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Tracking Headwaters Management for Wildfire Resilience in California

Technical Appendices

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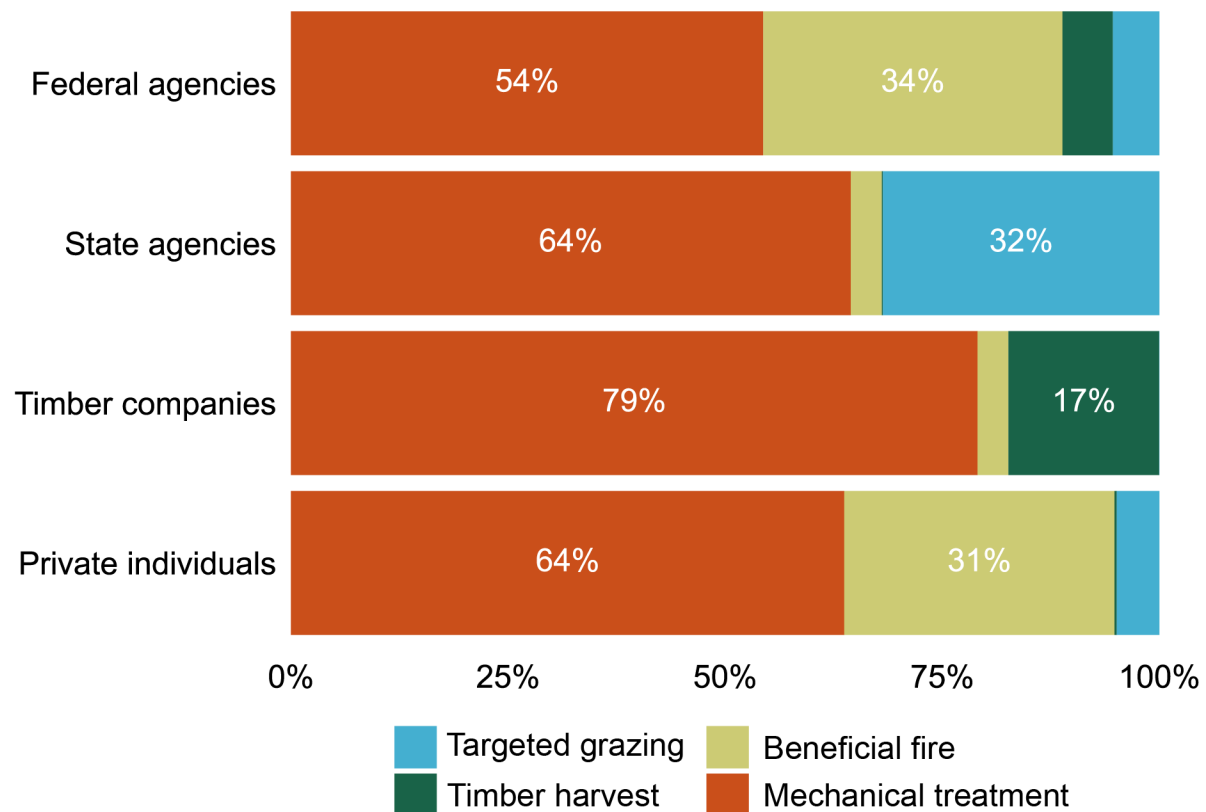
Appendix A. A Closer Look at Treatment Activities

A variety of treatment types are used to meet California’s wildfire hazard reduction goals. In the main report, we discuss the prevalence of the four main treatment types and the implications of counting many different treatment types towards a single goal. In this appendix, we explore the breadth of treatment types in greater detail. We start with a breakdown of the four major treatment types by land ownership. We then discuss the components of mechanical treatment and their prevalence. Finally, we explore four other activity types, including beneficial fire, timber harvest that reduces wildfire hazard, targeted grazing, and fuel breaks.

Mechanical treatment is the most common method, accounting for the majority of reported treatments in every landowner category. Beneficial fire is most prevalent on lands owned by federal agencies and private individuals, where it comprises around one-third of reported treatments. Targeted grazing is especially common on lands owned by state agencies, accounting for about one-third of reported treatments. Timber harvest is concentrated on lands owned by timber companies, comprising 17 percent of reported treatments.

FIGURE A1

Mechanical treatment is the most common treatment method
Percent of treatments from 2021–24



SOURCE: California Wildfire and Forest Resilience Task Force.

NOTES: Other landowner categories such as NGOs, Tribes, and local governments were excluded from this figure due to the relatively small amount of treatment that occurs on those lands.

Mechanical Treatment

Mechanical treatment—referred to by the task force as mechanical and hand fuels reduction—includes various types of activities that reduce wildfire hazard by modifying vegetation or removing it from the landscape altogether.

Thinning. The selective removal of small trees—conducted mechanically or by hand—accounts for 26 percent of mechanical treatments.

Herbicide application. The spraying of chemicals to kill vegetation and suppress growth accounts for 24 percent of mechanical treatments. Of these treatments, timber companies report conducting over half of herbicide application, Caltrans accounts for nearly 40 percent, and the remainder is conducted by other state agencies.

Fuel-size reduction. Processing woody biomass to speed decomposition—most commonly through chipping—accounts for 12 percent of mechanical treatments.

Mowing. Mowing targets grasses along roadsides and fuel breaks, representing 12 percent of mechanical treatments.

Piling. Collecting woody biomass into piles accounts for 11 percent of mechanical treatments.

FIGURE A2

Herbicide and thinning are the most common types of mechanical treatment
Percent of mechanical treatments from 2021–24



SOURCE: California Wildfire and Forest Resilience Task Force Interagency Treatment dashboard.

NOTES: "Size-reducing activities" include chipping, mastication, and lop and scatter. "Other" includes biomass removal, chaining/crushing, pruning, road clearance, landing treated-area mitigated, slash disposal, pest control, discing, trees felled (> 6 inches diameter at breast height), utility right-of-way clearance, yarding, and tree release and weed.

Beneficial Fire

Beneficial fire—including prescribed and cultural burning—aims to restore historical fire regimes by reintroducing burns at regular intervals. When done under controlled conditions, these burns can reduce hazardous fuels, improve forest health, and support ecosystem resilience.

Efficient removal of low-lying vegetation. Restoring historical forest conditions over large landscapes without the use of fire as a tool is extremely challenging. Grasses, shrubs, and other vegetation that cover the forest floor are difficult to remove with mechanical treatment. Under the right conditions, fire is an efficient way to target this vegetation and reduce wildfire hazard.

Ecological benefits. Reducing wildfire hazard is most effective when paired with efforts to restore forest ecosystem health. Many California ecosystems evolved with frequent, low-intensity fire, meaning restoration requires reintroducing this natural fire regime. Some conifers—such as the iconic giant sequoia—depend on fire to trigger seed release and enable regeneration.

Broadcast burning, which is the planned use of low-intensity fire to consume low-lying vegetation across a defined area under controlled conditions, comprises 54 percent of reported beneficial fire. Burning material that has been collected into piles accounts for another 28 percent, and 18 percent reflects acres burned in wildfires in areas where treatments were planned.

Most beneficial fire (72%) occurs on federal lands, followed by lands owned by private individuals (16%), lands owned by state agencies (6%), and lands owned by timber companies (4%). The remainder was spread across lands owned by NGOs, Tribes, and local governments. Regional variation is also substantial—39 percent of beneficial fire treatments occurred in the Sierra–Cascade headwaters, while almost none occurred in the Southern California mountains.

Timber Harvest that Reduces Wildfire Hazard

Timber harvest currently plays a minor role in reducing wildfire hazard. It accounts for 6 percent of reported treatments—including those on lands owned by timber companies.

Only timber harvest that reduces wildfire hazard is counted towards treatment goals. These methods of timber harvest are mainly commercial thinning and single-tree selection, which selectively remove smaller, less fire-resistant trees while retaining larger, more resilient ones.¹ By contrast, harvest methods that do not prioritize the removal of smaller, less resilient trees—such as clearcutting—are not counted toward treatment goals.

Timber harvest occurs on both privately-owned and federal lands. Over 60 percent of timber harvest was reported by timber companies, while the remaining acres were reported by the US Forest Service.²

¹ Commercial thinning accounted for 41 percent of reported 2021–24 timber harvest, while single-tree selection accounted for 24 percent. Transition harvest, rehabilitation of understocked areas, and group selection harvest account for most of the remainder.

Additional Management Types

Targeted Grazing

Targeted grazing, which accounts for 12 percent of all reported treatments, uses livestock such as cattle or goats to remove vegetation in targeted areas. This treatment method targets dry grasses and other low-to-the-ground fuels that can ignite easily and rapidly carry wildfire across the landscape. It is often applied where beneficial fire is not feasible and is commonly used to manage regrowth in areas previously affected by wildfire.

Most (78%) of 2021–24 targeted grazing occurred on lands owned by state agencies in the Central California foothills and coastal mountains. The California Department of Fish and Wildlife (CDFW) conducted 81 percent of targeted grazing treatments. CDFW’s prominent role reflects its responsibility for managing wildlife habitat areas that frequently overlap with grassland ecosystems where grazing is a viable vegetation management strategy. Most of the remaining targeted grazing occurred on federal lands, primarily conducted by the Bureau of Land Management.

Fuel Breaks

Fuel breaks are narrow strips of land where vegetation has been reduced or removed around a protected area, such as neighborhoods in wildland-urban interface (WUI). They impede the spread of fire due to the discontinuities in vegetation, and firefighters can use them to contain wildfires.

Most fuel breaks are constructed by CDFW on state lands, accounting for 5 percent of all reported treatments. CDFW is responsible for 61 percent of these treatments, with the remainder primarily reported by timber companies, the US Forest Service, and Cal Fire. Over half (58 %) of fuel breaks are constructed on lands owned by state agencies, while the rest are distributed relatively evenly across lands owned by federal agencies, timber companies, and private individuals.

Appendix B. Methods Used to Track Headwaters Management

Fundamentals of Wildfire Hazard Reduction Data

In the report, we simplify terminology used in task force documentation and in the dashboard. This appendix provides a more detailed explanation of how wildfire hazard reduction is accounted for and maps our terms to those used by the task force. Once introduced, the precise terms will be used throughout this appendix.

Treatment

In the report, we use “treatment” to refer to all reported activities that reduce wildfire hazard. This includes acres that were treated more than once within the same year and matches the task force’s “activity acres.”

In the dataset underlying the dashboard, “treatment” refers to larger sections of the landscape that experience multiple wildfire hazard reduction activities. A single treatment may include multiple activities, and each activity is reported with a treatment ID (Task Force 2023a; 2023b). This relationship between activities and treatments is important for estimating management footprint, treatment intensity, and the extent of combined treatments, as described below.

Acres Treated

We use “acres treated” to refer to the unique area managed for wildfire hazard reduction after accounting for overlap among activities. An acre that receives multiple treatments is only counted once in treated acre totals. This is synonymous with the task force’s “footprint acres” (Task Force 2023a).

For example, suppose one mechanical and hand fuels reduction activity (referred to as “mechanical treatment” in the report) and one beneficial fire activity occur on the same 10-acre plot. These activities would add up to 20 activity acres, but only 10 footprint acres.

TABLE B1

Naming conventions

This report	Task force term
Acres treated	Footprint acres
Mechanical treatment	Mechanical and hand fuels reduction activity
Treatment	Activity acres
Woody biomass fate	Residue fate

Use of Activity and Footprint Acres in the Report

We use “activity acres” to quantify who reported wildfire hazard reduction efforts, the types of activities that occurred, and the fate of woody biomass (referred to as “residue fate” by the task force). “Footprint acres” cannot be summarized by these attributes because they are dropped when overlap between activities is removed due to data incompatibility during the merge process. For most analyses that use activity acres, we report results as proportions of the total, rather than absolute acreage.

We use footprint acres to track progress towards most wildfire hazard reduction goals. Activity acres overestimate progress because some activities overlap spatially. By removing this overlap, footprint acres provide a more accurate estimate of acres on which wildfire hazard has been reduced. All acreage values in the report are footprint acre values except for analysis of the beneficial fire goal.³ Additional attributes such as land ownership and headwater region are added from GIS reference data after the footprints are estimated.

Further Details on Priority Areas for Treatment

Our priority areas provide one high-level way to view where treatment is most needed, but they have limitations. We include the wildland-urban interface (WUI) in our priority areas because it covers lands where dashboard activity types, particularly fuel breaks, are most appropriate. While our goal was to maintain consistency with the dashboard, this choice affects some results. Notably, our finding of significant undertreatment on lands owned by private individuals partly reflects this choice because many WUI areas are owned by private individuals. However, real challenges to scaling treatment among individual landowners in the WUI exist even under a narrower definition of priority areas.

To estimate the share of footprint acres that occurred in or near priority areas, we compared footprint centroids and activity points with priority area polygons. Footprints with centroids and activities with points that overlap priority areas or are within one kilometer of a priority area boundary are considered to be in or near priority areas. Footprint acres in or near priority areas are the sum of acres across footprints that meet either of these criteria. Similarly, activity acres in or near priority areas are the sum of acres across activities that meet either of these criteria. Use of centroids allows us to avoid calculating areas from the footprint polygons directly, which is not possible due to data limitations (see below). However, centroids may not accurately capture the extent of some irregularly shaped footprints, such as long sections of road that Caltrans has managed. Footprint acre values are used to describe the share of treated acres within priority areas and the landownerships where treated acres outside priority areas occurred. Activity acre values are used to describe who reported treatments outside priority areas.

How We Measure Progress toward Goals

A Lack of Precise Spatial Information Makes It Difficult to Measure Progress

A lack of precise spatial information for reported wildfire hazard reduction activities undermines our ability to track progress towards statewide goals because we cannot precisely determine where activities

³ Activity type information is removed in the process of removing overlap between activities. Since beneficial fire activities are unlikely to overlap within the four years of data available on the dashboard, we use activity acres to track progress towards this goal.

overlap. Activities are reported to the task force in four different formats, including polygons, lines, points, and activities without any spatial information (Task Force 2023c). At a minimum, all activities should be reported with points that approximate the treatment location. On average, we do not know the location of a quarter of all footprint acres each year. Most of these acres are reported by timber companies.

The gold standard would be for each reported activity to be accompanied by a polygon that represents the area on which wildfire hazard was reduced. Currently, only a fraction of activities is reported as polygons, and many of the reported polygons represent planned treatments rather than treatments that occurred. This is problematic because many activities end up reducing wildfire hazard on fewer acres than were planned, which means that the area of the reported polygons overestimates the treated area.

How the Footprint of Management is Estimated

We follow the same steps as the task force to estimate the footprint of management. First, we merged all activities reported with spatial information into a common polygon format by creating a buffer around the points and lines. A circle was drawn around each point, for which the radius was based on the count of acres managed around each point. Each line was widened out to an even width along both sides, with the width based on the count of acres managed along each line.

To remove overlap between activities reported with spatial information, activities were grouped by year and dissolved by treatment ID, resulting in a single polygon for each unique combination of treatment ID and year. These resulting polygons are the footprints of management.⁴ The footprint size is assigned based on the largest activity contained within the footprint (Task Force 2023a). This approach is used because the areas of the polygons themselves do not accurately represent treated areas.

There are two key limitations to the approach used by the task force to estimate the footprint of management.

- **The single-year footprint approach results in overestimation of progress towards goals.** In the current approach, activities that occur on the same acre in different years are counted multiple times, once for each year an activity occurred on that acre. Since the impact of most activities lasts longer than a single year, this approach likely results in overestimation.
- **Non-spatial activities bypass the footprint process, resulting in overestimation of progress.** Without any spatial information, there is no way to carry activities through the footprint process. Activities reported without spatial information are counted in footprint acre totals without accounting for potential overlap, which likely results in overestimation.

How We Estimate Treatment Intensity and Combined Treatment Values

In addition to the activity and footprint acre measures, we quantified how many and what type of activities occur within the same treatment. This is not captured in the dashboard, so we modified the task force's footprint methods for this analysis. To estimate both measures, we first identified the set of activities within each treatment based on treatment IDs.

⁴ There are some additional steps to convert the activities to footprints. Full details are documented in the project code, which is available upon request.

Treatment intensity is the number of activities per treatment. For example, a treatment that contains only a single activity would have an intensity value of one, while a treatment with three activities would have an intensity value of three.

Combined treatments include at least one mechanical and hand fuels reduction activity and at least one beneficial fire activity.⁵ We follow prior PPIC headwaters accounting methods by including any treatment that contains both activity types without considering the temporal sequence (McCann et al. 2020).

The relationship between activities and treatments is useful to estimate footprints, as well as the treatment intensity and combined treatment measures. However, the agencies and firms that report wildfire hazard reduction activities may use this relationship in different ways. For instance, some agencies and firms never report more than one activity per treatment. These include all efforts reported by timber companies, the US Department of Energy (DOE), the US Department of Defense (DOD), and California State Parks. Treatments reported by these parties are excluded from treatment intensity analysis. While combined treatment results may be underestimated due to reporting only a single activity for each treatment, the underestimation is likely to be minimal. The DOE, DOD, and State Parks together only account for about 2 percent of reported activity acres, and beneficial fire only accounts for about 5 percent of activity acres reported by timber companies.

An alternate approach to calculate treatment intensity and combined treatment is to spatially identify the set of activities that falls inside each footprint polygon. We opted to use the tabular treatment ID approach instead of a spatial approach for two reasons. First, the areas of the footprint polygons are likely larger than the treated areas. Second, current footprint methods are single-year but both treatment intensity and combined treatment are likely multi-year efforts in many cases. To calculate treatment intensity and combined treatment using a spatial approach, footprint polygons would need to accurately represent area treated and a multi-year footprint process would need to be used.

How Activity and Footprint Records Are Enriched

Activity and footprint acre records are enriched with attributes such as land ownership and headwater region from reference layers. Enrichment method varies by record type (activity or footprint), geometry type, and enrichment attribute. Our enrichment methods match those used by the task force, with some modifications for the region attribute. For activities reported with spatial information, we assign region as the headwater region nearest to each point, line centroid, and polygon centroid. The region of footprint records is assigned as the region of the largest activity within each treatment.⁶

How We Categorize Activity Types by Treatment Longevity

In the report, we categorize different activity types into short-lived and longer-lived categories to highlight the significant differences in longevity between activity types. We provide a more detailed list of the activity types in each category here.

⁵ All activity types within mechanical and hand fuels reduction and beneficial fire are included in combined treatment. Pile burning is included as a subcategory of beneficial fire.

⁶ Within a given year, there is one footprint record for each treatment ID.

- **Short-lived activity types.** Prescribed herbivory, discing, herbicide application, landing treated-area mitigated, mowing, pest control, pruning, road clearance, slash disposal, tree release and weed, utility right-of-way clearance, and invasive plant removal.
- **Longer-lived activity types.** Biomass removal, chaining/crushing, chipping, lop and scatter, mastication, pile burning, piling, manual thinning, mechanical thinning, trees felled (> 6-inch diameter at breast height), yarding, commercial thinning, group selection harvest, rehabilitation of understocked areas, sanitation harvest, single tree selection, transition harvest, and variable retention harvest. Beneficial fire activity types include broadcast burning, pile burning, and planned treatments burned in wildfire.

Appendix C. Headwater Region Snapshots

Sierra–Cascade Mountains

Role in California’s Water Supply

The Sierra–Cascade region is California’s primary source of developed water—the portion of the runoff water that is captured, stored, and managed for human use. Roughly 60 percent of California’s developed water originates here and more than three-quarters of Californians rely on water from these mountains. The region’s forest health and snowpack directly affect both the reliability and timing of water deliveries throughout the state.

Primary Ecosystems

Conifer forests are the most common ecosystem type in this region, covering about 60 percent of natural land. Shrublands make up 23 percent, mainly at lower elevations. Hardwood forests, woodlands, and grasslands account for the rest of the region’s land.

Land Ownership

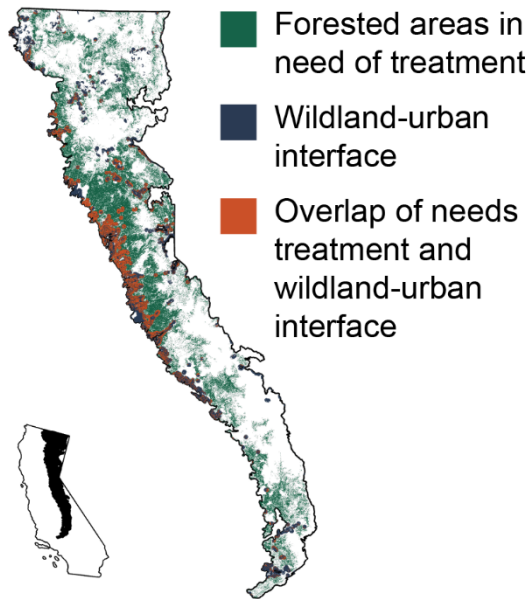
About 70 percent of the region is owned by federal agencies, mainly by the US Forest Service. The remaining 30 percent is privately owned—roughly 20 percent by individuals and 10 percent by companies, primarily timber operators. Other landowners, such as state agencies and Tribal lands, together make up about 1 percent of total ownership.

Priority Area for Treatment

Roughly 7.6 million acres in the Sierra–Cascades would benefit from wildfire hazard-reduction work. Of these, about 5 million acres are in areas that Cal Fire has determined need treatment, 1.6 million acres fall within the WUI, and nearly 1 million acres meet both criteria.

FIGURE C1

Sierra–Cascade Mountains priority areas



SOURCE: US Environmental Protection Agency, US Census Bureau, US Department of Transportation, Cal Fire, California Wildfire and Forest Resilience Task Force, Rudeen 2024, DeLyser et al. 2025

NOTES: Sierra–Cascade Mountains is composed of the Sierra Nevada, Cascades, and East Cascades slopes and foothills level III ecoregions from the US Environmental Protection Agency. Urban areas defined by the US Census Bureau and the US Department of Transportation were excluded from all headwater regions. Wildland-urban interface reference layers are from the Wildfire and Forest Resilience Task Force (Rudeen 2024). Areas in need of treatment reference layers are from the Cal Fire’s Needs Assessment (DeLyser et al. 2025).

Treated Area

In the Sierra–Cascades, 174,000 acres are treated annually on average, accounting for about 29 percent of acres treated. Treatment methods used generally mirror statewide patterns, except that almost no targeted grazing occurs—unsurprising given the region has little grassland.

North Coast Mountains

Role in California’s Water Supply

This is one of California’s most water-abundant regions, producing roughly 40 percent of the state’s natural runoff despite covering only 12 percent of its land area. Major rivers such as the Klamath, Trinity, Eel, and Russian rivers sustain local water supplies and ecosystems. These headwaters play a crucial role in maintaining water quality, environmental flows, and ecological health throughout Northern California.

Primary Ecosystems

Conifer forests dominate the North Coast Mountains, covering about 70 percent of natural land. Hardwood forests and woodlands account for roughly 15 percent, while shrublands and grasslands each cover less than 10 percent of the region’s land.

Land Ownership

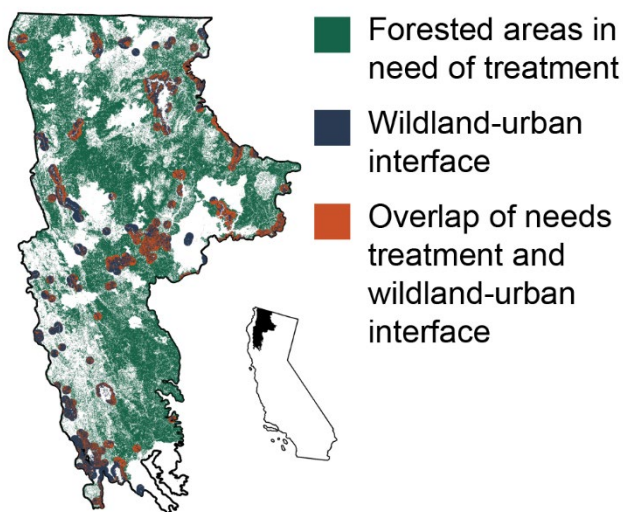
Similar to the Sierra–Cascade region, federal agencies—primarily the US Forest Service—own 63 percent of the land. Private individuals own about one-quarter of the land, and timber companies own about 10 percent. Tribes own 2 percent, while state agencies own less than 1 percent.

Priority Area for Treatment

An estimated 4.6 million acres in the North Coast Mountains would benefit from treatment. Of these, about 3.6 million acres are in areas that Cal Fire has determined need treatment, 600,000 acres fall within the WUI, and roughly 400,000 acres fall into both categories.

FIGURE C2

North Coast Mountains priority areas



SOURCE: US Environmental Protection Agency, US Census Bureau, US Department of Transportation, Cal Fire, California Wildfire and Forest Resilience Task Force, Rudeen 2024, DeLyser et al. 2025.

NOTES: North Coast Mountains is composed of the Klamath Mountains level III ecoregion from the US Environmental Protection Agency. Urban areas defined by the US Census Bureau and the US Department of Transportation were excluded from all headwater regions. Wildland-urban interface reference layers are from the Wildfire and Forest Resilience Task Force (Rudeen 2024). Areas in need of treatment reference layers are from the Cal Fire’s Needs Assessment (DeLyser et al. 2025).

Treated Area

The North Coast Mountains receive about 62,000 acres of treatment per year, or 10 percent of the statewide total. Only 1 percent of treatments in the North Coast Mountains are timber harvest—unexpected given the region’s strong forest products sector. This is likely because many treatments reported by timber companies lack location information. The North Coast Mountains rely much more on beneficial fire compared to the state as a whole (51% of regional treatment versus 18% of statewide treatment). Targeted grazing is almost absent, while mechanical treatment accounts for about half of the region’s treatments.

Central California Foothills and Coastal Mountains

Role in California’s Water Supply

The Central California foothills and coastal mountains are critical for local water supply and groundwater recharge. Most communities in this region rely on local headwater runoff and aquifers rather than imported water, making watershed health and recharge capacity essential for drought resilience.

Primary Ecosystems

Hardwood forests and woodlands cover 35 percent of the region’s land, while grasslands cover 42 percent. Shrublands cover 19 percent, and conifer forests cover less than 5 percent.

Land Ownership

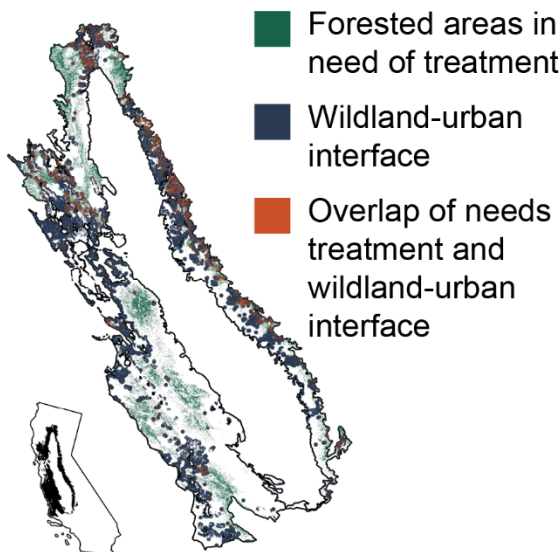
Approximately 75 percent of the region’s land is owned by private individuals, while 15 percent is owned by federal agencies. Private companies and state agencies each own roughly 3 percent.

Priority Area for Treatment

An estimated 7.5 million acres in the Central California Foothills and Coastal Mountains would benefit from treatment. Of these, about 1.8 million acres are in areas that Cal Fire has determined need treatment, 5 million acres lie within the WUI, and about 700,000 acres fall into both categories.

FIGURE C3

Central California foothills and coastal mountains priority areas



SOURCE: US Environmental Protection Agency, US Census Bureau, US Department of Transportation, Cal Fire, California Wildfire and Forest Resilience Task Force, Rudeen 2024, DeLyser et al. 2025.

NOTES: Central California Foothills and Coastal Mountains matches the level III ecoregion from the US Environmental Protection Agency of the same name. Urban areas defined by the US Census Bureau and the US Department of Transportation were excluded from all headwater regions. Wildland-urban interface reference layers are from the Wildfire and Forest Resilience Task Force (Rudeen 2024). Areas in need of treatment reference layers are from the Cal Fire’s Needs Assessment (DeLyser et al. 2025).

Treated Area

In the Central California foothills and coastal mountains region, about 107,000 acres are treated each year—or 18 percent of statewide totals. Targeted grazing accounts for more than half of treatments in the region, compared to just 12 percent of statewide treatments. Mechanical treatment is far less common in this region than it is across the state—accounting for 26 percent of regional treatments compared to 64 percent of statewide treatments. The share of beneficial fire in the region is similar to the statewide average, and no timber harvest is reported as contributing to wildfire hazard reduction goals.

Southern California Mountains

Role in California’s Water Supply

The Southern California Mountains are vital for local water supply and groundwater recharge in a region that is otherwise dependent on imported water. Runoff from these headwaters replenishes major groundwater basins that provide 30–80 percent of local water supplies in parts of Los Angeles, Orange, and Inland Empire communities and fills reservoirs that meet around 10 percent of San Diego’s needs.

Primary Ecosystems

Shrublands are the most common ecosystem type in the region, covering 67 percent of land. Conifer forests are located at higher elevations, accounting for 17 percent of land cover, while hardwood forests and woodlands comprise about 10 percent of land cover.

Land Ownership

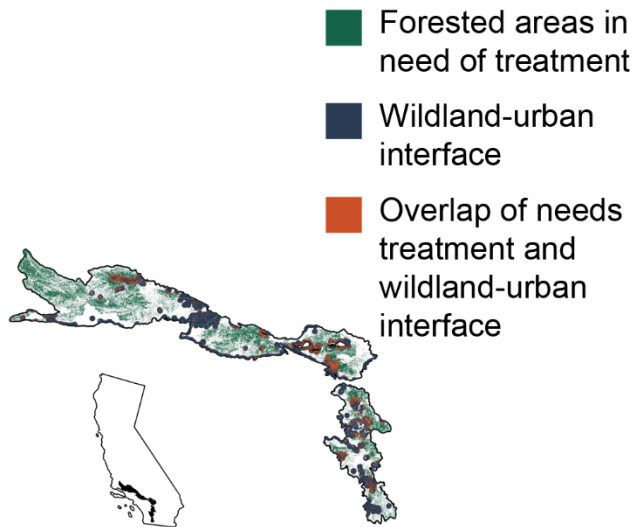
Federal agencies own 73 percent of the Southern California Mountains, largely the USFS. Private individuals own 16 percent, and state agencies and Tribes each own about 3 percent. There is virtually no land owned by timber companies in this region.

Priority Area for Treatment

About 1.9 million acres in the Southern California Mountains would benefit from treatment. Of these, approximately 900,000 acres are in areas that Cal Fire has determined need treatment, 800,000 acres fall within the WUI, and about 200,000 acres meet both criteria.

FIGURE C4

Southern California Mountains priority areas



SOURCE: US Environmental Protection Agency, US Census Bureau, US Department of Transportation, Cal Fire, California Wildfire and Forest Resilience Task Force, Rudeen 2024, DeLyser et al. 2025.

NOTES: Southern California Mountains matches the level III ecoregion from the US Environmental Protection Agency of the same name. Urban areas defined by the US Census Bureau and the US Department of Transportation were excluded from all headwater regions. Wildland-urban interface reference layers are from the Wildfire and Forest Resilience Task Force (Rudeen 2024). Areas in need of treatment reference layers are from the Cal Fire's Needs Assessment (DeLyser et al. 2025).

Treated Area

The Southern California Mountains region sees about 18,000 acres treated annually—about 3 percent of statewide treatments. Mechanical treatment makes up a much larger share of treatments in this region than statewide, accounting for 80 percent of regional treatments compared to 64 percent of statewide treatments. Beneficial fire and targeted grazing are used less in this region than statewide, accounting for just 15 percent and 5 percent of regional treatments, respectively. Almost no timber harvest that reduces wildfire hazard is reported in this region.

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