilience interagency treatment geodatabase. [geodatabase]. California Wildfire and Forest Resilience Task Force. ITS_Geodatabase_V1.1. https://portal.sparcal.sdsc.edu/arcgis/home/item.html?id=382c2b34f6b9405594f7066118e240d5. (July 29, 2025).

WFR Task Force. 2024d. Filling critical gaps in California's reforestation pipeline. Sacramento, CA: California Wildfire and Forest Resilence Task Force. 37 p. https://wildfiretaskforce.org/wp-content/uploads/2024/02/WFTF_Reforestation.pdf.

WFR Task Force. 2025a. 2025 Task Force key deliverables. Sacramento, CA: California Wildfire and Forest Resilience Task Force. 10 p. https://wildfiretaskforce.org/wp-content/uploads/2025/03/2025-Task-Force-Key-Deliverables-.pdf.

WFR Task Force. 2025b. Updates on California's wildfire resilience progress: Progress on key actions. California Wildfire and Forest Resilience Task Force. https://wildfiretaskforce.org/about/progress-on-key-actions/.

WFR Task Force. 2026. California wildfire and landscape resilience action plan: 2026–2031. Public draft dated June 2026. Sacramento, CA. 54 p. https://actionplan2026.wildfiretaskforce.org/wp-content/uploads/2026/06/Draft_Wildfire_and_Landscape_Resilience_Action_Plan06_10_2026.pdf.

Wood, J. 2024. Assembly Bill 2276, Forestry: Timber harvesting plans: Exemptions (Chapter 388). https://legiscan.com/CA/bill/AB2276/2023.

Woodall, C.W.; Weiskittel, A.R. 2021. Relative density of United States forests has shifted to higher levels over last two decades with important implications for future dynamics. Scientific Reports. 11(1): 18848. https://doi.org/10.1038/s41598-021-98244-w.

York, R.A.; Noble, H.; Quinn-Davidson, L.N.; Battles, J.J. 2021. Pyrosilviculture: Combining prescribed fire with gap-based silviculture in mixed-conifer forests of the Sierra Nevada. Canadian Journal of Forest Research. 51(6): 781–791. https://doi.org/10.1139/cjfr-2020-0337.

Zhou, X. 2015. Production, prices, employment, and trade in Northwest forest industries, all quarters 2013. Resour. Bull. PNW RB-266. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 163 p. https://doi.org/10.2737/PNW-RB-266.