Executive Summary

THE WILDLAND IMPERATIVE

Forests

California's forests and woodlands cover roughly one-third of the land base in the state. These forests are a valuable resource that support a broad range of environmental and socio-economic services that include carbon storage, protecting water supply and water quality, improving air quality, promoting biodiversity, and providing wildlife habitat, recreation opportunities, and sustainable wood products, as well as other services.

Forests are shaped by disturbance from wildfire, insects and diseases, drought, and other agents that occur both naturally and from management activities. Forests face a legacy of changes to ecosystem structure and function that have occurred since the arrival of Europeans in California. As the climate warms, our forests are experiencing heightened impacts from drought, pests, and altered fire regimes. While climate change will continue to impact ecosystem processes, management actions can be used to aid in our forests' ability to adapt to ongoing changes. Climate change is causing us to rethink how forests are managed and how to work collaboratively to implement management actions across broad landscapes that include multiple ownerships. Over the past 50 years, forest management has been strongly influenced by policies centered on sustainable use of forest resources and conservation of resources for future generations. Restoration practices have often focused on desired structural conditions, including tree density, size classes, and species composition. Over the past decade, there has been much greater concern that climate change is degrading forest health, permanently decreasing the area of forests in the state, and, in some cases, threatening the existence of forest species or their presence in some parts of their current geographic range. There is an increasing awareness of the need to restore ecosystem processes, including natural fire regimes, in addition to restoring ecosystem structure. Significant restoration efforts can conserve forests but may not completely halt climate change-driven loss of forest area in the state.

Rangelands

California rangeland (a land cover type that includes grasslands, deserts, and shrublands) covers 48% of the state and is one of the globe's most biologically diverse temperate ecosystems. Woodlands, which cover 9% of the state, can also be considered a rangeland type. These landscapes provide a suite of important ecosystem services including wildlife habitat, water filtration and storage, open space, recreation, and carbon storage. Rangelands also produce forage for grazing by domestic livestock, which can be an important component of rural economies.

Over 10 million acres of former rangelands have been converted to agriculture or development since the onset of Euro-American settlement, and while protective laws and conservation programs have slowed the pace of development and helped maintain the ranching industry in recent decades, development and conversion threats to these lands persist today. The economic sustainability of ranching operations, which is important for deterring such conversion, continues to decline. Major non-socioeconomic challenges to the sustainability of California's rangeland vegetation include climate change, invasive species, and wildfire. All three of these impacts interact on rangelands in ways that often exacerbate threats to native vegetation. Other concerns on California's rangelands relate to water quality, oak regeneration, and rare plant and animal species and their habitats.

In the face of a multitude of challenges to rangeland vegetation types and the important ecosystem services provided by them, opportunities exist for enhancing rangeland sustainability, including through existing state, local government, and nonprofit organization programs. State policies and programs have

been responsive to the threat climate change poses to rangelands, including actions such as the establishment of nature-based solutions (NBS) climate targets. Throughout the state, public agencies are using grazing to manage vegetation and meet resource management objectives including watershed management, fire fuels reduction, and wildlife habitat management. Where funding, suitable policy, public support, and workforce capacity exist, opportunities abound to promote rangeland conservation, restore or enhance ecosystem services, keep rangelands working, and support the solvency and stability of the state's livestock businesses.

Defining Resilience

Ecosystem resilience can be defined as the capacity of an ecosystem to withstand and recover from disturbance (Forzieri et al. 2022). Resilience encompasses narrower concepts such as resistance, which describes the ecosystem's ability to withstand disturbance without undergoing significant change (Hessburg et al. 2019). Resilience can be challenged when disturbance regimes diverge from what an ecosystem is adapted to, with changes to the frequency or magnitude of disturbance.

Resilient forests can experience wildfires, drought, pests, and other types of disturbance and still remain forests that support a broad range of ecosystem functions and contribute to human needs. Forest composition, structure, and stand density can greatly influence forest resilience; combined with the severity of disturbance, these factors can lead to a range of different ecological outcomes (Bushey et al. 2023, Falk et al. 2022, Johnstone et al. 2016). Resilience may encompass multiple scales from stand- to landscape-level. At the stand level, variation in forest structure and composition, including species and age classes as well as the spatial arrangement of trees into clumps and openings, can contribute to greater resilience. At the landscape scale, resilience is promoted by a variety of disturbance histories that lead to patchy, variable forest structures that match site conditions for climate and topography. The concept of the natural range of variation is often used in describing resilient forest conditions, as forest structure can change over space and time. In addition, the diversity of species in an ecosystem is thought to increase resilience by providing a level of functional equivalency if one species is severely impacted by disturbance and no longer present or well represented. The great diversity of ecosystem types in California supports a large number of native tree species, approximately 85–100 species depending on classification approach (Ritter and Kauffmann 2025, USFS 2024).

Managing for Resilience

Depending upon the location, ecosystem properties, and management legacy, managing for forest resilience may require a variety of different management approaches. Keeping forests as forests is a primary conservation goal. However, as the climate warms, researchers believe that drier conifer forests in much of California will need to be managed at much lower stand densities than currently exist (North et al. 2022). Given higher levels of stress placed on forests under a warmer climate and the larger magnitude of disturbance, a greater management emphasis will be needed to assist in recovery from uncharacteristically severe wildfire. Reforestation may be a forward-looking opportunity to embed resilience by designing for future stressors. For example, using variable spacing and species mixes, shifting away from uniform plantations, and using prescribed fire to build resilience in young stands may all enhance resilience (North et al. 2019).

For rangelands, ecological resilience operates at varying scales, including individual plant, plant community, grazing unit, and watershed. Examples of disturbances affecting plants directly include drought, herbivory, and wildfire. Managing rangelands for resilience means managing landscapes such that the current plant community avoids ecological thresholds, so that disturbances are less likely to drive the system beyond that threshold. Land managers can improve resilience in rangelands by better understanding how the site, plant community, and individual plants respond to a disturbance, as well as the natural variability of a site or landscape (Gillaspy and Green 2023). For example, resilience may be addressed by harvesting only a part of the available forage by using light stocking rates and short grazing periods.

Institutions also play an important role in supporting ecosystem resilience by shaping the social, political, and economic frameworks within which management decisions are made (Chaffin et al. 2014). They influence how resilience is defined, measured, and prioritized, and they govern access to resources, implementation of treatments, and long-term stewardship. Effective institutions can foster adaptive management by integrating scientific knowledge and supporting collaboration across jurisdictions (Prichard et al. 2021). Rigid institutional arrangements can prevent timely, coordinated response to ecological change. With the rapidly changing conditions we are now seeing on California's wildlands, the power of partnerships to build trust and to get resilience work done across our biophysically and administratively varied forest and rangeland landscape has never been needed more. Fortunately, many parties have been stepping up and bringing energy, resources, and consensus to the table. Continued support of federal, tribal, and state partnerships is critical to successfully addressing forest and rangeland resilience needs statewide.

Research, Monitoring, and Assessment

Accelerating biophysical and social change and uncertainty are overarching themes for California's forests and rangelands today. Maintaining or increasing our research capacity helps both to reduce this uncertainty and to build public trust in efforts to protect and manage forests and rangelands in these dynamic times. California Demonstration State Forests and federal Experimental Forests and Ranges play an important role in providing opportunities for multi-decadal research studies.

Monitoring and assessment are essential for evaluating the effectiveness of management actions. Rigorous research products bolster our ability to create transparent monitoring (data collection) and assessment systems. This information is needed to understand what resilience treatments are being implemented on our forests and rangelands and whether they are moving resource conditions in the directions desired, especially as background conditions also are changing with a warming climate.

Use of Indicators to Evaluate Resilience

The Forest and Rangelands Assessment report tracks status and trends in over 50 indicators that collectively evaluate a broad range of factors that influence the health and resilience of these lands (Appendix E.1). The indicators are based in part on the Montréal Process, an internationally recognized evaluation and reporting system. The Montréal Process consists of seven criteria, each with a set of indicators that were originally chosen to evaluate forest sustainability. The Fire and Resource Assessment Program (FRAP) first developed Montréal Process-based indicators specific to California in 2003 and later expanded the focus of each criterion to include rangelands using criteria and indicators developed by the Sustainable Rangelands Roundtable (Mitchell et al. 2010).

In the Executive Summary, we evaluate each Montréal Process Criterion (MPC) by synthesizing findings from the Assessment indicators found in each MPC across the chapters. In addition, for each MPC we identify policy issues that are established or emerging to address concerns in forest or rangeland resilience. To match the focus on resilience we have reordered the MPC so MPC3, Maintenance of Forest Ecosystem Health and Vitality, is discussed first.

MONTREAL PROCESS CRITERION 3: MAINTENANCE OF FOREST ECOSYSTEM HEALTH AND VITALITY

Summary

Current stand conditions, ongoing changes to the climate, and altered disturbance regimes combine to raise serious concerns about forest health. Past land management policies and practices and decades of fire exclusion in many areas (ⓘ4.1) have changed forest structure and composition (ⓘ1.2), resulting in vulnerability to high severity wildfire (ⓘ4.2, ⓘ4.4). California experienced heightened and ongoing widespread tree mortality from forest pests over the last decade (ⓘ5.1), along with increases in pest outbreaks (ⓘ5.2). Burned area and the extent of high severity fire in forests has dramatically increased in recent years (ⓘ4.3, ⓘ4.4). Statewide and across most ownerships, net tree growth is declining. Disturbance impacts on National Forest System lands are contributing to mortality losses and reducing net growth on both productive forestland and less productive forestland (ⓘ1.1, ⓘ7.5). These trends are consistent with impacts related to climate change, specifically increases in temperature (ⓘ7.1), multi-year drought (ⓘ7.2), and an increasingly arid atmosphere (ⓘ7.3). A warming climate and high stand density increase plant water use, resulting in greater climatic water deficit (ⓘ9.4). Loss of older forests is of particular concern as they make up a smaller proportion of the landscape and have high habitat value (ⓘ10.2). Sustained efforts are needed to scale up forest restoration and fuel reduction treatments (ⓘ4.5). Assessment analyses also raise concerns about the ability of various forest habitats to persist in some areas under future climate conditions (ⓘ10.4).

INDICATORS

- ⓘ1.1 Net Growth on Timberland
- ⓘ1.2 Timberland Restoration
- ⓘ4.1 Fire Return Interval Departure
- ⓘ4.2 Fire Threat
- ⓘ4.3 Wildfire Activity
- ⓘ4.4 Wildfire Severity
- ⓘ4.5 Vegetation Treatments
- ⓘ5.1 Tree Mortality
- ⓘ5.2 Native and Exotic Pests
- ⓘ7.1 Temperature
- ⓘ7.2 Precipitation
- ⓘ7.3 Vapor Pressure Deficit
- ⓘ7.5 Live Tree Carbon
- ⓘ9.4 Climatic Water Deficit
- ⓘ10.2 Forest Stand Age Class by Ownership
- ⓘ10.4 Habitat Vulnerability to Climate Change

Background

Forest ecosystem health and vitality in California is strongly linked to ecosystem processes such as an intact fire regime. Many forested areas in California were managed with fire by Indigenous communities in order to create and maintain resilient ecosystems. Current high forest stand densities (ⓘ1.2), departure from historic fire regimes (ⓘ4.1), increased fire severity (ⓘ4.4), and increased drought and pest mortality (ⓘ5.1) are significant components of the forest health problem and are symptomatic of past and current fire and land management policies as well as changes in climate (ⓘ7.1, ⓘ7.2, ⓘ7.3, ⓘ9.4). Reforestation needs have also become acutely heightened due to increasingly large and frequent patches of high severity wildfire. The Assessment chapters suggest numerous opportunities to address

these problems, many of which are already being implemented. For example, fuel reduction treatments are conducted by state and federal agencies (ⓘ4.5), but not commensurate to the need due to various constraints. Although efforts have been ramping up to increase capacity for beneficial forest management, challenges remain. In many parts of the state, lack of wood processing infrastructure (including biomass energy) constrains the ability of small owners to market wood products and of all owners to market low value removals typical of thinning or salvage operations. Concerns over smoke impacts, risk of escape, limited burn windows, and availability of qualified personnel may restrict the reintroduction of beneficial fire. An important area of ongoing effort is empowering Indigenous peoples to manage their ancestral lands with cultural fire.

Current stand conditions and trends related to wildfire, pests, and climate continue to raise serious concerns about forest health, particularly for yellow pine and mixed conifer forests.

Forest Stand Density

Overly dense forests have elevated fire and pest risks that can threaten these stands as well as surrounding landscapes. Old growth forests with large trees are rarer on the landscape than they were historically, offer the greatest benefits for wildlife and carbon storage, and are vulnerable to loss from pest outbreaks or high severity wildfire when they are overly dense. Based on 2012–2021 Forest Inventory and Analysis (FIA) data, total acreage potentially in need of treatment to reduce stand densities totals 7.1 million acres, including 4.6 million acres with full inter-tree competition (35–60% relative stand density index [SDI]) and 2.6 million acres in the zone of imminent mortality (≥60% relative SDI) (Figure E.1, ⓘ1.2). Dangerously high stand densities occur on public, forest industry, and nonindustrial timberlands. On the other hand, approximately 3.4 million acres of forestland are free of inter-tree competition. Some of this area is in need of reforestation, particularly in areas affected by large patches of high severity fire where there is a lack of natural regeneration capacity. Recently burned accessible areas in need of reforestation are estimated to total 1.5 million acres. The

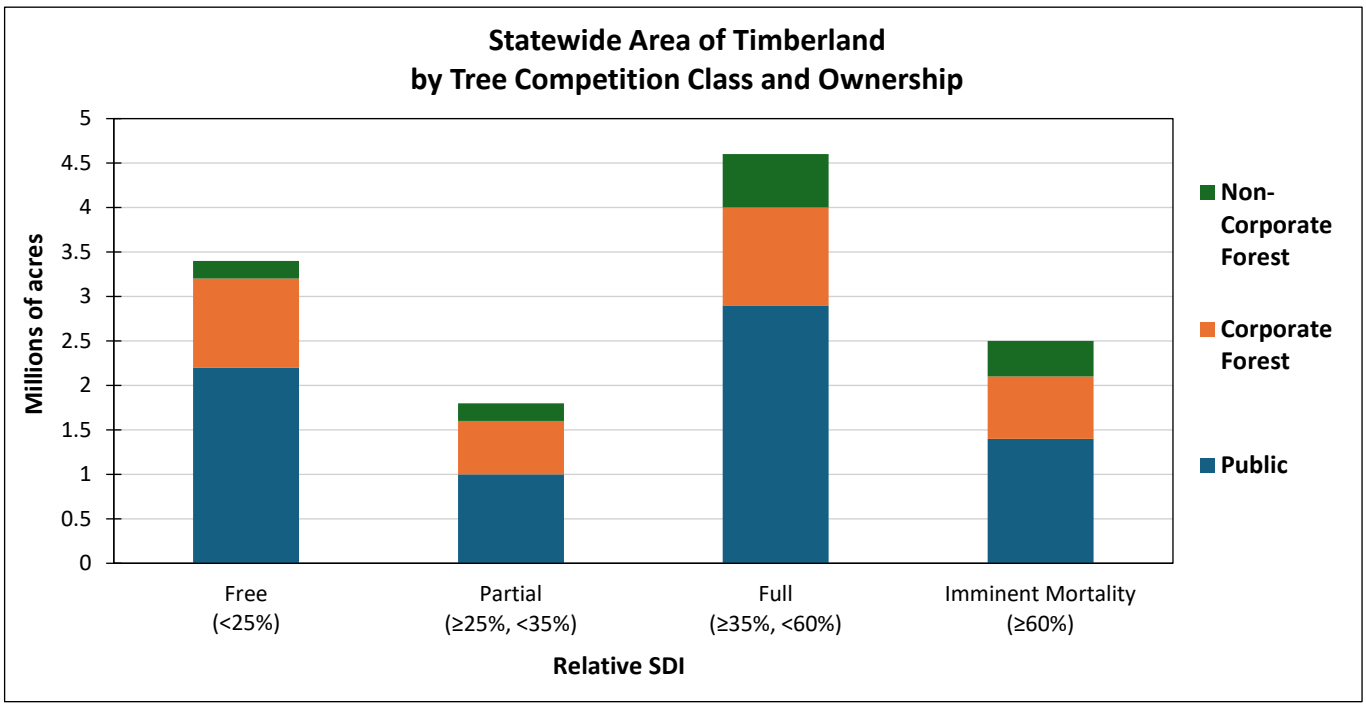


Figure E.1. Indicator 1.2, Timberland in Need of Restoration, shows acres of timberland by competition class (i.e., free, partial, full competition classes, or zone of imminent mortality). Classes are assigned based on the relative stand density index (SDI) of a site, which compares current stand density to a maximum stand density based on site productivity. This provides an estimate of acres for which treatments may be warranted to improve stand density based on inter-tree competition. Data Source: USFS (2024).

greatest area of forest in need of treatment is on public lands, which also comprise the majority of forestlands in the state. Additionally, statewide and across most ownerships, net growth of trees is declining with overall growth decreasing while mortality is increasing (ⓘ1.1, ⓘ7.5). A disproportionate amount of wildfire, pest, and drought-related mortality occurred on publicly owned lands (ⓘ4.4, ⓘ5.1). While active management such as beneficial fire can improve forest health and resilience, the sustainable stand density of forest ecosystems may decline in a warming climate.

Fire Return Interval Departure

Although the extent of burned area has increased in recent years (ⓘ4.3), most forestlands still exhibit a deficit of fire compared to their historical fire regime. Fire Return Interval Departure (FRID) measures the departure of current fire regimes from historical (pre-Euro-American settlement) regimes in terms of average number of years between burn events. Acres by vegetation group are characterized by degree of departure or condition class (ⓘ4.1). Negative condition class numbers represent areas where the current fire return interval (FRI) is shorter than the presettlement FRI; positive numbers identify areas where the current FRI is longer than the presettlement FRI.

Areas dominated by conifer, hardwood, and mixed conifer-hardwood vegetation are burning less frequently than they did in the pre-settlement era, with over 66–73% of these vegetation types by area in the high departure class (+3) (Figure E.2). The high departure is most evident in the Sierra Nevada, Southern Cascades, and Klamath-North Interior mountain ranges. Some shrub-dominated areas are burning more frequently than in the historical era, with 12% by area in moderate (-2) and 3% in high departure (-3) across the state (and much higher percentages in the South Coast region). However, the amount of negative departure in shrublands has decreased since the 2017 Assessment,

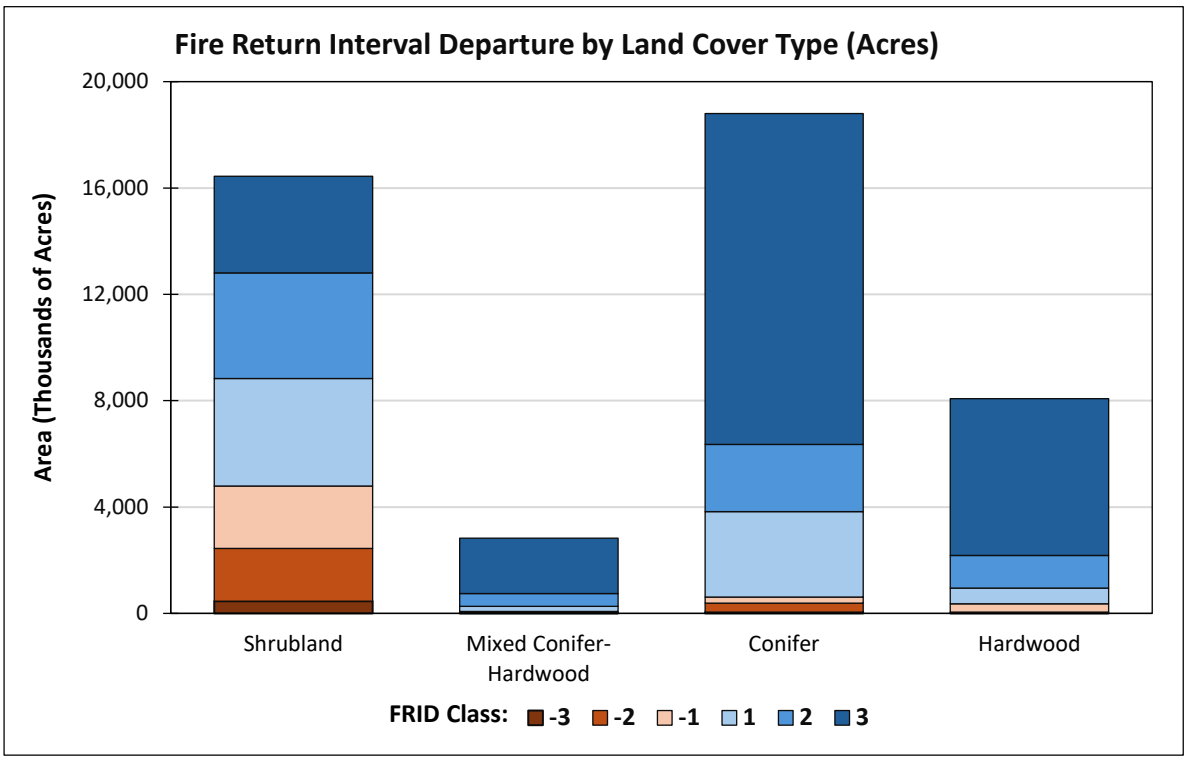


Figure E.2. Indicator 4.1, Fire Return Interval Departure, (FRID), quantifies the difference between current and reference fire frequencies (departure) for four broad vegetation classes (CA Wildlife Habitat Relationships Lifeform). Percent FRID (pFRID) scales departure between -100% and 100%, where negative values indicate fire is occurring at a greater frequency than reference (fire excess), and positive values indicate fire is occurring at a lower frequency (fire deficit). Condition Class groups pFRID values into equal-interval low, moderate, and high departure classes (-3, -2, -1, 1, 2, 3). Values of –1 and 1 indicate <33.3% departure and can be considered not substantially departed from reference frequencies. Data Source: Safford et al. (2022).

suggesting that fire suppression has been effective in aiding recovery of some shrublands that had previously burned with too high frequency.

Fire Severity

The most extensive forest types in the state, including yellow pine, mixed conifer, and montane hardwood, are dependent on a frequent low-severity fire regime that maintains fine-scale variation of forest structure, reduces fuel continuity, and promotes resilience to disturbance. Interruption of natural fire frequencies (ⓘ4.1) and changes to forest structure from over a century of fire exclusion and historical timber harvest that focused on removing the largest trees have resulted in overly dense, structurally homogeneous forests with too few large, fire-tolerant trees in many areas. These forests are not adapted to the large, contiguous patches of high severity fire that have occurred at increasing extent in recent years, leading to large-scale tree regeneration failure and type conversion to shrub or grass dominated vegetation in some areas. The oak species prevalent in montane hardwood forests can resprout after fire but may stay in a shrub form for decades after high severity fire. These landscape level changes raise concerns over negative impacts on soil productivity, water quality, wildlife habitat, and carbon storage. This trend is projected to worsen in the coming decades, but treating forests now to reduce the risk of high severity fire can mitigate some of the projected losses.

The extent of stand-replacing fire in forests, once shaped and maintained by frequent, low-severity fire, has continued to increase. High-severity patch size has also increased, threatening forest ecosystems by leading to regeneration failure, reduced snowpack retention, increased erosion potential, and a high likelihood of reburning at high severity in a subsequent wildfire.

Policy Issues

MPC3: Policy issues for maintenance of forest ecosystem health and vitality	
Policy Issue	**Options and Opportunities**
Restoration of natural fire regimes	Support collaborative landscape-level efforts and Indigenous land stewardship to reduce stand densities where needed, restore stand structure and composition, restore post-fire landscapes, leverage pyrosilviculture[1], and reintroduce beneficial fire to meet USFS and state treatment goals and improve forest health across all ownerships. Increase transparent monitoring and assessment processes to ensure desirable outcomes are achieved and support landscape-level planning efforts such as potential operational delineations (PODs).
Wood processing infrastructure deficit	Expand capacity to produce traditional and innovative wood products by developing a long-term plan for sustainable timber supply, improving project financing opportunities through new and existing programs such as low-cost bridge financing, development grants, tax incentives and subsidies, and addressing barriers related to existing and emerging products.
Workforce development	Develop and promote training and vocational programs and other efforts to expand the forest sector workforce, such as through workforce development grants. Maintain adequate funding and staffing for public land management.
Private nonindustrial forest management	Reduce barriers for more active management to maintain productive and resilient forests, including regulatory process/cost reduction, increased marketing options, increased availability of technical/financial assistance, and prescribed fire liability insurance.
Adapting policies and practices for climate change	Increase transparent monitoring and assessment processes to ensure desirable outcomes are achieved. Support critical research needed to anticipate changes and adapt programs, policies, and practices for climate change.
Data Note 1: Pyrosilviculture is a forest management approach that prioritizes the use of fire, both prescribed fire and managed wildfire, to achieve forest management objectives, or alters non-fire silvicultural treatments to optimize the incorporation of prescribed fire in the future.	

MONTREAL PROCESS CRITERION 2: MAINTENANCE OF PRODUCTIVE CAPACITY[1]

Summary

Maintaining productive capacity includes protecting forest and rangelands from conversion or from being withdrawn from production through legal or administrative action. It also involves ensuring timber, grazing, and fire management policies and practices do not diminish site conditions and productivity.

Maintaining forest and rangeland is affected by development pressures, though working landscapes are increasingly being protected from conversion through conservation easements and acquisitions by conservation organizations (ⓘ6.2). As a result, conversion rates have stayed relatively low in the last decade compared to earlier years (ⓘ2.1). The California Forest Practice Rules (FPRs) have evolved to better facilitate forest health treatments that yield some commercial timber products, and forest managers on working forests are demonstrating sustainable harvest (ⓘ1.1) and participating in various sustainability initiatives (ⓘ1.5). However, a variety of constraints limit more active management on both public and private lands, and there has been a steady decline in the number of harvested acres and volume since the 1990s (ⓘ1.3, ⓘ1.4). Reductions in wood processing facilities (ⓘ1.4, ⓘ12.2) and federal grazing allotments (ⓘ2.3) can impact the economic viability for maintaining forest and rangeland and preventing conversion.

As discussed above, current stand conditions created due to past fire and land management policies and practices, as well as trends related to climate change and altered disturbance regimes, raise serious concerns about forest health. Impacts related to climate change are occurring, with ongoing tree mortality from pests and drought (ⓘ5.1), increasing incidence of native and non-native pests (ⓘ5.2), and increased frequency and severity of wildfire (ⓘ4.3, ⓘ4.4). Statewide and across most ownerships, net tree growth is declining (ⓘ1.1, ⓘ7.5). Millions of acres are experiencing high fire threat and are in need of restoration (ⓘ1.2, ⓘ4.2). Vegetation treatments are used (ⓘ4.5) to address forest restoration needs and reduce surface fuels and the risk of high severity wildfire. However, projected climate

INDICATORS

- ⓘ1.1 Net Growth on Timberland
- ⓘ1.2 Timberland Restoration
- ⓘ1.3 Silvicultural Methods
- ⓘ1.4 Historic Timber Harvest
- ⓘ1.5 Sustainability Initiatives
- ⓘ2.1 Rangeland Conversion
- ⓘ2.3 Federal Grazing Allotments
- ⓘ4.2 Fire Threat
- ⓘ4.3 Wildfire Activity
- ⓘ4.4 Wildfire Severity
- ⓘ4.5 Vegetation Treatments
- ⓘ5.1 Tree Mortality
- ⓘ5.2 Native and Exotic Pests
- ⓘ6.2 Protected Private Wildlands
- ⓘ7.5 Live Tree Carbon
- ⓘ12.2 Biomass Energy

1 *This section also includes Sustainable Rangelands Roundtable Criterion III: Maintenance of rangeland productive capacity.*

trends and post-fire regeneration failure could impact the future extent of forests.

Background

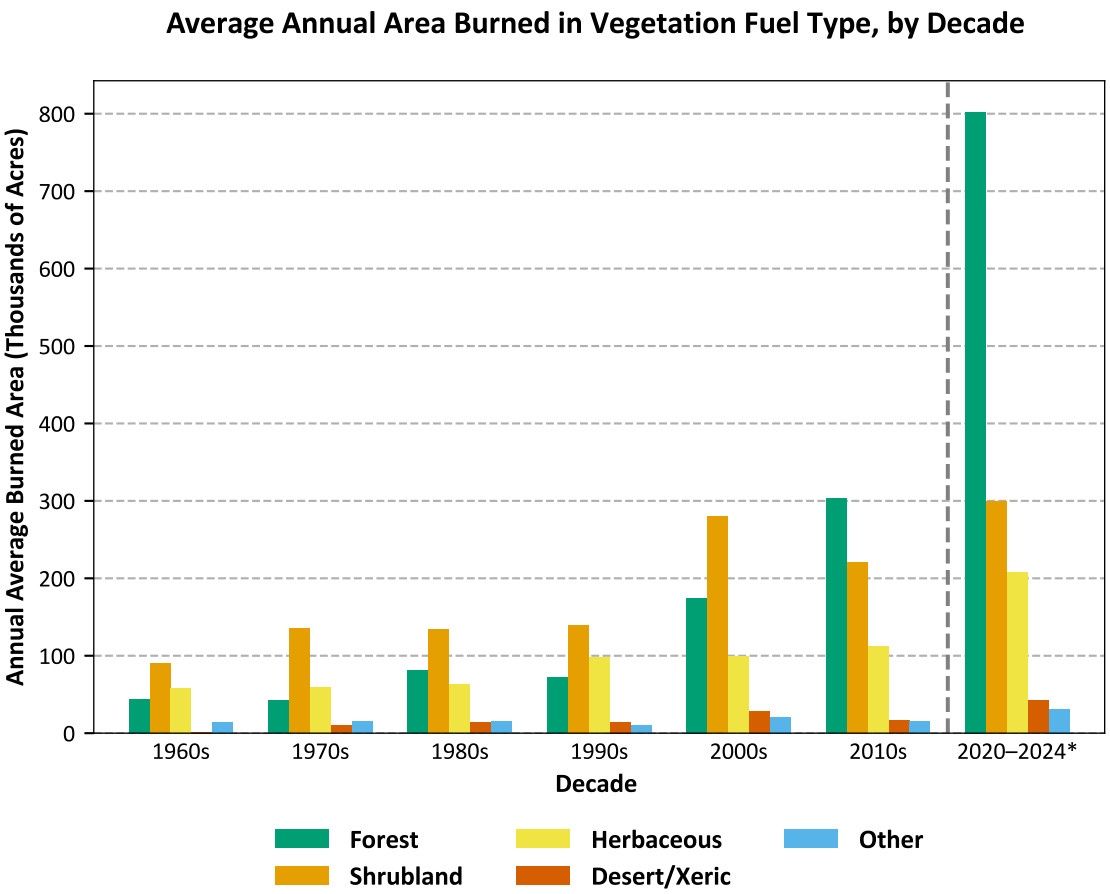
California has some of the most productive land in the world for growing timber and grazing livestock. In recent years, net conversion of productive forestland available for timber production (i.e., timberland) to developed or agricultural uses is less than 2,000 acres per year, and for all forestland it is closer to 7,000 acres per year, or around 0.02% of all forestland. Since 2010, the annual rangeland conversion to development has remained steady at about 7,500 acres per year, rising to 10,000 acres per year in 2022 (ⓘ2.1). Between 2019 and 2023, CAL FIRE received fewer than 600 acres per year in less-than-three-acre Timberland Conversion Exemption requests and just one to two larger requests per year. In 2023, there were close to 450,000 acres of timberland, 592,300 acres of all forestland, and 1.6 million acres of rangeland under conservation easements (ⓘ6.2).

Loss of forests and rangelands in earlier decades led to state programs under the Williamson Act (1965) and Forest Tax Reform Act (1976) aimed at protecting these lands from conversion through tax incentives. More recently, a growing awareness of the economic, social, and environmental importance of these lands is driving trends towards "smart growth" that reduces sprawl and increases efforts to protect open spaces and working landscapes through land acquisitions and conservation easements (ⓘ6.2). For example, state and federal Forest Legacy Program working forest conservation easements are protecting forests from conversion to non-forest uses. Governor Gavin Newsom's "30x30" initiative, led by the California Natural Resources Agency (CNRA), is aimed at conserving 30% of California's lands and coastal waters by 2030 and tracks lands that are durably protected, with 25% of lands conserved as of 2024.

Productive capacity can also be influenced by past timber, grazing, and fire policies and practices, and the resulting condition of the land and vegetation. Approximately 80% of productive forestland in the state is available for timber production. The FPRs have evolved, and forest managers on working forests are demonstrating sustainable harvest (ⓘ1.1) and participating in various sustainability initiatives (ⓘ1.5). Overharvesting of existing softwood growing stock does not appear to be an issue, as growth exceeds harvest and mortality on timberlands for each ownership group when assessed at the landscape scale (ⓘ1.1).

Under future climate, California could lose 48% of its forest area, mainly from increases in high severity fire area and post-fire regeneration failure.

Nevertheless, forests face a variety of threats. An ongoing concern is the impact of climate change on productive capacity, which may vary by region or vegetation type. Some studies indicate that California's forests will experience a net loss in carbon, biomass, and area over the next 50 years. One estimate projects that under a business as usual management regime with projected climatic warming as much 50% of the carbon and 48% (15 million acres) of the forest area could be lost by 2071 due mainly to increased extent of stand-replacing wildfire and post-fire regeneration failure. Ongoing tree mortality from pests and drought (ⓘ5.1), increasing incidence of native and non-native pests (ⓘ5.2), and increased extent and severity of wildfire (ⓘ4.3, ⓘ4.4) have had significant impacts on vegetation condition and timber operations. As a result, statewide and across most ownerships, average net growth of trees has declined since the 2017 Assessment with overall average growth decreasing and average mortality increasing (ⓘ1.1, ⓘ7.5). Further analysis is needed to determine the relative impacts on net growth from individual tree-level changes in growth rates versus the impact from loss of live trees due to mortality. Mortality losses exceeded growth on National Forest System lands on both productive forestland and less productive forestland, following a disproportionate amount of wildfire, pest, and drought-related mortality occurring on publicly owned lands (ⓘ4.4, ⓘ5.1). The scope and scale of restorative treatments needed at the landscape scale, including



**Annual burned area averages for 2020–2024 include January 2025.*

Figure E.3. Indicator 4.3, Wildfire Activity, shows average annual area burned within broad vegetation fuel classes by decade. Data Source: CAL FIRE (2025a).

reducing stand densities in certain areas, managing fuels associated with tree mortality, and restoring forests post-fire, is significant and challenging (ⓘ1.2).

A variety of constraints limit more active management on both public and private lands. Some constraints include, but are not limited to, concerns over impacts to state and federally listed species, limited and uncertain funding and staff in federal agencies, and lack of skilled workers. There has been a steady decline in the number of harvested acres and volume since the 1990s (ⓘ1.3, ⓘ1.4). Declines in harvest have been accompanied by a corresponding decline in wood processing facilities in some parts of the state. These reductions in wood processing facilities (ⓘ1.4, ⓘ12.2) can reduce the economic viability for managing and maintaining forestland. Similarly, there are many limitations that affect the reforestation process and limit the ability to complete post-fire restoration activities.

Efforts to facilitate forest health and fuel reduction treatments are underway, such as changes in the FPRs (e.g., the additions of Emergency and Exemption Notices), collaborations like the California Wildfire and Forest Resilience Task Force (WFR Task Force), joint state-private investment in reforestation seedling production, increased availability of technical and financial landowner assistance programs, and efforts to restore Indigenous land stewardship. Vegetation treatments are increasing to address restoration needs (ⓘ4.5). Recent state and federal emergency declarations centered around wildfire hazard aim to streamline and fast-track environmental review and permitting, in some cases by streamlining compliance with environmental

review, the Endangered Species Act, and the National Historic Preservation Act.

On timberlands, there has been a major increase in acres filed for harvesting under Emergency Conditions (California Code of Regulations 2017) (ⓘ1.3). There have been over 352,000 reported acres under post-fire Emergency Notices since the 2014 fire season. Following unprecedented wildfires in 2020 and 2021, 215,000 harvested acres, or 68% of the total harvested area, were covered by Emergency Notices. 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. Additionally, state and federal emergencies were declared at the beginning of 2025 related to forest health and fire hazard. The state subsequently developed the Statewide Fuels Reduction Environmental Protection Plan, which is expediting project implementation by providing an alternative means for meeting requirements for environmental review.

Similarly, a variety of stressors threaten rangeland productivity, though comprehensive statewide monitoring data are lacking for range condition. Climate change, invasive species, and wildfire interact on rangelands in ways that often exacerbate threats to native vegetation and reduce forage quantity or quality. Climate change can influence productivity by changing the length or timing of the dry season, increasing precipitation variability, and intensifying drought. In deserts and shrublands, the widespread presence of non-native annual grasses alters fire regimes by providing more continuous and highly flammable fuels, and in some areas can lead to a grass-fire-grass cycle that inhibits native vegetation dominance. Additionally, in woodlands, competition from non-native annual grasses and overgrazing can inhibit oak regeneration, further impacting productivity. Federal grazing allotments have slightly declined in recent years (ⓘ2.3), however in some areas conversion of forest to rangelands from high severity fire could increase forage availability and make some allotments more desirable.

Efforts to improve forest health, restore ecological processes and natural fire regimes, and restore post-fire landscapes on both forests and rangelands will be critical for maintaining productive ecosystems that are resilient to the impacts of climate change.

Policy Issues

MPC2: Policy issues for maintenance of productive capacity	
Policy Issues	**Options and Opportunities**
Forest and rangelands conversion	Support ecological and economic sustainability of rangelands by continuing to honor Williamson Act contracts in cases where there is a clear conservation and/or economic benefit. Continue use of the Timberland Production Zone (TPZ) to provide tax incentives to maintain productive timberland as timberland. Sustain and increase efforts to protect working landscapes through easements. Work to achieve the state's NBS climate targets.
Forest and rangeland health	See MPC3 for detailed discussion of forest health issues. Restoring ecological processes, natural fire regimes, post-fire landscapes, and Indigenous land stewardship are important to improve forest and rangeland health. Support workforce development and viable forest product markets and infrastructure to better facilitate forest restoration treatments. Increase transparent monitoring and assessment to ensure desirable outcomes are achieved.
Climate change	Improve overall ecosystem health (see MPC3) to maintain or increase resiliency and reduce climate change impacts. Support research and adaptive management approaches for changing management practices to maintain resilient ecosystems as climate changes. Support overall efforts at many levels to reduce greenhouse gas emissions.
Landowner assistance	Continue to improve regulatory processes and enhance efforts to provide technical and financial assistance to small landowners to improve the productivity and health of forest and rangelands. Maintain adequate funding, staffing, and collaborative relationships to support forest and rangeland treatments on public lands. Expand CAL FIRE nursery operations to provide seedlings to landowners for replanting following tree mortality from drought, pest outbreaks, and wildfire.

MONTREAL PROCESS CRITERION 5: FOREST CONTRIBUTION TO GLOBAL CARBON CYCLES

Summary

Forests, rangelands, and urban shade trees play a fundamental role in regulating global carbon cycles by storing carbon in vegetation and soils and by exchanging CO_2 with the atmosphere. As global warming increases and changes in temperature (ⓘ7.1), precipitation (ⓘ7.2), seasonal vapor pressure deficit (ⓘ7.3), spring runoff (ⓘ9.3), and climatic water deficit (ⓘ9.4) occur, there are concerns that ecosystems will struggle to adapt to rapid changes in climate and altered disturbance regimes.

Current stand conditions (ⓘ1.2) combined with the increasing frequency of large, severe wildfires (ⓘ4.3, ⓘ4.4), drought and pests (ⓘ5.2), and associated tree mortality (ⓘ5.1) have begun to impact carbon storage (ⓘ7.4, ⓘ7.5) and overall forest sector carbon sequestration (ⓘ7.6). Inventory methods differ on whether the state's forests are currently a carbon source or sink, but sequestration rates appear to be decreasing. The capacity of forests to store carbon is expected to continue to decrease in a warming climate. Vegetation treatments (ⓘ4.5) can be used to stabilize the remaining carbon stored. Treatments can address both the legacy of altered fire regimes on forest density and fuel loads, as well as reduce the heightened competition trees are experiencing in a warming climate.

Wood utilization associated with forest management also can enhance forest sector carbon sequestration (ⓘ7.6). However, reductions in wood processing facilities (ⓘ1.4, ⓘ12.2) can impact the feasibility of conducting forest management and limit utilization. In some cases, forest carbon offset projects are being implemented to enhance the carbon sequestration potential of forests (mainly in the North Coast) and contribute to greenhouse gas mitigation (ⓘ1.6).

INDICATORS

- ⓘ1.2 Timberland Restoration
- ⓘ1.4 Historic Timber Harvest
- ⓘ1.6 Carbon Offset Projects
- ⓘ3.1 Urban Tree Canopy Cover
- ⓘ4.3 Wildfire Activity
- ⓘ4.4 Wildfire Severity
- ⓘ4.5 Vegetation Treatments
- ⓘ5.1 Tree Mortality
- ⓘ5.2 Native and Exotic Pests
- ⓘ7.1 Temperature
- ⓘ7.2 Precipitation
- ⓘ7.3 Vapor Pressure Deficit
- ⓘ7.4 Carbon Storage - Forests
- ⓘ7.5 Live Tree Carbon
- ⓘ7.6 Carbon Sequestration
- ⓘ9.3 Spring Runoff
- ⓘ9.4 Climatic Water Deficit
- ⓘ12.2 Biomass Energy

Background

California has among the most productive temperate forests in the world, which can serve as vital sinks for atmospheric CO_2 (a primary greenhouse gas), storing carbon in living and dead standing plants, downed logs, forest litter, soils, and long-lived durable wood products (ⓘ7.4, ⓘ7.5). Through natural processes and proper sustainable management, forests can function through

time, sequestering carbon for timescales from decades to centuries.

Over the last 100 years, air temperature has shown steady increases (ⓘ7.1) and future climate change scenarios predict that trend to continue. By contrast, the annual amount of precipitation has shown no clear trend (ⓘ7.2). However, the increase in the proportion of precipitation occurring in intense rainfall events leads to more extreme conditions. In addition, increases in temperature alone will result in changes in spring runoff (ⓘ9.3), increases in climatic water deficit (ⓘ9.4), and increases in atmospheric dryness, particularly in summer months (ⓘ7.3).

Changes to these climate factors that have occurred as a result of increasing atmospheric CO_2 concentrations can result in changes in tree growth, the range and distribution of species, and disturbance regimes. These include changes in the extent (ⓘ4.3) and severity (ⓘ4.4) of wildfires, pest infestations (ⓘ5.2) and related mortality (ⓘ5.1), and other agents of disturbance, which have implications for the quality and durability of California's forest carbon sinks. Increases in area burned (Figure E.3) can have both positive and negative effects. Low to moderate severity fire can improve resilience of the remaining trees and carbon, while high severity may permanently decrease carbon storage if trees are not reestablished.

Carbon Storage

Total carbon storage in above and belowground living and dead plant materials in California's forests is 11,403 Tg CO_2e (ⓘ7.4). Two-thirds of carbon storage is found on federal, state, and other public lands. Total carbon storage is greatest across the Sierra Cascades and Klamath/Interior Coast Ranges, while the greatest storage of carbon per acre is found in the North Coast. Across all forestlands, the amount of carbon stored as dead pools has increased from 8% to 9.5% since the 2017 Assessment. California's forests can store large amounts of carbon, but the amount of above ground carbon storage must be balanced against the risk of losses from wildfire, pests, and disease. Managing forests to promote health and resilience can result in a short-term reduction in the amount of carbon stored but is an essential strategy to prevent larger losses from disturbance events. When forest management activities are paired with wood utilization, carbon benefits associated with management can be enhanced. Carbon stored in harvested wood products originating from harvest in California between 1904–2021 amounts to 518 Tg CO_2e. New additions to the harvested wood product storage pool have slowed in the last two decades, but the total amount stored has continued to increase.

Carbon Sequestration by Ownership Groups

This Assessment estimates California's forest sector to be a net sink, sequestering an average of 22.0 Tg CO_2e per year when considering the net change in all components of the forest sector and wood utilization data (ⓘ7.6). However, inventory methods differ on whether the state's forests are currently a carbon source or sink. While FIA data used for the Assessment indicate that California's forests functioned as a net carbon sink over the most recent remeasurement period (ⓘ7.4), the rate of sequestration has been decreasing and rapid changes may have a lag in the data due to the multi-year data collection cycle. Other carbon inventories based on annual data over shorter timeframes indicate that California's forests may already be a net carbon source (CARB 2022, DeLyser et al. 2025).

Land management policies involve trade-offs between carbon sequestration, carbon storage in live trees versus wood products, and risk of loss from wildfire and pests (ⓘ7.5). For example, intensive management for wood products as practiced by forest industry (often on the most productive timberlands in the state) is associated with higher rates of sequestration, lower levels of mortality, and harvest resulting in carbon storage in long-lasting wood products, but can still leave trees at risk to high severity wildfire. Gross tree growth on industrial lands was highest and exceeded removal from harvest and mortality, reflecting sustained yield (Figure E.4). The aboveground live tree (AGL) pool on these lands saw a net gain of 0.88 Mg CO_2e/acre/year or a total of 4.7 Tg CO_2e/year. Achieving net positive carbon sequestration may be most easily attained on sites that are naturally more productive.

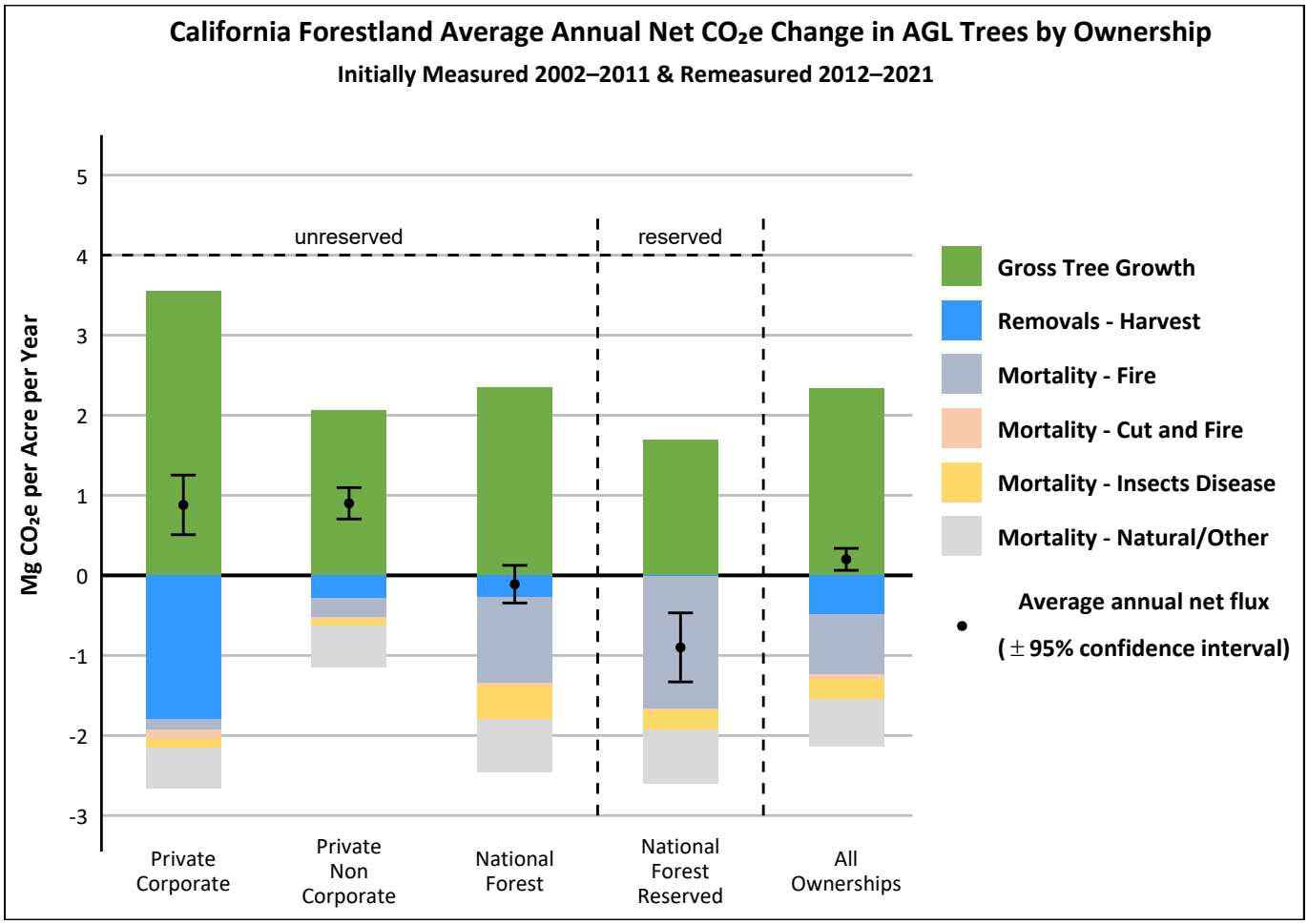


Figure E.4. Indicator 7.5, Live Tree Carbon, shows average annual growth, removals, mortality by cause, and net change in aboveground live (AGL) tree carbon on all forestland by owner/reserve class over the FIA remeasurement period (2002–2011 to 2012–2021). Rapid changes to forests may have a lag before they are reflected in the FIA data. Reserved land is unavailable for management for timber production. Data Source: USFS (2024).

National Forest System (NFS) unreserved forestlands vary in site quality and conditions and are managed for multiple objectives, including ecosystem services. These lands have lower harvest rates than private forests and higher per acre growth rates than NFS reserved lands. The AGL pool on these lands saw a net loss of -0.11 Mg CO_2e/acre/year or a total loss of -0.6 Tg CO_2e/year due to high rates of tree mortality, particularly from fire and drought. Although total carbon stocks are highest on public lands due to the sheer areal extent of these lands (ⓘ7.4), they also have experienced the greatest combined losses from fire and insect mortality (with the greatest increases in these losses since the 2017 Assessment).

Tree maintenance and new tree planting in urban forests (ⓘ3.1) can also contribute directly to carbon sequestration. Urban tree canopy can reduce greenhouse gas emissions related to air conditioning by cooling urban areas, as well as contribute to quality of life for residents by reducing heat island effects and providing aesthetic value. Trees in urban forests also face threat from increased incidence of pests (ⓘ5.2).

Management of California's Forest Carbon Resources

Proactively managing forests to reintroduce beneficial fire, promote forest health, reforest burned areas, and aid in climate adaptation is the best approach to managing forest carbon. Forest thinning typically increases tree growth rates by reducing competition, especially for younger trees. In addition, low severity fire, including prescribed fire, can stabilize the carbon stored in forests by decreasing subsequent wildfire severity, and thinning can reduce drought stress. Climate mitigation

strategies that incorporate the whole forest sector, including forest ecosystem and harvested wood product carbon, with additional consideration of wood material and energy substitution, can maintain forest ecosystem carbon while also increasing carbon benefits from harvested wood products. Managing trade-offs in forest health, carbon storage in live trees, growth rates based on age and density, and the risk of loss due to pests and wildfire may reduce forest ecosystem stocks or overall sequestration rates while enhancing overall forest resilience.

Policy Issues

MPC5: Policy issues for forest contribution to global carbon cycles	
Policy Issues	**Options and Opportunities**
Promote forest health to reduce large carbon losses	Support management of forests to restore fire regimes and match tree species and densities to topographic and climatic conditions. Maintain a variety of age classes and seral stages to enhance resilience to disturbance and balance tradeoffs in sequestration versus storage (see MPC3). Implement the WFR Task Force Action Plan and its pending 2026 update, California Air Resources Board (CARB) 2022 Scoping Plan, and NBS climate targets. This may reduce overall carbon but enhance carbon storage in live trees and minimize losses due to wildfire, insects, disease, and drought.
Reforestation of areas impacted by large-scale high severity wildfire	Encourage active reforestation followed by active land stewardship to increase rates or ability to recapture carbon and maintain forestland. Implement the NBS climate targets and the recommendations of DeLyser et al. (2025). Support the California Reforestation Pipeline Partnership.
Promote development of mature forest characteristics that can store more carbon on public lands, and protect existing mature and late-seral stands with active management to reduce surface fuel loads and lower wildfire risk	Conduct forest health and restoration treatments that maintain a variety of age classes and seral stages at the landscape-scale. Consider management on public lands that reduces losses of existing mature stands, fosters development of mature stands into late-seral, and facilitates reintroduction of beneficial fire. Implement the NBS climate targets, the CARB 2022 Scoping Plan, and the recommendations of DeLyser et al. (2025).
Increase carbon storage in wood products	Promote climate mitigation strategies that incorporate the whole forest sector, including forest ecosystem and harvested wood product carbon. See the WFR Task Force Action Plan and its pending 2026 update and DeLyser et al. (2025).
Carbon sequestration and heat island mitigation through urban forests	Maintain and enhance urban trees and tree cover.

MONTREAL PROCESS CRITERION 1: CONSERVATION OF BIOLOGICAL DIVERSITY[2]

Summary

California's plant and animal species are experiencing increasing pressure due to higher wildfire severity (ⓘ4.4), more forest pests and invasive species (ⓘ5.1, ⓘ5.2), and continuing human development (ⓘ2.1). Climate change poses an additional threat to wildlife habitats (ⓘ10.4). Modeling efforts under different climate scenarios show that the quantity, quality, and spatial distribution of habitat types are expected to change, including reduction in forest area.

There is increasing action being undertaken to conserve the natural landscapes that provide habitat for the state's diverse plant and animal species.

Protecting natural landscapes from development is being accomplished through acquiring fee title by public or conservation organizations and increasing the establishment of conservation easements on private lands (ⓘ6.2). Additionally, the state has a goal of conserving 30% of California's lands and coastal waters by 2030 to restore biodiversity and build resilience to climate change. Approximately 25% of California's

2 *This section also includes Sustainable Rangelands Roundtable Criterion II: Conservation and Maintenance of Plant and Animal Resources on Rangelands.*

lands met the target goal and criteria through 2024. Implementation of the state's NBS climate targets also will contribute to the conservation of forests and rangelands and their wildlife.

Background

Detailed accounting of wildlife sustainability concerns and conservation strategies are provided by the California Department of Fish and Wildlife's (CDFW) State Wildlife Action Plan (SWAP) 2025 Update. The 2025 FRAP Assessment focuses on specific concerns related to species at risk, habitat conversion and protection, habitat structure, habitat quality and degradation, and climate change impacts.

Species at Risk

The Assessment indicators show that California's plant and animal species are under increasing threats. Of the approximately 7,500 plants and animals native to California, 415 (5.5%) are listed as threatened or endangered under either the California or federal Endangered Species Act as of April 2024 (ⓘ10.1), an increase of seven species since the 2017 Assessment. Fifteen of 32 salmonid populations in California are listed (compared to 14 in 2017), and 45% of California salmonid populations are likely to be extinct by 2070 unless significant actions are taken. Dam removals, such as have recently taken place on the Klamath River, are one of several approaches being used to aid salmonid recovery. The most comprehensive account of at-risk species in the state is provided by CDFW's list of Species of Greatest Conservation Need (SGCN), which consisted of 1,439 species in 2025 (359 invertebrates, 88 amphibians and reptiles, 180 birds, 100 fish, 175 mammals, and 537 plants). Overall, approximately 18% of California's native plant and animal species are considered SGCN.

Habitat Conservation and Protection

After a steep decline in annual rangeland conversion to development during the recession of 2007–2009, the number of rangeland acres converted has held relatively steady at around 7,500 acres per year. The last few years have seen a slight uptick in rangeland development to above 10,000 acres per year (ⓘ2.1). Projected population trends through 2060 are expected to allow this recent trend to continue (ⓘ6.1).

In addition to significant areas of forest and rangeland being protected from development under public ownership, approximately 4% of forest and range habitats are directly protected from conversion through conservation organization ownership or through establishing conservation easements on private lands (ⓘ6.2). In 2022, conservation easements protected about 600,000 acres of forestland (including woodlands) and 1.6 million acres of rangeland, many of which are working landscapes where timber management and grazing continue to contribute to local economies. The

INDICATORS

- ⓘ1.5 Sustainability Initiatives
- ⓘ2.1 Rangeland Conversion
- ⓘ4.4 Fire Severity
- ⓘ5.1 Area of Tree Mortality from Forest Pests
- ⓘ5.2 Native and Exotic Pests
- ⓘ6.1 Recent and Projected Population Trends
- ⓘ6.2 Protected Private Wildlands
- ⓘ10.1 Species at Risk
- ⓘ10.2 Forest Stand Age by Ownership
- ⓘ10.3 Habitat Degradation
- ⓘ10.4 Habitat Vulnerability to Climate Change
- ⓘ10.5 Protected Habitat

irregular pattern of protected areas across ownerships and elevations creates issues for adequate habitat connectivity. Easements can expand and connect biologically important fragmented areas into more viable habitats. Voluntary use of Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs) provide additional protections to fish and wildlife (ⓘ1.5).

High-elevation forest types within the California Wildlife Habitat Relationships (CWHR) system such as Red Fir, Subalpine Conifer, and Aspen are at least 90% protected in almost all regions through public ownership. Nearly 80% of hardwood woodland habitat types are privately owned and thus have low protected status (e.g., Blue Oak Woodland [21%], Valley Oak Woodland [19%], Foothill Pine [24%] and Coastal Oak Woodland [37%]) (ⓘ10.5). Annual Grassland and Coastal Scrub rangeland communities also tend to have lower protection.

Habitat Structure

Forest structure and wildlife habitat requirements continue to be a concern. Stand age and structure vary significantly by ownership group. Forests on private working lands are dominated by early- to mid-seral stand ages, while at least 80% of late seral stands (stand age >200 years old based on the average age of the most abundant size class of canopy trees) are found on lands managed by the U.S. Department of Agriculture Forest Service (USFS). Currently only 14% of California conifer forests meet the above definition for late seral (ⓘ10.2). As discussed above, concerns over loss of mature forests due to high severity wildfire (ⓘ4.4) and tree mortality (ⓘ5.1) have spurred significant efforts in managing forests to be more resilient, including increasing the pace and scale of restoration treatments and reintroducing natural fire regimes where feasible.

Habitat Quality and Degradation

Human development, including urbanization, farming, and ranching, has split much of the state into smaller, disconnected patches. Terrestrial landscape intactness has been quantified for California based on several human impacts (ⓘ10.3). Vegetation types with the most extensive human disturbance (low intactness) are coastal, foothill, riparian, and wetland vegetation types, such as Valley Foothill Riparian (71% low intactness), Desert Riparian (42%), Valley Oak Woodland (43%), Coastal Scrub (30%), Montane Riparian (25%), and Coastal Oak Woodland (27%).

Numerous additional factors continue to degrade the state's wildlife habitat. Wildfires have become larger and more severe in the past decade, particularly in forestlands (ⓘ4.4). The highest percentage of stand-replacing fire from 2015 to 2021 occurred in White Fir (15.9%), Klamath Mixed Conifer (13%), Douglas Fir (10.8%), and Sierran Mixed Conifer (13%) CWHR forest types. High severity wildfire, drought, and bark beetle-related tree mortality have resulted in 30% of the southern Sierran Nevada conifer forest becoming shrublands or sparsely treed landscapes since 2010 (Steel et al. 2023). Additionally, non-native, invasive species adversely impact both plant and animal communities. Approximately 215 non-native plants are considered invasive and a threat to wildlands (DiTomaso et al. 2017). Native and non-native insects and diseases continue to cause extreme tree mortality, with non-native forest pest species having tripled since the 1950s (ⓘ5.2). Solar and wind projects also are impacting habitat. Utility-scale solar energy photovoltaic farms have greatly expanded in the past 10 years, primarily on desert, grassland, and agricultural lands.

Climate Change Impact

Climate change is an overarching threat to wildlife habitat, including salmonid streams. Modeling under different climate scenarios predicts that the quantity and spatial distribution of habitat types will change as the location of suitable climates shift. Sixty animal species are projected to have a high degree of climate exposure impacts across the majority of their potentially suitable habitat under a high emissions scenario, with reptiles having the highest number and percentage of species impacted (ⓘ10.4). This suggests that their habitat distribution may move or contract substantially. In terms of climate change impacts to individual tree species, modeling shows that whitebark pine, red fir, and giant sequoia are particularly vulnerable.

Policy Issues

MPC1: Policy issues for conservation of biological diversity	
Policy Issues	**Options for Opportunities**
Protect forest and rangelands from conversion	Continue to work towards California's goal of conserving 30% of the state's land base by 2030 (30x30). Incentivize landowners to conserve and improve habitat. Re-examine the potential for certain well-protected working forests to fit within the 30% rubric.
Adaptation to climate change	Utilize updated climate models and monitoring data such as the California Sentinel Site Network to inform land management and policy decisions. Implement the state's NBS climate targets.
Wildlife habitat connectivity	Focus on conservation efforts that prioritize optimal connectivity. Implement the state's 30x30 policy.
Anadromous fish habitat	Implement the California Salmon Strategy for a Hotter, Drier Future and the strategies included for anadromous salmonids in CDFW's SWAP 2025 Update.
Ecosystem health	Consider biodiversity, wildlife habitat, and reduction of invasive species when implementing forest resilience or fuels reduction projects. Implement the state's NBS climate targets.

MONTREAL PROCESS CRITERION 4: SOIL AND WATER RESOURCES

Summary

Forests and woodlands account for only 32% of lands within California, but forested watersheds produce approximately 70% of California's surface water supply (Liu et al. 2021). With large urban populations and vast agricultural systems dependent upon forested watersheds for abundant, high-quality water, it is necessary to understand the stressors on these systems, as well as how watershed outputs may change under drier and warmer climates and changing disturbance regimes. Water resource indicators (ⓘ9.1, ⓘ9.2, ⓘ9.3, ⓘ9.4) showed only minor changes from the 2017 Assessment report. Forests still maintain relatively good water quality and continue to provide substantial water supply to farms and urban areas. However, there is increasing interannual variability in precipitation (ⓘ7.2), and combined with increasing temperature (ⓘ7.1), drought events are becoming more severe. In addition, annual area burned by wildfire is increasing (ⓘ4.3), as is the proportion of wildfire burning at high severity (ⓘ4.4), particularly in forestlands. This increases the risk of post-fire debris flows and flooding, degrades water quality, and increases reservoir sedimentation rates.

INDICATORS

- ⓘ1.3 Silvicultural Methods
- ⓘ4.3 Wildfire Activity
- ⓘ4.4 Wildfire Severity
- ⓘ4.5 Vegetation Treatments
- ⓘ7.1 Temperature
- ⓘ7.2 Precipitation
- ⓘ7.3 Vapor Pressure Deficit
- ⓘ9.1 Water Quality
- ⓘ9.2 Snowpack
- ⓘ9.3 Spring Runoff
- ⓘ9.4 Climatic Water Deficit

Background

Healthy forests play an important role in the hydrologic cycle, promoting infiltration, holding soil on slopes, and maintaining the delivery of high-quality water to streams and downstream uses. Despite this pivotal role, forest watershed functions have been undervalued. In many watersheds, the management practices and fire exclusion have resulted in forests that are either at risk from fire and pests or have already been heavily impacted by such disturbances. In addition, post-fire erosion from large wildfires and other disturbances is

negatively impacting water quality, downstream water storage, and critical water supply infrastructure.

Indicators and key findings suggest that California's climate and hydrology are changing, resulting in more extreme droughts (ⓘ7.2) and warmer annual temperatures, with increases in both maximum and minimum temperatures (ⓘ7.1). In turn, warmer temperatures are causing declining snowpack (ⓘ9.2) and altering the timing of spring runoff (ⓘ9.3). As snowmelt begins to occur earlier in the spring, California is likely to see longer dry periods and an increase in wildfire activity (ⓘ4.3) across a longer portion of the year. In addition, as evapotranspiration from forest vegetation increases under warmer temperatures (ⓘ7.3, ⓘ9.4), vegetation becomes further stressed, especially when there are prolonged drought conditions (ⓘ7.2). Climatic water deficit (ⓘ9.4) has shown steady increases in summer months and is associated with increased wildfire activity. When these climatic factors are combined with overly dense stands, forests are more susceptible to damage from drought, pests, and severe wildfires.

Soil Erosion and Water Quality

There are a number of potential impacts from forest management on hydrologic and geomorphic processes. Over the past three decades, forest harvesting practices on non-federal and federal lands have mostly been found to be protective of water quality when they are properly implemented. Fuel reduction treatments in forested areas, including mechanical thinning, prescribed fire, and mastication, have increased in the past seven years (ⓘ4.5) and generally have been found to produce limited adverse hydrologic impacts. Forest roads remain the largest source of anthropogenic erosion associated with both standard timber harvesting and fuel reduction treatments. Post-fire salvage logging is increasing in California due to increasingly extensive and severe fire in forested areas (ⓘ1.3). In recent years (2020–2024), salvage operations have ranged from 50,000 to 100,000 acres annually, and in 2021–2022 the acreage of salvage operations exceeded the acreage of standard (green tree) timber harvest. Salvage logging can 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). Positive outcomes from salvage logging require a high degree of planning and a high standard of best management practice implementation (Wagenbrenner et al. 2023).

Rangeland practices are not regulated under a comprehensive system like the California Forest Practice Rules. The State Water Resources Control Board and the Regional Water Quality Control Boards are developing a new, non-regulatory guidance document on livestock grazing management to replace the voluntary 1990s era California Rangeland Water Quality Management Plan. The federal Clean Water Act, under the Total Maximum Daily Load (TMDL) process, provides a regulatory approach to take corrective action when necessary. There are 20 grazing-related TMDL listings in the state, spread across five of the nine water quality regions. Grazing impacts to water quality can include soil erosion, soil compaction, loss of streambank stability, degraded water quality, and lowered aquatic habitat quality. Water quality indicators show that a greater proportion of rangeland watercourses are in poorer condition compared to forested streams (ⓘ9.1). Water quality impacts from grazing tend to be associated with increased nutrient concentrations, pathogens and bacterial contamination, and sediment. The impacts from grazing depend on the season of use, intensity, and type of livestock. Improved range management practices have been shown to be effective in protecting water quality and human health.

Wildfire Activity

Wildfire activity has increased dramatically in recent decades and currently averages over 1.65 million acres burned annually since 2020 (ⓘ4.3). The annual average for this period (2020–2024) includes years with both very low and very high burned area, as there tends to be high variability in area burned from year to year. The area burned at high severity has also increased over the last four decades and exceeds the historical range for some vegetation types (ⓘ4.4). The combination of more extensive areas burned and greater proportion at high severity has caused mean annual post-fire erosion to increase significantly in the past decade (Dow et al.

2024). High severity wildfires are adversely impacting water quality, small reservoir storage, and critical water supply infrastructure, as well as increasing post-fire debris flow and flooding hazards. A notable example is the large December 2017 Thomas Fire, which burned approximately 282,000 acres in Ventura and Santa Barbara counties. In January 2018, heavy rains hit the unincorporated community of Montecito in Santa Barabara County, producing debris flows that resulted in 23 fatalities, damaged or destroyed more than 500 structures and bridges, and shut down U.S. Highway 101 for 13 days (Lancaster et al. 2021).

Protection and Restoration of Headwater Forests

Headwater forests, including stream channels and mountain meadows that feed into downstream water supplies, play a critical role in our water supply and water management system. As discussed under MPC3, they are threatened by factors including climate change, changes in disturbance regimes, and management approaches that vary among mixed ownerships. Forests with high stand densities compete for limited resources, including available soil water, and are subject to higher disturbance and mortality rates. These conditions result in changes to disturbance regimes that can impact water resources. Many of the management actions taken to reduce wildfire risk and improve forest health can also serve to restore and enhance water resources in headwater forests. Stream channels and mountain meadows are important features in headwater regions that have been degraded by past management actions, and in some cases, impaired to the point that they no longer properly function. Process-based restoration of these features to reestablish natural hydrologic processes is needed for enhanced watershed recovery and to make watersheds more resilient to fire, drought, and floods. For example, California's NBS climate targets call for conservation and restoration of mountain meadow wetlands through restoring proper hydrologic flow, removing encroaching conifers, and beaver re-introduction.

Policy Issues

MPC4: Policy issues for soil and water resources	
Policy Issues	**Options and Opportunities**
Disturbance and changes to forest hydrology	Continue investment in federal and state programs for monitoring and assessment associated with water supply and water quality concerns.
Protection and restoration of headwater forests	Prioritize funding for restoration of headwater forests, target fuel reduction and expanded use of beneficial fire, and restoration of forests subject to severe wildfire. Prioritize restoration of mountain meadows and degraded stream channels. Where practical, work with ranchers to develop agreements to retire or modify grazing practices in allotments with ecologically and hydrologically important mountain meadows. Implement California's NBS climate targets to protect and restore headwater forests and meadows.
Long-term impacts on water resources from forest management and changes in climate	Encourage sustained funding and continued investment in long-term monitoring, assessment, and experimental watershed studies (including maintaining cooperative state and federal partnerships).

MONTREAL PROCESS CRITERION 6: MAINTENANCE AND ENHANCEMENT OF LONG-TERM MULTIPLE SOCIO-ECONOMIC BENEFITS TO MEET THE NEEDS OF SOCIETIES

Summary

California's forests and rangelands play a crucial role in supporting both environmental health and rural economies, providing essential services such as timber, grazing, recreation, carbon storage, water, and renewable energy. However, these ecosystems are facing growing pressures from a combination of climate change, past land management practices, and the challenges associated with past rapid population growth.

Economic trends show resilience in the overall economy and in certain sectors, but the state's rural counties, which accounted for approximately 1% of the state's economic activity in 2023, have experienced widening income disparities and stagnant wage

growth (ⓘ8.1, ⓘ8.2). California's rural economies are shaped to a lesser extent than they used to be by timber production, ranching, recreation, and renewable energy. Timber harvests have declined, with private lands now producing most commercial timber (ⓘ1.3, ⓘ1.4) and sawmill infrastructure shrinking. Despite this, forest management, including timber harvest, remains important to rural economies, and may play a bigger role as the state increases the pace and scale of forest management to mitigate wildfire risk. Ranching has consolidated over time, with a decrease in small-scale operations (ⓘ2.2). The renewable energy sector, including solar and wind power (ⓘ12.1), offers opportunities, while the forest biomass energy sector has declined considerably over the past several decades (ⓘ12.2).

Health disparities are evident in a number of ways. Within urban areas, many low-income neighborhoods have less access to green infrastructure, such as parks, tree canopy, and open spaces, compared to wealthier areas. These amenities play an important role in mitigating the adverse effects of heat and air pollution (ⓘ3.3, ⓘ3.4). The disparities also exist across the urban-rural gradient, since rural areas often face higher exposure to wildfire smoke (ⓘ11.5) and heat extremes. Wildfire risks, particularly in the wildland-urban interface (WUI), exacerbate economic and social vulnerabilities, with the effectiveness of wildfire resilience efforts reliant on addressing funding, land-use planning, and community preparedness.

Background

California's forests and rangelands provide vital natural resources and environmental services, including wood products, forage for commercial livestock, recreation, water supply, biodiversity, carbon storage, and renewable energy. In urban areas, trees and green spaces provide a different but equally important set of benefits, helping to mitigate heat, improve air quality, and enhance public health, livability, and property value. While traditional land uses such as timber harvesting and ranching have declined as a share of the rural economy, the demand for ecosystem services from these landscapes has grown. Increasingly, there is interest in

INDICATORS

- ⓘ1.3 Silvicultural Methods
- ⓘ1.4 Historic Timber Harvest
- ⓘ2.2 Beef Cattle Farms by Size Class
- ⓘ3.1 Urban Tree Canopy Cover
- ⓘ3.2 Impervious Surfaces
- ⓘ3.3 Air Pollution
- ⓘ3.4 Urban Heat
- ⓘ6.1 Population Trends
- ⓘ8.1 Economic Performance
- ⓘ8.2 Economic Prosperity
- ⓘ8.3 Economic Stress
- ⓘ8.4 Economic Structure
- ⓘ11.1 Structure Loss
- ⓘ11.2 Housing by Hazard Class
- ⓘ11.3 Housing in WUI
- ⓘ11.4 Community-Level Wildfire Planning
- ⓘ11.5 Annual Frequency of Hazardous Smoke Days
- ⓘ12.1 Contribution of Renewable Energy Sources to California
- ⓘ12.2 Biomass Energy

managing natural lands to enhance their role in wildfire risk reduction, climate mitigation, and community resilience.

Forests and rangelands, and their associated ecosystem services, now face mounting pressure from a combination of climate change, altered disturbance regimes, and demographic shifts. The erosion of ecosystem health jeopardizes the long-term delivery of environmental services and contributes to public safety threats and economic risks in rural and urban settings alike. The consequences of these changes include record-setting wildfire with devastating impacts on lives, homes, and infrastructure; severe post-fire flooding and debris flow events; and growing public health challenges linked to smoke exposure and extreme heat. Yet these challenges also create opportunities. Strategic investment in forest and rangeland restoration, sustainable land and groundwater management, and community resilience initiatives can reduce risk, support ecological recovery, and generate employment.

California's overall economy has continued to show strength, but many rural areas face persistent challenges, including limited access to infrastructure, workforce shortages, and uneven recovery from economic shocks. Expanding and diversifying rural economies—through sustainable use of forest and rangeland resources and investment in new sectors such as biomass utilization and climate resilience—remains essential for long-term economic vitality.

In California's cities and towns, climate change is also straining the health of urban forests and intensifying environmental inequities. Vulnerable populations often face the highest exposure to heat and poor air quality, underscoring the importance of targeted urban forestry efforts.

Forest and Rangeland Contributions to the Rural Economy

Timber harvests, though substantially reduced from their historical peak, continue to be a source of economic activity in rural regions. There has been a long-term decline in the total acreage harvested on both federal and non-federal lands, with recent harvests on non-federal lands increasingly driven by post-disturbance salvage logging under Emergency Conditions (ⓘ1.3). The timber industry has experienced a 72% drop in total harvest volume since 1955, with private lands producing the majority of commercial timber (ⓘ1.4). The sawmill infrastructure has simultaneously contracted, with only 31 operational mills remaining statewide (ⓘ1.4). Despite this contraction, timber harvest and other forest management remain a key component of the rural economic structure, albeit increasingly challenged by regulatory, ecological, market, and workforce constraints. In 2023, agriculture, forestry, fishing, and hunting combined accounted for 7% of gross domestic product (GDP) in rural counties.

California's rural economies are also shaped by ranching activities and demographic change. A steep decline in small-scale cattle operations has occurred, while the largest cattle farms have remained stable, suggesting a consolidation of agricultural production (ⓘ2.2). Meanwhile, population dynamics show that rural counties experienced slight growth during the COVID-19 pandemic but returned to long-term decline trends in 2023, reinforcing the challenge of maintaining economic vitality in these areas (ⓘ6.1). This challenge is reflected in economic performance indicators: rural counties account for just over 1% of the state's total economic activity (ⓘ8.1), with real per capita GDP and household incomes substantially lower than metro areas (ⓘ8.2), and a widening income and productivity gap over the past two decades. This economic divide influences access to healthcare, education, and other social determinants of well-being. While statewide social vulnerability scores are not systematically higher in rural areas (ⓘ8.3), there is marked variation within and across rural counties, with some communities exhibiting high socioeconomic stress and limited adaptive capacity. Economic structures in rural counties tend to be more dependent on a narrow set of industries, heightening their exposure to sector-specific downturns (ⓘ8.4), thereby limiting resilience and compounding the challenges of economic transition or recovery from disasters.

The energy sector presents both opportunities and trade-offs for rural economies. Renewable energy mandates have stimulated growth in solar and wind power, but forest biomass has declined by 25% in output and facilities since 2001 (ⓘ12.2). This reduction constrains the ability of forest-rich rural counties to derive economic value from hazardous fuels and mill residuals. Achieving long-term socio-economic benefits will depend on aligning renewable energy development with local capacities and ecosystem constraints, and ensuring that energy infrastructure investments support—not displace—rural communities and land-based livelihoods.

Urban Forestry Contributions to Health, and Well-Being

Urban forests and green infrastructure contribute significantly to health and well-being, particularly in mitigating the impacts of heat and air pollution. Urban tree canopy cover varies widely across counties, with an average of 21% statewide. There is a legislatively mandated statewide goal for a 10% urban tree canopy coverage increase per urban area by 2035 (ⓘ3.1). Tree canopy can help reduce urban heat islands and improve air quality, yet many urban and rural communities—often in disadvantaged or under-resourced areas—remain below target thresholds. Impervious surfaces, which exacerbate heat and runoff issues, have increased by 5% statewide from 2011 to 2021 (ⓘ3.2). These trends are concerning when viewed alongside a rising number of days over 90°F (ⓘ3.4), particularly in inland areas, posing risks to public health. Elevated temperatures combined with poor air quality, where PM2.5[3] and ozone exceedances persist (ⓘ3.3), have very harmful effects for vulnerable populations, including children, the elderly, and those with pre-existing health conditions. Smoke exposure from wildfires has also increased in recent years (ⓘ11.5).

Building Resilient Communities

One of the most significant and growing threats to health and well-being in both rural and WUI communities is wildfire. The risk to structures from wildfire has escalated due to a combination of increased development in fire-prone areas, particularly in past decades, and climate- and fuels-driven changes in fire behavior (ⓘ11.1, ⓘ11.2, and ⓘ11.3). Community Wildfire Protection Plans (CWPPs) serve as a critical tool for coordinating local efforts to reduce fire risk and prioritize fuel treatments, yet implementation is often hindered by funding constraints and fragmented jurisdictional authority (ⓘ11.4). The consequences of wildfire extend beyond direct structure loss—smoke exposure (ⓘ11.5), displacement, long-term economic disruption, and mental health impacts all affect community well-being. The effectiveness of CWPPs and other resilience efforts will depend on integrating land use planning; hardening structures for fire resistance; and implementing regulations associated with high and very high fire hazard severity zones (FHSZs), forest management, and community preparedness, particularly in areas where high vulnerability to wildfire and low economic capacity intersect.

3 *PM2.5 refers to fine particulate matter that is inhalable with a diameter of 2.5 micrometers (~0.0001 inch) or less, which is a mixture of dust, soot, chemicals, and other microscopic particles.*

Policy Issues

MPC6: Policy issues for maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies	
Policy Issues	**Options and Opportunities**
Expand economic opportunities in rural California	Support resilient communities, particularly through renewed investment in forest and land-based sectors such as sustainable timber production, biomass utilization, rangeland management, and forest restoration. These sectors offer local employment potential to rural counties, while contributing to climate resilience, watershed health, and wildfire risk reduction.
Support the provisioning of ecosystem services in forest and rangeland systems	Develop policies to support long-term stewardship, adaptive management, and restoration investment to ensure ecosystems continue to provide important socio-economic benefits into the future.
Reduce exposure to wildfire smoke and expand urban forestry to mitigate heat and air quality impacts	Support integrated policies that expand access to clean air spaces, improve public health communication, and invest in preventive infrastructure. Invest in urban forestry to reduce heat exposure and deliver co-benefits for climate resilience and community livability.
Improve community resilience to wildfire through risk reduction, preparedness, and adaptation strategies	Support investments in defensible space, home hardening, landscape-scale fuels reduction, and community planning. These efforts present opportunities to align public safety with ecological restoration and workforce development.
Support urban forestry initiatives	Enhance urban forests and access to green spaces to improve social well-being, since urban tree cover is underdeveloped in many areas.

MONTREAL PROCESS CRITERION 7: LEGAL, INSTITUTIONAL, AND ECONOMIC FRAMEWORK FOR FOREST CONSERVATION AND SUSTAINABLE MANAGEMENT

Summary

In the face of the ecological, socioeconomic, and management challenges discussed above, the state, federal government, and many partners have been vastly increasing levels of facilitative laws, policies, and investment in addressing the state's forest resilience and wildfire problems. The ability of entities to maintain this level of activity and investment into the future is paramount to meeting the critical need for adaptive management of the state's forests and rangelands.

Background

Legislation, institutional capacity, research, collaborative efforts, and monetary arrangements, with associated policy measures, can create an enabling environment for the management of forests and rangelands. These elements broadly underpin circumstances for favorable outcomes under the other six MPC.

Legislation, Regulation, and Policies Supporting the Sustainable Management of Forests

State and federal legislation and policies supporting the sustainable management of forests in California have grown significantly since 1995. The state has passed 104 bills closely related to forest and wildfire management

INDICATORS

- ⓘ1.5 Sustainability Initiatives
- ⓘ11.4 Community-Level Wildfire Planning
- ⓘ13.1 Legislative Bills and Governors' Executive Orders and Proclamations Addressing Wildfire and Forest Management
- ⓘ13.2 CAL FIRE Expenditures and Staffing
- ⓘ13.3 Peer Reviewed Journal Articles Relating to Forest and Wildfire Management in California
- ⓘ13.4 Partnerships and Public Engagement in Forest-Related Decision Making

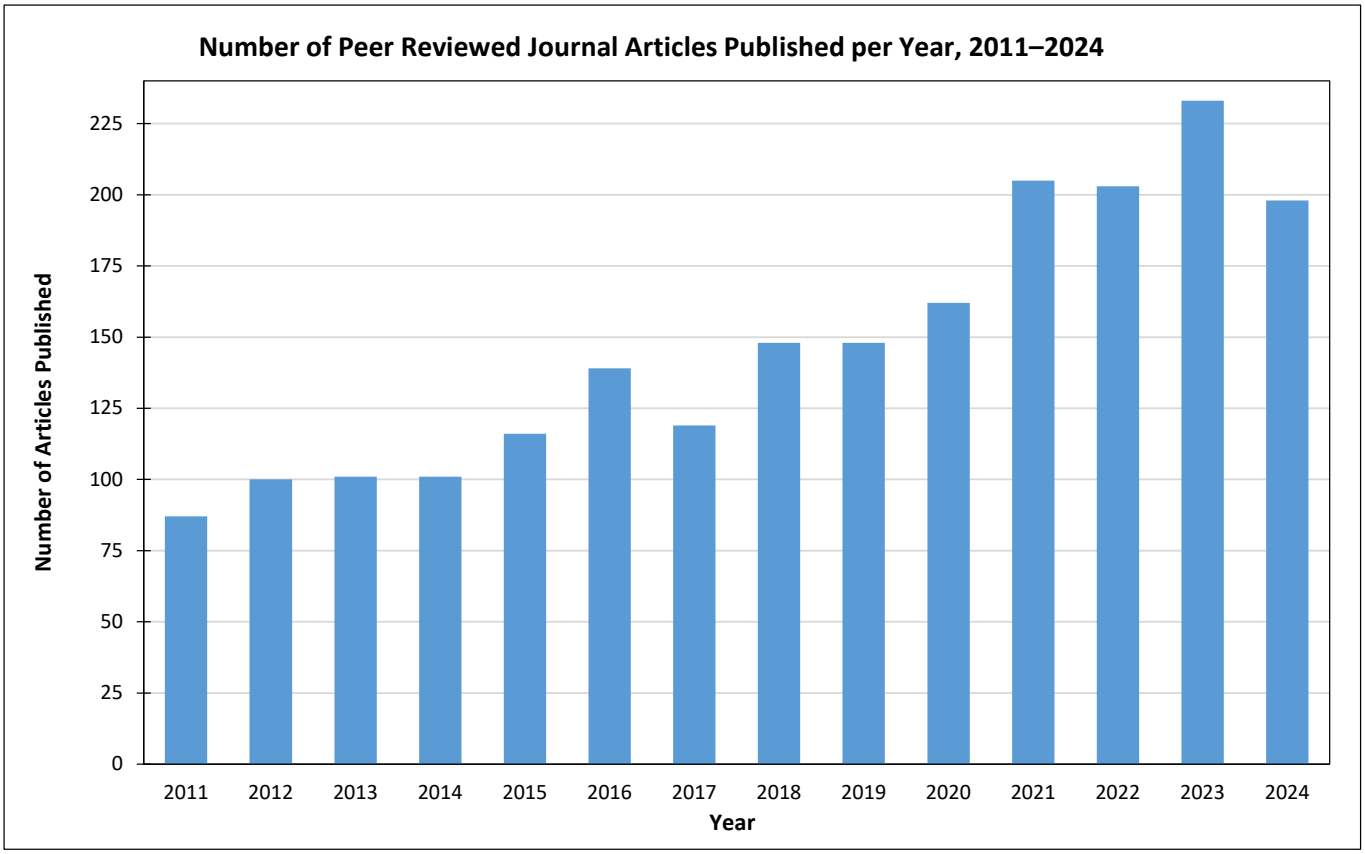


Figure E.5. Indicator 13.3, Number of peer-reviewed research articles related to wildfire and forest management in California from 2011–2024, based on a Web of Science search for relevant terms.

during this period, with most of the bills passed since 2015 (ⓘ13.1). A similar trend exists for state forest policies in the form of governors' Executive Orders and Emergency Proclamations, with 260 issued since 1995, including 85 since 2020 (ⓘ13.1). Recent federal legislation has provided significant new resources for the management of federal and non-federal forestlands as well as urban forests, including the Inflation Reduction Act (2022) and Bipartisan Infrastructure Law (2021). However, resources provided by these bills are being spent down and there is little support for these measures in the current federal administration. A March 2025 presidential executive order (U.S. President Trump 2025), followed by a memo from the Secretary of the Department of Agriculture (USDA 2025) and further direction from USFS Acting Deputy Chief (USFS 2025a), have set in motion an effort to significantly increase management on National Forest System and Bureau of Land Management lands, including both fuels management and commercial timber harvest. There is uncertainty, however, as to the level of federal resources (staff and funding) that will be available to implement these directives. Good Neighbor Authority agreements can help facilitate cross-agency collaboration for implementing projects.

Over the past 10–15 years, the State of California and its many partners (federal and local government, NGOs, and private sector) have made significant progress in building a strong institutional response—in terms of legislation, governor directives, policies, programs, plans, research, funding, and on-the-ground projects—to the fast-changing dynamics of forest, rangeland, and climatic conditions in the state.

In order to increase the pace and scale of ecological restoration, CNRA implemented a "cutting green tape" initiative (CNRA 2025). Progress from this initiative has included streamlining environmental

review, simplifying grant and loan programs, and enhancing communication and collaboration (CNRA 2022). Building on this, the governor's March 1, 2025 Emergency Proclamation (Newsom 2025) set up significant provisions for further environmental review streamlining to facilitate fuels treatment projects, and resulted in the new Environmental Protection Plan process for project approval.

The Board of Forestry and Fire Protection (BOF), in part through legislative direction and in part through its own initiative, has put in place new Forest Practice Exemption and Emergency Notice rules applicable to non-federal forestlands to facilitate forest resilience treatments that have a commercial timber harvest component. Similarly, the BOF-developed Vegetation Treatment Program (CalVTP) Environmental Impact Report is helping to reduce environmental review barriers for a wide range of fuel treatment activities on non-federal lands throughout California.

The legislative creation of the Timber Regulation and Forest Restoration Program under AB 1492 (Committee on Budget et al. 2012) and subsequent cross-agency program implementation and coordination led by CNRA has provided significant new and ongoing funding and capacity for enforcement of state forest sustainability laws related to commercial timber harvesting on non-federal lands in the state. It also has provided better cross-agency program and policy coordination, leading to improved processes for Timber Harvesting Plan submitters.

Cross-Sectoral Policy and Coordination, Programs, Services, and Other Resources Supporting the Sustainable Management of Forests

Several iterations of governors' task forces since 2015, culminating in the current WFR Task Force, have provided a high level of cross-sectoral policy and program coordination. Federal and state agencies, local governments, non-governmental organizations (NGOs), tribes, and private landowners have all been deeply involved in the work of the WFR Task Force. Entities such as the North Coast Resource Partnership (NCRP 2025), the Healthy Eldorado Landscape Partnership (HELP 2025), and the Resource Conservation District of Greater San Diego County (RCD 2025) are providing coordination at the regional level.

A vital wood products industry is important to support sustainable forest management. New programs, such as the Joint Institute for Wood Products Innovation established under the BOF pursuant to the 2018 Executive Order B-52-18 (Brown 2018) and the CAL FIRE Business and Workforce Development Grant Program (CAL FIRE 2025b) initiated in 2022 are helping to expand the wood products industry and the workforce needed to staff work in forest management and forest products. The latter program awarded $105 million to educational institutions, non-profits, new business startups, and existing forestry and forest products businesses between 2022 and 2024. The state's iBank Climate Catalyst Revolving Loan Program has approved $25 million for financing biomass utilization projects (WFR Task Force 2025e). Federal grant programs, such as the U.S. Department of Agriculture's Timber Production Expansion Guaranteed Loan Program (USDA 2024) and the USFS's various wood products grants (USFS 2025b), also provide support to the wood products industry and communities.

Higher agency funding (including funding for grant programs) and staffing levels can increase the resources available to support forest and rangeland resilience objectives across all ownership classes. Budgets and staffing across all program areas at CAL FIRE have increased significantly in the past 10 years. Expenditures have increased from $2.6 billion in fiscal year (FY) 2015–16 to $4.2 billion in FY 2024–25 (constant 2024$; preliminary figure for FY 2024–25), a 62% increase (ⓘ13.2). Staffing has increased from 6,704 FTE (full-time equivalent positions) to 12,523 FTE over the same period, an 87% increase.

Since 2021, nearly $6 billion in state and federal funds have been committed to forest health and wildfire resilience projects and programs (WFR Task Force 2025a). Collaborative investment between the state (CAL FIRE) and private industry (Sierra Pacific Industries) has resulted in the establishment of a new reforestation

nursery in northern California, with an eventual capacity of producing 25 million seedlings per year, which are greatly needed for addressing significant reforestation backlogs in the state. Acreage of private forestlands managed under regulatory or voluntary sustainability initiatives has also generally increased since the 2017 Assessment (ⓘ1.5).

Monitoring and Research on Sustainable Management of Forests

There has been a large increase over time in published peer-reviewed research articles related to wildfire and forest management in California (ⓘ13.3). In 1995, fewer than 10 scientific journal articles were published, as compared to over 200 published in 2023 (Figure E.5). In 2015, the ongoing Forest Health Research Program was established by CAL FIRE's FRAP. Through 2024, CAL FIRE has awarded 102 forest health research grants totaling $46.1 million.

At the same time, monitoring, assessment, and reporting on progress towards sustainable forest management has been rapidly expanding in California. This work is occurring through efforts of the state, federal agencies, and many NGOs. Transparency of this work is being emphasized as a means to build trust. CNRA is leading the Wildfire, Ecosystem Resilience, and Risk Assessment (WERK) (WFR Task Force 2025b) project to generate updatable, high resolution, wall-to-wall datasets for California's fire-adapted ecosystems and also incorporate datasets from other sources. The WFR Task Force has developed the online California Wildfire and Landscape Interagency Treatment Dashboard (WFR Task Force 2024) to transparently track forest resilience projects being implemented across the state. The USFS developed the Broader-Scale Monitoring Strategy website (USFS 2025c) to support National Forest plan monitoring and answer questions at a geographic scale broader than one forest plan area. Examples of expanding and evolving NGO efforts to provide data, assessment, monitoring, and planning tools for forestlands in California include Planscape (WFR Task Force 2025c), Land Tender (Vibrant Planet 2025), the Wildfire and Forest Resilience Data Hub (WFR Task Force 2025d), and multiple on-line tools developed by the Conservation Biology Institute (CBI 2025).

The Effectiveness Monitoring Committee was jointly established by the BOF and CNRA in 2014 (CA BOF 2025). The Committee provides an adaptive management loop to policymakers, managers, agencies, and the public by soliciting and funding scientific research that examines the effectiveness of the FPRs and other related laws and regulations at meeting multiple resource protection objectives. Also focusing on state timber harvesting regulations, the state's Forest Practice Review Team agencies (CAL FIRE, CDFW, California Geological Survey, Regional Water Quality Control Boards) have worked together to conduct field monitoring of the implementation and outcomes of timber harvesting Notices of Exemption or Emergency, prepare reports, and inform the BOF and public.

Partnerships and Public Engagement in Forest-Related Decision Making

Partnerships to support the sustainable management of forests in California have grown greatly since 1995, including in recent years. The WFR Task Force is an example of a critical high-level partnership (ⓘ13.4). The state's Regional Forest and Fire Capacity Program (CA DOC 2025) awarded $72 million in grants in 2023 to build the capacity of organizations to develop, implement, and monitor projects to improve forest resilience. Other state and federal grant programs, such as those at CAL FIRE and the USFS, have been providing funds for on-the-ground project implementation.

Agreement among various interests as to the kind and scale of treatments needed to improve forest resilience are currently at a high level in California. Factors contributing to this include the scale of devastation from wildfire seen in the state over the past decade; increasing understanding of the wildfire risks that climate change and past management practices have created in our forests; and the work to more robustly bring science and scientists into discussions and collaboratives. The WFR Task Force works closely with a Science Advisory Panel that was assembled as a key advisory component. Science synthesis reports prepared by the USFS Pacific

Southwest Research Station have helped to better inform the public and practitioners alike. Conflict resolution also is addressed through bottom-up organization, development, and implementation of forest treatment plans, including efforts at local and regional levels.

Public support for natural resource enhancement in California has been indicated by voters' passage of multiple large "environmental" bond acts over the years. Most recently, the voters in November 2024 passed the $10 billion Proposition 4, the Safe Drinking Water, Wildfire Prevention, Drought Preparedness, and Clean Air Bond Act. It includes $1.5 billion for wildfire and forest resilience programs, $100 million for urban greening, and $50 million for urban forests.

In addition, public engagement through community planning is a valuable collaborative process related to forest management and fire prevention (ⓘ11.4). As of May 2025, there are 234 standalone CWPPs, 42 county CWPPs, 16 fire protection district CWPPs, and 125 communities with completed safety elements. Community planning efforts, and associated pre-fire actions, have the potential to reduce wildfire frequency, severity, and damage. This is especially important in communities identified as having elevated risk.

Policy Issues

MPC7: Policy issues for legal, institutional and economic framework for conservation and sustainable management	
Policy Issues	**Options and Opportunities**
Institutional capacity	Maintain funding and support for staffing related to sustainable forest and wildland fire management and enhanced collaboration across state, tribal, federal and non-governmental entities.
Funding	Maintain funding and support work to create systems of resilience treatments and forest products that have market economic viability. Collaboration remains a key element in getting forest resiliency work done efficiently.
Monitoring and evaluation	Ensure that monitoring wildland resource conditions, transparently tracking forest resilience projects (particularly those paid for by the public or initiated under streamlined environmental review), and evaluating on-the-ground outcomes remain high priority for continued funding. Facilitate use of monitoring information into resource management decision making. Demonstration State Forests and federal Experimental Forests and Ranges play an important role in providing opportunities for multidecadal studies and monitoring.
Need for research in a time of dynamic change for forests and rangelands	Continue to fund research relevant to forest and rangeland management, including federal funding of the USFS Research Stations and Forest Products Laboratory and state funding of the CAL FIRE Forest Health Research Program.
Tribal engagement and actions	Continue to promote tribal land stewardship with legislation, executive orders, state-tribal agreements, recognition of the value and importance of traditional ecological knowledge (TEK), program funding, and other state and federal commitments to collaborate with tribes to facilitate co-management on public lands and enhance tribal cultural management, including use of fire.
Collaboration, coordination, and partnerships	Continue to build on existing partnerships such as regional collaboratives like the North Coast Resource Partnership, intergovernmental agreements like the State-USFS Region 5 Agreement for Shared Stewardship (State of California and USFS PSW 2020) and Good Neighbor Authority Agreements, and the collaboration and coordination work of the WFR Task Force.

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APPENDIX

Appendix E.1. List of indicators by chapter and Montréal Process Criteria (MPC)								
Chapter	**Indicator Name**	**MPC1 Conservation of Biological Diversity**	**MPC2 Maintenance of Productive Capacity**	**MPC3 Maintenance of Forest Ecosystem Health and Vitality**	**MPC4 Soil and Water Resources**	**MPC5 Forest Contribution to Global Carbon Cycles**	**MPC6 Maintenance and Enhancement of Long-term Multiple Socio-Economic Benefits to Meet the Needs of Societies**	**MPC7 Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management**
Resilient Forests	1.1 Net Growth on Timberland		X	X				
	1.2 Timberland Restoration		X	X		X		
	1.3 Silvicultural Methods		X		X		X	
	1.4 Historic Timber Harvest		X			X	X	
	1.5 Sustainability Initiatives	X	X					X
	1.6 Carbon Offset Projects					X		
Sustainable Rangelands	2.1 Rangeland Conversion	X	X					
	2.2 Beef Cattle Farms by Size Class						X	
	2.3 Federal Grazing Allotments		X					
Urban Forests	3.1 Tree Canopy Cover					X	X	
	3.2 Impervious Surfaces						X	
	3.3 Air Pollution						X	
	3.4 Urban Heat						X	
Wildfire	4.1 Fire Return Interval Departure			X				
	4.2 Fire Threat		X	X				
	4.3 Wildfire Activity		X	X	X	X		
	4.4 Fire Severity	X	X	X	X	X		
	4.5 Vegetation Treatments		X	X	X	X		
Forest Pests	5.1 Area of Tree Mortality from Forest Pests and Drought	X	X	X		X		
	5.2 Number of Native and Exotic Forest Pest Species Occurrences	X	X	X		X		
Population Growth and Development	6.1 Population Trends	X					X	
	6.2 Protected Private Wildlands	X	X					
Climate Change	7.1 Temperature			X	X	X		
	7.2 Precipitation			X	X	X		
	7.3 Vapor Pressure Deficit			X	X	X		
	7.4 Carbon Storage - Forests					X		
	7.5 Aboveground Live Tree Carbon Sequestration		X	X		X		
	7.6 Forest Sector Carbon Sequestration					X		

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California's Non-Metro Regional Economy	8.1 Economic Performance						X	
	8.2 Economic Prosperity						X	
	8.3 Economic Stress						X	
	8.4 Economic Structure						X	
Water Resources	9.1 Stream Condition Index				X			
	9.2 Snowpack				X			
	9.3 Spring Runoff				X	X		
	9.4 Climatic Water Deficit			X	X	X		
Wildlife Habitat	10.1 Species at Risk	X						
	10.2 Forest Stand Age Class by Ownership	X		X				
	10.3 Habitat Degradation	X						
	10.4 Habitat Vulnerability to Climate Change	X		X				
	10.5 Protected Habitat	X						
Wildfire Risk to Communities	11.1 Structure Loss						X	
	11.2 Housing by Hazard Class						X	
	11.3 Housing in WUI						X	
	11.4 Community-level Wildfire Planning						X	X
	11.5 Annual Frequency of Hazardous Smoke Days						X	
Renewable Energy	12.1 Contribution of Renewable Energy Sources to California Electrical Generation						X	
	12.2 Contribution of Forest Biomass to California Electricity Generation		X			X	X	
Institutional Response	13.1 Legislative Bills and Governors' Executive Orders and Proclamations Addressing Wildfire and Forest Management							X
	13.2 CAL FIRE Expenditures and Staffing							X
	13.3 Peer-reviewed Journal Articles Relating to Forest and Wildfire Management in California							X
	13.4 Partnerships and Public Engagement in Forest-related Decision Making							X