

CALIFORNIA LANDSCAPE METRICS (CLM) DICTIONARY

Consolidating Metrics from all four Regional Resource Kits (RRK)

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TABLE OF CONTENTS

Introduction	9
What is the California Landscape Planning Metrics effort?	9
What this document is and its intended purpose	10
Organizational Structure	10
Metrics	11
Generating Metrics with the F3 Model	13
General F3 Process	13
Advantages and Limitations	14
Updating F3 Data for Change Events	15
Air Quality	15
Particulate Matter	16
Potential Total Smoke Production Index	16
Potential Avoided Smoke Production Index	17
Heavy Fuels	19
Biodiversity Conservation	19
Species Diversity	20
Wildlife Species Richness	20
Threatened/Endangered Vertebrate Species Richness	21
Forest Raptors Species Richness	21
Open Habitat Raptors Species Richness	22
Hummingbirds Species Richness	23
Focal Species	23
Plants	24
Distribution of Redwood Structure Classes	24
Giant Sequoia Stands	26
California Black Oak Stands	26
Joshua Tree	27
Invertebrates	28
Hermes Copper Butterfly	28
Laguna Mountains Skipper	29
Quino checkerspot butterfly	30
Fish	31
California Coastal Chinook Salmon Critical Habitat	31
Northern California Coast Coho Salmon Critical Habitat	32
Northern California DPU Steelhead Critical Habitat	33
California Coastal Chinook Salmon Distribution	34
Northern California Coast Coho Salmon Distribution	35
Northern California Winter steelhead Distribution	36
Northern California Summer steelhead Distribution	38

Unarmored threespine stickleback Habitat	39
Reptiles & Amphibians	39
California red-legged frog	40
Mountain yellow-legged frog potential Habitat	41
Birds	42
Band-Tailed Pigeon	42
Marbled Murrelet Suitable Nesting Habitat	43
Marbled Murrelet Critical Habitat	44
California Spotted Owl Suitable Habitat	45
Northern Goshawk Suitable Habitat	46
Northern Spotted Owl Nesting/Roosting Forest Cover Type Suitability Index	48
Northern Spotted Owl Habitat Suitability Index	50
Northern Spotted Owl; Changes in Suitable Habitat 1993-2022	52
Northern Spotted owl Habitat; Topo-Climatic Fire refugia	53
Nuttall's woodpecker Habitat Suitability	55
Loggerhead Shrike Habitat Suitability	56
Least Bell's Vireo Nesting Habitat	57
Mammals	59
Mountain Lion Suitable Habitat	59
Pacific Marten Suitable Habitat	60
Humboldt Marten Predicted Distribution	61
Pacific Fisher Predicted Habitat	61
Pacific Fisher Suitable Habitat	62
Ringtail Cat Habitat Suitability	63
Peninsular Bighorn Sheep	64
Community Integrity	64
Terrestrial Connectivity	64
Full Climate Connectivity Network	67
Present Day Connectivity in California (Omniscape)	68
Functional Group Species Richness	69
Carbon Sequestration	70
Carbon Storage	70
Total Aboveground Carbon	70
Total Carbon (F3)	71
Annual Biomass Data 2001 and 2021, WWETAC (Western Wildland Environmental Threat Assessment Center)	72
Carbon Stability	75
Aboveground Carbon Turnover Time	75
Large Tree Carbon	76
Dead Carbon	77
Economic Diversity	78

Wood Product Industry	78
SNV - Sawtimber	79
SNV - Biomass	79
SNV - Cost of Potential Treatments	80
Reference Tables	81
SoCal - Cost of Potential Treatments	82
CenCal - Cost of Potential Treatments	84
NorCal - Cost of Potential Treatments	85
Biomass Residues (40% Thin From Below Treatment)	88
Fire Adapted Communities	90
Hazard	90
Structure Exposure Score	90
Damage Potential	91
Ember Load Index	93
Source of Ember Load to Buildings	93
Wildfire Hazard Potential	94
Ignition Cause	95
Fire Ignition Probability	96
Fire Dynamics	97
Functional Fire	97
FRID:	98
Mean Percent FRI Departure, Since 1908	99
Mean Percent FRI Departure, Since 1970	99
Mean FRID Condition Class For Departure	100
Time Since Last Fire	101
Current Fire Return Interval Departure, Since 1908	101
Current Fire Return Interval Departure, Since 1970	102
Severity	102
Annual Burn Probability	102
Probability of Fire Severity (Low, Moderate, High)	103
Total Dead/Down Fuels	104
Standing Dead and Ladder Fuels	105
Total Fuel Exposed to Fire	106
Forest and Shrubland Resilience	107
Structure	107
Canopy Layer Count	108
Canopy Veg Height	108
Canopy Veg Cover	109
LARGE TREE DENSITY	109
SNV - Density Large Trees	109
SoCal - Density Large Trees	111

CenCal - Density Large Trees	112
NorCal Density Large Trees	113
Natural Conifer Regeneration Probability	114
Basal Area	115
Density – Trees Per Acre	116
Density – Snags	117
Stand Density Index	117
Proportion of Maximum SDI	118
Fine-Scale Heterogeneity	119
Fine-Scale Heterogeneity Index	120
Percent Canopy Cover	120
Composition	121
Tree Cover	121
Shrub Cover	122
Herbaceous Cover	122
Seral Stage	122
Absolute Change in Herbaceous Cover	124
Distribution of obligate resprouting, obligate seeding, and facultative seeding shrub species (and Tree and Herb)	124
Shrublands with Low natural regeneration potential post-fire in southern California	126
Disturbance	128
Cumulative Tree Cover Loss	128
Cumulative Shrub Cover Loss	129
Risk of Tree Dieoff During Drought	129
Potential Climate Refugia -Baseline (Historical) Conditions	130
Potential Climate Refugia - under Modeled Climate Change (MIROC model - hotter and drier)	131
Potential Climate Refugia - Combined Modeled Climate Change (MIROC model - (Hotter and drier) and CNRM-CM5 (wetter and warmer)	133
Goldspotted Oak Borer	135
Shrub resiliency. Number of disturbance events per 15 year interval since 1975	136
Multi-stressor Refugia	136
Time Since Last Disturbance	137
Tree Mortality – Past 5 Years and Past 1 year	138
Social and Cultural Well-Being	138
Equitable Opportunity	138
Poverty Percentile	139
Housing Burden Percentile	140
Unemployment Percentile	141
American Indian Land Area Representation (LAR)	142
American Indian Lands (Census Data)	144

Populations by Region	145
Sierra Nevada - American Indian or Alaska Native race alone Population Concentration	145
Sierra Nevada - Hispanic/Latino Population Concentration	148
Sierra Nevada - Hispanic and/or Black, Indigenous or person of color (HSPBPOC)	150
Sierra Nevada - Asian Population Concentration	152
Sierra Nevada - Multi-Race, Except Part-American Indian Population Concentration	155
Sierra Nevada - Low Income Population Concentration	157
SoCal - American Indian or Alaska Native Race Alone and Multirace Population Concentration	160
SoCal - Hispanic/Latino Population Concentration	162
SoCal - Black/African American Population Concentration	164
SoCal - Hispanic and/or Black, Indigenous or person of color (HSPBPOC)	167
SoCal - Asian Population Concentration	169
SoCal - Multi-Race, Except Part-American Indian Population Concentration	172
SoCal - Low Income Population Concentration	174
CenCal - Hispanic/Latino Population Concentration	176
CenCal -Black/African American Population Concentration	179
CenCal -Hispanic and/or Black, Indigenous or person of color (HSPBPOC)	181
CenCal -Asian Population Concentration	183
CenCal -Multi-Race, Except Part-American Indian Population Concentration	186
CenCal -Low Income Population Concentration	188
NorCal - American Indian or Alaska Native race alone Population Concentration	191
NorCal - Hispanic/Latino Population Concentration	193
NorCal - Black/African American Population Concentration	195
NorCal - Hispanic and/or Black, Indigenous or person of color (HSPBPOC)	198
NorCal - Asian Population Concentration	200
NorCal - Low Income Population Concentration	202
Recreation Quality	205
Trail Density	205
Water Security	205
Quantity	206
Actual Evapotranspiration to Precipitation Fraction During Drought	206
Precipitation Minus Actual Evapotranspiration during average conditions	206
Drought Sensitivity	207
Change in average Climatic Water Deficit	208
Groundwater Basin Boundaries	208
Quality	209
Percent Impervious Surface	209
Wetland Integrity	210
Hydrologic Function	210

Meadow Sensitivity Index	210
Composition	210
Aquatic Species Richness	211
Wetland Diversity	211
Riparian Habitat	212
Operational Data Layers	212
Fire	213
Recent Fire Severity Class	213
Housing Unit Density	213
Potential Operational Delineations	214
Wildland Urban Interface	216
Administrative	216
Land Designations	216
Ownership	217
Urban-Agriculture Land Use	218
Building Structure Density	218
High-Use Recreation Areas	219
Wilderness - Protected Area Database 3.0	219
Northwest Forest Plan (NWFP) Boundary	220
Timber Production Zone Lands	220
Biomass Power Plants and Sawmills	221
Roads	221
PG&E Transmission Lines - Low Voltage	222
PG&E Distribution Lines	222
SDG&E Transmission Lines	223
SDG&E Primary Distribution Lines	224
SCE Transmission Lines	224
SCE Primary Distribution Lines	226
Terrestrial	227
CWHR Vegetation	227
Forest Type	240
Protected Activity Centers (PAC)	241
Statewide Crop Mapping - Provisional	241
Aquatic	242
Lakes/Reservoirs	242
Perennial and Intermittent Streams	243
Meadows	243
Data Disclaimers	245
Department of Forestry and Fire Protection (CALFIRE)	245
California Department of Fish and Wildlife (CDFW)	245
Area of Conservation Emphasis (ACE)	245

Biogeographic Information and Observation System (BIOS)	246
Farmland Mapping and Monitoring Program (FMMP)	247
California Department of Water Resources	247
Open Data Commons Open Database License (ODBL)	247
Open Street Map	247
LANDFIRE (uisfs/usdoj)	247
National Marine Fisheries Service NOAA	248
California Forest Observatory (Salo Sciences)	248
Open Data Commons Open Database License (ODbL)	248
California Office of Environmental Health Hazard Assessment (OEHHA)	248
Center for Ecosystem Climate Solutions (CECS) – UC Irvine	248
Pyrologix	249
University of California Division Agriculture and Natural Resources	249
USDA Forest Service (USFS)	249
USDA Forest Service (USFS) - Forest Inventory and Analysis (FIA) Program	250
US Fish and Wildlife Service (USFWS)	250
U.S. Geological survey (USGS)	250
Additional Resources	250
References	251

INTRODUCTION

WHAT IS THE CALIFORNIA LANDSCAPE METRICS EFFORT?

Reducing the risk of large, high intensity fire (and other mega-disturbances) through forest treatments has become a management imperative in California. A [Strategy for Shared Stewardship](#) (2018) and the USFS [Wildfire Crisis Implementation Plan](#) (2022) reinforce specific goals for pace and scale of strategic forest treatments over the next decade. Concurrently, the State of California has issued a new [Wildfire and Forest Resilience Action Plan](#) (2022), designed to strategically accelerate efforts to restore the health and resilience of California landscapes through a joint federal and State framework.

High quality geospatial data are essential to drive analytic tools for planning and investments to restore and conserve California's landscapes. To support these initiatives, an interagency team of scientists from the USDA Forest Service Pacific Southwest Research Station (PSW), USDA Forest Service Region 5, CAL FIRE's Fire and Resource Assessment Program (FRAP), the Climate and Wildfire Institute (CWI), and researchers from the University of California Berkeley, University of California Irvine, and the USDA California Climate Hub collaborated to develop a comprehensive set of mapped data layers. These high quality data developed from ecological modeling techniques, informative analytical approaches and the resulting credible scientific outputs enable landscape level assessment to inform and support large landscape restoration planning and implementation.

The data layers included in this California Landscape Metrics (CLM) project are meant to assist land managers in assessing their current landscape and plan for treatments to enhance resilience to human and natural disturbances. Thus, each layer represents what the interagency team believes are the most relevant and reliable geospatial data available at this time. Each layer has been examined by the team and is supported by published data and/or was developed using standard methods. The methods for developing each layer are documented in the metric dictionary; however, the accuracy of each layer has not been quantified. It is anticipated that all data layers will be updated and refined as methods and source data evolve and improve.

The CLM represents a next, important step in the cataloging and availability of metrics. When the Regional Resources Kits (RRK) were originally conceived and made available (September 2022), the metrics were the only resource in the kits. The plan was to create kits for each of the four regions identified by the California Wildfire & Forest Resilience Task Force (<https://wildfiretaskforce.org/>) and that is what was done over the next year. Recently (April 2024) all four regions were updated to bring in some corrections and updates to improve each kit.

This framework made sense originally however, as we have worked on building these sets of metrics and, in particular, learned much more about how we can efficiently and effectively manage and present the data, we have decided to make some changes. This CLM compilation now includes the data for all regions of California. We believe this is an important step in making data available efficiently for any part of California.

Many CLM metrics cover the entire state, others cover only a portion of the state. Users can access the data for the maximum geographic extent available for that particular dataset.

Future software modifications by the [Task Force Data Hub](#) will make it possible for a user to use any number of geographic “areas of interest”, regions, counties, watersheds, or even a shapefile that defines a project area that a user can submit, to define the area for which they want data.

The CLM will make access to the metrics more effective overall because:

- Maintenance of the CLM will be much more efficient:
 - Files are all stored in one directory
 - Only one metric dictionary is needed
 - Updates/changes are only needed once, not four times
- Users can see what is available in the entire CLM suite, they do not have to search four separate kits
- Users can access whatever area of interest is relevant to them, avoiding confusion for areas along the boundary of regions
- We are still able to retain the tiering of metrics; some do, in fact, cover the entire state (tier 1); others are inherently only relevant to and available for certain portions of the state (tier 2)

We have labeled this CLM compilation as version 5, to enable a fresh start. And we call it the “California Landscape Metrics” to reflect its geographic breadth and completeness. We will retain the structure of housing the metrics within the Regional Resource Kits for a time as people become familiar with these changes. Ultimately this will be the singular repository for metrics made available by the Task Force.

WHAT THIS DOCUMENT IS AND ITS INTENDED PURPOSE

ORGANIZATIONAL STRUCTURE

This document has been organized to reflect the “Framework for Resilience” as set forth by the Tahoe Central Sierra Initiative (Manley et al. 2020, 2022). The framework is comprised of ten “**Pillars**” which support the full array of landscape management objectives that are inherently interdependent. Each pillar represents the desired long-term, landscape-scale outcome to restoring resilience. They include ecological values, such as biodiversity, as well as societal benefits to communities, such as water security. Within each pillar are “**Elements**” which represent the primary processes and core functions of that pillar, such as focal species, water quality, or economic health. Finally, within each element are the individual “**Metrics**” which describe the characteristics of elements in quantitative or qualitative terms. Metrics are used to assess, plan for, measure, and monitor progress toward desired outcomes and greater resilience.

The framework pillars are:

- **Fire Dynamics**
- **Forest and Shrubland Resilience**
- **Biodiversity Conservation**
- **Wetland Integrity**
- **Water Security**
- **Carbon Sequestration**
- **Air Quality**

- **Economic Diversity**
- **Fire Adapted Communities**
- **Social & Cultural Well-Being**

It is important to understand that while pillars and elements are consistent across California, the metrics used by a group may vary from region to region based on ecological and social differences (for example forest types or economy), available data, and the user preferences. It is equally important to recognize that due to the interdependent nature of the framework, some metrics overlap into multiple elements/pillars however have only been addressed a single time within this document.

METRICS

The metrics are organized by the 10 pillars of resilience in the Framework for Resilience. Each pillar represents a resource outcome associated with resilient forest and shrubland landscapes. There are 199 metrics within the CLM compilation, those specifically covering the entire state. The metrics describe the characteristics of the elements (key characteristics) of each pillar in quantitative or, in a few cases, qualitative terms. Metrics are used to assess current conditions, plan treatments, and monitor for, measure, and monitor progress toward desired outcomes and greater resilience. Metrics are selected to be informative, meaningful, and actionable to meet the needs of management.

Tiers:

The metrics are divided into three "tiers." Among all these metrics, some are created and relevant statewide and are included in the CLM data.

Tier 1 - metrics that are a single, consistent data layer, developed statewide. Example: Annual Burn Probability.

Tier 2 - metrics relevant to and available for a single region or relevant to multiple regions but data layers differ among regions because of varied data availability (sources) across regions. Example: California Gnatcatcher Habitat Suitability.

Tier 3 - metrics are those that would be of interest to some land managers for specific applications but not included in the CLM. Example: Distribution of the Quino Checkerspot Butterfly.

Some data layers contain null values. We point this out here so users of the data will be aware and take whatever measures appropriate as they use and analyze the data. For some raster datasets, areas have been masked (blanked) out and have a cell value of NoData (also referred to as null, NaN or missing). We, as producers and users of the data, cannot ignore NoData or fill them with zeros, since zero is often a valid value for some datasets. Removing NoData cells is not an option, a raster is a continuous grid. For users of the data performing further analyses and combining or "stacking" rasters, these NoData cells will mask out all values in that location in the output. To avoid this issue, the user must create values for the cells before combining them (i.e. 999 or any numeric value that is not real and clearly out of the range of the other values). Reasons for masking (blanking) out cells in data include:

- Cells are located in water bodies (e.g., lakes, reservoirs, or large rivers)
- Cells are located in urban areas
- Cells are located in areas used for irrigated agriculture

- Cells contain no information relevant to the dataset (e.g. for a streams data layer, areas outside of streams have NoData)
- Area (cells) subject to fire or other disturbance but the post disturbance condition or value is unknown.

Intended Purpose

Landscape level assessments, using high-quality data combined with decision support tools to help evaluate alternative treatment strategies, are fundamental to inform and support large landscape restoration planning. These data have been assembled in one place to provide comprehensive access for land managers.

Through this “metric dictionary,” each metric has been defined to help end-users of the data (and for use with any decision support tools) to understand:

- Data vintage
- The definition meant by a given metric
- The expected use(s) of the metric
- The resolution of the developed data
- The data sources used to derive the metric
- The method of metric derivation
- The root file names

References have been included to help the reader understand potential methods for deriving metrics. It is our hope this information will help people make better use of all the assembled information and how it can best be used with various decision support tools. This dictionary will be updated periodically, as necessary.

Note that most data layers have been masked (i.e. blocked out) for open water (lakes, reservoirs) and a selected few have been masked for the urban and agricultural landscape (see the list of operational layers at the end of this document). This is done to avoid confusion with vegetation values coming from urban areas (e.g. city parks) or agricultural areas (e.g. irrigated farm land).

The metrics (by Pillar) available in this CLM compilation are listed below. A file naming convention has been developed to help organize it and make a file easily identifiable.

File Naming Convention:

A standardized naming convention, as follows, has been developed to help organize files and describe what is contained:

{regional prefix if applicable, none if statewide}_{description}_{vintage of source data}_{latest publish date}_{tier #}_{CLM version #}.{file format}

Examples:

- PotentialTotalSmoke_202209_202312_T1_v5.tif
- NorCal_BiomassTrmntCostHigh_202309_202401_T2_v5.tif
- CumulTreeCoverLoss_19912020_202312_T1_v5.tif (vintage represents a range from 1991 - 2020)

Use of prefixes:

- If a layer exists in every region, it is Tier 1 and does not get a regional prefix.
- If a layer does not exist in every region but it could if statewide coverage was available, it is Tier 2 and gets a regional prefix. For example, F3 layers only exist for the Sierra Nevada, but we hope in the future datasets like this could be developed statewide.
- If a layer does not exist in every region and it never will, it is Tier 2 and gets no prefix.

Definitions for the four regional prefixes used in file naming are as follows:

- SNV = Sierra Nevada
- SoCal = Southern California
- CenCal = Central California
- NorCal = Northern California

GENERATING METRICS WITH THE F3 MODEL

Many metrics related to vegetation structure and composition have been generated using a modeling framework known as **F3** ([Huang et al 2018](#)). The F3 process, developed by scientists at the US Forest Service Region 5 Mapping and Remote Sensing (MARS) Team, is a collection of algorithms that combine remotely sensed, biophysical setting, climate and Forest Inventory and Analysis (FIA) data. The F3 framework couples FIA plot measurements and the Forest Vegetation Simulator ([FVS](#)) to compute forest structure and biophysical characteristics estimates. The plot-level estimates are then imputed using the FastEmap (Field And Satellite for Ecosystem MAPPING; [Huang et al 2017](#)) algorithm to produce spatially explicit representations of each calculated metric. The following section is an overview of the general F3 process, and it is highly recommended that interested readers become familiar with the afore-linked scientific articles.

This work was produced with data and the collaboration of the USDA Forest Service, Pacific Northwest Research Station, Forest Inventory and Analysis Program.

GENERAL F3 PROCESS

The framework for F3 begins with the FIA inventory data which has been pulled from the NIMS Oracle database and ranges from the early 2000s up to 2019 (the most recent collection of FIA plot data due to COVID complications). The inventory data is first filtered and plots which have been disturbed (by fire, insect, harvest) are removed from the pool of available plots prior to being run through FVS. Plots measured prior to 2019 are grown to the concurrent 2019 year through FVS under natural succession conditions (i.e., no management). This allows all data to reflect a single year condition. The multi-temporal scenario projections from FVS provide forest structure and biophysical characteristic estimates which are point specific and joined to a point shapefile representing FIA plot locations. The FastEmap algorithm then extrapolates these point specific forest metrics to spatially contiguous map products based on remote sensing and other auxiliary geospatial data.

The step-by-step FastEmap process starts with the FVS results shapefile and concurrent Landsat 8 data (2019) with cloud and shadow removed. FastEmap begins by extracting the remote sensing (RS) values and environmental properties (i.e., topography, soil, elevation, aspect, slope precipitation, temperature) of the pixel where a FIA plot is located. Next 'virtual plots' are identified that are nearly identical in RS values and environmental properties to the identified plot pixel; the FVS metric measurement from the plot is assigned to these extremely similar pixels and the process is repeated for every field plot. The area is then stratified into different groups which have similar

RS values and environmental conditions and the expanded plots (actual and virtual) that fall within a group are identified and weightings calculated. FastEmap uses a stepwise regression analysis to predict the metric measurement and the process is repeated for all stratified groups. Finally, local interpolation and strata median filling are used for those pixels still not imputed. The FastEmap process is run three times, allowing for an average of the three results to be spatially compiled into the final result. Several steps are taken in the processing workflow to ensure FIA plot security is maintained. Among these measures, for metrics provided, rasters were upscaled to 300 m by computing the average or majority value for continuous and discrete metrics, respectively, within a moving 10 x 10 window of 30 m pixels. The following flowchart from the F3 article has been included to help illustrate the full F3 process.

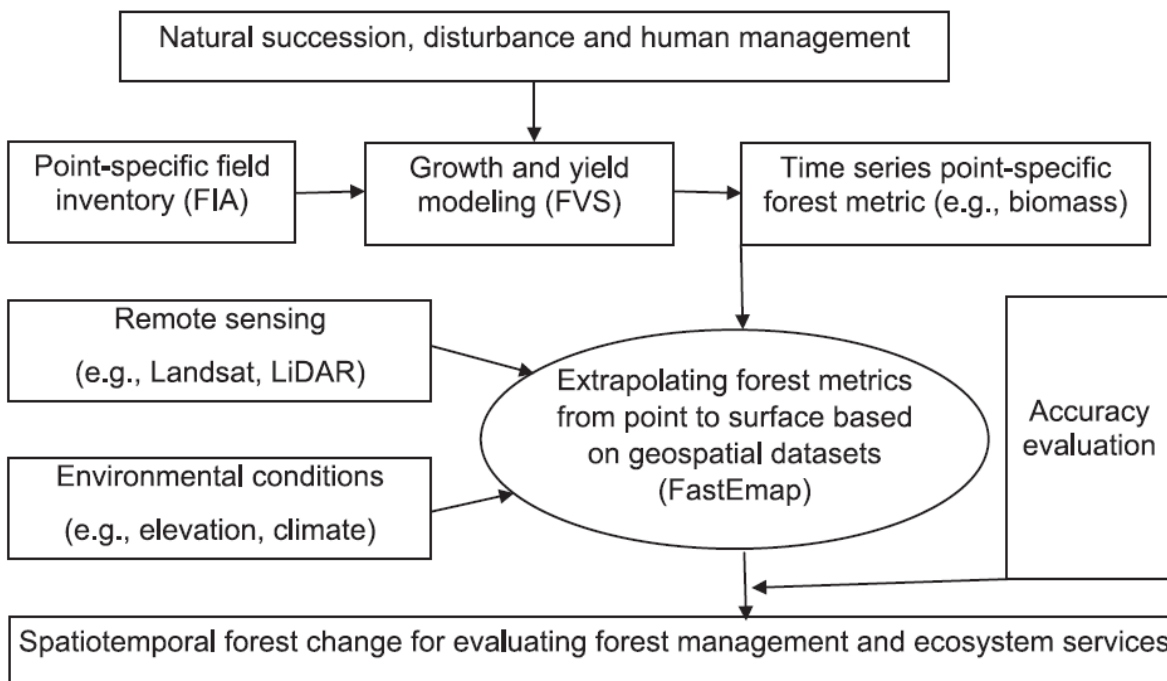


Fig. 1. Flowchart of F³ modeling framework.

ADVANTAGES AND LIMITATIONS

The advantage of F3 comes from the leveraging of highly detailed information of stand condition, revisited over time in FIA plot data, which in turn drives the FVS natural succession model simulating stand change and extrapolates this point-specific plot information to a landscape level. F3 modeled outputs provide landscape managers information that is “high-detailed, spatially-explicit, multi-temporal, and scenario-comparable” (Huang *et al* 2018).

However, there are important limitations to the F3 data for users to keep in mind. The first limitation is that for this iteration of the SNV CLM, the F3 products are current to 2019 conditions and therefore do not capture recent disturbances (i.e., fire events of 2020 and 2021). To address this limitation, an approach to identify and update these recently disturbed pixels was implemented which incorporates the Ecosystem Disturbance and Recovery Tracker (eDaRT; [Koltunov et al. 2020](#)), a Landsat-based high density time series anomaly detection algorithm. (See the next section for additional information.)

Another acknowledged limitation of F3 stems directly from the original FIA plot inputs. FIA plots are only sampled in “forested” conditions, defined as exceeding 10% canopy cover of trees, and therefore are an incomplete

representation of reality. The areas that do not meet the definition of forested conditions will not have tree information collected and this directly affects the performance of F3 in non-forested areas that contain trees (such as meadows). To mitigate this type of condition misrepresentation, a meadow mask is applied to the combined averaged data layer during the final processing steps.

While F3 can incorporate management scenarios into the products, it is beyond the scope of this effort, as these data are being produced at the Sierra Nevada range scale and management scenarios are produced at a forest scale or finer. Finally, although F3 products are delivered as 30-meter pixels, the products have been designed for landscape level analyses and as such, analysis at the single pixel scale is not recommended.

UPDATING F3 DATA FOR CHANGE EVENTS

2019 Data Products

The remote sensing data used for this product are a May-September medoid composite for year 2019 from Landsat; therefore, any actual disturbance (e.g., fire, logging, beetle, and drought) that took place in the latter half of 2019 are not reflected in the F3 product.

2021 Data Products

F3 2019 data products were modeled forward to conditions in 2021 using the Ecosystem Disturbance and Recovery Tracker (eDaRT; Koltunov et al. 2020). The newly developed estimate of fractional canopy cover loss in eDaRT, called Mortality Magnitude Index (MMI) uses anomaly metrics representing normalized statistics of vegetation indices derived from Landsat data at 30m scale (Slaton et al., in prep). MMI was calibrated for drought- and insect-caused tree mortality, but also serves as a reasonable proxy for severity of other forest disturbances, including fire (US Forest Service, 2020). In many cases, MMI values were used to directly adjust F3 metrics from the year 2019 to 2021, while in other cases, additional conversion factors based on published literature were required. The logic and ruleset for adjustments for each metric are provided within the metrics section of this document.

eDaRT disturbance events are attributed with an onset date corresponding to the two-week time period of the first Landsat image in which the disturbance was detected and this sub-annual timing was relied upon for the F3 year 2021 adjustments. First it is important to note that while the F3 2019 composite represents May-September, an image stack medoid for summer months in temperate ecoregions will naturally represent conditions earlier in that time period, before ecosystem disturbances such as fire, insect- and drought-related tree mortality, and restoration activities accumulate over the course of the season. Inspection of the image confirmed that August-September disturbances were not apparent. Therefore, we used disturbances from eDaRT with start dates from August 1, 2019 through November 30, 2021. Some actual disturbances late in that time window may have been omitted, because sufficient subsequent images following a disturbance (i.e. late 2021 or into 2022) are required to confirm events from late 2021.

AIR QUALITY

The goal of healthier forests is aligned with the goal of having healthier air (Cisneros et al., 2014, Long et al., 2018). Forests with sustainable fuel loads create less emissions overall, and support less rapid fire growth, which reduces emissions per day and decreases the chances that smoke from a wildland fire event will create long duration, intense smoke episodes like those we've seen at regional scales during the past decade. Key to supporting the proactive management of smoke and minimization of impacts is a granular understanding at the project scale of where the fuels are, and what potential emissions might occur under wildfire and/or Rx fire scenarios. Those

emissions (e.g., from maps like those produced by F3 below) combined with estimates of daily spread can be used to inform operational or scenario-based dispersion modeling (and would be compatible with California's PFIRS smoke management system), which in turn would help fire and air managers better understand where smoke is likely to go, and help inform the public where and when it's likely to occur at potentially unhealthy concentrations.

Tradeoffs between wildfire and Rx fire smoke production (daily, or in total) could be quantified on a first order basis by summing daily or total emissions from high severity vs moderate severity over the area of the respective fire spread polygons. Note that Rx fire smoke impacts are not only different due to per acre differences in emissions, but because the per day emissions can also differ quite substantially. Those emissions numbers could also inform dispersion modeling scenarios showing the relative differences in smoke impacts between wildfire and prescribed scenarios, or even between different wildfire management scenarios.

DESIRED OUTCOME: Emissions from fires are limited to primarily low- and moderate-severity fires in wildland ecosystems. Forests improve air quality by capturing pollutants.

PARTICULATE MATTER

Particle pollution represents a main component of wildfire smoke and the principal public health threat. Fine particles (also known as PM_{2.5}) are particles generally 2.5 µm in diameter or smaller and represent a main pollutant emitted from wildfire smoke. Fine particles from wildfire smoke are of greatest health concern.

POTENTIAL TOTAL SMOKE PRODUCTION INDEX

Tier: 1

Data Vintage: 2022

Metric Definition and Relevance: This metric is an index of the potential smoke production (represented by particulate matter that is 2.5 microns or less in diameter, or PM_{2.5}) that could be emitted for a given 30-meter pixel under fire weather conditions that produce high severity fire effects. By showing spatial variation in potential smoke emissions under standardized fuel moisture conditions, this index is intended to help identify potential emissions hotspots within a region if a high severity wildfire occurs in the future. It may be useful for regional scale planning and/or prioritization.

However, the actual moistures and fire weather conditions under which these fuels may convert to smoke will vary; therefore, the map does not represent actual smoke production (PM_{2.5} emissions) during an actual fire event. For data users interested in near-term smoke forecasts that reflect the environmental drivers of emissions, project-specific modeling tools are recommended. For example, the BlueSky Playground (<https://tools.airfire.org/playground>) can tailor model inputs based on the fuel and moisture conditions observed or planned for in the project area of interest.

Potential smoke emissions do not consider the probability of a fire or the transport of smoke to more distant locations; they only reflect what would happen locally if a pixel were to burn.

Data Resolution: 30m Raster

Data Units: 0 - 1, a unitless number serving as an index; on a per 30-m pixel basis

Creation Method: Potential TOTAL smoke production index is the smoke production expected for a given pixel under severe fire weather conditions. It is based on model outputs from the First Order Fire Effects Model (FOFEM) developed by the U.S. Forest Service (Spatial FOFEM: <https://www.firelab.org/project/fofem-fire-effects-model>). Key drivers (and model inputs) for this mapped variation are (1) fuel loads spatially extracted from the Landfire

FCCS modeled fuelbeds map (LANDFIRE 2022 Update (LF 2.3.0), https://www.landfire.gov/lf_230.php), and (2) fuel moistures, which are assigned to approximate the extremely dry conditions under which high severity fire generally occurs. The data are dimensionless and linearly normalized from 0 to 1 based on the statewide maximum value, with 1 being the maximum PM_{2.5} emissions per 30-m pixel for the given region. Fuels are taken from LANDFIRE LF2022_FCCS_220. Spatial FOFEM was run as implemented in FlamMap 6.2 (<https://www.firelab.org/project/flammap>).

This index is a unitless number (ranging between 0 and 1) on a per 30-meter pixel basis, which is calculated using the following equation:

$$\text{Potential Total Smoke Production Index} = S_i / (\text{maximum } S_i \text{ statewide})$$

where

S_i = high severity PM_{2.5} emissions value for pixel i

Calculated with SpatialFOFEM (First Order Fire Effects Model), embedded in FlamMap 6.2. Fuels are LCP and FCCS 2022 from LANDFIRE (LCP_LF2022_FBFM40_220_CONUS and LF2022_FCCS_220_CONUS). FOFEM Parameters used for this application are:

Seasonality - (Summer)

Canopy consumption – 39%

Duff moisture – 20%

1 hour fuel moisture – 4%

10-hour fuel moisture – 6%

100-hour fuel moisture – 8%

1000-hour fuel moisture – 8%

Analysis was done at UC Irvine.

Data Source: LANDFIRE FCCS ([LANDFIRE Program: Data Products – Fuel – Fuel Characteristic Classification System Fuelbeds](#)) 2022

Rocky Mountain Research Station

<https://www.firelab.org/project/fofem-fire-effects-model>

File Name: PotentialTotalSmoke_202209_202312_T1_v5.tif

POTENTIAL AVOIDED SMOKE PRODUCTION INDEX

Tier: 1

Data Vintage: 2022

Metric Definition and Relevance: This is an index of how much *less* smoke (as defined by PM_{2.5} emissions) would be produced from a given pixel by burning under moderate fire weather conditions rather than the extreme conditions that lead to high-severity smoke production. This serves as a proxy for efforts to minimize smoke emissions by allowing a given area to burn under more desirable conditions (e.g., prescribed burning conditions)

vs. how it would burn under extreme conditions. Since identical fuelbeds are used as inputs in the high-severity and low-severity model runs, the index does *not* represent the effects of fuel treatments on subsequent wildfire. Rather, this metric represents the maximum potential difference between emissions under high vs. moderate fire weather conditions. Summing these reductions over large areas would be unrealistic because wildland fire burns with a mix of intensities and severities over landscapes, and does not burn everywhere in California, every year.

Wildland fire is often self-limiting in extent. In other words, wildfires may stop spreading when they reach the boundary of a recent burn. Since prescribed fire and managed wildfire can be selected to burn under moderate fire weather conditions, proactive fire use can shift high-severity-type fire emissions to low-severity-type fire emissions. This metric provides a rough index of the potential fire emissions benefits if a fire is allowed to burn under moderate weather conditions rather than in a wildfire under extreme weather. By showing the spatial variation in this potential benefit, this index is intended to help identify where fire management may have the greatest emissions benefit. It may be useful for regional scale planning and/or prioritization.

It is important to note that not all managed fire will produce an emissions benefit, because wildfire may not have otherwise burned in that location within the lifespan of the managed fire's effects, and the managed fire's footprint may not prevent a subsequent wildfire from burning in the same location. Furthermore, actual weather conditions vary from those used in model inputs. Therefore, the map does not represent actual avoided smoke production (PM_{2.5} emissions) during an actual fire event that may occur in the future. For data users interested in near-term smoke forecasts that reflect the environmental drivers of emissions, project-specific modeling tools are recommended. For example, the BlueSky Playground (<https://tools.airfire.org/playground>) can tailor model inputs based on the fuel and moisture conditions observed or planned for in the project area of interest.

Potential smoke emissions do not consider the probability of a fire or the transport of smoke to more distant locations; they only reflect what would happen locally if a pixel were to burn.

Data Resolution: 30m Raster

Data Units: 0 - 1, a unitless number serving as an index; on a per 30-m pixel basis

Creation Method: This index is a unitless number (ranging between 0 and 1) on a per 30-meter pixel basis, which is calculated using the following equation:

Potential Avoided Smoke Production Index = (D_i for a given pixel) / (the maximum D_i statewide)

where

D_i = the difference in modeled PM_{2.5} emissions between high severity and low severity scenarios for pixel i = (high severity PM_{2.5} emissions scenario for pixel i) – (low severity PM_{2.5} emissions scenario for pixel i)

“High severity PM_{2.5} emissions” were calculated as described for the “POTENTIAL TOTAL SMOKE PRODUCTION INDEX” metric.

Calculated with SpatialFOFEM (First Order Fire Effects Model), embedded in FlamMap 6.2. Fuels are LCP and FCCS 2022 from LANDFIRE (LCP_LF2022_FBFM40_220_CONUS and LF2022_FCCS_220_CONUS). Conditions for Low severity PM 2.5 emissions were calculated for the following settings (FOFEM parameters used for this application):

Seasonality: Spring

Canopy consumption - 5%
Duff moisture - 75%
1 hour fuel moisture - 14%
10-hour fuel moisture - 16%
100-hour fuel moisture - 18%
1000-hour fuel moisture - 25%

Analysis was done at UC Irvine.

Data Source: LANDFIRE FCCS ([LANDFIRE Program: Data Products - Fuel - Fuel Characteristic Classification System Fuelbeds](#)) 2022

Rocky Mountain Research Station

<https://www.firelab.org/project/fofem-fire-effects-model>

File Name: PotentialAvoidedSmoke_202209_202312_T1_v5.tif

HEAVY FUELS

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: Emissions (on which the modeled PFIRS and Smoke Spotter smoke plumes are based, and which are generated by the BlueSky Playground) are especially sensitive to changes in the coarse fraction of dead wood in the fuel bed, if those fractions are dry enough to be available. It is therefore important to map with project-scale detail where the heaviest fuels might be, so managers have a good estimate for operational smoke management and scenario planning at their project scale, and where perhaps the standard fuelbeds (and emissions estimates based on them) might be underestimating heat and smoke production that can drive unexpected fire behavior, plume loft, and/or smoke impacts.

Data Resolution: 30m raster

Data Units: Short tons biomass/acre

Creation Method: This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California. The [F3 model](#) generated several different raster surfaces of fuel loading estimates of the coarse woody debris by non-overlapping size classes; including 1, 10, 100, 1000-hour fuels (FLOAD_1-5). The model also produced estimates for coarse woody debris of heavy fuels by predefined non-overlapping size classes which are greater than the 1000-hour fuel size ($\geq 12''$; FLOAD_6-9).

2019 to 2021 Update: No adjustments were made for 2021 due to uncertainties in conversions based on the limits with which change detection information can quantify the individual components of this metric. For areas with disturbance 2019-2021 (defined as eDaRT MMI $\geq 10\%$ canopy cover loss), fuel values are not represented for 2021 (i.e., NULL). For areas undisturbed 2019-2021, it is a reasonable assumption that heavy fuel values did not change significantly over the course of two years.

This layer is derived from F3 layers (2021) using the following formula:

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: HeavyFuels_SNV_202109_202209_T2_v5.tif

BIODIVERSITY CONSERVATION

The California landscape provides habitat for over 300 species of native vertebrates and thousands of invertebrate species and plants. Management activities over the last century have impacted most species to varying degrees and some have declined significantly in recent decades. Protecting and enhancing native biodiversity has become a management imperative under both federal and state laws and policy. Native plants and animals provide a wide array of benefits to forests and other habitats in California; they help forests recover after a fire, control flooding and soil erosion, cycle nutrients, and are valued by people recreating in forests. Greater species diversity promotes adaptability and helps ecosystems withstand and recover from disturbance, including those caused by climate change. The Biodiversity Conservation pillar focuses on species diversity, critical habitat for focal species and non-native species distribution.

Habitat data to model the likelihood of species presence or absence was derived from the [FVEG CWHR data layer](#).

DESIRED OUTCOME: The network of native species and ecological communities is sufficiently abundant and distributed across the landscape to support and sustain their full suite of ecological and cultural roles.

SPECIES DIVERSITY

Species diversity is a function of both the number of different species in the community and their relative abundances. Larger numbers of species and more even abundances of species lead to higher species diversity. Species diversity can be calculated in a variety of ways to represent the type and magnitude of differences among species, their number, and their abundance.

WILDLIFE SPECIES RICHNESS

Tier: 1

Data Vintage: 04/2023

Metric Definition and Relevance: Native species richness is estimated based on high suitability reproductive habitat for a given species. Reproductive habitat is used to represent suitability because it is critical for species persistence and for most native species it has the most limited requirements. If a habitat is identified as high for a given species, it is considered suitable (1), and habitat identified as moderate, low or not suitable, it is considered unsuitable (0). Species richness values are used as a relative measure of biodiversity value; as such, areas with lower species richness based on these criteria may still have high biodiversity value, but not as high as areas with higher richness values. The number of native species per spatial unit (30m pixel) presented as simply the total number; this can be useful for assessing change in number/composition over space.

Data Resolution: 30m Raster

Data Units: Number of species

Creation Method: Generated using the California Wildlife Habitat Relationships model developed and managed by the California Department of Fish and Wildlife. CWHR habitat values are based on the FVEG vegetation data that has been updated. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed highly suitable for the reproduction of that species in the California Wildlife Habitat Relationship database.

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: WildlifeSpecRichness_202304_202406_T1_v5.tif

THREATENED/ENDANGERED VERTEBRATE SPECIES RICHNESS

Tier: 1

Data Vintage: 04/2023

Metric Definition and Relevance: Native species richness is estimated based on high suitability reproductive habitat for a given species. Reproductive habitat is used to represent suitability because it is critical for species persistence and for most native species it has the most limited requirements. If a habitat is identified as high for a given species, it is considered suitable (1), and habitat identified as moderate, low or not suitable, it is considered unsuitable (0). Species richness values are used as a relative measure of biodiversity value; as such, areas with lower species richness based on these criteria may still have high biodiversity value, but not as high as areas with higher richness values. The total number of federally threatened/endangered native species per spatial unit (30m pixel) can be useful for assessing change in number/composition over space.

Data Resolution: 30m Raster

Data Units: Number of species

Creation Method: Generated using the California Wildlife Habitat Relationships model developed and managed by the California Department of Fish and Wildlife. CWHR habitat values are based on the FVEG vegetation data that has been updated. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed highly suitable for the reproduction of that species in the California Wildlife Habitat Relationship database.

Only species classified in the CWHR database as federally endangered, federally threatened, California endangered, or California threatened have been included in the species richness count for this layer.

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: ThreatEndangerSpecRichness_202304_202406_T1_v5.tif

FOREST RAPTORS SPECIES RICHNESS

Tier: 1

Data Vintage: 04/2023

Metric Definition and Relevance: Native species richness is estimated based on high suitability reproductive habitat for a given species. Reproductive habitat is used to represent suitability because it is critical for species persistence and for most native species it has the most limited requirements. If a habitat is identified as high for a given species, it is considered suitable (1), and habitat identified as moderate, low or not suitable, it is considered unsuitable (0). Species richness values are used as a relative measure of biodiversity value; as such, areas with lower species richness based on these criteria may still have high biodiversity value, but not as high as areas with higher richness values. The total number of federally threatened/endangered native species per spatial unit (30m pixel) can be useful for assessing change in number/composition over space.

Data Resolution: 30m Raster

Data Units: Number of species

Creation Method: Generated using the California Wildlife Habitat Relationships model developed and managed by the California Department of Fish and Wildlife. CWHR habitat values are based on the FVEG vegetation data that has been updated. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed highly suitable for the reproduction of that species in the California Wildlife Habitat Relationship database.

Only raptor species that are associated with forest habitats have been included in the species richness count for this layer. The raptors included in this layer are Bald Eagle, California Spotted Owl, Cooper'S Hawk, Great-Horned Owl, Merlin, Northern Goshawk, Northern Spotted Owl, Osprey, Peregrine Falcon, Red-Shouldered Hawk, RedTailed Hawk, Screech Owl and Sharp-Shinned Hawk.

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: ForestRaptorSpecRichness_202304_202406_T1_v5.tif

OPEN HABITAT RAPTORS SPECIES RICHNESS

Tier: 1

Data Vintage: 04/2023

Metric Definition and Relevance: Native species richness is estimated based on high suitability reproductive habitat for a given species. Reproductive habitat is used to represent suitability because it is critical for species persistence and for most native species it has the most limited requirements. If a habitat is identified as high for a given species, it is considered suitable (1), and habitat identified as moderate, low or not suitable, it is considered unsuitable (0). Species richness values are used as a relative measure of biodiversity value; as such, areas with lower species richness based on these criteria may still have high biodiversity value, but not as high as areas with higher richness values. The total number of federally threatened/endangered native species per spatial unit (30m pixel) can be useful for assessing change in number/composition over space.

Data Resolution: 30m Raster

Data Units: Number of species

Creation Method: Generated using the California Wildlife Habitat Relationships model developed and managed by the California Department of Fish and Wildlife. CWHR habitat values are based on the FVEG vegetation data that has been updated. Species are considered present, and habitats considered suitable for each 30m cell for which

the canopy cover-size-vegetation combination have been deemed highly suitable for the reproduction of that species in the California Wildlife Habitat Relationship database.

Only raptor species that are associated with open habitats have been included in the species richness count for this layer. The raptors included in this layer are American Kestrel, Barn Owl, Burrowing Owl, Ferruginous Hawk, Golden Eagle, Long-Eared Owl, Northern Harrier, Prairie Falcon, Rough-Legged Hawk, Short-Eared Owl, Swainson'S Hawk, Turkey Vulture, White-Tailed Kite, California Condor and Great Grey Owl.

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: OpenRangeRaptorSpecRichness_202304_202406_T1_v5.tif

HUMMINGBIRDS SPECIES RICHNESS

Tier: 1

Data Vintage: 04/2023

Metric Definition and Relevance: Native species richness is estimated based on high suitability reproductive habitat for a given species. Reproductive habitat is used to represent suitability because it is critical for species persistence and for most native species it has the most limited requirements. If a habitat is identified as high for a given species, it is considered suitable (1), and habitat identified as moderate, low or not suitable, it is considered unsuitable (0). Species richness values are used as a relative measure of biodiversity value; as such, areas with lower species richness based on these criteria may still have high biodiversity value, but not as high as areas with higher richness values. The total number of federally threatened/endangered native species per spatial unit (30m pixel) can be useful for assessing change in number/composition over space.

Data Resolution: 30m Raster

Data Units: Number of species

Creation Method: Generated using the California Wildlife Habitat Relationships model developed and managed by the California Department of Fish and Wildlife. CWHR habitat values are based on the FVEG vegetation data that has been updated. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed highly suitable for the reproduction of that species in the California Wildlife Habitat Relationship database.

Only hummingbird species have been included in the species richness count for this layer.

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: HummingbirdSpecRichness_202304_202406_T1_v5.tif

FOCAL SPECIES

Some of the Focal Species metrics below were created using the [California Wildlife Habitat Relationships program](#). The California Wildlife Habitat Relationship (CWHR) System contains life history, geographic range, and management information for more than 700 species of amphibians, reptiles, birds, and mammals that regularly occur within the state. A number of subspecies and distinct population segments (DPSs) have also been added and

more information at these taxonomic and management levels will be added as it becomes available. CWHR also contains detailed information on 59 habitat types and their spatial distributions. The core of the CWHR system is a database which relates these species to each of the habitats which support them, and an intuitive user interface enabling users to query this information. CWHR products aid in understanding, conserving, and managing California's wildlife.

The values provided in the metrics for these species represent relative suitability of the combination of vegetation type, size class, and canopy cover classes. For the specific combinations of vegetation types, size classes, and canopy cover classes that result in a low, moderate, or high habitat suitability rating, please refer to the CWHR tables [here](#) and select: > 'Species' tab -> select species by name -> under select species details: Reports -> check 'Habitats'. This process will create a full list of all suitable combinations for that species.

PLANTS

DISTRIBUTION OF REDWOOD STRUCTURE CLASSES

Tier: 2

Data vintage: 2012

Metric Definition and Relevance: Coast Redwoods grow in a band from the coast of central California to southern Oregon (thus these data are only in the Northern and Central California Regions). Compared to forests of the past, today's redwood forests are fragmented, smaller, and more stressed than ever throughout their range. Logging and clearcutting that began over a century ago destroyed redwood forests on an industrial scale for many decades. Forest regeneration after clearcutting created unnaturally dense forests with high competition among trees for light and water, reduced genetic diversity, and impaired ability to store carbon or provide ample habitat for native species. The remaining old-growth forests are fragmented by these logged forests and threatened by residential development, roads, changes in climate, and the lack of productive, natural fires.

The current extent of old-growth forest in the coast redwood ecosystem is only 5 percent of the original 2.2-million acre forest (~113,000 acres) and is, therefore, of significant concern. The vast majority of remaining old-growth (89,000 acres) is in Humboldt and Del Norte counties.

The first-ever State of Redwoods Conservation Report provides a contemporary look at the state of coast redwood and giant sequoia forest health in California. Its purpose is to serve as a reference guide to their status today and discuss the key variables that matter most to their future health: overall age and condition of the forests, varied ownership and protection of redwood and giant sequoia forests, key stressors, and environmental challenges. As governments, nonprofits, landowners, and community partners work to repair the damage done over the last centuries, this report will help all of us in the critical work of protecting what we have, rehabilitating what is damaged, and identifying critical areas and opportunities for future protection and restoration.

Data Resolution: 30m Raster

Data Units: Thematic

Value SpStruct

- 19 Redwood-Canopy Closure
- 20 Redwood-Early Biomass Accumulation
- 21 Redwood-Mid Biomass Accumulation
- 22 Redwood-Late Biomass Accumulation
- 23 Redwood-Maturation
- 24 Redwood-Large Complex Forest

Creation Method: The project area was defined as any Hydrologic Unit Code (HUC) 12 watershed, the smallest hydrological units comprehensively mapped by the U.S. Geological Survey, within 1.6 km (1 mile) of known existing natural redwoods (CALVEG 2004; Save the Redwoods League, unpublished data). When clipped to this region the Landscape Ecology, Modeling, Mapping and Analysis Gradient Nearest Neighbor (LEMMA GNN) structure map (hereafter LEMMA) contained 3,867 pixel classes, with each pixel corresponding to a 30 m x 30 m LANDSAT pixel (Ohmann and Gregory 2002). These pixel classes were classified into 24 species and structure classes.

Forest species was biased toward redwood by first categorizing any pixel with > 10 percent of basal area of redwood as redwood, likewise any remaining pixels with > 70 percent basal area of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), > 50 percent basal area of tanoak (*Notholithocarpus densiflorus* (Hook. & Arn.) P.S. Manos, C.H. Cannon, & S.H. Oh) were classified as those species, and the remaining pixels were classified as mixed conifer-hardwood.

Structure classes were based on four classes in Spies and Franklin (1991): 1) Canopy Closure, 2) Biomass Accumulation, 3) Maturation and 4) Large Complex Forest (LCF). The Biomass Accumulation stage was further subdivided into three classes (early, middle, late). The LCF class includes areas of old-growth, but the term LCF is used because some areas with structural complexity similar to old growth forest may actually consist of largely second growth trees. This distinction is important, in part, because remote sensing is unreliable at determining forest age.

Pixels were classified into these six classes using trees per acre (TPA) and dominant quadratic mean diameter (QMD) as modeled by LEMMA. The classes were defined as:

- 1) Canopy Closure: 50 percent of stems < 20.3 cm (8 inches)
- 2a) Early biomass accumulation (BA): QMD < 40.6 cm (16 inches) or 300 TPA and QMD < 81.3 cm (32 inches)
- 2b) Mid BA: QMD < 61 cm (24 inches) or 200 TPA and QMD < 81.3 cm (32 inches)
- 2c) Late BA: QMD < 81.3 cm (32 inches);
- 3) Maturation: 50 percent of stems < 122 cm (48 inches)
- 4) LCF: <50 percent of stems <122 cm (48 inches).

The Save the Redwoods League then used its old-growth database, which includes polygons of old growth throughout the range, to further refine the LCF class. The old growth database was developed in 2009 through a combination of field data and review of aerial images. To ensure that these areas were appropriately captured as

LCF, LEMMA pixel types (based on the Forest Inventory and Analysis plots that were used in the LEMMA GNN model) that are only found inside an old-growth polygon were converted to LCF throughout the range.

Data Source: State of Redwoods Conservation Report: <https://www.savetheredwoods.org/about-us/publications/state-of-redwoods-conservation-report-2018/>

File Name: DistRedwoodStructureClasses_2012_202401_T2_v5.tif

GIANT SEQUOIA STANDS

Tier: 2

Data Vintage: 2022

Metric Definition and Relevance: The population of giant sequoia (*Sequoiadendron giganteum* [SEGI]) trees is an irreplaceable heritage to be studied, protected, and preserved as it faces increased threats from drought and fire. This species is only found in the Sierra Nevada Region and thus the data are only from that Region.

Data Resolution: 30m raster

Data Units: Binary, 1 = existence, 0 = non-existence

Creation Method: The Giant Sequoia grove locations are well described, and their approximate delineations have been used for analysis work for years with the Administrative Grove Boundary (AGB) dataset. These AGB polygons were exaggerated for a variety of reasons and led to erroneous analysis results. An explicit delineation of SEGI populations was needed, especially as the range of the tree is exposed to increased threats instigated by a mega-drought not seen in the region in over a millennia. This dataset addressed that need across the entire range of SEGI.

While some 70+ “Groves” are recognized with the AGB dataset; the historic naming conventions of groves lost to generalization have been reapplied for this work, referencing each distinct area as a “Map Unit.” Consider ‘Grove’ a general term with ‘Map Unit’ a distinct population distribution for a unique SEGI population. There are 94 Map Units as of 2022 covering 26,270 acres. To create the Map Unit linework, individual SEGI pints were identified, both remotely and in the field, to inform the boundary line work. In the case of the National Park Map Units, the historic Sequoia Tree Inventory (STI) dataset dictated the boundary shape. Elsewhere, the Observed Tree Inventory (OTI) points guided the boundary formation.

For this effort, the giant sequoia stand polygons were subsequently converted to a raster grid at 30m resolution based on existence/non-existence.

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: GiantSequoiaMapUnits_2022_202209_T2_v5.tif

CALIFORNIA BLACK OAK STANDS

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: California black oak serves as important wildlife habitat and as a traditional food source for indigenous Californians. The map is intended to be used to inform – and potentially prioritize –

management of California black oak stands (*e.g.*, fuels treatments to protect the resource) and to assist those seeking stands for acorn collection (*i.e.*, for reforestation or food).

A satellite-derived map of California black oak (*Quercus kelloggii*; QUKE) stand distribution from a model trained to Landsat imagery. This work was done only for the Sierra Nevada portion of the distribution of black oak. Further work is needed to apply this to other parts of California.

Data Resolution: 30m raster

Data Units: Value, 0 to 1000

Creation Method: Statistical models were fit to seasonal median Landsat 8 spectral bands 1 – 7 for the period encompassing 2016 – 2020. Training occurrence data spanned the Sierra Nevada RRK project boundary and consisted of 325 30m radius plots assessed via aerial imagery to have $\geq 90\%$ California black oak (QUKE) canopy cover and filtered to exclude plots that experienced $> 10\%$ loss of absolute tree canopy cover after the date of the image used to assess QUKE canopy cover (Wang et al. 2022). Training occurrence data were combined with 98,506 pseudo-absence locations. From a candidate set that included multiple model-fitting approaches (*e.g.*, Maxent, Random Forests, LDA) Maxent (default settings, version 3.4.3) was selected for its consistently high out-of-sample predictive performance. Seasonal periods of Landsat imagery were defined as follows: Winter (Jan 1 – March 1), Spring (March 31 – May 20), Summer (June 1 – Aug 18), Fall (Oct 17 – Nov 26). Spatial predictions from the statistical model were masked to exclude agricultural urban areas (FVEG), riparian areas (Abood et al. 2022), meadows (UC Davis & USDA Forest Service 2017), and areas with canopy height < 5 m (Salo Sciences, Spring 2020). Spatial predictions were multiplied by 1000 and rounded to the nearest integer to reduce file size.

Resulting out-of-sample predictive performance was high for delineating areas of $\geq 90\%$ QUKE canopy cover from the broader landscape (AUC = 0.997; mean QUKE cover in sample = 95%). Though the model was trained on plots with $\geq 90\%$ QUKE canopy cover, out-of-sample performance remained relatively high for areas of 50 – 90% QUKE canopy cover (AUC = 0.981; mean QUKE cover in sample = 80%) and areas of 10 – 50% QUKE canopy cover (AUC = 0.959; mean QUKE cover in sample = 34%). The model appears to have moderate skill in predicting continuous QUKE cover – in our sample (biased toward higher QUKE canopy cover plots with mean QUKE cover of 82%) the Spearman's rank correlation coefficient between the model output QUKE score and QUKE canopy cover was 0.54. Notable areas of commission error include certain other deciduous vegetation types, such as aspen.

QUKE Score	Interpretation
0	Very low likelihood of overstory QUKE dominance or very low QUKE overstory cover.
1 – 50	Low likelihood of overstory QUKE dominance or low QUKE overstory cover.
51 – 500	Moderate likelihood of overstory QUKE dominance or moderate QUKE overstory cover.
501 – 1000	High likelihood of overstory QUKE dominance or high QUKE overstory cover.

Data Source:

- Center for Watershed Sciences, UC Davis – [see Meadows](#)
- California Forest Observatory (Salo Sciences), 2020

File Name: SNV_BlackOakStandDist_2016to2020_T2_v5.tif

Tier: 2

Data Vintage: 2003

Metric Definition and Relevance: This data set represents the digital range map of Joshua Tree (*Yucca brevifolia*) in western North America. It is only found in the Southern California Region of California.

Data Resolution: 30m Raster

Data Units: Binary layer, 1 represents current range, 0 not in range

Creation Method: Data from multiple sources, including existing digitized maps, tabular data, personal communication, and figures from other publications, were synthesized to create a single digital distribution. Several steps were undertaken in the process of generating the final distribution. Paper map or figure sources were scanned using a flatbed scanner. Scanned images were then georeferenced in ArcMap (ESRI ArcGIS 8.3) using the Georeferencing Toolbar utilities. Once georeferenced, scanned images were then digitized using heads-up digitizing into respective shapefiles using ArcMap (ESRI ArcGIS 8.3). These shapefiles were then used, in conjunction with a digital elevation model (GTOPO30 from <http://edcdaac.usgs.gov/gtopo30/gtopo30.html>), to visually compare, edit, and generate a new distribution. Editing encompassed moving, adding, deleting, and reshaping polygons in the shapefile subjectively based upon visual comparison of all datasets in the GIS. Only polygons of species presence are included in the final version, and all polygons of presence have a CODE equal to 1. Once a draft distribution was completed, the distribution was distributed to regional experts and critically reviewed. Following review, the distribution draft version was iteratively edited and modified to meet the suggestions of the aforementioned reviewers. Subsequent review is possible, and the current version of this data set could be modified again in the near future based on feedback from existing and additional reviewers. The purpose of this digital data set is to delimit the modern geographic distribution of Joshua Tree (*Yucca brevifolia*) based on existing publicly available data.

The polygons were then transformed to a binary 30m raster layer, where 1 represents Joshua Tree's range.

Credits: Kenneth L. Cole, Keith Pohs, and John A. Cannella. U.S. Geological Survey, Southwest Biological Science Center, Colorado Plateau Field Station

Data Source: USGS

File Name: JoshuaTreeRange_2003_202312_T2_v5.tif

INVERTEBRATES

HERMES COPPER BUTTERFLY

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: This is a dataset representing the boundaries for the Hermes copper butterfly (*Lycaena hermes*) as understood by the United States Fish and Wildlife Service. This species is listed as a

threatened species by the USFWS. This species is only found in the Southern California Region (and in Baja California).

Data Resolution: 30m Raster

Data Units: Binary layer, 1 represents current range

Creation Method: Contains the current range polygons as contained in the ECOS database; no generalization was performed and no data was intentionally omitted.

Data Source: The U.S. Fish and Wildlife Service Region 8

File Name: HermesCopperButterfly_2021_202312_T2_v5.tif

LAGUNA MOUNTAINS SKIPPER

Tier: 2

Data Vintage: 2006 (critical habitat)

Metric Definition and Relevance: The current range represents the boundaries for Laguna Mountains skipper (*Pyrgus ruralis lagunae*) as understood by the United States Fish and Wildlife Service.

The critical data identifies, in general, the areas of Final critical habitat for the species. Critical habitat constitutes areas considered essential for the conservation of a listed species. These areas provide notice to the public and land managers of the importance of the areas to the conservation of this species. Special protections and/or restrictions are possible in areas where Federal funding, permits, licenses, authorizations, or actions occur or are required. This species is listed as an endangered species by the USFWS. This species is only found in the Southern California Region.

Data Resolution: 30m Raster

Data Units: Integer - see definitions below

Creation Method: The current range contains the current range polygons as contained in the ECOS database; no generalization was performed and no data was intentionally omitted.

The critical habitat was initially digitized based on 1:24,000 USGS quadrangle maps, digital orthophoto quarter quadrangle images, species information from various sources, and staff knowledge of the habitat and hydrology in the area, focusing on elevation ranging between 4000 and 6100 feet, where host plant *Horkelia clevelandii* is present, and slope and soils are suitable for species survival.

This layer integrates the critical habitat and the current range of the Laguna Mountains skipper. The critical habitat and current range polygons were transformed to a binary 30m raster layer, where 1 represents the species critical habitat and current range, respectively. In the final layer, overlapping areas of these two layers were assigned a value of '1', areas that are critical habitat but not current range were assigned '2', and areas that are current range but not critical habitat were assigned '3'.

Value	Interpretation
1	critical habitat that is also current range
2	critical habitat that is not current range
3	current range that is not critical habitat

Data Source: U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office

File Name: LagunaMtnsSkipperHabRange_2006_202312_T2_v5.tif

QUINO CHECKERSPOT BUTTERFLY

Tier: 3

Data Vintage: 2009

Metric Definition and Relevance: These data identify, in general, the areas of Final critical habitat for *Euphydryas editha quino* (Quino checkerspot butterfly). This species is listed as an endangered species by the USFWS.

Critical habitat constitutes areas considered essential for the conservation of a listed species. These areas provide notice to the public and land managers of the importance of the areas to the conservation of this listed species. Special protections and/or restrictions are possible in areas where Federal funding, permits, licenses, authorizations, or actions occur or are required. This species is only found in the Southern California Region (and in Baja California).

Data Resolution: 30m Raster

Data Units: Binary layer, 1 represents current habitat

Creation Method: The authors considered several quantitative and qualitative criteria in the selection and designation of specific areas or units for Quino checkerspot butterfly critical habitat. These criteria focused on: (1) lands considered to be occupied: lands within recovery unit boundaries and with confirmed recent (since 1986) Quino checkerspot butterfly locations that are part of identified habitat complexes, (2) lands not known to be occupied that provide landscape connectivity between adjacent occupied habitat complexes, and (3) lands not known to be occupied that contain confirmed historic Quino checkerspot locations and are part of identified habitat complexes, and are contiguous with occupied lands.

Critical habitat for the Quino checkerspot butterfly was delineated based on interpretation of multiple data sources available during the preparation of this rule, including confirmed Quino checkerspot butterfly observation and collection records, 2005 one-meter digital aerial photography at 1:24,000 scale (comparable to the scale of a 7.5 minute U.S. Geological Survey topographic quadrangle map), current aerial photography prints, boundaries of approved habitat conservation plans (HCP), and projects authorized for take through section 7 consultations. In defining critical habitat boundaries, the authors made an effort to avoid:

- (1) developed lands such as towns and agricultural fields,
- (2) other non-habitat lands that do not contain one or more primary constituent elements of Quino checkerspot butterfly habitat,

(3) non-essential habitat lands that may contain Quino checkerspot butterfly habitat features, but are too isolated or fragmented to provide for long-term conservation of populations, and

(4) lands covered by an existing, legally operative, incidental take permit under section 10(a)(1)(B) of the Act in which the Quino checkerspot butterfly is a covered species.

However, the minimum mapping unit that the authors used to approximate their delineation of critical habitat for the Quino checkerspot butterfly did not allow them to exclude all areas described above. Existing features and structures within the boundaries of the mapped units, such as buildings, paved or improved roads, aqueducts, railroads, airports, other paved areas, lawns, large areas of closed canopy chaparral, portions of agricultural fields, and other urban landscaped areas do not contain the primary constituent elements. Federal actions limited to those areas, therefore, would not trigger a section 7 consultation, unless they affect the species and/or primary constituent elements in adjacent critical habitat. Initial polygons were created using the process described above. Edits based on staff biological input to include essential habitat and eliminate non-essential areas, and to eliminate as much urban and agriculture as visually possible within or adjacent to the target area was completed in this release. Polygon edits were accomplished using heads-up digitizing and ArcInfo coverage feature extraction from various sources. Heads-up digitizing was completed using 1-meter resolution USDA NAIP (National Agriculture Imagery Program) - USDA NAIP 2005) and coverage features were extracted from data sources such as:

- California Spatial Information Library,
- CaSIL (roads, county lines, contour lines, and hydrolines),
- Riverside County GIS (Stevens Kangaroo Rat (SKR) Core Reserve Boundary),
- San Diego Association of Governments (SANDAG) (Multiple Habitat Planning Areas, major roads, vegetation, ownership, county boundaries),
- City of Chula Vista (Preserve design),
- County of San Diego (major amendment areas, pre-approved mitigation areas),
- U.S. Fish and Wildlife Service (USFWS) (San Diego National Wildlife Refuge, Otay-Sweetwater Unit),
- California Department of Fish and Game (CDFG) (ownership), and
- USFWS-Carlsbad Fish and Wildlife Office Proposed Quino Recovery Units Boundaries (See Recovery Data metafile for information on units and creation process).

The critical habitat polygons were then transformed to a binary 30m raster layer, where 1 represents critical habitat.

Data Source: U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office

File Name: QuinoCheckSpotButterflyCritHab_2009_202312_T3_v5.tif

FISH

CALIFORNIA COASTAL CHINOOK SALMON CRITICAL HABITAT

Tier: 2

Data vintage: 09/2005

Metric Definition and Relevance: The California Coastal Chinook salmon (*Oncorhynchus tshawytscha*) is a threatened species. This evolutionarily significant unit, or ESU, includes naturally spawned Chinook salmon originating from rivers and streams south of the Klamath River to and including the Russian River. NOAA Fisheries issued a final rule designating critical habitat for five Evolutionarily Significant Units (ESUs) of West Coast salmon and two ESUs of steelhead listed as of the date of this designation under the Endangered Species Act (ESA) of 1973, as amended. The specific areas designated in the rule include approximately 8,935 net mi (14,269 km) of riverine habitat. It is found only in the Northern Region of California.

Critical habitat is the specific area within the geographic range of the species, occupied by the species at the time it was listed, that contain the physical or biological features that are essential to the conservation of endangered and threatened species and that may need special management or protection. Critical habitat may also include areas that were not occupied by the species at the time of listing but are essential to its conservation.

Critical habitat designations affect only Federal agency actions or federally funded or permitted activities. Critical habitat designations do not affect activities by private landowners if there is no Federal “nexus”—that is, no Federal funding or authorization. Federal agencies are required to avoid “destruction” or “adverse modification” of designated critical habitat. The ESA requires the designation of “critical habitat” for listed species when “prudent and determinable.”

Data Resolution: 30m Raster

Data Units: Binary; 0 = not critical habitat, 1 = designated critical habitat.

Creation Method: The National Marine Fisheries Service proposed a critical habitat designation, publishing it in the Federal Register and requesting public comments. Final designation of critical habitat is based on the best scientific data available, after taking into consideration the probable economic and other impacts of the designation. After reviewing the comments, the National Marine Fisheries Service responded to them and published a rule, including final boundaries, in the Federal Register.

Data Source: National Marine Fisheries Service (NOAA Fisheries), West Coast Region
[Final Rule \(70 FR 52487; September 2, 2005\)](#)

File Name: ChinookSalmonCriticalHab_200509_202401_T2_v5.tif

NORTHERN CALIFORNIA COAST COHO SALMON CRITICAL HABITAT

Tier: 2

Data vintage: 05/1999

Metric Definition and Relevance: The Southern Oregon/Northern California Evolutionary Significant Unit (SONCC ESU) of Coho Salmon was listed as threatened under the ESA on May 6, 1997. National Marine Fisheries Service designated critical habitat for two Evolutionarily Significant Units (ESUs) of coho salmon (*Oncorhynchus kisutch*) pursuant to the Endangered Species Act in 1999). Critical habitat for the Southern Oregon/ Northern California Coasts ESU encompasses accessible reaches of all rivers (including estuarine areas and tributaries) between the Mattole River in California and the Elk River in Oregon, inclusive. It is found only in the Northern Region of California.

Critical habitat is the specific area within the geographic range of the species, occupied by the species at the time it was listed, that contain the physical or biological features that are essential to the conservation of endangered and threatened species and that may need special management or protection. Critical habitat may also include areas that were not occupied by the species at the time of listing but are essential to its conservation.

Critical habitat designations affect only Federal agency actions or federally funded or permitted activities. Critical habitat designations do not affect activities by private landowners if there is no Federal “nexus”—that is, no Federal funding or authorization. Federal agencies are required to avoid “destruction” or “adverse modification” of designated critical habitat. The ESA requires the designation of “critical habitat” for listed species when “prudent and determinable.”

Data Resolution: 30m Raster

Data Units: Binary; 0 = not critical habitat, 1 = designated critical habitat.

Creation Method: The National Marine Fisheries Service proposed a critical habitat designation, publishing it in the Federal Register and requesting public comments. Final designation of critical habitat is based on the best scientific data available, after taking into consideration the probable economic and other impacts of the designation. After reviewing the comments, the National Marine Fisheries Service responded to them and published a rule, including final boundaries, in the Federal Register.

Data Source: National Marine Fisheries Service (NOAA Fisheries), West Coast Region
[May 5, 1999 \(64 FR 24049\)](#)

File Name: CohoSalmonCriticalHab_199905_202401_T2_v5.tif

NORTHERN CALIFORNIA DPU STEELHEAD CRITICAL HABITAT

Tier: 2

Data vintage: 09/2005

Metric Definition and Relevance: The Northern California Distinct Population Unit (DPU) of Steelhead Trout (*Oncorhynchus mykiss*) is a threatened species. This distinct population segment, or DPS, includes naturally spawned anadromous steelhead (*Oncorhynchus mykiss*) originating below natural and manmade impassable barriers in California coastal river basins from Redwood Creek to and including the Gualala River. Steelhead trout are vulnerable to many stressors and threats including blocked access to spawning grounds and habitat degradation caused by dams and culverts. The specific areas designated in the rule include approximately 8,935 net mi (14,269 km) of riverine habitat. It is found only in the Northern Region of California.

Critical habitat is the specific area within the geographic range of the species, occupied by the species at the time it was listed, that contain the physical or biological features that are essential to the conservation of endangered and threatened species and that may need special management or protection. Critical habitat may also include areas that were not occupied by the species at the time of listing but are essential to its conservation.

Critical habitat designations affect only Federal agency actions or federally funded or permitted activities. Critical habitat designations do not affect activities by private landowners if there is no Federal “nexus”—that is, no

Federal funding or authorization. Federal agencies are required to avoid “destruction” or “adverse modification” of designated critical habitat. The ESA requires the designation of “critical habitat” for listed species when “prudent and determinable.”

Data Resolution: 30m Raster

Data Units: Binary; 0 = not critical habitat, 1 = designated critical habitat.

Creation Method: The National Marine Fisheries Service proposed a critical habitat designation, publishing it in the Federal Register and requesting public comments. Final designation of critical habitat is based on the best scientific data available, after taking into consideration the probable economic and other impacts of the designation. After reviewing the comments, the National Marine Fisheries Service responded to them and published a rule, including final boundaries, in the Federal Register.

Data Source: National Marine Fisheries Service (NOAA Fisheries), West Coast Region
[Final Rule \(70 FR 52487; September 2, 2005\)](#)

File Name: SteelheadCriticalHab_200509_202401_T2_v5.tif

CALIFORNIA COASTAL CHINOOK SALMON DISTRIBUTION

Tier: 2

Data vintage: 09/2005

Metric Definition and Relevance: This layer was created to aid SWR biologists in establishing Critical Habitat for Chinook in the California Coastal ESU. The layer represents an approximation of Chinook occupancy and habitat quality in the region and is best suited for mapping those properties in the aforementioned region.

'CC_Chinook_Distribution_06_2005' depicts Chinook presence as well as habitat type and quality in the California Coastal Evolutionary Significant Unit (ESU). The data was compiled by the National Marine Fisheries Service (NOAA Fisheries) Southwest Regional Office (SWR) in an effort to designate Critical Habitat for Chinook in California. The linework for this layer is based on the California Department of Fish and Game (CDFG) and Pacific States Marine Fisheries Commission (PSMFC) 1:100,000 scale stream based routed hydrography. SWR biologists divided the routed hydrography into stream segments using the best available information to represent local Chinook distribution and habitat. As a result, each segment has its own unique identifier (GIS_Link) and related presence and habitat information. The data set is in shapefile format and can be included as a map layer in a GIS. This data set is an update of 'CC_Chinook_Draft_2004'. It is found only in the Northern Region of California.

Data Resolution: 30m Raster

Data Units: Binary; 0 = not habitat, 1 = habitat.

Creation Method: Stream segments were identified and assigned attributes by SWR biologists using CDFG 1:100,000 hydrography data and other basemap information on hard copy maps. The segments' upper and lower extents were manually marked onto the basemaps by the biologists. This information was then visually interpreted from the paper maps and entered into a digital format using the "Route Tools" extension provided by CDFG. The

resulting event table was then used with the CDFG routed hydrography as the route reference to create routed events based on the biologists' segment determinations. The Microsoft Access table containing the accompanying segment attribute information was joined using 'GIS_Link' as the related field, and the shapefile 'CC_Chinook_Draft_2004' was created from the routed events. To minimize errors that may have occurred during the process, the completed digital file was compared against the marked maps for consistency. The biologists also reviewed the completed digital file to ensure attribute information was associated with the correct stream segments. Public comments were received following draft publication of the Critical Habitat Proposed Rule in December 2004. These comments were incorporated into the data set and the final distribution file 'CC_Chinook_Distribution_06_2005' was created.

Data Source: National Marine Fisheries Service (NOAA Fisheries), West Coast Region

Data layers from the following were used as basemap layers or as detailed in the 'Process Description' section during the designation process: California Department of Fish and Game, Pacific States Marine Fisheries Commission, California Geospatial Information Data Library, State Coastal Conservancy, California Department of Forestry, US Geological Survey.

File Name: ChinookSalmonDist_200509_202401_T2_v5.tif

NORTHERN CALIFORNIA COAST COHO SALMON DISTRIBUTION

Tier: 2

Data vintage: 11/2022

Metric Definition and Relevance: This dataset represents the "Observed Distribution" for coho salmon in California by using observations made only between 1990 and the present (November 2022). It was developed for the express purpose of assisting with species recovery planning efforts. The process for developing this dataset was to collect as many observations of the species as possible and derive the stream-based geographic distribution for the species based solely on these positive observations. It is found only in the Northern Region of California.

For the purpose of this dataset an observation is defined as a report of a sighting or other evidence of the presence of the species at a given place and time. As such, observations are modeled by year observed as point locations in the GIS. All such observations were collected with information regarding who reported the observation, their agency/organization/affiliation, the date that they observed the species, who compiled the information, etc. This information is maintained in the developer's file geodatabase (Environmental Science Research Institute (ESRI) 2016).

Examples of appropriate uses include:

- species recovery planning
- Evaluation of future survey sites for the species
- Validating species distribution models

Examples of inappropriate uses include:

- Assuming absence of a line feature means that the species are not present in that stream.
- Using this data to make parcel or ground level land use management decisions.
- Using this dataset to prove or support non-existence of the species at any spatial scale.

- Assuming that the line feature represents the maximum possible extent of species distribution.

All users of this data should seek the assistance of qualified professionals such as surveyors, hydrologists, or fishery biologists as needed to ensure that such users possess complete, precise, and up to date information on species distribution and water body location.

Any copy of this dataset is considered to be a snapshot of the species distribution at the time of release. It is incumbent upon the user to ensure that they have the most recent version prior to making management or planning decisions.

Data Resolution: 30m Raster

Data Units: Binary; 0 = not habitat, 1 = habitat.

Creation Method: To develop this distribution dataset, the species observations were applied to California Streams, a CDFW derivative of USGS National Hydrography Dataset (NHD) High Resolution hydrography. For each observation, a path was traced down the hydrography from the point of observation to the ocean, thereby deriving the shortest migration route from the point of observation to the sea. By appending all of these migration paths together, the "Observed Distribution" for the species is developed.

It is important to note that this layer does not attempt to model the entire possible distribution of the species. Rather, it only represents the known distribution based on where the species has been observed and reported. While some observations indeed represent the upstream extent of the species (e.g., an observation made at a hard barrier), the majority of observations only indicate where the species was sampled for or otherwise observed. Because of this, this dataset likely underestimates the absolute geographic distribution of the species. It is also important to note that the species may not be found on an annual basis in all indicated reaches due to natural variations in run size, water conditions, and other environmental factors. As such, the information in this dataset should not be used to verify that the species are currently present in a given stream. Conversely, the absence of distribution linework for a given stream does not necessarily indicate that the species does not occur in that stream.

The observation data were compiled from a variety of disparate sources including but not limited to CDFW, USFS, NMFS, timber companies, and the public. Forms of documentation include CDFW administrative reports, personal communications with biologists, observation reports, and literature reviews. The source of each feature (to the best available knowledge) is included in the data attributes for the observations in the geodatabase, but not for the resulting linework. The spatial data has been referenced to California Streams, a CDFW derivative of USGS National Hydrography Dataset (NHD) High Resolution hydrography.

Data Source: California Department of Fish and Wildlife; Citation: Coho Distribution [ds326]

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File Name: CohoSalmonDist_202211_202401_T2_v5.tif

Tier: 2

Data vintage: 06/2012

Metric Definition and Relevance: Winter Steelhead Distribution June 2012 Version This dataset depicts observation-based stream-level geographic distribution of anadromous winter-run steelhead trout, *Oncorhynchus mykiss irideus* (*O. mykiss*), in California. It was developed for the express purpose of assisting with steelhead recovery planning efforts. This dataset represents stream reaches that are known or believed to be used by steelhead based on steelhead observations. Thus, it contains only positive steelhead occurrences. The absence of distribution on a stream does not necessarily indicate that steelhead do not utilize that stream. Additionally, steelhead may not be found in all streams or reaches each year. This is due to natural variations in run size, water conditions, and other environmental factors. The information in this data set should be used as an indicator of steelhead presence/suspected presence at the time of the observation as indicated by the 'Late_Yr' (Latest Year) field attribute. It is found only in the Northern Region of California.

The line features (converted to a 30m raster) in the dataset may not represent the maximum extent of steelhead on a stream; rather it is important to note that this distribution most likely underestimates the actual distribution of steelhead. This distribution is based on observations found in the Aquatic Species Observation Database (ASOD) database. The individual observations may not have occurred at the upper extent of anadromous occupation. In addition, no attempt was made to capture every observation of *O. mykiss* and so it should not be assumed that this dataset is complete for each stream. The distribution dataset was built solely from the ASOD observational data. No additional data (habitat mapping, barriers data, gradient modeling, etc.) were utilized to either add to or validate the data. It is very possible that an anadromous observation in this dataset has been recorded above (upstream of) a barrier as identified in the Passage Assessment Database (PAD).

Examples of appropriate uses include: - steelhead recovery planning - Evaluation of future survey sites for steelhead - Validating steelhead distribution models.

Examples of inappropriate uses include: - Assuming absence of a point feature means that steelhead are not present in that stream. - Using this data to make parcel or ground level land use management decisions. - Using this dataset to prove or support non-existence of steelhead at any spatial scale. - Assuming that the point feature represents the maximum possible extent of steelhead range.

Data Resolution: 30m Raster

Data Units: Binary; 0 = not habitat, 1 = habitat.

Creation Method: The distributions reported in this dataset were derived from a subset of the data contained in the Aquatic Species Observation Database (ASOD), a Microsoft Access multi-species observation data capture application. ASOD is an ongoing project designed to capture as complete a set of statewide inland aquatic vertebrate species observation information as possible. Please note: A separate distribution is available for summer-run steelhead. Contact information is the same as for the above. ASOD Observation data were used to develop a network of stream segments. These lines are developed by "tracing down" from each observation to the sea using the flow properties of USGS National Hydrography Dataset (NHD) High Resolution hydrography. Lastly these lines, representing stream segments, were assigned a value of either Anad Present (Anadromous present). The end result (i.e., this layer) consists of a set of lines representing the distribution of steelhead based on observations in the Aquatic Species Observation Database.

Data Source: California Department of Fish and Wildlife

Citation: Winter Steelhead Distribution [ds0340]

File Name: WinterSteelheadDist_201206_202401_T2_v5.tif

NORTHERN CALIFORNIA SUMMER STEELHEAD DISTRIBUTION

Tier: 2

Data vintage: 10/2009

Metric Definition and Relevance: Summer Steelhead Distribution October 2009 Version This dataset depicts observation-based stream-level geographic distribution of anadromous summer-run steelhead trout, *Oncorhynchus mykiss irideus* (*O. mykiss*), in California. It was developed for the express purpose of assisting with steelhead recovery planning efforts. This dataset represents stream reaches that are known or believed to be used by steelhead based on steelhead observations. Thus, it contains only positive steelhead occurrences. The absence of distribution on a stream does not necessarily indicate that steelhead do not utilize that stream. Additionally, steelhead may not be found in all streams or reaches each year. This is due to natural variations in run size, water conditions, and other environmental factors. It is found only in the Northern Region of California.

The information in this data set should be used as an indicator of steelhead presence/suspected presence at the time of the observation as indicated by the 'Late_Yr' (Latest Year) field attribute. The line features (converted to a 30m raster) in the dataset may not represent the maximum extent of steelhead on a stream; rather it is important to note that this distribution most likely underestimates the actual distribution of steelhead. This distribution is based on observations found in the ASOD database. The individual observations may not have occurred at the upper extent of anadromous occupation. In addition, no attempt was made to capture every observation of *O. mykiss* and so it should not be assumed that this dataset is complete for each stream.

Examples of appropriate uses include: - steelhead recovery planning - Evaluation of future survey sites for steelhead - Validating steelhead distribution models.

Examples of inappropriate uses include: - Assuming absence of a point feature means that steelhead are not present in that stream. - Using this data to make parcel or ground level land use management decisions. - Using this dataset to prove or support non-existence of steelhead at any spatial scale. - Assuming that the point feature represents the maximum possible extent of steelhead range.

Data Resolution: 30m Raster

Data Units: Binary; 0 = not habitat, 1 = habitat.

Creation Method: The distributions reported in this dataset were derived from a subset of the data contained in the Aquatic Species Observation Database (ASOD), a Microsoft Access multi-species observation data capture application. ASOD is an ongoing project designed to capture as complete a set of statewide inland aquatic vertebrate species observation information as possible. Please note: A separate distribution is available for winter-run steelhead. ASOD Observation data were used to develop a network of stream segments. These lines are developed by "tracing down" from each observation to the sea using the flow properties of USGS National Hydrography Dataset (NHD) High Resolution hydrography. Lastly these lines, representing stream segments, were

assigned a value of either Anad Present (Anadromous present). The end result (i.e., this layer) consists of a set of lines representing the distribution of steelhead based on observations in the Aquatic Species Observation Database.

The distribution dataset was built solely from the ASOD observational data. No additional data (habitat mapping, barriers data, gradient modeling, etc.) were utilized to either add to or validate the data. It is very possible that an anadromous observation in this dataset has been recorded above (upstream of) a barrier as identified in the Passage Assessment Database (PAD). In the near future, we hope to perform a comparative analysis between this dataset and the PAD to identify and resolve all such discrepancies. Such an analysis will add rigor to and help validate both datasets. This dataset has recently undergone a review. Data source contributors as well as CDFW fisheries biologists have been provided the opportunity to review and suggest edits or additions during a recent review. Data contributors were notified and invited to review and comment on the handling of the information that they provided. The distribution was then posted to an intranet mapping application and CDFG biologists were provided an opportunity to review and comment on the dataset. During this review, biologists were also encouraged to add new observation data. This resulting final distribution contains their suggestions and additions.

Data Source: California Department of Fish and Wildlife

Citation: Summer Steelhead Distribution [ds0341]

File Name: SummerSteelheadDist_200910_202401_T2_v5.tif

UNARMORED THREESPINE STICKLEBACK HABITAT

Tier: 3

Data Vintage: 2021

Metric Definition and Relevance: This is a dataset representing the boundaries for the Unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*) as understood by the United States Fish and Wildlife Service. This subspecies is only found in the Southern California Region.

Data Resolution: 30m Raster

Data Units: Binary layer, 1 represents potential habitat

Creation Method: Contains the current range polygons as contained in the ECOS database; no generalization was performed and no data was intentionally omitted. Polygons are created by field staff utilizing the ECOS system to select range per office. The office datasets are then dissolved into one species range file and simplified using the Douglas-Peucker algorithm with a 0.0001 tolerance. The polygons were then transformed to a binary 30m raster layer. The polygons were then transformed to a binary 30m raster layer, where 1 represents potential habitat.

Data Source: U.S. Fish and Wildlife Service (USFWS), Ecological Services Division

File Name: Unarmored3spineSticklebackHab_2021_202312_T3_v5.tif

REPTILES & AMPHIBIANS

CALIFORNIA RED-LEGGED FROG

Tier: 1

Data Vintage: 06/2001

Metric Definition and Relevance: This dataset represents a species habitat distribution map for California Red-legged Frog (*Rana draytonii*) within the conterminous United States (CONUS) based on 2001 ground conditions.

Data Resolution: 30m Raster

Data Units: Binary layer, 1 represents suitable habitat, 0 is not suitable habitat

Creation Method: This Gap Analysis Project (GAP) habitat map is a prediction of the spatial distribution of suitable environmental and land cover conditions within the United States for the species. Mapped areas represent places where the environment is suitable for the species to occur (i.e. suitable to support one or more life history requirements for breeding, resting, or foraging), while areas not included in the map are those predicted to be unsuitable for the species. While the actual distributions of many species are likely to be habitat limited, suitable habitat will not always be occupied because of population dynamics and species interactions. Furthermore, these maps correspond to midscale characterizations of landscapes, but individual animals may deem areas to be unsuitable because of presence or absence of fine-scale features and characteristics that are not represented in our models (e.g. snags, vernal pools, shrubby undergrowth). These maps are intended to be used at a 1:100,000 or smaller map scale.

This habitat map is created using a deductive model to predict areas suitable for occupation within a species range. The deductive habitat models are built by compiling information on the species' habitat associations and entering it into a relational database. Information is compiled from the best available characterizations of the species' habitat, which included species accounts in books and databases, primary peer-reviewed literature. The literature references for each species are included in the "Species Habitat Model Report" and "Machine Readable Habitat Database Parameters" files attached to each habitat map item in the ScienceBase repository. The compiled habitat information is used by a biologist to determine which of the ecological systems and land use classes represented in the National Gap Analysis Project's (GAP) Land Cover Map Ver. 1.0 the species is associated with.

The maps are generated using a python script that queries the model parameters in the database; reclassifies the GAP Land Cover Ver 1.0 and ancillary data layers within the species' range; and combines the reclassified layers to produce the final 30m resolution habitat map. Map output is, therefore, not only a reflection of the ecological systems that are selected in the habitat model, but also any other constraints in the model that are represented by the ancillary data layers.

Credits: U.S. Geological Survey (USGS) - Gap Analysis Project (GAP), 2018, California Red-legged Frog (*Rana draytonii*) aCRLFx_CONUS_2001v1 Habitat Map: U.S. Geological Survey data release, <https://doi.org/10.5066/F7T43RCM>.

Data Source: USGS

File Name: CAredLeggedFrogHab_200106_202307_T1_v5.tif

MOUNTAIN YELLOW-LEGGED FROG POTENTIAL HABITAT

Tier: 2

Data Vintage: 2018

Metric Definition and Relevance: This dataset represents a species habitat distribution map for Southern Mountain Yellow-legged Frog (*Rana muscosa*) within the conterminous United States (CONUS) based on 2001 ground conditions. This species is only found in the Southern California and Sierra Nevada Regions.

Data Resolution: 30m Raster

Data Units: Binary layer, 1 represents potential habitat

Creation Method: This habitat map was created by applying a deductive habitat model to remotely-sensed data layers within the species' known range.

This Gap Analysis Project (GAP) habitat map is a prediction of the spatial distribution of suitable environmental and land cover conditions within the United States for the species. Mapped areas represent places where the environment is suitable for the species to occur (i.e. suitable to support one or more life history requirements for breeding, resting, or foraging), while areas not included in the map are those predicted to be unsuitable for the species. While the actual distributions of many species are likely to be habitat limited, suitable habitat will not always be occupied because of population dynamics and species interactions. Furthermore, these maps correspond to midscale characterizations of landscapes, but individual animals may deem areas to be unsuitable because of presence or absence of fine-scale features and characteristics that are not represented in our models (e.g. snags, vernal pools, shrubby undergrowth). These maps are intended to be used at a 1:100,000 or smaller map scale.

This habitat map is created by applying a deductive habitat model to remotely-sensed data layers within the species' range. The deductive habitat models are built by compiling information on the species' habitat associations and entering it into a relational database. Information is compiled from the best available characterizations of the species' habitat, which included species accounts in books and databases, primary peer-reviewed literature. The literature references for each species are included in the "Species Habitat Model Report" and "Machine Readable Habitat Database Parameters" files attached to each habitat map item in the ScienceBase repository. The compiled habitat information is used by a biologist to determine which of the ecological systems and land use classes represented in the National Gap Analysis Project's (GAP) Land Cover Map Ver. 1.0 the species is associated with.

The maps are generated using a python script that queries the model parameters in the database; reclassifies the GAP Land Cover Ver 1.0 and ancillary data layers within the species' range; and combines the reclassified layers to produce the final 30m resolution habitat map. Map output is, therefore, not only a reflection of the ecological systems that are selected in the habitat model, but also any other constraints in the model that are represented by the ancillary data layers.

Source: - Gap Analysis Project (GAP), 2018, Southern Mountain Yellow-legged Frog (*Rana muscosa*) aSMFRx_CONUS_2001v1 Habitat Map: U.S. Geological Survey data release, <https://doi.org/10.5066/F70Z71KZ>.

Data Source: USGS

File Name: MtnYellowLeggedFrogSuitHab_2018_202312_T2_v5.tif

BIRDS

BAND-TAILED PIGEON

Tier: 1

Data Vintage: 4/2023

Metric Definition and Relevance: The Band-Tailed pigeon is a species of tribal value to California indigenous peoples and has been identified as a focal species for the CLM project. This metric identifies the current distribution and abundance of suitable habitat for band-tailed pigeons.

Data Resolution: 30m raster

Data Units: Categorical - classified into one of the following habitat suitability categories:

Value	Desc_
0	Not suitable
1	Moderate foraging
2	High foraging
10	Moderate reproduction
11	Moderate reproduction and foraging
12	High reproduction, Moderate foraging
21	Moderate reproduction, High foraging
22	High reproduction and foraging

Creation Method: This distribution map was created by identifying pixels which contained moderate and high value habitat for band-tailed pigeons in two categories of life history; reproduction, and feeding within habitat types where they are found. This is based on the ratings for habitat values found in the California Wildlife Habitat Relationships model managed by the California Department of Fish and Wildlife. The combined (reproduction and feeding) suitable habitat layer has been further refined and clipped to the U.S. Fish and Wildlife Service species range extent. Habitat which meets the following criteria is considered suitable:

- Suitable vegetation types: WHRTYPE = BOP, BOW, MHW, MHC, MRI, SMC, VOW, WFR
- Suitable high-quality habitat size/density classes by type:
 - BOP = 5M, 5D
 - BOW = 5M, 5D
 - MHW = 4M, 4D, 5P, 5M, 5D
 - MHC = 4M, 4D, 5S, 5P, 5M, 5D
 - MRI = 4M, 4D, 5S, 5P, 5M, 5D
 - SMC = 4M, 4D, 5S, 5P, 5M, 5D, 6
 - WFR = 4M, 4D, 5S, 5P, 5M, 5D, 6

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: BandTailedPigeonSuitHab_202304_202406_T1_v5.tif

MARBLED MURRELET SUITABLE NESTING HABITAT**Tier:** 2**Data vintage:** 09/2017

Metric Definition and Relevance: This data layer has been developed by an interagency team of scientists from the US Forest Service, US Fish and Wildlife Service, and Oregon State University. It was published in “Status and Trend of Nesting Habitat for the Marbled Murrelet Under the Northwest Forest Plan, 1993 to 2017” in 2021. It is part of the work to monitor the effectiveness of the Northwest Forest Plan. The data represent relative habitat suitability of habitat for marbled murrelet range in California for 2017; categorized as lower, moderate, and higher probability of nesting habitat, with probability gradients in each class. This species is only found in the Northern and Central California Regions.

Data Resolution: 30m Raster**Data Units:** relative suitability ranging from 0 - 1.0

Creation Method: Using Maxent species distribution models, the authors modeled the amount and distribution of probable nesting habitat in the murrelet’s range in 2017. Probability scores from Maxent provide information on the relative suitability of habitat. While thresholds were necessary in this report for estimating acres of habitat in different categories (e.g., comparing acres in 1993 to 2017), Maxent probability scores provide a complete, probabilistic map of habitat suitability.

Note: Imagery was obtained in late summer (July to September) rather than at the change in the calendar year (December to January). Thus, some 2017 fires were excluded from the analysis, such as the Chetco Bar Fire, which occurred in late summer in 2017.

Within the higher probability nesting habitat, the authors estimated the amount of contiguous habitat (core) versus the amount of habitat bounding core habitat (edge) and habitat scattered in small forest fragments (scatter). The authors considered this “core habitat” as the best habitat. Their models indicate that there were 1.51 million acre of higher probability nesting habitat over all lands in the murrelet’s range in Washington, Oregon, and California 1 year prior to the start of the Northwest Forest Plan (NWFP) in 1993. Of this, 0.14 million acres were identified as core habitat, which are defined as intact patches of higher probability nesting habitat >5.56 acre in size. The authors estimated a net loss of about 1.4 percent in higher probability nesting habitat across the NWFP area and 1.8 percent in core habitat from 1993 to 2017. Their analysis estimates that in 2017 there were 3,175,539 acres of lower probability nesting habitat, 35,939 acres of moderate probability nesting habitat, and 38,564 of higher probability habitat in California.

The CLM team combined the Low (0.003 - 0.38), Moderate (0.381 - 0.645) and High (0.646 - 1) suitability rasters into one raster. The modeled output covers the entire range of Northern Spotted Owls: Washington, Oregon, and northern California within the Northwest Forest Plan (NWFP) boundary.

Data Source: Regional Ecosystem Office (REO) - Northwest Forest Plan <https://www.fs.usda.gov/r6/reo/riec/>

Lorenz, T.J.; Raphael, M.G.; Young, R.D.; Lynch, D.; Nelson, S.K.; McIver, W.R. 2021. Status and trend of nesting habitat for the marbled murrelet under the Northwest Forest Plan, 1993 to 2017. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 64 p.

File Name: MarbledMurreletNestingHab_201709_202401_T2_v5.tif

MARBLED MURRELET CRITICAL HABITAT

Tier: 2

Data vintage: 01/2011

Metric Definition and Relevance: This data layer depicts lands designated as critical habitat under section 4 of the Endangered Species Act for the Marbled Murrelet in California. Critical habitat is the specific area within the geographic range of the species, occupied by the species at the time it was listed, that contain the physical or biological features that are essential to the conservation of endangered and threatened species and that may need special management or protection. Critical habitat may also include areas that were not occupied by the species at the time of listing but are essential to its conservation. This species is only found in the Northern and Central California Regions.

Critical habitat designations affect only Federal agency actions or federally funded or permitted activities. Critical habitat designations do not affect activities by private landowners if there is no Federal “nexus” —that is, no Federal funding or authorization. Federal agencies are required to avoid “destruction” or “adverse modification” of designated critical habitat. The ESA requires the designation of “critical habitat” for listed species when “prudent and determinable.”

Data Resolution: 30m Raster

Data Units: Binary, 0/1

Creation Method: Polygon layer from the California Department of Fish and Wildlife BIOS downloaded and converted to raster by the CLM team.

The U.S. Fish and Wildlife Service (Service) determined that the critical habitat for the marbled murrelet (*Brachyramphus marmoratus*), as designated in 1996 and revised in 2011, meets the statutory definition of critical habitat under the Endangered Species Act of 1973, as amended (Act). The current designation includes approximately 3,698,100 acres (1,497,000 hectares) of critical habitat in the States of Washington, Oregon, and California.

Final rule published at [61 FR 26256](#) and effective on June 24, 1996, as revised at [76 FR 61599](#), and effective on November 4, 2011.

The U.S. Fish and Wildlife Service originally proposed to designate critical habitat for the marbled murrelet (*Brachyramphus marmoratus marmoratus*) in Washington, Oregon, and California on January 27, 1994 (59 FR 3811). Based on comments received on the original proposal and additional information, the Service published a supplemental proposed designation of critical habitat for the marbled murrelet on August 10, 1995 (60 FR 40892).

The marbled murrelet is listed as a threatened species under the Endangered Species Act (Act). It is a small seabird of the Alcidae family that forages in the near-shore marine environment and nests in large trees in coniferous forests. Located primarily on Federal land, and to a lesser extent on State, county, city, and private lands, this final critical habitat rule would provide additional protection requirements under section 7 of the Act with regard to activities that are funded, authorized, or carried out by a Federal agency. Section 4 of the Act requires the Service to designate critical habitat for listed species on the basis of the best scientific information available and to consider the economic and other relevant impacts of including particular areas in the designation.

Data Source:

California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

<https://wildlife.ca.gov/Data/BIOS>

[Marbled Murrelet - Final Critical Habitat - USFWS \[ds157\] GIS Dataset](#)

File Name: MarbledMurreletCriticalHab_201101_202401_T2_v5.tif

CALIFORNIA SPOTTED OWL SUITABLE HABITAT

Tier: 1

Data Vintage: 04/2023

Metric Definition and Relevance: California spotted owl is continuously distributed on the western slope of the Sierra and inhabits elevations ranging from roughly 1,000 to over 7,000 feet. It is a Region 5 Forest Service “Sensitive Species” and a “Management Indicator Species” (representing late seral closed canopy coniferous forest). This subspecies is found primarily in the Sierra Nevada Region but is also found in the Southern and Central California Regions. In February of 2023 the U.S. Fish and Wildlife Service issued a proposal to list two distinct population segments (DPSs) of the California spotted owl (*Strix occidentalis occidentalis*) under the Endangered Species Act of 1973, as amended (Act). That proposal is still pending. Although the species is declining throughout much of its range and faces continued threats due to wildfire, habitat loss, and competition from barred owls, the USFWS determined that existing regulatory mechanisms are sufficient (USDI Fish and Wildlife Service 2019). This species is also recognized as a California “Species of Special Concern and a Species of Greatest Conservation Need.”

A conservation assessment for California spotted owl was conducted in 2017 (Gutiérrez, Manley, and Stine 2017). This was followed by the development of a conservation strategy to guide habitat management on National Forest System Lands (USDA Forest Service 2019). The conservation strategy for the California spotted owl in the Sierra Nevada aims to balance the need to conserve essential habitat elements around sites occupied by California spotted owls, while simultaneously restoring resilient forest conditions at the landscape scale (USDA Forest Service 2019).

The USDA Forest Service designates a 300-acre protected activity center (PAC) around each known nesting (reproduction) area or activity center. PACs are a USFS land allocation designed to protect and maintain high-quality California spotted owl nesting and roosting habitat around active sites. Territorial owls typically defend a geographic area consistently used for nesting, roosting, and foraging, containing essential habitat for survival and reproduction. The USDA Forest Service calls for an area of 1,000 acres in the central Sierra Nevada around core use areas, including the associated protected activity center, with a minimum of 400 acres of suitable habitat.

Data Resolution: 30m raster

Data Units: Categorical - classified into one of the following habitat suitability categories:

Value	Desc_
0	Not suitable
1	Moderate foraging (Suitable vegetation types with 4M or 4D size/density and 5M and 5D classes)
11	Moderate reproduction and foraging (Suitable vegetation types with 5M or 5D size/density classes)
21	Moderate reproduction, High foraging (Suitable vegetation types with 5M and 5D classes)
22	High reproduction and foraging (Suitable vegetation types with 5M or 5D size/density classes)

For the specific combinations of vegetation types, size classes, and canopy cover classes that result in a low, moderate, or high habitat suitability rating, please refer to the CWHR tables [here](#) and select: > 'Species' tab -> select species by name -> under select species details: Reports -> check 'Habitats'. This process will create a full list of all suitable combinations for that species.

Creation Method: CWHR classifications are based on a combination of [FVEG 2023](#) for canopy cover, size class and vegetation type. The vegetation data includes a variety of tree, shrub, grassland, and water dominated habitats. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed suitable for the reproduction or foraging of that species in the California Wildlife Habitat Relationship database. Habitat which meets the following criteria is considered suitable:

- Suitable vegetation types: WHRTYPE = PPN, SMC, RFR, DFR, MHC, MHW, SMC, WFR, RDW, KMC MRI and BOP
- Suitable foraging habitat: size/density classes = 4M, 4D
- Suitable nesting (reproduction) habitat: size/density classes = 5M, 5D, 6

CWHR high and moderate suitability values have been used to create separate data layers which identify suitable nesting (reproduction) and suitable foraging habitat. These data have been combined to create the identified “suitable habitat” layers. The combined suitable habitat layer has been further refined and clipped to the U.S. Fish and Wildlife Service species range extent.

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: CSO_OwlSuitHab_202304_202406_T1_v5.tif

NORTHERN GOSHAWK SUITABLE HABITAT

Tier: 2

Data Vintage: 04/2023

Metric Definition and Relevance: The Northern goshawk is a species of special concern to the US Forest Service, but it is not federally, or state listed at the present time and has therefore been identified as a focal species by Region 5 of the US Forest Service. The Northern goshawk is an old forest associate with particular habitat requirements in terms of nest trees, nest stands, and the structure of foraging habitat having open understory conditions to enable foraging maneuvers. It is found primarily in the Northern California and Sierra Nevada Regions but also to a limited degree in the Southern California Region.

Data Resolution: 30m raster

Data Units: Categorical - classified into one of the following habitat suitability categories:

Value	Desc_
0	Not suitable
1	Moderate foraging
2	High foraging
11	Moderate reproduction and foraging
21	Moderate reproduction, High foraging
22	High reproduction and foraging

Creation Method: CWHR classifications are based on a combination of FVEG 2023 for canopy cover, size class and vegetation type. The vegetation data includes a variety of tree, shrub, grassland, and water dominated habitats. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed suitable for the reproduction or foraging of that species in the California Wildlife Habitat Relationship database. Suitable habitat for the Northern goshawk is based on CWHR moderate and high suitability habitat for reproduction and foraging. Habitat which meets the following criteria is considered suitable:

- Suitable foraging vegetation types: WHRTYPE = MHW, LPN, MRI, SCN, DFR, MHC, JPN, SMC, EPN, KMC, ADS, PPN, RFR, WFR
- Suitable foraging habitat: size/density classes = 4P, 4S, 4M, 4D, 5P, 5S, 5M, 5D, 6
- Suitable nesting vegetation types: WHRTYPE = MHW, LPN, MRI, SCN, MHC, JPN, SMC, KMC, PPN, RFR, WFR
- Suitable nesting habitat: size/density classes = 4M, 4D, 5P, 5S, 5M, 5D, 6

The combined (reproduction and foraging) suitable habitat layer has been further refined and clipped to the U.S. Fish and Wildlife Service species range extent.

An additional data layer to identify locations that meet the criteria for a goshawk protected activity center (PAC; 300 acres of suitable nesting habitat in a contiguous block), has been provided with the Operational Data Layers – see [PAC layer](#).

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: NorthernGoshawkSuitHab_202304_202406_T2_v5.tif

NORTHERN SPOTTED OWL NESTING/ROOSTING FOREST COVER TYPE SUITABILITY INDEX

Tier: 2

Data vintage: 2023

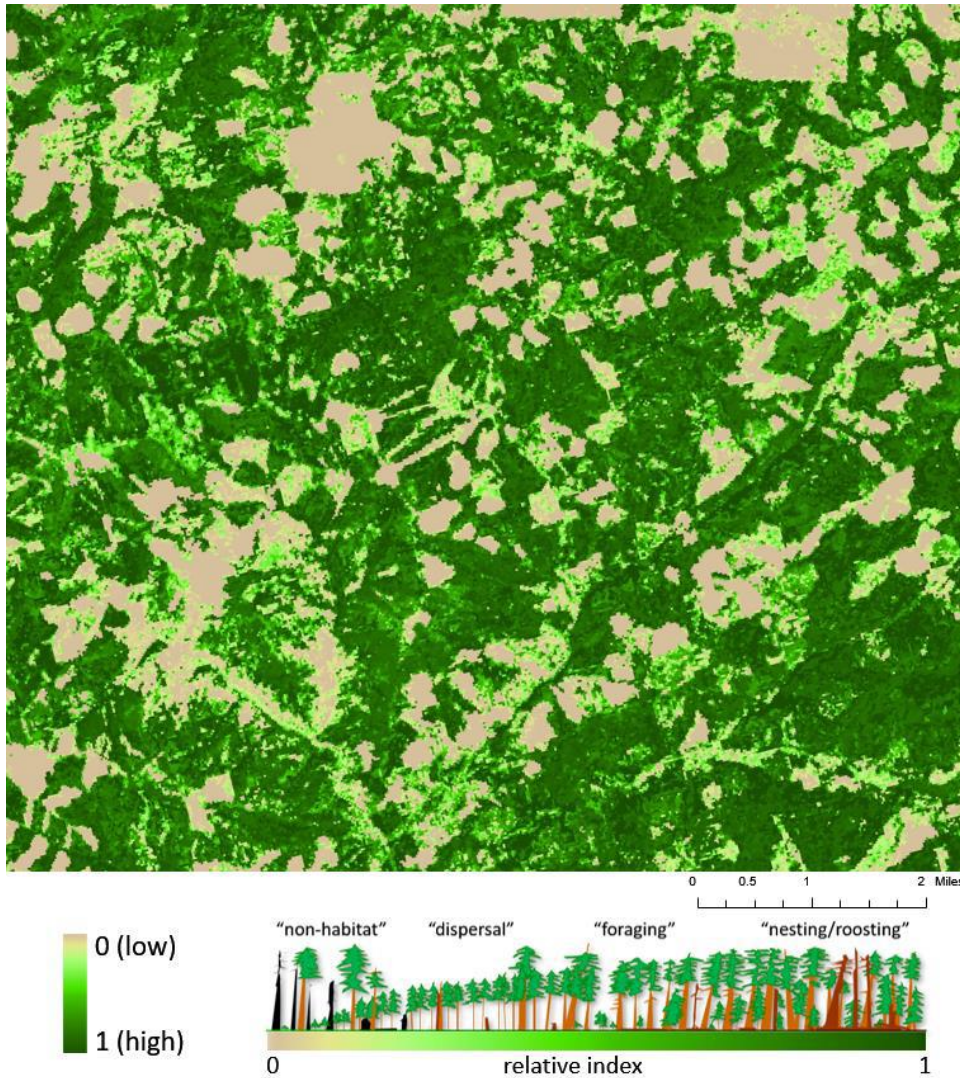
Metric Definition and Relevance: This is a measure, expressed as a relative index (0-1), of suitability (or similarity) of forest structure and composition for Northern Spotted Owl (NSO) (*Strix occidentalis caurina*) nesting/roosting. The data were developed by the Regional Ecosystem Office for the Northwest Forest Plan monitoring program. These data were produced using machine learning software Maxent and trained/tested with nesting/roosting pair locations (1993). As illustrated in the diagram below, an index near zero indicates forest structure/composition dissimilar to where NSO pairs nest/roost. An index nearer to one indicates similar conditions. Raster values are as follows:

- -1 = no data (non-forested)
- 0–10000 = relative suitability index from 0 to 1 (with a x10000 scalar applied). A value of 10,000 would indicate perfect habitat suitability of a pixel. Maximum value found (within the California portion of the range of NSO) is 8,628.

Annual forest vegetation structure and composition maps (30-m pixel resolution) for forest-capable lands from 1986 to 2023 were generated using the gradient nearest neighbor (GNN) imputation modeling and mapping methodology developed by Oregon State University Department of Forest Ecosystems and Society’s Landscape Ecology, Modeling, Mapping, and Analysis program (LEMMA 2020). GNN is a multivariate, nonparametric modeling and mapping framework that inputs forest inventory plot data to individual map pixels based on Landsat surface reflectance and environmental similarity in the gradient space (Ohmann and Gregory 2002). The version of GNN used in this analysis was based on the composite Landsat images produced to map the forest disturbances above, matching plot measurements to Landsat image years (Bell et al. 2021).

Methodological changes, described in detail in the late-successional and old-growth monitoring report (<https://www.fs.usda.gov/r6/reo/monitoring/northern-spotted-owl.php>), improved the quality of GNN compared to previous monitoring reports. This included using a consistent type of forest inventory plot for imputations, the ensemble LandTrendr imagery described above, imagery stabilization, and bootstrapped approximations utilizing multiple neighbors (k = 7) with weighted means proportional to the probability that a bootstrap sample would result in that plot being the nearest neighbor for a pixel.

This subspecies is found in the Northern California Region.



Data Resolution: 30m Raster

Data Units: 0–10000 = relative suitability index from 0 to 1 (with a x10000 scalar applied). A value of 10,000 would indicate perfect habitat suitability of a pixel. Maximum value found (within the California portion of the range of NSO) is 8,628.

Creation Method: Maps of forest types associated with owl nesting and roosting were produced following methods from previous monitoring reports (Davis et al. 2011, 2016), and that methodology is described briefly below. Open-source machine learning software Maxent (Phillips et al. 2006, 2017, 2021) was used to develop a forest cover type model for each modeling region using 10 bootstrapped random samples. We used 75 percent of NSO locations for model training and 25 percent for model testing. Training locations were analyzed against a random sampling of 10,000 background locations from forest-capable pixels within the modeling region.

The authors used a logistic model output as the relative index of forest suitability for nesting and roosting by NSO pairs. The forest suitability index ranged from 0 to 1.0, where values closer to zero represent forest structure and species composition unsimilar to that found at NSO locations and higher values are more similar.

See Davis et al. 2022 for more details on the methods.

Data Source:

Regional Ecosystem Office (REO) - Northwest Forest Plan

<https://www.fs.usda.gov/r6/reo/monitoring/northern-spotted-owl.php>

Bell, D.M.; Acker, S.A.; Gregory, M.J.; Davis, R.J.; Garcia, B.A. 2021. Quantifying regional trends in large live tree and snag availability in support of forest management. *Forest Ecology and Management*. 479: Article 118554. <https://doi.org/10.1016/j.foreco.2020.118554>.

Glenn, E.M., Lesmeister, D.B., Davis, R.J., Hollen, B., Poopatanpong, A. 2017. Estimating density of a territorial species in a dynamic landscape. *Landscape Ecol.* 32:563–579.

Davis, R.J.; Dugger, K.M.; Mohoric, S.; Evers, L.; Aney, W.C. 2011. Northwest Forest Plan—the first 15 years (1994–2008): status and trends of northern spotted owl populations and habitats. Gen. Tech. Rep. PNW-GTR-850. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 147 p. <https://doi.org/10.2737/PNW-GTR-850>.

Davis, R.J.; Hollen, B.; Hobson, J.; Gower, J.E.; Keenum, D. 2016. Northwest Forest Plan—the first 20 years (1994–2013): status and trends of northern spotted owl habitats. Gen. Tech. Rep. PNW-GTR-929. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 54 p. <https://doi.org/10.2737/PNW-GTR-929>.

Davis, Raymond J.; Lesmeister, Damon B.; Yang, Zhiqiang; Hollen, Bruce; Tuerler, Bridgette; Hobson, Jeremy; Guetterman, John; Stratton, Andrew. 2022. Northwest Forest Plan—the first 25 years (1994–2018): status and trends of northern spotted owl habitats. Gen. Tech. Rep. PNW-GTR-1003. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 38 p. <https://doi.org/10.2737/PNW-GTR-1003>.

Phillips, S.J.; Anderson, R.P.; Shapire, R.E. 2006. Maximum entropy modeling of species geographic distributions. *Ecological Modelling*. 190(3–4): 231–259. <https://doi.org/10.1016/j.ecolmodel.2005.03.026>.

Phillips, S.J.; Anderson, R.P.; Dudik, M.; Shapire, R.E.; Blair, M.E. 2017. Opening the black box: an open-source release of Maxent. *Ecography*. 40(7): 887–893. <https://doi.org/10.1111/ecog.03049>.

Phillips, S.J.; Dudík, M.; Shapire, R.E. 2021. Maxent software for modeling species niches and distributions (Version 3.4.1). http://biodiversityinformatics.amnh.org/open_source/maxent. (31 January 2021).

File Name: NSO_NestRoost_Suitability_2023_202401_T2_v5.tif

Tier: 2

Data vintage: 2023

Metric Definition and Relevance: These data are derived using analysis described in Glenn et al. (2017). The authors have developed a landscape-scale model to predict the distribution and density of the (territorial species) northern spotted owl (*Strix occidentalis caurina*). This model results in a rangewide relative habitat suitability estimates, on a pixel by pixel basis, using forest vegetation, topographic, and climate data. The ability to adequately predict territorial species distributions and densities across landscapes and through time is important for implementing effective conservation strategies as well as monitoring the success of those strategies in a spatially extensive and cost-effective manner.

This method and the resulting data have been developed by the Northwest Forest Plan (NWFP) Monitoring Program, a federal interagency monitoring program. The NWFP is governed by the Regional Interagency Executive Committee (RIEC), a consortium of federal land and resource management agencies in the Pacific Northwest, with support from agency personnel appointed to the Senior Managers Group and Regional Ecosystem Office staff.

The Northern Spotted Owl (NSO) Monitoring Program conducts long-term monitoring of NSO populations, forests, and habitat to determine the effectiveness of federal forest management on maintaining and restoring habitat conditions necessary to support viable populations of NSO on federally-administered forests throughout its range. Main objectives are to:

- Track status and trends of NSO populations on federal forests within its geographic range in the United States.
- Track status and trends in the amount and distribution of NSO forest cover types and habitat on federal forests.

This subspecies is found in the Northern California Region.

Data Resolution: 100m Raster

Data Units: Binary; 0 = not suitable, 1 = suitable.

Creation Method: The authors used the program MaxEnt, version 3.3.3k (Phillips et al. 2006) to produce relative habitat suitability models and maps for the six modeling regions (two which include the northern California portion of the range of this subspecies). MaxEnt estimates relative environmental suitability for species presence by using a machine learning process to develop algorithms that model the most uniform distribution (maximum entropy) of averaged environmental conditions at known species locations compared to a large randomly generated sample of available locations from within the modeling region (Phillips et al. 2006; Phillips and Dudik 2008).

Owl presence data for model training and testing was based on thousands of nest or day roost locations from 1993. These data were compiled from standardized survey protocols developed to identify spotted owl territorial sites in forested landscapes. The authors identified 9 environmental predictor variables for inclusion in the model that have demonstrated support for influencing spotted owl habitat selection and site occupancy. Amount and spatial arrangement of nesting/roosting forest cover are known to influence owl space use and fitness, thus four of our variables quantified amount and configuration of nesting/roosting cover at the nest patch (200 m radius) and

territory scale (600–1900 m radii). The remaining 5 variables were abiotic: elevation, topographic position, average minimum January temperature, average maximum August temperature, and average annual precipitation.

The modeled output covers the entire range of Northern Spotted Owls: Washington, Oregon, and northern California within the Northwest Forest Plan (NWFP) boundary.

See Glenn et al. 2017 for more details on the methods.

Data Source:

Regional Ecosystem Office (REO) - Northwest Forest Plan

<https://www.fs.usda.gov/r6/reo/monitoring/northern-spotted-owl.php>

Glenn, E.M., Lesmeister, D.B., Davis, R.J., Hollen, B., Poopatanpong, A. 2017. Estimating density of a territorial species in a dynamic landscape. *Landscape Ecol.* 32:563–579.

Davis, Raymond J.; Lesmeister, Damon B.; Yang, Zhiqiang; Hollen, Bruce; Tuerler, Bridgette; Hobson, Jeremy; Guetterman, John; Stratton, Andrew. 2022. Northwest Forest Plan—the first 25 years (1994–2018): status and trends of northern spotted owl habitats. Gen. Tech. Rep. PNW-GTR-1003. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 38 p. <https://doi.org/10.2737/PNW-GTR-1003>.

Phillips, S.J.; Anderson, R.P.; Shapire, R.E. 2006. Maximum entropy modeling of species geographic distributions. *Ecological Modelling.* 190(3–4): 231–259. <https://doi.org/10.1016/j.ecolmodel.2005.03.026>.

Phillips, S.J.; Anderson, R.P.; Dudík, M.; Shapire, R.E.; Blair, M.E. 2017. Opening the black box: an open-source release of Maxent. *Ecography.* 40(7): 887–893. <https://doi.org/10.1111/ecog.03049>.

Phillips, S.J.; Dudík, M.; Shapire, R.E. 2021. Maxent software for modeling species niches and distributions (Version 3.4.1). http://biodiversityinformatics.amnh.org/open_source/maxent. (31 January 2021).

File Name: NSO_SuitableHabitat_2023_202401_T2_v5.tif

NORTHERN SPOTTED OWL; CHANGES IN SUITABLE HABITAT 1993-2022

Tier: 3

Data vintage: 2022

Metric Definition and Relevance: These data track changes in Northern spotted owl habitat suitability from 1993-2022. The primary purpose of this ongoing monitoring is to track changes in habitat that could be used by NSO over the time frame of the Northwest Forest Plan (NWFP). Data to date reflect changes over the first 30 years of the NWFP. The modeled output covers the entire range of northern spotted owls, Washington, Oregon, and northern California. It has been clipped to the Northern California region. This data layer indicates:

- Forest capable lands that were not suitable habitat in 1993 and still are not
- Forest capable lands that were not suitable habitat in 1993 but are now

- Forest capable lands that were suitable habitat in 1993 but have been lost to disturbance (e.g. fire)
- Forest capable lands that were suitable habitat in 1993 and still are

This subspecies is found in the Northern California Region.

Data Resolution: 100m Raster

Data Units: categorical

null values = not forest capable

0 = not habitat in 1993 and still not

1 = not habitat in 1993 but is in 2022

11 = has been habitat since 1993 but lost (fires, etc)

12 = habitat in 1993 and still habitat in 2022

Creation Method: The authors followed methods for habitat modeling and estimating density of occupied territories that were developed by Glenn et al. (2017), who reported high predictability based on independent data. The authors relied upon the modeling technique, MaxEnt to to model the suitability of habitat. MaxEnt uses a machine learning process and a suite of potential response functions to estimate the most uniform distribution (maximum entropy) of the “average” environmental conditions at known species locations compared to what is available across the modeled area (background) (Phillips et al. 2006). The modeling process does not require an a priori specification of a set of models, but instead fits training data (presence locations of owl pairs) to environmental covariates using various combinations of response functions (features) such as linear, quadratic, product, hinge, and threshold structures. The authors modeled relative habitat suitability using known owl pair nest and roost locations to train and test the model which was based on vegetation, topographic, and climate data (see Glenn et al. 2017 for modeling data sources, methods, and results).

Each habitat suitability model performed well in predicting known territorial owl pair locations. The model was well-calibrated in all regions with higher densities of owls in areas with higher relative habitat suitability. 90% of the independent test locations were on or within 100 m of mapped suitable spotted owl habitat.

The modeled output covers the entire range of Northern Spotted Owls: Washington, Oregon, and northern California within the Northwest Forest Plan (NWFP) boundary.

Data Source: Regional Ecosystem Office (REO) - Northwest Forest Plan

<https://www.fs.usda.gov/r6/reo/monitoring/northern-spotted-owl.php>

Glenn, E.M., Lesmeister, D.B., Davis, R.J., Hollen, B., Poopatanpong, A. 2017. Estimating density of a territorial species in a dynamic landscape. *Landscape Ecol.* 32:563–579.

Davis, Raymond J.; Lesmeister, Damon B.; Yang, Zhiqiang; Hollen, Bruce; Tuerler, Bridgette; Hobson, Jeremy; Guetterman, John; Stratton, Andrew. (2022). Northwest Forest Plan—the first 25 years (1994–2017): status and trends of northern spotted owl habitats. Gen. Tech. Rep. PNW-GTR-1003. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 38 p.

File Name: NorCal_NSO_SuitHabChange_19932022_202310_T3_v5.tif

Tier: 3

Data vintage: 2019; Time period(s) represented (i.e. modeled): 2020

Metric Definition and Relevance: Maps that represent the relative probability of fire refugia generated from an empirical model trained on the aggregate history (1985-2019) of wildfire severity, topographical features, and climate normal data with the Random Forest modeling algorithm. Areas identified as having a higher probability for fire refugia are those that burn less severely than the surrounding landscape. Map values at the other end of the spectrum represent areas that will likely burn at higher severity. Values in the future map represent output from application of the model with projections of large wildfire suitability based on future predictions for temperature and precipitation.

These maps can be used to examine where forests, including old forests, are likely to survive a wildfire. Refugia models can be used to evaluate the outcomes of different types of past management and wildfire that influence the probability of fire refugia. Refugia products can be used to evaluate old forest dynamics by intersecting refugia probability maps with maps of old forest or spotted owl habitat, to evaluate the degree of overlap under different fire weather conditions and through time.

Aligning forest/fuels/fire management with topography (conditioned on current or future climate) that relates to normal wildfire severity (low to high). The future model provides forest managers, fire protection agencies, and policy-makers empirical estimates of how much and where climate change might affect the landscape patterns.

The modeled output covers the entire range of Northern Spotted Owls: Washington, Oregon, and northern California within the Northwest Forest Plan (NWFP) boundary. This subspecies is found in the Northern California Region.

Data Resolution: 90m Raster

Data Units: An index of fire refugia; from no refugia to maximum refugia (0-100). Nulls are non-forest capable land areas.

Creation Method: This product was developed by Ray Davis and Zhiqiang Yang (USFS) and Andrew Yost (Oregon Department of Forestry). The goal of the work was to model the probability of potential fire refugia across the Northwest Forest Plan and Bioregional Assessment areas using four topographic variables and conditioned on climate (normal fire environment from Davis et al. (2017) as explanatory variables. The topo-climatic fire refugia model does not include variability in vegetation/fuels as a driver of fire refugia, instead using a simple mask of forest-capable sites to represent the intrinsic underlying condition. Accordingly, it should be overlaid with existing forest conditions to identify contemporary opportunities for supporting mature and older forest. In addition, this model provides the opportunity to identify where on the landscape might be good locations to recruit high quality mature and old late-successional closed canopy forest, even if such conditions do not currently occur. The climate change projections from the model may identify locations most likely to persist as fire refugia into the future. The models prioritize a focus on the closed canopy late-successional, complex older forest context.

The topo-climatic fire refugia model is trained using multiple samples from contemporary fire severity data from the region (1985 to 2019), first building a model for probability of low-severity fire, next building a model for

probability of high-severity fire, then aggregating the models together with the normal fire environment metric to generate fire refugia probability (Yang et al. in prep). Because the topo-climatic fire refugia models include the Davis et al. (2017) fire environment as an explanatory variable, the climate change projections from that work were fed in as scenarios for current period (2020), mid-century (2060), and late century (2100) climate change estimates. Spatial resolution of the models is 90 m (aggregated Landsat remote sensing data). Data sets are available on the USFS T:/drive and available in the Fire Refugia ToolBox (preferred) folder listed in section 8 (Additional Resources). Additional information will be provided in Yang et al. (in prep) and on the Fire Refugia in Mature and Old Forests website.

Inputs were actual fire locations and fire environment triangle variables for topography and climate (based on 30-year averages, or a climate normal). Assumptions were that the current forest footprint used to train the model would remain static throughout this century and that the modeled relationship would remain temporally stable. As with all models there is always uncertainty. Since publication, this model continues to predict large wildfire occurrences well. The main uncertainty lies in whether the forest footprint will change as a result of climate change.

Data Source: USDA Forest Service, Region 6 - Pacific Northwest Region
Raymond Davis, Zhiqiang Yang, Andrew Yost, Cole Belongie, and Warren Cohen

Davis, R., Z. Yang, A. Yost, C. Belongie, and W. Cohen. 2017. The normal fire environment—Modeling environmental suitability for large forest wildfires using past, present, and future climate normals. *Forest Ecology and Management*, 390, pp.173-186.

Krawchuk, M.A., Hudec, J., Meigs, G.W. 2023. Manager’s brief: Integrating fire refugia concepts and data into vegetation management decisions. A case study on the Gifford Pinchot National Forest, Little White Salmon Project Area. 20 pages.

File Name: CurrentTopoclimateRefugia_2019_202401_T3_v5.tif

NUTTALL’S WOODPECKER HABITAT SUITABILITY

Tier: 1

Data Vintage: 2023

Metric Definition and Relevance: This layer shows highly suitable habitats for the reproduction and feeding of Nuttall’s Woodpecker (*Dryobates nuttallii*) within the species’ range.

Data Resolution: 30m Raster

Data Units: Categorical - classified into one of the following habitat suitability categories:

Value	Desc_
0	Not suitable
1	Moderate foraging

- 2 High foraging
- 21 Moderate reproduction, High foraging
- 22 High reproduction and foraging

Creation Method: CWHR classifications are based on a combination of FVEG canopy cover, size class and vegetation data. The vegetation data includes a variety of tree, shrub, grassland, and water dominated habitats. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed highly suitable for the reproduction or feeding of that species in the California Wildlife Habitat Relationship database.

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: NuttallsWoodpeckerSuitHab_202304_202406_T1_v5.tif

LOGGERHEAD SHRIKE HABITAT SUITABILITY

Tier: 1

Data Vintage: 2023

Metric Definition and Relevance: This layer shows highly suitable habitats for the reproduction and feeding of Loggerhead Shrike (*Lanius ludovicianus*) within the species' range.

Data Resolution: 30m Raster

Data Units: Categorical - classified into one of the following habitat suitability categories:

Value	Desc_
0	Not suitable
1	Moderate foraging
2	High foraging
11	Moderate reproduction and foraging
21	Moderate reproduction, High foraging
22	High reproduction and foraging

Creation Method: CWHR classifications are based on a combination of FVEG canopy cover, size class and vegetation data. The vegetation data includes a variety of tree, shrub, grassland, and water dominated habitats. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed highly suitable for the reproduction or feeding of that species in the California Wildlife Habitat Relationship database.

Data Source:

- [FVEG 2023](#)

- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: LoggerheadShrikeSuitHab_202304_202406_T1_v5.tif

LEAST BELL'S VIREO NESTING HABITAT

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Least Bell's Vireos (LBVI) are a state and federally listed endangered species that nests exclusively in riparian areas in California. Conservation Science and Data Visualization and Aerial Information Systems co-developed a standardized mapping protocol, called VireoVegMap, with the objective of providing a comprehensive map of potential LBVI nesting habitat. Dominant vegetation map units and secondary map attributes were chosen to provide specific information relevant to LBVI ecology, conservation, and management. We then applied this protocol, using 2020 aerial imagery, to create a baseline map of riparian vegetation to support vireo recovery planning and status evaluation.

These data cover primarily the range in the Southern California Region however they do occur in the Central California Region. Historically this subspecies was also found in the Central Valley and the foothills of the Sierra Nevada Region.

Mapping of 2020 riparian vegetation establishes a baseline for range-wide LBVI nesting habitat conditions that can be used to:

- Evaluate the range-wide status and distribution of riparian vegetation that LBVI may use for nesting.
- Develop *Arundo donax* (Giant Reed) removal strategies at the scale of HUC8 subbasins that will maintain or expand existing areas of native riparian vegetation nesting habitat. These areas, with follow-up management, will help LBVI reoccupy formerly suitable nesting habitat that has been lost to *Arundo*.
- Understand the extent of the threat to riparian vegetation that is imposed by the emerging stressor of shot-hole borer invasion and develop potential management strategies.
- Evaluate the potential impacts of groundwater management issues on vireo habitat across the species' potential breeding range.
- Evaluate the potential impacts of wastewater management issues on vireo habitat across the species' potential breeding range.
- Develop habitat-based management and restoration strategies.

Data Resolution: 30 meters

Data Units: Thematic, suitable riparian vegetation types that include at least 15% shrub willow/mulefat cover and/or >15% tree willow cover.

Creation Method: This data layer was developed by the Conservation Science Institute. The overall study area consists of twenty-eight USGS Hydrologic Unit Code (HUC) 8 subbasins in Central and Southern Coastal California and Southern California Deserts. This study area is represented by a polygon feature class in the project geodatabase called "Total Study Extent". Within this large study area, a Focused Mapping Area was developed to ensure near-complete coverage of all riparian vegetation within active channels and floodplains of Level 1 stream

networks (e.g., streams that terminate in the Pacific Ocean) within each HUC8 subbasin. Similar protocols were developed to cover active channels and floodplains of desert streams that flow eastward from Peninsular Ranges and terminate in playa lakes. Work was performed on the project between 2021 and 2023.

Project data was produced applying heads-up digitizing techniques in an Esri ArcMap environment using 2020 National Agricultural Imagery Program (NAIP) imagery (60-centimeter base; true-color and color infrared). Ancillary imagery and data sources provided context during mapping. Original data are in vector format. Each original map polygon was assessed for 6 attributes:

- Dominant vegetation map unit type (defined as the vegetation type with >50% relative cover, regardless of total percent vegetation).
- Tree Willow Cover (absolute percent cover of all species of willow trees combined). This ensures that all mapped stands include information on this primary tree nesting habitat type for LBVI.
- Shrub Willow/Mulefat Cover (absolute percent cover of all shrub willow species and mulefat, *Baccharis salicifolia*). This ensures that all mapped stands include information on this primary shrub nesting habitat type for LBVI.
- Arundo Cover (absolute percent cover of *Arundo donax*). This ensures that all mapped stands include information on this invasive exotic species, which degrades LBVI habitat and in some cases, replaces it.
- Tamarisk Cover (absolute percent cover of *Tamarix* spp.). This ensures that all mapped stands include information on this invasive exotic species.
- Dieback Index (absolute percent cover of all trees and/or shrubs within a mapped polygon that show signs of dieback). This provides useful information about vegetation conditions and potential drought effects on vireo habitat.

For all but one map unit, the minimum mapping unit (MMU) polygon size was 1 acre. Due to the importance of early detection of *Arundo*, in order to plan for its removal, smaller *Arundo donax* stands were mapped, with polygons as small as a half-acre.

Download link for the original vector data:

<https://drive.google.com/file/d/1mfwlqJq1upEPIQ1f3pVbrmOOyBNb31DV/view>

Download link for the final report describing mapping methods and summarizing results:

<https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=215147>

The original vector data were simplified to create a raster layer that represents Least Bell's Vireo nesting habitat for the Southern and Central California Coast Regions by:

- 1 Including only the subset of polygons within these two geographic regions
- 2 Including only the subset of polygons that had >15% shrub willow/mulefat cover and/or >15% tree willow cover (primary characteristics of Least Bell's Vireo nesting habitat).
- 3 Including only the subset of polygons at elevations less than 512 meters (LBVI rarely nest above this)
- 4 Rasterizing this subset of polygons on the VegName field (which represents the dominant classified vegetation type).

Dominant riparian vegetation map units with Least Bell's Vireo Habitat were, from highest to lowest acreage: Willow/Mulefat Shrub, Tree Willow, Cottonwood, Sycamore, Elderberry, Riparian Tamarisk, Riparian Oak, Riparian Alluvial Scrub, Alder, Post-fire disturbance, Post-disturbance (unknown cause), and Exotic Trees.

Data Source: Lott, C.A., Reyes, E., A. Glass, and D. Johnson. 2023. A Range Wide Map of Least Bell's Vireo Nesting Vegetation: Mapping Protocol. Conservation Science and Data Visualization; Boise, ID; and Aerial Information Systems, Inc.; Redlands, CA.; 111pp. Available at: <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=215147>

File Name: LBVireoNestingHab_2020_202312_T2_v5.tif

MAMMALS

MOUNTAIN LION SUITABLE HABITAT

Tier: 1

Data vintage: 04/2023

Metric Definition and Relevance: This layer shows highly suitable habitats for the reproduction and feeding of Mountain lion (*Puma concolor*).

Data Resolution: 30m Raster

Data Units: Categorical - classified into one of the following habitat suitability categories:

Value	Desc_
0	Not suitable
1	Moderate foraging
2	High foraging
10	Moderate reproduction
11	Moderate reproduction and foraging
12	High reproduction, Moderate foraging
20	High reproduction
21	Moderate reproduction, High foraging
22	High reproduction and foraging

Creation Method: CWHR classifications are based on a combination of FVEG canopy cover, FVEG size class and vegetation data. The vegetation data includes a variety of tree, shrub, grassland, and water dominated habitats. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-vegetation combination have been deemed highly or moderately suitable for the reproduction or feeding of that species in the California Wildlife Habitat Relationship database. Each cell was assigned the maximum suitability value, i.e. if a cell was moderately suitable for feeding and highly suitable for reproduction, it was considered highly suitable.

Data Source:

- [FVEG 2023](#)

- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: MountainLionSuitHab_202304_202406_T1_v5.tif

PACIFIC MARTEN SUITABLE HABITAT

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: The Pacific marten is a species of special concern, but it is not federally, or state listed at the present time. It is identified as a focal species by Region 5 of the US Forest Service. The Pacific marten is a high elevation, old forest associate that is sensitive to forest management and is an important carnivore in high elevation food webs. This metric evaluates the 1000 ac around each 30m pixel to determine if it meets the minimum habitat requirements to support a territory. The Pacific Marten includes the subspecies, Humboldt marten, which is limited to the coastal region of the northern California region. The Humboldt marten subspecies in California is covered in a separate metric.

Data Resolution: 30m raster

Data Units: Categorical - classified into one of the following habitat suitability categories:

Value	Desc_
0	Not suitable
1	Moderate foraging
2	High foraging
11	Moderate reproduction and foraging
22	High reproduction and foraging

Creation Method: CWHR classifications are based on a combination of FVEG canopy cover, FVEG size class and vegetation data. The vegetation data includes a variety of tree, shrub, grassland, and water dominated habitats. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed highly or moderately suitable for the reproduction or feeding of that species in the California Wildlife Habitat Relationship database. Each cell was assigned the maximum suitability value, i.e. if a cell was moderately suitable for feeding and highly suitable for reproduction, it was considered highly suitable.

- Suitable foraging vegetation types: WHRTYPE = MRI, RFR, DFR, WTM, LPN, SCN, MHC
- Suitable foraging habitat: size/density classes = 4M, 4D, 5M, 5D, 6
- Suitable denning vegetation types: WHRTYPE = MRI, RFR, DFR, LPN, SCN, MHC
- Suitable denning habitat: size/density classes = 4M, 4D, 5M, 5D, 6

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014



File Name: PacificMartenSuitHab_202304_202406_T2_v5.tif

HUMBOLDT MARTEN PREDICTED DISTRIBUTION

Tier: 2

Data vintage: 2020

Metric Definition and Relevance: This data layer has been developed by Moriarty et al. It was published in “Predicted distribution of a rare and understudied forest carnivore: Pacific marten (*Martes caurina humboldtensis*). The data represent the predicted current distribution of Humboldt marten, a subspecies of Pacific marten occurring in coastal Oregon and northern California.

Data Resolution: 30m Raster

Data Units: 0 =not suitable, 1 = moderately suitable, 2 = highly suitable.

Creation Method: Using Maxent species distribution models, the authors modeled Pacific marten distribution, using marten locations collected between 1996-2020. They excluded locations occurring in areas that were modified by fire or timber harvest after the location data and before 2016 (date of their vegetation data). They estimated the relative probability of marten presence. Unsuitable areas were those where the model performance was equal to or poorer than random chance, below 14% predicted suitability. Areas with 15-30% predicted suitability were defined as ‘suitable’, and with over 30% predicted suitability were defined as ‘highly suitable’. NA values within the Northern California region are areas not covered by the model.

Data Source:

Moriarty, et al.

Moriarty, K.M., Thompson, J., Delheimer, M., Barry, B.R., Linnell, M., Levi, T., Hamm, K., Early, D., Gamblin, H., Gunther, M.S. and Ellison, J., 2021. Predicted distribution of a rare and understudied forest carnivore: Humboldt marten (*Martes caurina humboldtensis*). *PeerJ*, 9, p.e11670.

File Name: HumboldtMartenSuitHab_2020_202401_T2_v5.tif

PACIFIC FISHER PREDICTED HABITAT

Tier: 2

Data vintage: 2013

Metric Definition and Relevance: This layer shows the predicted probability of Pacific fisher (*Pekania pennanti*) occurrence or potential habitat quality. This species is found in the Northern California and Sierra Nevada Regions.

Data Resolution: 90m Raster

Data Units: Probability, values range 0 - 0.8

Creation Method: The authors calculated and mapped habitat values using Maxent, environmental variables and detection points across portions of California, Oregon and Washington. They created a prediction of relative habitat suitability, and these values were converted to 0 in areas of recent clearcuts and high severity fire. They then smoothed the values by averaging them over a moving window that approximates the species' home range size. Layer was then clipped to the CLM statewide boundary, retaining the 90 meter resolution. NA (null) values within the Northern California and Sierra Nevada regions are areas not covered by the model.

Data Source:

- Conservation Biology Institute (CBI) - layer modeled in 2013 for the USFWS listing evaluation and used in Klamath Basin Connectivity Modeling as the basis for the resistance surface and core use areas. [Habitat Suitability, Pacific Fisher | Data Basin](#)

Spencer, W., Brice, J., DiPietro, D., Gallo, J., Reilly, M. and Rusigian-Romsos, H., 2019. Habitat Connectivity for Fishers and Martens in the Klamath Basin Region of California and Oregon. *Conservation Biology Institute*. <https://doi.org/10.1007/s11631-019-0009-9>, p.m9.

File Name: PacificFisherPredOcc_201306_202401_T2_v5.tif

PACIFIC FISHER SUITABLE HABITAT

Tier: 2

Data Vintage: 04/2023

Metric Definition and Relevance: The Pacific fisher population in the southern Sierra is federally listed as a threatened population and resides primarily on National Forest System lands. Habitat management for this species is determined based on a Conservation Strategy developed by the US Forest Service and augmented by a recovery strategy developed by the US Fish and Wildlife Service. This species is found in the Northern California and Sierra Nevada Regions.

Data Resolution: 30m raster

Data Units: Categorical - classified into one of the following habitat suitability categories:

Value	Desc_
0	Not suitable
1	Moderate foraging
2	High foraging
12	High reproduction, Moderate foraging
21	Moderate reproduction, High foraging
22	High reproduction and foraging

Creation Method: CWHR classifications are based on a combination of [FVEG 2023](#) for canopy cover, size class and vegetation type. The vegetation data includes a variety of tree, shrub, grassland, and water dominated habitats. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed suitable for the reproduction or foraging of that species in the California Wildlife Habitat Relationship database.

Suitable habitat for the Pacific fisher is based on CWHR moderate and high suitability habitat for denning (reproduction) and foraging. CWHR suitability values were used to create a data layer that separately identifies suitable denning and suitable foraging habitat which meets the following criteria:

- Suitable foraging vegetation types: WHRTYPE = DFR, EPN, JPN, MHC, MHW, MRI, PPN, SMC, WFR, RFR, LPN
- Suitable foraging habitat: size/density classes = 4M, 4D, 5M, 5D, 6
- Suitable denning vegetation types: WHRTYPE = DFR, EPN, JPN, MHC, MHW, MRI, PPN, SMC, WFR
- Suitable denning habitat: size/density classes = 4D, 5M, 5D, 6

The combined (denning and foraging) suitable habitat layer has been further refined and clipped to the U.S. Fish and Wildlife Service species range extent from the Environmental Conservation Online System (ECOS) available at <https://ecos.fws.gov/ecp/species/3651#rangeInfo>.

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: PacificFisherSuitHab_202304_202406_T2_v5.tif

RINGTAIL CAT HABITAT SUITABILITY

Tier: 1

Data Vintage: 2023

Metric Definition and Relevance: This layer shows highly suitable habitats for the reproduction and feeding of Ringtail Cat (*Bassariscus astutus*) within the species' range.

Data Resolution: 30m Raster

Value	Desc_
0	Not suitable
1	Moderate foraging
10	Moderate reproduction
11	Moderate reproduction and foraging
12	High reproduction, Moderate foraging
21	Moderate reproduction, High foraging
22	High reproduction and foraging

Creation Method: CWHR classifications are based on a combination of FVEG canopy cover, size class and vegetation data. The vegetation data includes a variety of tree, shrub, grassland, and water dominated habitats. Species are considered present, and habitats considered suitable for each 30m cell for which the canopy cover-size-vegetation combination have been deemed highly suitable for the reproduction or feeding of that species in the California Wildlife Habitat Relationship database.

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: RingtailCatSuitHab_202304_202406_T1_v5.tif

PENINSULAR BIGHORN SHEEP**Tier:** 2**Data Vintage:** 2008

Metric Definition and Relevance: These data identify, in general, the areas where the final revised critical habitat for the Peninsular bighorn sheep (*Ovis canadensis nelsoni*) occurs. This subspecies is only found in the Southern California Region.

Data Resolution: 30m Raster**Data Units:** Binary layer, 1 represents current habitat

Creation Method: The authors designate revised critical habitat for the Peninsular bighorn sheep, a distinct population segment (DPS) of desert bighorn sheep (*Ovis canadensis nelsoni*) occupying the Peninsular Ranges of Southern California, under the Endangered Species Act of 1973, as amended (Act). In total, approximately 376,938 acres (ac) (152,542 hectares (ha)) fall within the boundaries of the critical habitat designation. This revised designation of critical habitat for Peninsular bighorn sheep reduces the 2001 designation by approximately 467,959 ac (189,377 ha). The revised critical habitat is located in Riverside, San Diego, and Imperial Counties, California. This revision takes into account comments from the public, including biologists familiar with the Peninsular bighorn sheep, on areas essential to the conservation of the Peninsular bighorn sheep. As a result of these comments, new information received, and a revision of their criteria used to identify critical habitat, they reevaluated the proposed revised critical habitat boundary and determined that some additions and deletions should be made. The critical habitat polygons were then transformed to a binary 30m raster layer, where 1 represents critical habitat.

Data Source: U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office.**File Name:** PeninsularBighornSheep_2008_202312_T2_v5.tif**COMMUNITY INTEGRITY**

The ability of communities to adapt to changing ecological, social, and economic conditions. This entails the capability of an ecological system to sustain a community of organisms that retains the pre-settlement species composition, diversity, and functional organization of natural habitats within a region.

TERRESTRIAL CONNECTIVITY

Tier: 1

Data Vintage: 03/2024

Metric Definition and Relevance: The Terrestrial Connectivity dataset is one of the four key components of the California Department of Fish and Wildlifes (CDFW) Areas of Conservation Emphasis (ACE) suite of terrestrial conservation information along with terrestrial Biodiversity, Significant Habitats, and Climate Resilience. The Terrestrial Connectivity dataset summarizes information on terrestrial connectivity by ACE hexagon including the presence of mapped corridors or linkages and the juxtaposition to large, contiguous, natural areas. This dataset was developed to support conservation planning efforts by allowing users to spatially evaluate the relative contribution of an area to terrestrial connectivity based on the results of statewide, regional, and other connectivity analyses.

Each hexagon (2.5 mi²) is ranked into one of the following categories based on the identification of corridors and linkages in statewide, regional, and species-movement studies:

ACE Rank 1-5, where 5 indicates highest connectivity conservation priority.

Rank 5:

1. Hexagon contains a known priority species movement corridor. This may include known road crossing locations based on gps collar or roadkill data. -OR-
2. Greater than 25% of the hexagon is mapped as channelized by Omniscape (TNC 2018) -OR-
3. Greater than 5% of a hexagon is mapped as channelized by Omniscape (TNC 2018) AND is identified as a statewide or regional habitat linkage. -OR-
4. Greater than 5% of a hexagon is mapped as channelized by Omniscape (TNC 2018) AND no species-specific regional habitat connectivity data is available for the area. -OR-
5. Hexagon intersects one or more high use ungulate migration corridor polygons.

Rank 4:

1. Greater than 25% of a hexagon is mapped as a statewide or regional habitat linkage AND hex is not assigned Rank 5 by above rules. -OR-
2. Hexagon intersects one or more moderate use ungulate migration corridor centerlines AND hex is not assigned Rank 5 by above rules.

Rank 3:

1. Greater than 5% of a hexagon is mapped as a statewide or regional habitat linkage AND hex is not assigned Rank 4 or 5 by above rules. -OR-
2. Greater than 5% of a hexagon is mapped as channelized or intensified by Omniscape (TNC 2018) AND hex is not assigned Rank 4 or 5 by above rules. -OR-
3. Greater than 5% of a hexagon is mapped as a core habitat by a regional habitat connectivity study AND hex is not assigned Rank 4 or 5 by above rules. -OR-
4. Hexagon intersects one or more ungulate migration corridor centerlines AND hex is not assigned Rank 4 or 5 by above rules.

Rank 2:

1. Greater than 25% of a hexagon is mapped as a CEHC Natural Landscape Block AND no more than 50% of the hexagon is mapped as urbanized based on recent landcover maps AND hex is not assigned Rank 3, 4, or 5 by above rules. -OR-
2. Greater than 5% of a hexagon is mapped as a CEHC Natural Landscape Block AND mean CBI Intactness score is moderate or high AND hex is not assigned Rank 3, 4, or 5 by above rules.

Rank 1:

1. Greater than 50% of a hexagon is mapped as urbanized based on recent landcover maps AND hex is not assigned Rank 2, 3, 4, or 5 by above rules. -OR-
2. Mean CBI Intactness score is low AND hex is not assigned Rank 2, 3, 4, or 5 by above rules. -OR-
3. Hex is not assigned Rank 2, 3, 4, or 5 by above rules (e.g., lakes).

Data Resolution: Vector - 2.5 square mile hexagons. The ACE Terrestrial Connectivity polygons are maintained as 2.5 square mile hexagons. The resolution of these data do not warrant conversion to 30 meter pixels.

Data Units: Categorical; 5 (listed above)

Creation Method: The California Department of Fish and Wildlife's (CDFW) Areas of Conservation Emphasis (ACE) is a compilation and analysis of the best-available statewide spatial information in California on biodiversity, rarity and endemism, harvested species, significant habitats, connectivity and wildlife movement, climate vulnerability, climate refugia, and other relevant data (e.g., other conservation priorities such as those identified in the State Wildlife Action Plan (SWAP), stressors, land ownership). ACE addresses both terrestrial and aquatic data. The ACE model combines and analyzes terrestrial information in a 2.5 square mile hexagon grid and aquatic information at the HUC12 watershed level across the state to produce a series of maps for use in non-regulatory evaluation of conservation priorities in California. The model addresses as many of CDFW's statewide conservation and recreational mandates as feasible using high quality data sources. High value areas statewide and in each USDA Ecoregion were identified. The ACE maps and data can be viewed in the ACE online map viewer, or downloaded for use in ArcGIS. For more detailed information see <https://www.wildlife.ca.gov/Data/Analysis/ACE> and <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=24326>.

Use Limitations:

The ACE data is subject to certain assumptions and limitations that must be considered in any use or application of the data. All ACE data layers are limited by the accuracy and scale of the input data. ACE is a compilation of the best available scientific information; however, many of these datasets are not comprehensive across the landscape, may change over time, and should be revised and improved as new data become available.

The user accepts sole responsibility for the correct interpretation and use of these data, and agrees not to misrepresent these data. CDFW makes no warranty of any kind regarding these data, express or implied. By downloading these datasets, the user understands that these data are in draft condition and subject to change at any time as new information becomes available. The user will not seek to hold the State or the Department liable

under any circumstances for any damages with respect to any claim by the user or any third party on account of or arising from the use of data or maps. CDFW reserves the right to modify or replace these datasets without notification.

The ACE maps display biological and recreational values based on available data and constrained by the limitations of the data. The values may be influenced by level of survey effort in a given area. The ACE data represent broad-scale patterns across the landscape, and the value of any single hexagon should be interpreted with caution. ACE is a decision-support tool to be used in conjunction with species-specific information and local-scale conservation prioritization analyses.

The ACE maps do not replace the need for site-specific evaluation of biological resources and should not be used as the sole measure of conservation priority during planning. No statement or dataset shall by itself be considered an official response from a state agency regarding impacts to wildlife resulting from a management action subject to the California Environmental Quality Act (CEQA).

Data Source: California Department of Fish and Wildlife; Terrestrial Connectivity, Areas of Conservation Emphasis (ACE), version 3.2.1

File Name: TerrestrialConn_202403_202407_T1_v5.shp

FULL CLIMATE CONNECTIVITY NETWORK

Tier: 3

Data Vintage: 2021

Metric Definition and Relevance: This linkage network is designed to allow for local movements among individual preserves while supporting landscape-scale regional connectivity. Habitat connectivity is the most frequently recommended strategy to support adaptation to climate change, habitat fragmentation, and post-disturbance recolonizations. In southern California, conservation planning efforts have resulted in protected area networks to address widespread habitat fragmentation across the region. These plans are designed to protect biodiversity by establishing networks of core habitats. Connectivity is essential if these networks are to support the long-term goals of protecting biodiversity, particularly as species' ranges are likely to shift in response to climate change. These data have been created for the Southern California Region only.

Data Resolution: polygon

Data Units: Categorical, 4 - See report for field definitions

Creation Method: The Institute of Ecological Monitoring and Management at San Diego State University, funded by California's Wildlife Conservation Board and a State Wildlife Grant from the California Department of Fish and Wildlife, developed a landscape linkage network to support connectivity for preservation of biodiversity across southern California under climate and land-use changes. Linkages depicted in this dataset were developed using an ensemble of approaches. First, species distribution models (SDMs) were developed for five focal species under historic conditions and four future climate scenario projections (warmer, wetter, reduced emissions - CNRM-CM5 RCP 4.5; warmer, wetter, business as usual emissions - CNRM-CM5 RCP 8.5; warmer, drier, reduced emissions - MIROC5 RCP 4.5; warmer, drier, business as usual emissions - MIROC5 RCP 8.5). Suitability surfaces resulting from the SDMs were used to identify core habitat areas to be connected and converted to resistance surfaces for least cost corridor connectivity modeling under historic conditions and future periods at decadal intervals. Linkage maps for each species were combined into a single, multispecies linkage network based on a prioritization using a fuzzy-

logic based modeling toolbox, Environmental Evaluation and Modeling System 2.02 in ArcGIS (Sheehan and Gough, 2016). Prioritization was based on linkage importance under future conditions, feasibility of implementation, connectivity and habitat value, and biological importance derived from metapopulation models. The top linkage segments for each species were selected based on the maximum value for any single species, the average value across all five focal species, and the count of focal species represented. These segments were then supplemented with geodiversity linkages representing valley and narrow valley features on the landscape, which were not already identified in the focal species linkage segments. Linkages in the central portion of the network were expanded based on a multispecies maximum and average from Circuitscape modeling which also relied on the resistance surfaces derived from SDM suitability maps for each species. Finally, the network was manually trimmed in areas of recent development and expanded in several urban areas to match up with urban conservation planning efforts such as the Rim of the Valley Plan, the Emerald Necklace Vision, and the Santa Ana River Parkway. For more information on methods and data products, visit the project page to download the full report at [Climate Resilient Connectivity For The South Coast Ecoregion of California | IEMM \(sdsu.edu\)](https://www.sdsu.edu/ieem/ClimateResilientConnectivityForTheSouthCoastEcoregionofCalifornia.html)

Data Source: San Diego State University CWC Project Team.

Jennings, M.K., E. Conlisk, E. Haueser, and R.L. Lewison. 2019. Climate Resilient Connectivity for the South Coast Ecoregion. Prepared for the California Department of Fish and Wildlife and the California Wildlife Conservation Board.

File Name: FullClimateConnNetwork_2021_202312_T3_v5.shp

PRESENT DAY CONNECTIVITY IN CALIFORNIA (OMNISCAPE)

Tier: 1

Data Vintage: 01/2023

Metric Definition and Relevance: This data represents a wall-to-wall characterization of regional habitat connectivity potential in California for plant and animal species whose movement is inhibited by developed or agricultural land uses.

This model of present-day connectivity assumes there will be more ‘current flow’, representing wildlife movement, coming from and going to areas that are less modified. Wildlife may encounter barriers and land uses that are not conducive to movement en route. They may avoid moving through these areas entirely or these areas will increase their risk of harm. Land use, energy infrastructure, roads, and night lights are some of the factors that affect the ‘resistance’ to movement in this analysis.

Present Day Connectivity is partitioned into 11 classes (and the code used in the data):

- 1) 3 - Land use may restrict movement:
- 2) 4 - Permeable lands that contribute little to regional connectivity
- 3) 19 - Impeded
- 4) 25 - Diffuse - Med
- 5) 29 - Diffuse - High
- 6) 31 - Intensified - Low
- 7) 35 - Intensified - Med
- 8) 39 - Intensified - High
- 9) 41 - Channelized - Low

- 10) 45 - Channelized - Med
- 11) 49 - Channelized - High

Connectivity classes are assembled into categories based on whether an area had more or less flow than would be expected in the absence of barriers. For example, when animal movement is restricted by surrounding land uses, it channelizes into a single movement pathway, or a linkage. These **Intensified** and **Channelized** linkages are areas with more flow and far more flow, respectively, than would be expected in the absence of nearby barriers to movement. **Diffuse** connectivity areas are broadly, permeable areas with as much flow as is expected. Roads and intensive development can cause complete or partial barriers to animal movement, impeding their ability to traverse the landscape. **Impeded** areas are areas where there is less flow than is expected.

The Omniscape output 'current flow' was classified into high, medium and low classes and further categorized by the amount of flow compared to what would be expected in the absence of barriers. The 'Channelized' class has 1.7 times more flow than expected in the absence of barriers and represents the last remaining natural pathway through a modified landscape. The 'Intensified' class has 1.3-1.7 times more flow than expected and represents areas where there are a few remaining natural pathways. The 'Diffuse' class has as much flow as expected and represents lands that have many or unlimited movement options.

Data Resolution: 30m Raster

Data Units: Categorical; 11 (listed above)

Creation Method: The approach uses Omniscape, a modified version of Circuitscape (www.circuitscape.org/) with a moving-window algorithm, to quantify ecological flow (potential connectivity) among all pixels within a 50km radius. Circuitscape treats landscapes as resistive surfaces, where high-quality movement habitat has low resistance and barriers have high resistance. The algorithm incorporates all possible pathways between movement sources and destinations and identifies areas of high flow via low-resistance routes, i.e., routes presenting relatively low movement difficulty because of lower human modification, and thus mortality risk.

Data Source: The Nature Conservancy (TNC) Omniscape

c.k.stanley@tnc.org

The Nature Conservancy: A World Where People & Nature Thrive

File Name: PresentDayConn_202301_202401_T1_v5.tif

FUNCTIONAL GROUP SPECIES RICHNESS

Tier: 1

Data Vintage: 2023

Metric Definition and Relevance: Functional groups are sets of species that share life history characteristics that perform particular functions within an ecosystem. The six functional groups are represented and include a range of trophic levels and ecosystem services. A primary consideration in management is to maintain conditions, adapt to changing conditions and transition to alternate but still productive conditions over time. The maintenance of ecosystem services is a primary concern with climate change.

Data Resolution: 30m Raster

Data Units: Number of species

Creation Method: Species list created from CWHR is divided into six functional groups based on literature. The six functional groups include herbivores, predators, insectivores, soil aerators, seed/spore dispersers and cavity nesters/excavators. The diversity of each functional group is first determined by the number of species for which a given location provides high suitability reproductive habitat (as per species richness calculations). Target conditions can be generated based on percentiles of functional group richness across all patches, so that the 90th percentile or higher is considered in target conditions and the 10th percentile or below is considered to be in a fully departed condition.

Data Source:

- [FVEG 2023](#)
- California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: CavityNestersSpecRichness_202304_202406_T1_v5.tif;
HerbivoresSpecRichness_202304_202406_T1_v5.tif; InsectivoresSpecRichness_202304_202406_T1_v5.tif;
PredatorsSpecRichness_202304_202406_T1_v5.tif; SeedSporeDispSpecRichness_202304_202406_T1_v5.tif;
SoilAeratorsSpecRichness_202304_202406_T1_v5.tif

CARBON SEQUESTRATION

Forests play an important role in mitigating climate by sequestering and storing large amounts of carbon. However, forests are at risk of losing carbon because of rates of decay and disturbance, especially with high severity wildfires. Knowing where carbon exists provides a context for where changes in forest conditions will have the greatest impact on carbon storage and sequestration objectives.

DESIRED OUTCOME: Carbon sequestration is enhanced in a stable and sustainable manner that yields multiple ecological and social benefits.

Note that all values for carbon have been expressed in Mg C/ha, the international standard for how carbon is measured. If needed, to convert back to the native short tons per acre, divide the Mg/ha by 2.2417023114334.

CARBON STORAGE

Carbon storage in forest biomass is an essential attribute of stable forest ecosystems and a key link in the global carbon cycle. After carbon dioxide is converted into organic matter by photosynthesis, carbon is stored in forests for a period of time before it is ultimately returned to the atmosphere through respiration and decomposition or disturbance (e.g., fire). A substantial pool of carbon is stored in woody biomass (roots, trunks, branches). Another portion eventually ends up as organic matter in forest floor litter and in soils. Soil carbon does not change very quickly and is difficult to measure directly.

TOTAL ABOVEGROUND CARBON

Tier: 1

Data Vintage: 09/2020

Metric Definition and Relevance: Identifying ecosystem carbon is essential to land managers and the Total Aboveground Carbon metric provides an estimate of the amount of existing carbon and its location on California's landscape. The metric also serves to provide context for the other metrics used to quantify carbon sequestration. For example, instability or lack of resilience in forests with low total aboveground carbon would be of less concern than the same degree of instability in a forest that has large total aboveground carbon.

Data Resolution: 30m Raster

Data Units: Grams dry matter/m²

Creation Method: The Center for Ecosystem Climate Solutions (CECS) DataEngine model tracks monthly carbon in multiple pools from 1986 to 2020. The carbon components are initialized with eMapR (see [Additional Resources](#)) observations for the early Landsat era; the model then runs freely based on Landsat and other observations. Disturbances and disturbance intensity are tracked annually by Landsat (see other metrics developed by CECS) and used to quantitatively transfer or combust pools. The model allocates and turns over material based on allometric scaling theory, as adjusted by observational data sets. Aboveground pools (live tree, live shrubs and dead material) are summed for September of 2020.

CECS data that reflect landscape changes resulting from disturbances require 6 to 12 months of Landsat observations **after a given year that included major disturbances (such as a high severity wildfire)** to fully quantify that disturbance. CECS data that reflect disturbance, such as this data layer, are therefore available **through water year 2020 (i.e. through September 2020)**.

Data Source: CECS; <https://california-ecosystem-climate.solutions/>

File Name: CStocksTotalAbove_202009_202312_T1_v5.tif

TOTAL CARBON (F3)

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: Identifying ecosystem carbon is essential to land managers and the Total Carbon (F3) metric provides an estimate of the amount of existing carbon and its location on California's landscape. The metric also provides context for the other metrics used to quantify carbon sequestration. For example, instability or lack of forest resilience, if there wasn't much carbon in the first places, would be of lesser concern than if there were a lot of carbon, all other things being equal.

Data Resolution: 30m raster

Data Units: Mg C/ha

Creation Method: This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California. The [F3 model](#) generated multiple raster surfaces from the Fire and Fuels Extension of the FVS Carbon Report. These raster surfaces estimated the total aboveground live trees, including stems, branches and foliage (not including roots) to provide the Tons C per acre (Aboveground); the belowground live tree roots (Belowground) and belowground roots of dead and cut trees (Belowgro_1); standing dead trees for all size classes including stems, branches, and foliage still present but not including roots (Standing_D); forest down dead wood, regardless of size (Forest_Dow); forest floor litter and duff (Forest_Flo); and the herbs and shrubs (Forest_Shr). Conversion from short tons per acre (the default F3 output units) to Mg/ha requires multiplication by 2.2417023114334.

2019 to 2021 Update: Values for 2021 were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. Values for the total aboveground live tree carbon raster (Abovegroun) and for the belowground live tree roots carbon raster (Belowgroun) were adjusted for 2021 following the same procedure using eDaRT MMI. MMI values for canopy cover loss were used as a direct proxy to estimate Carbon loss, following the formula:

$$2021\ Abovegroun = 2019\ Abovegroun - (2019\ Abovegroun * MMI/100)$$

The assumption of direct correlation between canopy cover and Carbon should be viewed with caution.

The 2021 values for the standing dead trees raster (Standing_D) and for the belowground roots of dead and cut trees raster (Belowgro_1) were adjusted in a similar procedure:

- Standing_D: The difference between 2019 and 2021 live volume (as estimated using eDaRT MMI) was converted to short tons/acre using a conversion factor of 32.1 cubic feet/ton and the result was summed with 2019 standing dead.
- Belowgro_1: The difference between 2019 and 2021 belowground live tree roots (as estimated using eDaRT MMI) was summed with 2019 belowground roots of dead and cut trees.

No adjustments were made for 2021 (Forest_Dow, Forest_Flo, Forest_Shr) due to uncertainties in conversions based on the limits with which change detection information can quantify the individual components of this metric. For areas with disturbance 2019-2021 (defined as eDaRT MMI \geq 10% canopy cover loss), raster values are not represented for 2021 (i.e., NULL). For areas undisturbed 2019-2021, it is a reasonable assumption that raster values did not change significantly over the course of two years.

This layer for the Total Carbon metric is derived from F3 layers (2021) using the following formula:

$$[sum(Abovegroun, Belowgroun, Belowgro_1, Standing_D, Forest_Dow, Forest_Flo, Forest_Shr)]*2.2417023114334$$

In cases where any individual input to the formula is NULL, the resulting sum cannot be computed and is therefore also NULL.

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_TotalCarbon_202111_202209_T2_v5.tif

ANNUAL BIOMASS DATA 2001 AND 2021, [WWETAC \(WESTERN WILDLAND ENVIRONMENTAL THREAT ASSESSMENT CENTER\)](#)

Tier: 2

Data Vintage: 2001 and 2021

Metric Definition and Relevance: Biomass estimates for shrubland-dominated ecosystems in southern California have, to date, been limited to national or statewide efforts which can underestimate the amount of biomass; are limited to one-time snapshots; or estimate aboveground live biomass only. These data were developed using a consistent, repeatable method to assess four vegetative biomass pools from 2001-2021 for the southern California study area (totaling 6,441,208 ha), defined by the Level IV Ecoregions (Bailey 2016) that intersect with USDA Forest Service lands (Figure 1). Aboveground live biomass estimates were developed first (Schradler-Patton and Underwood 2021), and then belowground, standing dead, and litter biomass pools were calculated using field data

in the peer-reviewed literature (Schrader-Patton et al. 2022). Over half (52.3%) of the study area is shrubland, and the method accounts for different amounts of carbon associated with three post-fire shrub regeneration strategies: obligate resprouting, obligate seeding, and facultative seeding. Biomass estimates were also generated for trees and herbs, giving a total of five life form post-fire regeneration strategy types. These data provide an important contribution to the management of shrubland-dominated ecosystems to assess the impacts of wildfire and management activities, such as fuel management and restoration, and for monitoring carbon storage over the long term. These data have been prepared for the Southern California Region only.

The biomass data are a key input into the online web mapping tool SoCal EcoServe, developed for US Department Of Agriculture Forest Service resource managers to help evaluate and assess the impacts of wildfire on a suite of ecosystem services including carbon storage. The tool is available at

<https://manzanita.forestry.oregonstate.edu/ecoservices/> and described in Underwood et al. (2022).

Data Resolution: 30 meters

Data Units: kg/m²

Creation Method: Researchers generated spatial estimates of above ground live biomass (AGLBM) for 2000-2021 for the southern California area, illustrated in the figure below. The study area, totaling 6,441,208 ha, is defined by the 42 Level IV Ecoregions (Bailey 2016) that intersect the four southern US Department of Agriculture (USDA) National Forests in southern California; Angeles, Cleveland, Los Padres, and San Bernardino:



The researchers created biomass raster layers (30m spatial resolution) by modeling a set of covariates (Normalized Difference Vegetation Index [NDVI]), precipitation, solar radiation, actual evapotranspiration, aspect, slope, climatic water deficit, elevation, flow accumulation, landscape facets, hydrological recharge and runoff, and soil type) to predict AGLBM using 766 field plots from the USDA Forest Service Forest Inventory and Analysis (FIA); the Landfire Reference Database (LFRDB) plot data; and other research plots. The dates of field data spanned 2001-2012. The NDVI raster data were derived from Landsat TM/ETM+/OLI multispectral satellite data (onboard Landsat 5, 7, and 8, respectively). NDVI data were composited from all available Landsat images for the months of July and August for each year 2001-2021. Annual precipitation data for each water year (October 1 - September 30) 2001-2021 were downloaded from PRISM (<http://www.prism.oregonstate.edu/>). For each field plot, we extracted the raster values for all covariates; NDVI and precipitation data were matched to the year of plot visit.

AGLBM was predicted using the set of 17 covariates in a Random Forest [RF] model in R statistical computing software. To create an AGLBM raster surface for each year 2001-2021, NDVI and precipitation raster data specific to each year were integrated into the RF model (see [Schrader-Patton and Underwood 2021](#) for details).

To estimate other shrubland biomass pools (standing dead, litter, and below ground) a multi-step process was employed:

1) First, the study area was segmented by community type using the California Wildlife Habitat Relationships (CWHR) data (Mayer and Laudenslayer 1988). The wildland vegetation of the study area (excluding agricultural, urban, water, and barren classes) contains 45 CWHR classes, 14 of which are $\geq 0.75\%$ of the wildland vegetation in the study area. CWHR classes were divided into 14 classes; shrubland-dominated versus non-shrubland-dominated types (annual grass, oak, conifer, mixed hardwood).

2) For the shrubland types the researchers determined the per pixel proportion of biomass by three plant life forms: tree, shrub, and herb. We further subdivided the shrub life form into three post-fire regeneration strategies: Obligate Resprouters (OR), obligate seeders (OS), and facultative seeders (FS), providing five plant types in total. Rasters depicting the proportion of biomass in each of the five plant types were created by first calculating the proportion of biomass in each type for the plots used in Schrader-Patton and Underwood (2021). The plot data contained individual plant species, crown width and height measurements. Using these measurements, the biomass was estimated for each individual plant within the plot by applying published allometric equations (see [Schrader-Patton and Underwood 2021](#) for details). The individual plants in the plots were classified into the five plant types and the proportion of biomass in each type were calculated for each plot. A multinomial model was used to relate these proportions to a suite of geophysical and remote sensing variables which, in turn, was applied to raster surfaces of these predictors. The final outputs were raster maps of the proportion of biomass by life form (tree, shrub, herb) and, for shrubs, the proportion of biomass by post-fire regeneration strategy (OR, OS, and FS) (Underwood et al. [2023](#)). We used these raster layers to estimate other vegetative pools of biomass (e.g., below-ground shrub biomass using above- to below- ground ratios) for each post-fire regeneration strategy type (OR, OS, and FS) using information found in the published literature.

3) Third, estimates of standing dead, litter, and below ground biomass pools by either applying fractions of AGLBM gleaned the available published literature or by using biomass estimates in existing spatial datasets. The specific method used was dependent on the percentage of the WHR class in the study area and the vegetation type (shrub or non-shrub)

File naming:

WWETAC_UCD_aboveGround_2001_202312_T2_v5.tif (Aboveground Live Biomass 2001)

WWETAC_UCD_aboveGround_2021_202312_T2_v5.tif (Aboveground Live Biomass 2021)

WWETAC_UCD_belowGround_2001_202312_T2_v5.tif (Belowground Live Biomass 2001)

WWETAC_UCD_belowGround_2021_202312_T2_v5.tif (Belowground Live Biomass 2021)

WWETAC_UCD_litter_2021_202312_T2_v5.tif (Litter Biomass 2001)

WWETAC_UCD_litter_2021_g_m2_v22.tif (Litter Biomass 2021)

WWETAC_UCD_standingDead_2001_202312_T2_v5.tif (Standing Dead Biomass 2001)

WWETAC_UCD_standingDead_2021_202312_T2_v5.tif (Standing Dead Biomass 2021)

Data Source:

Schrader-Patton, C.C., E.C. Underwood, and Q.M. Sorenson. 2023. Annual biomass spatial data for southern California (2001–2021): Above- and belowground, standing dead, and litter. *Ecology* e4031.

Schrader-Patton, C.C. and E.C. Underwood. 2022. Annual biomass data (2001-2021) for southern California: above- and below-ground, standing dead, and litter. Dryad, Dataset, <https://doi.org/10.5061/dryad.qz612jmit>

Underwood, E.C., Q.M. Sorenson, C.C. Schrader-Patton, N.A. Molinari and H.D. Safford. 2023. Resprouting, seeding, and facultative seeding shrub species in California’s Mediterranean-type climate region. *Frontiers in Ecology and Evolution* 11:1158265. doi: 10.3389/fevo.2023.1158265

Data available is for 2001 and 2021 (year in file name changes accordingly). The full set of data for intervening years can be downloaded from: <https://doi.org/10.5061/dryad.qz612jmit> .

File Name: WWETAC_UCD_aboveGround_2001_202312_T2_v5.tif;
WWETAC_UCD_aboveGround_2021_202312_T2_v5.tif; WWETAC_UCD_belowGround_2001_202312_T2_v5.tif;
WWETAC_UCD_belowGround_2021_202312_T2_v5.tif; WWETAC_UCD_litter_2001_202312_T2_v5.tif;
WWETAC_UCD_litter_2021_202312_T2_v5.tif; WWETAC_UCD_standingDead_2001_202312_T2_v5.tif;
WWETAC_UCD_standingDead_2021_202312_T2_v5.tif

CARBON STABILITY

Carbon stability is an important feature in carbon sequestration calculations because carbon turnover – high levels of loss, even if followed by high rates of sequestration – are not as ecologically beneficial as high residency rates for carbon and larger pool values, particularly when stored in large live trees which have many other ecological benefits. The carbon in dead biomass is considered a more unstable component of the carbon pool itself, and a potential destabilizing factor for the live carbon pool in fire-adapted forest ecosystems, especially where it exceeds certain thresholds (e.g., over 46 Mg (total biomass)/ha, Stephens et al., 2022).

ABOVEGROUND CARBON TURNOVER TIME

Tier: 1

Data Vintage: 09/2020

Metric Definition and Relevance: The average lifetime of aboveground live and dead carbon in years. Locations where the lifetime or turnover time is longer have more carbon in more stable pools, such as large trees or large coarse woody debris. Locations where the lifetime or turnover time is shorter have more carbon in labile pools, such as live or dead leaves.

Data Resolution: 30m Raster

Data Units: Years

Creation Method: Calculated from the ratio of total aboveground carbon and annual decomposition. Aboveground carbon and annual decomposition are both calculated for 2020 from a Landsat-driven pools and

fluxes model, as described for the total aboveground carbon product. Aboveground turnover time does not currently account for carbon losses and removals with combustion or harvest.

CECS data that reflect landscape changes resulting from disturbances require 6 to 12 months of Landsat observations **after a given year that included major disturbances (such as a high severity wildfire)** to fully quantify that disturbance. CECS data that reflect disturbance, such as this data layer, are therefore available **through water year 2020 (i.e. through September 2020)**.

Data Source: CECS; <https://california-ecosystem-climate.solutions/>

File Name: CStocks_Turnovertime_202009_202312_T1_v5.tif

LARGE TREE CARBON

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: Large trees in this metric were calculated as the sum of branch and stemwood plus foliage for trees over 20 inches in diameter. This is intended to represent the most stable (possibly other than soil) component of the carbon pool, and can be an indicator of the carbon stock's resilience/stability. For this metric, higher values generally indicate more stability, and upward trends in this value may be interpreted as generally increasing resilience of the aboveground C pool.

Data Resolution: 30m raster

Data Units: Mg C/ha

Creation Method: This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California. The [F3 model](#) generated several different raster surfaces to estimate the biomass of stemwood in non-overlapping predefined size classes (BMSTM_x) and for the branchwood, foliage, and the unmerchantable portion of stemwood above 4" in the same non-overlapping predefined size classes (BMCWN_x).

A recent paper (Bernal et al., 2022), suggests that due to drought/temps expected beyond 2040, the Sierra Nevada may not be able to support carbon loads of aboveground live trees over 20 Mg C/ha (note that they report biomass values, not carbon values). Carbon values are generally assumed to be half of biomass (See CAL FIRE's "AB 1504" methodology, Christensen et al., 2019). Conversion from short tons per acre (the default F3 output units) to Mg/ha requires multiplication by 2.2417023114334.

2019 to 2021 Update: Values for 2021 were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. The MMI value for canopy cover loss was used as a direct proxy to estimate biomass loss, following the formula:

$$2021\ BMCWN_x = 2019\ BMCWN_x - (2019\ BMCWN_x * MMI/100)$$

Although the assumption of direct correlation between canopy cover and biomass should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022). The assumption that canopy cover loss as estimated using eDaRT MMI was equitably distributed among the predefined size classes may result in over- or under-estimates of actual large tree biomass, depending on location.

Values for each of the non-overlapping, predefined, large tree size class for stemwood (BMSTM_x) rasters and for branchwood, foliage, and unmerchantable portion of stemwood above 4" (BMCWN_x) rasters were adjusted for 2021 following the same procedure using eDaRT MMI.

This layer for the Large Tree Carbon metric is derived from F3 layers (2021) using the following formula:

$$[(\text{sum}(\text{BMCWN}_{25}, \text{BMCWN}_{35}, \text{BMCWN}_{40}, \text{BMSTM}_{25}, \text{BMSTM}_{35}, \text{BMSTM}_{40})/2) * 2.2417023114334]$$

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_LargeTreeCarbon_202111_202209_T2_v5.tif

DEAD CARBON

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: Dead carbon includes dead and down (litter, duff, fine, coarse, and heavy fuels, including 1000+ hour logs) which are inherently unstable due to prevailing fire and decay processes, and a destabilizing factor in the fire-adapted forests of the Sierra to the extent that they contribute to uncharacteristic fire behavior. In addition to that dead carbon, this metric includes the carbon from the canopies of small trees, which is readily released during fire (specifically, trees less than 10 inches in diameter). Standing dead carbon is also included, representing the slower leak from the landscape carbon stock. As a result, this metric is a proxy for unstable carbon: fire liable carbon on the landscape which is more vulnerable to combustion.

Data Resolution: 30m raster

Data Units: Mg C/ha

Creation Method: This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California. The [F3 model](#) generated several different raster surfaces in non-overlapping predefined size classes to estimate the small size live tree (those <10" DBH) branchwood and foliage plus unmerchantable portions of stemwood above 4-inch diameter (BMCWN_x), plus the standing dead estimates for all size classes (including stems, branches, and foliage still present) from the FVS Fire and Fuels extension carbon report (Standing_D). The model also generated several raster surfaces of fuel loading estimates of the coarse woody debris by non-overlapping predefined size classes: including 1, 10, 100, and 1000-hour fuels (FLOAD_1-5); and estimates for coarse woody debris of heavy fuels by non-overlapping predefined size classes greater than the 1000-hour fuel sizes (>=6" and <8"; FLOAD_6-9) and for litter and duff.

A recent paper (Bernal et al., 2022), suggests that due to drought/temps expected beyond 2040, the Sierra Nevada may not be able to support carbon loads of aboveground live trees over 20 Mg C/ha (note that they report biomass values, not carbon values). Carbon values are generally assumed to be half of biomass (See CAL FIRE's "AB 1504" methodology, Christensen et al., 2019). Conversion from short tons per acre (the default F3 output units) to Mg/ha requires multiplication by 2.2417023114334.

2019 to 2021 Update: The 2021 values described below for Total Dead/Down Fuels and for Standing Dead and Ladder Fuels, were summed and converted to Mg C/ha to derive this metric.

No adjustments were made for 2021 to the Total Dead/Down Fuels (FLOAD_x, LITTER, DUFF), due to uncertainties in conversions based on the limits with which change detection information can quantify the individual components of this metric. For areas with disturbance 2019-2021 (defined as eDaRT MMI >= 10% canopy cover

loss), total dead/down fuel values are not represented for 2021 (i.e., NULL). For areas undisturbed 2019-2021, it is a reasonable assumption that total dead/down fuels did not change significantly over the course of two years.

Values for 2021 Standing Dead and Ladder Fuels (Standing_D, BMCWN_x) were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. The MMI value for canopy cover loss was used as a direct proxy to estimate biomass loss, following the formula:

$$2021 \text{ BMCWN}_x = 2019 \text{ BMCWN}_x - (2019 \text{ BMCWN}_x * \text{MMI}/100)$$

Although the assumption of direct correlation between canopy cover and biomass should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022). The assumption that canopy cover loss, as estimated using eDaRT MMI, was equitably distributed among the predefined size classes may result in over- or under-estimates of actual tree biomass, depending on location.

Adjustments for the standing dead trees raster (Standing_D) took the difference between 2019 and 2021 live volume (as estimated using MMI) converted to short tons/acre using a conversion factor of 32.1 cubic feet/ton and the result was summed with 2019 standing dead.

Values of undisturbed areas of Total Dead/Down Fuels (FLOAD_x, LITTER, DUFF) were added to the non-overlapping predefined size classes for the small size live trees (<10" DBH) branchwood and foliage plus unmerchantable portions of stemwood above 4-inch diameter (BMCWN_x), which had been adjusted for 2021 using MMI percent adjustments. This total biomass was halved converting to carbon values and added to the adjusted standing dead and the result converted to Mg C/ha.

This layer for the Dead Carbon metric is derived from F3 layers (2021) using the following formula:

$$[(\text{sum}(\text{FLOAD}_{1-9}, \text{LITTER}, \text{DUFF}, \text{BMCWN}_0, \text{BMCWN}_2, \text{BMCWN}_7)/2) + \text{Standing_D}] * 2.2417023114334$$

In cases where any individual input to the formula is NULL, the resulting sum cannot be computed and is therefore also NULL.

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_DeadCarbon_202111_202209_T2_v5.tif

ECONOMIC DIVERSITY

Economic Diversity increases business opportunities that provide regional economic vitality and additional benefits to rural and vulnerable populations. Ecosystem services and forest products provide a foundation for many local and regional economic activities and employment opportunities. Forest management should support a sustainable natural resource-based economy.

DESIRED OUTCOME: Forest management and outdoor activities support a sustainable, natural-resource-based economy, particularly in rural communities.

WOOD PRODUCT INDUSTRY

The wood product industry, with some exceptions, is largely limited to the North Coast and Sierra Nevada Regions. However, restoration activities, including vegetation management, are necessary and require financial investments to make progress. This work brings jobs and income to local communities.

SNV - SAWTIMBER

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: This metric expresses the amount of total existing, aboveground, live tree stem biomass measured in dry weight tons per acre for the Sierra Nevada region. This metric can be used to assess the sawtimber volume present at the 30m cell level.

Data Resolution: 30m raster

Data Units: Dry weight tons/acre

Creation Method: The [F3 model](#) generated raster surfaces to provide an estimate of the total aboveground live tree stem biomass (ABGDLVSM).

2019 to 2021 Update: Values for 2021 were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. The MMI value for canopy cover loss was used as a direct proxy to estimate biomass loss, using the formula:

$$2021\ ABGDLVSM = 2019\ ABGDLVSM - (2019\ ABGDLVSM * MMI/100)$$

Although the assumption of direct correlation between canopy cover and biomass should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022).

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_SawtimberVolume_202111_202209_T2_v5.tif

SNV - BIOMASS

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: This metric expresses the total amount of existing biomass volume (measured in dry weight tons per acre) from all live tree crowns (branchwood and foliage) and the tree stems less than 10" dbh for the Sierra Nevada region. This metric can be used to assess the volume of biomass present at the 30m cell level. It is recognized in some forest types, shrub biomass can be a significant contributor to the total biomass, however due to the [aforementioned limitations](#) of the F3 model, the shrub component has not been included.

Data Resolution: 30m raster

Data Units: Dry weight tons/acre

Creation Method: The [F3 model](#) generated several raster surfaces to provide an estimate of the total aboveground live tree crown (including foliage) biomass for all trees (ABGDLVBR) and estimates of the tree stem

biomass of live small trees (BMSTM; <10" dbh). Since the F3 model data is driven by FIA plot data (which is an incomplete source for shrub metrics), the shrub biomass cannot currently be generated.

2019 to 2021 Update: Values for 2021 were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. Values for each non-overlapping predefined small tree size class for stemwood biomass (BMSTM_x) raster and for the total aboveground live tree crown biomass for all trees (ABGDLVBR) raster were adjusted for 2021 following the same procedure using eDaRT MMI. The MMI value for canopy cover loss was used as a direct proxy to estimate biomass loss using the MMI percent adjustments, e.g.:

$$2021\ BMSTM_x = 2019\ BMSTM_x - (2019\ BMSTM_x * MMI/100)$$

Although the assumption of direct correlation between canopy cover and biomass should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022). The assumption that canopy cover loss, as estimated using eDaRT MMI, was equitably distributed among predefined size classes may result in over- or under-estimates of actual small tree stem biomass, depending on location.

This layer for the available Biomass metric is derived from F3 layers (2021) using the following formula:

$$sum(ABGDLVBR, BMSTM_0, BMSTM_2, BMSTM_7)$$

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_AvailableBiomass_202111_202209_T2_v5.tif

SNV - COST OF POTENTIAL TREATMENTS

Tier: 2

Data Vintage: 2022

Metric Definition and Relevance: This metric represents cost of potential treatments for the Sierra Nevada region and is dependent on predefined treatments or silvicultural prescriptions, which are best generated at the local and/or project level. The cost to perform each treatment depends on a defined prescription and should consider an array of factors including the spatial juxtaposition of the resources and infrastructure, as well as the location of the saw timber and biomass processing plants.

Treatment cost calculations take into consideration the multiple costs necessary to move material from the forest harvest site to a processing location (sawmill or biomass facility) and includes the costs of felling, processing, skidding and hauling:

- costs to move material along different types of roads (i.e., dirt, paved, highways, etc.)
- across barriers (i.e., water courses)
- operational costs
- machine costs
- speed of moving material across the landscape.

Cost values have been broken down into the costs to move either biomass or sawlogs.

Data Resolution: 30m raster

Data Units: \$/ton for operation costs and \$/acre for prescribed fire and hand treatments

Creation Method: The methods are based on the “RMRS Raster Utility and Function Modeling” and the “Delivered Cost Modeling” approaches developed by John Hogland at the Rocky Mountain Research Station. Using a series of sliders that define various rates for multiple harvesting system and then running the delivered cost model. Within the modeling, the following analyses will be performed:

1. Subset and attribute OSM roads with speed based on criteria in [Table 1](#).
2. Create barrier to offroad motion for off road analysis using a subset of OSM streams, water bodies, interstates, and highways.
3. Estimate potential on road and offroad cost surfaces for each harvesting system using interactive sliders based on the criteria in [Table 2](#).
4. Create felling and processing surfaces and add potential costs.
5. Specify where harvesting systems occur and subset system costs to those locations.
6. Create final spatial representation of the potential cost to treat each raster cell on a dollar per CCF basis.
7. Save final raster surfaces.

The data has been extracted from open street maps and USFS 3dep and consist of base Raster and Vector datasets that have been used throughout the study area:

- Elevation (raster): elevation surface units meters (3dep)
- Roads (vector): Open Street Map roads based on Tiger Lines (OSM)
- Streams (vector): Open Street Map streams based on NHD (OSM)
- Water bodies (vector): OSM water bodies
- Sawmills (vector): location of the sawmill
- Biomass facilities (vector): location of biomass facilities (USFS)
- SNV RRK study area extent (vector): SNV RRK study area extent

Data Source: Rocky Mountain Research Station, U.S. Forest Service

File Name: SNV_SkidderSawCost_2022_202209_T2_v5.tif; SNV_SkidderBiomassCost_2022_202209_T2_v5.tif

REFERENCE TABLES

Table 1. Road segment travel speed by [OSM highway](#) class types.

Query	Speed (MPH)
Residential	25
Unclassified	15
Tertiary	35
Secondary	45
Primary	55
Trunk	55
Motorway	65

Table 2. Criteria used to spatially define harvesting systems and treatment costs. Machine rate of travel, and capacity estimates derived from meetings with Lisa Ball, Jacob Baker (STF), Michael Jow (STF), Brian McCrory, and John Hogland.

Component	System	Rate	Rate of Travel	Payload	Where it can occur
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	Rubber Tire Skidder	\$165/hr	1.5 MPH	1.25 CCF	Slopes <= 35% and Next to Roads (distance < 460m from a road)
Offroad	Skyline	\$400/hr	2.0 MPH	1.04 CCF	Slopes > 35% and within 305m of a road
	Helicopter	\$8,000/hr	2.4 MPH	1.67 CCF	Areas not covered by the other two and distance < 915m from landing area
Felling	Feller Buncher	\$15/CCF	NA	NA	Slopes <= 35%
	Hand Felling	\$27/CCF	NA	NA	Slopes > 35%
Processing	Delimiting, cutting to length, chipping and loading	\$56/CCF	NA	NA	NA
On road	Log Truck	\$98/hr	Table 1	12.5 CCF	NA
Additional Treatments	Hand Treatment	\$2470/ac	NA	NA	Forested Areas
	Prescribed Fire	\$2470/ac	NA	NA	Forested Areas

SOCAL - COST OF POTENTIAL TREATMENTS

Tier: 2

Data Vintage: 2023

Metric Definition and Relevance: The principle method for maintaining or restoring resilience to the southern California landscape involves vegetation treatments. There are many variations on treatments involving different kinds of equipment and different activities of managing vegetation. The metric has gathered available information on the costs of the major treatment methods and incorporated this information into a geospatial database.

There are no treatments of vegetation in southern California that generate revenue. All treatments included here are represented simply as costs per acre.

Field definitions:

Mastication = CALFIRE estimates for treatments per acre (Brush = \$1,669, Herbaceous = \$1,813, Woodland = \$1,198, Forest = \$1,788)

Masticat_1 = USFS estimates per acre (low end = \$800), depends on amount of vegetation

Masticat_2 = USFS estimates per acre (high end = \$1700), depends on amount of vegetation

Thinning_m = CALFIRE estimates for manual thinning per acre (Brush = \$2,534, Herbaceous = \$1,851, Woodland = \$2,683, Forest = \$1,461)

Thinning_1 = USFS estimates per acre (low end = \$450), depends on amount of vegetation

Thinning_2 = USFS estimates per acre (high end = \$950), depends on amount of vegetation

Thinning_3 = CALFIRE estimates mechanical thinning per acre (Brush = \$2,500, Herbaceous = N/A, Woodland = \$2,807, Forest = \$957)

Thinning_4 = USFS estimates mechanical thinning per acre (low end = \$945), depends on amount of vegetation

Thinning_5 = USFS estimates mechanical thinning per acre (high end = \$1,800), depends on amount of vegetation

Piling_man = CALFIRE estimates manual piling per acre (Brush = \$2,551, Herbaceous = N/A, Woodland = N/A, Forest = \$1,071)

Piling_m_1 = USFS estimates manual piling per acre (low end = \$400), depends on amount of vegetation

Piling_m_2 = USFS estimates manual piling per acre (high end = \$1,200), depends on amount of vegetation

Piling_mec = CALFIRE estimates mechanical piling per acre (Brush = \$1,521, Herbaceous = N/A, Woodland = \$251, Forest = \$640)

Piling_m_3 = USFS estimates mechanical piling per acre (low end = \$800), depends on amount of vegetation

Piling_m_4 = USFS estimates mechanical piling per acre (high end = \$1,200), depends on amount of vegetation

LopScatter = CALFIRE estimates lop and scatter per acre (Brush = \$1,263, Herbaceous = N/A, Woodland = \$1,217, Forest = \$1,616)

LopScatt_1 = USFS estimates lop and scatter per acre N/A

LopScatt_2 = USFS estimates lop and scatter per acre N/A

Herbicide_ = CALFIRE estimates herbicide (post-treatment) per acre (Brush = \$675, Herbaceous = \$396, Woodland = \$667, Forest = \$325)

Herbicide1 = USFS estimates herbicide (post-treatment) per acre (low end = \$250), depends on amount of vegetation

Herbicide_1 = USFS estimates herbicide (post-treatment) per acre (high end = \$450), depends on amount of vegetation

Pileburn_C = CALFIRE estimates pile burn per acre (Brush = \$2,303, Herbaceous = \$3,125, Woodland = N/A, Forest = \$810)

Pileburn_U = USFS estimates lop and scatter per acre N/A

Pileburn_1 = USFS estimates lop and scatter per acre N/A

Data Resolution: 30m Raster

Data Units: Dollars per acre

Creation Method: Multiple land managers in southern California (Forest Service, CALFIRE) were contacted to obtain current estimates of costs of different treatment methods. We received current estimates from both on treatment costs per acre for a variety of treatment methods. Those cost estimates varied by vegetation type and treatment method. These data were linked to the updated FVEG spatial data and rolled up into a single raster with attributes reflecting these two cost variables. These data are subject to further refinement and changes in costs. Data will continue to be gathered to improve these estimates.

Data Source:

CALFIRE

USDA Forest Service

File Name: SoCal_CostPotentialTrmnt_2023_202312_T2_v5.tif

CENCAL - COST OF POTENTIAL TREATMENTS

Tier: 2

Data Vintage: 2023

Metric Definition and Relevance: The principle method for maintaining or restoring resilience to the Central Coast landscape involves vegetation treatments. There are many variations on treatments involving different kinds of equipment and different activities of managing vegetation. The metric has gathered available information on the costs of the major treatment methods and incorporated this information into a geospatial database.

There are no treatments of vegetation in the Central Coast that generate revenue. All treatments included here are represented simply as costs per acre.

Field definitions:

Mastication = CALFIRE estimates for treatments per acre (Brush = \$1,669, Herbaceous = \$1,813, Woodland = \$1,198, Forest = \$1,788)

Masticat_1 = USFS estimates per acre (low end = \$800), depends on amount of vegetation

Masticat_2 = USFS estimates per acre (high end = \$1700), depends on amount of vegetation

Thinning_m = CALFIRE estimates for manual thinning per acre (Brush = \$2,534, Herbaceous = \$1,851, Woodland = \$2,683, Forest = \$1,461)

Thinning_1 = USFS estimates per acre (low end = \$450), depends on amount of vegetation

Thinning_2 = USFS estimates per acre (high end = \$950), depends on amount of vegetation

Thinning_3 = CALFIRE estimates mechanical thinning per acre (Brush = \$2,500, Herbaceous = N/A, Woodland = \$2,807, Forest = \$957)

Thinning_4 = USFS estimates mechanical thinning per acre (low end = \$945), depends on amount of vegetation

Thinning_5 = USFS estimates mechanical thinning per acre (high end = \$1,800), depends on amount of vegetation

Piling_man = CALFIRE estimates manual piling per acre (Brush = \$2,551, Herbaceous = N/A, Woodland = N/A, Forest = \$1,071)

Piling_m_1 = USFS estimates manual piling per acre (low end = \$400), depends on amount of vegetation

Piling_m_2 = USFS estimates manual piling per acre (high end = \$1,200), depends on amount of vegetation

Piling_mec = CALFIRE estimates mechanical piling per acre (Brush = \$1,521, Herbaceous = N/A, Woodland = \$251, Forest = \$640)

Piling_m_3 = USFS estimates mechanical piling per acre (low end = \$800), depends on amount of vegetation

Piling_m_4 = USFS estimates mechanical piling per acre (high end = \$1,200), depends on amount of vegetation

LopScatter = CALFIRE estimates lop and scatter per acre (Brush = \$1,263, Herbaceous = N/A, Woodland = \$1,217, Forest = \$1,616)

LopScatt_1 = USFS estimates lop and scatter per acre N/A

LopScatt_2 = USFS estimates lop and scatter per acre N/A

Herbicide_ = CALFIRE estimates herbicide (post-treatment) per acre (Brush = \$675, Herbaceous = \$396, Woodland = \$667, Forest = \$325)

Herbicide1 = USFS estimates herbicide (post-treatment) per acre (low end = \$250), depends on amount of vegetation

Herbicide_1 = USFS estimates herbicide (post-treatment) per acre (high end = \$450), depends on amount of vegetation

Pileburn_C = CALFIRE estimates pile burn per acre (Brush = \$2,303, Herbaceous = \$3,125, Woodland = N/A, Forest = \$810)

Pileburn_U = USFS estimates lop and scatter per acre N/A

Pileburn_1 = USFS estimates lop and scatter per acre N/A

Data Resolution: 30m Raster

Data Units: Dollars per acre

Creation Method: Multiple land managers (Forest Service, CALFIRE) were contacted to obtain current estimates of costs of different treatment methods. We received current estimates from both on treatment costs per acre for a variety of treatment methods. Those cost estimates varied by vegetation type and treatment method. These data were linked to the updated FVEG spatial data and rolled up into a single raster with attributes reflecting these two cost variables. These data are subject to further refinement and changes in costs. Data will continue to be gathered to improve these estimates.

Data Source:

CALFIRE

USDA Forest Service

File Name: CenCal_CostPotentialTrmnt_2023_202312_T2_v5.tif

NORCAL - COST OF POTENTIAL TREATMENTS

Tier: 2

Data Vintage: 09/2023

Metric Definition and Relevance: This metric represents cost of potential treatments for the Northern California region and is dependent on predefined treatments or silvicultural prescriptions, which are best generated at the local and/or project level. The cost to perform each treatment depends on a defined prescription and should consider an array of factors including the spatial juxtaposition of the resources and infrastructure, as well as the location of the saw timber and biomass processing plants.

Treatment cost calculations take into consideration the multiple costs necessary to move material from the forest harvest site to a processing location (sawmill or biomass facility) and includes the costs of felling, processing, skidding and hauling:

- costs to move material along different types of roads (i.e., dirt, paved, highways, etc.)

- across barriers (i.e., water courses)
- operational costs
- machine costs
- speed of moving material across the landscape.

Cost values have been broken down into the costs to move either biomass or sawlogs, and for a high-cost and low-cost scenario (reflecting variation in machine rates). Non-mechanical hand treatments, piling and burning operations, and prescribed fire treatments are not addressed in this data set. We hope to provide cost estimates on those types of treatments later.

Data Resolution: 30m Raster

Data Units: Dollars per CCF (100 cubic feet) for sawlog layers and Dollars per BDT (bone dry ton) for biomass layers

Creation Method: The methods are based on the “RMRS Raster Utility and Function Modeling” and the “Delivered Cost Modeling” approaches developed by John Hogland at the Rocky Mountain Research Station. Using a series of sliders that define various rates for multiple harvesting systems and then running the delivered cost model. Within the modeling, the following analyses will be performed:

1. Subset and attribute OSM roads with speed based on criteria in Table 1.
2. Create barrier to offroad motion for off road analysis using a subset of OSM streams, water bodies, interstates, and highways.
3. Estimate potential on road and offroad cost surfaces for each harvesting system using interactive sliders based on the criteria in Table 2.
4. Create felling and processing surfaces and add potential costs.
5. Specify where harvesting systems occur and subset system costs to those locations.
6. Create final spatial representation of the potential cost to treat each raster cell on a dollar per CCF basis.
7. Save raster surfaces.
8. Remove non-forest types (source [FVEG 2023](#))
9. Remove wilderness areas (source [PAD Wilderness](#))
10. Convert units on biomass rasters from \$/CCF to \$/BDT (bone dry ton)

The data has been extracted from open street maps and USFS 3dep and consist of base Raster and Vector datasets that have been used throughout the study area:

- Elevation (raster): elevation surface units meters (3dep)
- Roads (vector): Open Street Map roads based on Tiger Lines (OSM)
- Streams (vector): Open Street Map streams based on NHD (OSM)
- Water bodies (vector): OSM water bodies
- Sawmills (vector): location of the sawmill
- Biomass facilities (vector): location of biomass facilities (USFS)
- North Coast RRK study area extent (vector): North Coast RRK study area extent

Reference Tables

Table 1: Road segment travel speed by [OSM highway](#) class types

Query	Speed (MPH)
Residential	25
Unclassified	15
Tertiary	35
Secondary	45
Primary	55
Trunk	55
Motorway	65

Table 2: Criteria used to spatially define harvesting systems and treatment costs. Default machine rate of travel, and capacity estimates (“high cost scenario”) derived from meetings with Lisa Ball, Jacob Baker (STF), Michal Jow (STF), Brian McCrory, and John Hogland. Machine rates of travel for “low cost scenario” derived from Chang et al. 2023.

Chang, H., et al. (2023). "The Cost of Forest Thinning Operations in the Western United States: A Systematic Literature Review and New Thinning Cost Model." Journal of Forestry **121**(2): 193-206.

Component	System	Rate	Rate of Travel	Payload	Where it can occur
Offroad	Rubber Tire Skidder	\$165/hr	1.5 MPH	1.25 CCF	Slopes <= 35% and Next to Roads (distance < 460m from a road)
	Skyline	\$400/hr	2.0 MPH	1.04 CCF	Slopes > 35% and within 305m of a road
	Helicopter	\$8,000/hr	2.4 MPH	1.67 CCF	Areas not covered by the other two and distance < 915m from landing area
Felling	Feller Buncher	High Cost: \$15/CCF Low Cost: \$9	NA	NA	Slopes <= 35%
	Hand Felling	High Cost: \$27/CCF Low Cost: \$15	NA	NA	Slopes >= 35%
Processing	Delimiting, cutting to length, chipping, and loading	High Cost: \$56/CCF Low Cost: \$35	NA	NA	NA
On road	Log truck	\$98/hr	Table 1	12.5 CCF	NA

Data Source:

- Rocky Mountain Research Station, U.S. Forest Service
- U.S. Geological Survey (USGS), Protected Areas Database (PAD-US) 3.0
- [FVEG 2023](#)

Chang, H, Han-Sup Han, Nathaniel Anderson, Yeon-Su Kim, Sang-Kyun Han. 2023. The Cost of Forest Thinning Operations in the Western United States: A Systematic Literature Review and New Thinning Cost Model. *Journal of Forestry*, **121**(2): 193-206

File name: NorCal_BiomassTrmntCostLow_202309_202401_T2_v5.tif;
 NorCal_BiomassTrmntCostHigh_202309_202401_T2_v5.tif;
 NorCal_SawlogTrmntCostLow_202309_202401_T2_v5.tif;
 NorCal_SawlogTrmntCostHigh_202309_202401_T2_v5.tif

BIOMASS RESIDUES (40% THIN FROM BELOW TREATMENT)

Tier: 3

Data Vintage: 08/2018

Metric Definition and Relevance: This raster layer represents forest residues for the state of California in 2018. It was developed by the Schatz Energy Research Center as part of the C-BREC (California Biomass Residue Emissions Characterization) model. The raster is based on the LEMMA (Landscape Ecology, Modeling, Mapping, and Analysis) group's forest state data for 2012, which was grown forward to represent residues in 2018 by NRSIG (Natural Resource Spatial Informatics Group) at University of Washington using FVS (Forest Vegetation Simulator).

Data Resolution: 30m Raster

Data Units: Imperial short tons per acre

Creation Method: Pixel values are estimates of the total biomass residue generated by a 40% Thin From Below treatment, reported in imperial short tons per acre. The value for a given pixel is the sum of biomass estimates across all residue size classes (foliage, branches, logs 4-6" in diameter, logs 6-9" in diameter, and logs greater than 9" in diameter).

For more information on the C-BREC model, you can visit the following links:

- C-BREC tool webpage: <https://schatzcenter.org/cbrec/>
- C-BREC model background and use: <https://iopscience.iop.org/article/10.1088/1748-9326/acbd93#erlacbd93s3>

Data Source: Schatz Energy Research Center

File Name: BiomassResidues_201808_202401_T3_v5.tif

FIRE ADAPTED COMMUNITIES

Wildfires are a keystone disturbance process in western US forests. However, the capacity for humans to coexist in the wildland urban interface (WUI) requires different restoration strategies aimed at the protection of life and property. This pillar evaluates the degree to which communities are living safely with fire and are accepting of management and natural ecological dynamics. It also evaluates the capacity for communities to manage desired, beneficial fire and suppress unwanted fire.

DESIRED OUTCOME: Communities have adapted to live safely in forested landscapes and understand the significance of fire to maintaining healthy forests. They have sufficient capacity to manage desired fire and suppress unwanted fire.

HAZARD

STRUCTURE EXPOSURE SCORE

Tier: 1

Data Vintage: 12/2022

Metric Definition and Relevance: Structure Exposure Score is an integrated rating of wildfire hazard that includes the likelihood of a wildfire reaching a given location along with the potential intensity and ember load when that occurs. SES varies considerably across the landscape.

Pyrologix uses a standard geometric-interval classification to define the ten classes of SES, where each class break is 1.5 times larger than the previous break. So, homes located within Class X are 1.5 times more exposed than those in Class IX, and so on.

1. (SES I): 0
2. (SES II): 0.01 to 50
3. (SES III): 50 to 75
4. (SES IV): 75 to 113
5. (SES V): 113 to 169
6. (SES VI): 169 to 253
7. (SES VII): 253 to 380
8. (SES VIII): 380 to 570
9. (SES IX): 570 to 854
10. (SES X): 854+

Data Resolution: 30m raster

Data Units: Relative index, 10 classes

Creation Method: Structure Exposure Score (SES) is a proprietary index representing the level of wildfire exposure for a structure (e.g., a home) if one were to exist on a given pixel. It is an integrated measure that includes three components: the likelihood of a wildfire of any intensity occurring in a given year (annual burn probability), potential wildfire intensity for a given pixel, and ember load to that pixel from surrounding vegetation.

SES data was produced by Pyrologix LLC, a wildfire threat assessment research firm, as part of a spatial wildfire hazard assessment across all land ownerships for the state of California. The ongoing work generally follows the framework outlined in Scott and Thompson (2013), with custom methods and significant improvements developed

by Pyrologix. The project generally consists of three components: fuelscape calibration and updates, wildfire hazard assessment, and risk assessment. It utilizes a combination of wildfire models and custom tools, including the FSim large wildfire simulator (Finney et al., 2011), and WildEST, a custom modeling tool developed by Pyrologix (Scott, 2020). To date, this work has resulted in a wide variety of spatial data layers related to wildfire hazard and risk, including Structure Exposure Score (SES), representing conditions prior to the 2020, 2021 and 2022 fire seasons. Work to date has been funded by the USDA Forest Service Region 5, the California Energy Commission, and the USDI Bureau of Land Management with data contributions from CAL FIRE.

For this project, the FSim large-fire simulator is used to quantify annual wildfire likelihood across the analysis area. FSim is a comprehensive fire occurrence, growth, behavior, and suppression simulation system that uses locally relevant fuel, weather, topography, and historical fire occurrence information to make a spatially resolved estimate of the contemporary likelihood and intensity of wildfire across the landscape.

WildEST (Wildfire Exposure Simulation Tool) is used to quantify wildfire intensity and ember loads across the analysis area. WildEST is a deterministic wildfire modeling tool developed by Pyrologix that integrates spatially continuous weather input variables, weighted based on how they will likely be realized on the landscape. This makes the deterministic intensity values developed with WildEST more robust for use in effects analysis than the stochastic intensity values developed with FSim. This is especially true in low wildfire occurrence areas where predicted intensity values from FSim are reliant on a very small sample size of potential weather variables. It also allows for more appropriate weighting of high-spread conditions into fire behavior calculations. WildEST also produces indices of conditional and expected ember production from vegetated areas (pixels) and load to other pixels in the analysis area. Please reference the Pyrologix 2021 project report (Volger et al., 2021) for more information on WildEST analysis.

FSim was run for the CAL 2022 fuelscape at 120m resolution. WildEST was run for the CAL 2022 fuelscape at 30-m resolution. Both models utilized gridded hourly historical California weather data provided by CALFIRE. Results for annual burn probability (FSim), fire intensity (WildEST) and ember load (WildEST) were used to create Structure Exposure Score.

Data Source:

- Pyrologix, LLC

FILE NAME: StructureExposureScore_202212_202406_T1_v5.tif

DAMAGE POTENTIAL

Tier: 1

Data Vintage: 12/2022

Metric Definition and Relevance: The composite Damage Potential (DP) dataset represents a relative measure of wildfire's potential to damage a home or other structure if one were present at a given pixel, and if a wildfire were to occur (conditional exposure). It is a function of ember load to a given pixel, and fire intensity at that pixel, and considers the generalized consequences to a home from fires of a given intensity (flame length). This index does not incorporate a measure of annual wildfire likelihood.

Data Resolution: 30m raster

Data Units: Relative index, low to high

Creation Method: DP values were binned based on the following ranges into 6 classes and assigned class names.

0. (None): Values = 0
1. (Very Low): Values 0.01 to 20
2. (Low): Values 20 to 35
3. (Moderate): Values 35 to 50
4. (High): Values 50 to 80
5. (Very High): Values 80+

Damage Potential (DP) data was produced by Pyrologix LLC, a wildfire threat assessment research firm, as part of a spatial wildfire hazard assessment across all land ownerships for the state of California. The ongoing work generally follows the framework outlined in Scott and Thompson (2013), with custom methods and significant improvements developed by Pyrologix. The project generally consists of three components: fuelscape calibration and updates, wildfire hazard assessment, and risk assessment. It utilizes a combination of wildfire models and custom tools, including WildEST (Wildfire Exposure Simulation Tool), a custom modeling tool developed by Pyrologix (Scott, 2020). To date, this work has resulted in a wide variety of spatial data layers related to wildfire hazard and risk, including Damage Potential (DP), representing conditions prior to the 2020, 2021 and 2022 fire seasons. Work to date has been funded by the USDA Forest Service Region 5, the California Energy Commission, and the USDI Bureau of Land Management with data contributions from CAL FIRE. Please reference the Pyrologix 2021 project report (Volger et al., 2021) for more information about the project or WildEST analysis.

Damage Potential (DP) is a proprietary index developed by Pyrologix LLC representing wildfire's potential to damage a home or other structure if a wildfire were to occur (conditional exposure). It is a function of ember load to a given pixel and fire intensity at that pixel, and it considers the generalized consequences to a home from fires of a given intensity (flame length). DP is calculated based on two other datasets developed by Pyrologix: conditional risk to potential structures (cRPS) and conditional ember load index (cELI).

cRPS represents the potential consequences of fire to a home at a given location if a fire occurs there and if a home were located there. It is a measure that integrates wildfire intensity with generalized consequences to a home on every pixel. Wildfire intensity (flame length) is calculated using Pyrologix' WildEST tool. WildEST is a scripted geospatial process used to perform multiple deterministic simulations under a range of weather types (wind speed, wind direction, fuel moisture content). Rather than weighting results solely according to the temporal relative frequencies of the weather scenarios, the WildEST process integrates results by weighting them according to their weather type probabilities (WTP), which appropriately weights high-spread conditions into the calculations. For fire-effects calculations, WildEST generates flame-length probability rasters that incorporate non-heading spread directions, for which fire intensity is considerably lower than at the head of the fire.

The response function characterizing potential consequences to an exposed structure is applied to fire effects flame lengths from WildEST for all burnable fuel types on the landscape regardless of whether an actual structure is present or not. The response function does not consider building materials of structures and is meant as a measure of the effect of fire intensity on structure exposure. The response function is provided below:

- Flame length probability of 0-2 ft: -25
- Flame length probability of 2-4 ft: -40
- Flame length probability of 4-6 ft: -55

- Flame length probability of 6-8 ft: -70
- Flame length probability of 8-12 ft: -85
- Flame length probability of >12 ft: -100

These results were calculated using 30m fire-effects flame-length probabilities from the WildEST wildfire behavior results and then further smoothed.

cELI is also calculated in WildEST, and represents the relative ember load per pixel, given that a fire occurs, based on surface and canopy fuel characteristics, climate, and topography within the pixel. Units are the relative number of embers. cELI is based on heading-only fire behavior.

Damage Potential is then calculated as the arithmetic mean of cELI and cRPS for each pixel across the landscape.

$$DP = cRPS + cELI/2$$

Although flame length and its potential impact to structures is a function of the fire environment at the subject location only, ember load is a function of ember production and transport in the area surrounding the subject location. A location with light fuel (and therefore low flame length) could still have significant Damage Potential if surrounded by a fire environment that produces copious embers.

Data Source:

- Pyrologix, LLC

File Name: DamagePotential_202212_202406_T1_v5.tif

EMBER LOAD INDEX

Tier: 1

Data Vintage: 12/2022

Metric Definition and Relevance: This ember load dataset represents the ember load index (ELI) per pixel, for a given pixel, based on surface and canopy fuel characteristics, climate, and topography within the pixel. The Ember Load Index (ELI) incorporates burn probability (BP). BP is incorporated into calculations of the ember production before the distribution of embers across the landscape to determine ember load. Given that ELI incorporates burn probability, this index can be used to identify where on the landscape hardening buildings may be needed to resist ignition and the priority for doing so according to the likelihood of the area being visited by fire.

Data Resolution: 30m Raster

Data Units: Relative number of embers.

Creation Method: ELI is not simply the multiplication of ember load and burn probability (BP). Rather, BP is incorporated into calculations of the ember production prior to the distribution of embers across the landscape to determine ember load. ELI is based on heading-only fire behavior.

Data Source: Pyrologix, LLC

File Name: EmberLoadIndex_202212_202406_T1_v5.tif

SOURCE OF EMBER LOAD TO BUILDINGS

Tier: 1

Data Vintage: 12/2022

Metric Definition and Relevance: The ember transport model used in WildEST tracks the travel of embers from each source pixel to downwind receiving pixels. The relative number of embers landing on a given receiving pixel is summed across all potential source pixels. If the receiving pixel has a nonzero WRC Building Cover value (meaning the pixel is within 75 m of a qualifying building), then we separately sum the relative number of embers from the source pixel. The final SELB raster represents the expected annual relative ember production that lands on building cover across all weather types.

Data Resolution: 30m Raster

Data Units: Relative index

Creation Method: The WildEST modeling contains a module for producing indices of conditional and expected ember production and load. The Conditional Ember Production Index (cEPI) is an index of the relative number of embers lofted at a given landscape pixel given the fire environment there, given that a fire occurs. Ember Production Index (EPI) is the expected value of cEPI; it is the expected annual relative number of embers lofted from a given landscape pixel.

The Conditional Ember Load Index (cELI) is a relative index of the relative number of embers that land at a given landscape location, including nonburnable pixels. Finally, Ember Load Index combines the conditional ELI and the likelihood of that ember load occurring. All ember characteristics are based on headfire behavior. These

The ember load indices represent relative ember load at a pixel. Similar to ember production, ember load is also based on surface and canopy fuel characteristics, climate, and topography at the pixel. Ember load incorporates downwind ember travel.

The Ember Load Index (ELI) incorporates burn probability; however, ELI is not simply the multiplication of condition ember load (cELI) and burn probability (BP). Rather, BP is incorporated into calculations of the ember production before the distribution of embers across the landscape to determine ember load. Given that ELI incorporates burn probability, this index can be used to identify where on the landscape hardening buildings may be needed to resist ignition and the priority for doing so according to the likelihood of the area being visited by fire.

Data Source: Pyrologix, LLC

File Name: SourceEmberLoadToBldgs_202212_202406_T1_v5.tif

WILDFIRE HAZARD POTENTIAL

Tier: 1

Data Vintage: 12/2021. Includes disturbances through the end of 2021.

Metric Definition and Relevance: Wildfire Hazard Potential (WHP) is an index that quantifies the relative potential for wildfire that may be difficult to control. WHP can be used as a measure to help prioritize where fuel treatments may be needed.

Data Resolution: 30m Raster

Data Units: Relative index

Creation Method: Pyrologix calculated WHP following the methods established by Dillon et al. (2015) and Dillon (2018). The original methods utilize lower-resolution FSim inputs, while our approach uses higher-resolution inputs including 30-m CAL vegetation inputs (derived from LANDFIRE 2016), 30-m CAL fuel model outputs, 30-m CAL burn probability results, and 30-m CAL fire-effects flame-length probabilities from the WildEST wildfire behavior results.

Data Source: Pyrologix, LLC

File Name: WildfireHazardPotential_202112_202406_T1_v5.tif

IGNITION CAUSE

Tier: 1

Data Vintage: 1992 - 2020

Metric Definition and Relevance: The original point layer (WildfireOccurrence_CA_1992_2020.shp) contains a spatial database of wildfires that occurred in the United States from 1992 to 2020. It is the fifth update of a publication originally generated to support the national Fire Program Analysis (FPA) system. The wildfire records were acquired from the reporting systems of federal, state, and local fire organizations. The following core data elements were required for records to be included in this data publication: discovery date, final fire size, and a point location at least as precise as a Public Land Survey System (PLSS) section (1-square mile grid). The data were transformed to conform, when possible, to the data standards of the National Wildfire Coordinating Group (NWCG), including an updated wildfire-cause standard (approved August 2020). Basic error-checking was performed and redundant records were identified and removed, to the degree possible. The resulting product, referred to as the Fire Program Analysis fire-occurrence database (FPA FOD), includes 2.3 million geo-referenced wildfire records, representing a total of 180 million acres burned during the 29-year period. Identifiers necessary to link the point-based, final-fire-reporting information to published large-fire-perimeter and operational-situation-reporting datasets are included. Short, Karen C. 2022. Spatial wildfire occurrence data for the United States, 1992-2020 [FPA_FOD_20221014]. 6th Edition. Fort Collins, CO: Forest Service Research Data Archive.

<https://doi.org/10.2737/RDS-2013-0009.6>

Data Resolution: Vector(points) and 30m Raster

Data Units: Categorical

Creation Method: Rocky Mountain Research Station (U.S. Forest Service) scientist, Karen Short, is the principal creator of this data set. Points were converted to 30m raster cells using the “most frequent” function on the NWCG_CAUSE_CLASSIFICATION attribute (Broad classification of the reason the fire occurred) creating three rasters:

- Human caused ignition
- Lightning (natural) caused ignition
- All causes of ignition - Human or Natural and Missing data/not specified/undetermined

“MostFrqCau” indicates the most frequent cause of the fire in that location.. “FireCount” indicates the number of fires that occurred between 1992 and 2020, regardless of cause. It is noted that locations with hundreds of counts may be a result of the method of how ignitions are reported/recorded. Both the accuracy and precision of the location estimates are generally much lower than that implied by the stored coordinate information – which, for example, may have been calculated from a PLSS section centroid. Efforts were made to purge redundant records to the best of the authors’ ability. Despite this, some locations may have multiple records that may reflect

redundant records or multiple reports of fires due to the imprecision of the location record, the reporting process of an individual authority, or the possible reality of multiple initiations at a given location.

Data Source: Rocky Mountain Research Station, U.S. Forest Service

File Name: WildfireOccurrence_19922020_202312_T1_v5.shp;
WldfireIgnCauseHuman_19922020_202312_T1_v5.tif; WldfireIgnCauseLightning_19922020_202312_T1_v5.tif;
WldfireIgnAllCauses_19922020_202312_T1_v5.tif

FIRE IGNITION PROBABILITY

Tier: 3

Data Vintage: 1992 to 2015

Metric Definition and Relevance: These rasters depict the predicted human- and lightning-caused ignition probability for the state of California. Ignition is regulated by complex interactions among climate, fuel, topography, and humans. Considerable studies have advanced our knowledge on patterns and drivers of total areas burned and fire frequency, but much is less known about wildfire ignition. To better design effective fire prevention and management strategies, it is critical to understand contemporary ignition patterns and predict the probability of wildfire ignitions from different sources. UC Davis researchers modeled and analyzed human- and lightning-caused ignition probability across the whole state and sub-ecoregions of California, USA.

Findings reinforce the importance of varying humans vs biophysical controls in different fire regimes, highlighting the need for locally optimized land management to reduce ignition probability. Based on the most complete ignition database available, researchers developed maximum entropy models to predict the spatial distribution of long-term human- and lightning-caused ignition probability at 1 km and investigated how a set of biophysical and anthropogenic variables controlled their spatial variation in California and across its sub-ecoregions. Results showed that the integrated models with both biophysical and anthropogenic drivers predicted well the spatial patterns of both human- and lightning-caused ignitions in statewide and sub-ecoregions of California. Model diagnostics of the relative contribution and marginalized response curves showed that precipitation, slope, human settlement, and road network were the most important variables for shaping human-caused ignition probability, while snow water equivalent, lightning density, and fuel amount were the most important variables controlling the spatial patterns of lightning-caused ignition probability. The relative importance of biophysical and anthropogenic predictors differed across various sub-ecoregions of California.

Data Resolution: 1km Raster

Data Units: Probability, 0-1

Creation Method: Maximum entropy models were developed to estimate wildfire ignition probability and understand the complex impacts of anthropogenic and biophysical drivers, based on a historical ignition database.

UC Davis researchers developed maximum entropy models to estimate wildfire ignition probability and understand the complex impacts of anthropogenic and biophysical drivers, based on a historical ignition database. Researchers used the US Forest Service Fire Program Analysis-Fire Occurrence Database (FPA-FOD), compiled from reporting systems of US federal, state, and local fire agencies (Short 2017). This homogenized and comprehensive dataset includes wildfire ignition records on both public and private lands from 1992 to 2015, and accounted for many small fires that are not included in many other fire datasets.

Researchers used spatial layers of population density, transportation road network, and nighttime lights, to quantify human settlement and accessibility. Researchers assembled statewide geospatial layers to evaluate the biophysical controls from topography, climate, and fuels on spatial variation of wildland ignitions (table 1). The 2010 global 250 m terrain elevation data (GMTED2010) was used to characterize slope and aspect at 1 km spatial resolution. Weather information came from the gridded Daily Surface Weather and Climatological Summaries meteorological data at 1 km (Daymet) (Thornton et al 2020), including precipitation (Prcp), minimum and maximum temperature (Tmin and Tmax), incident shortwave radiation (Srad), water vapor pressure (VP), and snow water equivalent (SWE), or the amount of water that would be released from melting snowpack. We derived long-term annual means during 1992–2015 for these meteorological variables at 1 km.

Researchers modeled the spatial pattern of ignition probability using the maximum entropy statistical method (MaxEnt v3.3.3k) (Phillips et al 2004, 2006, 2021). MaxEnt is a machine-learning technique originally designed to model species distribution from presence-only data using multidimensional environmental inputs (Phillips et al 2004, 2006). It estimates a target probability distribution by iteratively searching for the probability distribution with maximum entropy (i.e. the one that is most uniform), subject to the environmental variables at each observation (i.e. presence-only point).

The models captured well the spatial patterns of human and lightning started wildfire ignitions in California. The human-caused ignitions dominated the areas closer to populated regions and along the traffic corridors. Model diagnosis showed that precipitation, slope, human settlement, and road network shaped the statewide spatial distribution of human-started ignitions. In contrast, the lightning-caused ignitions were distributed more remotely in Sierra Nevada and North Interior, with snow water equivalent, lightning strike density, and fuel amount as primary drivers. Separate region-specific model results further revealed the difference in the relative importance of the key drivers among different sub-ecoregions.

Data Source: Bin Chen and Yufang Jin, University of California Davis, bch@ucdavis.edu

Spatial patterns and drivers for wildfire ignitions in California - IOPscience

Short K C 2017 Spatial wildfire occurrence data for the United States, 1992-2015 [FPA_FOD_20170508]

File Name: PredLightningIgnCause_19922015_202406_T3_v5.tif;
PredHumanIgnCause_19922015_202406_T3_v5.tif

FIRE DYNAMICS

Fire dynamics reflect fire as an ecological process and the function that it performs. It can be broken into two key elements: functional fire and fire severity. Although fire dynamics pertain to the entire landscape, the ecological role of fire is most relevant to landscapes outside of the wildland urban interface (WUI).

DESIRED OUTCOME: Fire burns in an ecologically beneficial and socially acceptable way that perpetuates landscape heterogeneity and rarely threatens human safety or infrastructure.

FUNCTIONAL FIRE

Increasing the pace and scale of restoration on the landscape will require using a variety of tools to accomplish restoration targets. The use of prescribed fire and managed wildfires, where appropriate, can contribute to the restoration need. This is particularly true where fires burn at low and moderate severity, which we are referring to

as “functional fire”. Functional fire is when fire burns in an ecologically beneficial and socially acceptable way, perpetuating landscape heterogeneity and rarely threatening human safety or infrastructure.

FRID:

Discussion of the Fire Return Interval Departure (FRID) Methods

Definition and Relevance: The fire return interval departure (FRID) analysis quantifies the difference between current and pre-settlement fire frequencies, allowing managers to target areas at high risk of threshold-type responses owing to altered fire regimes and interactions with other factors.

Creation Method: The FRID methodology was developed and described by Van de Water and Safford (2011). The feature class is now produced and maintained by the U.S. Forest Service, Region 5, Information Management – Mapping and Remote Sensing (MARS) Team. Contemporary FRIs were calculated using the fire dates and footprints from California Interagency Fire Perimeters database (maintained by the California Department of Forestry and Fire Protection (CalFire-FRAP). The vegetation type stratification (i.e. to calculate the FRI for individual vegetation types) was based on the MARS Existing Vegetation (EVEG) map for California from the year 2011, with the vegetation typing (“CALVEG”) cross-walked (grouped) into 28 pre-settlement fire regime (PFR) types.

For assorted reasons, portions of San Benito and San Luis Obispo Counties never received a full EVEG Baseline Mapping assessment and thus data in the FRID Central California layer has some holes in these areas. In 2009, an EVEG mapping project was started for these areas but never finalized. San Luis Obispo County, the southern part of Santa Clara County, and all of San Benito County were baseline mapped using the Hardwood Dataset as a foundation for regional dominance (vegtype). Additional data sources from the National Land Cover Database, San Luis Obispo County Farm Data, Farmland Mapping & Monitoring Program, Bureau of Reclamation, and National Hydrology Database were then used to overwrite the Hardwood data where it was relevant. Structural attributes for forested conditions came primarily from the Hardwoods Dataset for canopy values while tree size was derived from a classification of Thematic Mapper 30-meter imagery.

Preparation of the Fire Return Interval Departure (FRID) data requires use of up to date statewide vegetation data. For this purpose we have been using EVEG, as described above. This has been adequate for most of California but there are some areas, because of missing data, that required some adjustments.

Although incomplete as an EVEG database, these “best available data” were used by the CLM team to fill holes in FRID for the Central California RRK project. The MARS team completed a crosswalk from Regional Dominance Type 1 (vegtype) to the FRID PFR attribute and calculations for the “gap” areas were run for fire return interval departure. We have used this “patch” to address FRID needs for the near-term. The data for these areas will show vulnerabilities to analysis at larger scales until a time that these areas can be visually edited to match the level of precision seen in the adjoining Los Padres NF.

Other gaps (NoData):

Although areas mapped as grasslands and meadows were included in the GIS layer, FRI and departure statistics were not calculated for these types because reliable information about pre-Euro American settlement fire regimes is lacking. These values (-999) have been converted to NoData in the CLM datasets.

Data Source: USDA Forest Service, Region 5, MARS Team

References: Information on pre-Euroamerican settlement FRIs (fire return intervals) was compiled from an exhaustive review of the fire history literature, expert opinion, and vegetation modeling (Van de Water and Safford

2011; Safford and Van de Water 2014). Contemporary FRIs were calculated using the California Interagency Fire Perimeters database (maintained by the California Department of Forestry and Fire Protection (CAL FIRE-FRAP). The vegetation type stratification was based on the US Forest Service existing vegetation map (USDA Forest Service, Mapping and Remote Sensing Team) for California from the year 2011, with the vegetation typing (“CALVEG”) grouped into 28 pre-settlement fire regime (PFR) types, as defined by Van de Water and Safford (2011). The 2011 eVeg map is used as the baseline for all subsequent FRID maps to freeze the underlying vegetation template and permit temporal comparisons without introducing vegetation type change as a confounding factor.

MEAN PERCENT FRI DEPARTURE, SINCE 1908

Tier: 1

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: This metric, mean percent FRID, is a measure of the extent to which contemporary fires (i.e., since 1908) are burning at frequencies similar to the frequencies that occurred prior to Euro-American settlement, with the mean reference FRI as the basis for comparison. Mean PFRID is a metric of fire return interval departure (FRID), and measures the departure of current FRI from reference mean FRI in percent.

Data Resolution: 30m raster

Data Units: Percent

Creation Method: The current FRI is calculated by dividing the number of years in the fire record (e.g., 2019-1908=112 years inclusive) by the number of fires occurring between 1908 and the current year in a given polygon plus one (CurrentFRI = Number of years/Number of fires +1). The mean reference FRI is an approximation of how often, on average, a given PFR likely burned in the three or four centuries prior to significant Euro-American settlement. This measure does not return to zero when a fire occurs, unlike FRID values used in some other analyses (e.g., NPS FRID Index). Instead, the following formulas are used to calculate Mean PFRID:

When current FRI is longer than reference FRI (the common condition in most coniferous PFRs) the formula is:

$$[1-(MeanRefFRI/CurrentFRI)]*100$$

When current FRI is shorter than reference FRI (common in some shrub dominated PFRs, and areas in the Wildland Urban Interface) the formula is:

$$-[[1-(CurrentFRI/MeanRefFRI)]]*100$$

For areas dominated by PFRs with a mean reference FRI greater than 112 years, and that have not burned in the period of historical record considered in this analysis (i.e., since 1908), the FRID is assumed to equal zero.

Data Source:

- Fire History (2022), CAL FIRE
- Existing Vegetation (CALVEG 2011), Region 5, MARS Team

File Name: FRID_MeanPrct_19082022_202401_T1_v5.tif

MEAN PERCENT FRI DEPARTURE, SINCE 1970

Tier: 1

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: Percent FRID (PFRID) quantifies the extent in percentage to which recent fires (i.e., since 1970) are burning at frequencies similar to those that occurred prior to Euro-American settlement, with the mean reference FRI as the basis for comparison. Mean PFRID measures the departure of current FRI from reference mean FRI in percent

Data Resolution: 30m Raster

Data Units: Percent

Creation Method: The current FRI is calculated by dividing the number of years in the fire record (e.g., 2019-1970=49 years inclusive) by the number of fires occurring between 1970 and the current year in a given polygon plus one ($\text{CurrentFRI} = \text{Number of years} / \text{Number of fires} + 1$). The mean reference FRI is an approximation of how often, on average, a given PFR likely burned in the three or four centuries prior to significant Euro-American settlement. This measure does not return to zero when a fire occurs, unlike FRID values used in some other analyses (e.g., NPS FRID Index).

Data Source:

- Fire History (2022), CAL FIRE
- Existing Vegetation (CALVEG 2011), Region 5, MARS Team

File Name: FRID_MeanPrct_19702022_202401_T1_v5.tif

MEAN FRID CONDITION CLASS FOR DEPARTURE

Tier: 1

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: This metric, uses the mean percent FRID to a measure of the extent to which contemporary fires (i.e., since 1908) are burning at frequencies similar to the frequencies that occurred prior to Euro-American settlement, with the mean reference FRI binned into another basis for comparison. Mean PFRID is a metric of fire return interval departure (FRID), and measures the departure of current FRI from reference mean FRI in percent.

Data Resolution: 30m raster

Data Units: Integer, -3 to 3

Creation Method: This is a condition class categorization of the data in the Mean PFRID field. MeanCC_FRI categorizes the percent differences calculated in Mean PFRID using the following scale:

- 1: 0 to 33.3% departure
- 2: 33 to 66.7% departure
- 3: >66.7% departure

Negative condition classes (i.e., where fires are burning more often than under pre-Anglo-American settlement conditions) are categorized on the negative of the same scale:

- -1: 0 to -33.3%
- -2: -33 to -66.7%
- -3: <-66.7%

CC1 and CC-1 are mapped in the same class because they are both within 33% of the mean pre-settlement value.

Data Source:

- Fire History (2022), CAL FIRE
- Existing Vegetation (CALVEG 2011), Region 5, MARS Team

File Name: FRID_ConditionClass_2022_202401_T1_v5.tif

TIME SINCE LAST FIRE

Tier: 1

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: Time Since Last Fire (TSLF), from the Fire Return Interval Departure (FRID) map, provides information (in years) to indicate the length of time since an area last burned.

Data Resolution: 30m raster

Data Units: Years

Creation Method: Time Since Last Fire (TSLF), from the Fire Return Interval Departure (FRID) map, provides information (in years) to indicate the length of time since an area last burned. Specifically, the number of years elapsed between the most recent fire recorded in the fire perimeters database and the version year of the FRID map being used. To illustrate, if the version year of the FRID map is 2019, and the area in question last burned in 1995, TSLF will be 24 (2019 minus 1995).

Data Source:

- Fire History (2022), CAL FIRE
- Existing Vegetation (CALVEG 2011), Region 5, MARS Team

File Name: FRID_TimeSinceLastFire_2022_202401_T1_v5.tif

CURRENT FIRE RETURN INTERVAL DEPARTURE, SINCE 1908

Tier: 1

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: The fire return interval departure (FRID) analysis quantifies the difference between current and pre-settlement fire frequencies, allowing managers to target areas at high risk of threshold-type responses owing to altered fire regimes and interactions with other factors. This is a measure of the extent to which contemporary fires (i.e. since 1908) are burning at frequencies similar to the frequencies that occurred prior to Euro-American settlement.

Data Resolution: 30m Raster

Data Units: Average Years

Creation Method: Current fire return interval 1908 is calculated by dividing the number of years in the fire record by the number of fires occurring between 1908 and the current year in a given polygon plus one.

$$\text{CurrentFRI} = \text{Number of years} / \text{Number of Fires} + 1$$

Data Source:

Fire History (2022), CAL FIRE
Existing Vegetation (CALVEG 2011), USDA Forest Service, Region 5, MARS Team

File Name: FRI_Current_19082022_202401_T1_v5.tif

CURRENT FIRE RETURN INTERVAL DEPARTURE, SINCE 1970

Tier: 1

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: The fire return interval departure (FRID) analysis quantifies the difference between current and pre-settlement fire frequencies, allowing managers to target areas at high risk of threshold-type responses owing to altered fire regimes and interactions with other factors. This is a measure of the extent to which contemporary fires (i.e. since 1970) are burning at frequencies similar to the frequencies that occurred prior to Euro-American settlement, with the mean reference FRI as the basis for comparison. With this metric, mPFRID_1970, the same formulas are used as with meanPFRID but with 1970 as the baseline rather than 1908. Important note: because 1970 is the baseline for this measure, no fires before 1970 are taken into account and all PFRs start at a PFRID of zero beginning in 1970.

Data Resolution: 30m Raster

Data Units: Average Years

Creation Method: Current fire return interval 1970 is calculated by dividing the number of years in the fire record by the number of fires occurring between 1970 and the current year in a given area plus one.

$$\text{CurrentFRI}_{1970} = \text{Number of years} / \text{Number of Fires} + 1$$

Data Source:

Fire History (2022), CAL FIRE

Existing Vegetation (CALVEG 2011), USDA Forest Service, Region 5, MARS Team

File Name: FRI_Current_19702022_202401_T1_v5.tif

SEVERITY

Uncharacteristic proportions of high severity fire over the area burned, particularly in the last decade, has been a common theme in the megafires that have occurred throughout California recently. The following metrics characterize, map, and quantify some of the factors that contribute.

ANNUAL BURN PROBABILITY

Tier: 1

Data Vintage: 12/2022. Includes disturbances through the end of 2022

Metric Definition and Relevance: Annual Burn Probability represents the likelihood of a wildfire of any intensity occurring at a given location (pixel) in a single fire season. In a complete assessment of wildfire hazard, wildfire occurrence and spread are simulated in order to characterize how temporal variability in weather and spatial variability in fuel, topography, and ignition density influence wildfire likelihood across a landscape. In such cases, the hazard assessment includes modeling of burn probability, which quantifies the likelihood that a wildfire will burn a given point (a single grid cell or pixel) during a specified period of time. Burn probability for fire

management planning applications in this case is reported on an annual basis - the probability of burning during a single fire season.

Data Resolution: 30m raster

Data Units: Probability, 0 to 1

Creation Method: Annual Burn Probability was produced by Pyrologix LLC, a wildfire threat assessment research firm, as part of a spatial wildfire hazard assessment across all land ownerships for the state of California. The ongoing work generally follows the framework outlined in Scott and Thompson (2013), with custom methods and significant improvements developed by Pyrologix. The project generally consists of three components: fuelscape calibration and updates, wildfire hazard assessment, and risk assessment. It utilizes a combination of wildfire models and custom tools, including the FSim large wildfire simulator (Finney et al., 2011). To date, this work has resulted in a wide variety of spatial data layers related to wildfire hazard and risk, including Annual Burn Probability, representing conditions prior to the 2020, 2021 and 2022 fire seasons. Work to date has been funded by the USDA Forest Service Region 5, the California Energy Commission, and the USDI Bureau of Land Management with data contributions from CAL FIRE.

For this project, the USFS modeling system called FSim is used to quantify annual wildfire likelihood across California. The model is parameterized using spatial datasets of historical weather, fire occurrence, fuels, weather, and topography in order to simulate thousands of fire-years on a landscape. Annual Burn Probability is calculated from these simulations using a Monte Carlo approach to make a spatially resolved estimate of the contemporary annual likelihood of wildfire across the landscape. For more information on FSim or the wildfire hazard modeling being performed by Pyrologix, please see Volger et al., 2021.

Data Source: Pyrologix, LLC

File Name: AnnualBurnProbability_202212_202406_T1_v5.tif

PROBABILITY OF FIRE SEVERITY (LOW, MODERATE, HIGH)

Tier: 1

Data Vintage: 12/2022. Includes disturbances through the end of 2022

Metric Definition and Relevance: These metrics represent the probability of low, moderate, or high severity fire, respectively, as constructed by Pyrologix LLC. Operational-control probability rasters indicate the probability that the headfire flame length in each pixel will exceed a defined threshold for certain types of operational controls, manual and mechanical.

Low severity fire represents fire with flame lengths of less than 4 feet and can be controlled using manual control treatments. Moderate severity fire represents fire with flame lengths between 4 and 8 feet and can be controlled using mechanical control treatments. High severity fire represents fire with flame lengths exceeding 8 feet and are generally considered beyond mechanical control thresholds.

Data Resolution: 30m raster

Data Units: Probability, 0 to 1

Creation Method: Probability of High Fire Severity (>8 ft) was produced by Pyrologix LLC, a wildfire threat assessment research firm, as part of a spatial wildfire hazard assessment across all land ownerships for the state of California. The ongoing work generally follows the framework outlined in Scott and Thompson (2013), with custom methods and significant improvements developed by Pyrologix. The project generally consists of three

components: fuelscape calibration and updates, wildfire hazard assessment, and risk assessment. To date, this work has resulted in a wide variety of spatial data layers related to wildfire hazard and risk, including operational control probabilities based on conditions prior to the 2020, 2021 and 2022 fire seasons. Work to date has been funded by the USDA Forest Service Region 5, the California Energy Commission, and the USDI Bureau of Land Management with data contributions from CAL FIRE. Please reference the Pyrologix 2021 project report (Volger et al., 2021) for more information.

Pyrologix uses the Wildfire Exposure Simulation Tool (WildEST), a deterministic wildfire modeling tool that integrates variable weather input variables and weights them based on how they will likely be realized on the landscape. WildEST is more robust than the stochastic intensity values developed with FSim. This is especially true in low wildfire occurrence areas where predicted intensity values from FSim are reliant on a very small sample size of potential weather variables.

The low severity fire raster (<4 ft) is created using the Pyrologix raster, *xmanualctrl_4* which is fire that can be controlled using manual control and is calculated as

$$1 - xmanualctrl_4$$

The moderate severity fire raster (4-8 ft) is created using the Pyrologix raster, *xmechctrl_8*, which is fire that can be controlled using mechanical control and *xmanualctrl_4* (manual control) and is calculated as

$$xmanualctrl_4 - xmechctrl_8$$

The high severity fire raster (*xmechctrl_8*) was developed using WildEST; the raster is directly from the Pyrologix library and represents fires which are expected to exceed mechanical control treatments (> 8 ft).

Data Source: Pyrologix, LLC

File Name: ProbFireSeverityLow_202208_202406_T1_v5.tif; ProbFireSeverityMod_202208_202406_T1_v5.tif; ProbFireSeverityHigh_202208_202406_T1_v5.tif

TOTAL DEAD/DOWN FUELS

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: Stephens et al. (2022) note that total dead/down values over 20 (short) tons/ac (40 Mg/ha) resulted in high severity in 56% of the pixels. Higuera and Abatzoglou (2020) note that fuel and fuel aridity, **where fuel is “non-limiting”**, are a primary control on area burned at interannual to millennial timescales. Thus, it is more important than ever to define fuel limitation and map where it is on the landscape as a fundamental metric for where, even under hotter climates, low to moderate severity fire is still a strong likelihood.

Data Resolution: 30m raster

Data Units: Short tons/acre

Creation Method: This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California. The [F3 model](#) generated several different raster surfaces of fuel loading estimates of the coarse woody debris by non-overlapping predefined size classes; including 1, 10, 100, 1000-hour fuels (FLOAD_1-5). The model also produced estimates for coarse woody debris of heavy fuels by non-overlapping predefined size classes which are greater than the 1000-hour fuel size (>=12”; FLOAD_6-9) and for litter and duff.

2019 to 2021 Update: No adjustments were made for 2021 due to uncertainties in conversions based on the limits with which change detection information can quantify the individual components of this metric. For areas with disturbance 2019-2021 (defined as eDaRT MMI \geq 10% canopy cover loss), total dead/down fuel values are not represented for 2021 (i.e., NULL). For areas undisturbed 2019-2021, it is a reasonable assumption that total dead/down fuels did not change significantly over the course of two years.

This layer for the Total Dead/Down Fuels metric is derived from F3 layers (2021) using the following formula:

$$\text{sum}(\text{FLOAD}_{1-9}, \text{LITTER}, \text{DUFF})$$

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_TotalFuelLoad_202111_202209_T2_v5.tif

STANDING DEAD AND LADDER FUELS

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: This is the material that may burn at the extreme end of the spectrum and contribute to mass fire behavior (Stephens et al., 2022), especially during crown spread type events. Live “ladder” fuels for trees less than 10” in diameter are also included in this calculation.

Data Resolution: 30m raster

Data Units: Short tons/acre

Creation Method: This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California. The [F3 model](#) generated raster surfaces to estimate the small size live trees (those $<10''$ DBH) branchwood and foliage plus unmerchantable portions of stemwood above 4-inch diameter (BMCWN_x) as ladder fuels. The model also generated the standing dead estimates for all size classes (including stems, branches, and foliage still present) from the FVS Fire and Fuels extension carbon report (Standing_D).

2019 to 2021 Update: Values for 2021 were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. The MMI value for canopy cover loss was used as a direct proxy to estimate biomass loss, following the formula:

$$2021 \text{ BMCWN}_x = 2019 \text{ BMCWN}_x - (2019 \text{ BMCWN}_x * \text{MMI}/100)$$

Although the assumption of direct correlation between canopy cover and biomass should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022). The assumption that canopy cover loss, as estimated using eDaRT MMI, was equitably distributed among predefined size classes may result in over- or under-estimates of actual small size trees, depending on location.

Adjustments for the standing dead trees raster (Standing_D) took the difference between 2019 and 2021 live volume (as estimated using eDaRT MMI) converted to short tons/acre using a conversion factor of 32.1 cubic feet/ton and the result was summed with 2019 standing dead. This adjusted value was then added to the non-overlapping, predefined size classes for the small size live trees ($<10''$ DBH) branchwood and foliage plus

unmerchantable portions of stemwood above 4-inch diameter (BMCWN_x), which had been adjusted for 2021 using MMI percent adjustments.

This layer for the Standing Dead and Ladder Fuels metric is derived from F3 layers (2021) using the following formula:

$$\text{sum}(\text{Standing_D}, \text{BMCWN_0}, \text{BMCWN_2}, \text{BMCWN_7})$$

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_StndDeadLadderFuels_202111_202209_T2_v5.tif

TOTAL FUEL EXPOSED TO FIRE

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: This is the sum of standing dead, ladders, and the dead and down, documented above. This metric quantifies the total amount of biomass available to contribute to the extreme fire intensity and spread rates that lead to high severity fire (Stephens et al., 2022).

This metric is also applicable to the [Air Quality](#) pillar, in that total fuel load is a value often required in smoke management plans to get Rx fire projects approved.

Data Resolution: 30m raster

Data Units: Short tons/acre

Creation Method: This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California. The [F3 model](#) generated several raster surfaces; to estimate the small size live trees (those <10" dbh) branchwood and foliage plus the unmerchantable portions of stemwood above 4-inch diameter (BMCWN_x), to estimate fuel loading of coarse woody debris in non-overlapping predefined size classes (FLOAD_x), to estimate both litter and duff, and to estimate the standing dead for all size classes (including stems, branches, and foliage still present) from the FVS Fire and Fuels extension carbon report (Standing_D).

2019 to 2021 Update: The 2021 values (described below) from the Standing Dead and Ladder Fuels and from the Total Dead/Down Fuels, were summed to derive this metric.

Values for 2021 Standing Dead and Ladder Fuels (Standing_D, BMCWN_x) were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. The MMI value for canopy cover loss was used as a direct proxy to estimate biomass loss, following the formula:

$$2021 \text{ BMCWN}_x = 2019 \text{ BMCWN}_x - (2019 \text{ BMCWN}_x * \text{MMI}/100)$$

Although the assumption of direct correlation between canopy cover and biomass should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022). The assumption that canopy cover loss, as estimated using eDaRT MMI, was equitably distributed among predefined size classes, may result in over- or under-estimates of actual ladder fuels, depending on location.

Adjustments for the standing dead trees raster (Standing_D) took the difference between 2019 and 2021 live volume (as estimated using eDaRT MMI) converted to short tons/acre using a conversion factor of 32.1 cubic feet/ton and the result was summed with 2019 standing dead. This adjusted value was then added to the non-overlapping, predefined size classes for the small size live trees (<10" DBH) branchwood and foliage plus unmerchantable portions of stemwood above 4-inch diameter (BMCWN_x), which had been adjusted for 2021 using MMI percent adjustments.

Values for 2021 Total Dead/Down Fuels (FLOAD_x, LITTER, DUFF) were not adjusted due to uncertainties in conversions based on the limits with which change detection information can quantify the individual components of the metric. For areas undisturbed 2019-2021, it is a reasonable assumption that total dead/down fuels did not change significantly over the course of two years. For areas with disturbance 2019-2021 (defined as eDaRT MMI >= 10% canopy cover loss), total dead/down fuel values are not represented for 2021 (i.e., NULL).

This layer for the Total Fuel Exposed to Fire metric is derived from F3 layers (2021) using the following formula:

$$[sum(Standing_D, BMCWN_0, BMCWN_2, BMCWN_7, FLOAD_1-9, LITTER, DUFF)]$$

In cases where any individual input to the formula is NULL, the resulting sum cannot be computed and is therefore also NULL.

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_TotalFuelExposedFire_202111_202209_T2_v5.tif

FOREST AND SHRUBLAND RESILIENCE

Forest and shrubland resilience is the ability of forest and shrubland vegetation and structure to remain a forest or shrubland in the face of disturbance (e.g., fire, forest management, climate change, etc.). The Forest and Shrubland Resilience Pillar evaluates forest and shrubland vegetation composition and structure to determine its alignment with desired disturbance dynamics and within tolerances of current and future biophysical conditions when considering changes due to climate change. The last 100 years of forest and shrubland management, combined with changing climates, have resulted in forest and shrubland structure and composition which are not resilient to contemporary disturbances. Forest or shrubland structure and composition are one of the few elements of a wildland that management can modify through treatments to improve conditions.

DESIRED OUTCOME: Vegetation composition and structure align with topography, desired disturbance dynamics, and landscape conditions, and are adapted to climate change.

STRUCTURE

Forest or shrubland structure is the spatial distribution of vegetation (live and dead) both vertically and horizontally on the landscape. Prior to European settlement, forests in the Central Coast Region were characterized by heterogeneous spatial patterns replete with individual large trees, gaps, and tree clumps of various sizes – patterns that were shaped by recurrent fire and other disturbances. After a century-plus of fire exclusion, timber harvesting, agricultural development, urbanization, and other land-use practices, the predominant trend across Californian landscapes is that they have become less resilient to natural and human-caused disturbances. In many cases some sort of restoration treatment may be necessary to reverse these trends.

CANOPY LAYER COUNT

Tier: 1

Data Vintage: 06/2020

Metric Definition and Relevance:

This layer represents the number of distinct vertical canopy layers of trees. Vertical layer count is a proxy for leaf area index, and maps canopy complexity. Since LANDFIRE doesn't support a NoData value, all NoData pixels in canopy fuel metrics were set to 0 in the Landscape files. (e.g., canopy cover was set to 0 in all NoData locations). Topographic data and surface fuel model remain unaltered.

Data Resolution: 10m Raster

Data Units: Count

Creation Method: Each forest structure metric was derived directly from airborne lidar data, hosted by the USGS 3D Elevation Program. However, these data are only available for a small fraction of California's 423,970 km² area. To overcome this, we trained deep learning models—a form of pattern recognition—to identify these forest structure patterns in satellite imagery, then mapped each metric statewide.

These algorithms are of the U-net family of neural network architectures that perform pixel-wise regression and classification tasks. The satellite data includes imagery from Sentinel-1 C-band radar sensors and Sentinel-2 multispectral sensors at 10 m spatial resolution, collected in Fall 2019. Future versions will include imagery from PlanetScope multispectral sensors at 3 m resolution.

Downloaded from [California Forest Observatory - Organizations - WIFIRE Commons Data Catalog \(sdsc.edu\)](https://forestobservatory.com/about.html#about). For more information, go to <https://forestobservatory.com/about.html#about>

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: CanopyLayerCount_202006_202312_T1_v5.tif

CANOPY VEG HEIGHT

Tier: 1

Data Vintage: 06/2020

Metric Definition and Relevance: This layer represents distance between the ground and the top of the canopy. Canopy height is a proxy for aboveground biomass and the amount of foliage that may be consumed in a canopy fire. Since LANDFIRE doesn't support a NoData value, all NoData pixels in canopy fuel metrics were set to 0 in the Landscape files. (e.g., canopy cover was set to 0 in all NoData locations). Topographic data and surface fuel model remain unaltered.

Data Resolution: 10m Raster

Data Units: meters, min 0 - max 80; each pixel value represents the average height above ground for vegetation within that pixel

Creation Method: Each forest structure metric was derived directly from airborne lidar data, hosted by the USGS 3D Elevation Program. However, these data are only available for a small fraction of California's 423,970 km² area. To overcome this, we trained deep learning models—a form of pattern recognition—to identify these forest structure patterns in satellite imagery, then mapped each metric statewide.

These algorithms are of the U-net family of neural network architectures that perform pixel-wise regression and classification tasks. The satellite data includes imagery from Sentinel-1 C-band radar sensors and Sentinel-2 multispectral sensors at 10 m spatial resolution, collected in Fall 2019. Future versions will include imagery from PlanetScope multispectral sensors at 3 m resolution.

Downloaded from [California Forest Observatory - Organizations - WIFIRE Commons Data Catalog \(sdsc.edu\)](https://forestobservatory.com/about.html#about). For more information, go to <https://forestobservatory.com/about.html#about>

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: CanopyVegHeight_202006_202312_T1_v5.tif

CANOPY VEG COVER

Tier: 1

Data Vintage: 06/2020

Metric Definition and Relevance: This layer represents horizontal cover fraction occupied by tree canopies. Maps community type & fire regime, as well as available habitat for tree-dwelling species.

Data Resolution: 10m Raster

Data Units: Canopy cover is a 0-100% cover fraction and may be more precisely described as "canopy density." It calculates the proportion of all lidar returns ≥ 5 m divided by the total number of returns in that grid cell. This, therefore, does not include all vegetation, but instead describes the density of vegetation in the canopy vertical stratum (veg 5m and taller).

Creation Method: Each forest structure metric was derived directly from airborne lidar data, hosted by the USGS 3D Elevation Program. However, these data are only available for a small fraction of California's 423,970 km² area. To overcome this, we trained deep learning models—a form of pattern recognition—to identify these forest structure patterns in satellite imagery, then mapped each metric statewide.

These algorithms are of the U-net family of neural network architectures that perform pixel-wise regression and classification tasks. The satellite data includes imagery from Sentinel-1 C-band radar sensors and Sentinel-2 multispectral sensors at 10 m spatial resolution, collected in Fall 2019. Future versions will include imagery from PlanetScope multispectral sensors at 3 m resolution.

Downloaded from [California Forest Observatory - Organizations - WIFIRE Commons Data Catalog \(sdsc.edu\)](https://forestobservatory.com/about.html#about). For more information, go to <https://forestobservatory.com/about.html#about>

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: CanopyCover_202006_202312_T1_v5.tif

LARGE TREE DENSITY

SNV - DENSITY LARGE TREES

Tier: 2

Data Vintage: 06/2020

Metric Definition and Relevance: Large trees are important to forest managers for multiple reasons: they have a greater likelihood of survival from fire; they are an important source of seed stock; they provide vitally important wildlife habitat; and they contribute to other critical processes like carbon storage and nutrient cycling. Large trees are often the focus of management in order to protect existing ones and to foster recruitment of future ones., “Large trees” have been designated in two categories, 24”-30” and greater than 30” dbh. The data provided are an estimate of density of trees (in each dbh class) within a pixel.

Data Resolution: 30m Raster

Data Units: Percent live trees per pixel

Creation Method: To determine the cutoff for large trees, we developed an allometric equation to predict tree diameter as a function of height. We selected data for plots located in the Sierra Nevada region from the USDA Forest Inventory and Analysis program (FIA) for California (FIA DataMart 2023; California 2022 database; ver. 9.0.1).

We included trees that met the following criteria: alive; crown class code of open-grown, dominant, or co-dominant; diameter at breast height (DBH, breast height = 4.5 ft) at least 1 inch; and height (HT) at least 5 feet. To minimize the impact of outliers, we trimmed the maximum tree height to the 0.995th percentile. These selection criteria yielded 82,444 trees. We used an information theoretic approach to select the best allometric model (Burnham and Anderson 2002). We evaluated three alternative functions: : linear, power, and saturating. The criteria for model selection were based on the Akaike Information Criterion (AIC). For this set of 3 potential models, we calculated the difference in AIC between every model and the model with the lowest AIC (ΔAIC).

The best allometric model was a saturating function where:

$$DIA = (187.2 * HT) / (588.5 + HT)$$

The root mean square error on the DBH prediction was 6.02 in and the pseudoR² = 0.71. Predicted diameters from heights are summarized here:.

Predicted DBH (in)	Height (ft)
<=1	<=3
>1-6	>3 - 19
>6-11	>19 - 37
>11-24	>37 - 87
>24-30	>87 - 112
30+	>112

Block statistics were run on California Forest Observatory (CFO) canopy height pixels for the following ranges with a 3x3 window to calculate the sum for input cells within a 30m rectangular neighborhood. This assigned number of pixels per 30m (900m²) cell. Resultant values of 1 through 9 were converted to percent.

- 24in - 30in
- greater than 30in

References

Burnham, K.P., and D.R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd ed. New York, Springer-Verlag.

FIA DataMart. 2023. USDA Forest Inventory and Analysis DataMart.
<https://experience.arcgis.com/experience/3641cea45d614ab88791aef54f3a1849/>

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: SNV_LrgTreeDens_24in30in_202006_202401_T2_v5.tif;
SNV_LrgTreeDens_gt30in_202006_202401_T2_v5.tif

SOCAL - DENSITY LARGE TREES

Tier: 2

Data Vintage: 06/2020

Metric Definition and Relevance: Large trees are important to forest managers as they have a greater likelihood of survival from fire, provide sources of seed stock, wildlife habitat, and contribute to other critical processes like carbon storage and nutrient cycling. Large trees are often the focus of management in order to protect existing ones and to foster future ones. In consultation with National Forests, “large trees” have been designated as greater than 30” dbh.

Data Resolution: 30m Raster

Data Units: Percent live trees per pixel

Creation Method: To determine the cutoff for the definition of large trees in the southern California area (> 30” dbh - need reference), a statistical relationship between tree dbh and tree height was developed. We used Forest Inventory & Analysis (FIA) 2022 plot data from the region, testing three fits of DBH ~ HGT: Saturating (Michelis Menton), Power, or Linear. Saturating was the best according to Akaike information criterion (AIC). We then extracted heights that predicted DBH cut-offs:

Predicted DBH (inches)	Height (feet)	RMSE (inches)
<=1	2.5	1.5
>1 - 6	14.5	2.4
>6 - 11	27	5.3
>11 - 24	64.5	6.8
>=30	83.5	7.3

Block statistics were run on California Forest Observatory (CFO) canopy height pixels greater than or equal to 83.5’ (25m) with 3x3 window to calculate the sum for input cells within a 30m rectangular neighborhood. This assigned number of pixels per 30m (900m²) cell. Resultant values of 1 through 9 were converted to percent. All background values were calculated to equal 0, meaning 0% large tree existence.

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: SoCal_LrgTreeDens_gt30in_202006_202312_T2_v5.tif

CENCAL - DENSITY LARGE TREES

Tier: 2

Data Vintage: 06/2020

Metric Definition and Relevance: Large trees are important to forest managers as they have a greater likelihood of survival from fire, provide sources of seed stock, wildlife habitat, and contribute to other critical processes like carbon storage and nutrient cycling. Large trees are often the focus of management in order to protect existing ones and to foster future ones. In consultation with National Forests, “large trees” have been designated as greater than 30” dbh.

Data Resolution: 30m Raster

Data Units: Percent live trees per pixel

Creation Method: To determine the cutoff for large trees, we developed an allometric equation to predict tree diameter as a function of height. We selected data for plots located in the Central California region from the USDA Forest Inventory and Analysis program (FIA) for California (FIA DataMart 2023; California 2022 database; ver. 9.0.1).

We included trees that met the following criteria: alive; crown class code of open-grown, dominant, or co-dominant; diameter at breast height (DBH, breast height = 4.5 ft) at least 1 inch; and height (HT) at least 5 feet. To minimize the impact of outliers, we trimmed the maximum tree height to the 0.995th percentile. These selection criteria yielded 7,089 trees. We used an information theoretic approach to select the best allometric model (Burnham and Anderson 2002). We evaluated three alternative functions: linear, power, and saturating. The criteria for model selection were based on the Akaike Information Criterion (AIC). For this set of 3 potential models, we calculated the difference in AIC between every model and the model with the lowest AIC (ΔAIC).

The best allometric model was a saturating function where:

$$DBH (in) = 0.752 * HT(ft)^{0.772}$$

The root mean square error on the DBH prediction was 6.67 in and the pseudoR² = 0.70. Predicted diameters from heights are summarized here:.

Predicted DBH (in)	Height (ft)
<=1	<=1
>1-6	>1 - 15
>6-11	>15 - 32
>11-24	>32 - 89
>24-30	>89 - 119
30+	>119

Block statistics were run on California Forest Observatory (CFO) canopy height pixels greater than or equal to 119' (36m) with 3x3 window to calculate the sum for input cells within a 30m rectangular neighborhood. This assigned number of pixels per 30m (900m²) cell. Resultant values of 1 through 9 were converted to percent. All background values were calculated to equal 0, meaning 0% large tree existence.

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: CenCal_LrgTreeDens_gt30in_202006_202312_T2_v5.tif

NORCAL DENSITY LARGE TREES

Tier: 2

Data Vintage: 06/2020

Metric Definition and Relevance: Large trees are important to forest managers for multiple reasons: they have a greater likelihood of survival from fire; they are an important source of seed stock; they provide vitally important wildlife habitat; and they contribute to other critical processes like carbon storage and nutrient cycling. Large trees are often the focus of management in order to protect existing ones and to foster recruitment of future ones. In consultation with National Forests, "large trees" have been designated in three categories, 24"-30", 30"-40", and >40" dbh. The data provided are an estimate of density of trees (in each dbh class) within a pixel.

Data Resolution: 30m Raster

Data Units: Percent live trees per pixel

Creation Method: To determine the cutoff for large trees, we developed an allometric equation to predict tree diameter as a function of height. We selected data for plots located in the Northern California region from the USDA Forest Inventory and Analysis program (FIA) for California (FIA DataMart 2023; California 2022 database; ver. 9.0.1).

We included trees that met the following criteria: alive; crown class code of open-grown, dominant, or co-dominant; diameter at breast height (DBH, breast height = 4.5 ft) at least 1 inch; and height (HT) at least 5 feet. To minimize the impact of outliers, we trimmed the maximum tree height to the 0.995th percentile. These selection criteria yielded 71,412 trees. We used an information theoretic approach to select the best allometric model (Burnham and Anderson 2002). We evaluated three alternative functions: linear, power, and saturating. The criteria for model selection were based on the Akaike Information Criterion (AIC). For this set of 3 potential models, we calculated the difference in AIC between every model and the model with the lowest AIC (Δ AIC).

The best allometric model was a power function (Δ AIC = 58.7) where:

$$\text{DBH (in)} = 0.2071 * \text{HT(ft)}^{1.0296}$$

The root mean square error on the DBH prediction was 5.8 in and the pseudoR² = 0.75. Predicted diameters from heights are summarized here:.

Predicted DBH (in)	Height (ft)
<=1	<=5
>1-6	>5 - 26
>6-11	>26 - 47
>11-24	>47 - 101
>24-30	>101 - 126
>30 - 40	>126 - 166
40+	166+

The Aggregate Tool (ArcGISPro) was run on California Forest Observatory (CFO) 10 meter [canopy height](#) pixels for the following ranges to create three rasters. Aggregate resamples a raster to a coarser resolution (10m to 30m in this case) based on the sum of cells per neighborhood.

- 24in - 30in
- 30in - 40in
- greater than 40in

If NoData values existed for any of the cells that fell within a larger cell on the output raster, the NoData values were ignored when determining the value for output cell locations. This method assigned the number of pixels per 30m (900m²) cell. Resultant values of 1 through 9 were converted to percent.

References:

Burnham, K.P., and D.R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd ed. New York, Springer-Verlag.

FIA DataMart. 2023. USDA Forest Inventory and Analysis DataMart.
<https://experience.arcgis.com/experience/3641cea45d614ab88791aef54f3a1849/>

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: NorCal_LrgTreeDens_24in30in_202006_202401_T2_v5.tif;
 NorCal_LrgTreeDens_30in40in_202006_202401_T2_v5.tif; NorCal_LrgTreeDens_gt40in_202006_202401_T2_v5.tif

NATURAL CONIFER REGENERATION PROBABILITY

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: This metric is intended to be used to identify areas where reforestation may be necessary if stakeholders want to reestablish coniferous forests following fire. Conifers in our region generally lack the capacity to resprout after fire and are thus dependent on seedling recruitment for regeneration. Under pre colonial fire regimes – of frequent, small, and typically lower severity fires – conifer seeds were generally able to travel the relatively short distances from live trees to burnt patches. In contrast, the recent emergence of large stand-replacing fires poses a significant challenge for conifer regeneration because long-distance seed dispersal events – needed to span the long distances between surviving trees and large burnt patches – are relatively rare.

As a result, many areas formerly occupied by conifers may be poised for vegetation type conversion if conifers are not deliberately replanted. This data layer currently exists only for the Sierra Nevada region.

Data Resolution: 30m raster

Data Units: Probability, 0 to 1

Creation Method: This metric is the modeled probability of natural conifer regeneration – within 4.4m radii (60 m²) circular plots, five years after fire – for fires occurring from 2012 to 2021. In areas that burned more than once, the probability of regeneration following the most recent fire is reported.

The predictive model was fit using data from 1,234 4.4m radius (60 m²) plots, spanning 19 wildfires, each measured five years after wildfire (Stewart et al. 2021). Predictor variables include seed availability, burn severity, postfire precipitation 1 – 5 water years following each fire, slope, and equinox solar insolation. Burn severity was derived from Landsat composite imagery using methods derived from Parks et al (2018). Topographically downscaled postfire precipitation data was used as available (i.e., up to the 2022 water-year) and assumed to be equivalent to historical mean conditions (1981 – 2010) for future or incomplete water-years (Daly et al. 1994). Species-specific seed availability was derived from available forest structure maps (2012-2017; Ohmann et al. 2011), allometric equations, a dispersal kernel, and a basal-area-loss-to-fire function (Stewart et al. 2021).

When available, average species-specific basal area up to 5 years following fire was used to estimate seed availability. When unavailable (i.e., for 2017-2021 fires), a composite of 2016 and 2017 structure maps were adjusted to account for the effects of subsequent fires. I.e., to avoid unreliable regions of the 2017 forest structure map – that were derived from summer composite imagery that spans a period both before, during, and after 2017 fires – the 2016 map (adjusted for 2017 fire effects) was used in these areas. Subsequent years were adjusted for the effects of wildfires that occurred from 2018 to 2021. For additional details see Stewart et al. (2021) or the Postfire Conifer Reforestation Planning Tool (accessed at: <https://reforestationtools.org/postfire-conifer-reforestation-planning-tool/>). Predictions were made using version 0.125 of the Postfire Conifer Reforestation Planning Tool.

- Postfire regeneration and seed production data, Stewart et al. 2022
- Monthly climate data, Daly et al 1994
- Forest structure maps, Ohmann et al. 2011
- National Elevation Dataset, USGS
- Landsat 4-8, NASA
- Fire History (2021), CAL FIRE
- Postfire mortality data, Miller et al. 2009

Data Source: Department of Plant Sciences, UC Davis

File Name: SNV_NatConRegenProb_20122021_202209_T2_v5.tif

BASAL AREA

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: Basal area (BA) is a common forest structure measurement that provides a useful index of forest and habitat condition. Basal area is the cross-sectional area of the bole of a tree at diameter

breast height (dbh). It is measured at the stand level as the cumulative sum of basal area of all trees and expressed as square feet per acre.

Data Resolution: 30m raster

Data Units: Sq ft/acre

Creation Method: This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California. The [F3 model](#) generated several raster surfaces as estimates of basal area. This raster surface represents all live trees greater than 1" dbh (BASATOT).

2019 to 2021 Update: Values for 2021 were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. The MMI value for canopy cover loss was used as a direct proxy to estimate basal area loss, using the formula:

$$2021 \text{ Basal Area} = 2019 \text{ Basal Area} - (2019 \text{ Basal Area} * \text{MMI}/100)$$

Although the assumption of direct correlation between canopy cover and basal area should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022).

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_BasalArea_202111_202209_T2_v5.tif

DENSITY – TREES PER ACRE

Tier: 2

Data Vintage: 2022

Metric Definition and Relevance: Trees per acre (TPA) is a common forest structure measurement that provides a useful index of forest and habitat condition. Many other metrics can be derived from having accurate estimates of trees per acre.

Data Resolution: 30m raster

Data Units: Live trees/acre

Creation Method: This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California. The [F3 model](#) generated several raster surfaces of trees per acre as estimates of tree density on the landscape. This raster surface represents all live trees greater than 1" dbh (TPA). Reference conditions can be generated from contemporary reference sites for mature forest conditions outside of the WUI.

2019 to 2021 Update: Values for 2021 were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. The MMI value for canopy cover loss was used as a direct proxy to estimate TPA loss, using the formula:

$$2021 \text{ TPA} = 2019 \text{ TPA} - (2019 \text{ TPA} * \text{MMI}/100)$$

Although the assumption of direct correlation between canopy cover and TPA should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022).

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_TreesPerAcre_gt1in_202111_202209_T2_v5.tif

DENSITY – SNAGS

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: The number of standing dead trees (snags) on the landscape is important to forest managers; high densities of standing dead trees are known to contribute to extreme fire events while snags of certain sizes provide critical habitat to wildlife. For this metric, the snag density for all species and all decay classes with diameters of 20” dbh and greater have been estimated.

Data Resolution: 30m raster **Data Units:** Standing dead trees/acre

Creation Method: This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California. The [F3 model](#) generated several raster surfaces of snags per acre for all species and all decay classes in non-overlapping, predefined size classes. For this metric, the three largest, predefined non-overlapping size categories have been included: 20-29.9”, 30-39.9”, and >=40”.

2019 to 2021 Update: Values for 2021 were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. Each of the predefined non-overlapping size category trees per acre rasters (TPA_x) were adjusted following the same procedure. The MMI value for canopy cover loss was used as a direct proxy to estimate TPA loss, using the formula:

$$2021\ TPA_x = 2019\ TPA_x - (2019\ TPA_x * MMI/100)$$

Although the assumption of direct correlation between canopy cover and TPA should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022). The assumption that canopy cover loss, as estimated using eDaRT MMI, was equitably distributed among the predefined size classes may result in over- or under-estimates of actual tree density loss per individual size class, depending on location.

This loss of live trees per acre (TPA) between 2019 and 2021 was then added to the 2019 estimate for snag density (of the same size category; SNG_x) from F3. The layers for Snag Density were each derived from F3 layers (2021) using the following formula:

$$(2019\ TPA_x - 2021\ TPA_x) + 2019\ SNG_x$$

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_DensitySnags25_202111_202209_T2_v5.tif; SNV_DensitySnags30_202111_202209_T2_v5.tif; SNV_DensitySnags40_202111_202209_T2_v5.tif

STAND DENSITY INDEX

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: Stand density index (SDI) helps vegetation managers to identify levels of site utilization and competition to determine management scenarios to meet objectives and is often used for forest health-oriented treatments. SDI was also proposed by North et al., (2022) as an operational resilience metric for western fire adapted forests. This metric is a quantitative measure that relates the current stand density to the size class distribution of the stand. Reineke uses quadratic mean diameter, a weighted mean, to estimate the stand size class, whereas the Zeide method (also known as the summation method) uses D_r (Reineke's diameter). For additional details on both calculations, see the Essential FVS Guide.

Data Resolution: 30m Raster

Data Units: Number of trees per acre expressed as an equivalent density in a stand with a quadratic mean diameter of 10 inches

Creation Method: FVS generated estimates of the stand density index metric using either the Reineke 1933 or the Zeide 1983 index calculations for all trees ≥ 1.0 " dbh based on max SDI derived from FIA plot data. Then the [F3 model](#) imputed the SDI calculations to the landscape. This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California.

2019 to 2021 Update: SDI values were adjusted for 2021 following the same procedure as outlined for density – trees per acre (described below).

Tree density values for 2021 were adjusted independently for each predefined non-overlapping diameter size class (10-inch bins) using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. The MMI value for canopy cover loss was used as a direct proxy to estimate TPA loss, using the formula:

$$2021\ TPA = 2019\ TPA - (2019\ TPA * MMI/100)$$

Although the assumption of direct correlation between canopy cover and TPA should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022). The assumption that canopy cover loss, as estimated using eDaRT MMI, was equitably distributed among the predefined size classes may result in over- or under-estimates of actual tree density per individual size class, depending on location.

QMD was then recalculated for 2021 using adjusted tree densities and by assigning trees in each size class to the respective mid-point diameter of that class.

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_SDI_Reineke_202111_202209_T2_v5.tif; SNV_SDI_Zeide_202111_202209_T2_v5.tif

PROPORTION OF MAXIMUM SDI

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: Stand density index (SDI) helps vegetation managers to identify levels of site utilization and competition to determine management scenarios to meet objectives and is often used for forest health-oriented treatments. The maximum forest stand density represents an approximate upper limit to the SDI of a site, and tree growth may be limited by competition as SDI approaches maximum SDI. This approximate upper limit on potential site SDI has been considered to be species- and site-specific by several authors using different variables to characterize the stand.

Data Resolution: 30m raster

Data Units: Proportion, 0 to 1

Creation Method: These raster data present the SDI proportion of the estimated max Stand Density Index (SDI) for both the Reineke (1933) and Zeide (1983) calculations. This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of F3 data for the rest of California.

2019 to 2021 Update: SDI values were adjusted for 2021 following the same procedure as outlined for density – trees per acre. Tree density values for 2021 were adjusted independently for each diameter size class (10-inch bins) using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. The MMI value for canopy cover loss was used as a direct proxy to estimate TPA loss, using the formula:

$$2021\ TPA = 2019\ TPA - (2019\ TPA * MMI/100)$$

Although the assumption of direct correlation between canopy cover and TPA should be viewed with caution, it serves as a reasonable approximation for representative mixed conifer forests in the Sierra Nevada affected by the recent drought (Slaton et al. 2022). The assumption that canopy cover loss, as estimated using eDaRT MMI, was equitably distributed among the predefined size classes may result in over- or under-estimates of actual tree density per individual size class, depending on location.

QMD was then recalculated for 2021 using adjusted tree densities and by assigning trees in each size class to the respective mid-point diameter of that class. These adjusted values for actual SDI were used to calculate percentages in combination with the max SDI values from 2019.

The maximum SDI was calculated as the 99th percentile of observed values for each of five broad climate classes. The classes were derived from the Basin Characterization Model (BCM; [Flint and Flint](#)) developed at a 270m spatial resolution. The variables (1981-2010) AET, climatic water deficit, Tmin, and Tmax were rescaled using a linear transformation to a range of 0-100 and clustered into five classes using a k-means algorithm.

Finally for each pixel, the proportion of maximum SDI is simply calculated as SDI divided by maximum SDI:

$$Proportion_MaxSDI = SDI/MaxSDI$$

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_MaxSDI_Reineke_202111_202209_T2_v5.tif; SNV_MaxSDI_Zeide_202111_202209_T2_v5.tif

FINE-SCALE HETEROGENEITY

Fine-scale heterogeneity has been represented in two dimensions – as a fractal dimension of canopy cover and as a proportion of canopy cover.

FINE-SCALE HETEROGENEITY INDEX

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: A key component of forest structure descriptions is the spatial heterogeneity (i.e., tree clumps and gaps), which influences vegetation growth, competition, and succession, disturbance processes, and wildlife habitat. Developing spatial heterogeneity through mechanical and prescribed fire treatments is often a goal of restoration projects and targets for the distribution of individual trees, clumps and gaps are often derived from historical estimates of stand structure.

This fractal dimension index is intended to be used in combination with the percent canopy cover as a measure of fine-scale heterogeneity. Fine-scale heterogeneity in forest structure may interrupt fuel continuity and reduce mortality of overstory trees. Fractal dimension is a measure of the complexity of shapes and ranges from 1, for simple shapes (fewer canopy interruptions), to 2, for complex shapes (more canopy interruptions). Fractal dimension is typically applied to single-part shapes, here we apply it to forest canopy within a 90m x 90m moving window.

The following diagram illustrates how fractal dimension index values correspond with spatial patterns of forest canopy coverage. Green areas denote canopy coverage and brown areas denote low-growing vegetation or bare areas. Areas where the shape of canopy coverage is more complex or patchy thereby have higher fractal area index.

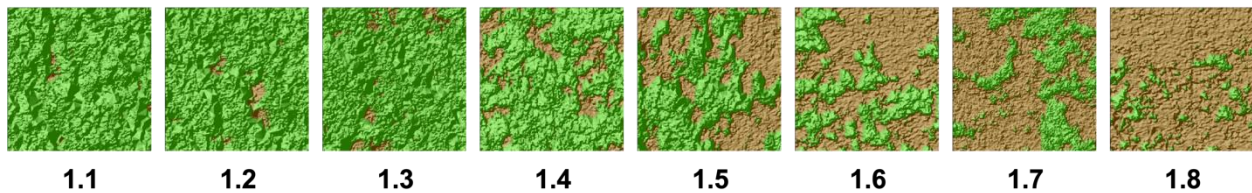


Image courtesy of Jonathan T. Kane, University of Washington.

Data Resolution: 30m raster

Data Units: Fractal dimension index, 1 to 2

Creation Method: The metric is derived from 3m resolution PhoDAR estimates of spring 2020 canopy height produced by Salo Sciences. Pixels with height greater than 2m were classified as canopy; pixels with height less than or equal to 2m were classified as canopy gaps. Fractal dimension index was calculated within a 90m (900-pixel) moving window using the following expression, applicable to shapes represented by rectilinear pixels (McGarigal and Marks 1995). This data layer currently exists only for the Sierra Nevada region. $2 * \ln(p/4) / \ln(a)$

Where a and p are, respectively, the area and perimeter of forest canopy (height > 2m) within the moving window.

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: SNV_FineScaleHeteroIndex_202006_202209_T2_v5.tif

PERCENT CANOPY COVER

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: This percent canopy cover is intended to be used in combination with the fractal dimension index as a measure of fine-scale heterogeneity.

Data Resolution: 30m raster

Data Units: Percent

Creation Method: The metric is derived from 3m resolution PhoDAR estimates of spring 2020 canopy height produced by Salo Sciences. Pixels with height greater than 2m were classified as canopy; pixels with height less than or equal to 2m were classified as canopy gaps. This data layer currently exists only for the Sierra Nevada region.

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: SNV_PrctCanopyCover_202006_202209_T2_v5.tif

COMPOSITION

The composition of a forest is a reference to the biodiversity of the landscape; this includes a diversity of vegetation species, types (e.g., trees, shrubs, forbs, etc.), and distribution. Tree species composition affects many aspects of forest dynamics and function. A diversity of tree and shrub species can confer greater resilience to climate change and beetle outbreaks. The vegetation composition also affects fire dynamics, water reliability, carbon pools and sequestration, and economic diversity pillars. Since European settlement and the adoption of fire suppression and logging, forests of the Central Coast Region shifted to increased dominance of shade-tolerant and fire-intolerant species like white fir and red fir, incense cedar, Douglas fir, and tanoak. Other species like ponderosa pine, Jeffrey pine, sugar pine, and black oak, which are more shade-intolerant and fire-tolerant, declined in coverage. With increasingly larger and higher-severity fires occurring, forest-cover loss may be significant and shrub cover will increase.

TREE COVER

Tier: 1

Data Vintage: 12/2021

Metric Definition and Relevance: Total tree cover as measured by the fractional non-overlapping absolute tree cover, viewed vertically. Provides a first order measure of vegetation type when combined with parallel observations of shrub and herbaceous cover. Data from the National Land Cover Database (NLCD) are used for training, and NLCD definitions for cover (for example, the distinction between tree vs shrub) are expected to be similar in the CECS data sets.

Data Resolution: 30m Raster

Data Units: Fractional non-overlapping absolute cover; continuous variable from 0 to 1.

Creation Method: Machine learning (Random Forest) using the National Land Cover Database for training and Landsat observations as predictors. See <https://doi.org/10.1029/2021AV000654> for further information.

Data Source: CECS; <https://california-ecosystem-climate.solutions/>

File Name: TreeCoverRatio_202112_202312_T1_v5.tif

SHRUB COVER

Tier: 1

Data Vintage: 12/2021

Metric Definition and Relevance: Total shrub cover as measured by the fractional non-overlapping absolute shrub cover, viewed vertically. Provides a first order measure of vegetation type when combined with parallel observations of tree and herbaceous cover. Data from the National Land Cover Database (NLCD) are used for training, and NLCD definitions for cover (for example, the distinction between tree vs shrub) are expected to be similar in the CECS data sets.

Data Resolution: 30m Raster

Data Units: Fractional non-overlapping absolute cover; continuous variable from 0 to 1.

Creation Method: Machine learning (Random Forest) using the National Land Cover Database for training and Landsat observations as predictors. See <https://doi.org/10.1029/2021AV000654> for further information.

Data Source: CECS; <https://california-ecosystem-climate.solutions/>

File Name: ShrubCoverRatio_202112_202312_T1_v5.tif

HERBACEOUS COVER

Tier: 1

Data Vintage: 12/2021

Metric Definition and Relevance: Total herbaceous cover as measured by the fractional non-overlapping absolute herbaceous cover, viewed vertically. Provides a first order measure of vegetation type when combined with parallel observations of tree and herbaceous cover. Data from the National Land Cover Database (NLCD) are used for training, and NLCD definitions for cover (for example, the distinction between tree vs shrub) are expected to be similar in the CECS data sets.

Data Resolution: 30m Raster

Data Units: Fractional non-overlapping absolute cover; continuous variable from 0 to 1.

Creation Method: Machine learning (Random Forest) using the National Land Cover Database for training and Landsat observations as predictors. See <https://doi.org/10.1029/2021AV000654> for further information.

Data Source: CECS; <https://california-ecosystem-climate.solutions/>

File Name: HerbCoverRatio_202112_202312_T1_v5.tif

SERAL STAGE

Tier: 1

Data Vintage: 04/2023

Metric Definition and Relevance: The seral stages are categories that represent the developmental progression of forest ecosystems from initial establishment or following a stand replacing event (e.g., high severity fire) to a forest dominated by trees in the upper age classes for a given forest type. Late seral forests are also often characterized by multiple ages of forest trees and dead and dying trees in some form of equilibrium. Seral conditions across

landscapes were highly variable prior to major European settlement in the western US. These patterns were highly attuned to dominant disturbance regimes and the multi-scaled variability in environmental conditions across topographic and climatic gradients. These patterns helped to reinforce fire regimes dominated by low- to moderate-severity fire across much of the region and provided for multiple habitat requirements for a wide variety of species.

This metric contains three related data layers. The first is an assignment to each 30 meter pixel of the seral stage it is currently in, either early, mid, or late seral stage (SeralStage_EML_202304.tif). The other two layers (EarlySeralStageDist_202304_202406_T1_v5.tif; LateSeralStageDistr_202304_202406_T1_v5.tif) represent the proportion of a HUC 12 watershed that is in 1) early seral stage or 2) late seral stage.

Data Resolution: 30m raster

Data Units:

- Seral Stage: Categorical 1 - 3
- Early or Late Stage: continuous variable 0-1 representing percentage of a HUC

Creation Method: The FVEG data, used in characterizing vegetation and habitat conditions for a number of metrics in the CLM, contain data on tree size (see FVEG discussion above). Seral stages for forested lands are binned into one of three categories of tree size (Early, Mid, Late) and those are defined by tree diameter, per the CWHR system.

Size Class	Size (inches DBH)	Seral Stage
1 Seedling	less than 1	Early (1)
2 Sapling	1 – 6	Early (1)
3 Pole	6 – 11	Mid (2)
4 Small	11 – 24	Mid (2)
5 Medium to Large	24+	Late (3)
6 Multi-storied	36 – 48	Late (3)

Late Seral conditions have been lumped into a single classification (24” and up).

The first layer provided here assigns a early, mid, or late seral value to each cell based on dominant tree size in the canopy. Null or NoData values in this raster represent areas of non-forest. The second and third data layer provided identify the proportion of the HUC12-scale (typically 10,000-30,000 acres in size) that is either early seral forest or late seral forest, respectively. These patterns can be highly variable at finer-scales so we used a HUC 12 watershed as the unit for expressing relative abundance. For each HUC12, the proportion of the watershed covered by the evaluated seral stage has been calculated.

Data Source:

- [FVEG 2023](#)
- CALFIRE, CDFW, LANDFIRE, California Forest Observatory (SALO), USDA Forest Service

File Name: SeralStageDist_202304_202406_T1_v5.tif; EarlySeralStageDist_202304_202406_T1_v5.tif; LateSeralStageDistr_202304_202406_T1_v5.tif

ABSOLUTE CHANGE IN HERBACEOUS COVER

Tier: 3

Data Vintage: 2020

Metric Definition and Relevance: A raster dataset representing absolute change of herbaceous fractional (%) land cover in the Southern California Region.

Data Resolution: 30m Raster

Data Units: Percent

Creation Method: Absolute change was calculated for annual and perennial grasses and forbs and litter, called “herbaceous” vegetation, using five-year-averages for 1986-1990 and 2016-2019 with data from the Rangeland Analysis Platform (RAP). $\text{Absolute Change} = (2016 - 2020 \text{ Average}) - (1986-1990 \text{ Average})$

In areas where herbaceous cover increased over this period, values will be positive (up to 60%); where herbaceous cover decreased, values will be negative (down to -60%). These data may be used as an indicator of vegetation type conversion resulting from high fire frequency or other disturbances.

These data only represent herbaceous cover; therefore, a second layer of information is required to determine what the cover changed to in areas that experienced a decrease in herbaceous cover over the time period examined.

The Rangeland Analysis Platform (RAP) was created in collaboration with the U.S. Department of Agriculture’s Natural Resources Conservation Service, the Department of Interior’s Bureau of Land Management, and the University of Montana to map western United States rangelands. The data can be used by landowners, managers, conservationists, and scientists to inform land management, planning, decision making, and evaluation of outcomes. For more information about RAP, please refer to the website: <https://rangelands.app/>

RAP fractional (percent) cover maps are produced by combining field plots from the Bureau of Land Management (BLM) Assessment, Inventory, and Monitoring (AIM) datasets and National Resources Conservation Service (NRCS) National Resources Inventory (NRI) with the historical Landsat satellite record. Due to a low amount of field points collected in the CWC focus area, the data products should be used alongside local knowledge and site-specific data to inform actions and decision making. To learn more about how RAP maps and data are intended to be used, refer to this site: <https://support.rangelands.app/article/46-new-to-rap-start-here-landing>

Data Source: San Diego State University CWC Project Team

File Name: SoCal_AbsChgInHerbCov_2020_202312_T3_v5.tif

DISTRIBUTION OF OBLIGATE RESPROUTING, OBLIGATE SEEDING, AND FACULTATIVE SEEDING SHRUB SPECIES (AND TREE AND HERB)

Tier: 2

Data Vintage: 2011

Metric Definition and Relevance: This dataset consists of 5 raster files of the proportion of above ground live biomass in these vegetation type categories: (1) Shrub obligate resprouting; (2) Shrub obligate seeding; (3) Shrub facultative seeding; (4) Tree; and (5) Herb. The spatial extent of these data cover 6,441,208 ha and is defined by

the 42 Level IV Ecoregions (Bailey 2016) that intersect the four southern US Department of Agriculture (USDA) National Forests in southern California (Angeles, Cleveland, Los Padres, and San Bernardino):



Mediterranean-climate region (MCR) shrublands have evolved a set of regeneration strategies in response to periodic, high-intensity wildfires: obligate seeding (OS), obligate resprouting (OR), and facultative seeding (FS) species. Spatial variation is seen in different regeneration strategies. In California, previous studies have found a higher abundance of OR species in mesic environments and OS species in xeric environments).

Analyzing the spatial rasters depicting OS-, OR- or FS- dominated pixels, researchers found dramatically different spatial patterns between the three shrub regeneration strategies. FS species covered the greatest spatial distribution, accounting for 3,372,125 ha (71%) of shrub dominated pixels in the study area: the FS group covered a range of productivity gradients and vegetation types, although it was notably absent from high elevation areas. In contrast, OS-dominated pixels covered the smallest spatial area (21,899 ha, 5% of shrub dominated pixels) occurring throughout the study area from coastal Big Sur and the Santa Ynez Mountains on the Los Padres National Forest to interior locations including the eastern fringes of the San Jacinto mountains (desert shrub vegetation) in the south. Finally, pixels dominated by OR species covered a similarly small area, 25,075 ha (5% of shrub dominated pixels in the study area), showing aggregations in the San Bernardino and San Geronio Mountains on the San Bernardino National Forest; San Gabriel Mountains on the Angeles National Forest, and throughout higher elevations on the Los Padres National Forest. OR-dominated pixels were notably absent in lower elevation areas with low water availability, as indicated in the relationship with climatic water deficit and solar radiation. The proportion of each post-fire shrub regeneration type is critical for a number of reasons, including assessing the ability of shrublands to recover from multiple, short-interval fires or helping to prioritize areas for post-fire restoration.

Data Resolution: 30 meters

Data Units: Percentage of life history/post-fire regeneration type per pixel (0 – 100)

Creation Method: Researchers developed a multinomial model using temporally dynamic and static variables to predict the distribution of the three shrub post-fire regeneration strategies - obligate seeders (OS), facultative seeders (FS), obligate resprouters (OR), plus trees and herbs, in southern California. Researchers used 222 USDA Forest Service Forest Inventory and Analysis (FIA) plots and 17 predictor variables including: median 2001-2020 NDVI and biomass, vegetation type, precipitation, slope, aspect, and soil characteristics. Each predictor variable was available as a raster dataset to which the model was applied to produce the 5 raster files which estimate the proportion (percentage) of biomass within each of the five groups. Overall, model cross-validation showed the accuracy achieved 50% of predicted value within 8 to 24 percent of the actual value, with prediction accuracy highest for herb biomass and lowest for OR. Of the three shrub regeneration strategies, OS biomass was predicted with the highest accuracy and narrowest environmental range.

The files are named as follows:

ObResprouters = percentage of obligate resprouter biomass per pixel.

ObSeeders= percentage of obligate seeder biomass per pixel.

FacSeeders= percentage of facultative seeder biomass per pixel.

TreeBiomass = percentage of tree biomass per pixel.

HerbBiomass = percentage of herb biomass per pixel.

Data Source: Underwood, E.C., Q.M. Sorenson, C.C. Schrader-Patton, N.A. Molinari and H.D. Safford. 2023. Resprouting, seeding, and facultative seeding shrub species in California's Mediterranean-type climate region. *Frontiers in Ecology and Evolution* 11:1158265. doi: 10.3389/fevo.2023.1158265

Underwood, E.C.; Q.M. Sorenson, C.C. Schrader-Patton (2023). Obligate resprouting, obligate seeding, and facultative seeding shrub species in California's Mediterranean-type climate region [Dataset]. Dryad. <https://doi.org/10.25338/B8FS9V>

File Name: SoCal_ObResprouters_2011_202312_T2_v5.tif; SoCal_ObSeeders_2011_202312_T2_v5.tif; SoCal_FacSeeders_2011_202312_T2_v5.tif; SoCal_TreeBiomass_2011_202312_T2_v5.tif; SoCal_HerbBiomass_2011_202312_T2_v5.tif

SHRUBLANDS WITH LOW NATURAL REGENERATION POTENTIAL POST-FIRE IN SOUTHERN CALIFORNIA

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Identifying locations where shrubland vegetation will not recover naturally post-fire is a challenge given the vast areas that are regularly burned in southern California. When shrublands are within the historic fire return interval, e.g., 55 years for low-elevation shrubland, biomass accumulates and shrub cover recovers after 10–14 years. However, in many parts of southern California, the fire return interval has decreased, often in conjunction with an increase in non-native plant species, drought, and nitrogen deposition. Under these conditions, post-fire biomass recovery can be impeded and, in some cases, may result in type conversion from native shrubland to non-native grassland. Researchers developed a repeatable method to identify areas of low regeneration potential in southern California using fire history data and applying two thresholds guided by the published literature. Low regeneration pixels either had a 'number of fires in the last 40 years' of three or more

fires, or the 'time since last fire' was <10 years. Researchers identified pixels that met these criteria as having low natural regeneration potential post-fire and, as a consequence, these areas could represent candidate areas for post-fire restoration in shrublands.

The spatial extent of these data cover 6,441,208 ha and is defined by the 42 Level IV Ecoregions (Bailey 2016) that intersect the four southern US Department of Agriculture (USDA) National Forests in southern California (Angeles, Cleveland, Los Padres, and San Bernardino):



Data Resolution: 30 meters

Data Units: Binary. 1 = shrub pixel has low regeneration potential post-fire, 0 = shrub pixel has potential to regenerate post-fire (based on decision rules).

Creation Method: Researchers obtained the historical wildfire perimeter database from the California Department of Forestry and Fire Protection (FRAP 2021). They then generated from this database a set of binary rasters indicating the occurrence of fire in a pixel for a given year across the southern California study area. The years for this input data stack range from 1967 to 2020. Researchers implemented a script to calculate the low natural regeneration potential rasters.. Two binary rasters were created for each year, one with the number of fires that burned in the last 40 years and one with the number of fires in the last 10 years. These inputs were then used to create a raster depicting low shrub regeneration potential for any given year, defined as 3 or more fires in 40 years or 1 or more fires in the last 10 years (see Dryad publication for more details).

Description of the data and file structure: The full dataset contains 9 rasters for the years 2008, 2009, 2010, 2015, 2016, 2017, 2018, 2019, and 2020. Using the fire perimeters specific for each year (FRAP 2021) the researchers identified shrub pixels with low regeneration potential using two criteria: either the 'number of fires in the last 40 years' was three or more fires or the 'time since last fire' was <10 years. These two criteria are based on published literature[ECU1] [SC(FU2)].

Shrubland pixels identified with these fire history characteristics are unlikely to regenerate naturally post-fire. This information provides a key input into the SoCal EcoServe tool designed for US Department of Agriculture Forest Service resource managers and also the Post-fire Restoration Prioritization tool which integrates these data with

other spatial data which might influence shrubland recovery post-fire, such as drought and non-native annual grasses.

Data Source: Underwood, E.C. and A. D. Hollander. 2023. Areas of low natural regeneration potential post-fire in shrublands of southern California (selected years between 2008 and 2020) [Dataset]. Dryad.

<https://doi.org/10.25338/B8CH2T>

See Underwood and Hollander 2023 for rasters for the other 8 years

File Name: SoCal_prepregen2020_202312_T2_v5.tif

DISTURBANCE

California forests evolved with a suite of frequent disturbances: wildfires (both from lightning and burning by indigenous people), bark beetle-caused mortality, drought-caused mortality, avalanches, landslides, and windthrow, all of which created forest heterogeneity across the landscape. This heterogeneity included variations in surface and ladder fuels, which moderated fire behavior and spread. The variations in stand density and forest opening also served as critical habitats for wildlife. Forested areas are now more homogeneous due to lack of disturbance. The lack of disturbance is evident in the forest structure.

CUMULATIVE TREE COVER LOSS

Tier: 1

Data Vintage: 12/2020

Metric Definition and Relevance: The cumulative loss of tree cover over a 30-year period (1992-2020). Tree cover loss reflects fires, harvest/management and dieoff. Only disturbances that are sufficient to trigger the Continuous Change Detection and Classification algorithm are included; low-level, diffuse dieoff is likely missed.

Data Resolution: 30m Raster

Data Units: Cumulative fractional non-overlapping absolute tree cover loss, where tree cover is a continuous variable from 0 to 1. Cumulative loss can exceed 1 in cases with multiple disturbances.

Creation Method: Vegetation disturbances were identified over the Landsat TM/ETM+/OLI era using the Continuous Change Detection and Classification algorithm (CCDC). The corresponding annual change in tree cover was determined with machine learning (Random Forest) using the National Land Cover Database for training and Landsat/CCDC observations as predictors; this produced a ~35-year stack of rasters that identified the locations and severity of tree cover loss. This stack was then summed for 1992-2020 to calculate the cumulative tree cover loss over a 30-year period. See <https://doi.org/10.1029/2021AV000654> for further information.

CECS data that reflect landscape changes resulting from disturbances require 6 to 12 months of Landsat observations **after a given year that included major disturbances (such as a high severity wildfire)** to fully quantify that disturbance. CECS data that reflect disturbance, such as this data layer, are therefore available **through water year 2020 (i.e. through September 2020)**.

Data Source: CECS; <https://california-ecosystem-climate.solutions/>

File Name: CumulTreeCoverLoss_19912020_202312_T1_v5.tif

CUMULATIVE SHRUB COVER LOSS

Tier: 1

Data Vintage: 12/2020

Metric Definition and Relevance: The cumulative loss of shrub cover over a 30-year period (1992-2020). Shrub cover loss reflects fires, harvest/management and dieoff. Only disturbances that are sufficient to trigger the Continuous Change Detection and Classification algorithm are included; low-level, diffuse dieoff is likely missed.

Data Resolution: 30m Raster

Data Units: Cumulative fractional non-overlapping absolute shrub cover loss, where shrub cover is a continuous variable from 0 to 1. Cumulative loss can exceed 1 in cases with multiple disturbances.

Creation Method: Vegetation disturbances were identified over the Landsat TM/ETM+/OLI era using the Continuous Change Detection and Classification algorithm (CCDC). The corresponding annual change in shrub cover was determined with machine learning (Random Forest) using the National Land Cover Database for training and Landsat/CCDC observations as predictors; this produced a ~35-year stack of rasters that identified the locations and severity of shrub cover loss. This stack was then summed for 1992-2021 to calculate the cumulative tree cover loss over a 30-year period. See <https://doi.org/10.1029/2021AV000654> for further information.

CECS data that reflect landscape changes resulting from disturbances require 6 to 12 months of Landsat observations **after a given year that included major disturbances (such as a high severity wildfire)** to fully quantify that disturbance. CECS data that reflect disturbance, such as this data layer, are therefore available **through water year 2020 (i.e. through September 2020)**.

Data Source: CECS; <https://california-ecosystem-climate.solutions/>

File Name: CumulShrubCoverLoss_19912020_202312_T1_v5.tif

RISK OF TREE DIEOFF DURING DROUGHT

Tier: 1

Data Vintage: 12/2021

Metric Definition and Relevance: A quantitative continuous variable that reflects the risk of tree dieoff during a significant drought period (SPI48 drought = -2).

Data Resolution: 30m Raster

Data Units: This is a dimensionless index that ranges from 0 to ~20000. Low values indicate minimal or no risk of tree dieoff during drought, either or both because there are few trees in the pixel and/or there is ample local moisture even during periods of extreme precipitation shortfall. High values indicate significant risk of tree dieoff during drought, as a result of both a high density of trees at the site and likelihood of extreme local moisture shortfall.

Creation Method: Calculated by combining information on the local moisture balance and tree density. Local moisture balance was calculated as the ratio of Annual Evapotranspiration with the canopy observed in 2021 to Precipitation during a SPI 48 drought = -2 based on local P observations during 1991-2020. This ratio quantifies the local moisture deficit/surplus that would be expected during a 48-month period with precipitation that is 2

standard deviations below the local 30 year Normal. Tree cover was determined from Landsat. See <https://doi.org/10.1038/s41561-019-0388-5> for further information.

Data Source: CECS; <https://california-ecosystem-climate.solutions/>

File Name: RiskTreeDieoff_202112_202312_T1_v5.tif

POTENTIAL CLIMATE REFUGIA -BASELINE (HISTORICAL) CONDITIONS

Tier: 3

Data Vintage: 1981 - 2010

Metric Definition and Relevance: This raster dataset represents habitat types (natural vegetation communities) and their distribution across the array of climate conditions that each separate habitat type is found in under the baseline climate conditions. A 2015 map of the state’s natural vegetation compiled from multiple sources was classified to the National Vegetation Classification Standard’s mid-level classification, called “Macrogroup”. Thirty one natural vegetation macrogroups are identified in the map, covering 99.87% of the state’s natural terrestrial vegetation, and occupying 353,271 km².

This serves as the foundation from which habitat types will be exposed to predicted changes in climate. Data are arrayed across 0 to 1 in terms of their exposure to current climate conditions. This data layer provides a baseline of vegetation adapted to “historic” conditions; i.e. climate conditions from the recent past; 1980-2010.

Data Resolution: 270m Raster

Data Units: 0- 1. Low values indicate higher resilience to threats. High values indicate significant exposure to climate change. -1 represents ‘non analog’ areas, i.e. locations that are outside the historic climate envelope of a given vegetation type.

Creation Method: The vegetation climate exposure analysis takes advantage of the 2015 vegetation map compiled for California by CALFIRE. Each Macrogroup (MG) was analyzed to determine which California habitats and associated dominant plant species make up its definition. California habitats are defined by the California Department of Fish and Wildlife (CDFW) through their California Wildlife Habitat Relationship (WHR) models⁹. WHR types are made up of plant species, such as the dominant trees, shrubs, and smaller plants. CDFW experts determined which WHR types correspond to each individual macrogroup; this cross-walk was used to develop a list of the dominant plant species that comprise each macrogroup.

The climate space occupied by each distinct vegetation macrogroup (largely equivalent to a CWHR habitat type) from the current time period was identified. This was done by using the points for each type and applying a kernel density estimator on a 2-d surface composed of the first two principal components of the climate conditions. The result is a smoothed continuous point density surface, showing the prevalence of each vegetation type across the range of sampled climatic conditions. This surface was partitioned by fitting contour lines so that they enclose a proportion of the original points from the current time period. Contours were calculated at 5% increments. For example the innermost 5% contour line encloses the 5% of pixels for the given vegetation type which are at the core of the climate space for that type, as determined by its density in the climate space. Cells further away from the dense central core, are considered to be more marginal in the vegetation type’s distribution. The outer contours are fit to enclose the 95-99% of climatically marginal points, with the last 1% of cells (beyond the 99% contour) being the most marginal. In addition, if a cell lies outside the space defined by the 99% contour of any vegetation type, it is considered to be “non-analog,” which means that it experiences climatic conditions outside of the conditions where we have a good sample in the initial time period. Excluded from this assessment are non-

vegetated types such as snow, open water, and ice; and non-natural landcover types mapped as vineyards, tilled earth, orchards and Urban.

For more information on methods for the development of these climate refugia data see:

Thorne et al. 2015

Thorne et al. 2016

Thorne et al. 2017

Thorne et al. 2020

Data Source: Information Center for the Environment, UC Davis

File Name: PotRefugiaBaseline_19812010_202401_T3_v5.tif

POTENTIAL CLIMATE REFUGIA - UNDER MODELED CLIMATE CHANGE (MIROC MODEL - HOTTER AND DRIER)

Tier: 3

Data Vintage: 2016

Metric Definition and Relevance: This raster dataset represents habitat types (CWHR habitat classes) and their predicted exposure to climate stress across the array of predicted climate conditions (separate layers for early (2010 - 2039), mid (2040-2069), and late century (2070-2099)) for all habitat types in comparison to the baseline climate conditions. This serves as the foundation from which habitat types will be exposed to predicted changes in climate. Data are arrayed across 0 to 1 in terms of their exposure to current climate conditions. These three data layers can be used to help land managers allocate limited resources for climate-adaptive field work by providing a view of climate risk that varies across the lands they manage.

The Climate Change Model used in this analysis is the Miroc Earth System Model. This ESM, named “MIROC-ESM”, is based on a global climate model MIROC (Model for Interdisciplinary Research on Climate) which has been cooperatively developed by researchers in Japan and others. This model suggests a hotter and drier future. The emission scenario used is the RCP 8.5, which represents a range of warming statewide from 1.99 to 4.56°C and between a 24.8% decrease in precipitation and a 22.9% increase, respectively.

Data Resolution: 270m Raster

Data Units: 0- 1. Low values indicate higher resilience to threats. High values indicate significant exposure to climate change. -1 represents ‘non analog’ areas, i.e. locations that are outside the historic climate envelope of a given vegetation type.

Creation Method: The vegetation climate exposure analysis takes advantage of the 2015 vegetation map compiled for California, which is described above. The vegetation climate exposure model is implemented in the R programming language, and takes the vegetation and climate raster files as the primary input data. The values of the climate raster files were randomly sampled at 100,000 points on the landscape, which were used to fit a statistical model characterizing the relationship between the variables both in the current time and for the modeled future data.

At each of these 100,000 points, 9 hydro-climatic variables were sampled to characterize the range and variation of conditions in the study region. These variables were: annual mean minimum temperature (Tmin), annual mean maximum temperature (Tmax), annual precipitation (PPT), actual evapotranspiration (AET), potential

evapotranspiration (PET), climatic water deficit (CWD), snowpack depth on April 1st, runoff, and recharge. The variation between these variables was modeled using a principal component analysis²¹ (PCA) to identify the dominant components of variation. The top-two principal components axes, representing about 79% of the variability across the four climate projections, were extracted as a two-dimensional space, and are portrayed as the axes for the PCA plots shown in each macrogroup chapter below. This was done to simplify the representation of the climate space, while maintaining the most important information on the variables to be associated with the observed vegetation distributions.

The climate space occupied by each distinct macrogroup from the current time period was identified. This was done by using the points for each type and applying a kernel density estimator on a 2-d surface composed of the first two principal components of the climate conditions. The result is a smoothed continuous point density surface, showing the prevalence of each vegetation type across the range of sampled climatic conditions. This surface was partitioned by fitting contour lines so that they enclose a proportion of the original points from the current time period. Contours were calculated at 5% increments. For example the innermost 5% contour line encloses the 5% of pixels for the given vegetation type which are at the core of the climate space for that type, as determined by its density in the climate space. Cells further away from the dense central core, are considered to be more marginal in the vegetation type's distribution. The outer contours are fit to enclose the 95-99% of climatically marginal points, with the last 1% of cells (beyond the 99% contour) being the most marginal. In addition, if a cell lies outside the space defined by the 99% contour of any vegetation type, it is considered to be "non-analog," which means that it experiences climatic conditions outside of the conditions where we have a good sample in the initial time period. As a result, the status of that point is uncertain. There are occasionally a few extreme points which appear to be far outside the general distribution for the type. These may be due to misclassified vegetation types in the source data, microclimatic conditions not captured by the climate data, historic anomalies in long-lived species, etc.

Climate exposure is the level of climate change expected in the areas where each macrogroup is dominating. This report uses the term "vegetation climate exposure analysis" to describe the following analysis which was conducted on each macrogroup. The vegetation climate exposure analysis is calculated using the mapped extent of each macrogroup. Every grid cell of each macrogroup was ranked as to its level of exposure, relative to the entire area of that macrogroup. This was done for the current time, and used to define the common climate found for each macrogroup. Once each type's "climate envelope" was defined, we then assessed how much every grid cell changed under various future climate projections. This allowed a measure of the vegetation stress, or climate exposure. The area extent of each macrogroup that will be lost from the most commonly occurring climate conditions ($\leq 80\%$) and the area that will fall into current marginal, or stressed, climate conditions ($>95\%$) or outside the current climate conditions was calculated. This approach is particularly useful for resource managers, who often are constrained to work in specified areas, and need estimates of what areas within their jurisdiction are likely to be highly stressed, and what areas are likely to be less stressed, in effect climate refuge areas.

To consider how refugial conditions from a range of stressors can inform conservation planning and management, the authors integrated metrics of refugial capacity across different domains, which are defined as social, ecological, or physical drivers, processes, or cycles that influence landscape structure, function, or composition. To persist in the California landscape, species and ecosystems may need refugia from shifting climatic conditions, including extremely hot summers and prolonged droughts, but non-climate stressors can also affect conservation outcomes. In this landscape, changes in fire frequency can be a significant stressor affecting plant community structure and persistence. Anthropogenic features that modify hydrologic flows alter the ability of watersheds to sustain functional habitats. And finally, protected areas are often designed to mitigate the impacts of anthropogenic activities; however, recreational activities may alter the refugial capacity of the protected land,

affecting the ability of the landscape to sustain species and their habitats. We combined these individual metrics to assess landscape level refugial capacity.

Sites with high refugial capacity (super-refugia sites) have, on average, 30% fewer extremely warm summers, 20% fewer fire events, 10% less exposure to altered river channels and riparian areas, and 50% fewer recreational trails than the surrounding landscape. Our results suggest that super-refugia sites (~8,200 km²) for some natural communities are underrepresented in the existing protected area network, a finding that can inform efforts to expand protected areas.

For more information on methods for the development of these climate refugia data see:

Thorne et al. 2015

Thorne et al. 2016

Thorne et al. 2017

Thorne et al. 2020

Data Source: Information Center for the Environment, UC Davis

File Name: PotRefugiaHotDryHighEm_20102039_202401_T3_v5.tif;
PotRefugiaHotDryHighEm_20402069_202401_T3_v5.tif; PotRefugiaHotDryHighEm_20702099_202401_T3_v5.tif

POTENTIAL CLIMATE REFUGIA - COMBINED MODELED CLIMATE CHANGE (MIROC MODEL - (HOTTER AND DRIER) AND CNRM-CM5 (WETTER AND WARMER))

Tier: 3

Data Vintage: 2016

Metric Definition and Relevance: This raster dataset represents habitat types (Macro Veg Type, largely equivalent to CWHR habitat classes) and their predicted exposure to climate stress across the array of predicted climate conditions (separate layers for early (2010 - 2039), mid (2040-2069), and late century (2070-2099)) for all habitat types in comparison to the baseline climate conditions. This serves as the foundation from which habitat types will be exposed to predicted changes in climate. Data are arrayed across 0 to 1 in terms of their exposure to current climate conditions. These three data layers can be used to help land managers allocate limited resources for climate-adaptive field work by providing a view of climate risk that varies across the lands they manage.

This analysis uses both the Miroc Earth System Model and the CNRM-CM5. CNRM-CM5 is an Earth system model designed to run climate simulations. It consists of several existing models designed independently and coupled through the OASIS software. Both were used under the RCP 8.5 emission scenario given that this is more likely under current emission levels.

This data layer is provided as a summary of likely exposure results. **Exposure Scores:**

- 1 = Refugia: CNRM-CM5 only (CNRM exposure values < 80%)
- 2 = Refugia: MIROC-ESM only (MIROC exposure values < 80%)
- 3 = Refugia Consensus (both models agree exposure values < 80%)
- **8 = High Exposure (both models agree exposure values >95%)**
- **9 = Very High Exposure (both models agree exposure values >99%)**

Data Resolution: 270m Raster

Data Units: 0, 1, 2, 3, 8, 9 Low values indicate higher resilience to threats. High values indicate significant exposure to climate change. -1 represents 'non analog' areas, i.e. locations that are outside the historic climate envelope of a given vegetation type.

Creation Method: Each dominant species is scored for its sensitivity to, and ability to adapt (adaptive capacity) to climate change. Sensitivity refers to the degree to which changes in climate are thought to directly impact different species. Adaptive capacity refers to estimates of the degree to which different species can use their life history characteristics to moderate impacts from changing climate. These two sets of scores represent the biological attributes of the dominant species in each macrogroup. We scored each of the dominant species comprising each macrogroup, according to life history characteristics defined in attribute tables of the California Manual of Vegetation, and supplemented by information found in the USDA plants database and the Jepson Interchange, a web portal for California plant taxonomy. The scores were combined to generate a single sensitivity and adaptive capacity (S&A) score.

Climate exposure is the level of climate change expected in the areas where each macrogroup is dominating. This report uses the term "vegetation climate exposure analysis" to describe the following analysis which was conducted on each macrogroup. The vegetation climate exposure analysis is calculated using the mapped extent of each macrogroup. Every grid cell of each macrogroup was ranked as to its level of exposure, relative to the entire area of that macrogroup. This was done for the current time, and used to define the common climate found for each macrogroup. Once each type's "climate envelope" was defined, we then assessed how much every grid cell changed under various future climate projections. This allowed a measure of the vegetation stress, or climate exposure. The area extent of each macrogroup that will be lost from the most commonly occurring climate conditions ($\leq 80\%$) and the area that will fall into current marginal, or stressed, climate conditions ($> 95\%$) or outside the current climate conditions was calculated. This approach is particularly useful for resource managers, who often are constrained to work in specified areas, and need estimates of what areas within their jurisdiction are likely to be highly stressed, and what areas are likely to be less stressed, in effect climate refuge areas.

To consider how refugial conditions from a range of stressors can inform conservation planning and management, the authors integrated metrics of refugial capacity across different domains, which are defined as social, ecological, or physical drivers, processes, or cycles that influence landscape structure, function, or composition. To persist in the California landscape, species and ecosystems may need refugia from shifting climatic conditions, including extremely hot summers and prolonged droughts, but non-climate stressors can also affect conservation outcomes. In this landscape, changes in fire frequency can be a significant stressor affecting plant community structure and persistence. Anthropogenic features that modify hydrologic flows alter the ability of watersheds to sustain functional habitats. And finally, protected areas are often designed to mitigate the impacts of anthropogenic activities; however, recreational activities may alter the refugial capacity of the protected land, affecting the ability of the landscape to sustain species and their habitats. We combined these individual metrics to assess landscape level refugial capacity.

Sites with high refugial capacity (super-refugia sites) have, on average, 30% fewer extremely warm summers, 20% fewer fire events, 10% less exposure to altered river channels and riparian areas, and 50% fewer recreational trails than the surrounding landscape. Our results suggest that super-refugia sites ($\sim 8,200 \text{ km}^2$) for some natural communities are underrepresented in the existing protected area network, a finding that can inform efforts to expand protected areas.

For more information on methods for the development of these climate refugia data see:

Thorne et al. 2015

Thorne et al. 2016

Thorne et al. 2017

Thorne et al. 2020

Data Source: Information Center for the Environment, UC Davis

File Name: PotClimateRefugiaCombined_2016_202401_T3_v5.tif

GOLDSPOTTED OAK BORER

Tier: 2

Data Vintage: 2010 to 2021

Metric Definition and Relevance: Tree mortality and other forest damage is detected by annual aerial surveys over forested lands by state and federal agency staff. The primary purpose of the aerial survey is to create sketch maps of areas containing current year conifer and hardwood mortality, defoliation, and other damage. Number of trees and acres with damage are calculated for areas surveyed and reported annually using the methodology described below. Aerial surveys have been recognized for over fifty years as an efficient and economical method of detecting and monitoring forest change events over large forested areas. As with all remotely sensed data, some amount of ground-truthing is required before the data can be considered reliable. The goldspotted oak borer was identified based on field surveys starting in 2006, and coded as goldspotted oak borer during aerial detection surveys beginning in 2010.

Field definitions:

DCA_CODE = damage casual agent code

DCA = Damage casual agent

Damage_typ = damage type

Mort_TPA = mortality trees per acre, the modifier used to determine number of trees when multiplied by acres

NUM_TREES = estimated number of trees

RPT_YR = report year

HOST_ALL_C = compilation of host and HostGroup names and codes

HOST_ALL = compilation of host and HostGroup names

For more information, go to <https://www.fs.usda.gov/foresthealth/applied-sciences/mapping-reporting/digital-mobile-sketch-mapping.shtml>

Data Resolution: 30 m Raster

Data Units: specific to each attribute

Creation Method: Recent tree mortality and currently active non-mortality damage is sketch mapped on a mobile device by an aerial observer flying in a small fixed wing aircraft at ≈1000' above ground level (AGL) searching for visibly dried and discolored foliage, typically yellow to reddish brown. Generally, two observers are onboard the aircraft surveying on opposite sides with about a two-mile swath width for each surveyor.

Drawn polygons are then attributed with the following: a) damage type, mortality or one of several non-lethal damage types (topkill, defoliation, branch flagging, die back or discoloration) (field name: DAMAGE_TYP) b)

percentage category of forest area affected, c) affected tree species and d) probable damage-causing agent (e.g., goldspotted oak borer). For more information go to https://www.fs.usda.gov/detail/r5/forest-grasslandhealth/?cid=fsbdev3_046707

https://www.fs.usda.gov/detail/r5/forest-grasslandhealth/?cid=fsbdev3_046696

Data Source: R5 Aerial Detection Monitoring

File Name: GoldspottedOakBorer_20102021_202312_T2_v5.tif

SHRUB RESILIENCY. NUMBER OF DISTURBANCE EVENTS PER 15 YEAR INTERVAL SINCE 1975

Tier: 2

Data Vintage: 2019

Metric Definition and Relevance: Count of short return interval fires (within 15 years) across southern CA (1950-2019) that can be used to identify sites that have experienced frequent fire (e.g. more than one fire within a 15 year period) that could lead to vegetation-type conversion.

Data Resolution: 270m Raster

Data Units: A count metric indicating the number of times each site (at the pixel level) met a threshold of a 15-year fire-return interval from 1950 to 2019.

Creation Method: Counts were aggregated from the CalFire state fire perimeter dataset using a moving time window of 15 years, which has been identified as a minimum threshold for chaparral or coastal sage scrub recovery after fire. Areas with more frequent fires within a 15-year window could result in decreased chaparral or coastal sage scrub recovery and increased occurrence of invasive species. Counts of 0 indicate a site experienced a single fire but no repeat fires within the 15-yr moving window. Counts of 1 to 9 indicate the number of fires beyond the initial event that recurred at the same pixel within the 15-yr moving window. Data can be used to identify sites that are likely to experience vegetation-type conversion.

Source: Conlisk, E., A.D. Syphard, E. Storey, K. West, C. Ross, M.K. Jennings, D. Stow. 2021. Connecting Wildlands and Communities Research Team; San Diego State University

Data Source: San Diego State University CWC Project Team

File Name: SoCal_ShribResil_19502019_202312_T2_v5.tif

MULTI-STRESSOR REFUGIA

Tier: 3

Data Vintage: 2021

Metric Definition and Relevance: This raster dataset represents sites that may provide protection for natural communities from multiple threats including climate, fire, altered river channels, and density of recreational activities. This data layer currently exists only for the Southern California region.

Data Resolution: 270m Raster

Data Units: This is a dimensionless index that ranges from 1.91 to 3.68. Low values indicate lower resilience to threats. High values indicate significant protection from threats.

Creation Method: Domains of Refugia: To consider how refugial conditions from a range of stressors can inform conservation planning and management, we integrated metrics of refugial capacity across different domains, which we define as social, ecological, or physical drivers, processes, or cycles that influence landscape structure, function, or composition. To persist in the Southern California landscape, species and ecosystems may need refugia from shifting climatic conditions, including extremely hot summers and prolonged droughts, but non-climate stressors can also affect conservation outcomes. In this landscape, changes in fire frequency can be a significant stressor affecting plant community structure and persistence. Anthropogenic features that modify hydrologic flows alter the ability of watersheds to sustain functional habitats. And finally, protected areas are often designed to mitigate the impacts of anthropogenic activities; however, recreational activities may alter the refugial capacity of the protected land, affecting the ability of the landscape to sustain species and their habitats. We combined these individual metrics to assess landscape level refugial capacity.

Sites with high refugial capacity (super-refugia sites) have, on average, 30% fewer extremely warm summers, 20% fewer fire events, 10% less exposure to altered river channels and riparian areas, and 50% fewer recreational trails than the surrounding landscape. Our results suggest that super-refugia sites (~8,200 km²) for some natural communities are underrepresented in the existing protected area network, a finding that can inform efforts to expand protected areas.

Data Source: San Diego State University CWC Project Team

File Name: SoCal_MultistressorRefugia_2021_202312_T3_v5.tif

TIME SINCE LAST DISTURBANCE

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: The metric for time since disturbance ("tsd") was measured as time in years before 2021 since the most recent disturbance of at least 25% canopy cover loss per 30m pixel as defined by eDaRT Mortality Magnitude Index (MMI) layers. MMI values less than 25% were not considered.

The most recent disturbance class ("dist_class") of the most recent disturbance of 25% magnitude or greater detected by eDaRT and were prioritized in the order: fire (1), treatment (2), eDaRT (3). For example, if a pixel intersected a fire perimeter and a treatment polygon, that pixel would be assigned a code of 1 (fire) rather than 2 (treatment). Note that while the occurrence of and magnitude of a disturbance was determined using eDaRT, disturbance class was determined first using fire perimeters and FACTS activities, with remaining eDaRT disturbances collectively assigned to insect- and disease-related tree mortality. This data layer currently exists only for the Sierra Nevada region.

Data Resolution: 30m raster

Data Units: Years

Creation Method: Layers representing time since disturbance, most recent disturbance magnitude, and most recent disturbance class were produced using the Ecosystem Disturbance and Recovery Tracker (eDaRT), Forest Activities ([FACTS](#)) and CAL FIRE Timber Harvesting Plan ([THP](#)) databases, and the CAL FIRE Fire and Resource Assessment Program ([FRAP](#)) fire perimeter dataset. All layers are complete for the entire area within the 300s and 400s eDaRT scenes as well as for scenes 103, 105, and 501. The reference year was set to 2021 since fire history

and eDaRT only reported up through 2020. The earliest year assessed was 2010 since eDaRT data prior to 2010 was used for model training and is not reliable.

Data Source: Caden Chamberlain, Environmental and Forest Sciences, University of Washington

File Name: SNV_TimeSinceLastDisturb_2021_202209_T2_v5.tif

TREE MORTALITY – PAST 5 YEARS AND PAST 1 YEAR

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: The dead tree canopy cover fraction change from the Mortality Magnitude Index (MMI) for eDaRT events. This metric is provided to complement data (in terms of spatial resolution and canopy cover loss estimates) available from the Region 5 Insect and Disease Survey that performs aerial detection monitoring in support of tracking tree mortality that includes affected hosts and agents (available at: https://www.fs.usda.gov/detail/r5/forest-grasslandhealth/?cid=fsbdev3_046696).

Data Resolution: 30m raster

Data Units: Percent of 30m pixel (absolute, not relative, value)

Creation Method: Insect- and disease-caused tree mortality was compiled at the 30 m scale from the Ecosystem Disturbance and Recovery Tracker (eDaRT; Koltunov et al. 2020), described in the [Introduction](#). This metric represents the 2021 status of cumulative tree mortality occurring over the years 2017 to 2021. An additional version represents the mortality of the last 1 year (2021). Note that tree mortality which, since its occurrence, was affected by fire or land management activities has been removed. This data layer currently exists only for the Sierra Nevada region. Efforts are underway to explore development of these data for the rest of California.

Data Source: USDA Forest Service, Region 5, MARS Team

File Name: SNV_TreeMort_2021_202209_T2_v5.tif; SNV_CumulTreeMort_20172021_202209_T2_v5.tif

SOCIAL AND CULTURAL WELL-BEING

The landscape provides a place for people to connect with nature, recreate, to maintain and improve their overall health, and an opportunity to contribute to environmental stewardship. While the elements of this pillar include public health and engagement, recreation quality, and equitable opportunities producing quantifiable, measurable and actionable metrics remains challenging. These metrics are still under development and insights into these potential metrics are appreciated.

DESIRED OUTCOME: The landscape provides a place for people to connect with nature, to recreate, to maintain and improve their overall health, and to contribute to environmental stewardship, and is a critical component of their identity.

EQUITABLE OPPORTUNITY

Equitable Opportunity is the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income regarding the development, implementation and enforcement of environmental laws, regulations, policies and land management.

Note:

The Black/African American Population Concentration is not included as one of the metrics for ethnic population concentrations in the Sierra Nevada. The total population there that identifies as such is statistically too small to include as a distinct population concentration.

The American Indian or Alaska Native Race Alone and Multi-race Population Concentration is not included as one of the metrics for ethnic population concentrations in the Central California region. The total population there that identifies as such is statistically too small to include as a distinct population concentration.

POVERTY PERCENTILE

Tier: 1

Data Vintage: 10/2021

Metric Definition and Relevance: Percent of population living below two times the federal poverty level. The U.S. Census Bureau determines the federal poverty level each year. The poverty level is based on the size of the household and the age of family members. If a person or family's total income before taxes is less than the poverty level, the person or family are considered in poverty. Many studies have found that people living in poverty are more likely than others to become ill from pollution.

Data Resolution: 30m Raster

Data Units: percentile

Creation Method: CalEnviroScreen, Version 4.0, is a science-based method for identifying impacted communities by taking into consideration pollution exposure and its effects, as well as health and socioeconomic status, at the census-tract level. CalEnviroScreen 4.0 uses the census tract as the unit of analysis. Census tract boundaries are available from the Census Bureau. CalEnviroScreen uses the Bureau's 2010 boundaries. New boundaries will be drawn by the Census Bureau as part of the 2020 Census but will not be available until after 2022. OEHHA will address updates to census tract geography in CalEnviroScreen at that time. There are approximately 8,000 census tracts in California, representing a relatively fine scale of analysis. Census tracts are made up of multiple census blocks, which are the smallest geographic unit for which population data are available. Some census blocks have no people residing in them (unpopulated blocks).

The poverty percentile is derived from

- The 2015-2019 American Community Survey, a dataset containing the number of individuals below 200 percent of the federal poverty level was downloaded by census tracts for the state of California.
- The number of individuals below 200% of the poverty level was divided by the total population for whom poverty status was determined.
- Unlike the US Census, ACS estimates come from a sample of the population and may be unreliable if they are based on a small sample or population size. The standard error (SE) and relative standard error (RSE) were used to evaluate the reliability of each estimate.
- The SE was calculated for each census tract using the formula for approximating the SE of proportions provided by the ACS (American Community Survey Office, 2013, pg. 13, equation 4). CalEnviroScreen 4.0 189 When this approximation could not be used, the formula for approximating the SE of ratios (equation 3) was used instead.

- The RSE is calculated by dividing a tract's SE by its estimate of the percentage of the population living below twice the federal poverty level, and taking the absolute value of the result.
- Census tract estimates that met either of the following criteria were considered reliable and included in the analysis:
 - RSE less than 50 (meaning the SE was less than half of the estimate) OR
 - SE was less than the mean SE of all California census tract estimates for poverty.
- Census tracts with unreliable estimates received no score for the indicator (null). The indicator was not factored into that tract's overall CalEnviroScreen score.
- Census tracts that met the inclusion criteria were sorted and assigned percentiles based on their position in the distribution.

Data Source: California Environmental Protection Agency, CalEnviroScreen 4.0, [CalEnviroScreen 4.0 | OEHHA](#)

File Name: PovertyPrct_2020_202209_T1_v5.tif

HOUSING BURDEN PERCENTILE

Tier: 1

Data Vintage: 10/2021

Metric Definition and Relevance: Housing-Burdened Low-Income Households. Percent of households in a census tract that are both low income (making less than 80% of the HUD Area Median Family Income) and severely burdened by housing costs (paying greater than 50% of their income to housing costs). (5-year estimates, 2013-2017).

The cost and availability of housing is an important determinant of well-being. Households with lower incomes may spend a larger proportion of their income on housing. The inability of households to afford necessary non-housing goods after paying for shelter is known as housing-induced poverty. California has very high housing costs relative to much of the country, making it difficult for many to afford adequate housing. Within California, the cost of living varies significantly and is largely dependent on housing cost, availability, and demand.

Areas where low-income households may be stressed by high housing costs can be identified through the Housing and Urban Development (HUD) Comprehensive Housing Affordability Strategy (CHAS) data. We measure households earning less than 80% of HUD Area Median Family Income by county and paying greater than 50% of their income to housing costs. The indicator takes into account the regional cost of living for both homeowners and renters, and factors in the cost of utilities. CHAS data are calculated from US Census Bureau's American Community Survey (ACS).

Data Resolution: 30m Raster

Data Units: Percent

Creation Method: CalEnviroScreen, Version 4.0, is a science-based method for identifying impacted communities by taking into consideration pollution exposure and its effects, as well as health and socioeconomic status, at the census-tract level. CalEnviroScreen 4.0 uses the census tract as the unit of analysis. Census tract boundaries are available from the Census Bureau. CalEnviroScreen uses the Bureau's 2010 boundaries. New boundaries will be drawn by the Census Bureau as part of the 2020 Census but will not be available until 2022. OEHHA will address updates to census tract geography in CalEnviroScreen at that time. There are approximately 8,000 census tracts in California, representing a relatively fine scale of analysis. Census tracts are made up of multiple census blocks,

which are the smallest geographic unit for which population data are available. Some census blocks have no people residing in them (unpopulated blocks).

The CalEnviroScreen model is based on the CalEPA working definition in that:

- The model is place-based and provides information for the entire State of California on a geographic basis. The geographic scale selected is intended to be useful for a wide range of decisions.
- The model is made up of multiple components cited in the above definition as contributors to cumulative impacts.
- The model includes two components representing Pollution Burden – Exposures and Environmental Effects
- The model includes two components representing Population Characteristics – Sensitive Populations (e.g., in terms of health status and age) and Socioeconomic Factors.

The American Community Survey (ACS) is an ongoing survey of the US population conducted by the US Census Bureau and has replaced the long form of the decennial census. Unlike the decennial census, which attempts to survey the entire population and collects a limited amount of information, the ACS releases results annually based on a sub-sample of the population and includes more detailed information on socioeconomic factors. Multiple years of data are pooled together to provide more reliable estimates for geographic areas with small population sizes. Each year, the HUD receives custom tabulations of ACS data from the US Census Bureau. These data, known as the "CHAS" data (Comprehensive Housing Affordability Strategy), demonstrate the extent of housing problems and housing needs, particularly for low-income households. The most recent results available at the census tract scale are the 5-year estimates for 2013-2017. The data are available from the HUD user website (see page 174 in the document link below:

<https://oehha.ca.gov/media/downloads/calenviroscreen/report/calenviroscreen40reportf2021.pdf>

Data Source: California Environmental Protection Agency, CalEnviroScreen 4.0

File Name: HousingBurdenPrct_2020_202209_T1_v5.tif

UNEMPLOYMENT PERCENTILE

Tier: 1

Data Vintage: 10/2021

Metric Definition and Relevance: Percentage of the population over the age of 16 that is unemployed and eligible for the labor force. Excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty (5-year estimate, 2015-2019).

Because low socioeconomic status often goes hand-in-hand with high unemployment, the rate of unemployment is a factor commonly used in describing disadvantaged communities. On an individual level, unemployment is a source of stress, which is implicated in poor health reported by residents of such communities. Lack of employment and resulting low income often constrain people to live in neighborhoods with higher levels of pollution and environmental degradation.

Data Resolution: 30m Raster

Data Units: Percent

Creation Method: CalEnviroScreen, Version 4.0, is a science-based method for identifying impacted communities by taking into consideration pollution exposure and its effects, as well as health and socioeconomic status, at the

census-tract level. CalEnviroScreen 4.0 uses the census tract as the unit of analysis. Census tract boundaries are available from the Census Bureau. CalEnviroScreen uses the Bureau's 2010 boundaries. New boundaries will be drawn by the Census Bureau as part of the 2020 Census but will not be available until 2022. OEHHA will address updates to census tract geography in CalEnviroScreen at that time. There are approximately 8,000 census tracts in California, representing a relatively fine scale of analysis. Census tracts are made up of multiple census blocks, which are the smallest geographic unit for which population data are available. Some census blocks have no people residing in them (unpopulated blocks).

The CalEnviroScreen model is based on the CalEPA working definition in that:

- The model is place-based and provides information for the entire State of California on a geographic basis. The geographic scale selected is intended to be useful for a wide range of decisions.
- The model is made up of multiple components cited in the above definition as contributors to cumulative impacts.
- The model includes two components representing Pollution Burden – Exposures and Environmental Effects
- The model includes two components representing Population Characteristics – Sensitive Populations (e.g., in terms of health status and age) and Socioeconomic Factors.

The American Community Survey (ACS) is an ongoing survey of the US population conducted by the US Census Bureau. Unlike the decennial census, which attempts to survey the entire population and collects a limited amount of information, the ACS releases results annually based on a sub-sample of the population and includes more detailed information on socioeconomic factors such as unemployment. Multiple years of data are pooled together to provide more reliable estimates for geographic areas with small population sizes. The most recent results available at the census tract level are the 5-year estimates for 2015-2019. The data are made available using the U.S. Census data download website.

Data Source: California Environmental Protection Agency, CalEnviroScreen 4.0, [CalEnviroScreen 4.0 | OEHHA](#)

File Name: UnemploymentPrct_2020_202209_T1_v5.tif

AMERICAN INDIAN LAND AREA REPRESENTATION (LAR)

Tier: 1

Data Vintage: 09/2023

Metric Definition and Relevance: These data, developed for the Bureau of Indian Affairs, Department of Interior, provide the details for tracts, parcels, and other relevant BIA lands. The data depict locations of Tribally controlled land mapped to the parcel level for all Land Area Codes (LAC) held in trust or restricted-fee by the United States. The Division of Land Titles and Records (LTR) compiled the data to support the Bureau of Indian Affairs Tribal Reservations. The source information for the parcel records are from the Trust Asset and Accounting Management System (TAAMS), which is the system of record. The term "Indian land" means: (A) Any land located within the boundaries of an Indian reservation, pueblo, or rancharia; (B) Any land not located within the boundaries of an Indian reservation, pueblo, or rancharia, the title to which is help: (i) In trust by the United States for the benefit of an Indian tribe or an individual Indian; (ii) By an Indian tribe or an individual Indian, subject to restriction against alienation under laws of the United States Definition: Indian land from 25 USC § 3501(2) | LII / Legal Information Institute.

Data Resolution: 30m Raster (rasterized from a polygon data layer)

Data Units: 1 = LAR exists

Creation Method: Original source data: The purpose of the American Indian (and Alaska Native) Land Area Representation (AIAN-LAR) Geographic Information System (GIS) dataset is to depict the external extent of federal Indian reservations and the external extent of associated land held in “trust” by the United States, “restricted fee” or “mixed ownership” status for federally recognized tribes and individual Indians. This dataset includes other land area types such as Public Domain Allotments, Dependent Indian Communities and Homesteads.

This GIS Dataset is prepared strictly for illustrative and reference purposes only and should not be used, and is not intended for legal, survey, engineering or navigation purposes. No warranty is made by the Bureau of Indian Affairs (BIA) for the use of the data for purposes not intended by the BIA. This GIS Dataset may contain errors. There is no impact on the legal status of the land areas depicted herein and no impact on land ownership. No legal inference can or should be made from the information in this GIS Dataset. The GIS Dataset is to be used solely for illustrative, reference and statistical purposes and may be used for government to government Tribal consultation.

Reservation boundary data is limited in authority to those areas where there has been settled Congressional definition or final judicial interpretation of the boundary. Absent a settled Congressional definition or final judicial interpretation of a reservation boundary, the BIA recommends consultation with the appropriate Tribe and then the BIA to obtain interpretations of the reservation boundary. The land areas and their representations are compilations defined by the official land title records of the Bureau of Indian Affairs (BIA) which include treaties, statutes, Acts of Congress, agreements, executive orders, proclamations, deeds and other land title documents.

The trust, restricted, and mixed ownership land area shown here, are suitable only for general spatial reference and do not represent the federal government’s position on the jurisdictional status of Indian country. Ownership and jurisdictional status is subject to change and must be verified with plat books, patents, and deeds in the appropriate federal and state offices.

Included in this dataset are the exterior extent of off reservation trust, restricted fee tracts and mixed tracts of land including Public Domain allotments, Dependent Indian Communities, Homesteads and government administered lands and those set aside for schools and dormitories. There are also land areas where there is more than one tribe having an interest in or authority over a tract of land but this information is not specified in the AIAN-LAR dataset.

The dataset includes both surface and subsurface tracts of land (tribal and individually held) “off reservation” tracts and not simply off reservation “allotments” as land has in many cases been subsequently acquired in trust. These data are public information and may be used by various organizations, agencies, units of government (i.e., Federal, state, county, and city), and other entities according to the restrictions on appropriate use. It is strongly recommended that these data be acquired directly from the BIA and not indirectly through some other source, which may have altered or integrated the data for another purpose for which they may not have been intended. Integrating land areas into another dataset and attempting to resolve boundary differences between other entities may produce inaccurate results. It is also strongly recommended that careful attention be paid to the content of the metadata file associated with these data. Users are cautioned that digital enlargement of these data to scales greater than those at which they were originally mapped can cause misinterpretation. The BIA AIAN-LAR dataset’s spatial accuracy and attribute information are continuously being updated, improved and is used as the single authoritative land area boundary data for the BIA mission. These data are available through the Bureau of Indian Affairs, Office of Trust Services, Division of Land Titles and Records, Branch of Geospatial Support.

Interpreting the presence/absence of AIANNH features and LAR features requires care. Essentially, the Land Area Representation (LAR) delineates an area of land that is often but not always under Tribal and/or Trust control of/for a Tribe. It is likely that areas within the LAR that are not Reservation or Trust lands are considered lands of significant interest by the Tribe in question, and direct government-to-government consultation with the concerned Tribe is strongly encouraged to understand the Tribe's interpretation of the LAR and parcel features. The AIANNH feature is in almost all cases essentially a realty data set that indicates where Tribes have some legal interest in actual land parcels, either because they are part of a reservation, are held in trust for the tribe, or the Tribe itself has a controlling ownership interest in fee.

Data Source: U.S. Department of Interior, Bureau of Indian Affairs Developed by the U.S. Department of the Interior. [Indian Lands \(geoplatform.gov\)](https://www.indianlands.gov/)

File Name: AIAN_LandAreaRep_202309_202406_T1_v5.tif

AMERICAN INDIAN LANDS (CENSUS DATA)

Tier: 1

Data Vintage: 05/2022

Metric Definition and Relevance: Lands under the control of federally recognized Tribes. These boundaries have been clipped to the boundary of California so that only the portions of each Tribal area that fall within California are included. For purposes of this designation, a Tribe may establish that a particular area of land is under its control even if not represented as such on CalEPA's DAC map and therefore should be considered a DAC by requesting a consultation with the CalEPA Deputy Secretary for Environmental Justice, Tribal Affairs and Border Relations at TribalAffairs@calepa.ca.gov

The AIANNH feature class from the Census Bureau depicts actual parcels of land which fall into one of the following classifications:

- Federally designated Tribal reservation
- Off-reservation trust land (ORTL) (U.S. Trust – owned by the US Government, managed by the BIA on behalf of the designated Tribe)

Data Resolution: 30m Raster (rasterized from a polygon data layer)

Data Units: Categorical

Definition of field name COMPTYPE (Component type):

- "R" is Federally recognized American Indian Reservations (AIRs)
- "T" is Off-Reservation Trust Lands (ORTL)

Creation Method: CalEnviroScreen, Version 4.0, is a science-based method for identifying impacted communities by taking into consideration pollution exposure and its effects, as well as health and socioeconomic status, at the census-tract level. CalEnviroScreen 4.0 uses the census tract as the unit of analysis. Census tract boundaries are available from the Census Bureau. CalEnviroScreen uses the Bureau's 2010 boundaries. New boundaries will be drawn by the Census Bureau as part of the 2020 Census but will not be available until 2022. OEHHA will address updates to census tract geography in CalEnviroScreen at that time. There are approximately 8,000 census tracts in California, representing a relatively fine scale of analysis. Census tracts are made up of multiple census blocks, which are the smallest geographic unit for which population data are available. Some census blocks have no

people residing in them (unpopulated blocks). The CalEnviroScreen model is based on the CalEPA working definition in that:

- The model is place-based and provides information for the entire State of California on a geographic basis. The geographic scale selected is intended to be useful for a wide range of decisions.
- The model is made up of multiple components cited in the above definition as contributors to cumulative impacts.
- The model includes two components representing Pollution Burden – Exposures and Environmental Effects
- The model includes two components representing Population Characteristics – Sensitive Populations (e.g., in terms of health status and age) and Socioeconomic Factors.

The American Community Survey (ACS) is an ongoing survey of the US population conducted by the US Census Bureau and has replaced the long form of the decennial census. Unlike the decennial census, which attempts to survey the entire population and collects a limited amount of information, the ACS releases results annually based on a sub-sample of the population and includes more detailed information on socioeconomic factors. Multiple years of data are pooled together to provide more reliable estimates for geographic areas with small population sizes. Each year, the HUD receives custom tabulations of ACS data from the US Census Bureau. These data, known as the "CHAS" data (Comprehensive Housing Affordability Strategy), demonstrate the extent of housing problems and housing needs, particularly for low-income households. The most recent results available at the census tract scale are the 5-year estimates for 2013-2017. The data are available from the HUD user website (see page 174 in the document link below:

<https://oehha.ca.gov/media/downloads/calenviroscreen/report/calenviroscreen40reportf2021.pdf>

Data Source: California Environmental Protection Agency, CalEnviroScreen 4.0

File Name: SB535tribalBoundaries_202205_202312_T1_v5.tif

POPULATIONS BY REGION

The analyses of human population demographics was conducted by Dr. Mark Adams, a geographer with Forest Service Research and Development. His work specializes in integrating demographic, political, and ecological data sets in GIS to answer complex research questions about ecological and community changes within coupled human and natural systems. These analyses were done by each of the four Task Force Regions individually to capture the more specific demographic characteristics of each of these Regions.

SIERRA NEVADA - AMERICAN INDIAN OR ALASKA NATIVE RACE ALONE POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Sierra Nevada region’s American Indian population. The variable AIAN_ALN_AND_MULTIRACE includes BOTH individuals who select American Indian or Alaska Native as their sole racial identity (they *only* identify as American Indian), AND individuals who select American Indian / Alaska Native as one of two or more racial identities (they *partly* identify as American Indian) in response to the Census questionnaire. **IMPORTANT:** this self reported ancestry and Tribal membership are distinct identities and one does not automatically imply the other. These data should not be interpreted as a distribution of “Tribal people.”

“Relative concentration” is a measure that compares the proportion of population within each Census block group data unit that identify as American Indian / Alaska Native alone to the proportion of all people that live within the 775 block groups in the Sierra Nevada RRK region that identify as American Indian / Alaska native alone. Example: if 5.2% of people in a block group identify as AIANALN, the block group has twice the proportion of AIANALN individuals compared to the Sierra Nevada RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then AIANALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Sierra Nevada region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Sierra Nevada region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Sierra Nevada region population in total

- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Sierra Nevada region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%)
- Class Code 8: *Exceptionally high*. The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region
- Class Code 99: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force Regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of AIAN_ALN_AND_MULTIRACE population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Sierra Nevada RRR boundary. The resulting 775 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: SNV_AIAN_ALN_MULTIRACE_2020_202406_T2_v5.tif

SIERRA NEVADA - HISPANIC/LATINO POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Sierra Nevada region's Hispanic/Latino population. The variable HISPANIC records all individuals who select Hispanic or Latino in response to the Census questionnaire, regardless of their response to the racial identity question.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as American Indian / Alaska Native alone to the proportion of all people that live within the 775 block groups in the Sierra Nevada RRK region that identify as American Indian / Alaska native alone. Example: if 5.2% of people in a block group identify as HISPANIC, the block group has twice the proportion of HISPANIC individuals compared to the Sierra Nevada RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then HISPANIC individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Sierra Nevada region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Sierra Nevada region population in total

- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Sierra Nevada region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Sierra Nevada region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force Regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of HISPANIC population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection

with the Sierra Nevada RRK boundary. The resulting 775 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 775 Census block groups within or intersecting the Sierra Nevada RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: SNV_HISPANIC_2020_202406_T2_v5.tif

SIERRA NEVADA - HISPANIC AND/OR BLACK, INDIGENOUS OR PERSON OF COLOR (HSPBPOC)

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Sierra Nevada region's Hispanic and/or Black, Indigenous or person of color (HSPBPOC) population. The variable HSPBPOC is equivalent to all individuals who select a combination of racial and ethnic identity in response to the Census questionnaire EXCEPT those who select "not Hispanic" for the ethnic identity question, and "white race alone" for the racial identity question. This is the most encompassing possible definition of racial and ethnic identities that may be associated with historic underservice by agencies, or be more likely to express environmental justice concerns (as compared to predominantly non-Hispanic white communities). Until 2021, federal agency guidance for considering environmental justice impacts of proposed actions focused on how the actions affected "racial or ethnic minorities." "Racial minority" is an increasingly meaningless concept in the USA, and particularly so in California, where only about 3/8 of the state's population identifies as non-Hispanic and white race alone - a clear majority of Californians identify as Hispanic and/or not white. Because many federal and state map screening tools continue to

rely on "minority population" as an indicator for flagging potentially vulnerable / disadvantaged/ underserved populations, our analysis includes the variable HSPBIPOC which is effectively "all minority" population according to the now outdated federal environmental justice direction. A more meaningful analysis for the potential impact of forest management actions on specific populations considers racial or ethnic populations individually: e.g., all people identifying as Hispanic regardless of race; all people identifying as American Indian, regardless of Hispanic ethnicity; etc.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as HSPBIPOC alone to the proportion of all people that live within the 775 block groups in the Sierra Nevada RRK region that identify as HSPBIPOC alone. Example: if 5.2% of people in a block group identify as HSPBIPOC, the block group has twice the proportion of HSPBIPOC individuals compared to the Sierra Nevada RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then HSPBIPOC individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Sierra Nevada region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Sierra Nevada region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force Regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of HSPBIOPOC population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Sierra Nevada RRK boundary. The resulting 775 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from [census.data.gov](https://www.census.gov/data) and joined to TIGER Census block group features. There are 775 Census block groups within or intersecting the Sierra Nevada RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: SNV_HSPBIPOC_2020_202406_T2_v5.tif

SIERRA NEVADA - ASIAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Sierra Nevada region's Asian American population. The variable ASIANALN records all individuals who select Asian as their SOLE racial identity in response to the Census questionnaire, regardless of their response to the Hispanic ethnicity question. Both Hispanic and non-Hispanic in the Census questionnaire are potentially associated with the Asian race alone.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as ASIANALN alone to the proportion of all people that live within the 775 block groups in the Sierra Nevada RRK region that identify as ASIANALN alone. Example: if 5.2% of people in a block group identify as HSPBIPOC, the block group has twice the proportion of ASIANALN individuals compared to the Sierra Nevada RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then ASIANALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Sierra Nevada region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Sierra Nevada region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Sierra Nevada region population in total

- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Sierra Nevada region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 8: *Exceptionally high*. The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region
- Class Code 99: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force Regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of ASIANALN population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Sierra Nevada RRK boundary. The resulting 775 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to

the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 775 Census block groups within or intersecting the Sierra Nevada RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: SNV_ASIANALN_2020_202406_T2_v5.tif

SIERRA NEVADA - MULTI-RACE, EXCEPT PART-AMERICAN INDIAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: The Relative concentration of the Sierra Nevada region's population that identifies as "Multiracial", EXCEPT those with part-American Indian identity, in response to the Census questionnaire. "Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identifies as Multiiracial to the proportion of all people that live within the 775 census block groups in the Sierra Nevada RRK region. People with part-American Indian identity are not included here but are included in the American Indian or Alaska Native Race Alone and Multirace Population, described above.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Sierra Nevada region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Sierra Nevada region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Sierra Nevada region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 99: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and

Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force Regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note: 1) The pixels attributed with a categorical data unit describing the relative concentration of MULTIRACE_NOT_AIAN_20 population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Sierra Nevada RRK boundary. The resulting 775 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from [census.data.gov](https://www.census.gov/data) and joined to TIGER Census block group features. There are 775 Census block groups within or intersecting the Sierra Nevada RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the [Data.Census.Gov](https://data.census.gov) web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: SNV_MULTIRACE_NOT_AIAN_2020_202406_T2_v5.tif

SIERRA NEVADA - LOW INCOME POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the estimated number of people in the Sierra Nevada region that live in a household defined as "low income." There are multiple ways to define low income. These data apply the most common standard: low income population consists of all members of households that collectively

have income less than twice the federal poverty threshold that applies to their household type. Household type refers to the household's resident composition: the number of independent adults plus dependents that can be of any age, from children to elderly. For example, a household with four people – one working adult parent and three dependent children – has a different poverty threshold than a household comprised of four unrelated independent adults.

Due to high estimate uncertainty for many block group estimates of the number of people living in low income households, some records cannot be reliably assigned a class and class code comparable to those assigned to race/ethnicity data from the decennial Census.

“Relative concentration” is a measure that compares the proportion of population within each Census block group data unit to the proportion of all people that live within the 775 block groups in the Sierra Nevada RRR region. See the “Data Units” description below for how these relative concentrations are broken into categories in this “low income” metric.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Sierra Nevada region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Sierra Nevada region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Sierra Nevada region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Sierra Nevada region population in total

- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Sierra Nevada region population in total (the upper limit is determined by natural breaks if exceptional outliers are present, but is typically over 6 times (600%)
- Class Code 9: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data are reported in Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force Regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Notes: The pixels attributed with a categorical data unit describing the relative concentration of LOW_INCOME population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Sierra Nevada RRK boundary. The resulting 775 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

- Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

- Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions.
<https://doi.org/10.1016/j.apgeog.2017.12.014>

Data Source: U.S. Department of Commerce, Census Bureau, 2020 American Community Survey 5-Year Survey Estimates.

Data estimating household income as a percent of the applicable federal poverty threshold are reported in Table C17002 of the 2020 ACS 5-year data. Estimates of population living in low income households were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units below). Table C17002 provides estimates and error margins for total population living in households with income, and population by ratio of income to applicable poverty: 50% of poverty, 50-99%, etc. Additional calculations are performed to generate an estimate for all people in households with income less than 200% of applicable poverty.

FMI: <https://www.census.gov/newsroom/press-releases/2022/acs-5-year-estimates.html>

File Name: SNV_LowIncome_2020_202406_T2_v5.tif

SOCAL - AMERICAN INDIAN OR ALASKA NATIVE RACE ALONE AND MULTIRACE POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Southern California region's American Indian population. The variable AIAN_ALN_AND_MULTIRACEAIANALN includes BOTH individuals who select American Indian or Alaska Native as their sole racial identity (they *only* identify as American Indian), AND individuals who select American Indian / Alaska Native as one of two or more racial identities (they *partly* identify as American Indian) in response to the Census questionnaire. **IMPORTANT:** this self reported ancestry and Tribal membership are distinct identities and one does not automatically imply the other. These data should not be interpreted as a distribution of "Tribal people." Numerous Rancherias in the Southern California region account for the wide distribution of very to extremely high concentrations of American Indians.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as American Indian / Alaska Native alone to the proportion of all people that live within the 13,312 block groups in the Southern California RRK region that identify as American Indian / Alaska native alone. Example: if 5.2% of people in a block group identify as AIANALN, the block group has twice the proportion of AIANALN individuals compared to the Southern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then AIANALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 8: *Exceptionally high*. The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region
- Class Code 99: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto

Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force Regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of AIAN_ALN_AND_MULTIRACE_2020 population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Southern California RRR boundary. The resulting 13,312 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: SoCal_AIAN_ALN_MULTIRACE_2020_202312_T2_v5.tif

SOCAL - HISPANIC/LATINO POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Southern California region’s Hispanic/Latino population. The variable HISPANIC records all individuals who select Hispanic or Latino in response to the Census questionnaire, regardless of their response to the racial identity question.

“Relative concentration” is a measure that compares the proportion of population within each Census block group data unit that identify as American Indian / Alaska Native alone to the proportion of all people that live within the 13,312 block groups in the Southern California RRK region that identify as American Indian / Alaska native alone. Example: if 5.2% of people in a block group identify as HISPANIC, the block group has twice the proportion of HISPANIC individuals compared to the Southern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then HISPANIC individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g.,

Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force Regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note: 1) The pixels attributed with a categorical data unit describing the relative concentration of HISPANIC population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Southern California RRR boundary. The resulting 13,312 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 13,312 Census block groups within or intersecting the Southern California RRR region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: SoCal_HISPANIC_2020_202312_T2_v5.tif

SOCAL - BLACK/AFRICAN AMERICAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Southern California region's Black/African American population. The variable BLACKALN records all individuals who select black or African American as their SOLE racial identity in response to the Census questionnaire, regardless of their response to the Hispanic ethnicity question. Both Hispanic and non-Hispanic in the Census questionnaire are potentially associated with black race alone.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as Black/African American alone to the proportion of all people that live within the 13,312 block groups in the Southern California RRK region that identify as Black/African American alone. Example: if 5.2% of people in a block group identify as BLACKALN, the block group has twice the proportion of BLACKALN individuals compared to the Southern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then BLACKALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total

- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 8: *Exceptionally high*. The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region
- Class Code 99: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force Regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note: 1) The pixels attributed with a categorical data unit describing the relative concentration of BLACKALN population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Southern California RRR boundary. The resulting 13,312 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that

depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 13,312 Census block groups within or intersecting the Southern California RRG region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: SoCal_BLACKALN_2020_202312_T2_v5.tif

SOCAL - HISPANIC AND/OR BLACK, INDIGENOUS OR PERSON OF COLOR (HSPBIPOC)

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Southern California region's Black/African American population. The variable HSPBIPOC is equivalent to all individuals who select a combination of racial and ethnic identity in response to the Census questionnaire EXCEPT those who select "not Hispanic" for the ethnic identity question, and "white race alone" for the racial identity question. This is the most encompassing possible definition of racial and ethnic identities that may be associated with historic underservice by agencies, or be more likely to express environmental justice concerns (as compared to predominantly non-Hispanic white communities). Until 2021, federal agency guidance for considering environmental justice impacts of proposed actions focused on how the actions affected "racial or ethnic minorities." "Racial minority" is an increasingly meaningless concept in the USA, and particularly so in California, where only about 3/8 of the state's population identifies as non-Hispanic and white race alone - a clear majority of Californians identify as Hispanic and/or not white. Because many federal and state map screening tools continue to rely on "minority population" as an indicator for flagging potentially vulnerable / disadvantaged/ underserved populations, our analysis includes the variable HSPBIPOC which is effectively "all minority" population according to the now outdated federal environmental justice direction. A more meaningful analysis for the potential impact of forest management actions on specific populations considers

racial or ethnic populations individually: e.g., all people identifying as Hispanic regardless of race; all people identifying as American Indian, regardless of Hispanic ethnicity; etc.

“Relative concentration” is a measure that compares the proportion of population within each Census block group data unit that identify as HSPBIPOC alone to the proportion of all people that live within the 13,312 block groups in the Southern California RRK region that identify as HSPBIPOC alone. Example: if 5.2% of people in a block group identify as HSPBIPOC, the block group has twice the proportion of HSPBIPOC individuals compared to the Southern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then HSPBIPOC individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total

- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total

- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total

- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto

Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force Regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of HSPBPOC population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Southern California RRR boundary. The resulting 13,312 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from [census.data.gov](https://www.census.gov/data) and joined to TIGER Census block group features. There are 13,312 Census block groups within or intersecting the Southern California RRR region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: SoCal_HSPBPOC_2020_202312_T2_v5.tif

SOCAL - ASIAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Southern California region's Asian American population. The variable ASIANALN records all individuals who select Asian as their SOLE racial identity in response to the Census questionnaire, regardless of their response to the Hispanic ethnicity question. Both Hispanic and non-Hispanic in the Census questionnaire are potentially associated with the Asian race alone.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as ASIANALN alone to the proportion of all people that live within the 13,312 block groups in the Southern California RRK region that identify as ASIANALN alone. Example: if 5.2% of people in a block group identify as HSPBIPOC, the block group has twice the proportion of ASIANALN individuals compared to the Southern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then ASIANALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern

California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%)

- Class Code 99: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note: 1) The pixels attributed with a categorical data unit describing the relative concentration of ASIANALN population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Southern California RRR boundary. The resulting 13,312 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 13,312 Census block groups within or intersecting the Southern California RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: SoCal_ASIANALN_2020_202312_T2_v5.tif

SOCAL - MULTI-RACE, EXCEPT PART-AMERICAN INDIAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: The Relative concentration of the Southern California region's population that identifies as "Multiracial", EXCEPT those with part-American Indian identity, in response to the Census questionnaire. "Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identifies as Multiiracial to the proportion of all people that live within the 13,312 census block groups in the Southern California RRK region. People with part-American Indian identity are not included here but are included in the American Indian or Alaska Native Race Alone and Multirace Population, described above.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 99: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note: 1) The pixels attributed with a categorical data unit describing the relative concentration of MULTIRACE_NOT_AIAN_20 population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Southern California RRK boundary. The resulting 13,312 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result

is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 13,312 Census block groups within or intersecting the Southern California RRR region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: SoCal_MULTIRACE_NOT_AIAN_2020_202312_T2_v5.tif

SOCAL - LOW INCOME POPULATION CONCENTRATION

Tier: 2

Data Vintage:2020

Metric Definition and Relevance: Relative concentration of the estimated number of people in the Southern California region that live in a household defined as "low income." There are multiple ways to define low income. These data apply the most common standard: low income population consists of all members of households that collectively have income less than twice the federal poverty threshold that applies to their household type. Household type refers to the household's resident composition: the number of independent adults plus dependents that can be of any age, from children to elderly. For example, a household with four people – one working adult parent and three dependent children – has a different poverty threshold than a household comprised of four unrelated independent adults.

Due to high estimate uncertainty for many block group estimates of the number of people living in low income households, some records cannot be reliably assigned a class and class code comparable to those assigned to race/ethnicity data from the decennial Census.

“Relative concentration” is a measure that compares the proportion of population within each Census block group data unit to the proportion of all people that live within the 13,312 block groups in the Southern California RRK region. See the “Data Units” description below for how these relative concentrations are broken into categories in this “low income” metric.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 99: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data are reported in Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks

3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Notes: The pixels attributed with a categorical data unit describing the relative concentration of LOW_INCOME population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Southern California RRR boundary. The resulting 13,312 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

- Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

- Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data Source: U.S. Department of Commerce, Census Bureau, 2020 American Community Survey 5-Year Survey Estimates.

Data estimating household income as a percent of the applicable federal poverty threshold are reported in Table C17002 of the 2016-2020 ACS 5-year data. Estimates of population living in low income households were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units below). Table C17002 provides estimates and error margins for total population living in households with income, and population by ratio of income to applicable poverty: 50% of poverty, 50-99%, etc.

Additional calculations are performed to generate an estimate for all people in households with income less than 200% of applicable poverty.

FMI: <https://www.census.gov/newsroom/press-releases/2022/acs-5-year-estimates.html>

File Name: SoCal_LowIncome_2020_202312_T2_v5.tif

CENCAL - HISPANIC/LATINO POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Central California region's Hispanic/Latino population. The variable HISPANIC records all individuals who select Hispanic or Latino in response to the Census questionnaire, regardless of their response to the racial identity question.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as American Indian / Alaska Native alone to the proportion of all people that live within the 4,961 block groups in the Central California RRK region that identify as American Indian / Alaska native alone. Example: if 5.2% of people in a block group identify as HISPANIC, the block group has twice the proportion of HISPANIC individuals compared to the Central California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then HISPANIC individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Central California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Central California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Central California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Central California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Central California region population in total

- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Central California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Central California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Central California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of HISPANIC population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Central California RRK boundary. The resulting 4,961 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 4,961 Census block groups within or intersecting the Central California RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: CenCal_HISPANIC_2020_202312_T2_v5.tif

CENCAL -BLACK/AFRICAN AMERICAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Central California region's Black/African American population. The variable BLACKALN records all individuals who select black or African American as their SOLE racial identity in response to the Census questionnaire, regardless of their response to the Hispanic ethnicity question. Both Hispanic and non-Hispanic in the Census questionnaire are potentially associated with black race alone.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as Black/African American alone to the proportion of all people that live within the 4,961 block groups in the Central California RRK region that identify as Black/African American alone. Example: if 5.2% of people in a block group identify as BLACKALN, the block group has twice the proportion of BLACKALN individuals compared to the Central California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then BLACKALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Central California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Central California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Central California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Central California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Central California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Central California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Central California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Central California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 8: *Exceptionally high*. The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region
- Class Code 99: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto

Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of BLACKALN population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Central California RRK boundary. The resulting 4,961 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from [census.data.gov](https://www.census.gov/data) and joined to TIGER Census block group features. There are 4,961 Census block groups within or intersecting the Central California RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the [Data.Census.Gov](https://data.census.gov) web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: CenCal_BLACKALN_2020_202312_T2_v5.tif

CENCAL -HISPANIC AND/OR BLACK, INDIGENOUS OR PERSON OF COLOR (HSPBIOCP)

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Central California region’s Hispanic and/or Black, Indigenous or person of color (HSPBIPOC) American population. The variable HSPBIPOC is equivalent to all individuals who select a combination of racial and ethnic identity in response to the Census questionnaire EXCEPT those who select "not Hispanic" for the ethnic identity question, and "white race alone" for the racial identity question. This is the most encompassing possible definition of racial and ethnic identities that may be associated with historic underservice by agencies, or be more likely to express environmental justice concerns (as compared to predominantly non-Hispanic white communities). Until 2021, federal agency guidance for considering environmental justice impacts of proposed actions focused on how the actions affected "racial or ethnic minorities." "Racial minority" is an increasingly meaningless concept in the USA, and particularly so in California, where only about 3/8 of the state's population identifies as non-Hispanic and white race alone - a clear majority of Californians identify as Hispanic and/or not white. Because many federal and state map screening tools continue to rely on "minority population" as an indicator for flagging potentially vulnerable / disadvantaged/ underserved populations, our analysis includes the variable HSPBIPOC which is effectively "all minority" population according to the now outdated federal environmental justice direction. A more meaningful analysis for the potential impact of forest management actions on specific populations considers racial or ethnic populations individually: e.g., all people identifying as Hispanic regardless of race; all people identifying as American Indian, regardless of Hispanic ethnicity; etc.

“Relative concentration” is a measure that compares the proportion of population within each Census block group data unit that identify as HSPBIPOC alone to the proportion of all people that live within the 4,961 block groups in the Central California RRK region that identify as HSPBIPOC alone. Example: if 5.2% of people in a block group identify as HSPBIPOC, the block group has twice the proportion of HSPBIPOC individuals compared to the Central California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then HSPBIPOC individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Central California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Central California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Central California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Central California region population in total

- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Central California region population in total

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of HSPBIPOC population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Central California RRR boundary. The resulting 4,961 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set

table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 4,961 Census block groups within or intersecting the Central California RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: CenCal_HSPBIPOC_2020_202312_T2_v5.tif

CENCAL -ASIAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Central California region's Asian American population. The variable ASIANALN records all individuals who select Asian as their SOLE racial identity in response to the Census questionnaire, regardless of their response to the Hispanic ethnicity question. Both Hispanic and non-Hispanic in the Census questionnaire are potentially associated with the Asian race alone.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as ASIANALN alone to the proportion of all people that live within the 4,961 block groups in the Central California RRK region that identify as ASIANALN alone. Example: if 5.2% of people in a block group identify as HSPBIPOC, the block group has twice the proportion of ASIANALN individuals compared to the Central California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then ASIANALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Central California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Central California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Central California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Central California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Central California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Central California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Central California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Central California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of ASIANALN population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Central California RRK boundary. The resulting 4,961 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by

the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 4,961 Census block groups within or intersecting the Central California RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: CenCal_ASIANALN_2020_202312_T2_v5.tif

CENCAL -MULTI-RACE, EXCEPT PART-AMERICAN INDIAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: The Relative concentration of the Central California region's population that identifies as "Multiracial", EXCEPT those with part-American Indian identity, in response to the Census questionnaire. "Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identifies as Multiiracial to the proportion of all people that live within the 4,961 census block groups in the Central California RRK region. People with part-American Indian identity are not included here but are included in the American Indian or Alaska Native Race Alone and Multirace Population, described above.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Central California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Central California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Central California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Central California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Central California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Central California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Central California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Central California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 99: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and

Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note: 1) The pixels attributed with a categorical data unit describing the relative concentration of MULTIRACE_NOT_AIAN_20 population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Central California RRK boundary. The resulting 4,961 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from [census.data.gov](https://www.census.gov/data) and joined to TIGER Census block group features. There are 4,961 Census block groups within or intersecting the Central California RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the [Data.Census.Gov](https://data.census.gov) web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: CenCal_MULTIRACE_NOT_AIAN_2020_202312_T2_v5.tif

CENCAL -LOW INCOME POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the estimated number of people in the Central California region that live in a household defined as "low income." There are multiple ways to define low income. These data apply the most common standard: low income population consists of all members of households that

collectively have income less than twice the federal poverty threshold that applies to their household type. Household type refers to the household's resident composition: the number of independent adults plus dependents that can be of any age, from children to elderly. For example, a household with four people – one working adult parent and three dependent children – has a different poverty threshold than a household comprised of four unrelated independent adults.

Due to high estimate uncertainty for many block group estimates of the number of people living in low income households, some records cannot be reliably assigned a class and class code comparable to those assigned to race/ethnicity data from the decennial Census.

“Relative concentration” is a measure that compares the proportion of population within each Census block group data unit to the proportion of all people that live within the 4,961 block groups in the Central California RRK region. See the “Data Units” description below for how these relative concentrations are broken into categories in this “low income” metric.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Central California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Central California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Central California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Central California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Central California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Central California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Central California region population in total

- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Central California region population in total (the upper limit is determined by natural breaks if exceptional outliers are present, but is typically over 6 times (600%)
- Class Code 8: *Exceptionally high*. The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region
- Class Code 9: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data are reported in Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Notes: The pixels attributed with a categorical data unit describing the relative concentration of LOW_INCOME population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Central California RRR boundary. The resulting 4,961 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

- Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

- Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data Source: U.S. Department of Commerce, Census Bureau, 2020 American Community Survey 5-Year Survey Estimates.

Data estimating household income as a percent of the applicable federal poverty threshold are reported in Table C17002 of the 2020 ACS 5-year data. Estimates of population living in low income households were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units below). Table C17002 provides estimates and error margins for total population living in households with income, and population by ratio of income to applicable poverty: 50% of poverty, 50-99%, etc. Additional calculations are performed to generate an estimate for all people in households with income less than 200% of applicable poverty.

FMI: <https://www.census.gov/newsroom/press-releases/2022/acs-5-year-estimates.html>

File Name: CenCal_LowIncome_2020_202312_T2_v5.tif

NORCAL - AMERICAN INDIAN OR ALASKA NATIVE RACE ALONE POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Northern California region's American Indian population. The variable AIANALN records all individuals who select American Indian or Alaska Native as their SOLE racial identity in response to the Census questionnaire, regardless of their response to the Hispanic ethnicity question. Both Hispanic and non-Hispanic in the Census questionnaire are potentially associated with American Indian / Alaska Native race alone. IMPORTANT: this self reported ancestry and Tribal membership are distinct identities and one does not automatically imply the other. These data should not be interpreted as a distribution of "Tribal people." Numerous Rancherias in the Northern California region account for the wide distribution of very to extremely high concentrations of American Indians outside the San Francisco Bay Area.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as American Indian / Alaska Native alone to the proportion of all people that live within the 1,207 block groups in the Northern California RRK region that identify as American Indian / Alaska native alone. Example: if 5.2% of people in a block group identify as AIANALN, the block group has twice the proportion of AIANALN individuals compared to the Northern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then AIANALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Northern California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Northern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Northern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Northern California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Northern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Northern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Northern California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Northern California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 8: *Exceptionally high*. The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto

Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of AIANALN population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Northern California RRR boundary. The resulting 1,207 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: NorCal_AIANALN_2020_202401_T2_v5.tif

NORCAL - HISPANIC/LATINO POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Northern California region’s Hispanic/Latino population. The variable HISPANIC records all individuals who select Hispanic or Latino in response to the Census questionnaire, regardless of their response to the racial identity question.

“Relative concentration” is a measure that compares the proportion of population within each Census block group data unit that identify as Hispanic or LatinoAmerican Indian / Alaska Native alone to the proportion of all people that live within the 1,207 block groups in the Northern California RRK region that identify as Hispanic or LatinoAmerican Indian / Alaska native alone. Example: if 5.2% of people in a block group identify as HISPANIC, the block group has twice the proportion of HISPANIC individuals compared to the Northern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then HISPANIC individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Northern California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Northern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Northern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Northern California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Northern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Northern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Northern California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Northern

California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%)

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of HISPANIC population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Northern California RRK boundary. The resulting 1,207 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 1,207 Census block groups within or intersecting the Northern California RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: NorCal_HISPANIC_2020_202401_T2_v5.tif

NORCAL - BLACK/AFRICAN AMERICAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Northern California region's Black/African American population. The variable BLACKALN records all individuals who select black or African American as their SOLE racial identity in response to the Census questionnaire, regardless of their response to the Hispanic ethnicity question. Both Hispanic and non-Hispanic in the Census questionnaire are potentially associated with black race alone.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as Black/African American alone to the proportion of all people that live within the 1,207 block groups in the Northern California RRK region that identify as Black/African American alone. Example: if 5.2% of people in a block group identify as BLACKALN, the block group has twice the proportion of BLACKALN individuals compared to the Northern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then BLACKALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Northern California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Northern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Northern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Northern California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Northern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Northern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Northern California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Northern California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 8: *Exceptionally high*. The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of BLACKALN population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Northern California RRR boundary. The resulting 1,207 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that

depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 1,207 Census block groups within or intersecting the Northern California RRR region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: NorCal_BLACKALN_2020_202401_T2_v5.tif

NORCAL - HISPANIC AND/OR BLACK, INDIGENOUS OR PERSON OF COLOR (HSPBPOC)

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Northern California region's Hispanic and/or Black, Indigenous or person of color (HSPBPOC) population. The variable HSPBPOC is equivalent to all individuals who select a combination of racial and ethnic identity in response to the Census questionnaire EXCEPT those who select "not Hispanic" for the ethnic identity question, and "white race alone" for the racial identity question. This is the most encompassing possible definition of racial and ethnic identities that may be associated with historic underservice by agencies, or be more likely to express environmental justice concerns (as compared to predominantly non-Hispanic white communities). Until 2021, federal agency guidance for considering environmental justice impacts of proposed actions focused on how the actions affected "racial or ethnic minorities." "Racial minority" is an increasingly meaningless concept in the USA, and particularly so in California, where only about 3/8 of the state's population identifies as non-Hispanic and white race alone - a clear majority of Californians identify as Hispanic and/or not white. Because many federal and state map screening tools continue to rely on "minority population" as an indicator for flagging potentially vulnerable / disadvantaged/ underserved populations, our analysis includes the variable HSPBPOC which is effectively "all minority" population according to the now outdated federal environmental justice direction. A more meaningful analysis for the potential impact of forest management actions on specific populations considers racial or ethnic populations individually: e.g., all

people identifying as Hispanic regardless of race; all people identifying as American Indian, regardless of Hispanic ethnicity; etc.

“Relative concentration” is a measure that compares the proportion of population within each Census block group data unit that identify as HSPBIPOC alone to the proportion of all people that live within the 1,207 block groups in the Northern California RRK region that identify as HSPBIPOC alone. Example: if 5.2% of people in a block group identify as HSPBIPOC, the block group has twice the proportion of HSPBIPOC individuals compared to the Northern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then HSPBIPOC individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Northern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Northern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Northern California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Northern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Northern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Northern California region population in total

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto

Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of HSPBIPOC population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Northern California RRK boundary. The resulting 1,207 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from [census.data.gov](https://www.census.gov) and joined to TIGER Census block group features. There are 1,207 Census block groups within or intersecting the Northern California RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the [Data.Census.Gov](https://data.census.gov) web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: NorCal_HSPBIPOC_2020_202401_T2_v5.tif

NORCAL - ASIAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Northern California region’s Asian American population. The variable ASIANALN records all individuals who select Asian as their SOLE racial identity in response to the Census questionnaire, regardless of their response to the Hispanic ethnicity question. Both Hispanic and non-Hispanic in the Census questionnaire are potentially associated with the Asian race alone.

“Relative concentration” is a measure that compares the proportion of population within each Census block group data unit that identify as ASIANALN alone to the proportion of all people that live within the 1,207 block groups in the Northern California RRK region that identify as ASIANALN alone. Example: if 5.2% of people in a block group identify as HSPBIPOC, the block group has twice the proportion of ASIANALN individuals compared to the Northern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then ASIANALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Northern California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Northern California region population in total
- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Northern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Northern California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Northern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Northern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Northern California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Northern

California region population in total (the upper limit is determined by natural breaks, if exceptional outliers are present, but is typically over 6 times (600%)

- Class Code 8: *Exceptionally high*. The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region

Creation Method: Data reporting units are Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Note; 1) The pixels attributed with a categorical data unit describing the relative concentration of ASIANALN population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Northern California RRR boundary. The resulting 1,207 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data were derived from the 2020 Census Total population for the block group from the redistricting file (PL 94-171) of the 2020 Census, released summer 2021. The raw data were obtained directly from the Census Bureau data set table named in "Origin"; all data sets downloaded from census.data.gov and joined to TIGER Census block group features. There are 1,207 Census block groups within or intersecting the Northern California RRK region boundary.

Data Source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above)

File Name: NorCal_ASIANALN_2020_202401_T2_v5.tif

NORCAL - LOW INCOME POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the estimated number of people in the Northern California region that live in a household defined as "low income." There are multiple ways to define low income. These data apply the most common standard: low income population consists of all members of households that collectively have income less than twice the federal poverty threshold that applies to their household type. Household type refers to the household's resident composition: the number of independent adults plus dependents that can be of any age, from children to elderly. For example, a household with four people – one working adult parent and three dependent children – has a different poverty threshold than a household comprised of four unrelated independent adults.

Due to high estimate uncertainty for many block group estimates of the number of people living in low income households, some records cannot be reliably assigned a class and class code comparable to those assigned to race/ethnicity data from the decennial Census.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit to the proportion of all people that live within the 1,207 block groups in the Northern California RRK region. See the "Data Units" description below for how these relative concentrations are broken into categories in this "low income" metric.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Northern California region population in total
- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Northern California region population in total

- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Northern California region population in total
- Class Code 3: *Proportionate*. The subject population concentration is roughly proportionate to the corresponding proportion in the Northern California region population in total - from about 85% to 115% of the regional proportion
- Class Code 4: *Somewhat high*. The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Northern California region population in total
- Class Code 5: *High*. The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Northern California region population in total
- Class Code 6: *Very high*. The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Northern California region population in total
- Class Code 7: *Extremely high*. The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Northern California region population in total (the upper limit is determined by natural breaks if exceptional outliers are present, but is typically over 6 times (600%))
- Class Code 8: *Exceptionally high*. The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region
- Class Code 9: *Unclassifiable*. The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Creation Method: Data are reported in Census block groups. Standard block groups are clusters of Census blocks within the same census tract that have the same first digit of their 4-character census block number (e.g., Blocks 3001, 3002, 3003 to 3999 in census tract 1210.02 belong to block group 3). Block groups delineated for the 2020 Census generally contain 600 to 3,000 people.

Census blocks are statistical areas bounded on all sides by visible features (e.g., streets, roads, streams, and railroad tracks), and by non-visible boundaries (e.g., city, town, township, county limits, and short line-of-sight extensions of streets and roads). Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features (e.g., roads, streams, and/or transmission line rights-of-way). In remote areas, census blocks may encompass hundreds of square miles. Census blocks cover all territory in the United States, Puerto Rico, and the Island areas. Blocks do not cross the boundaries of any entity for which the Census Bureau tabulates data. See note 1.

Data describing concentrations of population characteristics that are potentially related to environmental justice issues were provided to CWI through a collaboration with the USDA Forest Service, Geospatial Technology and

Applications Center. The concentration methodology was created by GTAC for social science analysis applications within the Forest Service; it is based on research published in 2018 and 2020 (See Note 2). Data were compiled and prepared for incorporating in the Task Force regions by Mark Adams, Geographer, USFS-GTAC. For more information, contact: mark.adams1@usda.gov.

Notes: The pixels attributed with a categorical data unit describing the relative concentration of AIANALN population are derived from a vector polygon feature that has been modified as follows: Census block groups from the Census Bureau's TIGER/Line geodatabase features for 2021 are selected based on their spatial intersection with the Northern California RRR boundary. The resulting 1,207 block group features are modified by first erasing from the feature the area of all constituent Census blocks which have neither housing nor population recorded in the PL-94171 Redistricting dataset for 2020. In a second step, areas of federal and state public lands on which housing by definition is not located are erased from the interim feature. The result is a block group feature that depicts to the maximum practicable extent the areas within the block group where people that are represented by the Census Bureau's Census count could actually be residing. It is this modified block group feature that has been rasterized to match the 30m pixel grid that all biophysical datasets are reported in.

References for the concentration levels analysis:

- Adams, Mark D. O. and S. Charnley. 2020. The Environmental Justice Implications of Managing Hazardous Fuels on Federal Forest Lands, *Annals of the American Association of Geographers*, 110:6, 1907-1935, DOI: 10.1080/24694452.2020.1727307

- Adams, Mark D. O. and S. Charnley. 2018. Environmental justice and U.S. Forest Service hazardous fuels reduction: A spatial method for impact assessment of federal resource management actions. <https://doi.org/10.1016/j.apgeog.2017.12.014>

Data Source: U.S. Department of Commerce, Census Bureau, 2020 American Community Survey 5-Year Survey Estimates.

Data estimating household income as a percent of the applicable federal poverty threshold are reported in Table C17002 of the 2020 ACS 5-year data. Estimates of population living in low income households were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units below). Table C17002 provides estimates and error margins for total population living in households with income, and population by ratio of income to applicable poverty: 50% of poverty, 50-99%, etc. Additional calculations are performed to generate an estimate for all people in households with income less than 200% of applicable poverty.

FMI: <https://www.census.gov/newsroom/press-releases/2022/acs-5-year-estimates.html>

File Name: NorCal_LowIncome_2020_202401_T2_v5.tif

RECREATION QUALITY

TRAIL DENSITY

Tier: 2

Data Vintage: 2023

Metric Definition and Relevance: A raster dataset representing density of trails in the Southern California Region.

Data Resolution: 30m Raster

Data Units: km/km² of trails

Creation Method: This dataset represents the density of trails across the landscape, measured as km/km² of trails. The information was derived from the OpenStreetMap data and includes footways, cycleways, pedestrian paths, service roads, paths, tracks, and unclassified features. Based on local knowledge, inclusion of these different categories was required to capture the majority of popular hiking destinations including authorized and unauthorized routes.

Data Source: San Diego State University CWC Project Team

File Name: SoCal_TrailDensity_2023_202312_T2_v5.tif

WATER SECURITY

Forests serve as natural water collection, storage, filtration, and delivery systems as water flows from forests into rivers providing critical aquatic and wetland habitat, while also supplying water for drinking and agriculture. From a more mechanistic perspective, the energy and water balance of forest ecosystems are fundamentally linked. Water is essential to photosynthesis and the latent energy exchange of transpiration is a major driver of water loss. In short, the fate of forests directly influences the quantity and quality of California's freshwater supply.

DESIRED OUTCOME: Watersheds provide a reliable supply of clean water despite wide swings in annual precipitation, droughts, flooding, and wildfire.

QUANTITY

Understanding the interaction between water supply and ecosystem demand informs both the extent of moisture stress and the amount of water available for storage.

ACTUAL EVAPOTRANSPIRATION TO PRECIPITATION FRACTION DURING DROUGHT

Tier: 1

Data Vintage: 09/2021

Metric Definition and Relevance: Plants respond to conditions in their immediate vicinity. Thus, to understand the vegetative moisture stress during drought, it is important to measure the local moisture balance. The actual evapotranspiration fraction (AETF) provides such a measure. Specifically, it indicates whether a location is expected to experience local drying during a drought, or whether the location receives sufficient precipitation that it will remain moist even during an extended drought. An extended drought is defined by a 48-month period where the Standardized Precipitation Index (SPI, NCAR 2022) is two standard deviations below the long-term mean (SPI-48 = negative 2). The AETF ranges from 0 to > 1; a low value indicates a wetter location during drought and a high value indicates a drier location. Locations <1 would be expected to generate runoff, even during a significant drought (SPI-48 drought = negative 2.0), and would be expected to continue generating runoff. Locations > 1 would be expected to desiccate the soil during drought, with negligible runoff, and increasing vegetation drought stress. AET/P does not account for lateral water inflow, either as runoff or irrigation.

Data Resolution: 30m Raster

Data Units: Dimensionless fraction (AET in mm/P in mm).

Creation Method: Calculated as the ratio of actual evapotranspiration (AET) during 2021 Water Year (WY) and precipitation that would be expected for each pixel under a significant drought (SPI-48 drought = negative 2.0). AET is calculated based on Landsat observations and eddy covariance, along with information on local monthly irradiance that accounts for Top of Atmosphere and topographic effects. The AET calculated for 2021 is then divided by the precipitation that would be expected for each pixel under a significant drought (SPI-48 drought = negative 2.0). This quantity of precipitation is calculated for each pixel based on local, down-scaled PRISM data for 1991-2020. This fraction provides a measure of the local water balance during drought, with the higher values indicating a drier location. See <https://doi.org/10.1029/2012JG002027> and <https://doi.org/10.1073/pnas.1319316111> for further information.

Data Source: CECS; <https://california-ecosystem-climate.solutions/>

File Name: WaterFlux_AETFrac_202109_202312_T1_v5.tif

PRECIPITATION MINUS ACTUAL EVAPOTRANSPIRATION DURING AVERAGE CONDITIONS

Tier: 1

Data Vintage: 09/2021

Metric Definition and Relevance: Runoff is a measure of the water available for storage. It is determined by both the water supply and the demand of the existing vegetation. Annual mean runoff measures the “average” vegetative demand and thus provides a comparative index on the potential available runoff. Specifically, Annual Mean Runoff is the expected surplus water that would discharge to surface or groundwater flows during a series of years with average precipitation. Larger values indicate more runoff under mean conditions.

Data Resolution: 30m Raster

Data Units: mm/y

Creation Method: The Center for Ecosystem Climate Solutions at UC Irvine (CECS) is working with the State and Federal governments in developing scientifically rigorous, stakeholder-informed methods that have produced tailored, integrated data for land management decision makers. The CECS DataEngine model tracks monthly water balance from 1986 to 2021. The Annual Mean Runoff layer is calculated using this CECS DataEngine model logic forced with a series of 4 years that each received precipitation according to the timing and magnitude of the 30-year climate Normal Precipitation (SPI = 0 by definition).

The model water inputs are determined from downscaled PRISM gridded datasets (<https://prism.oregonstate.edu/>). In the case of the Annual Mean Runoff, this reflects the monthly 30 year Normal for each pixel calculated for 1991-2020. Actual evapotranspiration (AET) is calculated from Landsat observations and eddy covariance during 2021, along with information on local monthly irradiance that accounts for Top of Atmosphere (TOA) and topographic effects, as well as monthly temperature and drought stress. Precipitation Minus Actual Evapotranspiration is calculated as the difference; it provides an excellent measure of the long-term runoff from upland pixels. Areas with a higher P-ET produce greater runoff, and areas with a low P-ET tend to produce little or no runoff during average or dry years. See <https://doi.org/10.1029/2012JG002027> and <https://doi.org/10.1073/pnas.1319316111> for further information.

Data Source: CECS; <https://california-ecosystem-climate.solutions/>

File Name: WaterFlux_Runoff_202109_202312_T1_v5.tif

DROUGHT SENSITIVITY

Tier: 3

Data Vintage: 2018

Metric Definition and Relevance: This layer represents an estimation of the probability that drought will substantially impact post-fire shrub recovery, potentially leading to vegetation type conversion to invasive grasses and forbs. This type conversion may increase the risk of fire ignition and fire spread. It is only available for the Southern California Region.

Data Resolution: 30m Raster

Data Units: Relative index, low to high

Creation Method: These data are based on estimates of change in canopy cover over the period 1984-2018 from satellite data, and includes some areas that have already degraded, but mostly areas predicted to change in future drought episodes.

Specifically, this data set portrays estimates of the probability that absolute shrub cover will decline substantially (up to 30 percent) as a result of failed vegetation recovery consequential of drought. This drought sensitivity index is based on estimates of change in shrub cover between the periods 1984–1989 and 2014–2018, which were derived from June-solstice Landsat Normalized Difference Vegetation Index (NDVI) image time series (source: espa.cr.usgs.gov). These 30-m spatial resolution estimates of change in fractional cover were sampled randomly based on 491 points located within chaparral areas that burned only once during the period 1984–2018, and therefore were not subject to the potential impacts of repeated (short-interval) fires upon seed production or resprouting vigor.

Credits: Emanuel Storey, Ph. D; San Diego State University's Connecting Wildlands and Communities Project Team

Data Source: San Diego State University CWC Project Team

File Name: SoCal_DroughtSensitivity_2018_202312_T3_v5.tif

CHANGE IN AVERAGE CLIMATIC WATER DEFICIT

Tier: 3

Data Vintage: 2022

Metric Definition and Relevance: Change in Average Annual Climatic Water Deficit - Near Future - Drier. This raster dataset represents a projection of the difference in the mean annual climatic water deficit between the baseline period (1950-1980), and a near future period (2030-2059) under the MIROC (Drier) scenario of climate change. It is only available for the Southern California Region.

Data Resolution: 30m Raster

Data Units: mm

Creation Method: The climate variable in this layer is the change in average annual accumulated climatic water deficit relative to a baseline period. Climatic water deficit (CWD) measures the evaporative demand that exceeds available water, reflecting the impacts of available water or drought stress on plants. Higher CWD indicates a higher level of drought stress.

Baseline annual accumulated CWD was averaged between 1950-1980

Near Future shows the average change in CWD as modeled for 2030-2059

Drier future projections were generated using the MIROC5 climate model under the business as usual RCP 8.5.

Data Source: San Diego State University; Connecting Wildlands and Communities Project Team

File Name: SoCal_ChangeAvgAnnCWD_2022_202312_T3_v5.tif

GROUNDWATER BASIN BOUNDARIES

Tier: 3

Data Vintage: 02/2022

Metric Definition and Relevance: This dataset shows the boundaries of groundwater basins and subbasins as defined by the California Department of Water Resources as last modified by the Basin Boundary Emergency Regulation adopted on October 21, 2015 and subsequent modifications requested through the Basin Boundary Modification Request Process.

Data Resolution: 30m raster

Data Units: Binary

Creation Method: Groundwater basins are represented as polygon features and designated on the basis of geological and hydrological conditions - usually the occurrence of alluvial or unconsolidated deposits. When practical, large basins are also subdivided by political boundaries, as in the Central Valley. Basins are named and numbered per the convention of the Department of Water Resources.

Data Source: California Department of Water Resources

https://gis.water.ca.gov/arcgis/rest/services/Geoscientific/i08_B118_CA_GroundwaterBasins/FeatureServer

File Name: GroundwaterBasins_202202_202312_T3_v5.tif

QUALITY

Understanding the interaction between water supply and ecosystem demand informs both the extent of moisture stress and the amount of water available for storage.

PERCENT IMPERVIOUS SURFACE

Tier: 1

Data Vintage: 06/2019

Metric Definition and Relevance: This National Land Cover Database (NLCD) product represents urban impervious surfaces as a percentage of developed surface over every 30-meter pixel of California, extracted from a nationwide layer. The definition of impervious means water does not seep into the ground, it runs off into storm sewers and then into local creeks. Examples of impervious surfaces include highways, streets and pavement, driveways, and house roofs. The relevance of impervious surfaces is the higher the proportion of impervious surfaces the more likely flooding can occur.

Data Resolution: 30m Raster

Data Units: Percent Imperviousness

Creation Method: The NLCD 2019 design aims to provide consistent and robust methodologies for production of a multi-temporal land cover and land cover change database from 2001 to 2019 at 2–3-year intervals.

Comprehensive research was conducted and resulted in developed strategies for NLCD 2019: continued integration between impervious surface and all landcover products with impervious surface being directly mapped as developed classes in the landcover, a streamlined compositing process for assembling and preprocessing based on Landsat imagery and geospatial ancillary datasets; a multi-source integrated training data development and decision-tree based land cover classifications; a temporally, spectrally, and spatially integrated land cover change analysis strategy; a hierarchical theme-based post-classification and integration protocol for generating land cover and change products; a continuous fields biophysical parameters modeling method; and an automated scripted operational system for the NLCD 2019 production. For information see [Data | Multi-Resolution Land Characteristics \(MRLC\) Consortium](#)

Data Source: National Land Cover Database (NLCD)

File Name: PrctImperviousSurface_2019_202312_T1_v5.tif

WETLAND INTEGRITY

Wetlands provide critical habitat, store carbon, enhance water quality, control erosion, filter and retain nutrient pollution, and provide spaces for recreation. They are local and regional centers of biodiversity, and support species found nowhere else across western landscapes. Functional wetland ecosystems will serve increasingly important roles in buffering impacts from extreme climate events, and upland disturbances such as flooding and erosion. Meadow and riparian ecosystems provide ecosystem services and are key linkages between upland and aquatic systems in forested landscapes.

DESIRED OUTCOME: Wetland ecosystems are biologically intact, provide multiple ecosystem services, and meadow and riparian ecosystems provide key linkages between upland and aquatic systems in forested landscapes.

HYDROLOGIC FUNCTION

MEADOW SENSITIVITY INDEX

Tier: 2

Data Vintage: 2019

Metric Definition and Relevance: Sensitivity is a measure of the slope of the relationship between April 1st Snowpack and September vegetation wetness (Normalized Difference Water Index; NDWI). Data is based on percentile rank for the study region.

The purpose of this dataset is to be used in conjunction with the decision framework: Gross, S., M. McClure, C. Albano, and B. Estes. 2019. *A spatially explicit meadow vulnerability decision framework to prioritize meadows for restoration and conservation in the context of climate change. Version 1*. The decision framework and this dataset

can aid in the prioritization of meadow conservation and restoration in the context of other priorities in the Sierra Nevada and Cascade ranges in California.

Data Resolution: 30m raster

Data Units: Relative index

Creation Method: This dataset was developed based on Albano et. al. 2019 and is a spatially explicit vulnerability assessment for the meadows in the Sierra Nevada ecoregion based on water availability and stress. By joining the climate vulnerability point layer on ID to the Sierra Nevada Multi-source Meadow Polygon Compilation layer, the meadow polygons that had values for the Sensitivity Index (SensNDWI) were selected and converted to raster.

Data Source: Center for Watershed Sciences, UC Davis – see [Meadows](#)

File Name: MeadowSensIndex_2019_202209_T2_v5.tif

COMPOSITION

Wetland composition pertains to the array of different wetland types, their relative abundance, the uniqueness of their co-occurrence and composition, and their integrity in a given location and area within and across landscapes. Wetland ecosystems include all lentic (e.g. lakes, ponds, bogs, fens) and lotic (e.g., rivers, streams, springs, seeps) aquatic ecosystems, as well as associated vegetated wetlands such as wet meadows and riparian vegetation.

AQUATIC SPECIES RICHNESS

Tier: 1

Data Vintage: 02/2018

Metric Definition and Relevance: Aquatic native species richness is a measure of species biodiversity, and is one measurement used to describe the distribution of overall species biodiversity in California for the California Department of Fish and Wildlife (CDFW) Areas of Conservation Emphasis Project (ACE). Native species richness represents a count of the total number of native aquatic species potentially present in each watershed based on species range and distribution information. The data can be used to view patterns of species diversity, and to identify areas of highest native richness across the state. The species count consists of four taxonomic groups – fish, aquatic invertebrates, aquatic amphibians, and aquatic reptiles.

Data Resolution: 30m Raster

Data Units: Count

Creation Method: For more information, see the Aquatic Native Species Richness Factsheet (2018) at <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=150852>

The California Department of Fish and Wildlife (CDFW) Areas of Conservation Emphasis (ACE) is a compilation and analysis of the best-available statewide spatial information in California on biodiversity, rarity and endemism, harvested species, significant habitats, connectivity and wildlife movement, climate vulnerability, climate refugia, and other relevant data (e.g., other conservation priorities such as those identified in the State Wildlife Action Plan (SWAP), stressors, land ownership). ACE addresses both terrestrial and aquatic data.

Data Source:

Aquatic Native Species Richness Summary, Areas of Conservation Emphasis (ACE), version 3.0, California
Department of Fish and Wildlife (CDFW)
ACE database

File Name: AquaticSpecRichness_201802_202209_T1_v5.tif

WETLAND DIVERSITY

Tier: 1

Data Vintage: 06/2018

Metric Definition and Relevance: This data set represents the extent, approximate location, and type of wetlands and deepwater habitats in California. These data delineate the areal extent of wetlands and surface waters as defined by Cowardin et al. (1979).

Data Resolution: 30m raster

Data Units: Thematic

Creation Method: Downloaded from the National Wetlands Inventory (NWI), polygon converted to 30 meter raster. For more information see <https://www.fws.gov/program/national-wetlands-inventory>.

Definition of values:

- Lake = Lake or reservoir basin. Lacustrine wetland and deepwater (L).
- Freshwater Emergent Wetland = Herbaceous marsh, fen, swale and wet meadow. Palustrine emergent (PEM).
- Estuarine and Marine Wetland = Vegetated and non-vegetated brackish and saltwater marsh, shrubs, beach, bar, shoal or flat. Estuarine intertidal and Marine intertidal wetland (E2, M2).
- Other = Farmed wetland, saline seep and other miscellaneous wetland. Palustrine wetland (Misc. types, PUS, Pf..)
- Freshwater Pond = Pond. Palustrine unconsolidated bottom, Palustrine aquatic bed (PUB, PAB).
- Estuarine and Marine Deepwater = Open water estuary, bay, sound, open ocean. Estuarine and Marine subtidal water (E1, M1).
- Riverine = River or stream channel. Riverine wetland and deepwater (R).
- Freshwater Forested/Shrub Wetland = Forested swamp or wetland shrub bog or wetland. Palustrine forested and/or Palustrine shrub (PFO, PSS).

Data Source: The National Wetlands Inventory, US Fish & Wildlife Service (USFWS)

File Name: WetlandDiversity_2018_202209_T1_v5.tif

RIPARIAN HABITAT

Tier: 1

Data vintage: 04/2019

Metric Definition and Relevance: These data depict 10-meter raster riparian areas for 50-year flood heights for California in 2019.

Data Resolution: 10m Raster

Data Units: binary

Creation Method: Fifty-year flood heights were estimated using U.S. Geological Survey (USGS) stream gage information. NHDPlus version 2.1 was used as the hydrologic framework to delineate riparian areas. The U.S. Fish and Wildlife Service’s National Wetland Inventory and USGS 10-meter digital elevation models were also used in processing these data. See <https://doi.org/10.2737/RDS-2019-0030>

Credits: Sinan Abood, Ph.D. GISP; Research Scientist, Forest Service Washington Office (WO) – Biological & Physical Resources (BPR)

Data Source: USDA Forest Service

File Name: RiparianHab_201904_202209_T1_v5.tif

OPERATIONAL DATA LAYERS

In addition to the metric data layers assembled for this California Landscape Metrics project, a set of “operational” GIS data layers have been assembled to support use of the metrics. These data provide land use context (e.g. ownership, land use designations, background ecological information (e.g. climate refugia, stream locations, climate classes), infrastructure (roads, operational constraints, powerline corridors), and Forest Service policy information (spotted owl PACs, critical habitat maps for listed species, wilderness/roadless/wild and scenic rivers). These data are provided to assist managers in putting proposed treatments into context for what is feasible and what might constrain project planning.

Data layers provided within this designation of operational data are in their native projection and format with any embedded metadata maintained.

FIRE

RECENT FIRE SEVERITY CLASS

Data Vintage: 2012 - 2021

Metric Definition and Relevance: Fire severity classification (low, moderate, high) that burned within the last 10 years (2012-2021).

Data Resolution: 30m raster

Data Units: Value, 1 to 3

Creation Method: The difference-adjusted relativized difference normalized burn ratio (RdNBR) was calculated using methods modified from Parks et al (2018). Fire perimeters were obtained from CAL FIRE’s April 2021 fire perimeter database. A function for estimating basal area loss from RdNBR values was fit to data from Miller et al (2009) using quasibinomial logistic regression and applied to the 2012-2021 fires. Estimated basal area loss was thresholded to represent low (< 25% loss), moderate (25% – 75% loss), and high (> 75% loss) burn severity. For areas where multiple sequential fires burned from 2012-2021 the maximum burn severity is reported. Updated April 2023 to incorporate CAL FIRE’s October-2022 revisions to fire perimeters and to minimize data loss resulting from spatial reprojection.

- 1: Low Severity
- 2: Moderate Severity
- 3: High Severity

Data Source:

- Joe Stewart, UC Davis
- Fire History (April 2022), CAL FIRE
- Landsat 8, NASA
- Postfire mortality data, Miller et al. 2009

File Name: fire_severity_class_max_2012to2021_all_CA_v2.tif

HOUSING UNIT DENSITY

Data Vintage: 01/2020

Metric Definition and Relevance: HUDen is a raster of housing-unit density measured in housing units per square kilometer. The HUDen raster was generated using population and housing-unit count and data from the U.S. Census Bureau, building footprint data from Microsoft, and land cover data from LANDFIRE.

Data Resolution: 30m Raster

Data Units: Housing units per square kilometer

Creation Method: Generate the HUDen raster from the building points. We first converted the building points to a 30-m raster where the raster value is the sum of the housing-units-per-centroid attribute of all building centroids within each raster grid cell. We then generated a smoothed density raster using a three-step process: 1) calculate a 200-m radius moving-window sum of the 30-m housing-unit count raster; 2) calculate a 200-m radius moving-window sum of habitable land cover (in sq km), where habitable land cover is all land covers except open water and permanent-snow/ice; and 3) divide the smoothed housing-unit count raster by the smoothed habitable land cover raster to generate housing unit density in housing units/sq km. To produce the final integer version of the HUDen raster, we set values less than 0.1 HU/sq km to zero, values between 0.1 and 1.5 to a value of 1 HU/sq km, and rounded all other values to the nearest integer.

Data Source: Pyrologix, LLC

File Name: HUden_2020.tif

POTENTIAL OPERATIONAL DELINEATIONS

Data Vintage: 07/2022

Metric Definition and Relevance: This vector dataset represents Potential Operational Delineations, or PODs, for the Northern California Region of California. PODs are mapped polygons whose boundary features are relevant to fire control operations (e.g., roads, ridgetops, and water bodies). These PODs were developed using funding from the California Department of Conservation Regional Forest and Fire Capacity Program awarded to the Northern California Resource Partnership.

Please note, creating and refining this NCRP PODs layer is an on-going, iterative process. The PODs layer for the NCRP is NOT an authoritative dataset, and is currently a working draft. This layer needs further review, both in GIS

and in the field. Specifically, since this layer could be used during wildfires with limited time frames for cultural review, it is imperative that this layer not be used to guide suppression actions without prior Tribal input. It is intended to be used as a risk management and planning tool for wildfire suppression, prescribed and cultural fire, and hazardous fuels mitigation.

Potential Operational Delineations, or PODs, are a spatial tool for fire planning and wildfire prevention. They are being developed regionally across the United States.

PODs are a network of connected features across a landscape that are relevant for fire control operations. This includes a network of roads, ridgetops, riparian areas, and other fuel breaks. PODs provide land managers a formal process for developing landscape-scale wildfire response options before fires start, because they outline where the best potential locations are to contain fire and create management units.

Data Resolution: File Geodatabase Polygon Feature Class

Data Units: The main attribute of note in the dataset is the field called “PODEditor”. There are three attribute values, “Workshop”, “USFS” and “NCRP- Not Part of a POD”. PODs that were created from the workshops hosted by the NCRP are labeled “Workshop”, PODs submitted by the Forest Service and unchanged from the workshops are labeled “USFS” and PODs that are used to fill in the NCRP region, such as coastline slivers, but are not relevant for fire control operations are called “NCRP-Not Part of a POD”.

Creation Method:

PODs are created by drawing a lattice of connecting lines through geographic features that could be suitable for fire operations. This is best accomplished through in-person meetings with regional experts discussing the pros and cons of different control features and drawing on physical maps. From December 2021-May 2022, the NCRP hosted several workshops across the Northern California Region to solicit input on the PODs dataset. These workshops included representatives from the following organizations:

- CAL FIRE
- Local Fire Departments
- United States Forest Service
- The Watershed Training Center
- Several Fire Safe Councils
- Timber Industry Representatives
- County Government Officials
- Tribal Representatives
- Cooperative Extension Specialists
- Land Trusts
- Resource Conservation District (RCD) Representatives

The basemaps that the PODs are drawn on use various wildfire planning models to help guide the best location for the PODs. The foundational datasets used included:

1. Suppression Difficulty Index, or SDI, is a quantitative rating of relative difficulty in performing fire control work. Factors include topography, fuels, expected fire behavior under severe fire weather conditions, firefighter line production rates in various fuel types, and accessibility
2. Potential Control Locations, or PCLs, show the probability of a point or feature on a landscape being successfully used as a containment point for large wildfires. PCLs are developed through similar data inputs as the SDI with special attention to proximity to fire stations and response time.

In addition, PODs have been created by partners at the USDA Forest Service. The team integrated existing PODs from the Mendocino National Forest, Six Rivers National Forest, and Modoc National Forest into the basemaps to give workshop attendees the chance to review and refine existing PODs.

While this dataset was drafted to cover the North Coast Resource Partnership (NCRP) region, the PODs are built out beyond the boundaries of the NCRP.

Data Source: North Coast Resource Partnership (NCRP), Oregon State University, Mid Klamath Watershed Council, Western Klamath Restoration Partnership, Tukman Geospatial LLC

File Name: PODs.shp

WILDLAND URBAN INTERFACE

Data Vintage: 03/2022

Metric Definition and Relevance: The wildland urban interface (WUI) is the area where urban development is in close proximity to wildland vegetation. WUI data for the conterminous U.S. based on 125 million building locations where buildings intermingle with or abut wildland vegetation according to the Federal Register definitions of the WUI. According to the definitions used for our building-based maps and for the census-based maps, WUI is where building density exceeds 6.17 units/km² and where land cover is either (1) at least 50% wildland vegetation (intermix) or (2) under 50% wildland vegetation but within 2.4 km (1.5 miles) of a patch of wildland vegetation at least 5 km² in area that contains at least 75% vegetation (interface). The distance selected for the interface definition is based on research from the California Fire Alliance suggesting that this is the average distance firebrands can travel from an active wildfire front (Stewart et al., 2007).

Data Resolution: 30m Raster

Data Units: Categorical

Creation Method: Building point locations were obtained from a Microsoft product released in 2018, updated to 2019-2020 for most of California, which classified building footprints based on high-resolution satellite imagery. Maps were also based on wildland vegetation mapped by the 2016 National Land Cover Dataset (Yang et al., 2018). The mapping algorithm utilized definitions of the WUI from the U.S. Federal Register (USDA & USDI, 2001) and Radeloff et al. (2005). Both classes required a minimum building density of 6.17 buildings per km². This map of intermix and interface WUI was generated using a circular neighborhood size based on radius distance of 100m to

determine building density and vegetation cover on a pixel-by-pixel basis (Bar Massada et al., 2013). Source: USGS ScienceBase Data Catalog; <https://www.sciencebase.gov/catalog/item/617bfb43d34ea58c3c70038f>

Values in the raster are defined as:

- 0: Not WUI
- 1: Intermix WUI
- 2: Interface WUI

Data Source: WUI, Carlson et al, 2022

File Name: MSB_WUI_CA_100m.tif

ADMINISTRATIVE

LAND DESIGNATIONS

Definition and Relevance: Wilderness, Roadless, Wild and Scenic River

Data Vintage: 01/2023

Data Resolution: ArcGIS file geodatabase: Vector, polygon

Data Units: Tabular attributes

Creation Method: Data layers pulled from the Enterprise Data Warehouse for land designations:

- *Wilderness* – area designated as a National Wilderness in the National Wilderness Preservation System
- *Inventoried Roadless Areas* – the 2001 Roadless Rule establishes prohibitions on road construction, road reconstruction, and timber harvesting on inventoried roadless areas on National Forest System lands by the following classifications:
 - 1B = Inventoried Roadless Areas where road construction and reconstruction is prohibited
 - 1B-1 = Inventoried Roadless Areas that are recommended for wilderness designation in the forest plan and where road construction and reconstruction is prohibited
 - 1C = Inventoried Roadless Areas where road construction and reconstruction is not prohibited
- *Wild and Scenic Rivers* – area designated as a National Wild, Scenic, or Recreational River within the National Wild and Scenic River System. The designations and definitions are:
 - Wild (W) – Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.
 - Scenic (S) – Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.
 - Recreational (R) – Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

Data Source: USFS Enterprise Data Warehouse (EDW)

File Name: Wilderness_2023.shp; RoadlessArea_2001.shp; WildScenicRiver_2023.shp

OWNERSHIP

Definition and Relevance: Ownership is a commonly used base layer used in a wide range of business functions and these data are intended to provide a depiction of the land ownership within the CLM project area.

Data Vintage: FS_BasicOwnership: 01/2023, ownership: 05/2022

Data Resolution: Vector, polygon

Data Units: Tabular attributes

Creation Method:

- *FS_BasicOwnership_2023.shp* – an area depicted as surface ownership parcels dissolved on the same ownership classification administered by the USDA Forest Service (USFS).
- *ownership22_1* – California Multi-Source Land Ownership, includes lands owned by each federal agency (including USFS), state agency, local government entities, conservation organizations, and special districts. It does not include lands of private ownership.

Data Source: USDA Forest Service, CAL FIRE

File Name: FS_BasicOwnership_2023.shp; ownership22_1.shp

URBAN-AGRICULTURE LAND USE

Definition and Relevance: This dataset covers the urban and agricultural landscape for all forms of urban and agricultural land use in California. It was created using a combination of best available land cover data from multiple sources (see below). These data are used as a mask for selected metrics in the CLM project where inclusion of urban and agricultural cover potentially creates confusion in calculations of the metric.

Data Vintage: 06/2020

Data Resolution: Raster, 30m

Data Units: Thematic

Creation Method:

1. [Farmland Mapping and Monitoring Program \(FMMP\)](#) land-use data from 2018 was converted to 30m raster as the base input, using the values from the Type field of:
 - Farmland of Statewide Importance
 - Unique Farmland
 - Farmland of Local Importance
 - Urban and Built-Up Land
 - Rural Residential Land
 - Confined Animal Agriculture
2. Secondly, to bring more current data in, [LANDFIRE 2020 Existing Vegetation Type \(EVT\)](#) from 2020 was converted to 30m raster, using the values from EVT group name of:
 - Developed-Low Intensity
 - Developed-Medium Intensity
 - Developed-High Intensity
 - Agriculture-Cultivated Crops and Irrigated Agriculture

3. Lastly, [Building Footprints - Bing Maps \(microsoft.com\)](#) polygons were converted to 30m raster and added to the stack to include the most recent urban footprints.

Data Source:

Farmland Mapping and Monitoring Program (FMMP)

LANDFIRE: Existing Vegetation Type, U.S. Department of Agriculture and U.S. Department of the Interior

MS Building Footprints

File Name: UrbanAgLanduse_RRK_2020.tif

BUILDING STRUCTURE DENSITY

Definition and Relevance: A raster dataset containing building footprints of California. The vintage of the footprints depends on the vintage of the underlying imagery. Bing Imagery is a composite of multiple sources with different capture dates.

Data Vintage: 2012-2020.

Data Resolution: Raster, 10m

Data Units: binary

Creation Method: Vector spatial data called US Building Footprints contained in a Microsoft dataset (available at <https://github.com/microsoft/USBuildingFootprints>) downloaded, clipped to California and converted to a 10m raster. For more information visit: [Building Footprints - Bing Maps \(microsoft.com\)](#)

Data Source: MS Building Footprints

File Name: CA_bldgFootprints_10m.tif

HIGH-USE RECREATION AREAS

Definition and Relevance: A recreation site is a discrete area on a National Forest that provides recreation opportunities, receives recreational use, and requires a management investment to operate and/or maintain to standard under the direction of an administrative unit in the National Forest System. Recreation sites range in development from relatively undeveloped areas, with little to no improvements (Development Scale 0 and 1), to concentrations of facilities and services evidencing a range of amenities and investment (Development Scale 2 through 5).

Recreation opportunities are point locations of recreational site activities available to visitors and populates the Forest Service websites (<https://www.fs.usda.gov/>), and the interactive visitor map (<https://www.fs.usda.gov/ivm/>).

Data Vintage: 01/2023

Data Resolution: Points

Data Units: Tabular attributes

Creation Method: see Metadata

Data Source: USFS Enterprise Data Warehouse (EDW)

File Name: RECAREAACTIVITIES_V_2023.shp

WILDERNESS - PROTECTED AREA DATABASE 3.0

Definition and Relevance: The PAD-US geodatabase was originally developed to organize and assess the management status (i.e. apply 'GAP Status Code') of elements of biodiversity protection by identifying species and plant communities not adequately represented in existing conservation lands (<https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap>). In cooperation with the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), PAD-US also supports global conservation analyses to inform policy decisions (<https://www.protectedplanet.net/country/USA> , <https://www.protectedplanet.net/en/resources/global-reports>). The dataset is robust and has been expanded in recent years with major additions of local parks data to PAD-US 2.1, to support the recreation, natural resource management, wildfire planning, emergency management, transportation, research, and public health communities. New applications of the data are frequently discovered. Multiple attributes and a flexible database structure provide context for data to be used at local, regional, state, national, and international scales. See <https://www.usgs.gov/gapanalysis/PAD-US-resources> for more information.

Includes wilderness on ALL federal lands within California.

Data Vintage: 01/2022

Data Resolution: File Geodatabase Polygon Feature Class

Data Units: Tabular attributes

Creation Method: Polygons with [Designation Type] = 'Wilderness' extracted from the PADUS3_0_State_CA_GDB feature class for use in this project. Polygons projected to California Teale Albers projection and 'exploded' into single part features.

Data Source: U.S. Geological Survey (USGS)

File Name: PAD3_0_Wilderness.gdb/PAD_Wilderness3_0_2022_CA_sPart

NORTHWEST FOREST PLAN (NWFP) BOUNDARY

Definition and Relevance: Corporate data contained within the NWFP_Boundary_2002 feature class is intended for spatial display and analysis purposes. Coverage is for use to describe the general extent of the Northwest Forest Plan.

Data Vintage: 2002

Data Resolution: File Geodatabase Polygon Feature Class

Data Units: Tabular attributes

Creation Method: This shapefile contains polygon corporate data which depicts the Northwest Forest Plan boundary updated as requested by the Regional Interagency Executive Committee (RIEC), FEMAT 2002. This feature class is a product of the Pacific Northwest Region Coverage to Geodatabase Conversion Project in an effort to standardize data throughout the Region.

Data Source: OR/WA BLM & USFS R6, Pacific Northwest Region, Forest Service, U.S. Department of Agriculture

File Name: NWFP_Boundary_2002.shp

TIMBER PRODUCTION ZONE LANDS

Definition and Relevance: This layer was created to show lands taxed as 'Timber Production Zones (TPZ)' timberlands across the NCRP region of the Northern California area of California.

Data Vintage: 06/2022

Data Resolution: Vector, polygons

Data Units: binary

Creation Method: For Sonoma, Trinity, Del Norte, Siskiyou, Humboldt, Mendocino, and Modoc Counties, TPZ parcels were identified from county parcel and zoning datasets. Once the TPZ parcels across the region were identified, they were merged together. Areas mapped in the 2021b California Protected Areas Database as public lands (along with a 60 meter buffer on these lands) were removed from the TPZ layer.

Data Source: North Coast Resource Partnership, West Coast Watershed, Tukman Geospatial

File Name: all_tpz_no_public_lands.shp

BIOMASS POWER PLANTS AND SAWMILLS

Definition and Relevance: This layer displays data for currently operational biomass power plants and sawmills within California.

Data Vintage: 06/2022

Data Resolution: Vector, points

Data Units: Attribute definitions can be accessed here: https://docs.google.com/spreadsheets/d/e/2PACX-1vS8af0NSbIXJU-TECBSvCHprNrCxR87a30BBMpZbpp7yxrWTerQe4uRcJXc5_-51TvisQVI1nr2JdnX/pubhtml?gid=764308543&single=true

Creation Method: Tabular data were downloaded from the University of California Cooperative Extension Wood Facilities Database and x, y (longitude, latitude) coordinates were converted to points.

Data Source: University of California Cooperative Extension Wood Facilities Database

[https://ucanr.edu/sites/WoodyBiomass/California Biomass Power Plants](https://ucanr.edu/sites/WoodyBiomass/California_Biomass_Power_Plants)

File Name: BiomassPowerPlants_CA_2023.shp; Sawmills_CA_2023.shp

ROADS

Definition and Relevance: This California statewide dataset was downloaded from [Geofabrik's free download server](#) for California. This server has data extracts from the OpenStreetMap project which are normally updated every day.

Data Vintage: 09/2022

Data Resolution: Vector, line

Data Units: Tabular attributes

Creation Method: To simplify the layer, major roads were exported with the following selection of the attribute "fclass":

- 5111 = motorway

- 5112 = trunk
- 5113 = primary
- 5114 = secondary
- 5121 = unclassified
- 5122 = residential
- 5123 = living street

Data Source: [Open Street Map](#) roads based on Tiger Lines (OSM)

File Name: OSM_majorRoads_CA_2022.shp

PG&E TRANSMISSION LINES - LOW VOLTAGE

Definition and Relevance: This electric transmission line California statewide dataset was downloaded from PG&E (Pacific Gas & Electric) and was subsetting to include only lines less than or equal to 115 kV (kilovolts). This subset was chosen from the original dataset for use in planning because it has been determined (via inspections of PG&E database of fires caused by power lines from 2020-2022) that virtually every fire caused by power lines was from a distribution lines less than 115 kv. Most wildfires caused by power lines are from distribution lines less than 44kv. Thus this database provides information on where those power lines are and can be used to compare with locations that have potential for high severity wildfire.

Data Vintage: 2023

Data Resolution: Vector, line

Data Units: Tabular attributes

Creation Method: PG&E's Integration Capacity Analysis (ICA) map is designed to help contractors and developers find information on potential project sites for distributed energy resources (DERs). ICA is a complex modeling study that uses detailed information about the electric distribution system, which includes items such as physical infrastructure, load performance, and existing and queued generators. The analysis simulates the ability of individual distribution line sections to accommodate additional DERs without potentially causing issues that would impact customer reliability and power quality. Potential issues could result in distribution line upgrade requirements that would impact cost and/or timeline for DER interconnections.

Transmission lines:

- Carry electricity across the state
- Transport bulk electricity at high voltages ranging from 60 kV-500 kV
- Are usually supported on tall metal towers, but sometimes on wooden poles
- Have different vegetation standards than distribution lines due to the high voltages they carry
- Are managed using the utility industry's best-management practice of Wire Zone Border Zone
- Require only low-growing vegetation underneath—typically nothing taller than 10 feet at maturity

https://www.pge.com/en_US/safety/yard-safety/powerlines-and-trees/transmission-vs-distribution-power-lines.page

Data Source: PG&E

[PG&E Integration Capacity Analysis and Distribution Investment Deferral Framework maps \(pge.com\)](#)

File Name: TransmissionLines_upTo_115kV.shp

PG&E DISTRIBUTION LINES

Definition and Relevance: This electric distribution line California statewide dataset was downloaded from PG&E (Pacific Gas & Electric). This 'FeederDetail' dataset carries voltage under the 'Nominal_Voltage' attribute for the distribution system, all under 44kV. These distribution lines often can cross wildlands and through vegetated areas and are typically the most likely to be related to a wildfire.

Data Vintage: 2023

Data Resolution: Vector, line

Data Units: Tabular attributes

Creation Method: PG&E's Integration Capacity Analysis (ICA) map is designed to help contractors and developers find information on potential project sites for distributed energy resources (DERs). ICA is a complex modeling study that uses detailed information about the electric distribution system, which includes items such as physical infrastructure, load performance, and existing and queued generators. The analysis simulates the ability of individual distribution line sections to accommodate additional DERs without potentially causing issues that would impact customer reliability and power quality. Potential issues could result in distribution line upgrade requirements that would impact cost and/or timeline for DER interconnections.

Distribution lines:

- Deliver electricity to neighborhoods and communities over a shorter distance than transmission lines
- Are generally supported by wooden poles and not as high as transmission lines
- Are the final stage of electricity delivery to homes and businesses
- Carry lower voltage electricity that is still powerful enough to cause injury or death
- Trees growing near these lines may be managed with directional pruning, but removal is often best.

https://www.pge.com/en_US/safety/yard-safety/powerlines-and-trees/transmission-vs-distribution-power-lines.page

Data Source: PG&E

[PG&E Integration Capacity Analysis and Distribution Investment Deferral Framework maps \(pge.com\)](#)

File Name: FeederDetail.shp

SDG&E TRANSMISSION LINES

Definition and Relevance: The purpose of the Geographic Information Systems (GIS) data is for both the electrical corporations and Energy Safety to have a holistic understanding of the electrical corporation infrastructure, annual targets as reported in its WMP, and quarterly planning and progress for each initiative. These data enable Energy Safety to evaluate the electrical corporation's WMP and compliance.

Data Vintage: All data in the Transmission Line feature class represents the as-built electric data model; the data represents the active and active to be removed Transmission Lines as at the time the data is extracted from PRO_VAQ_ELEC (approximately 1 month prior to submission date). The data does not contain preliminary segments as they do not physically exist as the time of the data extract.

Data Resolution: ArcGIS file geodatabase: Vector, line

Data Units: Tabular attributes

See <https://energysafety.ca.gov/who-we-are/department-organization/electrical-infrastructure-directorate/data-analytics-division/> "Energy Safety Data Guidelines" for further detail on the attributes (page 37 for transmission lines and page 40 for distribution lines).

Creation Method: The Transmission Line feature class is derived from data within SDG&E's Electric GIS database (PRO_VAQ_ELEC) in addition to leveraging other source systems data, PowerWorkz and SAP. The data is extracted within 5 business days after the quarter closes to ensure the submission contains a constant dataset.

Data Source: San Diego Gas & Electric® Company

File Name: SDGE_2023_Q2NonConfidential.gdb\SDGE_TransmissionLine_2023_Q2

SDG&E PRIMARY DISTRIBUTION LINES

Definition and Relevance: The purpose of the Geographic Information Systems (GIS) data is for both the electrical corporations and Energy Safety to have a holistic understanding of the electrical corporation infrastructure, annual targets as reported in its WMP, and quarterly planning and progress for each initiative. These data enable Energy Safety to evaluate the electrical corporation's WMP and compliance.

Data Vintage: All data in the Primary Distribution Line feature class represents the as-built electric data model; the data represents the active and active to be removed Transmission Lines as at the time the data is extracted from PRO_VAQ_ELEC (approximately 1 month prior to submission date). The data does not contain preliminary segments as they do not physically exist as the time of the data extract.

Data Resolution: ArcGIS file geodatabase: Vector, line

Data Units: Tabular attributes

See <https://energysafety.ca.gov/who-we-are/department-organization/electrical-infrastructure-directorate/data-analytics-division/> "Energy Safety Data Guidelines" for further detail on the attributes (page 37 for transmission lines and page 40 for distribution lines).

Creation Method: The Primary Distribution Line feature class is derived from data within SDG&E's Electric GIS database (PRO_VAQ_ELEC_PORTAL) in addition to leveraging other source systems data, PowerWorkz and SAP. The data is extracted within 5 business days after the quarter closes to ensure the submission contains a constant dataset.

Data Source: San Diego Gas & Electric® Company

SCE TRANSMISSION LINES

Definition and Relevance: Southern California Edison (SCE) provides data on its electrical facilities through their Distributed Resources Plan External Portal (DRPEP). DRPEP is home to SCE’s Distribution Resource Plan (DRP)-related information supporting SCE’s efforts to support customer use of clean energy technologies, streamline the interconnection process and help California meet its clean energy goals. As described in the Rulemaking 14-08-013 issued in February 2015, the California Public Utilities Commission (CPUC) required SCE and other utilities to publish a DRP by July 1, 2015. In the final guidance for the completion of the DRP, the CPUC ordered each utility to perform what is referred to as an Integration Capacity Analysis (ICA) for each line section or node in the distribution system and to perform the Commission-approved Locational Net Benefit Analysis (LNBA) methodology in their distribution systems.

DRPEP is an interactive web portal providing public access to:

- General locations of SCE distribution circuits, substations, and subtransmissions systems
- Distribution Energy Resources (DER) Integration Capacity Analysis (ICA) results (i.e., hosting capacity) Current, queued, and total distributed generation interconnection amounts
- Downloadable datasets with future API capabilities
- Location Net Benefit Analysis (LNBA) results
- Grid Needs Assessment (GNA) data
- Distribution Deferral Opportunity Report (DDOR) data
- Load Integration Capacity Analysis (ICA) - Substation & Circuit data
- Load Integration Capacity Analysis (ICA) Heat Map
- Historical Public Safety Power Shutoff (PSPS) data
- Distribution Circuits
- Future Transmission projects
- High Fire Risk Areas

For purposes of this California Landscape Metrics compilation we are focusing on the data that indicate the footprint of the electrical lines and their voltage. The provided data include other attributes that may or may not be of interest. The attributes in the attribute table for the transmission lines include the following:

Transmission table

Circuit_ID = Circuit ID

Circuit_NO = Circuit Number

Circuit_TY = Circuit Type: Transmission or Subtransmission

Circuit_VO = Circuit Voltage

Data Vintage: All data in the Transmission Line shapefile represents the as-built electric data. The data are updated regularly by SCE. These data are current as of the fall of 2023.

Data Resolution: Vector, line

Data Units: Tabular attributes

Creation Method:

For additional information specific to the SCE data please visit:

<https://drpep.sce.com/drpep/>

and their user guide at:

<https://drpep.sce.com/drpep/drpep-interactive-user-guide/index.html#/>

Data Source: Southern California Edison (SCE)

File Name: SCE_ICA_TransmissionLines.shp

SCE PRIMARY DISTRIBUTION LINES

Definition and Relevance: Southern California Edison (SCE) provides data on its electrical facilities through their Distributed Resources Plan External Portal (DRPEP). DRPEP is home to SCE's Distribution Resource Plan (DRP)-related information supporting SCE's efforts to support customer use of clean energy technologies, streamline the interconnection process and help California meet its clean energy goals. As described in the Rulemaking 14-08-013 issued in February 2015, the California Public Utilities Commission (CPUC) required SCE and other utilities to publish a DRP by July 1, 2015. In the final guidance for the completion of the DRP, the CPUC ordered each utility to perform what is referred to as an Integration Capacity Analysis (ICA) for each line section or node in the distribution system and to perform the Commission-approved Locational Net Benefit Analysis (LNBA) methodology in their distribution systems.

DRPEP is an interactive web portal providing public access to:

- General locations of SCE distribution circuits, substations, and subtransmissions systems
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- Location Net Benefit Analysis (LNBA) results
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- Load Integration Capacity Analysis (ICA) - Substation & Circuit data
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- Future Transmission projects
- High Fire Risk Areas

The purpose of the Geographic Information Systems (GIS) data is for both the electrical corporations and Energy Safety to have a holistic understanding of the electrical corporation infrastructure, annual targets as reported in its WMP, and quarterly planning and progress for each initiative. These data enable Energy Safety to evaluate the electrical corporation's WMP and compliance. For purposes of this California Landscape Metrics compilation we are focusing on the data that indicate the footprint of the electrical lines and their voltage. The provided data include other attributes that may or may not be of interest. The attributes in the attribute table for the distribution lines include the following:

Distribution table

Note = notes (if applicable)

Sub_name = Substation Name

Circuit_ty = Circuit Type: A – DISTRICT POLE TOP; D – DISTRIBUTION ; S – SUBTRANSMISSION

Substation = Substation Name with high voltage/low voltage class appended

Sys_name = System Name only

Circuit_id = Circuit ID

Circuit_vo = Circuit Voltage

SHAPE_Len = Total length (approximate) of the circuit geometry perimeter in terms of meters.

Circuit_nam = Circuit Name

Data Vintage: All data in the Distribution Line shapefile represents the as-built electric data. The data are updated regularly by SCE. These data are current as of the fall of 2023.

Data Resolution: Vector, line

Data Units: Tabular attributes

Creation Method:

For additional information specific to the SCE data please visit:

<https://drpep.sce.com/drpep/>

and their user guide at:

<https://drpep.sce.com/drpep/drpep-interactive-user-guide/index.html#/>

Data Source: Southern California Edison (SCE)

File Name: SCE_Distribution_circuits.shp

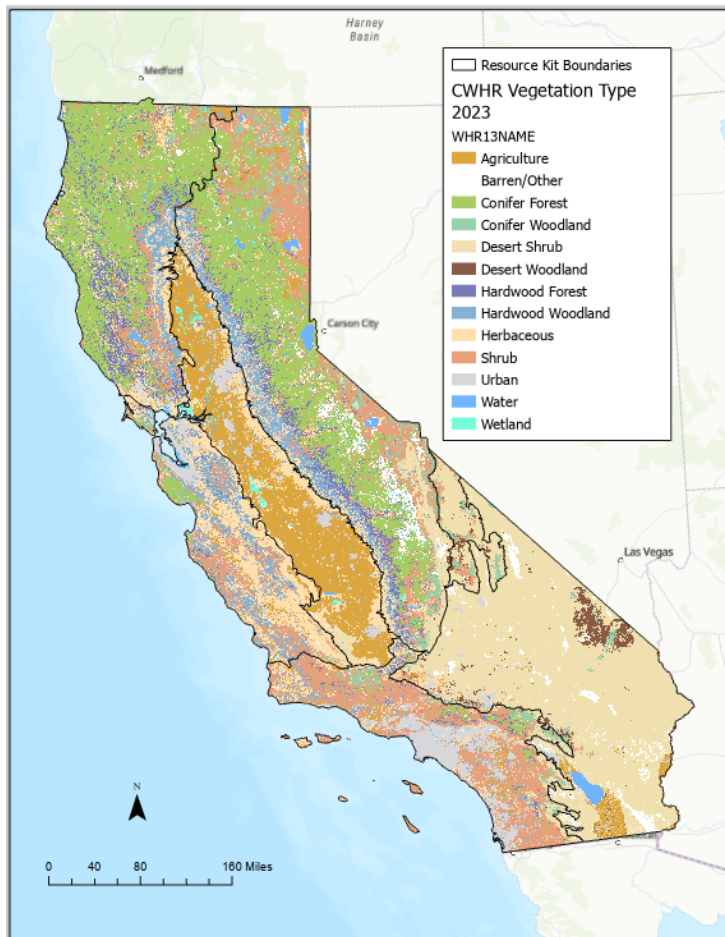
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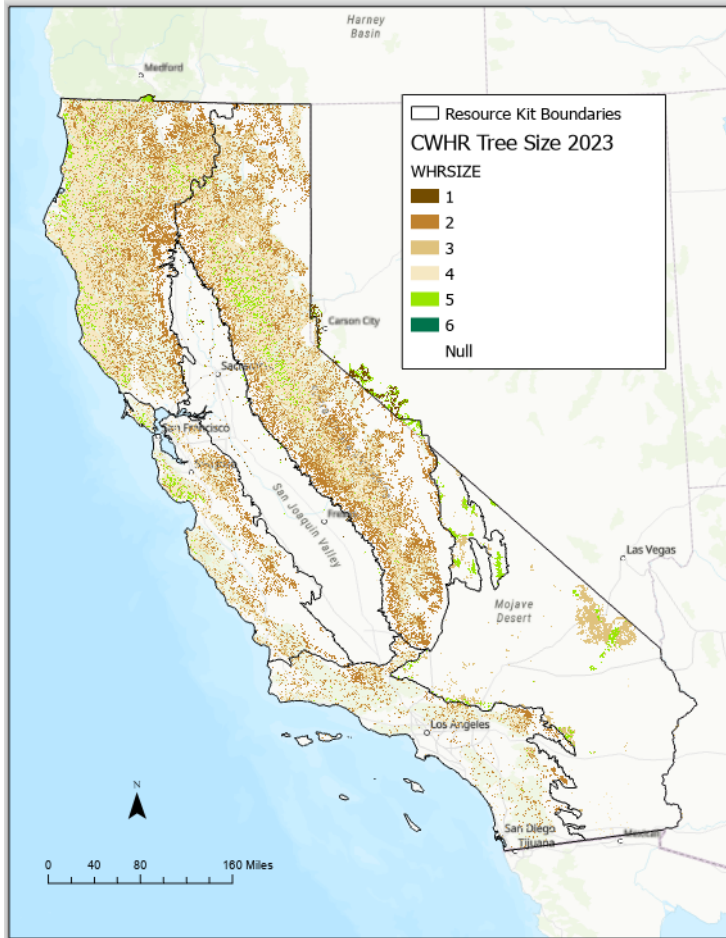
CWHR VEGETATION

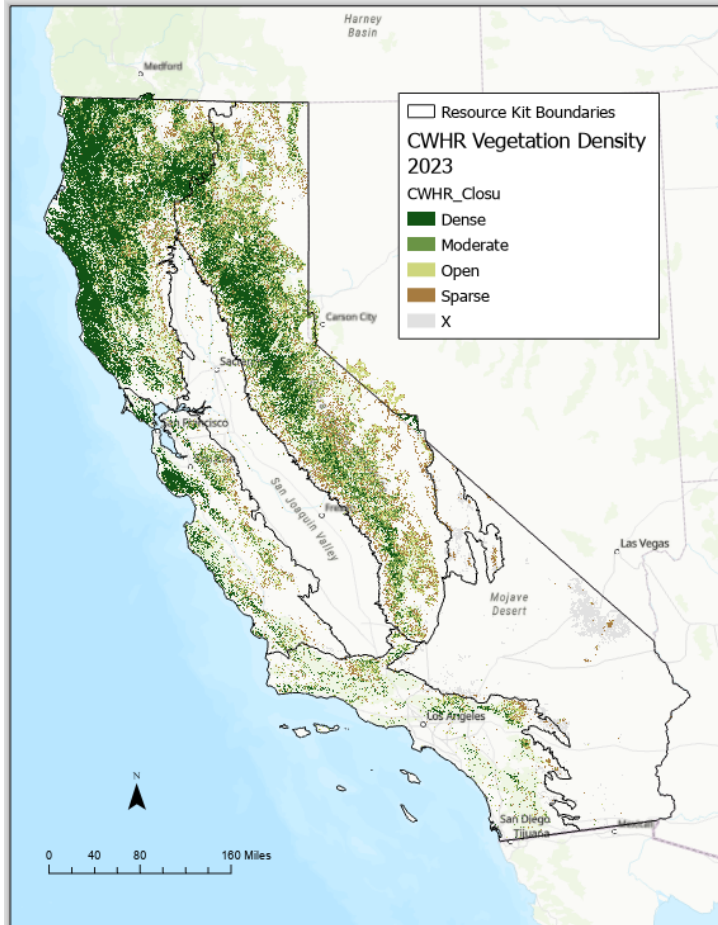
Vegetation maps play a vital role in characterizing conditions for many metrics. We need high resolution details on vegetation composition and structure; a vegetation classification, mapping, and inventory processes that provides vegetation information for a wide variety of metrics. The broader land management community continues to develop such products and make incremental improvements.

The current version displayed here is a new iteration of the FVeg. This is a product of CALFIRE-FRAP, which compiles the "best available" land cover data into a single data layer, to support the various analyses required for the Forest and Rangeland Assessment. Fveg attempts to provide an accurate depiction of the spatial distribution of habitat types within California, required for a variety of legislatively-mandated government functions. This is a product of the California Department of Forestry and Fire Protections CALFIRE Fire and Resource Assessment Program (FRAP), in cooperation with California Department of Fish and Wildlife VegCamp program and extensive use of USDA Forest Service Region 5 Mapping and Remote Sensing (MARS). The data span a period from approximately 1990 to 2014. Typically the most current, detailed and consistent data were collected for various regions of the state. Decision rules were developed that controlled which layers were given priority in areas of overlap. Cross-walks were used to compile the various sources into the common classification scheme, the California Wildlife Habitat Relationships (CWHR) system.

This iteration of Fveg has been updated as explained below. There are three separate rasters provided; one for CWHR Vegetation Type, one for CWHR Tree Size Class, and one for CWHR Veg Canopy Cover (Density) Class.







Definition and Relevance: Vegetation maps are important for characterizing many important features of a landscape such as wildlife habitat, fuels conditions, forest composition, and carbon. Such data are most useful if they can depict vegetation type, cover, and tree size class. This version was created to capture current conditions as best as possible through a variety of existing and current sources. Cross-walks were used to compile the various sources into the common classification scheme, the California Wildlife Habitat Relationships (CWHR) system. See CWHR for more details on the CWHR system ([California Wildlife Habitat Relationships](#)).

Key field names in this data set (there are others) are defined as follows:

WHRALL - Unique habitat data label. Concatenated from separate habitat attributes WHRtype, WHRsize and WHRdensity.

WHRNUM - Unique number for each Wildlife Habitat Relationship class (WHRtype).

WHRNAME - Unique name for each Wildlife Habitat Relationship class (WHRtype)

WHRTYPE - Unique Wildlife Habitat Relationship (WHR) class code

WHRSIZE - Wildlife Habitat Relationship Size Class (tree types only)

WHRDENSITY - Wildlife Habitat Relationship class (tree types only)

SOURCE_NAME - General description of where the source data layer used for a given geography

SOURCE_YEAR - Year of base imagery that source data layer references for a given geography

WHR Codes for Vegetation Types:

Tree Dominated Habitats

CWHR Code	Type Description
ASP	Aspen
BOP	Blue Oak-Foothill Pine
BOW	Blue Oak Woodland
COW	Coastal Oak Woodland
CPC	Closed-Cone Pine-Cypress
DFR	Douglas Fir
DRI	Desert Riparian
EPN	Eastside Pine
EUC	Eucalyptus
JPN	Jeffrey Pine
JST	Joshua Tree
JUN	Juniper
KMC	Klamath Mixed Conifer
LPN	Lodgepole Pine
MHC	Montane Hardwood-Conifer
MHW	Montane Hardwood
MRI	Montane Riparian
PJN	Pinyon-Juniper

POS	Palm Oasis
PPN	Ponderosa Pine
RDW	Redwood
RFR	Red fir
SCN	Subalpine Conifer
SMC	Sierran Mixed Conifer
VOW	Valley Oak Woodland
VRI	Valley Foothill Riparian
WFR	White fir

Shrub Dominated Habitats

CWHR Code	Type Description
ADS	Alpine Dwarf-Shrub
ASC	Alkali Desert Scrub
BBR	Bitterbrush
CRC	Chamise-Redshank Chaparral
CSC	Coastal Scrub
DSC	Desert Scrub
DSS	Desert Succulent Shrub
DSW	Desert Wash
LSG	Low Sage
MCH	Mixed Chaparral
MCP	Montane Chaparral

SGB	Sagebrush
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Herbaceous Dominated Habitats

CWHR Code	Type Description
AGS	Annual Grass
FEW	Fresh Emergent Wetland
PAS	Pasture
PGS	Perennial Grass
SEW	Saline Emergent Wetland
WTM	Wet Meadow

Aquatic Habitats

CWHR Code	Type Description
EST	Estuarine
LAC	Lacustrine
MAR	Marine
RIV	Riverine

Developed Habitats

CWHR Code	Type Description
CRP	Cropland
DGR	Dryland Grain Crops
DOR	Deciduous Orchard

EOR	Evergreen Orchard
IGR	Irrigated Grain Crops
IRF	Irrigated Row and Field Crops
IRH	Irrigated Hayfield
OVN	Orchard - Vineyard
RIC	Rice
URB	Urban
VIN	Vineyard

Non-vegetated Habitats

CWHR Code	Type Description
BAR	Barren

WHR Codes for Tree Size Classes:

CWHR Code	CWHR Size Class	Conifer Crown Diameter	Hardwood Crown Diameter	DBH
1	Seedling tree	n/a	n/a	<1.0"
2	Sapling tree	n/a	<15.0'	1.0" - 5.9"
3	Pole tree	<12.0'	15.0' - 29.9'	6.0" - 10.9"
4	Small tree	12.0' - 23.9'	30.0' - 44.9'	11.0" - 23.9"
5	Medium/large tree	≥24.0'	≥45.0'	≥24.0"
6	Multi-layered tree	A distinct layer of size class 5 trees over a distinct layer of size class 4 and/or 3 trees, and total tree canopy of the layers ≥60% (layers must have ≥10.0% canopy cover and distinctive height separation).		

WHR Codes for Density Classes:

WHR Code	CWHR Closure Class	Vegetation Cover (Canopy Closure)
S	Sparse Cover	10.0 - 24.9%
P	Open Cover	25.0 - 39.9%
M	Moderate Cover	40.0 - 59.9%
D	Dense Cover	≥60%
X	Not Determined / Not Applicable	

Data Vintage: 04/2023

Data Resolution: Raster, 30 meter pixels

Data Units: Categorical (see above)

Creation Method: Vegetation maps are an important feature of any natural resource management portfolio. Currently the vegetation map for the entire state that is considered the "best available" data is the CALFIRE data known as FVEG (*Vegetation (fveg) - CALFIRE FRAP [ds1327]*). This is an excerpt from the metadata:

“The California Department of Forestry and Fire Protections CALFIRE Fire and Resource Assessment Program (FRAP), in cooperation with California Department of Fish and Wildlife VegCamp program and extensive use of USDA Forest Service Region 5 Remote Sensing Laboratory (RSL) [*now known as Mapping and Remote Sensing Team (MARS)*], has compiled the "best available" land cover data available for California into a single comprehensive statewide data set. The data span a period from approximately 1990 to 2014. Cross-walks were used to compile the various sources into the common classification scheme, the California Wildlife Habitat Relationships (CWHR) system.”

Given the degree of fire in California in the last 30 plus years, especially in areas that experienced high severity fire, our CLM team thought that using the last version of FVEG (from 2015 but source data could be as old as 1987) would have too many glaring errors. Notwithstanding the challenge of creating reliable vegetation maps, we thought it would be possible to make improvements over the most recent map.

There are many avenues for improving vegetation maps. However, we did not have time to build anything from a new starting point, so we constructed a few simple rules for making [updates to the FVEG data layer](#).

There are three separate rasters provided; one for CWHR Vegetation Type, one for CWHR Tree Size Class, and one for CWHR Veg Canopy Cover (Density) Class.

The sources for updated data include:

- Fire severity data (from CALFIRE)

- LANDFIRE 2021 land cover data (wildland fire management programs of the USDA Forest Service and USDI)
- Herbaceous cover (Region 5 MARS Team)
- California Forest Observatory (SALO)

Updated FVEG; Methods for 2023 statewide updates to FVEG WHRtype, WHRsize, and WHRdensity

An accurate depiction of the spatial distribution of vegetation/habitat types within California is required for a number of the metrics included in the CLM, particularly for some of the fire, forest and rangeland resiliency, and biodiversity metrics. The California Department of Forestry and Fire Protections CALFIRE Fire and Resource Assessment Program (FRAP), in cooperation with California Department of Fish and Wildlife VegCamp program and extensive use of USDA Forest Service Region 5 Mapping and Remote Sensing unit (MARS) data, has compiled the "best available" land cover data available for California into a single comprehensive statewide data set. The data span a period from approximately 1990 to 2014.

Because the source data are in many cases fairly old and there has been extensive disturbance, particularly from wildfire, over the last 25 years, we made some updates to the 2015 version of FVEG. The methods for making those changes are described here.

WHRtype update

FVEG's WHRtype was updated with the LANDFIRE Existing Vegetation Type (EVT) data product version 2.2.0 (LANDFIRE 2020) and the Rangeland Analysis Platform (RAP) fractional ground cover data product version 3.0 (Jones et al. 2018, Allred et al. 2021). Pixels were considered for update where high severity wildfire occurred after the FVEG mapping date. High severity was defined as wildfire burned areas that experienced $\geq 75\%$ loss in basal area (Parks et al. 2018, Young-Hart et al. 2022) following the wildfire event. The type of update that occurred in each "high severity" pixel was dependent upon a lifeform conversion comparison (FVEG-to-LANDFIRE EVT), vegetation height (SALO 2020), and percent ground cover by annual and perennial grasses (RAP) (Table 1).

Table 1. FVEG-LANDFIRE update type for high severity pixels. Annual grass (AG) cover and perennial grass (PG) cover data were from the Rangeland Analysis Platform fractional ground cover data product version 3.0. Canopy height (CH) data were from the SALO forest observatory data product.

		FVEG Lifeform		
		<i>Herbaceous</i>	<i>Shrub</i>	<i>Tree</i>
LANDFIRE EVT Lifeform	<i>Herbaceous</i>	<ul style="list-style-type: none"> Where AG cover >50%, update to “Annual Grassland” <u>WHRname</u> (“AGS” <u>WHRtype</u>) 	<ul style="list-style-type: none"> Where CH <1m & AG cover >50%, update to “Annual Grassland” <u>WHRname</u> (“AGS” <u>WHRtype</u>) 	<ul style="list-style-type: none"> Where CH <2m & AG cover >50%, update to “Annual Grassland” <u>WHRname</u> (“AGS” <u>WHRtype</u>)
		<ul style="list-style-type: none"> Where PG cover >50%, update to “Perennial Grassland” <u>WHRname</u> (“PGS” <u>WHRtype</u>) 	<ul style="list-style-type: none"> Where CH <1m & PG cover >50%, update to “Perennial Grassland” <u>WHRname</u> (“PGS” <u>WHRtype</u>) 	<ul style="list-style-type: none"> Where CH <2m & PG cover >50%, update to “Perennial Grassland” <u>WHRname</u> (“PGS” <u>WHRtype</u>)
		<ul style="list-style-type: none"> Otherwise, no update to <u>WHRtype</u> 	<ul style="list-style-type: none"> Otherwise, FVEG-LANDFIRE crosswalk update 	<ul style="list-style-type: none"> Otherwise, FVEG-LANDFIRE crosswalk update
	<i>Shrub</i>	FVEG-LANDFIRE crosswalk update	No update to <u>WHRtype</u>	FVEG-LANDFIRE crosswalk update
	<i>Tree</i>	FVEG-LANDFIRE crosswalk update	<ul style="list-style-type: none"> FVEG-LANDFIRE crosswalk update 	No update to <u>WHRtype</u>

WHRdensity and WHRsize updates

Following the WHRtype update, pixels that had lifeform “tree” then had the FVEG attributes “WHRdensity” and “WHRsize” updated using the SALO Forest Observatory canopy height and canopy cover data products (SALO 2020). SALO data were available for the years 2016-2020, values of canopy height and canopy cover were averaged across years for the update[2].

To update WHRdensity, SALO canopy cover was converted to WHRdensity canopy closure class per the [Wildlife Habitat Relationships, Standards for Canopy Closure Table 114C](#).

To update WHRsize, we developed allometric equations that predict tree DBH (diameter at breast height, breast height = 4.5 ft) as a function of tree height (HT, ft). We used data from the USDA Forest Inventory and Analysis program (FIA) for California (FIA DataMart 2023; California 2022 database; ver. 9.0.1). For this analysis, we included live trees ≥ 4.5 ft tall with a crown class code of dominant, co-dominant, or open grown (N = 165,224 tree measurements between 1991 and 2019). Trees were grouped by region based on the “fuzzed” location of the plot. Regions were defined by the original Regional Resource Kits (2023, 4 regions) and separated into softwoods and hardwoods as defined by FIA (2 categories). For each analysis, three functions were evaluated: linear, saturating, and power:

Linear: $DBH = a + (b \cdot HT)$;

Saturating (Michaelis–Menten): $DBH = (V_m \cdot HT) / (K + HT)$;

Power: $DBH = aHT^b$.

For the most informative model (i.e., lowest AIC), we report both the root mean squared error (RMSE) and the pseudo R². In this case, pseudo R² was calculated as the coefficient of determination between the observed and predicted DBHs (Table 2). We used the most informative HT-to- DBH function for the region and tree category to

convert SALO canopy height data to DBH that was then converted to WHRsize class per the [Wildlife Habitat Relationships, Standards for Tree Size Table 114B](#).

Table 2. Height-to-DBH conversion equations by California region and tree class. DBH is in inches; Height (HT) is in feet. Only included trees with a HT > = 4.5 feet. Only included canopy class = dominant, co-dominant, or open. Equation (EQN) code: MM = Michaelis Menton; POWER = power; Linear = linear.

Region	Tree Class	EQN	a (Vm)	b (K)	RMSE	pseudoR ²	EQN formula
Sierra Nevada	Softwood	MM	223.39	712.20	6.57	0.69	DBH= (Vm*HT)/(K+HT)
Sierra Nevada	Hardwood	Linear	-0.391	0.294	4.69	0.57	DBH= a+b(HT)
Southern California	Softwood	MM	108.97	216.30	7.47	0.55	DBH = (Vm*HT)/(K+HT)
Southern California	Hardwood	MM	175.17	424.31	5.55	0.52	DBH = (Vm*HT)/(K+HT)
North Coast	Softwood	POWER	0.128	1.13	6.51	0.74	DBH = a*HT ^b
North Coast	Hardwood	Linear	0.135	0.242	5.2	0.49	DBH = a+b(HT)
Central Coast	Softwood	Linear	0.588	0.244	8.25	0.62	DBH = a+b(HT)
Central Coast	Hardwood	MM	68.51	161.40	6.24	0.45	DBH = (Vm*HT)/(K+HT)

Availability of Data and Materials

Data used for the 2023 FVEG updates can be obtained from the following:

- LANDFIRE – <http://www.landfire.gov/>

- Rangeland Analysis Platform – <https://rangelands.app/products/>
- SALO Forest Canopy – <https://forestobservatory.com/download>
- 10-year summary of basal area lost – <https://data.fs.usda.gov/geodata/rastergateway/acre>
- Perturbed FIA data – <https://experience.arcgis.com/experience/3641cea45d614ab88791aef54f3a1849>

Google Earth Engine Python API script can be obtained from: https://github.com/kjohnston73/fveg_update

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Data Source: CALFIRE, CDFW, LANDFIRE, California Forest Observatory (SALO), USDA Forest Service

File Name: FVEG_WHRtype_update_20230403.tif; FVEG_WHRsize_update_20230403.tif; FVEG_WHRdensity_updated.tif

FOREST TYPE

Data Vintage: 2021

Definition and Relevance: Managers work with forest types for a variety of purposes and knowing the major forest type of a target location helps to assess the best suited treatment for the site.

Data Resolution: 30m Raster

Data Units: FIA Forest Type Code

Creation Method: The [F3 model](#) relies on FVS to classify an FIA plot to a forest or vegetation type. The assigned forest or vegetation type is then imputed across the project area. Appendix B from the Essential FVS User’s guide provides a complete list of FIA forest types (<https://www.fs.fed.us/fmssc/ftp/fvs/docs/gtr/EssentialFVS.pdf>). The following is the list of FIA Forest Types within the Sierra Nevada project area:

FIA Code	Forest Type
183	Western Juniper
184	Juniper Woodland
185	Pinyon Juniper Woodland
221	Ponderosa Pine
222	Incense-cedar
224	Sugar Pine
241	Western White Pine
261	White Fir
262	Red Fir
270	Mountain Hemlock
281	Lodgepole Pine
342	Giant Sequoia
361	Knobcone Pine
365	Foxtail Pine / Bristlecone Pine
366	Limber Pine
367	Whitebark Pine
371	California Mixed Conifer
703	Cottonwood
901	Aspen
911	Red Alder
912	Bigleaf Maple
921	Gray Pine
922	California Black Oak
923	Oregon White Oak
924	Blue Oak
925	Deciduous Oak Woodland
931	Coast Live Oak
932	Canyon Live Oak / Interior Live Oak
941	Tanoak
942	California Laurel
951	Pacific Madrone
953	Mountain Brush Woodland

997	FVS Other Hardwoods
999	Non-stocked

2019 to 2021 Update: Values for 2021 were adjusted using the Ecosystem Disturbance and Recovery Tracker (eDaRT), described in the [Introduction](#). All eDaRT events beginning August 1, 2019 through November 30, 2021 were identified, and the corresponding Mortality Magnitude Index (MMI) values for these events was summed, giving the estimated fractional canopy cover loss per 30m pixel over that time period. The resulting value was subtracted from 2019 canopy cover to give 2021 canopy cover.

$$2021 \text{ Canopy Cover} = 2019 \text{ Canopy Cover} - (2019 \text{ Canopy Cover} * \text{MMI}/100)$$

It should be noted that the same MMI-based adjustment was used for CPYCOVR and STANDCC (corrected for crown overlap) which are based on stockable area for all live trees. For areas where 2021 STANDCC values dropped below 10%, the forest type code was changed to 999 (non-stocked).

Data Source: F3 data outputs, Region 5, MARS Team

File Name: Total3Run_FORTYPE_NoMGT_2021_V20220512.tif

PROTECTED ACTIVITY CENTERS (PAC)

Data Vintage: 2022

Definition and Relevance: The USDA Forest Service designates a 300-acre protected activity center (PAC) around each known nesting area or activity center. PACs are a USFS land allocation designed to protect and maintain high-quality nesting and roosting habitat around active sites. Territorial owls typically defend a geographic area consistently used for nesting, roosting, and foraging, containing essential habitat for survival and reproduction. The USDA Forest Service calls for an area of 1,000 acres in the central Sierra Nevada around core use areas, including the associated protected activity center, with a minimum of 400 acres of suitable habitat.

Data Resolution: ArcGIS geodatabase, Vector, polygon

Data Units: Tabular attributes

Description: The CSO PAC and the Northern goshawk's PAC is 300 acres of suitable nesting habitat in a contiguous block.

Creation Method: Downloaded from USFS NRM using the Geospatial Interface (GI)

Data Source: USFS_NRIS_FAUNA for Natural Resource Manager (NRM) Wildlife

File Name: ProtectedActivityCenters.gdb\SNV_All_PACS_20220301

STATEWIDE CROP MAPPING - PROVISIONAL

Definition and Relevance: Land use data is critically important to the work of the Department of Water Resources (DWR) and other California agencies. Understanding the impacts of land use, crop location, acreage, and management practices on environmental attributes and resource management is an integral step in the ability of Groundwater Sustainability Agencies (GSAs) to produce Groundwater Sustainability Plans (GSPs) and implement projects to attain sustainability.

Data Vintage: 2021

Data Resolution: Vector, polygons

Data Units: thematic - Fields were attributed with DWR crop categories and included citrus/subtropical, deciduous fruits and nuts, field crops, grain and hay, idle, pasture, rice, truck crops, urban, vineyards, and young perennials.

Creation Method: Land IQ was contracted by DWR to develop a comprehensive and accurate spatial land use database for the 2021 water year (WY 2021). The primary objective of this effort was to produce a spatial land use database with accuracies exceeding 95% using remote sensing, statistical, and temporal analysis methods. This project is an extension of the 2014, 2016, 2018, 2019, and 2020 land use mapping, which classified over 14 million acres of land into irrigated agriculture and urban areas. Unlike the 2014 and 2016 datasets, the WY 2018, 2019, 2020, and 2021 datasets include multi-cropping and incorporates DWR ground-truth data from Siskiyou, Modoc, Lassen and Shasta counties. Land IQ integrated crop production knowledge with detailed ground truth information and multiple satellite and aerial image resources to conduct remote sensing land use analysis at the field scale. Individual fields (boundaries of homogeneous crop types representing cropped area, rather than legal parcel boundaries) were classified using a crop category legend and a more specific crop type legend. A supervised classification method using a random forest approach was used to classify delineated fields and was carried out county by county where training samples were available. Random forest approaches are currently some of the highest performing methods for data classification and regression. To determine frequency and seasonality of multiple-cropped fields, peak growth dates were determined for annual crops.

Data Source: Land IQ, www.LandIQ.com, California Department of Water Resources, Division of Regional Assistance Regional Offices: Northern, North Central, South Central and Southern Regional Offices, and Water Use Efficiency Branch (Sacramento Headquarters).

Statewide Crop Mapping - Datasets - California Natural Resources Agency Open Data

File Name: i15_Crop_Mapping_2021_Provisional.shp

AQUATIC

LAKES/RESERVOIRS

Definition and Relevance: Water Bodies such as lake and reservoir features are represented in this layer pulled from the National Hydrography Dataset (NHD). These data were used to erase areas of lakes and ponds from every raster metric in the project dataset.

Data Vintage: 12/2022

Data Resolution: 30m Raster

Data Units: Binary, 1 = existence, 0 = non-existence

Creation Method: This dataset is a subset of vector polygon NHD water bodies, encompassing the project boundary and converted to a raster grid at 30m resolution.

Data Source: USGS National Hydrography Dataset (NHD); <https://www.usgs.gov/national-hydrography/national-hydrography-dataset>

File Name: NHD_lakesReservoirs_2022_RRK.tif

PERENNIAL AND INTERMITTENT STREAMS

Definition and Relevance: USGS National Hydrography Dataset (NHD); Flowline is the fundamental flow network consisting predominantly of stream/river and artificial path vector features. It represents the spatial geometry and carries the attributes

Data Vintage: 12/2022

Data Resolution: Vector, line

Data Units: Tabular attributes

Creation Method: Data selected from NHD Flowline feature class to contain only FType code 460, StreamRiver (Perennial, Intermittent) for the state of California.

Data Source: USGS National Hydrography Dataset (NHD); <https://www.usgs.gov/national-hydrography/national-hydrography-dataset>

File Name: NHD_Stream_2022.shp

MEADOWS

Data Vintage: 2019

Definition and Relevance: In practice, a meadow is an ecosystem type composed of one or more plant communities dominated by herbaceous species (Drew et. al. 2016). Meadows support plants that use surface water or shallow groundwater (generally at depths of less than 1 meter) during at least 2-4 weeks of the growing season. Woody vegetation like trees and shrubs may occur and be dense but are not dominant.

Data Resolution: Vector, polygon

Data Units: Tabular attributes

Creation Method: The original UC Davis Center for Watershed Sciences meadow map (Fryjoff and Viers 2012) compiled 44 meadow maps from multiple sources. The effort delineated meadows, generally, as open areas greater than 1 acre with wetland vegetation and dominated by herbaceous vegetation. Woody vegetation was sometimes present to varying degrees but not dominating the meadow. Versions 2 and 3 retained nearly all of those meadow delineations and added more using the same criteria.

Version 2 – The Sierra Nevada Multi-source Meadow Polygons Compilation boundaries were updated using ‘heads-up’ digitization from high resolution (1m) NAIP imagery. Version 1 retained only polygons larger than one acre. In version 2, existing polygons were split, reduced in size, or merged, and additional polygons not captured were digitized. If split, the Original ID was maintained in one half and a new ID created for the other half. When adjacent meadows were merged, only one ID was retained and the unused ID was “decommissioned.” Newly digitized meadows were assigned a new sequential ID.

Version 3 – Polygons for the entire Sierra National Forest (SNF) were replaced by more accurate data received from the GIS staff on the SNF. As in version 2, if a meadow was split the original ID from version 2 was retained for one half and a new sequential ID created for the other half if greater than 1 acre. Unused IDs were “decommissioned.”

Data Source: Center for Watershed Sciences, UC Davis

File Name: meadows.gdb\Sierra_Nevada_MultiSource_Meadow_Polygons_Compilation_v3

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The California’s Forest Products and Biomass Power Plant facilities is a resource developed through a collaborative effort of UC Cooperative Extension to monitor and analyze wood utilization capacity throughout the state of California.

We maintain current information on capacity, development, and status of facilities accepting feedstock from California wood resources. On this page you will find an interactive map and summary table of wood intake facilities. Here you can find a list of local community biomass initiatives and working groups. We also provide a variety of print-ready maps and raw data for download with assistance from the USFS.

This effort is built on contributions from the California Biomass Collaborative, California Energy Commission, California Public Utilities Commission, California Forestry Association, National Renewable Energy Laboratory, Biomass Power Association, California Biomass Energy Alliance, California Energy Almanac, University of Montana, Watershed Research and Training Center, and individual facilities. We appreciate the feedback and input from Tad Mason and Fred Tornatore at TSS Consultants and Rob Williams from the UC Davis California Biomass Collaborative. Funding support is provided by the California Department of Forestry and the USFS Region 5 State and Private Forestry.

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ADDITIONAL RESOURCES

California Department of Fish and Wildlife Areas of Conservation Emphasis program:

<https://wildlife.ca.gov/Data/Analysis/Ace>

California Department of Fish and Wildlife. California Interagency Wildlife Task Group. 2014. CWHR version 9.0 personal computer program. Sacramento, CA. <http://wildlife.ca.gov/Data/CWHR>

California Office of Environmental Health Hazard Assessment CalEnviroScreen 4.0 report:

<https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40>

California Forest Observatory (2020). A Statewide Tree-Level Forest Monitoring System. Salo Sciences, Inc. San Francisco, CA. <https://forestobservatory.com>

[Connecting Wildlands & Communities, Conservation Ecology Lab - San Diego State University.](#) [Connecting Wildlands & Communities | Climate Science Alliance](#)

Monitoring Trends in Burn Severity (MTBS) program: <https://www.mtbs.gov/>

Multi-Resolution Land Characteristics Consortium (MRLC): <https://www.mrlc.gov/>

Oregon State University Environmental Monitoring, Analysis, and Process Recognition (eMapR) Lab:
<http://emapr.ceoas.oregonstate.edu/>

Rapid Assessment of Vegetation Condition after Wildfire (RAVG): <https://burnseverity.cr.usgs.gov/ravg/>

Spatial Informatics Group: [Home - SIG \(sig-gis.com\)](http://sig-gis.com)

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