# Appendix B
# 2022 Natural Working Lands Inventory

March 2026

Bay Area Regional Climate Action Plan

September 2025

# 2022 Natural Working Lands Inventory Memorandum

# Table of Contents

# Glossary of Acronyms and Abbreviations

BARCAP: Bay Area Regional Climate Action Plan

CARB: California Air Resources Board

C: Carbon, as in MT C/ha

$CO_2$: Carbon Dioxide

$CO_2e$: Carbon Dioxide Equivalent

$CH_4$: Methane

EVC: Existing Vegetation Cover

EVH: Existing Vegetation Height

EVT: Existing Vegetation Type

GHG: Greenhouse Gas

Ha: or ha. Hectare; 10,000 square meters

IPCC: Intergovernmental Panel on Climate Change

KSSL: Kellogg Soil Survey Laboratory

MT: Metric Ton

MMT: Million Metric Ton; 1,000,000 MT

$N_2O$: Nitrous Oxide

NLCD: National Land-Cover Database

NWL: Natural & Working Lands

NSSC: National Soil Survey Center

NRCS: Natural Resources Conservation Service

ROI: Region of Interest

TSD: Technical Support Document

# Definitions

<u>Air District Planning Area</u>: The planning area covered in this analysis, which corresponds to the land area that falls under the regulatory jurisdiction of the Bay Area Air District (the Air District). The planning area encompasses the following counties in their entirety: Alameda, Contra Costa, Marin, Napa, San Francisco, and San Mateo. Additionally, the planning area includes portions of Southwestern Solano and Southern Sonoma counties. Note that the Air District's jurisdictional area does cover Santa Clara, which is not covered in this analysis.

<u>BARCAP</u>: An acronym for the Bay Area Regional Climate Action Plan, which is an initiative aimed at reducing greenhouse gas (GHG) emissions and addressing climate change in the Bay Area. This plan is being developed by the Bay Area Air District with funding from the U.S. Environmental Protection Agency's Climate Pollution Reduction Grant program.

<u>BARCAP—Region</u>: The region of interest for this analysis, the counties and partial counties that make up the Bay Area Regional Climate Action Planning (BARCAP) initiative; as opposed to all Bay Area counties. For this purpose of this analysis, this subset of counties does not include any portion of Santa Clara County, which is otherwise a part of the Air District's jurisdiction, but is not included under BARCAP as Santa Clara and San Benito County are writing a separate federally funded climate action plan.

<u>Biomass</u>: The total mass of organic material in a given area or system at a given time. This includes both above- and below-ground live biomass (e.g. roots, trucks, and branches) as well as dead (e.g. litter and dead wood).

<u>Biomass Carbon Stock</u>: The amount of carbon stored in biomass. In this analysis, Biomass Carbon Stock is represented in units of MT carbon per hectare.

<u>California Air Resources Board (CARB)</u>: CARB is responsible for safeguarding the public from the adverse impacts of air pollution and creating initiatives to combat climate change. CARB's mission is to enhance and preserve public health, welfare, and environmental resources by efficiently reducing air pollutants, while also taking economic impacts into account. As the primary agency for climate change initiatives, CARB supervises all air pollution control activities in California to achieve and uphold air quality standards that protect health.

<u>Total Carbon Stock</u>: Carbon stock refers to the amount of carbon stored in a given area or system at a given time. This includes carbon stored in living biomass (ex. plants, animals), dead biomass (ex. litter, dead wood), and soil. In this analysis, Total Carbon Stock was calculated by summing Biomass Carbon Stock and Soil Carbon Stock and is represented in units of MT carbon per hectare.

<u>Carbon Density</u>: The carbon stock per unit area or weight.

<u>Climate Smart Land Management:</u> Managing lands to deliver climate benefits. Specific actions or practices may be called climate smart practices, and in the case of agricultural practices may be referred to as climate smart agriculture.

<u>Greenhouse Gas (GHG):</u> Gases that trap heat in the atmosphere (e.g., carbon dioxide, methane, nitrous oxide, and ozone).

<u>gSSURGO</u>: A database of soil data produced and distributed by USDA NRCS in partnership with the National Cooperative Soil Survey (NCSS). The acronym stands for Gridded Soil Survey Geographic Database and is a geodatabase variant of the traditional SSURGO product. gSSURGO is sometimes referred to as SSURGO, as gSSURGO is derived from SSURGO and the data can often be used interchangeably.

Intergovernmental Panel on Climate Change (IPCC): IPCC was established in 1988 by the World Meteorological Organization and the United Nations Environmental Programme. It is a coalition of governments from UN or WMO member states, tasked with delivering regular evaluations of the scientific foundations of climate change, its effects, future risks, and strategies for adaptation and mitigation. Hundreds of specialists examine thousands of research studies to compile assessment reports, which provide thorough summaries of the current understanding of climate change.

Kellogg Soil Survey Laboratory (KSSL): Part of the Natural Resources Conservation Service and is the primary source for soil analytical data for the National Cooperative Soil Survey (NCSS). KSSL conducts comprehensive soil analyses to support soil classification and conservation efforts. The laboratory maintains a vast collection of soil samples and provides critical data for soil health, wetlands, and ecological site conservation.

LANDFIRE: The Landscape Fire and Resource Management Planning Tools is a collaborative program focused on mapping vegetation, fire, and fuel characteristics. Sponsored by the United States Department of the Interior and the United States Department of Agriculture, Forest Service, LANDFIRE generates a detailed, uniform, and scientifically reliable collection of geo-spatial data layers covering the entire United States.

National Land-cover Database (NLCD): A comprehensive program that provides nationwide data on land cover and land cover changes. Managed by the U.S. Geological Survey (USGS), NLCD offers detailed, consistent, and scientifically reliable geo-spatial data layers that help in understanding the landscape of the United States.

National Soil Survey Center (NSSC): Part of the Natural Resources Conservation Service and manages extensive databases on soils, ecology, and botany. The NSSSC provides technical support and data to help landowners and managers conserve natural resources and make informed decisions about soil use and management.

Natural Resources Conservation Service (NRCS): An agency within the United States Department of Agriculture. NRCS provides technical assistance to farmers, ranchers, and other private landowners to help them conserve natural resources. The agency supports voluntary conservation efforts to improve soil, water, air, and habitat quality across the United States.

Map Unit: A term from SSURGO/gSSURGO describing classifications of soils with similar landform and landscape characteristics. The name of the map unit usually includes the major soil type and the slope range of the area described.

ROI: The Region of Interest (ROI) for this analysis is a specifically defined portion of the Bay Area Air District. This ROI encompasses the Bay Area Air District Planning Area, excluding Santa Clara County.

SC Land Cover Class: Refers to the land cover classifications used in the Sonoma County inventory[1], published in October 2023.

Soil Carbon Stock: This refers to the amount of carbon stored in soil. In this analysis, soil carbon stock is estimated as the amount contained in the top 0 to 30 cm of the soil column and is represented in units of MT carbon per hectare.

United States Geological Survey (USGS): A scientific agency within the United States Department of the Interior. USGS conducts research on the landscape, natural resources, and natural hazards of the United

---

[1] https://sonomacounty.ca.gov/Main%20County%20Site/Administrative%20Support%20%26%20Fiscal%20Services/CAO/ Documents/Climate%20Action%20and%20Resiliency/Sonoma-County-Carbon-Inventory-and-Study-with-Executive-Summary.pdf

States. The agency provides valuable scientific data on water, energy, minerals, ecosystems, and the impacts of climate and land-use changes.

# Executive Summary

A carbon inventory provides a comprehensive assessment of the amount of carbon stored across a landscape, establishing a baseline of existing carbon stocks and the sequestration potential of natural and working lands (NWL). By offering a snapshot in time, an inventory captures the current state of carbon storage and sequestration, helping to inform land use decisions and climate strategies. Categorizing NWL by land cover type—such as forests, wetlands, and croplands—enables more precise, data-driven insights for local planning.

One key application of a carbon inventory is its ability to quantify and locate carbon at risk of being lost due to disturbance such as wildfires or land conversion. At the same time, it highlights opportunities to enhance carbon sequestration through improved land management practices and targeted climate initiatives.

This analysis represents the first detailed quantitative estimate of carbon stocks and their distribution for the Bay Area Air District (Air District). The resulting inventory will support the Bay Area Regional Climate Action Plan (BARCAP), providing critical data to guide climate-smart land management and NWL greenhouse gas reduction efforts. The inventory's quantitative estimates of carbon

stock and biomass was the foundation for modeling the effects of NWL climate change mitigation measures in BARCAP. This memorandum outlines the methodology and key findings from the Bay Area District's 2022 NWL inventory, which was designed to align with the California Air Resources Board's (CARB) 2022 Scoping Plan.[2]

This analysis was conducted for the Air District, creating an inventory of lands located in eight counties: 1) Alameda, 2) Contra Costa, 3) Marin, 4) Napa, 5) San Francisco, 6) San Mateo, 7) Solano, and 8) Sonoma. Notably, the area included in the analysis is limited to the official Air District boundary, which does not include the totality of area in all counties. Furthermore, although included in the complete Bay Area Air District jurisdiction, Santa Clara county was omitted from this analysis by request of the Air District as the Santa Clara County and San Benito County are conducting a parallel and aligned analysis as part of their EPA-funded comprehensive climate action plan effort.

As of 2022, the counties that make up the region of interest (ROI) subset of the Bay Area Air District held a total of approximately 92 MMT C total carbon stock, as reflected in the totals row of Tables 1 and 2.

---

[2] https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp_1.pdf

When categorized by land cover type, forests contain the highest carbon density (Table 1). At the county level, Napa County has the highest carbon density among all the counties in the Bay Area Regional Climate Action Plan (BARCAP) counties (Table 2).

**Table 1. 2022 Total Carbon Stock by Land Cover Class.**

The data in this table only includes the area (counties and partial counties) under Bay Area Air District jurisdiction, omitting Santa Clara County.

| Land Cover Class | Area in Hectares | Biomass Carbon Stock in MT C | Soil Carbon Stock in MT C | Total Carbon Stock in MT C | Total Carbon Stock in MT C per Hectare |
|---|---|---|---|---|---|
| Barren | 3,811 | 9,238 | 130,149 | 139,387 | 37 |
| Orchard | 4,133 | 234,565 | 142,928 | 377,494 | 91 |
| Vineyard | 40,909 | 163,636 | 1,509,421 | 1,673,057 | 41 |
| Cultivated and Field Crops | 25,826 | 167,420 | 2,230,023 | 2,397,443 | 93 |
| Pasture and Hay | 30,989 | 197,012 | 2,373,114 | 2,570,126 | 83 |
| Open Water | 49,452 | -- | 3,668,746 | 3,668,746 | 74 |
| Shrub/Scrub | 77,799 | 2,701,805 | 2,568,656 | 5,270,461 | 68 |
| Wetland | 65,094 | 1,899,193 | 6,733,661 | 8,632,855 | 133 |
| Grassland/ Herbaceous | 244,303 | 1,612,456 | 8,684,481 | 10,296,937 | 42 |
| Development | 304,801 | 893,301 | 9,759,188 | 10,652,489 | 35 |
| Forest | 266,268 | 37,001,485 | 9,654,650 | 46,656,135 | 175 |
| *Total* | *1,113,384* | *44,880,113* | *47,455,018* | *92,335,131* | *83* |

**Table 2. 2022 Total Carbon Stock by BARCAP—Region.**

The data in this table only includes the area (counties and partial counties) under Bay Area Air District jurisdiction, omitting Santa Clara County.

| BARCAP – Region | Area in Hectares | Biomass Carbon Stock in MT C | Soil Carbon Stock in MT C | Total Carbon Stock in MT C | Total Carbon Stock in MT C per Hectare |
|---|---|---|---|---|---|
| San Francisco | 12,227 | 67,555 | 158,842 | 226,397 | 19 |
| Solano | 98,304 | 1,168,051 | 7,402,503 | 8,570,553 | 87 |
| Alameda | 192,639 | 5,517,260 | 5,927,448 | 11,444,708 | 59 |
| Sonoma | 159,680 | 5,387,751 | 6,594,216 | 11,981,967 | 75 |
| San Mateo | 117,769 | 8,458,669 | 3,846,532 | 12,305,201 | 104 |
| Marin | 135,530 | 8,796,059 | 5,371,978 | 14,168,036 | 105 |
| Contra Costa | 193,136 | 4,601,826 | 10,270,398 | 14,872,224 | 77 |
| Napa | 204,099 | 10,882,942 | 7,883,101 | 18,766,043 | 92 |
| *Total* | *1,113,384* | *44,880,113* | *47,455,018* | *92,335,131* | *83* |

# Methodology

## Overview of Bay Area Air District Inventory Methods

The natural and working lands (NWL) carbon stock within the Bay Area Air District (Air District). was calculated for the 2022 inventory year. This analysis utilized LANDFIRE[3] land cover classification raster data, which was matched with biomass carbon stock estimates from the 2018 California Air Resources Board (CARB) inventory[4] for each land cover class. This matching was based on alignment between the two datasets on the following three metrics: Existing Vegetation Type (EVT), which represents the distribution of vegetation types; Existing Vegetation Height (EVH), which indicates the average height of dominant vegetation; and Existing Vegetation Canopy Cover (EVC), which refers to the percentage of ground covered by tree and shrub canopy. The resulting dataset produced a spatially explicit map of biomass carbon stock by carbon pool across the Bay Area Air District (see Figure 1A). Furthermore, this analysis incorporated measurements of soil carbon stock throughout the Air District, utilizing raster data from gSSURGO[5], and added those values to the values of biomass carbon stock throughout the region to produce estimates of total carbon stock (see Figures 1B and 1C). In short, biomass carbon stock (Figure 1A) + soil carbon stock (Figure 1B) = total carbon stock (Figure 1C).

As described further in the sections below, the Air District inventory is aligned with state and local analyses. Differences in methodology are described, and are due to application of expert judgement, data availability given the large 8-county scale of the BARCAP—Region, and knowledge that the State of California will soon be updating their methodology for carbon stocks on a statewide level, though finalized results of the inventory was not available at the time of conducting this analysis (State carbon inventory results and methodology are projected to be available in late winter of 2025).

## Assumptions and Interpolations

All unique combinations of EVT, EVC, and EVH that do not have an associated biomass carbon stock value were interpolated with a value of total biomass multiplied by the coefficient 0.55 as per FAO guidelines[6]. This coefficient is a widely used standard for converting biomass carbon stock to total biomass (above- and below-ground). The following land cover classes did not have total biomass measurements from CARB, as CARB assumes all annually harvested areas to have a total biomass of 0: Development, Cultivated and Field Crops, Orchard, Pasture and Hay, Vineyard. For these classes, the FAO interpolation was employed.

In less than 2% of the land cover area, missing data or mismatches occurred between EVT, EVC, and EVH classifications from the LANDFIRE and CARB datasets that could not be corrected using the FAO guideline. In these cases, values were interpolated using expert judgment and using two primary methods: (1) adjusting missing EVT, EVC, or EVH values to the most similar neighboring classification (e.g., increasing herbaceous cover from 25% to 55% while maintaining the same EVT classification) or (2) redefining an EVT without data to align with a similar EVT with available data (e.g., using biomass and

---

[3] https://www.landfire.gov/
[4] https://ww2.arb.ca.gov/sites/default/files/2025-02/CARB-2018-NWL-Carbon-Inventory-Report.pdf
[5] https://www.nrcs.usda.gov/resources/data-and-reports/gridded-soil-survey-geographic-gssurgo-database
[6] https://www.fao.org/4/y5490e/y5490e07.htm

carbon stock values from Mixed Conifer Forests to estimate values for Developed Mixed Conifer Forests).

Furthermore, in approximately 7% of the land cover area, gSSURGO did not contain estimates of soil carbon stock. Roughly 3% of the land cover area missing estimates of soil carbon stock could be assumed to be equal to 0. This occurred mostly with soil types describing water (including open water, dam, etc.), since gSSURGO does not quantify soil carbon underlying water, but also in quarries, pits, or other broken land. For the remaining 4% of land cover area, this analysis manually interpolated those regions by assigning the values of soil carbon stock from the closest matching map unit (e.g., replacing the null SOC value from "Rock outcrop-Xerorthents complex, 50 to 75 percent slopes" with the value of SOC from the closest matching map unit category of "Rock outcrop-Kidd complex, 50 to 75 percent slopes").

Despite gSSURGO not containing any measurements of soil carbon stock from soils underlying water, the land cover classification 'Open Water' is estimated as containing 3,668,746 MT C/ha (over 49,452 hectares in the ROI) from soil carbon. This is because the gSSURGO soils dataset did not map exactly to the LANDFIRE classifications. For example, a particularly wet marshland may be grouped into "Water" using LANDFIRE data, because of the high degree of wetness that is likely to mislead spectral imagery classification. However, gSSURGO uses different underlying data, including ground truthing, which may lead to the of that same area as "Wetland". Furthermore, the LANDFIRE dataset has a resolution of 30 $m^2$ and gSSURGO has a resolution of $10m^2$, meaning that the gSSURGO dataset has a finer resolution to differentiate land cover boundaries. Pixels from LANDFIRE may be classified as 'Open Water', but gSSURGO has a higher resolution and is able to quantify the soils alongside rivers, creeks, and other water bodies at a finer granularity (higher precision). These slight spatial margins are critically important and can lead to the large amount of carbon noted above. Since the carbon in soils alongside water bodies tends to be highly organic in the ROI, the category of 'Open Water' contains lots of carbon-rich soil, skewing this category higher than expected.

**Figure 1A, 1B. Biomass Carbon Stock in MT C/ha (left); Soil Carbon Stock in MT C/ha (right)**
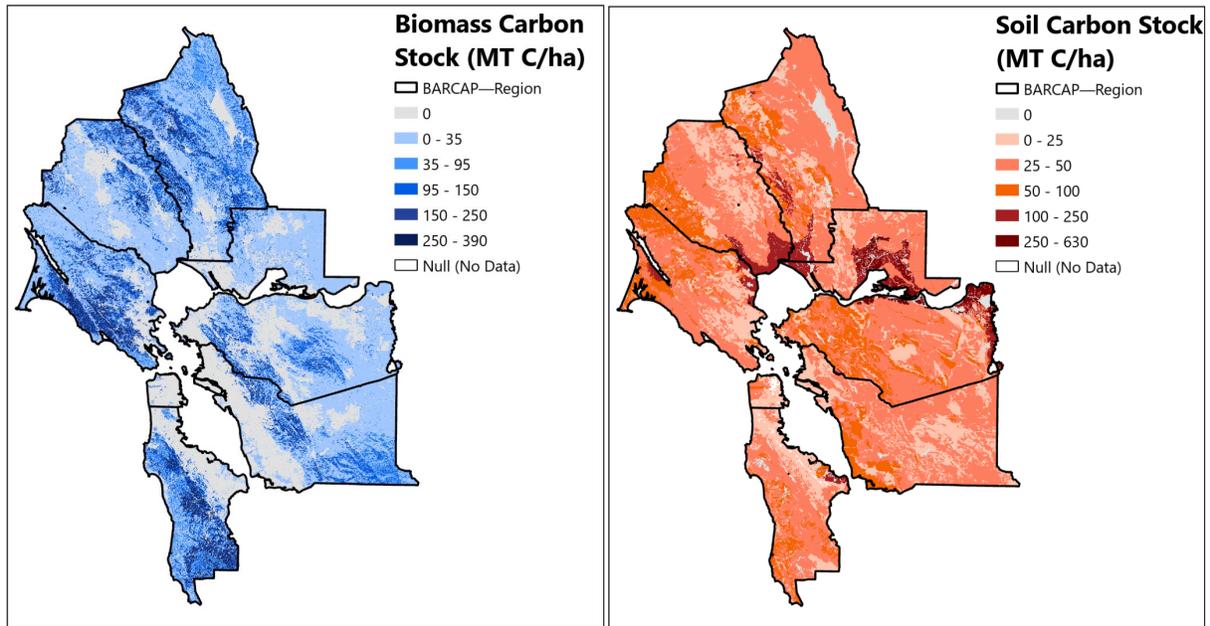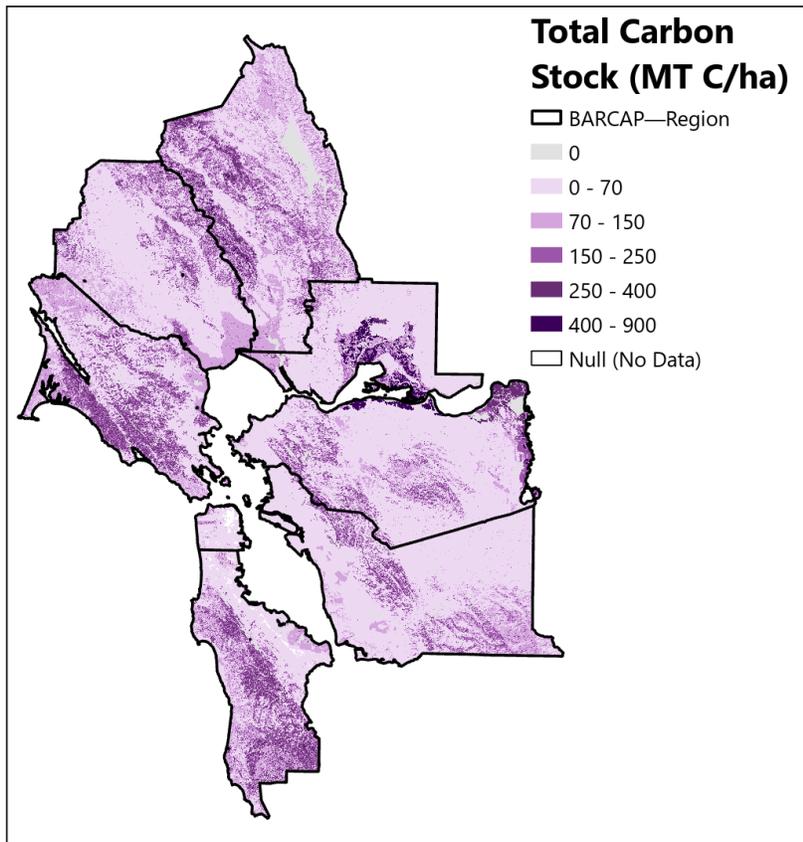


**Figure 1C. Total Stock in MT C/ha**



After determining carbon stocks; additional maps were created to illustrate land cover classifications to align with both international (IPCC) and local (Sonoma County) frameworks, as shown in Figures 2A and

2B. The IPCC classifications were already embedded within the California Air Resources Board (CARB) dataset, thus Figure 2A reflects the application of these classifications across the region of interest (ROI).

The Sonoma County classification in this analysis represents manual groupings of Existing Vegetation Type (EVT) from LANDFIRE that were understood to best align with Sonoma County land cover definitions. In cases of uncertainty surrounding the dominant vegetation type in a mixed-vegetation EVT, documentation originally used to establish EVTs in LANDFIRE[7] informed the best possible classification. The original classification methodology, outlined in detail in Appendix B of the 2023 Sonoma County Carbon Inventory and Sequestration Potential Study[8] could not be replicated in this analysis due to data availability constraints. See Appendix Table 1 for a full list of Sonoma County land cover definitions and the accompanying definitions used in this analysis; and see Appendix Table 2 for the result of that classification work.

**Figure 2A, 2,B. A. Land Cover Classes, IPCC Classifications (left); B. Land Cover Classes, Sonoma County Classifications (right)**
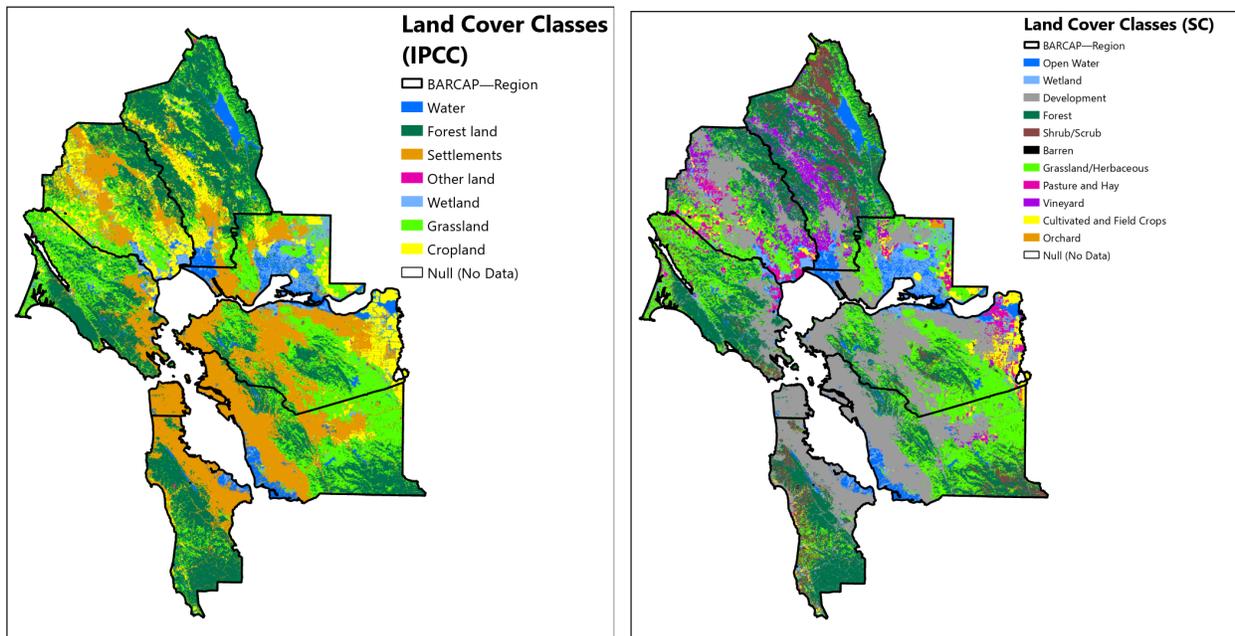


[7] https://www.natureserve.org/sites/default/files/pcom_2003_ecol_systems_us.pdf
[8] https://sonoma-county.legistar.com/LegislationDetail.aspx?ID=6399747&GUID=42EF9CFA-1B23-4B80-BE5C-6DC2B882A484

# Relation to the CARB NWL Inventory and Scoping Plan

The most recent California statewide inventory was published by CARB[9] in 2018. CARB's inventory utilized a combination of remotely sensed, survey, and field-based datasets to create a comprehensive, statewide assessment of biomass and soil carbon stocks. The foundation of this inventory was the LANDFIRE[10] dataset, which provided consistent, wall-to-wall land cover and vegetation data for the State of California. To ensure accuracy and alignment with international standards, CARB processed this data according to Intergovernmental Panel on Climate Change (IPCC) guidelines, and integrated ground-based measurements with remote sensing technology to monitor changes in land cover and biomass carbon stocks over time.

The LANDFIRE-based database of biomass carbon stocks from CARB quantifies above- and below-ground biomass carbon, including but not limited to living trees, roots, shrubs, standing dead trees, and leaf litter, but does not account for soil carbon. As in the CARB inventory, this analysis incorporated estimates of soil carbon stocks using raster data from gSSURGO. A detailed description of all data sources, models, and methodologies used in the CARB inventory can be found in the 2018 CARB Natural and Working Lands Inventory Technical Support Document (TSD)[11] and a table of all data sources can be found replicated below, in Table 3.

This inventory utilized the CARB methodology and database of carbon stock densities, based on the previously mentioned LANDFIRE datasets, as the foundation to produce spatially explicit carbon stock estimates in the Bay Area Air District for inventory year 2022. Inventory improvements and region-specific refinements that were made to this inventory include:

- Mapping LANDFIRE categories not included in the dataset delivered by CARB to carbon stocks in the existing datasets based on updated LANDFIRE classification manual and expert judgement,
- Adding in soil carbon stock estimates from missing regions based on closest available data by map unit, and
- Producing grouped land cover classifications that both align with CARB's IPCC mapping and the region-specific land cover classifications identified by Sonoma County, as detailed in Section 3.1.

---

[9] https://ww2.arb.ca.gov/sites/default/files/2025-02/CARB-2018-NWL-Carbon-Inventory-Report.pdf
[10] https://www.landfire.gov/
[11] https://carbstage.arb.ca.gov/resources/documents/2018-natural-and-working-lands-carbon-inventory-technical-support-document

**Table 3. Data Used for the California Statewide CARB Inventory (2018).**

| Inventory Method | Tier | Data | Publication Frequency | Latest Year |
|---|---|---|---|---|
| Forest and Other Natural Lands | Tier 3 | USFS FIA Data | Annual | 2016 |
| | | LANDFIRE | 2 years | 2014 |
| | | MODIS | Annual | 2012 |
| Wetland | Tier 2 | Tier 2 San Francisco Estuary Inst. | Undefined | 2016 |
| | | gSSURGO | Annual | 2016 |
| | | LANDFIRE | 2 years | 2014 |
| Cropland Biomass | Tier 3 | Digital Globe | Varies * | 2018 |
| | | LANDSAT | 16 days | 2018 |
| | | Google Street | ~5 years for rural areas* | 2018 |
| | | USDA NASS Census | 5 years | Census - 2012 |
| | | USDA NASS Survey | 1 year | Survey - 2017 |
| | | USDA Cropscape | Annual | 2017 |
| Urban Forest Biomass | Tier 3 | USDA NAIP data | Usually every 2 years | 2016 |
| | | USGS DOQQ data | No longer refreshed* | 1999 |
| | | USFS Urban FIA data | 5 years | 2015 |
| | | UFORE | Not refreshed* | Varies (2003-2015) |
| | | Municipal tree inventories | Varies / Decadal* | Varies (2003-2015) |
| Soil Carbon | Tier 3 for croplands outside of the Delta<br><br>Tier 1 for all other lands | DayMET | Annual | 2017 |
| | | NASS Census | 5 years | 2012 |
| | | NASS Survey | Annual | 2017 |
| | | LANDFIRE | 2 years | 2014 |
| | | gSSURGO | Annual | 2016 |
| | | National Atmospheric Deposition Program | Annual | 2017 |
| | | California Ag Commissioner | Annual | 2017 |
| | | SoilGrids | Annual | 2017 |

*Not needed for annual/biannual refresh

# Relation to the Contra Costa County Inventory

The most recent Contra Costa inventory[12], which is relevant as like Sonoma County, it is also a recent local analysis of carbon stocks in the BARCAP—Region, published in October 2023, calculated carbon stocks using similar methods to those employed in this inventory of the Bay Area Air District. The Contra Costa inventory similarly leveraged the CARB methodology and LANDFIRE carbon density data to estimate carbon stocks from Natural Lands (Forest, Shrubland, Grassland, etc.), and Agricultural Lands (Pasture and Hay, Orchards, Cultivated Crops, and Vineyards), along with gSSURGO raster data to estimate soil carbon stocks.

Unlike in this inventory, the Contra Costa inventory adjusted land cover classifications (originally from LANDFIRE) using satellite imagery from the National Land-Cover Database (NLCD). This additional imagery for categorization was employed after the developers of the Contra Costa inventory identified inaccuracies in shrubland classification from the LANDFIRE dataset in Contra Costa (ex. grassland/herbaceous areas categorized as shrub/scrub). Additionally, in another deviation from the Air District Inventory, Contra Costa sourced urban forest density data, which was used to calculate development carbon stock, from USDA Forest Service i-Tree Canopy (i7), rather than using the forest canopy data provided by LANDFIRE in the EVC layer.

The Contra Costa inventory similarly supplemented SSURGO data with estimates of soil carbon stock from a wide range of datasets (NCSS Characterization Database from the National Soil Survey Center (NSSSC)/Kellogg Soil Survey Laboratory (KSSL); National Soil Information System (NASIS) from USDA National Resource Conservation Service (NRCS); and Rapid Carbon Assessment (RaCA) from USDA NRCS). Instead of manually interpolating missing areas from SSURGO, as in this analysis, Contra Costa created a collective database of soil carbon stock measurements from all available data sources and interpolated that dataset, along with SSURGO, to produce wall-to-wall soil carbon stock estimates. All data used in establishing the Contra Costa inventory is illustrated below, in Figure 3.

There are key deliverable differences that differentiate this analysis from the Contra Costa analysis. In Contra Costa, land cover was classified using LANDFIRE data, as in this analysis, but Contra Costa invested additional resources in categorizing inaccuracies in the LANDFIRE (namely shrubland and grassland in the county) using NLCD data, as well incorporating the i-Tree Canopy Tool for urban forest density estimates, along with desktop ground truthing. In contrast, this analysis relied solely on LANDFIRE data for estimates of biomass carbon stock, with manual interpolation to proxy missing areas. Additionally, Contra Costa incorporated estimates of soil carbon from gSSURGO and various additional data sources, whereas this analysis solely accounted for soil carbon using gSSURGO data. Like this final inventory, the final Contra Costa Carbon inventory product is classified according to Existing Vegetation Type from LANDFIRE and NLCD, see Appendix Table 1 for the definitions and differences from this analysis. This classification ensures continuity between the two inventories.

---

[12] https://www.contracosta.ca.gov/DocumentCenter/View/79768/Healthy-Lands-Healthy-People-Final-Report

**Figure 3. Data Used for the Contra Costa County Inventories (2001 and 2021). Copied from the 2023 Contra Costa County inventory.**
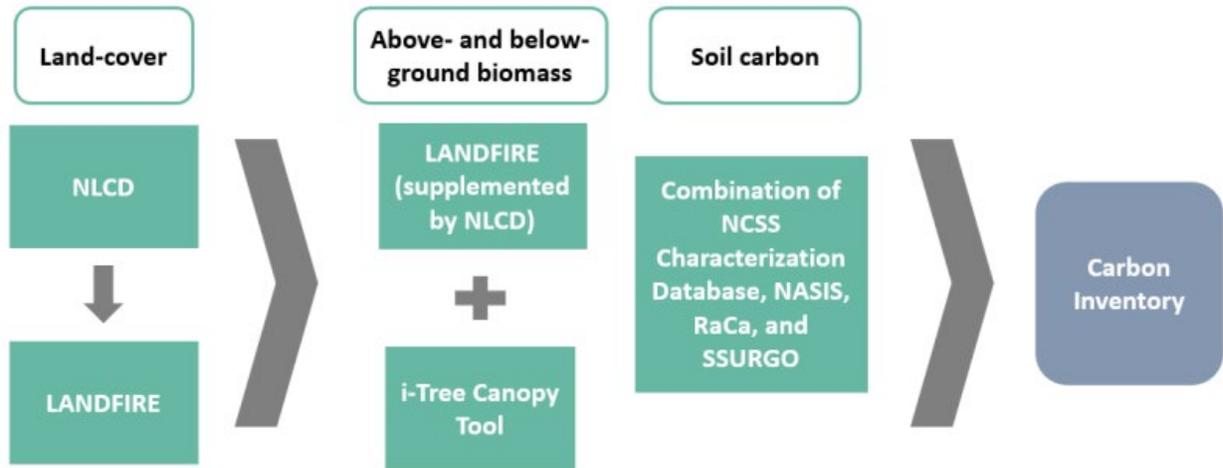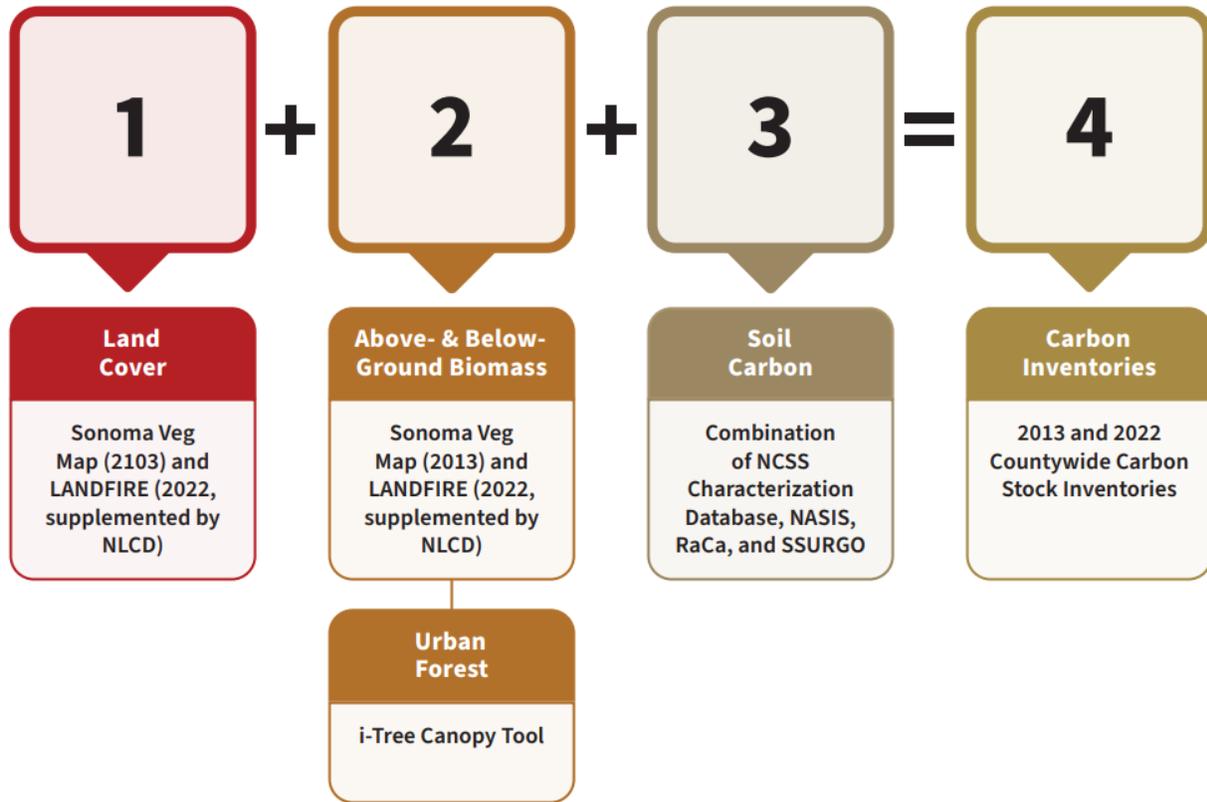
# Relation to the Sonoma County Inventory

The most recent Sonoma County inventory[13], published in October 2023, calculated carbon stocks using similar methods to those employed in this inventory of the Bay Area Air District that established land cover types from LANDFIRE data, measured carbon within each land cover type, then summed the amount of carbon by land cover type.

Sonoma County employed a similar methodology to CARB and this analysis in using LANDFIRE to calculate above- and below-ground biomass as part of the total carbon stock calculation. However, unlike in this inventory, and similarly to the Contra Costa inventory-- Sonoma County combined multiple data sources to create the final biomass carbon stock estimations (see Figure 4). Like in this Air District inventory, Sonoma County estimated values for soil carbon using SSURGO raster data. Unlike in this inventory, Sonoma County employed additional datasets (the NCSS Characterization database, NASIS, RaCa) to create a database for further soil carbon stock estimation via interpolation. All data used in establishing this inventory is illustrated below, in Figure 4.

There are key deliverable differences that differentiate this analysis from the Sonoma County analysis. Primarily, in 2013, Sonoma County used the Sonoma Veg Map for land classification, which is unique to the county. This produced deliverables and results that could not be replicated by any other analysis. In 2022, Sonoma County classified land cover using LANDFIRE data, as in this analysis, but Sonoma County invested additional resources in categorizing inaccuracies in the LANDFIRE (using NLCD for additional satellite imagery, similar to the Contra Costa inventory). Additionally, Sonoma County incorporated estimates of urban tree density (and associated carbon) from i-Tree, rather than consistently utilizing the LANDFIRE EVC, EVH, and EVT layers. Furthermore, Sonoma County quantified soil carbon using SSURGO raster data and various other data sources, detailed above, whereas this analysis consistently leveraged gSSURGO. Like this analysis, the final Sonoma County inventory product from 2022 is classified according to Existing Vegetation Type from LANDFIRE and NLCD, see Appendix Table 1 for the definitions and differences from this analysis. This classification facilitates continuity and comparison between the two inventories.

---

[13] https://sonomacounty.ca.gov/Main%20County%20Site/Administrative%20Support%20%26%20Fiscal%20Services/CAO/ Documents/Climate%20Action%20and%20Resiliency/Sonoma-County-Carbon-Inventory-and-Study-with-Executive-Summary.pdf

**Figure 4. Data Used for the Sonoma County Inventory (2013 and 2022). Copied from the 2023 Sonoma County inventory.**



| **1** | + | **2** | + | **3** | = | **4** |

**Land Cover**
Sonoma Veg Map (2103) and LANDFIRE (2022, supplemented by NLCD)

**Above- & Below-Ground Biomass**
Sonoma Veg Map (2013) and LANDFIRE (2022, supplemented by NLCD)

**Urban Forest**
i-Tree Canopy Tool

**Soil Carbon**
Combination of NCSS Characterization Database, NASIS, RaCa, and SSURGO

**Carbon Inventories**
2013 and 2022 Countywide Carbon Stock Inventories

# Results and Discussion

To better understand land cover distribution throughout the ROI, land cover area was summed by BARCAP—Region proportionally to area, Figure 3, and independently of area, Figure 4. This illustrates the dominant land cover classification in and among each county (or partial county; as BARCAP—Region), respectively. A discussion of carbon stocks, disaggregated by SC land cover type, follows below.

**Figure 5. Percent Land Cover by BARCAP—Region.**

The data in this figure only includes the area (counties and partial counties) under Bay Area Air District jurisdiction, omitting Santa Clara County.
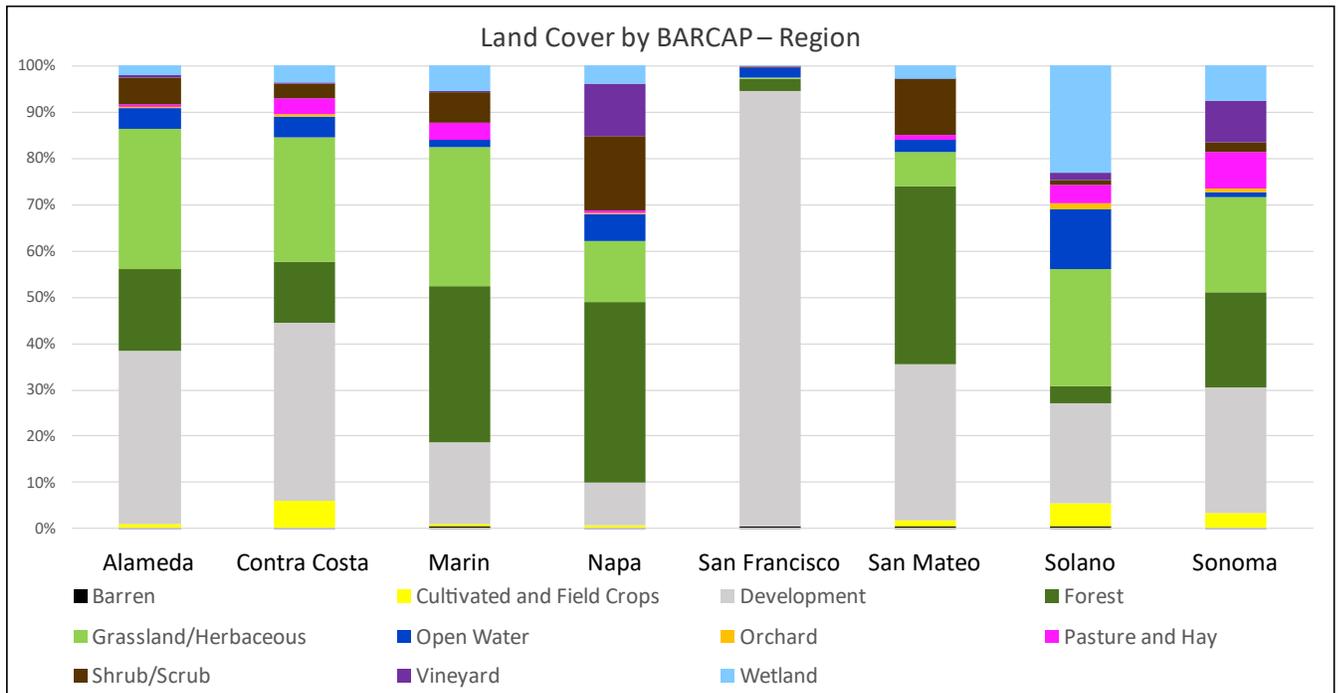


**Table 4. Percent Land Cover Area by BARCAP—Region.**

The data in this table only includes the area (counties and partial counties) under Bay Area Air District jurisdiction, omitting Santa Clara County.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Land Cover Classes (SC) Area Percentages by BARCAP—Region** | | | | | | | | | | | | |
| | **Barren** | **Cultivated and Field Crops** | **Development** | **Forest** | **Grassland/ Herbaceous** | **Open Water** | **Orchard** | **Pasture and Hay** | **Shrub/ Scrub** | **Vineyard** | **Wetland** | **Total** |
| *Alameda* | 9% | 6% | 24% | 13% | 24% | 18% | 11% | 3% | 14% | 3% | 6% | 17% |
| *Contra Costa* | 12% | 43% | 24% | 9% | 21% | 17% | 29% | 21% | 8% | 2% | 11% | 17% |
| *Marin* | 19% | 3% | 8% | 17% | 17% | 5% | 1% | 15% | 12% | 0% | 12% | 12% |
| *Napa* | 21% | 3% | 6% | 30% | 11% | 24% | 4% | 4% | 43% | 56% | 12% | 18% |
| *San Francisco* | 1% | 0% | 4% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 1% |
| *San Mateo* | 15% | 6% | 13% | 17% | 4% | 6% | 3% | 3% | 18% | 0% | 5% | 11% |
| *Solano* | 14% | 19% | 7% | 1% | 10% | 26% | 30% | 12% | 1% | 3% | 35% | 9% |
| *Sonoma* | 8% | 20% | 14% | 12% | 13% | 4% | 21% | 41% | 4% | 35% | 19% | 14% |
| Total | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

**Figure 6. Land Cover Area by BARCAP—Region.**

The data in this figure only includes the area (counties and partial counties) under Bay Area Air District jurisdiction, omitting Santa Clara County.
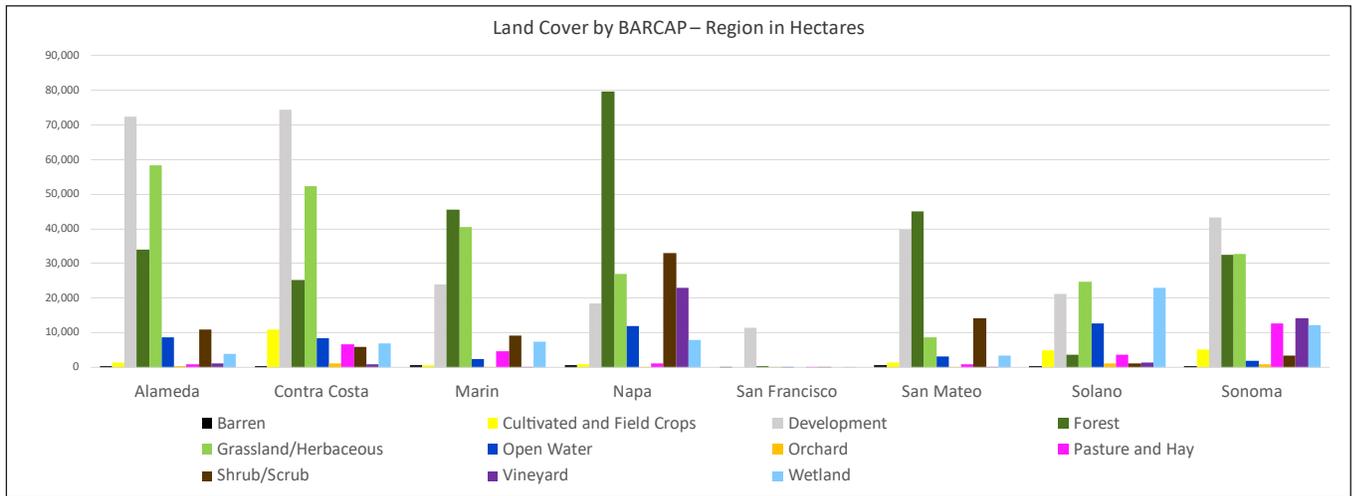


**Table 5. Land Cover Area by BARCAP—Region.**

The data in this table only includes the area (counties and partial counties) under Bay Area Air District jurisdiction, omitting Santa Clara County.

| | Barren | Cultivated and Field Crops | Development | Forest | Grassland/ Herbaceous | Open Water | Orchard | Pasture and Hay | Shrub/ Scrub | Vineyard | Wetland | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Land Cover Classes (SC) Area in Hectares by BARCAP—Region | | | | | | | | | | | | |
| Alameda | 335 | 1,520 | 72,390 | 33,921 | 58,240 | 8,674 | 462 | 942 | 10,885 | 1,209 | 4,061 | 192,639 |
| Contra Costa | 468 | 11,058 | 74,339 | 25,212 | 52,210 | 8,352 | 1,189 | 6,651 | 5,836 | 828 | 6,993 | 193,136 |
| Marin | 743 | 753 | 23,899 | 45,599 | 40,560 | 2,330 | 40 | 4,696 | 9,262 | 102 | 7,546 | 135,530 |
| Napa | 786 | 882 | 18,514 | 79,705 | 26,952 | 11,896 | 184 | 1,166 | 33,093 | 22,979 | 7,941 | 204,099 |
| San Francisco | 50 | 0 | 11,495 | 330 | 22 | 263 | 0 | 1 | 22 | 0 | 44 | 12,227 |
| San Mateo | 567 | 1,462 | 39,810 | 45,138 | 8,769 | 3,169 | 117 | 986 | 14,222 | 83 | 3,446 | 117,769 |
| Solano | 549 | 4,987 | 21,106 | 3,748 | 24,745 | 12,732 | 1,257 | 3,808 | 1,113 | 1,394 | 22,866 | 98,304 |
| Sonoma | 313 | 5,164 | 43,249 | 32,614 | 32,805 | 2,036 | 884 | 12,740 | 3,365 | 14,314 | 12,197 | 159,680 |
| Total | 3,811 | 25,826 | 304,801 | 266,268 | 244,303 | 49,452 | 4,133 | 30,989 | 77,799 | 40,909 | 65,094 | 1,113,384 |

# Development

San Francisco is dominated by developed, urban land (Figure 5). Over such a small land area, San Francisco could be an ideal choice to implement a climate-smart land management strategy for developed areas, as it would be targeted towards the dense development in the area. Alternatively, Contra Costa and Alameda have the most developed land by area (Table 5) and therefore have the most in which to invest.

The 2022 CARB Scoping Plan[14] recommends an increase in urban forestry investment by 200% above current levels, and tree watering that is 30% less sensitive to drought. In BARCAP, this could be accomplished through urban greening initiatives, which target an increase in urban canopy cover through improved maintenance of existing trees or planting of new trees. CARB Scoping Plan suggests an increase in urban forestry investment annually by 20 percent, relative to business as usual, which could be supported through BARCAP.

# Forest

Napa is dominated by forest and contains the most forest of any county (Figure 6, Table 5). This large expanse of forested area, which is also the highest of the land cover classifications in both MT carbon per hectare (Table 1), can be leveraged in implementing climate-smart forestry strategies.

This is especially critical, given that the 2022 CARB Scoping Plan prescribes treating at least 2.3 million acres statewide of forests, shrublands/chaparral, and grasslands with regionally specific, climate-smart management strategies[15]. Given the large risk of wildfire in these areas, the Scoping Plan recommends implementing climate-smart forest management strategies in line with the California Wildfire and Forest Resilience Action Plan[16]. In forests found throughout the BARCAP—Region, this could be fulfilled through engaging in Forest Slash Treatment (CPS 384) or prescribed burning, to reduce fuel loads and limit wildfire risk.

Moreover, the Scoping Plan recommends no land conversion to any other class from forests. Protecting existing forested land from conversion to agricultural or developed land in each county (or partial county) within the BARCAP—Region is in clear alignment with the CARB Scoping Plan, due to the carbon sequestration sustained by maintaining carbon-dense land cover. In BARCAP, this could be implemented through practices like Native Oak Restoration/Silvopasture (CPS 381) or planting of riparian forest buffer.

# Wetland

Solano County, for the purposes of this analysis meaning the southwestern portion from this ROI, has the most wetlands in the BARCAP—Region. Wetlands are the second most carbon-dense of the land cover classifications in MT per hectare of carbon (Table 1) and can be targeted to meet carbon sequestration goals.

The 2022 CARB Scoping Plan recommends the restoration of approximately 15 percent of all Sacramento–San Joaquin River Delta (Delta) wetlands, summing to 60,000 acres, by 2045. This emphasis on Deltaic wetland management in the Scoping Plan is due to the enormous carbon sink capacity of wetlands and the risk of carbon emissions from wetlands under certain conditions. Wetlands function as

---

[14] https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp_1.pdf
[15] https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp_1.pdf
[16] https://wildfiretaskforce.org/wp-content/uploads/2022/12/californiawildfireandforestresilienceactionplan.pdf

a carbon sink so long as the wet soils remain wet, once dried the soil carbon is more vulnerable to consumption by oxygen-loving microbes and emission as gas.

The Bay Area Air District contains Delta wetlands in Alameda, Contra Costa, and Solano counties, and so strategies under the BARCAP have large potential to uplift climate solutions for and using wetlands. This is particularly important, given that Delta wetland soils are some of the carbon-richest in the world[17]. Wetland restoration, alongside wetland creation and wetland enhancement, are strategies to bolster carbon sequestration from wetlands and help meet this goal.

# Cultivated Crops, Field Crops, and Vineyards

Regarding agriculture throughout the BARCAP—Region, Napa has the most vineyards and Contra Costa has the most farmland (Table 5). These agricultural lands already require active land management, and are therefore ready targets for the shift to a wide variety of climate-smart agriculture strategies.

The 2022 CARB scoping plan calls for implementation of climate smart practices for annual and perennial crops on ~80,000 acres annually. Some activities that help meet this goal include but are not limited to: Mulching (CPS 484), Residue and Tillage Management - No Till (CPS 329), Cover Cropping (CPS 340), Conservation Crop Rotation (CPS 328), Compost Application (CPS 808), and Nutrient Management (CPS 590).

# Grassland/Herbaceous and Shrub/Scrub

Alameda and Contra Costa are closely tied as counties (or partial counties) within the BARCAP—Region with the most land classified as Grassland/Herbaceous, and Napa has the most land classified as Shrub/Scrub (Table 5). These land cover types are grouped together for the purpose of this discussion as they require similar climate-smart land management strategies.

Guidance from the 2022 CARB scoping plan suggests the establishment and expansion of mechanisms that ensure both grasslands and shrublands are protected from land conversion or parcellation. Additionally, CARB recommends the implementation of management strategies that support soil carbon sequestration, biodiversity, and other ecological improvements. In the BARCAP, this could include native grassland restoration or riparian restoration.

# BARCAP—Region Carbon Stock

The carbon stocks from each land cover (e.g., Forest, Wetland) and each carbon stock source (e.g., Biomass, Soil) can be summed together to create an overall estimate of Total Carbon Stock throughout the BARCAP—Region. Over an area of 1,113,384 hectares, the ROI for this analysis accounted for 92,335,131 MT carbon. Figure 7, below, illustrates this.

---

[17] https://deeply.thenewhumanitarian.org/water/community/2017/06/09/californias-delta-poised-to-become-massive-carbon-bank

**Figure 7. Carbon Stocks in Bay Area Air District by Land Cover**. *The first number in each callout bubble represents Total Carbon Stock in MT C, the second represents the percentage of carbon contained in a given land cover class in the ROI. The land cover classifications reflect the Sonoma County classifications. The data in this figure only includes the area (counties and partial counties) under Bay Area Air District jurisdiction, omitting Santa Clara County.*



Total Carbon Stock by Land Cover in MT C/ha and Percent

- 139,387 MT C; 0.2%
- 377,494 MT C; 0.4%
- 1,673,057 MT C; 1.8%
- 2,397,443 MT C; 2.6%
- 2,570,126 MT C; 2.8%
- 3,668,746 MT C; 4.0%
- 5,270,461 MT C; 5.7%
- 8,632,855 MT C; 9.3%
- 10,296,937 MT C; 11.2%
- 10,652,489 MT C; 11.5%
- 46,656,135 MT C; 50.5%

Legend:
- Barren
- Orchard
- Vineyard
- Cultivated and Field Crops
- Pasture and Hay
- Open Water
- Shrub/Scrub
- Wetland
- Grassland/Herbaceous
- Development
- Forest
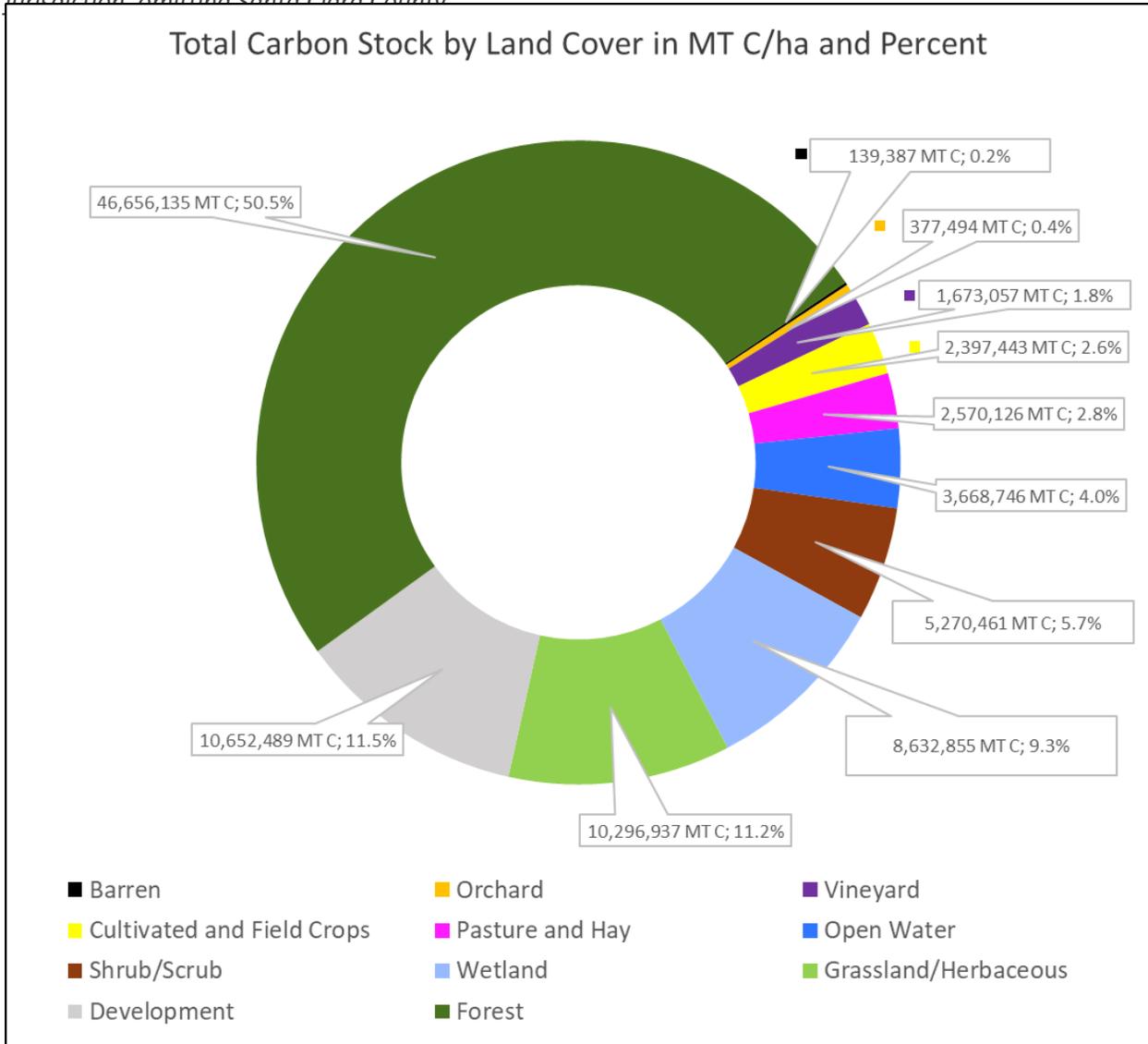
# Previously Published Results in the Region

## California Air Resources Board Results

According to CARB's 2018 ecosystem carbon inventory[18], built mainly using data from 2014, California's natural and working lands hold approximately 5,340 million metric tons of carbon. The majority of this carbon stock is found in forests and shrublands, which dominate California's landscape and boast the highest carbon density among all land cover types. Despite comprising over 35 percent of California's total acreage, other land categories account for only 15 percent of the carbon stocks. Approximately half of the 5,340 MMT of carbon is stored in soils, while the other half is contained within plant biomass. Figure 8, below, illustrates these findings. Note that Figure 5 uses 2014 distribution of biomass and soil carbon stocks on the California landscape in MMT carbon (rounded to the nearest 10 MMT).

**Figure 8. 2014 Carbon Stocks in California NWLs, copied from the 2018 CARB inventory**



---
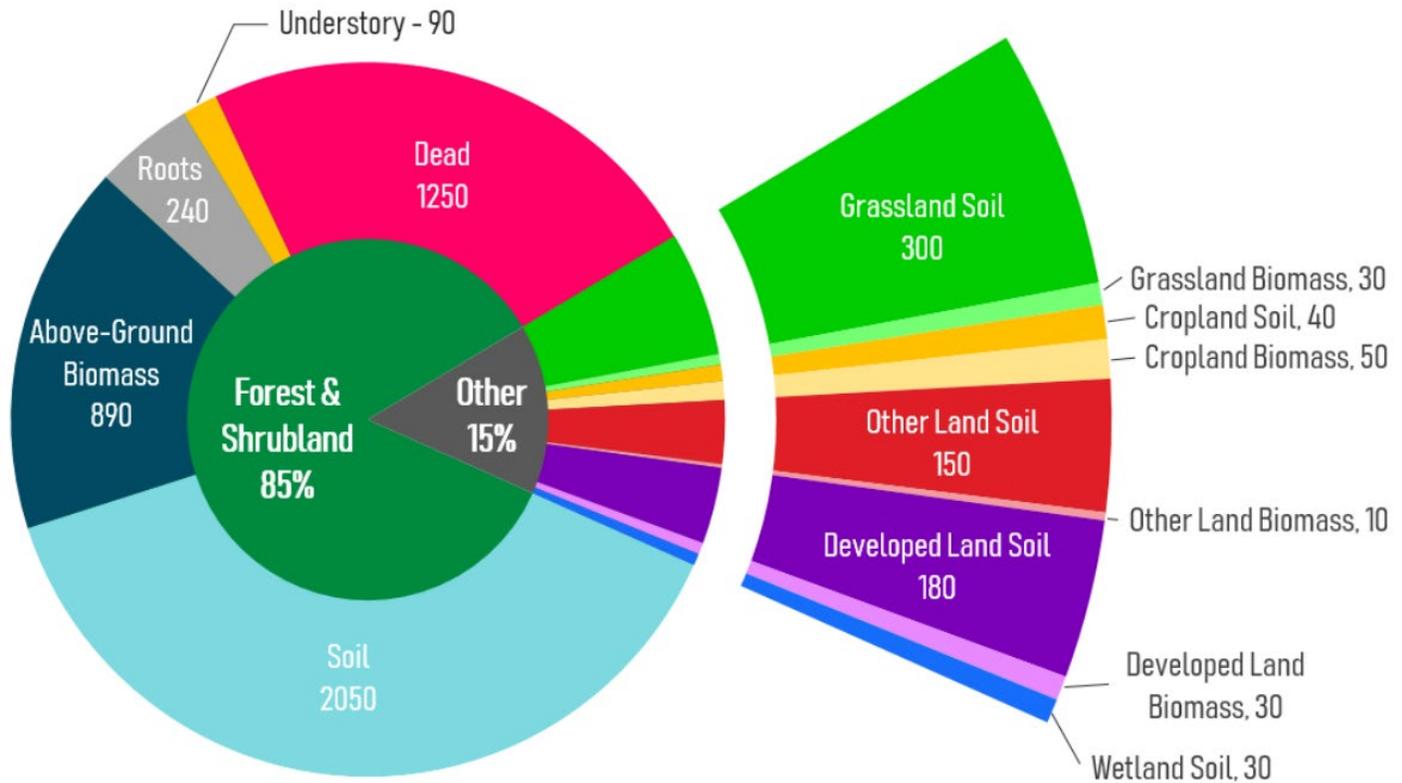
## Quantitative Comparison with the CARB Inventory

Although the CARB inventory and the Air District inventory disaggregate results using different land cover classifications (CARB using IPCC, Air District using SC classes), enough similarities exist between the two classifications that comparison between the two inventories is possible and appropriate. See Tables 6 and 7, below, for a breakdown of carbon stock by land cover class throughout California (as quantified by CARB) and the Bay Area Air District, respectively.

Both directionally and quantitatively, the two inventories are very similar. The land cover classification Forest and Shrubland from CARB and Forest from the Air District are the most carbon dense per hectare (197 and 175 MT C/ha, respectively). In both inventories, Wetland follows close behind as the next most carbon dense per hectare (142 and 133, respectively). CARB and the Air District inventories agree that Developed Land/Development are low in carbon density (55 and 35 MT C/ha, respectively).

However, CARB and the Air District inventory disagree on the relative density of IPCC Cropland (which corresponds to a combination of Cultivated and Field Crops, Orchard, Pasture and Hay, and Vineyard from the SC classification). CARB estimates Cropland as one of the least carbon dense classifications, only 24 MT C/hectare, whereas the Air District estimates this value in the 41-93 MT C/hectare range. This is likely due to the Air District's relatively high proportion of woody crops (e.g. orchards and vineyards) and higher SOC density as compared to the state as a whole. Given the various forms and densities of biomass that exist throughout the ROI and in each class, this estimation method is limited in its ability to predict biomass carbon stock.

**Table 6. Total Carbon Stock per Hectare and Total Carbon Stock (2014), from the 2018 CARB inventory.**

| CARB Carbon Stock per Hectare and Total Carbon Stock (2014) | | | |
|---|---|---|---|
| Land Category | Average Carbon Stock per Hectare (MT C/Hectare) | Total Carbon Stock (MT C) | Carbon Stock per Hectare Rank |
| Other Land | 20 | 160,000,000 | 6 |
| Cropland | 24 | 90,000,000 | 5 |
| Developed Land | 55 | 210,000,000 | 4 |
| Grassland | 78 | 330,000,000 | 3 |
| Wetland | 142 | 30,000,000 | 2 |
| Forest and Shrubland | 197 | 4,520,000,000 | 1 |
| *Total* | *126* | *5,340,000,000* | *NA* |

**Table 7. BARCAP—Region Carbon Stock per Hectare and Total Carbon Stock (2022), modified from Table 1.**

| BARCAP—Region Carbon Stock per Hectare and Total Carbon Stock (2022) | | | |
|---|---|---|---|
| Land Cover Class | Average Carbon Stock per Hectare (MT C/Hectare) | Total Carbon Stock (MT C) | Carbon Stock per Hectare Rank |
| Development | 35 | 10,652,489 | 11 |
| Barren | 37 | 139,387 | 10 |
| Vineyard | 41 | 1,673,057 | 9 |
| Grassland/Herbaceous | 42 | 10,296,937 | 8 |
| Shrub/Scrub | 68 | 5,270,461 | 7 |
| Open Water | 74 | 3,668,746 | 6 |
| Pasture and Hay | 83 | 2,570,126 | 5 |
| Orchard | 91 | 377,494 | 4 |
| Cultivated and Field Crops | 93 | 2,397,443 | 3 |
| Wetland | 133 | 8,632,855 | 2 |
| Forest | 175 | 46,656,135 | 1 |
| *Total* | *83* | *92,335,131* | *NA* |

# Contra Costa County Results

The 2023 Contra Costa inventory[19] found total carbon stocks using data from 2021 summing to 47,628,503 MT CO2e. In that inventory, grasslands covered an estimated 30% of land cover, developed land covered an estimated 24% of land cover, and forested land covered an estimated 17% of land cover in the county. Figure 9, below, illustrates these findings.

**Figure 9. 2021 Carbon Stocks by Land Cover, copied from the 2023 Contra Costa County inventory**



FIGURE 5. 2021 Carbon Stocks by Land Cover

**30.00%**
Grassland/Herbaceous
9,332,609 MT CO₂e ◆
59 MT CO₂e ■

**0.13%**
Barren
45,503 MT CO₂e ◆
62 MT CO₂e ■

**24.41%**
Development
10,515,137 MT CO₂e ◆
86 MT CO₂e ■

**5.30%**
Cultivated and Field Crops
7,077,346 MT CO₂e ◆
259 MT CO₂e ■

**16.87%**
Forest
10,567,969 MT CO₂e ◆
129 MT CO₂e ■

2021 Total Carbon Stocks
47,628,503 MT CO₂e

**2.46%**
Wetland
2,254,891 MT CO₂e ◆
175 MT CO₂e ■

**11.25%**
Open Water
946,128 MT CO₂e ◆
16 MT CO₂e ■

**0.40%**
Vineyard
82,157 MT CO₂e ◆
40 MT CO₂e ■

**2.35%**
Pasture and Hay
4,001,492 MT CO₂e ◆
330 MT CO₂e ■

**6.41%**
Shrub/Scrub
2,691,498 MT CO₂e ◆
89 MT CO₂e ■

**0.42%**
Orchard
113,773 MT CO₂e ◆
53 MT CO₂e ■

Percentages are rounded and do not add to 100%.
◆ Total Carbon Stock (2021)
■ Average Carbon Stock per Acre (2021)

## Quantitative Comparison with the Contra Costa County Inventory

Given that the entirety of Contra Costa County falls within the ROI for this analysis, there exists a unique opportunity to validate this analysis against the previously published Contra Costa inventory[20]. The Contra Costa inventory calculated 12,978,222 MT C (originally published as 47,626,503 MT CO2e) in

---

[19] https://www.contracosta.ca.gov/DocumentCenter/View/79768/Healthy-Lands-Healthy-People-Final-Report
[20] https://www.contracosta.ca.gov/DocumentCenter/View/79768/Healthy-Lands-Healthy-People-Final-Report

2021 over approximately 208,892 hectares (originally published as 516,185 acres). In comparison, for Contra Costa County, this inventory of the Bay Area Air District calculated 14,872,224 MT C over approximately 193,136 hectares (Table 2, above). The difference in hectares between the two inventories is negligible (the percent difference between 208,892 hectares and 193,136 hectares is 7.84%). Furthermore, the difference in MT C between the two inventories is relatively unsurprising (the percent difference between 12,978,222 MT C and 14,872,224 MT C is 13.6%). See Tables 8 and 9, below, for a breakdown of carbon stock by land cover class in Contra Costa and the Bay Area Air District, respectively.

The 13.6% difference in MT C between the two inventories is difficult to explore, as the documentation describing the inventory development process in Contra Costa County is limited, but can likely be partially attributed to differences in data sources. The decision by Contra Costa to employ multiple data sources, instead of manual interpolation from LANDFIRE as in this Air District inventory, may have introduced some slight uncertainty in the resultant estimations of carbon stock. There exists a risk in deriving insights from multiple data sources, because different data sources employ varied quantification methods which may not be readily comparable. For example, one dataset may contain an additional covariate that other datasets do not account for, leading to a higher skew in the regions where that dataset is applicable and resulting in a spike in carbon stock estimation in those regions. Furthermore, the re-classification from the LANDFIRE land cover classifications limits the degree to which these two inventories can be compared using land cover class, especially using the grassland/herbaceous category, which was specifically called out by the Contra Costa inventory as requiring reclassification.

When comparing the order of carbon stock per unit area between Contra Costa County (Table 8) and the Air District (Table 9); agricultural classes (Pasture and Hay, Cultivated and Field Crops) are far more relatively carbon-dense in the Contra Costa County inventory than in the Air District (ranked 1, 2 in CCC; ranked 3, 5 in the Air District). Furthermore, the per acre estimates of these categories and of wetlands are slightly higher than in the Air District inventory (for example, Pasture and Hay average 90 MT C/acre in Contra Costa but only 71 MT C/acre in the Air District). According to the Contra Costa inventory report, this high reported carbon density in those classes is likely because Contra Costa County pasture and hay, cultivated and field crops, and wetlands border the Delta and therefore hold some of the highest soil carbon per acre.

**Table 8. Contra Costa County Carbon Stock per Acre and Total Carbon Stock (2021), from the 2023 Contra Costa County inventory.**

| Contra Costa County Carbon Stock per Acre and Total Carbon Stock (2021) | | | |
|---|---|---|---|
| Land Cover Class | Average Carbon Stock per Acre (MT C/Acre) | Total Carbon Stock (MT C) | Cabon Stock per Acre Rank |
| Open Water | 4 | 257,820 | 11 |
| Vineyard | 11 | 22,388 | 10 |
| Orchard | 14 | 31,003 | 9 |
| Grassland/Herbaceous | 16 | 2,543,136 | 8 |
| Barren | 17 | 11,855 | 7 |
| Development | 23 | 2,865,375 | 6 |
| Shrub/Scrub | 24 | 733,433 | 5 |
| Forest | 35 | 2,879,772 | 4 |
| Wetland | 48 | 614,458 | 3 |
| Cultivated and Field Crops | 71 | 1,928,577 | 2 |
| Pasture and Hay | 90 | 1,090,407 | 1 |
| Total | NA | 12,978,222 | NA |

**Table 9. BARCAP—Region Carbon Stock per Acre and Total Carbon Stock (2022), modified from Table 1.**

| BARCAP—Region Carbon Stock per Acre and Total Carbon Stock (2022) | | | |
|---|---|---|---|
| Land Cover Class | Average Carbon Stock per Acre (MT C/Acre) | Total Carbon Stock (MT C) | Carbon Stock per Acre Rank |
| Barren | 15 | 139,387 | 11 |
| Development | 14 | 10,652,489 | 10 |
| Vineyard | 17 | 1,673,057 | 9 |
| Grassland/Herbaceous | 17 | 10,296,937 | 8 |
| Shrub/Scrub | 27 | 5,270,461 | 7 |
| Open Water | 30 | 3,668,746 | 6 |
| Pasture and Hay | 34 | 2,570,126 | 5 |
| Orchard | 37 | 377,494 | 4 |
| Cultivated and Field Crops | 38 | 2,397,443 | 3 |
| Wetland | 54 | 8,632,855 | 2 |
| Forest | 71 | 46,656,135 | 1 |
| Total | 34 | 92,335,131 | NA |

# Sonoma County Results

The 2023 Sonoma County inventory[21] analysis using data from 2013 found total carbon stocks summing to 117,593,161 MT CO2e. Using data from 2022, the same inventory found total carbon stocks summing to 105,365,950 MT CO2e. In both years, forest dominates as the land cover class contributing the most to the total carbon stock; about 60%. Figure 10, below, organizes these findings between years in a singular table for ready comparison.

**Figure 10. 2013 and 2022 Carbon Stocks by Land Cover, copied from the 2023 Sonoma County inventory.**

| Land Cover Class | 2013 Total Carbon Stock (MT CO$_2$e) | 2022 Total Carbon Stock (MT CO$_2$e) | Percent Change between 2013 and 2022 (MT CO$_2$e) |
|---|---|---|---|
| Barren | 440,119 | 367,468 | -17 |
| Cultivated and Field Crops | 100,577 | 101,027 | 0 |
| Development | 6,962,559 | 7,749,627 | 11 |
| Forest | 78,034,944 | 61,577,998 | -21 |
| Grassland/ Herbaceous | 18,109,720 | 17,986,840 | -1 |
| Open Water | 675,920 | 1,303,248 | 93 |
| Orchard | 239,362 | 202,396 | -15 |
| Pasture and Hay | 2,396,328 | 3,944,917 | 65 |
| Shrub/Scrub | 4,094,253 | 5,196,075 | 27 |
| Vineyard | 3,593,475 | 4,582,317 | 28 |
| Wetland | 2,945,905 | 2,354,039 | -20 |
| **Total** | **117,593,161** | **105,365,950** | **-10** |

## Quantitative Comparison with the Sonoma County Inventory

The Sonoma County inventory calculated 28,712,221 MT C (originally published as 105,365,950 MT CO2e) in 2022 over approximately 422,698 hectares (originally published as 1,044,510 acres). In comparison, for Sonoma County, this inventory of the Bay Area Air District calculated 11,981,967 MT

---

[21] https://sonomacounty.ca.gov/Main%20County%20Site/Administrative%20Support%20%26%20Fiscal%20Services/CAO/
Documents/Climate%20Action%20and%20Resiliency/Sonoma-County-Carbon-Inventory-and-Study-with-Executive-Summary.pdf

CO2e over approximately 159,680 hectares (Table 2, above). The difference in both hectares and acreage is unsurprising, given that the entirety of Sonoma County does not fall under the ROI for this analysis, the Air District only includes the southern portion of Sonoma County. See Tables 10 and 11, below, for a breakdown of carbon stock by land cover class in Sonoma County and the Bay Area Air District, respectively.

When comparing the order of carbon stock per unit area between Sonoma County Table 8) and the Air District (Table 7); the order of classes remains relatively directionally consistent (wetland and forest are first or second most carbon dense, vineyard is relatively low when compared to other classes). Moreover, all classes are relatively similar in carbon density between the two inventories; the Sonoma County inventory spans 16-48 MT C/acre and the Air District inventory spans 15-71 MT C/acre. This slight difference can be attributed to the inclusion of additional data sources in the Sonoma County inventory but not in this inventory, as outlined in the Methodology section above.

As in the Contra Costa inventory, the decision by Sonoma County to employ multiple data sources, instead of manual interpolation from LANDFIRE as in this Air District inventory, may have introduced uncertainty in the resultant estimations of carbon stock. Furthermore, the re-classification from the LANDFIRE land cover classifications limits the degree to which these two inventories can be effectively compared using land cover class.

**Table 10. Sonoma County Carbon Stock per Acre and Total Carbon Stock (2022), from the 2023 Sonoma County inventory.**

| Sonoma County Carbon Stock per Acre and Total Carbon Stock (2022) | | | |
|---|---|---|---|
| Land Cover Class | Average Carbon Stock per Acre 2022 (MT C/Acre) | Total Carbon Stock 2022 (MT C) | Carbon Stock per Acre Rank |
| Vineyard | 16 | 1,248,681 | 11 |
| Open Water | 16 | 355,135 | 10 |
| Orchard | 18 | 55,153 | 9 |
| Development | 20 | 2,111,773 | 8 |
| Cultivated and Field Crops | 22 | 27,530 | 7 |
| Grassland/Herbaceous | 23 | 4,901,414 | 6 |
| Barren | 24 | 100,135 | 5 |
| Pasture and Hay | 26 | 1,074,990 | 4 |
| Shrub/Scrub | 27 | 1,415,930 | 3 |
| Forest | 33 | 16,780,004 | 2 |
| Wetland | 48 | 641,476 | 1 |
| Total | NA | 28,712,221 | NA |

**Table 9. BARCAP—Region Carbon Stock per Acre and Total Carbon Stock (2022), modified from Table 1. (Reprinted)**

| BARCAP—Region Carbon Stock per Acre and Total Carbon Stock (2022) | | | |
|---|---|---|---|
| Land Cover Class | Average Carbon Stock per Acre (MT C/Acre) | Total Carbon Stock (MT C) | Carbon Stock per Acre Rank |
| Barren | 15 | 139,387 | 11 |
| Development | 14 | 10,652,489 | 10 |
| Vineyard | 17 | 1,673,057 | 9 |
| Grassland/Herbaceous | 17 | 10,296,937 | 8 |
| Shrub/Scrub | 27 | 5,270,461 | 7 |
| Open Water | 30 | 3,668,746 | 6 |
| Pasture and Hay | 34 | 2,570,126 | 5 |
| Orchard | 37 | 377,494 | 4 |
| Cultivated and Field Crops | 38 | 2,397,443 | 3 |
| Wetland | 54 | 8,632,855 | 2 |
| Forest | 71 | 46,656,135 | 1 |
| Total | 34 | 92,335,131 | NA |

# Appendix 1: Land Cover Classes Definitions

| Land Cover Class | Definition from 2023 Sonoma County Inventory | Definition from 2023 Contra Costa Inventory | Definition from this analysis |
|---|---|---|---|
| Barren | Areas where vegetation accounts for less than 15 percent of total cover, for example areas of bedrock, sand dunes, or gravel pits. | Areas with very little vegetative cover and accumulations of earthen material such as bedrock, beaches, desert, sand dunes, strip mines, gravel pits, and so on. | Areas of bedrock, sand dunes, or gravel pits. |
| Cultivated and Field Crops | Areas used for the production of vegetables and field crops generally grown for human consumption, such as squash, tomatoes, leafy greens, rye, and oat. | Areas used to produce annual crops, such as corn, tomatoes, or other vegetables. | Areas used to produce vegetables or field crops, including but not limited to wheat, bush fruit, and row crops. |
| Development | Areas with constructed materials, including buildings and roads | Areas with impervious surfaces and features generally associated with towns or cities including residential, commercial, and industrial uses. | All constructed areas. For this analysis, this includes all EVTs containing the word "Urban" or "Developed". |
| Forest | Areas dominated by trees with more than 10 percent tree cover (includes riparian areas that are dominated by trees with more than 10 percent tree cover). | Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. | Areas dominated by trees, including mixed-vegetation/riparian areas that are generally tree-dominant. |
| Grassland/Herbaceous | Areas dominated by herbaceous vegetation, with more than 10 percent herb cover, less than 10 percent tree cover and less than 10 percent shrub cover. | Areas dominated by grassy or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management, such as tilling, but can be utilized for livestock grazing. | Areas dominated by herbaceous vegetation, including mixed-vegetation/riparian areas that are generally grass/herbaceous-dominant. |
| Open Water | Areas of open water such as lakes, reservoirs, rivers, and oceans, generally with less than 25 percent cover of vegetation or soil. | Areas of open water such as lakes, reservoirs, rivers, and oceans, generally with less than 25% cover of vegetation or soil. | EVT of "Open Water". |
| Orchard | Areas used to grow perennial woody tree crops such as apples, olives, and stone fruit. | Areas used to grow perennial woody tree crops, such as cherries, almonds, etc. | Areas used to produce fruit or nuts. For this analysis, this is limited to the EVTs of "Western Warm Temperate Orchard" and "Western Cool Temperate Orchard". |
| Pasture and Hay | Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture or hay accounts for more than 20 percent of total vegetation. | Areas of grasses and/or legumes planted for livestock grazing, or the production of seed or hay crops, typically perennial plants. | Areas of grasses or areas used to produce seed or hay crops. For this analysis, this is limited to the EVTs of "Western Warm Temperate Pasture and Hayland" and "Western Cool Temperate Pasture and Hayland". |
| Shrub/Scrub | Areas dominated by shrubs greater than 10 percent of total shrub cover and less than 10 percent tree cover (includes | Areas dominated by shrubs, less than 5 meters tall, with shrub canopy typically greater than 20% of total vegetation. | Areas dominated by shrubs including mixed-vegetation/riparian areas |

| Land Cover Class | Definition from 2023 Sonoma County Inventory | Definition from 2023 Contra Costa Inventory | Definition from this analysis |
|---|---|---|---|
| | riparian areas that are dominated by shrubs greater than 10 percent of total shrub cover and less than 10 percent of tree cover. | | that are generally shrub-dominant. |
| Vineyard | Areas planted with grapevines, generally used for producing grapes used in winemaking. | Areas used to grow perennial woody vine crops such as grapes. | Areas used to produce wine. For this analysis, this is limited to the EVTs of "Western Warm Temperate Vineyard" and "Western Cool Temperate Vineyard". |
| Wetland | Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the perennial herbaceous vegetation indicate soil or substrate periodically saturated with or covered with water. | Areas where the soil or substrate is periodically saturated or covered with water. | Areas dominated by wetland with periodically saturated soil or substrate. |

# Appendix 2: Comparison of LANDFIRE, Sonoma County, & IPCC Land Cover Classes

| LANDFIRE Existing Vegetation Type (EVT) | Sonoma County | IPCC |
|---|---|---|
| California Central Valley and Southern Coastal Grassland | Grassland/Herbaceous | Grassland |
| California Central Valley Mixed Oak Savanna | Forest | Forest land |
| California Central Valley Riparian Shrubland | Wetland | Forest land |
| California Central Valley Riparian Woodland | Wetland | Forest land |
| California Coastal Closed-Cone Conifer Forest and Woodland | Forest | Forest land |
| California Coastal Live Oak Woodland and Savanna | Forest | Forest land |
| California Coastal Redwood Forest | Forest | Forest land |
| California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna | Forest | Forest land |
| California Lower Montane Blue Oak Woodland and Savanna | Forest | Forest land |
| California Lower Montane Foothill Pine Woodland and Savanna | Forest | Forest land |
| California Maritime Chaparral | Shrub/Scrub | Forest land |
| California Mesic Chaparral | Shrub/Scrub | Forest land |
| California Mesic Serpentine Grassland | Grassland/Herbaceous | Grassland |
| California Northern Coastal Grassland | Grassland/Herbaceous | Grassland |
| California Ruderal Grassland and Meadow | Grassland/Herbaceous | Grassland |
| California Ruderal Scrub | Shrub/Scrub | Forest land |
| California Xeric Serpentine Chaparral | Shrub/Scrub | Forest land |
| Californian Ruderal Forest | Forest | Forest land |
| Central and Southern California Mixed Evergreen Woodland | Forest | Forest land |
| Central California Coast Ranges Cliff and Canyon | Barren | Other land |
| Developed-High Intensity | Development | Settlements |
| Developed-Low Intensity | Development | Settlements |
| Developed-Medium Intensity | Development | Settlements |
| Developed-Roads | Development | Settlements |
| Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland | Forest | Forest land |
| Mediterranean California Foothill and Lower Montane Riparian Shrubland | Wetland | Forest land |
| Mediterranean California Foothill and Lower Montane Riparian Woodland | Wetland | Forest land |
| Mediterranean California Lower Montane Black Oak-Conifer Forest and Woodland | Forest | Forest land |
| Mediterranean California Lower Montane Black Oak Forest and Woodland | Forest | Forest land |
| Mediterranean California Lower Montane Conifer Forest and Woodland | Forest | Forest land |
| Mediterranean California Mesic Serpentine Chaparral | Shrub/Scrub | Forest land |
| Mediterranean California Mesic Serpentine Woodland | Forest | Forest land |
| Mediterranean California Mixed Evergreen Forest | Forest | Forest land |
| Mediterranean California Mixed Oak Woodland | Forest | Forest land |
| Mediterranean California Northern Coastal Dune | Barren | Other land |
| Mediterranean California Serpentine Foothill and Lower Montane Riparian Shrubland and Seep | Wetland | Wetland |
| Mediterranean California Serpentine Foothill and Lower Montane Riparian Woodland and Seep | Wetland | Wetland |
| Northern and Central California Dry-Mesic Chaparral | Shrub/Scrub | Forest land |
| Northern California Coastal Scrub | Shrub/Scrub | Forest land |
| Open Water | Open Water | Water |
| Quarries-Strip Mines-Gravel Pits-Well and Wind Pads | Barren | Other land |
| Southern California Coastal Scrub | Shrub/Scrub | Forest land |
| Temperate Pacific Freshwater Emergent Marsh | Wetland | Wetland |
| Temperate Pacific Subalpine-Montane Wet Meadow | Wetland | Wetland |
| Temperate Pacific Tidal Salt and Brackish Marsh | Wetland | Wetland |
| Western Cool Temperate Bush fruit and berries | Cultivated and Field Crops | Cropland |
| Western Cool Temperate Close Grown Crop | Cultivated and Field Crops | Cropland |

| LANDFIRE Existing Vegetation Type (EVT) | Sonoma County | IPCC |
|---|---|---|
| Western Cool Temperate Developed Deciduous Forest | Development | Settlements |
| Western Cool Temperate Developed Evergreen Forest | Development | Settlements |
| Western Cool Temperate Developed Herbaceous | Development | Settlements |
| Western Cool Temperate Developed Mixed Forest | Development | Settlements |
| Western Cool Temperate Developed Shrubland | Development | Settlements |
| Western Cool Temperate Fallow/Idle Cropland | Cultivated and Field Crops | Cropland |
| Western Cool Temperate Orchard | Orchard | Cropland |
| Western Cool Temperate Pasture and Hayland | Pasture and Hay | Cropland |
| Western Cool Temperate Row Crop | Cultivated and Field Crops | Cropland |
| Western Cool Temperate Row Crop - Close Grown Crop | Cultivated and Field Crops | Cropland |
| Western Cool Temperate Urban Deciduous Forest | Development | Settlements |
| Western Cool Temperate Urban Evergreen Forest | Development | Settlements |
| Western Cool Temperate Urban Herbaceous | Development | Settlements |
| Western Cool Temperate Urban Mixed Forest | Development | Settlements |
| Western Cool Temperate Urban Shrubland | Development | Settlements |
| Western Cool Temperate Vineyard | Vineyard | Cropland |
| Western Cool Temperate Wheat | Cultivated and Field Crops | Cropland |
| Western North American Ruderal Wet Meadow & Marsh | Wetland | Wetland |
| Western North American Ruderal Wet Shrubland | Wetland | Wetland |
| Western Warm Temperate Bush fruit and berries | Cultivated and Field Crops | Cropland |
| Western Warm Temperate Close Grown Crop | Cultivated and Field Crops | Cropland |
| Western Warm Temperate Developed Deciduous Forest | Development | Cropland |
| Western Warm Temperate Developed Evergreen Forest | Development | Cropland |
| Western Warm Temperate Developed Herbaceous | Development | Cropland |
| Western Warm Temperate Developed Mixed Forest | Development | Cropland |
| Western Warm Temperate Developed Shrubland | Development | Cropland |
| Western Warm Temperate Fallow/Idle Cropland | Cultivated and Field Crops | Cropland |
| Western Warm Temperate Orchard | Orchard | Cropland |
| Western Warm Temperate Pasture and Hayland | Pasture and Hay | Cropland |
| Western Warm Temperate Row Crop | Cultivated and Field Crops | Cropland |
| Western Warm Temperate Row Crop - Close Grown Crop | Cultivated and Field Crops | Cropland |
| Western Warm Temperate Urban Deciduous Forest | Development | Settlements |
| Western Warm Temperate Urban Evergreen Forest | Development | Settlements |
| Western Warm Temperate Urban Herbaceous | Development | Settlements |
| Western Warm Temperate Urban Mixed Forest | Development | Settlements |
| Western Warm Temperate Urban Shrubland | Development | Settlements |
| Western Warm Temperate Vineyard | Vineyard | Cropland |
| Western Warm Temperate Wheat | Cultivated and Field Crops | Cropland |
| Klamath-Siskiyou Lower Montane Serpentine Mixed Conifer Woodland | Forest | Forest land |
| California Montane Jeffrey Pine-(Ponderosa Pine) Woodland | Forest | Forest land |
| Klamath-Siskiyou Xeromorphic Serpentine Chaparral | Shrub/Scrub | Forest land |
| Klamath-Siskiyou Xeromorphic Serpentine Savanna | Grassland/Herbaceous | Forest land |
| Mediterranean California Mesic Mixed Conifer Forest and Woodland | Forest | Forest land |
| North Pacific Oak Woodland | Forest | Forest land |
| Klamath-Siskiyou Cliff and Outcrop | Barren | Other land |
| Mediterranean California Subalpine Meadow | Grassland/Herbaceous | Grassland |
| California Montane Woodland and Chaparral | Shrub/Scrub | Forest land |
| Mediterranean California Red Fir Forest | Forest | Forest land |
| Klamath-Siskiyou Upper Montane Serpentine Mixed Conifer Woodland | Forest | Forest land |
| Northern California Mesic Subalpine Woodland | Forest | Forest land |
| Mediterranean California Subalpine Woodland | Forest | Forest land |
| Mediterranean California Alpine Bedrock and Scree | Barren | Other land |
| North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest | Forest | Forest land |
| Inter-Mountain Basins Cliff and Canyon | Barren | Other land |
| Columbia Plateau Western Juniper Woodland and Savanna | Grassland/Herbaceous | Forest land |

| LANDFIRE Existing Vegetation Type (EVT) | Sonoma County | IPCC |
|---|---|---|
| Interior Western North American Temperate Ruderal Grassland | Grassland/Herbaceous | Cropland |
| Columbia Plateau Steppe and Grassland | Grassland/Herbaceous | Grassland |
| North Pacific Montane Riparian Woodland | Wetland | Forest land |
| North American Arid West Emergent Marsh | Wetland | Wetland |
| North Pacific Lowland Riparian Shrubland | Wetland | Forest land |
| Interior Western North American Temperate Ruderal Shrubland | Shrub/Scrub | Forest land |
| North Pacific Lowland Riparian Forest | Wetland | Forest land |
| Columbia Plateau Low Sagebrush Steppe | Shrub/Scrub | Forest land |
| Inter-Mountain Basins Big Sagebrush Shrubland | Shrub/Scrub | Forest land |
| North Pacific Montane Riparian Shrubland | Wetland | Forest land |
| Great Basin & Intermountain Introduced Annual Grassland | Grassland/Herbaceous | Grassland |
| Great Basin & Intermountain Ruderal Shrubland | Shrub/Scrub | Forest land |
| Inter-Mountain Basins Big Sagebrush Steppe | Shrub/Scrub | Forest land |
| Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland | Forest | Forest land |
| Sierra Nevada Cliff and Canyon | Barren | Other land |
| Rocky Mountain Aspen Forest and Woodland | Forest | Forest land |
| Sierran-Intermontane Desert Western White Pine-White Fir Woodland | Forest | Forest land |
| Inter-Mountain Basins Montane Sagebrush Steppe | Shrub/Scrub | Forest land |
| Sierra Nevada Subalpine Lodgepole Pine Forest and Woodland | Forest | Forest land |
| North Pacific Active Volcanic Rock and Cinder Land | Barren | Other land |
| North Pacific Wooded Volcanic Flowage | Barren | Forest land |
| North Pacific Montane Shrubland | Shrub/Scrub | Forest land |
| North Pacific Montane Massive Bedrock-Cliff and Talus | Barren | Other land |
| North American Glacier and Ice Field | Barren | Other land |
| Mediterranean California Alpine Dry Tundra | Grassland/Herbaceous | Grassland |
| North Pacific Alpine and Subalpine Dry Grassland | Grassland/Herbaceous | Grassland |
| Great Basin Pinyon-Juniper Woodland | Forest | Forest land |
| Great Basin Foothill and Lower Montane Riparian Shrubland | Wetland | Forest land |
| Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe | Shrub/Scrub | Forest land |
| Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland | Forest | Forest land |
| Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest | Forest | Forest land |
| Great Basin Foothill and Lower Montane Riparian Woodland | Wetland | Forest land |
| Great Basin & Intermountain Introduced Annual and Biennial Forbland | Grassland/Herbaceous | Grassland |
| Inter-Mountain Basins Semi-Desert Shrub-Steppe | Shrub/Scrub | Forest land |
| Inter-Mountain Basins Playa | Barren | Other land |
| Inter-Mountain Basins Wash | Barren | Other land |
| Inter-Mountain Basins Alkaline Closed Depression | Barren | Wetland |
| Inter-Mountain Basins Greasewood Flat | Shrub/Scrub | Wetland |
| Inter-Mountain Basins Mixed Salt Desert Scrub | Shrub/Scrub | Forest land |
| Great Basin & Intermountain Introduced Perennial Grassland and Forbland | Grassland/Herbaceous | Grassland |
| Great Basin Xeric Mixed Sagebrush Shrubland | Shrub/Scrub | Forest land |
| Rocky Mountain Subalpine-Montane Mesic Meadow | Grassland/Herbaceous | Grassland |
| Columbia Plateau Scabland Shrubland | Shrub/Scrub | Forest land |
| Rocky Mountain Alpine-Montane Wet Meadow | Grassland/Herbaceous | Wetland |
| Inter-Mountain Basins Semi-Desert Grassland | Grassland/Herbaceous | Grassland |
| Columbia Plateau Ash and Tuff Badland | Barren | Other land |
| Northern Rocky Mountain Montane-Foothill Deciduous Shrubland | Shrub/Scrub | Forest land |
| Southern Rocky Mountain Montane-Subalpine Grassland | Grassland/Herbaceous | Grassland |
| Rocky Mountain Subalpine-Montane Riparian Shrubland | Wetland | Forest land |
| Great Basin Foothill and Lower Montane Riparian Herbaceous | Wetland | Grassland |
| Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland | Forest | Forest land |
| Rocky Mountain Subalpine-Montane Riparian Woodland | Wetland | Forest land |
| Rocky Mountain Lower Montane-Foothill Shrubland | Shrub/Scrub | Forest land |
| Great Basin Semi-Desert Chaparral | Shrub/Scrub | Forest land |
| Sierra Nevada Alpine Dwarf-Shrubland | Shrub/Scrub | Forest land |

| LANDFIRE Existing Vegetation Type (EVT) | Sonoma County | IPCC |
|---|---|---|
| Interior West Ruderal Riparian Forest | Wetland | Wetland |
| Interior West Ruderal Riparian Scrub | Wetland | Wetland |
| Rocky Mountain Cliff Canyon and Massive Bedrock | Barren | Other land |
| Mojave Mid-Elevation Mixed Desert Scrub | Shrub/Scrub | Forest land |
| Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland | Forest | Forest land |
| Rocky Mountain Alpine Turf | Grassland/Herbaceous | Grassland |
| Mediterranean California Alpine Fell-Field | Grassland/Herbaceous | Forest land |
| Sonora-Mojave Mixed Salt Desert Scrub | Shrub/Scrub | Forest land |
| Sonora-Mojave Creosotebush-White Bursage Desert Scrub | Shrub/Scrub | Forest land |
| Inter-Mountain Basins Active and Stabilized Dune | Barren | Other land |
| North American Warm Desert Pavement | Barren | Other land |
| North American Warm Desert Bedrock Cliff and Outcrop | Barren | Other land |
| North American Warm Desert Badland | Barren | Other land |
| North American Warm Desert Ruderal & Planted Scrub | Shrub/Scrub | Forest land |
| North American Warm Desert Ruderal & Planted Grassland | Grassland/Herbaceous | Grassland |
| North American Warm Desert Volcanic Rockland | Barren | Other land |
| North American Warm Desert Active and Stabilized Dune | Barren | Other land |
| North American Warm Desert Playa | Barren | Other land |
| Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland | Forest | Forest land |
| Sonora-Mojave Semi-Desert Chaparral | Shrub/Scrub | Forest land |
| North American Warm Desert Lower Montane Riparian Shrubland | Wetland | Forest land |
| North American Warm Desert Lower Montane Riparian Woodland | Wetland | Forest land |
| North American Warm Desert Riparian Shrubland | Wetland | Forest land |
| North American Warm Desert Wash Shrubland | Wetland | Forest land |
| North American Warm Desert Riparian Woodland | Wetland | Forest land |
| North American Warm Desert Wash Woodland | Wetland | Forest land |
| North American Warm Desert Cienega | Wetland | Wetland |
| North American Warm Desert Riparian Mesquite Bosque Shrubland | Wetland | Forest land |
| North American Warm Desert Riparian Herbaceous | Wetland | Wetland |
| North American Warm Desert Riparian Mesquite Bosque Woodland | Wetland | Forest land |
| Southern California Dry-Mesic Chaparral | Shrub/Scrub | Forest land |
| Southern California Oak Woodland and Savanna | Forest | Forest land |
| Southern California Coast Ranges Cliff and Canyon | Barren | Other land |
| Mediterranean California Southern Coastal Dune | Barren | Other land |
| Rocky Mountain Gambel Oak-Mixed Montane Shrubland | Shrub/Scrub | Forest land |
| Southern Rocky Mountain Ponderosa Pine Woodland | Forest | Forest land |
| Baja Semi-Desert Coastal Succulent Scrub | Shrub/Scrub | Forest land |
| Sonoran Granite Outcrop Desert Scrub | Shrub/Scrub | Forest land |
| Sonoran Paloverde-Mixed Cacti Desert Scrub | Shrub/Scrub | Forest land |
| Agriculture-Cultivated Crops and Irrigated Agriculture | Cultivated and Field Crops | Cropland |
| Western Warm Temperate Aquaculture | Open Water | Cropland |
| Developed-Open Space | Development | Settlements |
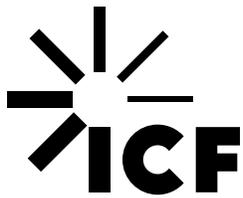
**ICF**

---

**icf.com**

---

**ICF Climate Center**
The ICF Climate Center offers compelling research and unique insights that help organizations establish clear, practical pathways forward through the combination of climate science and predictive analytics.

The Center builds upon the work of 2,000+ climate, energy, and environment experts worldwide—making us one of the world's largest science-based climate consultancies. ICF works with business, government, and nonprofit organizations to design and implement programs and policies that drive low-carbon transitions and build resilience against the effects of climate change. Learn more at icf.com/climate.

**About ICF**
ICF (NASDAQ:ICFI) is a global consulting services company with approximately 9,000 full-time and part-time employees, but we are not your typical consultants. At ICF, business analysts and policy specialists work together with digital strategists, data scientists and creatives. We combine unmatched industry expertise with cutting-edge engagement capabilities to help organizations solve their most complex challenges. Since 1969, public and private sector clients have worked with ICF to navigate change and shape the future.