

Sonoma Vegetation and Habitat Map

Final Report



AG + OPEN SPACE
SONOMA COUNTY



SONOMA **VEG** MAP

SONOMA COUNTY VEGETATION MAPPING & LIDAR PROGRAM

High-Quality Data for Planning, Conservation and Resource Management

Prepared by Tukman Geospatial and Kass Green & Associates for the Sonoma County Agricultural Preservation and Open Space District

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1. Executive Summary

This report documents the methods and results of the fine-scale, countywide vegetation and habitat map of Sonoma County, CA and associated products. The map represents the state of the landscape in fall, 2013, when the high-resolution imagery and LiDAR data were collected.

The Sonoma County Vegetation Mapping and LiDAR Program (Sonoma Veg Map) is a multi-year program to map Sonoma County's topography, physical and biotic features, diverse plant communities and habitats, and agriculture. It is a program of the Sonoma County Agricultural Preservation and Open Space District (Sonoma Ag + Open Space) in partnership with the Sonoma County Water Agency (Sonoma Water), NASA, and the California Department of Fish and Wildlife. Other contributing partners include the United States Geological Survey, the County of Sonoma Information Systems Department, the County of Sonoma Transportation and Public Works Department, the City of Petaluma, the Nature Conservancy, and Save the Redwoods League.

Over a 6-year period, the program has produced over 35 environmental map products including countywide LiDAR data, 1-foot contours, orthophotography, stream centerlines, watershed boundaries, and vegetation and land cover maps. An 82-class fine-scale vegetation map was completed in May 2017 that includes high-level land cover detail for vegetation communities and agricultural land cover types, including forests, grasslands, riparian vegetation, wetlands, and croplands.

The environmental data products from the Sonoma Veg Map are foundational and are used by many organizations and government departments for a wide range of purposes, including planning and management for watershed protection, flood control, and fire and fuels management. Existing datasets such as CALVEG were satisfactory for regional analysis, but not resolute enough for decision-making at the parcel level. Ag + Open Space uses high-resolution information to focus and prioritize its land conservation efforts toward healthy, connected ecosystems; save costs on piece-meal vegetation mapping and other environmental data collection needed for reporting and analysis; assess climate mitigation and adaptation strategies and benefits provided by the landscape; and track changes over time to Sonoma County's habitats and natural resources as a result of human activity or conservation efforts.

The fine-scale vegetation and habitat map was a team effort initiated and managed by Sonoma County Ag + Open Space and staffed by personnel from Tukman Geospatial, Kass Green and Associates, Prunuske Chatham, Inc., the California Department of Fish and Wildlife's Vegetation Classification and Mapping Program (VegCAMP), and the California Native Plant Society (CNPS).

The fine-scale map effort began with countywide survey data collection by CNPS and VegCAMP in 2013 and 2014 (for a chronology of program deliverables, see figure 1). Data from the over

850 vegetation surveys were used by the Department of Fish and Wildlife and CNPS to develop a Sonoma County-specific National Vegetation Classification compliant classification, as well as class descriptions and keys.

High density LiDAR data and 6-inch 4-band imagery were obtained countywide in the fall of 2013 to support the project. LiDAR and imagery were provided by the University of Maryland, which was awarded a \$1.2 million NASA research grant (NNX13AP69G) under the NASA Carbon Monitoring System project. Researchers at the University of Maryland (Dr. Ralph Dubayah and Dr. George Hurtt, Principal Investigators) are using these data to develop tools for measuring and monitoring forest carbon in Sonoma County. The LiDAR point cloud, and many of its derivatives, were used extensively during the process of developing the fine-scale vegetation and habitat map. Optical data used included countywide 6-inch resolution airborne 4-band imagery from 2011 and 2013, 4-band, 1-meter National Agriculture Imagery Program (NAIP) airborne imagery from 2009 and 2012 and Landsat satellite imagery from 2011 and 2013.

In early 2016, an 18-class lifeform map was produced which serves as the foundation for the much more floristically detailed fine-scale vegetation and habitat map. The lifeform map was developed using expert systems rulesets in Trimble Ecognition®, followed by manual editing. A croplands map and an impervious surfaces map were also released at the time the lifeform map was published.

In 2015, Tukman Geospatial staff and partners conducted countywide reconnaissance field work to support fine-scale mapping. Field-collected data were used to train automated machine learning algorithms, which produced a fully automated countywide fine-scale vegetation and habitat map. Throughout 2016, project staff manually edited the fine-scale maps, went to the field for validation trips to review the maps, and conducted a second round of manual editing based on the validation trips. In the second half of 2016, draft maps were reviewed by members of the Sonoma Veg Map Program's Local Ecology and Botany Advisory Group and Vegetation Mapping and Remote Sensing Advisory Group. Input from these groups was used to further refine the map. The countywide fine-scale vegetation and habitat and its related data products were made public on May 1, 2017. In total, 82 vegetation classes were mapped with a minimum mapping size of ¼ to ½ acres, varying by class.

Accuracy assessment plot data were collected in 2016, 2017, and 2018. Accuracy assessment results were compiled and analyzed in the summer of 2018. Overall accuracy of the life form map is 95%. Overall accuracy of the fine-scale vegetation and habitat map is 79%.

The Sonoma County fine-scale vegetation and habitat map was produced by many hands and is used by many people – for many purposes – in Sonoma County and regionally. The map was designed for a broad audience for use at many floristic and spatial scales. At its most

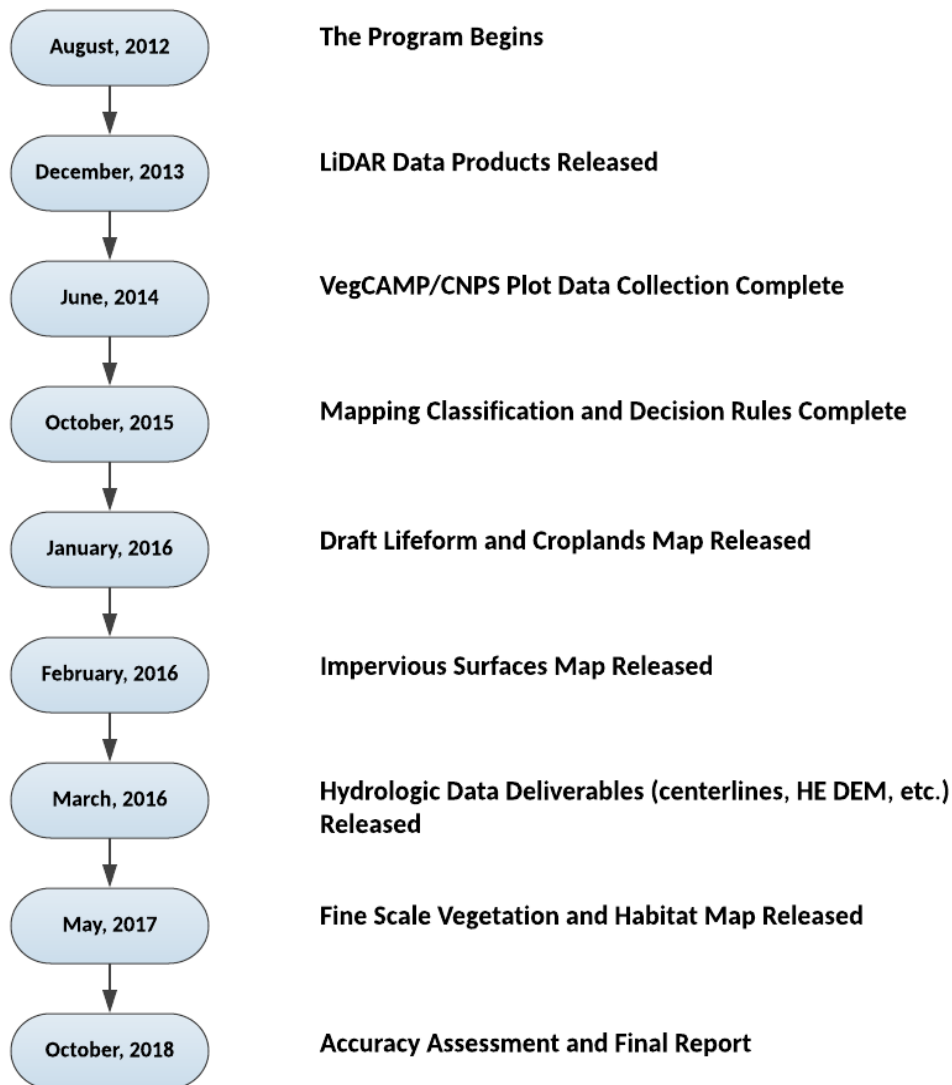
floristically resolute scale, the fine-scale vegetation map depicts the landscape at the National Vegetation Classification alliance level – which characterizes vegetation patches by their dominant plant species. This product is useful to managers interested in very specific information about vegetation composition. For those interested in more general land use and land cover, the lifeform map may be more appropriate. To make the information contained in the map accessible to the most users, the vegetation and habitat map is published as a suite of deliverables available in a number of formats, each with different end users in mind. These map products are available on <http://sonomavegmap.org/data-downloads>.

In addition to the numerous data products, the fine-scale vegetation and habitat map contains several attributes that provide utility to the end user beyond vegetation classification. The map contains LiDAR-derived information about stand height, stand canopy cover, and the percent of impervious cover in each vegetation and habitat map polygon.

This report details the methods used to develop the fine-scale vegetation map and its derivative products. Methods used to create the LiDAR products are detailed in a separate technical report, available for download on the <http://sonomavegmap.org/data-downloads>. This report is organized into the following sections:

- **Section 2. Acknowledgements**
- **Section 3. Mapping Methods** – details methods used to create the final map classes and rules, the lifeform map, and the fine-scale vegetation and habitat maps
- **Section 4. Accuracy Assessment Methods and Results** – provides information on the accuracy of the vegetation map overall, the accuracy by map class, and discussion of the major sources of confusion.
- **Section 5. Vegetation and Habitat Map Data Products** – provides a list of the vegetation map data products, instructions for obtaining the data products and specifications of the map products including minimum mapping units.
- **Section 6. Lessons Learned**
- **Section 7. References**
- **Section 8. Fine-scale Map Class Descriptions** – provides a page for each fine-scale map class that describes the map class, its distribution in the county, and information about the map classes' accuracy.

Figure 1. *A chronology of program deliverables*



2. Acknowledgements

The Sonoma County Vegetation Mapping and LiDAR Program was a multi-year effort made possible by the financial support of the following agencies and organizations:

- The Sonoma County Agricultural Preservation and Open Space District
- The Sonoma County Water Agency
- NASA & The University of Maryland
- The United States Geological Survey
- The California Department of Fish and Wildlife
- The County of Sonoma Information Systems Department

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- The County of Sonoma Transportation and Public Works Department
- The California Native Plant Society
- The Nature Conservancy
- The City of Petaluma
- Save the Redwoods League
- San Francisco Estuary Institute (SFEI)

This project would not have been successful without the in-kind support of the California Department of Fish and Wildlife's Vegetation Classification and Mapping Program (VegCAMP). VegCAMP spent many weeks in the field collecting plot data and developing the floristic classifications and descriptions that were foundational to the mapping workflow. NASA and the University of Maryland provided critical datasets for the project, including the 2013 LiDAR point cloud. The California Native Plant Society provided in-kind support for vegetation plot data collection and classification development. Dr. Matthew Clark (Sonoma State University) provided many hours of his time reviewing products, providing input and advice, and providing datasets such as LiDAR derivatives and hyperspectral imagery. Dr. Maggi Kelly (UC Berkeley) provided computing resources that allowed us to provide public access to high resolution orthoimagery. Lastly, we'd like to thank members of the Ecology and Botany Group and the Vegetation Mapping and Remote Sensing Advisory Committee for dedicating their time to advise on technical matters and local ecology and botany. These advisors are listed below in table 1.

Table 1. *Advisory committee members*

Ecology and Botany Group			
Aaron Arthur	Dave Cook	Keenan Foster	Rich Stabler
Ann Howald	Fred Euphrat	Liz Parsons	Roger Raiche
Arthur Dawson	Gene Cooley	Mariska Obedzinski	Sarah Gordon
Brendan O'Neil	Hattie Brown	Michelle Harbur	Shelly Benson
Caroline Christian	Jane Valerius	Peter Baye	Sherry Adams
Chris Kjeldsen	Joe Pecharich	Peter Conners	Steve Barnhart
Christina Sloop	John Herrick	Peter Warner	Tom Parker
Claudia Luke	Julian Meisler	Phil Northen	
Cyndy Shafer	Katheleen Kraft	Phil van Soelen	

Vegetation Mapping and Remote Sensing Advisory Committee			
Dr. Matthew Clark	Dr. Jordan Golinkoff	Jennifer Michaud	Mark Rosenberg
Charles Convis	Kass Green	John Nickerson	Joan Schwan
Michael Fitzgibbon	Dr. Todd Keeler Wolf	Carlos Ramirez	Mark Tukman
Karen Gaffney	Dr. Maggi Kelly	Tom Robinson	

Lastly, we would like to extend our gratitude to those landowners who provided access to their land for sampling. Sonoma Land Trust, Sonoma County Regional Parks, California State Parks, the United States Army Corps of Engineers, Pepperwood Preserve, and Audubon Canyon Ranch provided full access to their properties for field crews as well as access to existing vegetation information about their properties.

3. Mapping Methods

3.1. Introduction

As summarized by Green, Congalton, & Tukman (2017), using remotely sensed data and ancillary information to map vegetation type is effective because there is a high correlation between variation in the imagery and ancillary data and variation in vegetation as specified by the classification scheme. In other words, when the vegetation on the ground changes, the spectral response of the imagery and/or the classes of ancillary data also change. Using remotely sensed data and ancillary information to map land cover and land use requires an understanding of the factors that cause variation on the ground and how the imagery and ancillary information represent those variations. Therefore, vegetation mapping requires completion of three basic steps:

- Developing a classification scheme to specify the type of land cover and land use characteristics to be detected and mapped
- Controlling variation in the imagery and ancillary information that is not related to variation in the classification scheme
- Capturing the variation in the imagery and ancillary data that is related to the variation in the classification scheme.

Since the early 1900s, these steps have been completed through the manual interpretation of remotely sensed data to delineate and identify vegetation using seven indicators of vegetation type; color, tone, texture, location, context, height, and shape of the feature of interest (Spurr, 1960). While a mainstay for decades, manual interpretation can be extremely time consuming, costly, and inconsistent. Semi-automated classification involves machine learning to establish

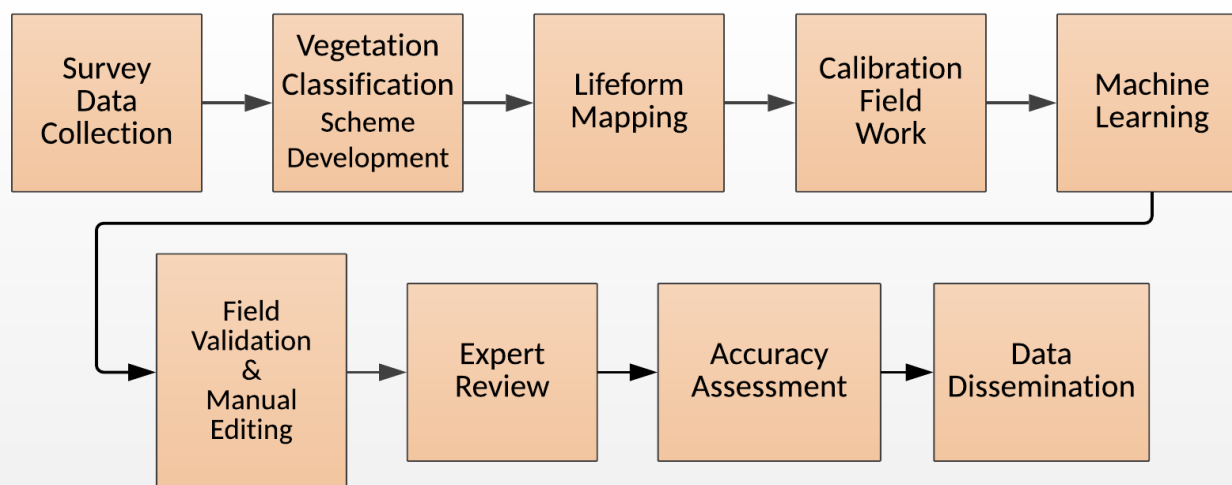
relationships between the imagery, ancillary information, and features on the ground. Semi-automated methods can be more cost effective and consistent than manual interpretation by allowing computer data analysis to label the easily identified features, thereby focusing the skilled remote sensing analysts' efforts on difficult and complex features. This project employed semi-automated techniques.

Innovations over the last decade have resulted in the development of the semi-automated classification method of object-oriented classification. Object-oriented image classification classifies image objects (image segments) instead of single pixels, allowing for the incorporation of not only texture, tone, and color, but also shape and context into the creation of vegetation data. Object-oriented classification closely mimics manual interpretation by creating vegetation polygons yet brings substantial increase to the speed of map production, consistency, accuracy, and detail. While powerful in the classification of medium resolution data (e.g. Landsat), object-oriented classification is pivotal for semi-automated classification of high-resolution airborne imagery because of the mixture of shadow and illuminated features in the imagery and the need to group pixels together to map vegetation classes instead of vegetation features such as individual trees.

This project's semi-automated techniques combine the computer automation of object-oriented image segmentation and machine learning with the human work of field data collection, vegetation classification development, manual image interpretation and editing to create Sonoma County's vegetation map products.

This section provides an overview of the methods – both automated and non-automated – and data used to make the fine-scale vegetation and habitat map. There were nine overall steps in the mapping team's methods (see figure 2).

Figure 2. *Fine-scale mapping steps*



3.2. Plot Data Collection and Classification Development

The fine-scale mapping effort began with countywide vegetation plot data collection by the California Native Plant Society (CNPS) and the Department of Fish and Wildlife’s Vegetation Classification and Mapping Program (VegCAMP). CNPS and VegCAMP collected over 800 relevé and rapid assessment plots countywide. These data were analyzed by VegCAMP to create a comprehensive classification, a dichotomous key that provides decision rules for labeling fine-scale vegetation classes, and vegetation descriptions for each fine-scale vegetation class in Sonoma County (see table 2). These products follow the same standards, framework, and hierarchy used by both the Manual of California Vegetation (Sawyer, Keeler-Wolf, & Evens, 2009) and the National Vegetation Classification System.

Table 2. *Table of classification and plot related data products*

Data Product	Description	Download URL
Department of Fish and Wildlife Classification Report, Volume 1	Introduction, methods, and results	http://vegmap.press/dfg_classreport_vol1
Department of Fish and Wildlife Classification Report, Volume 2	Vegetation descriptions	http://vegmap.press/dfg_classreport_vol2
Sonoma County Fine-scale Mapping Key	Key used for lifeform mapping and fine-scale vegetation mapping	http://vegmap.press/svm_finescale_key

During the classification development phase, minimum mapping units (MMUs) were established for the vegetation mapping project. An MMU is the smallest area to be mapped on the ground. Many mapping projects have a single MMU; for this project the mapping team chose to map different features at different MMUs. For example, riparian vegetation had a smaller MMU than upland vegetation types because riparian vegetation is a sensitive habitat, is relatively uncommon on the landscape, and very important from a land manager’s perspective. Table 3 shows the MMUs for the various features mapped in the Sonoma Veg Map data products.

Table 3. *Minimum mapping units by feature type*

Feature Type	Minimum Mapping Unit
Agricultural Classes	1/4 Acre
Woody Upland Classes	1/2 acre for contrasting lifeforms (e.g., forest surrounded by non-forest); 1 acre for different alliances in the same lifeform
Woody Riparian Classes	1/4 acre for contrasting lifeforms; 1 acre for different alliances in the same lifeform
Upland Herbaceous Classes	1/2 acre for contrasting lifeforms; 1 acre for different alliances in the same lifeform
Wetland Herbaceous Classes	1/4 acre for contrasting lifeforms; 1 acre for different alliances in the same lifeform
Bare Land	1/2 Acre
Impervious Features (in the impervious surfaces map)	1000 square feet; 200 square feet for buildings*
Developed (in the vegetation and habitat map)	1/5 Acre
Water	400 square feet

*These numbers apply to the Sonoma Veg Map impervious surfaces map, which is referenced in this report but is not a vegetation map product. The lifeform map and fine-scale vegetation map show major road polygons and impervious features that have contiguous impervious areas (not including roads) of .2 acres or more.

3.3. Lifeform Mapping

3.3.1. Overview

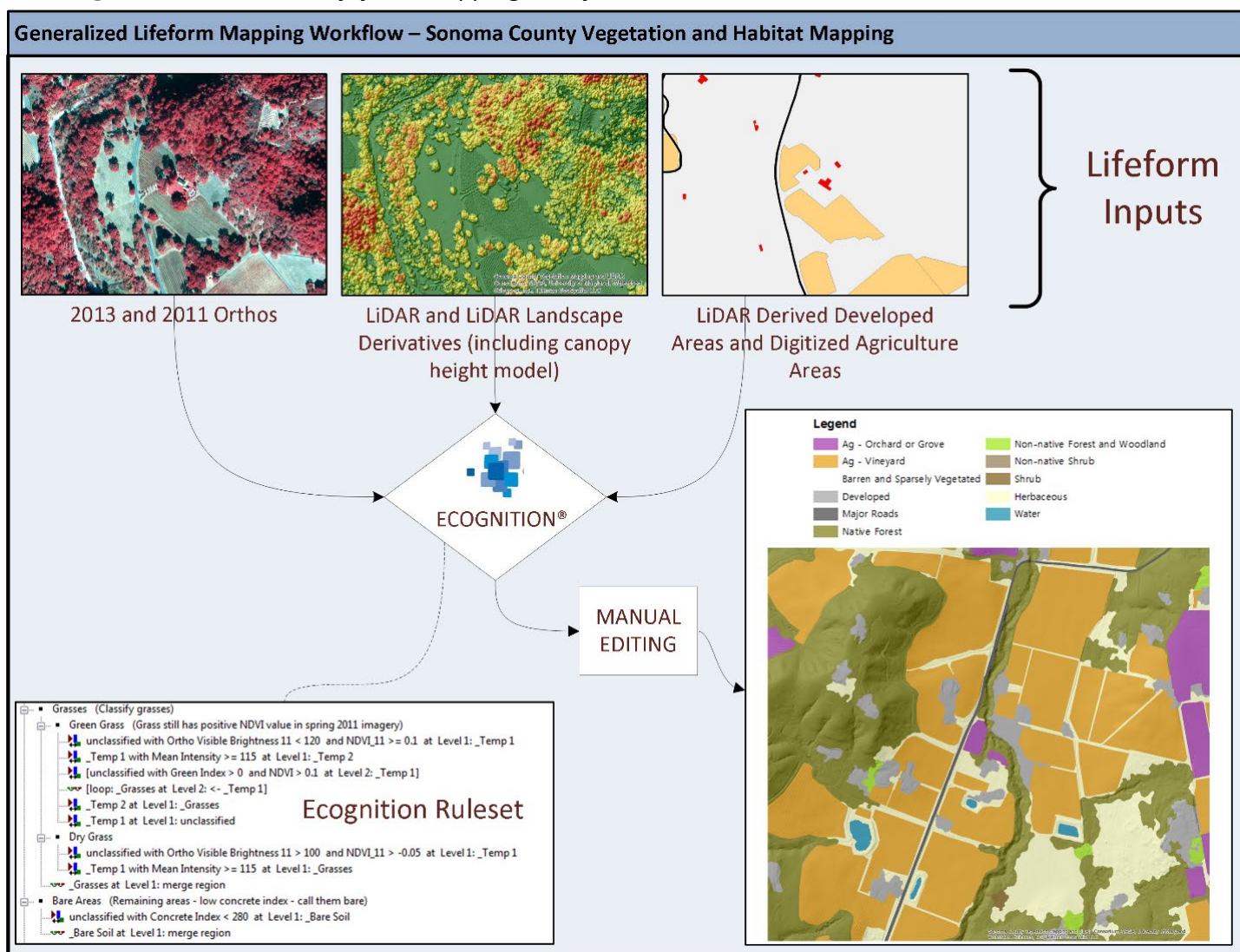
The lifeform map – first made available publicly in draft form in January 2016 and updated in 2017 when the fine-scale map was published – depicts land cover in a floristically general way and serves as the foundation for subsequent fine-scale mapping. This section describes the

creation of the lifeform map using Trimble Ecognition®, the special methods used to map the built and agriculture lifeform classes (section 3.3.3), and the processes of lifeform map expert review and manual editing (sections 3.3.4 and 3.3.5).

3.3.2. Lifeform Mapping with Ecognition®

The lifeform map was created using an expert systems rule set developed in Trimble® Ecognition®. The Ecognition® rule set combines automated image segmentation with object-based image classification. The rule set was developed heuristically based on the knowledge of experienced image analysts and input from the Vegetation Mapping and Remote Sensing Advisory Committee. Figure 3 shows the lifeform mapping workflow.

Figure 3. Generalized lifeform mapping workflow



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Key data sets used in the expert systems rule set for lifeform include high resolution aerial imagery for 2011 and 2013, the LiDAR-derived Canopy Height Model (CHM), and several other LiDAR-derived raster and vector datasets (see Table 4).

The lifeform map classifies the landscape into the following land use /cover type classes:

Urban Window	Annual Cropland
Water	Perennial Agriculture
Barren & Sparsely Vegetated	Irrigated Pasture
Major Road	Intensively Managed Hayfield
Developed	Nursery or Ornamental Horticultural Area
Orchard or Grove	Native Forest
Vineyard	Non-Native Forest
Vineyard Replant	Shrub
Herbaceous	Non-Native Shrub

Table 4. *Imagery and ancillary datasets used in lifeform mapping*

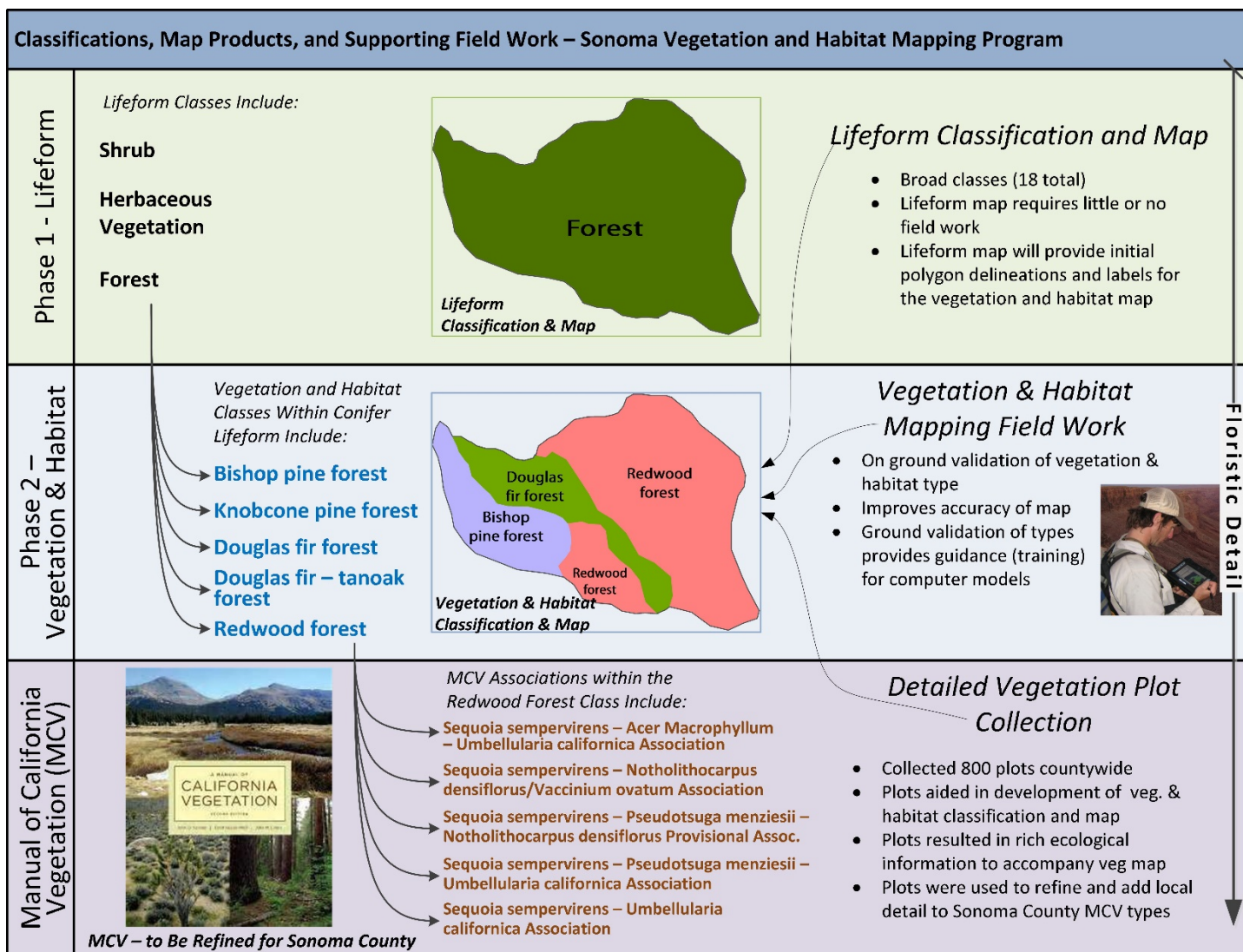
Layer	Roles in Lifeform Mapping	Source
Fall 2013 Orthoimagery	Used as the primary spectral input for lifeform mapping in Ecognition®.	Quantum Geospatial
Spring 2011 Orthoimagery	Used as a second source of high-resolution spectral information.	Quantum Geospatial
NDVI from Fall 2013 and Spring 2011 Imagery	Used in Ecognition® decision rules for discriminating between vegetated and non-vegetated areas.	Quantum Geospatial (2013), Woolpert (2011)
LiDAR Canopy Height Model (CHM)	Represents height of vegetation. The CHM was used widely as an input to the Ecognition® rule set, especially for mapping the natural lifeform classes.	Quantum Geospatial
LiDAR-derived Building Footprints (2013) and heads-up-digitized Building Footprints (2001)	The mapping team combined Quantum Spatial's 2013 LiDAR derived building footprints with heads-up digitized 2001 building footprints (created by the Sonoma County Information Systems Department), using the Quantum Spatial data as the primary footprint source. Building footprints were used in the Ecognition® rule set to map the 'Developed' and 'Urban Window' classes.	Quantum Geospatial, Sonoma County Information Systems Department
Agriculture Field Polygons	These polygons were the basis of the agriculture classes in the lifeform map. The mapping team refined the existing polygons, added many new ones, and added detail and consistency to the ag field labels. The refined croplands map was used in the Ecognition® rule set as the basis for the agricultural lifeform classes.	Sonoma County Water Agency

Layer	Roles in Lifeform Mapping	Source
Road Centerlines	The Sonoma County Road Centerlines dataset was enhanced by manual editing to include roads on private lands. Road centerlines were used in Ecognition® to map several classes including ‘Major Roads,’ ‘Developed’, and ‘Urban Window.’	Sonoma County Information Systems Department
Hydrologic Breaklines	Used to represent large water bodies in the lifeform map.	Quantum Geospatial
LiDAR-derived DEM, Slope and Aspect	Used for various Ecognition® decision rules.	Quantum Geospatial

Decision rules for the lifeform classes listed above are defined in pages 7-9 of the Sonoma County fine-scale mapping key (http://vegmap.press/svm_finescale_key).

Figure 4 illustrates the concept of the lifeform map and the hierarchy of mapping in the project. The top bar of the figure shows a lifeform polygon classified as native forest. Later phases of mapping (see sections 3.5 and 3.6) result in the subdivision of lifeform polygons and the alliance-level classification of these polygons. In this example, the native forest lifeform polygon is subdivided into four polygons (i.e. fine-scale segments) classified as Douglas fir forest, redwood forest, and bishop pine forest. This project does not map to the association level of the National Vegetation Classification (NVC), depicted in the lowest tier of figure 3. Mapping to the association level is often not feasible with a remote sensing approach, since many of the associations are defined by understory species that are not evident from above using satellite imagery or aerial photography.

Figure 4. Phases of mapping for Sonoma County



3.3.3. Lifeform Map - Built Classes and Agriculture

While the natural classes in the lifeform map were mapped by Ecognition® using rules developed solely from the imagery and the LiDAR data, classes depicting the built landscape and agriculture were mapped by Ecognition® using additional data sources and workflows. This section describes how the built and agricultural classes were mapped.

Urban, developed, and major roads were mapped as separate classes in the lifeform map. The ‘urban window’ class represents large, contiguous areas of urban landscape. This class was modeled after the approach used for Northern Sierra Nevada Foothills Mapping Project (Menke et al., 2011). Developed areas outside of the ‘urban window’ – such as rural residential

developments – are assigned the ‘developed’ class. Developed areas were included in the lifeform map if they exceeded 0.2 acres in size and contained significant man-made impervious cover or were highly altered. Highly altered areas included lawns, heavily landscaped garden and patio areas, bocce courts, tennis courts, sport courts, developed horse riding arenas, baseball fields, soccer fields, swimming pools, and playground areas. Figure 5 shows an example of the developed and urban window classes in an area around Santa Rosa and Rohnert Park.

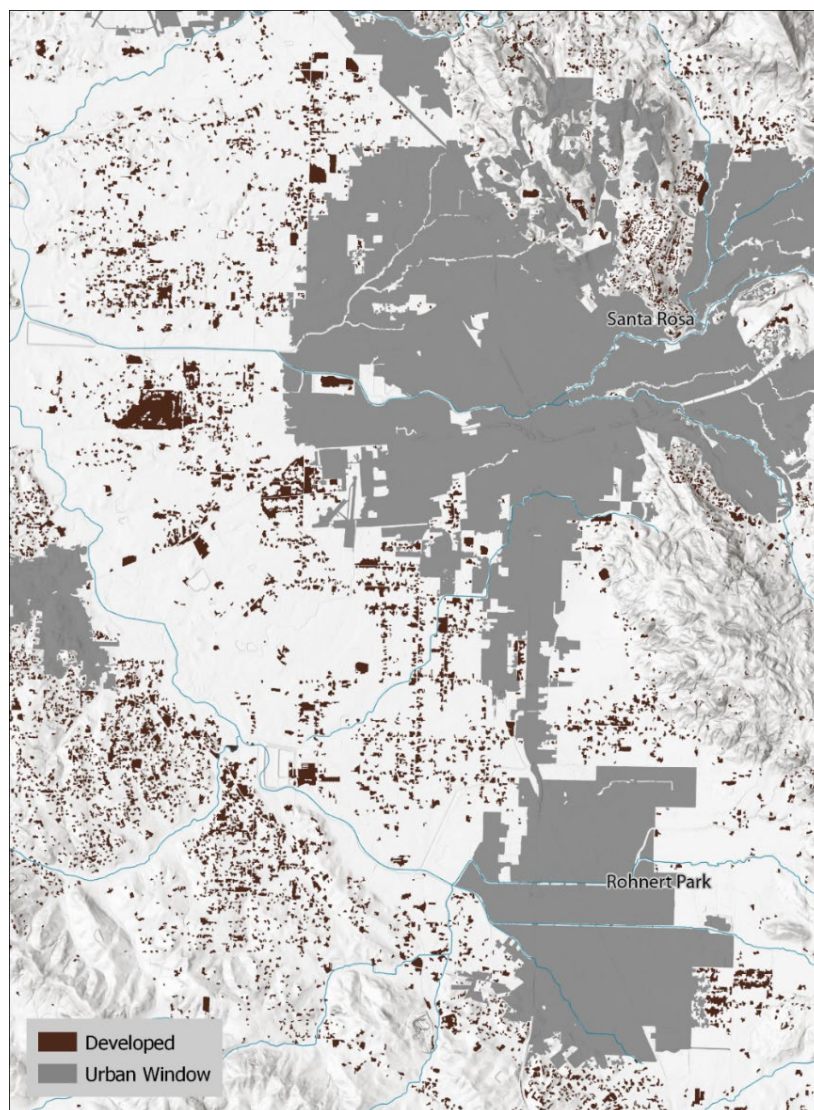
The following are requirements and conditions necessary for an area to receive ‘urban window’ classification:

1. The area must be part of one of the following incorporated cities: Cloverdale, Cotati, Healdsburg, Petaluma, Rohnert Park, Santa Rosa, Sebastopol, Sonoma and Windsor. Smaller urban areas, such as Kenwood, Forestville, and Guerneville, were not be included as part of the urban window.
2. Percent cover of impervious surfaces (houses, roads, parking lots, etc.) exceeds 35%.
3. The urban window can finger out into adjacent natural areas if it has sufficient impervious coverage.
4. Natural areas (e.g., riparian corridors) can extend into the urban window.
5. “Islands” of predominately natural land cover surrounded by urban core areas are mapped as part of the urban window if they are less than 10 acres in size. The MMU for natural vegetation within the urban core is 10 acres. If a natural area is greater than 10 acres (e.g., a large urban park), it is not considered part of the urban window and is mapped as natural vegetation.
6. Agriculture islands that exceed ¼ acre (the minimum mapping unit for agriculture) are preserved with their respective agricultural label inside the urban window.
7. Golf courses and playing fields are considered urban land cover and included as part of the urban window.
8. Forested riparian stands are mapped as natural vegetation within the urban window if they exceed 1/4 acre.

The urban window class was developed using Ecognition® and then edited manually. The Ecognition® rule set for creating the urban window had the following conceptual workflow:

1. Use the Sonoma County parcels as initial objects of analysis for Ecognition®.
2. Classify each parcel as either urban (>35% impervious) or natural (<=35% impervious) based on the Sonoma Veg Map impervious map from Ecognition® (see the discussion on the next page for more details on the impervious surfaces map).
3. Change isolated objects (parcels) of natural to urban if they are surrounded by urban parcels (e.g., small city parks).
4. Change isolated square objects or small groups of urban objects to non-urban window if they are under 1 square mile in extent.
5. Add detail and refine the urban window delineation using manual image interpretation.

Figure 5. *The urban window and developed classes in south central Sonoma County*



Major paved road polygons (highways and some major arterial roads) were included in the lifeform map and the fine-scale map as major roads, but minor paved roads and dirt roads were not included. Tukman Geospatial worked with the Sonoma County Ag + Open Space to determine exactly which roads and what type of roads to include.

Minor roads and individual building footprints were omitted from both the lifeform and fine-scale vegetation maps intentionally since these maps are meant to focus on the natural landscape. A separate Sonoma Veg Map product - the impervious surfaces map - includes polygons for all vehicle roads (paved and dirt), as well as all impervious surfaces down to a 1000 square foot MMU (200 square meters for buildings). It should be noted that the fine-scale vegetation map contains attributes for each polygon about percent imperviousness by

impervious cover type (e.g., % paved road, % other impervious). As such, the fine-scale detail regarding the built environment that exists in the impervious map is embedded in the fine-scale map polygons.

Agriculture was integrated into the lifeform map from a separate effort that mapped all croplands in Sonoma County. The Sonoma Veg Map Team received an “agricultural fields” dataset in late 2014 from the Sonoma County Water Agency. In late 2014 and early 2015 the Sonoma Veg Map Team worked to develop the agricultural fields data into a croplands dataset suitable for integration into the Sonoma County Vegetation and Habitat map. To this end, the team worked to 1) refine the accuracy of the polygon delineations using the 2013 6-inch imagery and 2) add new polygons or polygons that were missed by previous efforts and 3) normalize the classes so that mapped polygons are assigned one of the following lifeform class labels: perennial agriculture, annual croplands, nurseries, orchards/groves, irrigated pasture, intensively managed hayfields, nurseries or ornamental horticultural areas, vineyards, or vineyard replants. During its work, the Sonoma Veg Map team refined the boundaries of approximately 70% of the “agricultural fields” polygons in Sonoma County and created over 800 new polygons. The croplands map was integrated directly into the lifeform map and was also delivered as a stand-alone croplands dataset..

3.3.4. Lifeform Pilot Area Review

In mid-July 2014, the Sonoma Veg Map Team distributed a draft lifeform map for four small pilot areas to the Vegetation Mapping and Remote Sensing Advisory Committee as well as to numerous additional end users and stakeholders.

The goal of this map review was to obtain expert input and guidance on suggested changes to the methods and rule set before the lifeform map was created for the entire county. The draft lifeform map for the pilot area and the associated information was distributed to the following people in addition to all members of the Vegetation Mapping and Remote Sensing Advisory Committee:

- Julie Evens (California Department of Fish & Wildlife)
- Dr. Diana Hickson (California Department of Fish & Wildlife)
- Dr. Jarlath O’Neil-Dunne (University of Vermont/USDA Forest Service)
- Sonoma County Ag + Open Space
- Sonoma County Transportation and Public Works
- Sonoma County Water Agency

The pilot area map was distributed both as a webmap and as an ESRI layer package. The input that resulted from this review is embodied in the final specifications of the vegetation map products.

3.3.5. Lifeform Map Manual Editing

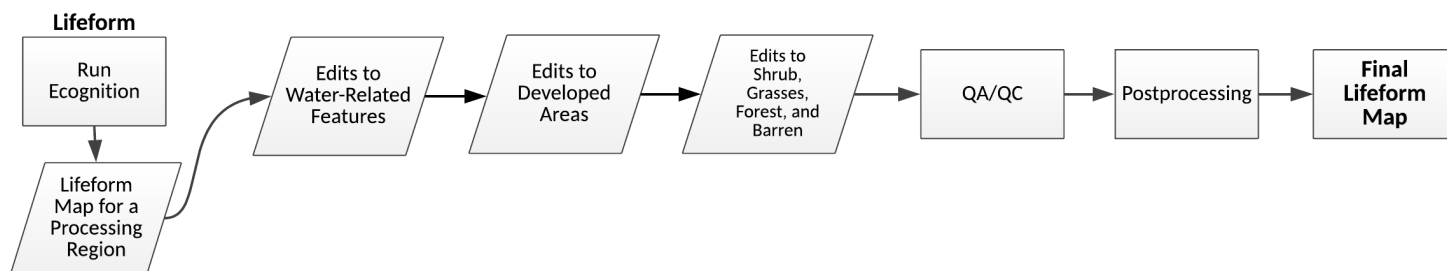
After it was produced using Ecognition®, the preliminary lifeform map was manually edited by photo-interpreters. Edits were made to accomplish the following:

- Splitting of map polygons that are not compositionally homogenous as per the lifeform mapping rules
- Addition of non-native forest and non-native shrub polygons where appropriate
- Edits to the lifeform label (e.g., changes from a forested lifeform to a shrub lifeform)

Manual editing was conducted using ArcMap and occurred in batches of 50,000 acres. A first pass of editing addressed errors related to water. A second pass of editing focused on the developed classes and the urban window. The final editing pass focused on the natural landscape.

Figure 6 shows a schematic of the lifeform editing workflow.

Figure 6. *Lifeform editing workflow*



3.4. Fine-scale Map Calibration Field Work

Calibration field work for the fine-scale vegetation map was conducted countywide in the fall of 2015. Calibration field work was a critical step in the mapping workflow, providing training data for machine learning (see section 3.5) as well as visual reference for analysts conducting manual editing of the fine-scale vegetation map (see section 3.6).

Fine scale image segments were labeled with their fine scale map class during calibration work. Before field work, fine-scale segments were created within forest and shrub lifeform map polygons. Fine-scale segmentation divided the large, floristically broad, lifeform areas into much smaller image segments suitable for fine-scale mapping. Fine-scale segmentation was conducted in Trimble Ecognition® and relied on spring 2011 high resolution imagery, fall 2013 high resolution imagery, and the 2013 LiDAR-derived canopy height model. Figure 8 shows the lifeform map on the left and the fine-scale segments on the right.

Fine scale segments were labeled with fine scale map class using a Trimble Yuma running ArcMap by field teams in vehicles and on foot (see figure 7). Field crews of two people per crew covered nearly all public roads in the county, many publicly accessible trails, and numerous private lands. During field work, fine-scale image segments were labeled with their-field observed fine-scale map class following the guidelines and protocols outlined in the Sonoma Veg Map Field Book (Tukman et al., 2015). The Sonoma Veg Map Field Book is a comprehensive document containing information about identifying and keying out map classes, field data collection protocols, and detailed vegetation composition tables for the fine-scale map classes. It was used by field data collection teams to standardize data collection and apply vegetation class labels consistently in the field and during manual editing.

Figure 7. *Calibration field work using Trimble Yuma*

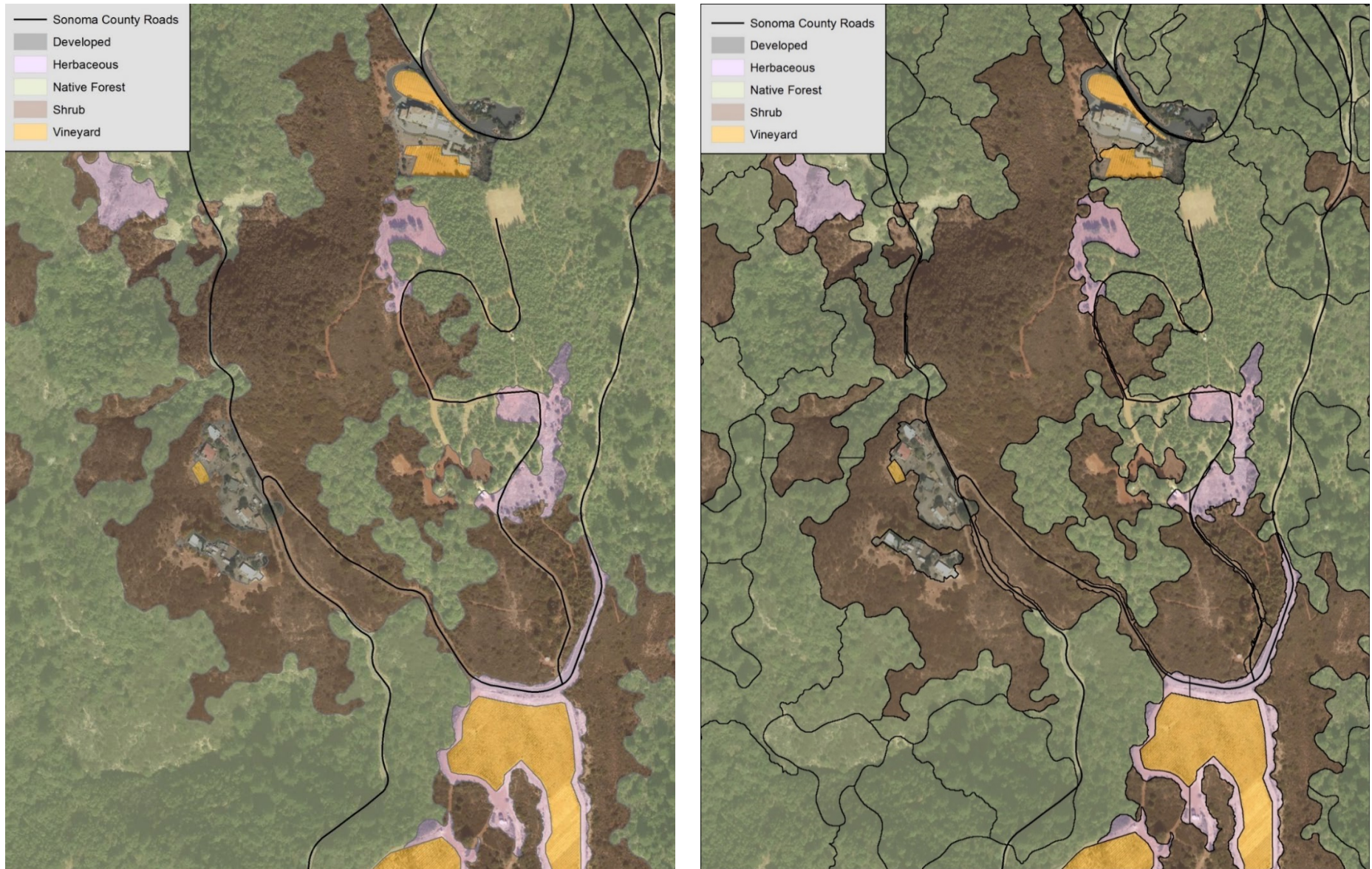


Map class labels were chosen from a “pick list” that included all the map classes in the Sonoma Veg Map Fine-Scale Mapping Key (see table 2). In addition to primary map class, field staff recorded secondary and/or tertiary “acceptable alternative map classes” if more than one class was deemed acceptable by the field crew. Alternative map classes were assigned in situations where a stand species composition was very close to fitting the membership rules for more than one map class.

Calibration field work resulted in thousands of segments labeled countywide with their field-verified fine-scale map class. GPS-tagged photos were also taken at many locations for reference. After field visits, analysts reviewed the field-validated image segments with the dual aims of correcting data entry errors and performing QA/QC on field classifications. Data entry errors included assignment of incorrect map classes from the pick lists (usually this was the mis-assignment of the class falling before or after the intended class in the pick list). QA/QC

resulted in throwing out or modifying field validated segments where in-office review showed inconsistencies between the field crew's map class assignment and what aerial imagery showed. When field labeled segments could not be reconciled with labels based on aerial imagery interpretation, they were removed as calibration candidates.

Figure 8. *Lifeform map (left) and lifeform map with fine-scale segments (right)*



3.5. Fine-scale Map Machine Learning

3.5.1. Overview

The Sonoma Veg Map Team utilized a type of algorithmic data modeling known as machine learning to automate the classification of fine-scale segments into one of Sonoma County's 82 fine-scale map classes. A form of supervised machine learning was adopted, whereby areas of known classification (training sites) are used to predict the map class for unknown areas through rigorous modeling techniques.

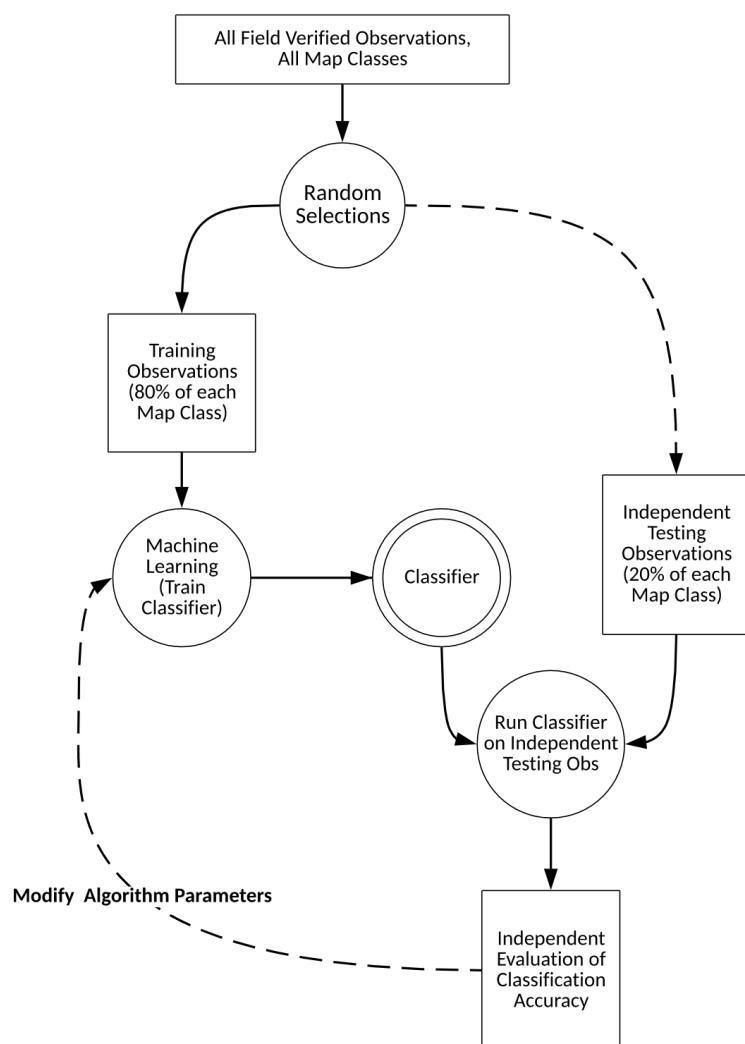
Field-calibrated segments discussed in the previous section were used as training data for machine learning, with their fine scale map class label serving as the dependent variable. The independent variables (referred to in this discussion as *predictor variables*) number over 300 and include variables that characterize the physical landscape and a wide variety of remotely sensed optical data to represent spectral reflectance of vegetation. The predictor variables are discussed in detail in the next section.

Based on a review of the current literature and input from the Vegetation Mapping and Remote Sensing Advisory Committee, two machine learning algorithms were chosen to predict fine-scale vegetation class:

- Random Forests (Breiman, 2001) (section 3.5.2.1)
- Support Vector Machines (Meyer et al., 2018) (section 3.5.2.2)

Machine learning is an iterative process that requires trial and error to fine-tune algorithm parameters and inputs to maximize model accuracy. The Sonoma Veg Map team employed the workflow shown in figure 9. At the beginning of the machine learning process, 20% (approximately 1,400) of the calibration segments were randomly selected for use as independent testing observations. These segments were not used to train the algorithm. The machine learning algorithms (random forests and support vector machines) were run on the remaining 80% (approximately 5,600) of the calibration segments to create the classifying model. The classifying model was then applied to the 20% of calibration segments reserved for independent testing, resulting in map class predictions for those segments. The predicted map class for each segment was compared to the field-verified map class and accuracy numbers were generated. Changes to parameters and training segments were applied, and each change was evaluated in the context of its effect on the model accuracy of the independent testing group of segments. The final parameters chosen for both random forests and support vector machines were those that maximized model accuracy for the independent testing group.

Figure 9. *Workflow for machine learning*



3.5.2. Random Forests and Support Vector Machines

Random forests and support vector machines (SVMs) were used in tandem in an ensemble approach. The two algorithms were implemented as a script using the R statistical computing package (R Core Team, 2013). Dr. Matt Clark, professor at Sonoma State University and a member of the Vegetation Mapping and Remote Sensing Advisory committee, wrote the script.

The ensemble approach uses random forests and SVMs so that both algorithms predict fine-scale map class labels for each unlabeled segment across the landscape. The script then compares the predictions against each other – if the prediction from the two algorithms is the same, the segment is labeled with that fine-scale map class. If the predictions are different, the fine-scale map class from the algorithm with the higher confidence is used (both random forest and SVMs provide metrics for confidence or probability of correctness). Both algorithms

produced a primary fine-scale map class label – the algorithm’s first choice for a segment – and a secondary class label – the algorithm’s second choice. These primary and secondary labels and their associated confidence values were used by manual editors to improve their editing accuracy (see section 3.6 for a discussion of manual editing).

In addition to predicting fine-scale map class for each segment, machine learning was also used to predict relative hardwood versus conifer cover. This was done using relative cover calibration sites collected during calibration field work and supplemented by photo interpreted sites.

3.5.2.1. Random Forests

Random forests “mines” the field-labeled training data and a “stack” of independent predictor variables and builds rules (if-then statements) in a decision tree to predict the fine-scale map class for all unlabeled segments across landscape. Random forest is a powerful modeling approach because:

- it can accept both continuous and categorical data inputs,
- the results are easy to interpret,
- unlike a maximum likelihood classifier, no assumptions are required concerning the distributions of the independent variables,
- it identifies simple and complex relationships between variables that other techniques might not uncover, and
- it forces consistency and analytical rigor into the segment labeling process.

Dr. Clark’s R code included several analytical tools that were helpful in interpreting the results of the random forest model and in providing information to help refine and improve model results. These items included – for each run of random forests – an importance matrix for assessing predictor variable importance (as an example, Table 6 shows the importance matrix for the *Quercus garryana* alliance), and a proximity matrix for understanding map class confusion. In addition, Dr. Clark’s code automatically created error matrixes for each run of random forests, providing user’s accuracy, producer’s accuracy, and overall accuracy for the independent testing segments. Lastly, for each segment on the landscape, the R code provided two votes – a first vote and a second vote. For both the first and second votes, Dr. Clark’s R code provided a confidence value (0 to 1) for its fine-scale vegetation class prediction for the segment. Random forests bases its confidence values on the percentage of individual trees (i.e. set of rules) that predict the class.

For random forests, analysts did not do any predictor variable selection or winnowing – the entire stack of predictor variables was used for each run and the model assessed their importance.

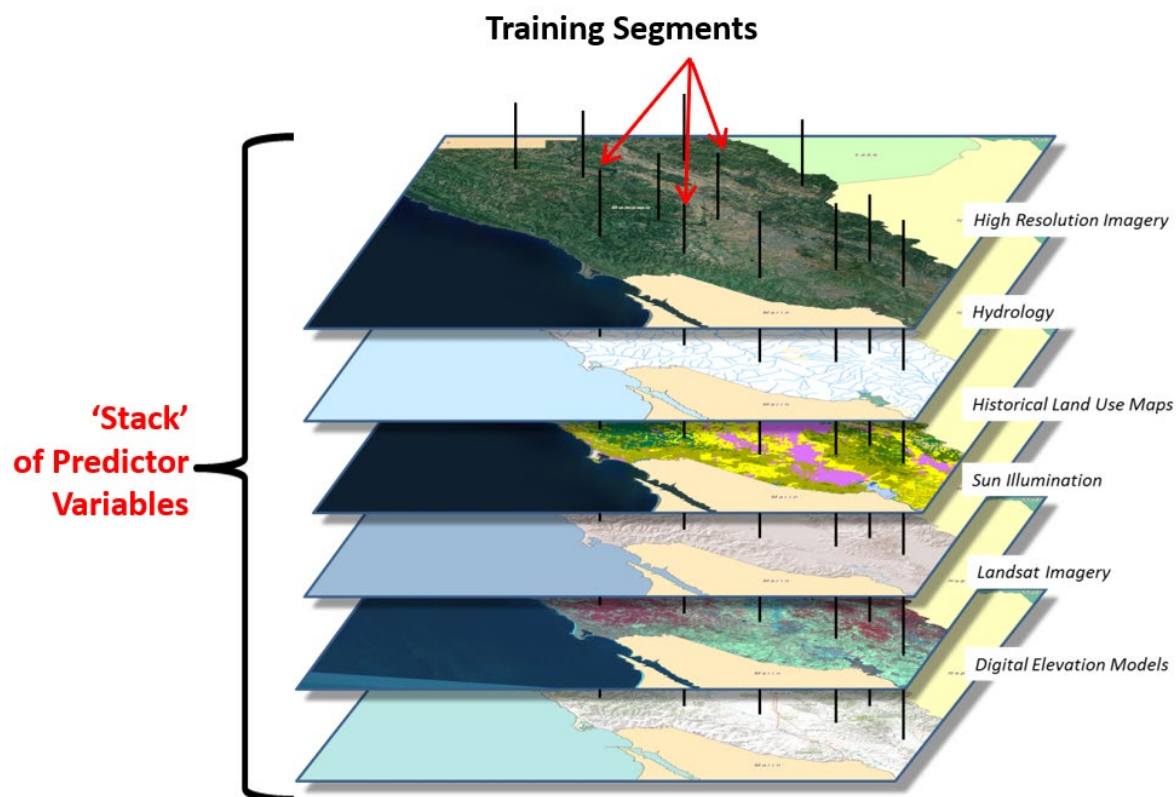
3.5.2.2. Support Vector Machines

Like Random Forests, SVMs are nonparametric supervised classifiers (Congalton, 2010). SVMs perform very well as a machine learning algorithm for vegetation mapping and have been widely adopted in the past few years. Like random forests, SVMs were used to assign each segment a predicted fine-scale map label, as well as a second label with lower confidence. As was done for random forests, Dr. Clark's R code provided error matrixes for SVMs' predictions for the independent testing segments.

3.5.1. Independent Variables

Both random forests and support vector machines require a "stack" of predictor variables for each segment. Figure 10 illustrates the concept of the predictor variable stack. The stack of predictor variables was created by running ESRI's zonal statistics tool iteratively in a python script to create a table with the rows representing the image segments and the columns representing the predictor variables.

Figure 10. The concept of the “stack” of machine learning predictor variables



Over 300 predictor variables were used, including high and medium resolution spectral information, spectral and hyperspectral indices derived from AVIRIS data from Dr. Clark, landscape characteristics such as slope & aspect, and other variables. Table 5 shows the list of predictor variables (excluding the AVIRIS indices).

Table 5. Predictor variables used in machine learning

Fires - 1939 to Present (zonal majority)	Mean 2011 green band
Fires - 1939 to 1969 (zonal majority)	Mean 2013 red band
Fires - 1970 to 2013 (zonal majority)	Mean 2011 red band
Fires - 1990 to 2013 (zonal majority)	Mean 2013 NIR band
Mean summer fog - June to August	Mean 2011 NIR band
Majority 32 class slope aspect index	SD 2013 blue band
Majority geologic type	SD 2011 blue band
Mean average annual precipitation	SD 2013 green band
Mean distance from coast	SD 2011 green band
Mean solar radiation	SD 2013 red band
Mean height above river (relative to nearest small stream)	SD 2011 red band
Mean height above river (relative to nearest large stream)	SD 2013 NIR band
Mean horizontal distance from nearest stream	SD 2011 NIR band

Sonoma County Vegetation Mapping and LiDAR Program

Mean flow accumulation of nearest point on large stream	Relative area of dark sub-objects ('11)
Mean flow accumulation of nearest point on small stream	Relative area of dark sub-objects ('13)
Mean Landsat 8 band 5 difference, April minus Feb	Relative area of dark sub-objects ('11 and '13)
Mean Landsat 8 band 6 difference, April minus Feb	Mean absolute canopy cover
Mean Landsat 8 band 7 difference, April minus Feb	Mean canopy height
Mean Landsat 8 band 5 difference, May minus Feb	SD canopy height
Mean Landsat 8 band 6 difference, May minus Feb	Mean median filtered canopy height
Mean Landsat 8 band 7 difference, May minus Feb	SD median filtered canopy height
Mean Landsat 8 band 5 difference, March minus Feb	Mean ground elevation
Mean Landsat 8 band 5 difference, March minus Feb	Percentage of canopy that is high NDVI (not including non-veg areas)
Mean Landsat 8 band 5 difference, March minus Feb	Percentage of canopy that is low NDVI (not including non-veg areas)
SD LS8 band 5 difference, April minus Feb	Mean LiDAR intensity
SD LS8 band 6 difference, April minus Feb	SD LiDAR intensity
SD LS8 band 7 difference, April minus Feb	Mean ortho visible brightness 2013
SD LS8 band 5 difference, May minus Feb	Mean ortho visible brightness 2011
SD LS8 band 6 difference, May minus Feb	Mean NDVI, 2013 orthos
SD LS8 band 7 difference, May minus Feb	Mean NDVI, 2011 orthos
SD LS8 band 5 difference, March minus Feb	Relative cover of trees greater than 60 feet
SD LS8 band 6 difference, March minus Feb	Mean slope from bare earth DEM
SD LS8 band 7 difference, March minus Feb	Ratio of NDVIs between '11 and '13
Mean LS8 tasseled cap brightness - 5/25/15	Mean slope of the highest hit DEM
Mean LS8 tasseled cap wetness - 5/25/15	Standard deviation of the highest hit DEM
Mean LS8 tasseled cap greenness - 5/25/15	Mean 2009 NAIP blue band
Mean LS8 tasseled cap brightness Topographically Corrected - 5/25/13	Mean 2009 NAIP red band
Mean LS8 tasseled cap wetness Topographically Corrected - 5/25/14	Mean 2009 NAIP green band
Mean LS8 tasseled cap greenness Topographically Corrected - 5/25/15	Mean 2009 NAIP NIR band
Mean LS8 Band 5 from 5/25/13	Mean 2009 NAIP NDVI
Mean LS8 Band 6 from 5/25/13	SD 2009 NAIP blue band
Mean LS8 Band 7 from 5/25/13	SD 2009 NAIP red band
Mean LS8 NDVI from 5/25/13	SD 2009 NAIP green band
Mean LS8 Band 5 Illumination Corrected from 5/25/13	SD 2009 NAIP NIR band
Mean LS8 Band 6 Illumination Corrected from 5/25/13	SD 2009 NAIP NDVI
Mean LS8 Band 7 Illumination Corrected from 5/25/13	Mean LiDAR 75th percentile height from lascanopy
SD tasseled cap brightness - 5/25/13	SD LiDAR 75th percentile height from lascanopy
SD tasseled cap wetness - 5/25/14	Mean LiDAR 5th percentile height from lascanopy
SD tasseled cap greenness - 5/25/15	SD LiDAR 5th percentile height from lascanopy
SD Band 5 from 5/25/13	Mean LiDAR 10th percentile height from lascanopy

SD Band 6 from 5/25/13	SD LiDAR 10th percentile height from lascanopy
SD Band 7 from 5/25/13	Mean LiDAR 25th percentile height from lascanopy
SD NDVI from 5/25/13	SD LiDAR 25th percentile height from lascanopy
Ecog brightness	Mean LiDAR 50th percentile height from lascanopy
Ecog greenness index	SD LiDAR 50th percentile height from lascanopy
% canopy density in the 15 to 60 foot range	Mean LiDAR 90th percentile height from lascanopy
% canopy density in the 100 to 150 foot range	SD LiDAR 90th percentile height from lascanopy
% canopy density in the 150 to 200 foot range	Mean LiDAR quadratic average height from lascanopy
% canopy density in the 200 to 250 foot range	Mean LiDAR skewness for height fom lascanopy
Mean 2013 blue band	Mean LiDAR kurtosis for height fom lascanopy
Mean 2011 blue band	Average LiDAR height from lascanopy
Mean 2013 green band	SD LiDAR height from lascanopy

To illustrate how predictor variables are used by the machine learning algorithms, Table 6 shows an importance matrix from random forests for the *Quercus garryana* alliance. The far-right column is the mean decrease in model accuracy that would result from *not using* the predictor variable. Table 6 shows that NDVI and a green index from the 2013 orthoimagery were the most important variables for random forests for classifying the *Quercus garryana* alliance. Other important predictors for *Quercus garryana* are the three Landsat TM 8 band 5 (NIR) spectral difference images that represent the difference in NIR reflectance between spring months (March, April, and May) and winter (February). Because *Quercus garryana* is deciduous, random forests found these band-difference images between leaf-on periods and leaf-off periods key to classifying these segments.

Table 6. Importance matrix for the *Quercus garryana* Alliance (variables listed in descending overall importance for model accuracy)

Predictor Variable Abbreviation	Predictor Variable Description	Mean Decrease in Accuracy
MN_HINDVI	% of canopy w/ high NDVI in '13 orthos (not including non-veg areas)	0.080
MN_GREENDX	Green index (Green-Red)/(Green + Red), 2013 orthos	0.075
MN_B5DF_32	Mean Landsat 8 band 5 difference, March minus Feb	0.060
MN_B5DF_42	Mean Landsat 8 band 5 difference, April minus Feb	0.057
MN_LONDVI	% of canopy w/ low NDVI in '13 orthos (not including non-veg areas)	0.055
MN_NDVI	Mean NDVI, 2013 orthos	0.048
MN_NDVI_RA	Ratio of NDVIs between 2011 and 2013 orthos	0.036
MN_B5DF_52	Mean Landsat 8 band 5 difference, May minus Feb	0.033
MN_SOLARRA	Mean solar radiation	0.030
MN_SLOPE	Mean slope from lidar-derived bare-earth DEM	0.028
MN_BRIGHT	Mean 2013 ortho brightness index (from Ecognition)	0.027
MN_TM_NDVI	Mean Landsat 8 NDVI from 5/25/13	0.024
MN_BARE	Mean ground elevations from lidar-derived bare-earth DEM	0.023
MN_TM_GN	Mean Landsat 8 tasseled cap greenness from 5/25/13	0.022
MN_Wtr1AbAr_AV	Mean AVIRIS leaf water absorption index	0.022
MN_P90_30F	Mean lidar 90th percentile height from lascanopy	0.020
SD_P10_30F	Standard deviation lidar 10th percentile height from lascanopy	0.018
MN_STD_30F	Standard deviation lidar height from lascanopy (all returns)	0.018
MN_PRECIP	Mean average annual precipitation	0.017

3.6. Fine-scale Manual Editing & Map Field Validation

3.6.1. Overview

Manual editing allowed experts to improve the detail and accuracy of the models' outputs. Editors used a variety of supporting datasets and best practice protocols to standardize and maintain high quality edits. Manual editing techniques are discussed in section 3.6.2. During manual editing, special attention was given to sensitive habitats including riparian, serpentine, and wetland areas. Sensitive habitat editing and mapping is discussed in section 3.6.3. Finally, validation field work was conducted to evaluate and refine the vegetation map. Validation field work is discussed in section 3.6.4.

3.6.2. Fine-scale Map Manual Editing

Editing is an individual endeavor, and because of the difficulty of precisely interpreting vegetation type and cover from imagery, different humans may assign different labels to the

same segment. To minimize inconsistencies among the numerous editors working on the map, protocols were followed to standardize the editing approach.

Editors were assigned specific areas to edit in contiguous batches of 100-acre tiles. Fine-scale map class edits were conducted at a scale of 1:2,000. Editors worked tile-by-tile— completing one tile and moving on to the next. Edits resulted in the following types of changes to the fine-scale map:

- Changes to fine-scale map class where the editor noted a different map class than what was assigned by machine learning
- Changes to segment shapes where a segment wasn't compositionally homogenous
- Changes to relative hardwood versus conifer class

Editors relied on a wide variety of imagery and other data sources during editing (see Table 7). High resolution imagery was the most important dataset for editing, but different imagery or combinations of imagery were used to interpret different types of vegetation.

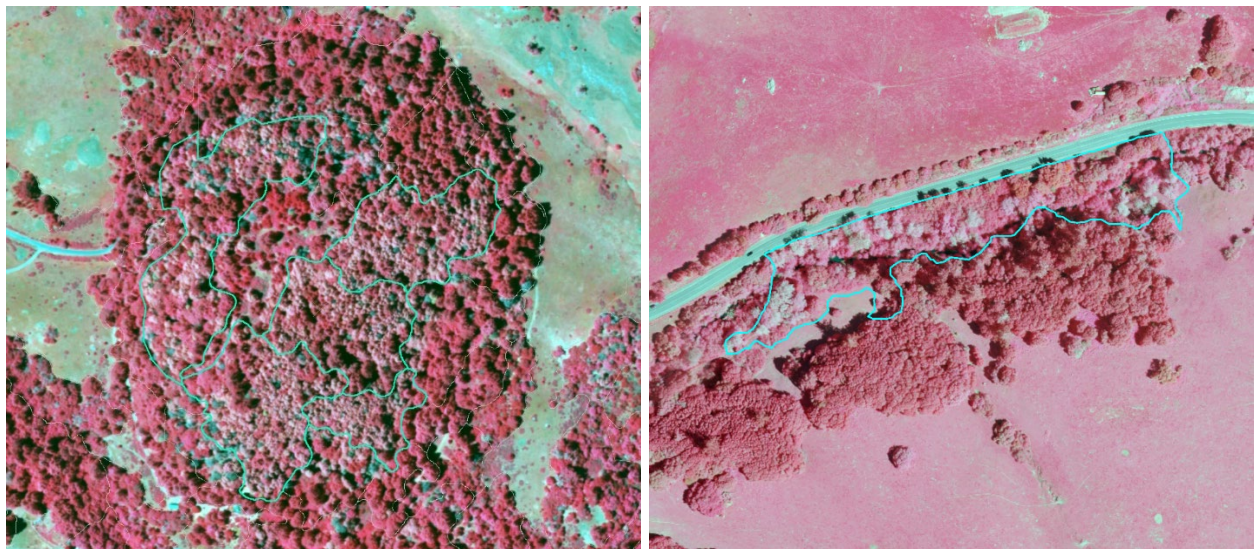
Table 7. *Datasets used as reference in fine-scale map class manual editing*

Raster Datasets	Vector Datasets
2008 Sonoma County Imagery (1-foot) (mostly leaf-off)	100-acre tiles (editing units) for tracking editing progress
2009 NAIP (1-meter, 4-band), displayed as an RGB and CIR composite	Roads and trails
2011 Sonoma County imagery (6-inch, 4-band), displayed as an RGB and CIR composite	Recon photos
2012 NAIP (1-meter, 4-band), displayed as an RGB and CIR composite	CNPS survey points
2013 Sonoma County imagery (6-inch, 4-band), displayed as an RGB and CIR composite	Field calibration segments
2013 LiDAR derived bare earth DEM	Geology (USGS)
2013 LiDAR derived bare earth hillshade	Soils (NRCS)
Vertical height above river (derived from 2013 LIDAR)	Ultramafic layer (CNPS)
2013 LiDAR derived canopy height	Serpentine mask
USGS 7.5-minute topography	Existing vegetation maps
	Fire history

For example, the 2009 NAIP imagery – when viewed in color infrared – showed *Notholithocarpus densiflorus* clearly, whereas other dates of imagery did not. Riparian vegetation was most distinguishable from upland vegetation using the color infrared 2011 6-inch imagery (see Figure 11 for an illustration of these two examples). To further illustrate how

each image dataset was key for discriminating specific map classes, the *Umbellularia californica* alliance was very difficult to discern from other types of hardwoods (and even conifers in certain conditions) using many available image datasets. But in the 2009 and 2012 NAIP imagery displayed in true color, *Umbellularia* was clearly discernable.

Figure 11. *Notholithocarpus densiflorus* (white crowns) in 2009 imagery displayed in infrared (left); *Vancouverian riparian deciduous forest* (bright pink) in 2011 imagery displayed in infrared (right)



All members of the mapping team worked with the same map document, loaded with the same image and ancillary datasets.

In addition to the pre-loaded raster and vector datasets, the map document contained symbology and advanced labeling rules to facilitate consistent fine-scale map class editing among the team of analysts working on the map. Labeling rules and symbology included the following (see figure 12 for an illustration):

- Labels that show the segment's map class with a unique color and abbreviation
- Labels that show machine learning confidence for the segment
- Labels that show the relative cover class for each segment
- X's (error flags) that automatically turned on if the relative cover was incompatible with the map class (e.g., if a redwood classified segment was assigned very low conifer relative cover)
- For edited segments, dynamically rendering labels that are much smaller font size and all the same color to inform the editor that they have already been edited

Figure 12. Fine scale editing in ArcMap



In addition to symbology and labeling, the map document that the editors used contained a number of important attributes that were easily accessible to the editor (see the "identify" window in figure 12). These are:

- SOURCE – Machine learning or field calibration/validation

- RFPredClass1 – Random forests primary fine-scale map class prediction
- RFPredClass2 – Random forests secondary fine-scale map class prediction
- RFMaxVote1 – Random forests confidence in its primary prediction
- RFMaxVote2 – Random forests confidence in its secondary prediction
- SVMPredClass1 – SVMs primary fine-scale map class prediction
- SVMPredClass2 – SVMs secondary fine-scale map class prediction
- SVMMaxProb1 – SVMs confidence in its primary prediction
- SVMMaxProb2 – SVMs confidence in its secondary prediction

Map editors had weekly calls to review challenging areas. Areas that were difficult to map were labeled by group consensus or prioritized for field review.

3.6.3. Sensitive Habitat Mapping

Sonoma County Ag + Open Space and other stakeholders recognized the need to map sensitive vegetation classes, including riparian vegetation, serpentine areas, and vernal pools & other herbaceous wetlands at a finer scale than other vegetation classes. Riparian areas are important for biodiversity, for water supply and quality, and protection from flooding and other disturbances. Serpentine (and related ultramafic substrate) areas, vernal pools, and herbaceous wetlands are areas of high endemism and species diversity and provide essential habitat for listed wildlife species.

3.6.3.1. Riparian Area Mapping

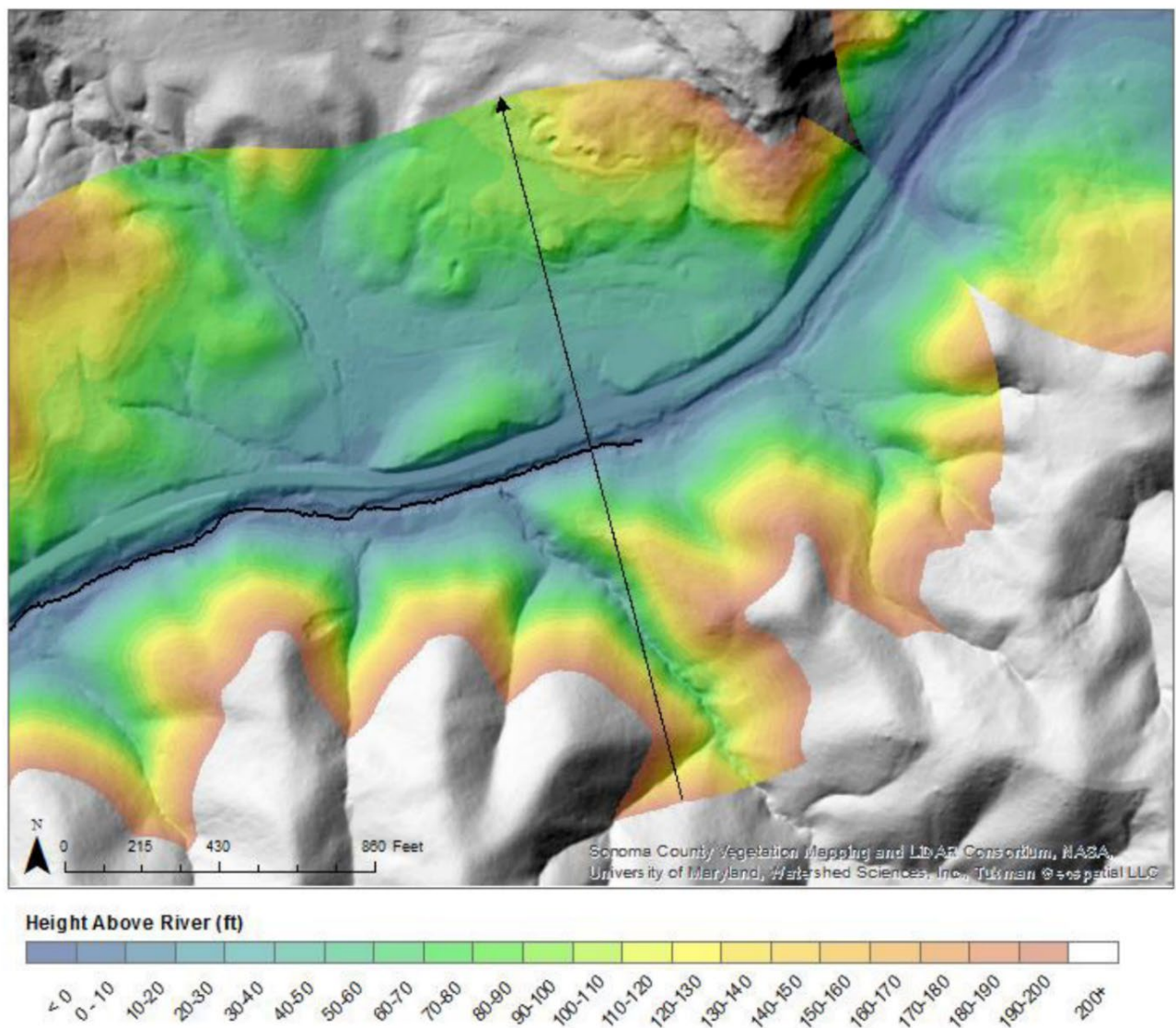
Riparian areas are unique because their extent and structure depend on fluvial processes, and in many areas they are heavily influenced by infrastructure and human modification. Like other fine-scale map classes, riparian areas were mapped using the same semi-automated steps as non-riparian fine-scale map classes. However, there were three enhancements to the semi-automated approach that resulted in a finer scale, more refined delineation of riparian types when compared to most fine-scale map classes. These are as follows:

- **¼ Acre Minimum Mapping Unit for Woody Riparian Types**
- **Focused and More Extensive Field Work in Riparian Areas** – The mapping team gave riparian areas special attention during field validation, collecting relatively more field validation sites in riparian areas than in other fine scale map classes.
- **Focused and More Extensive Manual Editing of Riparian Areas** – Map editors worked at a finer scale when editing riparian vegetation, giving extra attention to the detail of the riparian delineations and making sure to capture polygons at a ¼ acre minimum mapping unit for contrasting lifeforms. In addition, riparian editing occurred as its own independent editing workflow, where the map editor's single job was to edit the riparian types.

The mapping team added two riparian-specific predictor variables into the “stack” of predictor variables for machine learning, with the hope that they would increase accuracy and resolution for the modeling of riparian types. These variables were also very useful as reference during the manual editing of the riparian types. These riparian-specific predictor variables are:

- Horizontal distance from LiDAR derived streams
- Vertical distance from LiDAR derived streams - “Height Above River” or HAR (Dilts et al., 2010). This LiDAR derivative is a raster where pixel values represent the vertical distance above the nearest point on a stream. Figure 13 shows an illustration of HAR.

Figure 13. *Vertical Height Above River (HAR)*



3.6.3.2. Vernal Pool and Herbaceous Wetland Mapping

Due to their sensitivity and importance to resource managers, herbaceous wetland vegetation types were mapped at a finer spatial scale – ¼ acre – than most fine-scale classes in the vegetation map. Recent fine-scale wetland mapping efforts by the San Francisco Estuary Institute (SFEI), encompass a portion of southern Sonoma County and were integrated into the fine-scale vegetation map. These include the Bay Area Aquatic Resource Inventory (BAARI; SFEI, 2014) and the Northern California Aquatic Resource Inventory (NCARI; SFEI, 2017). For areas where fine-scale wetlands have been delineated as part of other efforts, these data were integrated directly into the fine-scale vegetation map and were augmented and/or refined by the mapping team as needed.

Fine-scale map classes for the wetlands and vernal pools were created using a crosswalk between SFEI map classes and Sonoma Veg Map fine-scale map classes (see Table 8). After SFEI's polygons were integrated and map classes were assigned using the crosswalk, the mapping team refined and augmented the wetland polygons with manual editing. Figure 14 illustrates the process of refinement.

Table 8. *Crosswalk between SFEI classes and vegetation map classes*

SFEI Map Class	Sonoma Veg Map Fine-Scale Map Class
All Open Water Classes (DOWU, DOWN, LOWU, COWN, COWU, SB)	Not integrated into Sonoma Veg Map; water was mapped countywide based on the 2013 imagery
Forested Slope, Riparian Forested Slope (FS, FSr)	Not integrated into Sonoma Veg Map. Forested wetlands were mapped by the Sonoma Veg Map team and labeled to one of numerous NVCS map classes
Slope Wetlands (SN, SU, SNf)	Western North American Freshwater Marsh Macrogroup
Depressional Vegetated (DUF, DVU, DVN)	Western North American Freshwater Marsh Macrogroup
Channel (CVU, CVN)	Western North American Freshwater Marsh Macrogroup
Wet Meadow (WM)	Western North American Freshwater Marsh Macrogroup
Lacustrine (LVU)	Western North American Freshwater Marsh Macrogroup
Individual Vernal Pool	Western North American Vernal Pool Macrogroup
Vernal Pool Complex	Not integrated (individual pools delineated with heads up digitizing)

SFEI Map Class	Sonoma Veg Map Fine-Scale Map Class
Tidal Vegetation	North American Pacific Coastal Salt Marsh Macrogroup
Tidal Bay Flat, Tidal Marsh Flat, Tidal Panne	Water or Tidal Bay Flat/Tidal Marsh Flat/Tidal Panne

For areas where no wetlands existed from previous mapping efforts (the northern $\frac{3}{4}$ of Sonoma County), the mapping team digitized herbaceous wetlands and vernal pools where they were apparent in the fall, 2013 imagery. Vernal pools were mapped to the Western North America Vernal Pool Macrogroup class. Other herbaceous wetlands were mapped to the following classes through imagery interpretation and landscape context:

- North American Pacific Coastal Salt Marsh Macrogroup – in the field, these stands were mapped to the alliance where possible
- Western North American Freshwater Macrogroup – in the field, these stands will be labeled to the alliance where possible

Figure 14. *Herbaceous wetland refinements and improvements; incorporating SFEI data and manual edits into the Veg Map*



Blue outlines show SFEI herbaceous wetlands

Blue shaded areas show expanded area of wetlands in Sonoma Veg Map

3.6.3.3. Serpentine Area Mapping

Serpentine fine-scale map classes (listed below in Table 9) were mapped using the same semi-automated techniques described in section 3.3.2 but were targeted for more in-depth field work and more refined manual editing than other upland areas.

The table below shows serpentine-adapted species and their fine-scale map classes.

Table 9. *Serpentine (and related ultramafic soil) species and their fine-scale map classes*

<i>Species</i>	<i>Map Class</i>	<i>Lifeform</i>	<i>Notes</i>
<i>Hesperocyparis macnabiana</i>	<i>Hesperocyparis macnabiana</i> Alliance	Forest and Woodland	Broad serpentine endemic
<i>Hesperocyparis sargentii</i>	<i>Hesperocyparis sargentii</i> Alliance		Broad serpentine endemic
<i>Pinus attenuata</i>	<i>Pinus attenuata</i> Alliance		On serpentine, other ultramafic, and other volcanic soils
<i>Pinus sabiniana</i>	<i>Pinus sabiniana</i> / <i>Quercus durata</i> Provisional Alliance		When on serpentine, occurring with serpentine endemic shrubs such as <i>Q. durata</i>
<i>Arctostaphylos bakeri</i>	<i>Arctostaphylos</i> (bakeri, montana) Provisional Alliance	Shrub	Uncommon/important; strict serpentine endemic.
<i>Quercus durata</i>	<i>Quercus durata</i> Alliance		Ultramafic endemic
<i>Eriodictyon californicum</i>	<i>Eriodictyon californicum</i> - <i>Lupinus albifrons</i> Alliance		On disturbed serpentine soils
<i>Rhododendron occidentale</i>	Southwestern North American Riparian/Wash Scrub Group (mapped at group level of NVC)		Dominant alone or with other serpentine indicator shrubs; occurs in very small patches or under-canopy
<i>Allium-Streptanthus-Eriogonum</i>	<i>Allium falcifolium</i> - <i>Eriogonum</i> spp. - <i>Streptanthus</i> spp. Provisional Alliance	Herbaceous	

During manually editing the mapping team relied on two layers depicting serpentine soils:

- Ultrabasic areas in California, produced by the Department of Conservation, California Geological Survey
- A subset of serpentine derived soils from the NRCS soil survey of Sonoma County, including the Henneke, Montara, and Huse soil units

3.6.4. Validation Field Work

Validation field work occurred during spring and summer, 2016. Validation field work provided the mapping team with an opportunity to review the manually edited map in the field and perform quality control on the map. The mapping team also relied on field validation for difficult-to-map areas to inform additional map refinement and manual editing.

During manual editing, analysts targeted areas where uncertainty in the fine-scale map class was high. These areas were prioritized and visited by field crews where access was possible. Validation field work – like calibration field work – results in field verified fine-scale map class labels for all areas visited. During validation field work, vegetation map polygons were labeled with their fine-scale map class using a Trimble Yuma running ArcMap by field teams in vehicles, ATVs, and on foot. See section 3.4 for more on how crews conducted this type of field work.

3.7. Fine-scale Map Expert Review

After the fine-scale vegetation map was manually edited and field validation work was completed, the fine-scale vegetation map was distributed to the Vegetation Mapping and Remote Sensing Advisory Committee, the Local Ecology and Botany Group, and several other stakeholders, advisors, and interested experts. The purposes of expert map review were as follows:

1. For land managers who are intimately familiar with a parcel or set of parcels to impart their local knowledge into the vegetation and habitat map. This input was requested from members of the Local Ecology and Botany Advisory Group (as well as others). Input was delivered to the mapping team in the form of edits to specific map polygon labels.
2. For members of the Vegetation Mapping and Remote Sensing Advisory Committee to review the map and provide more general technical guidance regarding map look and feel, the structure of the map's database, and the thematic content of the map.
3. For local land managers, ecologists, botanists, and the map's end users to provide comments on geographic areas that they are familiar with or suggestions on ways to improve the map for their end uses.

All changes suggested during the expert review period were integrated into the map products before the products were made public in May 2017.

3.8. Post-processing

After final review and a final round of manual editing was completed, post-processing was conducted to prepare the fine-scale vegetation map for publishing. Post-processing included the following steps:

- *Dissolving on vegetation type and relative conifer vs. hardwood cover:* This step ensured that two **fine-scale segments** with identical map classes and relative hardwood labels became a **single polygon** in the final vegetation map.
- *Adding the suite of attributes for percent imperviousness, carbon & biomass, and forest structure* (see section 5.4 for a list of all fine-scale map attributes).
- *QA/QC to ensure valid and complete data:* This step entailed review of all vegetation map polygons to ensure that each map polygon had complete and valid data. For example, each attribute of each polygon was checked for missing data, out-of-range or inappropriate values, etc.

4. Accuracy Assessment

Accuracy assessment entails collecting representative samples of the map and comparing the reference label of the sample to its map label. The reference labels are assumed to be the “true” label and are usually derived from a source of higher accuracy than the map (e.g. field plot samples). This section of the report reviews the accuracy assessment methods and results for the lifeform map and the fine-scale vegetation map. The first section describes how the accuracy assessment samples were selected and labeled. Next, analysis procedures are explained and the resulting error matrices are presented. The last section details the causes of the most significant confusion in the maps.

4.1. Sample Design

Fine-scale segments were used as accuracy assessment sample units. Fine-scale segments are areas of homogeneous land cover or land use class which resulted from the initial segmentation of the imagery in Ecognition® (see figure 4). Segments were chosen instead of the larger final map polygons to constrain the area of the samples, as final map polygons can encompass several hundred acres. All samples were also constrained to be at least greater than one acre in size, to avoid sampling sub-minimum mapping unit islands of vegetation.

Two types of samples were collected:

- Manual labelling of sites from the imagery for assessment of classes other than shrub and native forest
- Field verification of sites for assessment of the shrub and forest fine-scale vegetation map and lifeform classes

4.1.1. Manually Interpreted Samples

Lifeform map accuracy was assessed using both the lifeform map class assigned to field-verified samples (see below) and the lifeform map class manually interpreted from imagery. Unlike fine-scale vegetation labels, non-shrub and non-native forest lifeform classes are easy to interpret from imagery and do not require field verification. Therefore, accuracy assessment reference samples for the non-native forest and non-shrub lifeforms were labeled using manual image interpretation in the office. Two fine-scale classes (North American Pacific Coastal Salt Marsh Macrogroup and *Eucalyptus (globulus, camaldulensis)* Semi-natural Alliance) were also assessed using manual interpretation because they are similarly readily identifiable on the imagery. For the manually interpreted sites, a random number generator was used to select approximately 30 sample segments for each class resulting in a total of 392 manually interpreted reference samples. Only 13 of the 19 lifeform classes were assessed. The vineyard replant, perennial agriculture, and nursery classes were not assessed because there were too few sites for a reasonable sample size. The urban window and major road classes were not assessed because 1) they were developed from very high accuracy inputs (road centerlines, building footprints, and the impervious surface map) and 2) the build landscape is not the primary focus of this project.

4.1.2. Field-Verified Samples

Two sources were used for field-verified accuracy assessment samples – segments containing CDFW/CNPS surveys that were not used in the development of the lifeform and fine-scale vegetation maps, and newly established field sites which were chosen using a combined stratified random/cluster sampling approach. First, all access-restricted areas were masked out of the map, which focused the field sampling on public lands, conservation lands, or private lands whose landowners were willing to provide access. Next, areas with difficult access were also masked out. These ‘high travel cost’ areas were defined by a cost surface that identified areas far from accessible roads and trails, as well areas inaccessibility due to steep terrain. Within the remaining areas, 120 fine-scale segments were randomly selected per fine-scale map class to serve as the feasible set of field-verified accuracy assessment samples. To ensure that samples were not spatially autocorrelated, a minimum distance of ½ mile between sites of the same map class was required.

To reduce travel costs, field personnel were encouraged to choose and label two additional segments that were adjacent or nearby the randomly selected segment *with different fine-scale map classes* than the randomly selected target sample. The field crew kept a tally of the number of accuracy assessment sample segments per fine-scale map class. To ensure

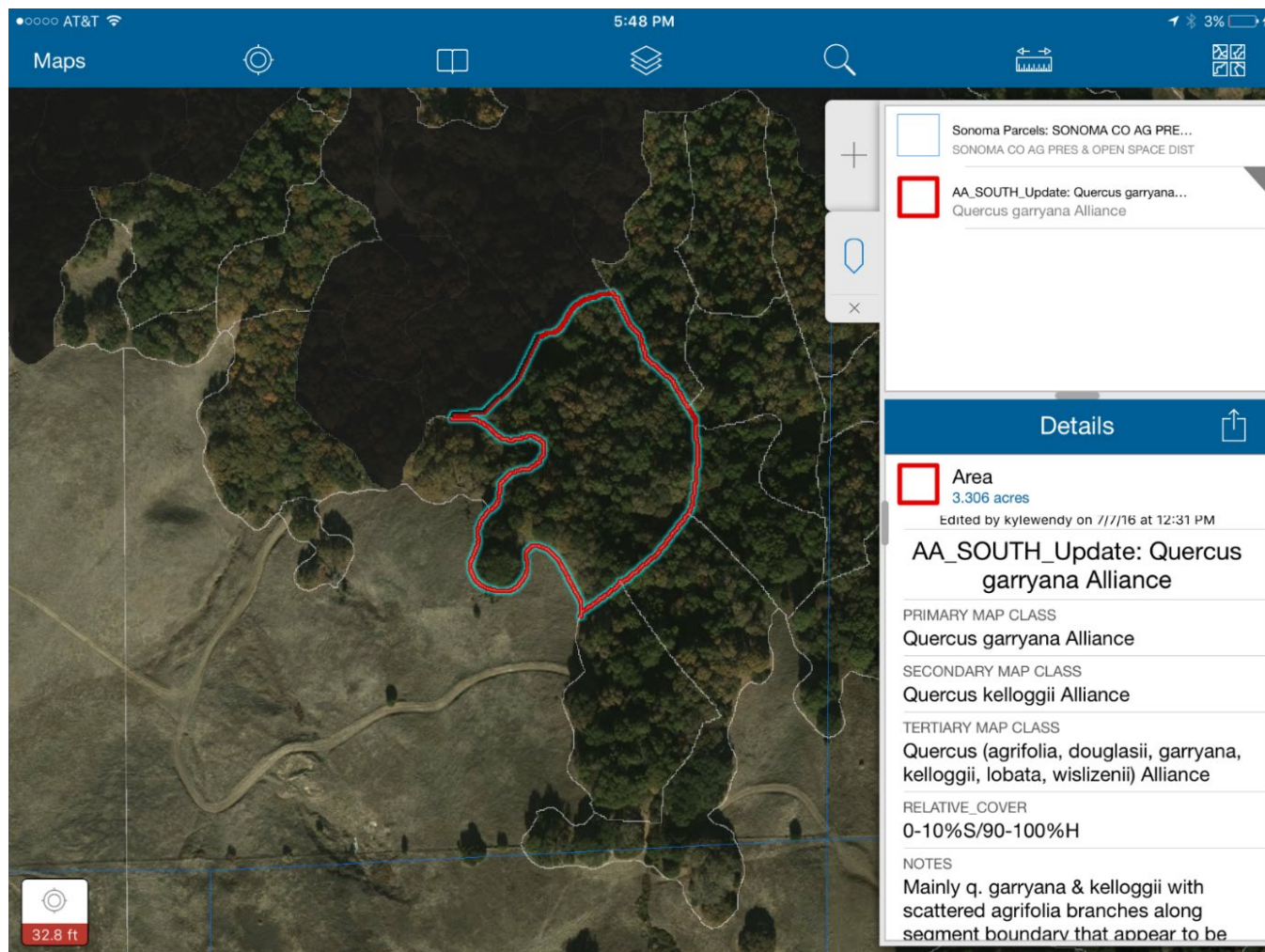
independence, field accuracy personnel never had access to the map labels and did not participate in creation of the map.

At the selected segments, field personnel viewed the entire area within a sample segment before assigning a reference map class for that sample. If the entire sample segment was not visible from a vantage point, the crew walked or drove through the remaining area of the sample segment. Following inspection of the sample segment, field personnel completed the accuracy assessment form on an iPad (see figure 15). Field personnel estimated the percent cover of each vegetative species visible in the imagery for each sample segment and used the mapping key to label the sample segment. Estimates of cover by species were determined through manual interpretation of the imagery to ensure that estimates were made from above, rather than below the canopy. Secondary (and, if necessary, tertiary) reference labels were also determined and entered if the field personnel believed an alternative label to be acceptable. More than one label may be acceptable because of a combination of the following factors:

- Humans are incapable of precisely estimating percent cover, resulting in an average variance in estimates of +/- 10% (Congalton and Green, 2019). While this will have little impact in a simple map such as the lifeform map, it can have significant impact on a map as detailed as the fine-scale map, with numerous classes that are often distinguished from one another in the key based on small species percent cover differences.
- Classification schemes impose boundaries between vegetation types. However, vegetation usually exists along a continuum of vegetation cover. If the composition of a sample meets the condition for two different map classes, then either label should be considered acceptable. For example, a sample could receive a primary label of *Quercus (agrifolia, douglasii, garryana, kelloggii, lobata, wislizenii)* Alliance and a secondary label of *Quercus garryana* Alliance based on the field personnel's uncertainty regarding the proportion *Quercus garryana* cover verses that of other oak species.

A total of 1012 field-verified samples were collected for 43 of the fine-scale map classes. Some classes received less than 30 samples because 30 spatially uncorrelated, non-training site segments did not exist within the field sampling accessible area. Other classes were not assessed because there were an insufficient number of accessible segments to constitute a valid sample size.

Figure 15. Accuracy assessment form on iPad (ESRI Collector App)



4.2. Analysis

Once the accuracy assessment reference data were collected, the map labels (assigned during the map classification process) for each sample segment were compared to the reference labels (assigned from manual interpretation or field validated samples). Extensive quality control was performed to ensure that reference labels and map labels were accurate, and that spatial autocorrelation did not exist between sample segments. As a result, 72 sample segments were removed from the data set for one or more of the following reasons:

- The sample received more than one map label because of post accuracy assessment editing.
- Two adjacent samples received the same reference label and map label, indicating that they were spatially autocorrelated. In this case, one of the samples was removed.

- The sample segment fell below the minimum mapping unit.
- There were non-recoverable errors in reference data entry.

Following quality control, the error matrices were created, and analysis was performed. The matrices can be found in Tables 10 (lifeform) and 12 (fine-scale vegetation). Error matrices provide a wealth of information about the map by indicating how many samples have agreement between the reference and map labels, and what classes are confused with one another. Samples with matching reference and map labels fall along the diagonal of the matrix with cells shaded in green.

Overall deterministic accuracy is determined by dividing the total number of samples on the diagonal by the total number of samples in the matrix. Confused samples fall off of the diagonal and indicate not only that error exists in the map, but what classes are confused with one another. Useful measures for each class are the user's and producer's accuracies because they measure the proportion of errors of commission and omission in each class, respectively. User's accuracy is the total number of samples in agreement divided by the number of map samples in a class and provides an indication of the errors of commission in each class. Producer's accuracy is the total number of samples in agreement divided by the number of reference samples in a class and indicates the level of errors of omission of each class.

Table 10 (lifeform) is a deterministic error matrix with no allotment for secondary or tertiary reference labels. Lifeform classes are relatively simple to discern and are also homogeneous, which greatly reduces any ambiguity in labeling. Overall lifeform accuracy is 95 percent, indicating that there is minimal confusion in the lifeform map. Table 11 lists the producer's and user's accuracies for each lifeform class.

Reference																		
	Annual Cropland	Barren & Sparsely Vegetated	Developed	Herbaceous	Intensively Managed Hayfield	Irrigated Pasture	Native Forest	Non-native Forest & Woodland	Non-native Shrub	Orchard or Grove	Native Shrub	Vineyard	Water	Total	User's Accuracy			
Map Label																		
Annual Cropland	29				1					1				31	94%			
Barren & Sparsely Vegetated	28			3										31	90%			
Developed			34	1										35	97%			
Herbaceous	1	1		28						1	2			33	85%			
Intensively Managed Hayfield		1			29	4						1		35	83%			
Irrigated Pasture						26								26	100%			
Native Forest							620	2			13		1	636	97%			
Non-native Forest & Woodland			1					33		1				35	94%			
Non-native Shrub				3					9		2			14	64%			
Orchard or Grove										30		1		31	97%			
Native Shrub				3			11				223			237	94%			
Vineyard												30		30	100%			
Water													30	30	100%			
Total	30	30	35	38	30	30	631	35	9	33	240	32	31	1204				
Producer's Accuracy	97%	93%	97%	74%	97%	87%	98%	94%	100%	91%	93%	94%	97%		95%			

Table 11. *Lifeform user's and producer's accuracies*

Map Class	Number of Map Samples	User's Accuracy	Number of Reference Samples	Producer's Accuracy
Annual Cropland	31	94%	30	97%
Barren & Sparsely Vegetated	31	90%	30	93%
Developed	35	97%	35	97%
Herbaceous	33	85%	38	74%
Intensively Managed Hayfield	35	83%	30	97%
Irrigated Pasture	26	100%	30	87%
Native Forest	636	97%	631	98%
Non-native Forest & Woodland	35	94%	35	94%
Non-native Shrub	14	64%	9	100%
Orchard or Grove	31	97%	33	91%
Native Shrub	237	94%	240	93%
Vineyard	30	100%	32	94%
Water	30	100%	31	97%

The error matrix in Table 12 (fine-scale vegetation) is a fuzzy accuracy matrix (derived from ‘fuzzy set theory’) developed using the approach suggested by Congalton and Green (2019) in their widely accepted accuracy assessment textbook. This type of matrix accounts for variation in human interpretation and the ambiguity between the complex and often heterogeneous fine-scale shrub and forest classes.

Table 12 can be interpreted as follows:

- Classes with map and primary reference labels in agreement fall on the diagonal with cells shaded in green.
- Confused classes fall off the diagonal and their number tallies are colored either green or red. Green numbers indicate the number of secondary and tertiary reference sample labels that matched the map label. Red numbers indicate the number of samples where the reference label did not agree with the map label and the map label was not deemed to be acceptable as either a secondary or tertiary label.

Deterministic accuracy (i.e. just the diagonal cells) of the fine-scale shrub and forest map classes is 70%. Overall fuzzy accuracy, which includes samples in agreement with acceptable secondary or tertiary labels, is 79% percent which is very high for a map of this complexity and detail. Table 13 lists the deterministic and fuzzy user’s and producer’s accuracies for the fine-scale vegetation classes which received one or more reference samples.

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Table 12. *Fine-scale map error matrix.* (Please see <https://sonomaopenspace.egnyte.com/dl/FxbUQC30Q2> for a larger-scale version of the error matrix)

[illegible]

Table 13. *Producer's and user's accuracies for the fine-scale vegetation map*

Map Label	Number of Map Sites	Deterministic User's Accuracy	Fuzzy User's Accuracy	Number of Reference Sites	Deterministic Producer's Accuracy	Fuzzy Producer's Accuracy
Acer macrophyllum Alliance	6	100%	100%	9	67%	89%
Adenostoma fasciculatum Alliance	46	65%	74%	45	67%	73%
Aesculus californica Alliance	2	50%	50%	1	100%	100%
Arbutus menziesii Alliance	27	67%	74%	27	67%	78%
Arctostaphylos (bakeri, montana) Alliance	6	83%	83%	7	71%	86%
Arctostaphylos (canascens, manzanita, stanfordiana) A. glandulosa Mapping Unit	26	77%	81%	27	74%	78%
Baccharis pilularis Alliance	29	86%	86%	28	89%	89%
California Annual and Perennial Grassland Macrogroup	3	33%	67%	1	100%	50%
California Coastal Evergreen Bluff and Dune Scrub Group	11	100%	100%	13	85%	85%
Californian Mesic Chaparral Group	9	44%	56%	5	80%	80%
Ceanothus cuneatus Alliance	13	54%	77%	20	35%	70%
Ceanothus oliganthus Alliance	5	40%	60%	5	40%	40%
Eucalyptus (globulus, camaldulensis) Semi-natural Alliance	27	96%	100%	26	100%	100%
Hesperocyparis macrocarpa Semi-Natural Alliance	2	100%	100%	2	100%	100%
Hesperocyparis sargentii Alliance	11	82%	82%	10	90%	90%
North American Pacific Coastal Salt Marsh Macrogroup	29	93%	97%	27	100%	100%
Notholithocarpus densiflorus Alliance	28	82%	89%	33	70%	85%
Pinus attenuata Alliance	14	86%	86%	17	71%	82%
Pinus muricata Alliance	24	100%	100%	26	92%	96%
Pinus ponderosa - Pseudotsuga menziesii Alliance	2	100%	100%	2	100%	100%
Pinus sabiniana / Quercus durata Provisional Alliance	28	89%	93%	25	100%	100%
Populus fremontii Alliance	15	87%	93%	31	42%	68%
Pseudotsuga menziesii - Notholithocarpus densiflorus Alliance	17	53%	65%	26	35%	54%
Pseudotsuga menziesii Alliance	46	67%	85%	46	67%	74%
Quercus (agrifolia, douglasii, garryana, kelloggii, lobata, wislizenii) Alliance	39	31%	62%	29	41%	55%
Quercus agrifolia Alliance	33	64%	76%	29	72%	83%
Quercus chrysolepis Alliance	17	65%	71%	27	41%	67%
Quercus douglasii Alliance	26	88%	88%	34	68%	82%
Quercus durata Alliance	36	69%	83%	26	96%	96%
Quercus garryana Alliance	45	67%	78%	40	75%	85%
Quercus kelloggii Alliance	20	80%	85%	28	57%	75%
Quercus lobata Alliance	36	69%	69%	32	78%	84%
Quercus wislizeni (shrub) Alliance	7	43%	57%	11	27%	36%
Quercus wislizeni (tree) Alliance	23	52%	57%	21	57%	62%
Rubus armeniacus Alliance	9	100%	100%	13	69%	77%
Sequoia sempervirens Alliance	46	65%	74%	38	79%	84%
Southwestern North American Riparian Evergreen and Deciduous Woodland Group	24	46%	67%	25	44%	64%
Southwestern North American Riparian/Wash Scrub Group	30	73%	87%	32	69%	78%
Umbellularia californica Alliance	32	63%	88%	29	69%	76%
Vancouverian Coastal Riparian Scrub Group	17	76%	82%	15	87%	87%
Vancouverian Riparian Deciduous Forest Group	68	59%	75%	49	82%	90%
Western North America Vernal Pool Macrogroup	1	100%	100%	1	100%	100%

An alternative approach for implementing fuzzy accuracy is that developed by the California Department of Fish and Wildlife in several mapping projects (CDFW & Aerial Information Systems, 2013; Menke et al., 2011). Rather than evaluating every sample for variation in interpretation, their approach applies a ruleset to the entire sample dataset as defined in table 14. This approach resulted in an overall accuracy of 88% in the assessment of the Sonoma County fine-scale vegetation map. Note that the abbreviations in table 14 are as follows: AAP is an *Accuracy Assessed Polygon*, PI is *photointerpretation*.

Table 14. CDFW evaluation criteria for fuzzy accuracy assessment

Code	Reason For Score	Score
A	PI completely correct.	5
B	The PI chose the correct Group OR the next level up in the hierarchy.	4
C	Threshold/transition between PI call and Final call. This was used when cover values of the dominant or indicator species were close to the values that would key to the PI's type (e.g., an AAP call of <i>Yucca brevifolia</i> Alliance for a stand with 1% evenly distributed <i>Yucca brevifolia</i> over <i>Larrea tridentata</i> - <i>Ambrosia dumosa</i> would get this score if the PI call was <i>Larrea tridentata</i> - <i>Ambrosia dumosa</i> Alliance with <1% <i>Yucca brevifolia</i>).	4
D	Correct Macrogroup OR next level up in hierarchy.	3
E	Based on close ecological similarity. Ecological similarity addresses assessed and mapped calls that contained vegetation with overlapping diagnostic species but were not technically closely related in the NVCS hierarchy. This was common in stands that contain a mix of species of late and early seral vegetation types and also common in zones of overlap between ecoregions.	3
F	Correct Division.	2
G	Some floristic/hydrologic similarity. This addresses cases in which the mapped and the assessed vegetation type had different diagnostic species, but bore some similarity in ecological traits based on predicted and actual setting such as hydrologic regime, overall climate, or successional state.	2
H	Correct only at Lifeform.	1
I	No similarity above Formation and incorrect life form.	0
J	Survey removed because there was a significant change in the polygon (e.g., the stand was burned, developed, or cleared since the date of the base imagery).	no score
K	Survey removed because inadequate portion (<10%) of the polygon was viewed by the field crew.	no score
L	Survey removed because field/PI data are incomplete, inadequate or confusing (e.g., cover values were not provided for key species in the stand).	no score
M	Supplementary record not scored (for multiple point assessments within a polygon where the AA call was the same).	no score

4.3. Discussion

As indicated by the lifeform error matrix, there is very little confusion in the lifeform map. Some confusion between shrub and native forest occurs, which often occurs for areas on the margins of those two classes. All but two of the lifeform classes have producer's and user's accuracies which exceed 80%. The only noteworthy confusion arises from errors of commission of both non-native and native shrub to herbaceous - a common source of confusion in areas of mixed shrub and herbaceous vegetation.

Most of the confusion in the fine-scale matrix consists of scattered confusion of 1 or 2 sites in various cells across the matrix. However, there are several types of confusion that are more significant and warrant understanding by both map users and producers:

- 25 samples confused between *Quercus (agrifolia, douglasii, garryana, kelloggii, lobata, wislizenii)* Alliance and the alliances of the species which comprise it. The confusion is almost equally composed of commission and omission errors and is not surprising given that the other *Quercus* alliances may all contain a mix of oak species. It is only the proportion of the mixture of oak species that divides the mixed oak alliance from the purer oak species alliances. The confusion is an excellent example of how a complex landscape is not easily divided into discrete map classes.
- 15 samples confused between the riparian classes of Southwestern North American Riparian Evergreen and Deciduous Woodland Group, Vancouverian Riparian Deciduous Forest Group, and Southwestern North American Riparian/Wash Scrub Group. The majority of this confusion stems from 9 samples of Southwestern North American Riparian Evergreen and Deciduous Woodland Group committed to the Vancouverian Riparian Deciduous Forest Group. Distinguishing between these map classes often depends on distinguishing between *Salix* species, a difficult task in the field and even more difficult in image interpretation. As a result, it is not surprising that these classes have confusion.
- 10 samples representing errors of omission of *Populus fremontii* Alliance mapped as either Southwestern North American Riparian Evergreen and Deciduous Woodland Group, Southwestern North American Riparian/Wash Scrub Group, or Vancouverian Riparian Deciduous Forest Group. Examination of these samples indicates that perhaps the reference field personnel often overestimated the percent cover of *Populus fremontii* in the sample. As only 5% absolute cover of *Populus fremontii* is required for a site to be labeled *Populus fremontii* Alliance, it is not surprising that overestimation of *Populus fremontii* cover would lead to this type of confusion.
- 10 samples representing errors of commission of either *Pseudotsuga menziesii* - *Notholithocarpus densiflorus* Alliance or *Pseudotsuga menziesii* Alliance to *Sequoia sempervirens* Alliance. Four of the confused samples contained cover of *Sequoia sempervirens*, but not at a level high enough (20% cover of *Sequoia sempervirens* is required) for the reference sample to receive the *Sequoia sempervirens* Alliance label.
- 6 samples of confusion between *Pseudotsuga menziesii* - *Notholithocarpus densiflorus* Alliance and the *Pseudotsuga menziesii* Alliance, with errors of commission and omission equal to one another. All 3 of the samples of errors of commission of the *Pseudotsuga menziesii* Alliance to the *Pseudotsuga menziesii* - *Notholithocarpus densiflorus* Alliance had *Notholithocarpus densiflorus* in the canopy, but not at a level high enough (10% required) to warrant the *Pseudotsuga menziesii* - *Notholithocarpus densiflorus* Alliance label.
- 6 errors of commission of either *Adenostoma fasciculatum* Alliance (4), *Arctostaphylos (canascens, manzanita, stanfordiana)* A. *glandulosa* Mapping Unit (1), or *Hesperocyparis sargentii* Alliance to *Quercus durata* Alliance. These errors may be the result of over-

aggressive editing in the final stages of map creation and may indicate that the map has over-mapped the *Quercus durata* Alliance.

- 5 samples with errors of commission from *Ceanothus cuneatus* Alliance to *Adenostoma fasciculatum* Alliance. All of these samples contain *Adenostoma fasciculatum* and occur within the 2004 Geysers fire perimeter where the rapidly regenerating vegetation is highly heterogeneous and dynamic.

Finally, it must be remembered that field reference labels were developed from the imagery viewed on an iPad. While the species composition of each sample was verified during the field visit, labelling percent cover based what can be seen on an iPad under field conditions can be problematic vis a vis labeling on a high resolution, large display in a light-controlled office. Some errors in the reference labels were most probably introduced as a result of the limitations of the iPads and the inability to control light.

5. Vegetation Map Data Products

5.1. Introduction

One of the aims of this program was to provide well-documented fine-scale vegetation data to the public in a way that made the data easily accessible and easy to use. This section provides an overview of the data products. Section 5.2 provides an overview of obtaining the data products and section 5.3 provides the datasheets for each of the data products.

5.2. Obtaining the Data Products

The vegetation map and its derivatives are available for download from <http://sonomavegmap.org/data-downloads>. There are numerous ways of obtaining the data products from the web site. Table 14 provides an overview of available formats for each data product. The formats for the available products are listed and described as follows:

- **Feature Service:** Streaming data from ArcGIS Online to GIS software or webmaps. Feature services are queryable (attributes are exposed to the end user) and their symbology can be changed.
- **Tile Service:** Streaming data layer from ArcGIS Online where the polygons are turned into vector tiles that draw quickly and use less bandwidth than a feature service. Tile services are not queryable and their symbology is immutable to the end user.
- **File Geodatabase:** ESRI proprietary data format containing feature classes, for use with ArcGIS Desktop products (ArcMap and ArcGIS Pro). File geodatabases are also readable by open source mapping software packages like QGIS.
- **Shapefile:** Generic spatial data format usable in a variety of mapping software packages including ArcGIS Desktop and QGIS.

- **Layer Package:** ESRI proprietary file type containing packaged feature classes and/or shapefiles which can be opened in ArcGIS Desktop products (ArcMap or ArcGIS Pro) with pre-defined symbology and labels already applied.
- **Layer File:** ESRI proprietary file type which can be applied to a specific layer in a map and will apply pre-defined symbology and labels to that layer.
- **Watershed Downloads:** A repository of vegetation map and LiDAR data downloadable in watershed- wide zipped data packages through sonomavegmap.org/data-downloads.
- **Datasheet:** Text descriptions of a data product.
- **PDF Posters:** Cartographic PDF files of selected data products created for the project.

Table 15. Available formats for vegetation map data products from sonomavegmap.org

Data Product	Feature Service	Tile Service	Countywide Geodatabase	Countywide Shapefile	Countywide Layer Package	Layer File	Watershed Downloads	Datasheet	PDF Posters
Sonoma County Fine-Scale Veg Map		✓	✓	✓	✓	✓	✓	✓	✓
Sonoma County Croplands	✓		✓	✓			✓	✓	
Sonoma County Lifeform Map		✓	✓	✓			✓	✓	
Sonoma County 'Forest' Lifeform Map			✓				✓	✓	
Sonoma County Impervious Surfaces		✓	✓				✓	✓	
Sonoma County Water and Wetland Vegetation			✓				✓	✓	✓
Sonoma County Carbon and Biomass			✓				✓	✓	✓

5.3. Data Product Specifications (Datasheets)

In addition to metadata for each spatial data product, datasheets were created and made available for each of the Sonoma Veg Map data products. Links to the datasheets for the vegetation map and its derivatives are provided in Table 15.

Table 16. *Datasheets for vegetation map products*

Product	Datasheet Link
Sonoma County Fine-scale Vegetation and Habitat Map	http://vegmap.press/svm_vegmap_datasheet
Sonoma County Croplands	http://vegmap.press/svm_croplands_datasheet
Sonoma County Lifeform Map and Sonoma County Forest Lifeform Map	http://vegmap.press/svm_forestlifeform_datasheet
Sonoma County Impervious Surfaces	http://vegmap.press/svm_impervious_datasheet
Sonoma County Water and Wetlands	http://vegmap.press/svm_wetland_datasheet
Sonoma County Aboveground Carbon and Biomass	http://vegmap.press/svm_biomass_datasheet

5.4. Attributes of the Fine-scale Vegetation Map

The fine-scale vegetation map has 212,391 polygons countywide. Each polygon includes its fine-scale map class and a suite of information about the polygon. Information is included in the form of numerous attributes that characterize the polygon's forest structure, its impervious composition, its relative hardwood versus conifer cover, and its carbon & biomass content. Table 16 includes a list and description of the numerous fine-scale vegetation map attributes.

Table 17. *Fine-scale vegetation map attributes*

Fine-scale Map Attributes (Name/Alias)	Description
MAP_CLASS/Map Class	National Vegetation Classification (NVCS) Map class. The full NVCS hierarchy is provided through a relationship class on this field.
SOURCE/Source	Source for label – ‘remotely sensed’ or ‘field’
REL_COV/Relative Cover	Relative softwood and hardwood cover in 5-classes for forested stands
ALLIANCE/Alliance	Field validated alliance if a stand with a group/macrogrou level map class was validated to the alliance
OID_COPY/OID_COPY	Unique Polygon Identifier
Abbrv/Abbrv	Map class abbreviations for use in cartography and visualization
LIFEFORM/Lifeform	19-class land-use-land-cover lookup, with more detail in ag and developed and less detail in forest
LF_FOREST/Forest Lifeform	17-class land-use-land-cover lookup, with more detail in forest and less detail in ag. and developed
SERP_FLAG/Serpentine Flag	Flag for map classes highly correlated to serpentine; 1 for serpentine classes, 0 for non-serpentine classes
TREE_HT_MN/Mean LiDAR Tree Height	Mean stand height from LiDAR-derived canopy height model (CHM)
TREE_HT_MX/Max LiDAR Tree Height	Max stand height from LiDAR-derived canopy height model (CHM)
TREE_HT_SD/Standard Deviation LiDAR Tree Height	Standard deviation of stand height from LiDAR-derived canopy height model (CHM)
ABS_COVER/Absolute % Tree Canopy Cover	Absolute canopy cover – represents percent of stand’s LiDAR returns that are greater than 15 feet above the ground
HDW_COV_LO/Absolute Hardwood Cover Low End	Low end of estimated absolute hardwood cover
HDW_COV_HI/Absolute Hardwood Cover High End	High end of estimated absolute hardwood cover for forest stands
CON_COV_LO/Absolute Conifer Cover Low End	Low end of estimated absolute conifer cover for forest stands
CON_COV_HI/Absolute Conifer Cover High End	High end of estimated absolute conifer cover for forest stands
PPT_IMPERV/Proportion Impervious	Percent of stand with impervious cover
PPT_PERV/Proportion Pervious	Percent of stand with pervious cover
PPT_PVD_RD/ Proportion Paved Road	Percent of stand that is paved road
PPT_DRT_RD/ Proportion Dirt Road	Percent of stand that is dirt road
PPT_OT_IMP/ Proportion Other Impervious	Percent of stand that is ‘other impervious’ (not road or building)

Fine-scale Map Attributes (Name/Alias)	Description
PPT_BUILD/ Proportion Buildings	Percent of stand that is buildings
BM_MG_HA/Aboveground Biomass (Metric Tons per Ha)	Aboveground biomass in metric tons per hectare
BM_MG_AC/Aboveground Biomass (Metric Tons per Acre)	Aboveground biomass in metric tons per acre
BM_MG/Aboveground Biomass (Metric Tons)	Aboveground biomass in metric tons
CB_MG_HA/Aboveground Carbon (Metric Tons per Hectare)	Aboveground carbon in metric tons per hectare
CB_MG_AC/Aboveground Carbon (Metric Tons per Acre)	Aboveground carbon in metric tons per acre
CB_MG/Aboveground Carbon (Metric Tons)	Aboveground carbon in metric tons
CB_EQVT_HA/Aboveground Carbon (Equivalents per Hectare)	Aboveground carbon in metric tons of CO ₂ equivalents (CO ₂ e) per hectare
CB_EQVT_AC/Aboveground Carbon (Equivalents per Acre)	Aboveground carbon in metric tons of CO ₂ equivalents (CO ₂ e) per acre
CB_EQVTS/Aboveground Carbon (Equivalents)	Aboveground carbon in metric tons of CO ₂ equivalents (CO ₂ e)
MN_P05/Mean of 5 th Percentile Height	Lascanopy mean 5 th percentile height for forest stands
SD_P05/Standard Deviation of 5 th Percentile Height	Lascanopy standard deviation 5 th percentile height for forest stands
MN_P10/Mean of 10 th Percentile Height	Lascanopy mean 10 th percentile height for forest stands
SD_P10/Standard Deviation of 10 th Percentile Height	Lascanopy standard deviation 10 th percentile height for forest stands
MN_P25/Mean of 25 th Percentile Height	Lascanopy mean 25 th percentile height for forest stands
SD_P25/Standard Deviation of 25 th Percentile Height	Lascanopy standard deviation 25 th percentile height for forest stands
MN_P50/Mean of 50 th Percentile Height	Lascanopy mean 50 th percentile height for forest stands
SD_P50/Standard Deviation of 50 th Percentile Height	Lascanopy standard deviation 50 th percentile height for forest stands
MN_P75/Mean of 75 th Percentile Height	Lascanopy mean 75 th percentile height for forest stands
SD_P75/Standard Deviation of 75 th Percentile Height	Lascanopy standard deviation 75 th percentile height for forest stands
MN_P90/Mean of 90 th Percentile Height	Lascanopy mean 90 th percentile height for forest stands
SD_P90/Standard Deviation of 90 th Percentile Height	Lascanopy standard deviation 90 th percentile height for forest stands
MN_QAV/Mean LiDAR Average Square Height	Lascanopy mean average square height (QAV) for forest stands
SD_QAV/Standard Deviation LiDAR Average Square Height	Lascanopy standard deviation average square height for forest stands

Fine-scale Map Attributes (Name/Alias)	Description
MN_SKE/Mean LiDAR Skewness	Lascanopy mean LiDAR skewness for forest stands
SD_SKE/Standard Deviation LiDAR Skewness	Lascanopy standard deviation LiDAR skewness for forest stands
MN_AVG/Mean of LiDAR Returns	Lascanopy mean of all LiDAR returns for forest stands
MN_KUR/Mean LiDAR Kurtosis	Lascanopy mean LiDAR kurtosis for forest stands
SD_KUR/Standard Deviation of LiDAR Kurtosis	Lascanopy standard deviation LiDAR kurtosis for forest stands
MN_STD/Mean of the Standard Deviations of LiDAR Returns	Lascanopy standard deviation of LiDAR returns from lascanopy for forest stands

6. Lessons Learned

The mapping team learned many useful lessons from this project. Some of these lessons were reinforced by this project; others are new lessons learned.

- Making vegetation map project data widely available and easily digestible increases the success of a vegetation mapping project. Making products available as they are completed (not just at project's end) results in early buy-in from constituents.
- Making products available in a variety of formats and through a variety of download options allows a broad variety of users (from expert to neophyte) to access them.
- Involvement of stakeholders and end users is critical to ensuring that a vegetation map serves its user base.
- Classification development by expert botanists, vegetation ecologists, and mappers is a critical prerequisite to a successful fine-scale mapping project.
- Calibration sites used for machine learning must be extremely well vetted; sites that aren't representative of a map class greatly reduce machine learning accuracy.
- Calibration and validation sites have increased utility if field photos accompany them.
- There is great value in curating and using as many dates of reference imagery for machine learning and manual editing as possible, as each date of imagery may provide keys to identifying different fine-scale map classes in different conditions.
- Manual editing should be conducted by editors who have visited the area they are editing in the field.

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8. Appendix: Fine-scale Map Class Descriptions

The following pages include a one-page summary for each of the 82 map classes in the fine-scale vegetation map. The one-page summaries detail the following information for each fine-scale map class:

Photos: Two photos are provided – a ground photo taken in the field and an aerial view from imagery.

Description: Descriptions are pulled from the Department of Fish and Wildlife’s report entitled *Classification of the Vegetation Alliances and Associations of Sonoma County, California Volume 2 of 2 – Vegetation Descriptions*. That full report is available here:

<https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=115808&inline=1>

For map classes that are above the alliance level of the National Vegetation Classification (e.g., riparian groups), the descriptions are adapted from the fine-scale mapping key, which is available at this URL: http://vegmap.press/svm_finescale_key

Most Abundant Species: The most abundant species for the map class are listed.

Distribution/Location: A summary of where the map class occurs on the landscape of Sonoma County is included.

Acres Mapped: The number of acres of the fine-scale map class mapped countywide.

Accuracy Information: User's accuracy, producer's accuracy, and the number of accuracy assessment map sites and reference sites for each map class.

Global/State Rarity Rank: Rarity rank is provided where available from the *Classification of the Vegetation Alliances and Associations of Sonoma County, California Volume 2 of 2 – Vegetation Descriptions*. See link on the previous page.

Map Class: *Abies grandis* Alliance

Common Name: Grand Fir Alliance



Ground View

Aerial View

NVC Association(s): NA

Description:

Statewide (Sawyer et al. 2009)

In this map class, *Abies grandis* is dominant or co-dominant in the tree canopy with *Alnus rubra*, *Picea sitchensis*, *Pinus muricata*, *Sequoia sempervirens*, and *Tsuga heterophylla*.

The *Abies grandis* Alliance is common in the Pacific Northwest; the southern limit of the species is Sonoma County (Griffin and Critchfield 1972). Infrequent in California, the alliance is limited to the north coastal strip, where logging has removed virtually all old-growth stands (Sawyer 2006, 2007). The few inventoried stands in Mendocino and Humboldt Counties are generally less than 20 hectares in size (CNDDDB). The alliance does not contain stands with *Abies grandis* × *concolor* hybrids found at montane elevations in the northern Coast Ranges and western Klamath Mountains (Hunt 1993, Sawyer 2006, 2007); those are included in the *Abies concolor* Alliance.

Stands of *Abies grandis* in California appear mostly seaward of the *Sequoia sempervirens* belt. The alliance's proximity to the coast, with its maritime temperatures and summer fog, yields conditions similar to those of the *Picea sitchensis* Alliance. However, unlike *P. sitchensis* stands, those of *A. grandis* occupy only upland settings, typically on mesic slopes above creeks and river mouths.

Sonoma County

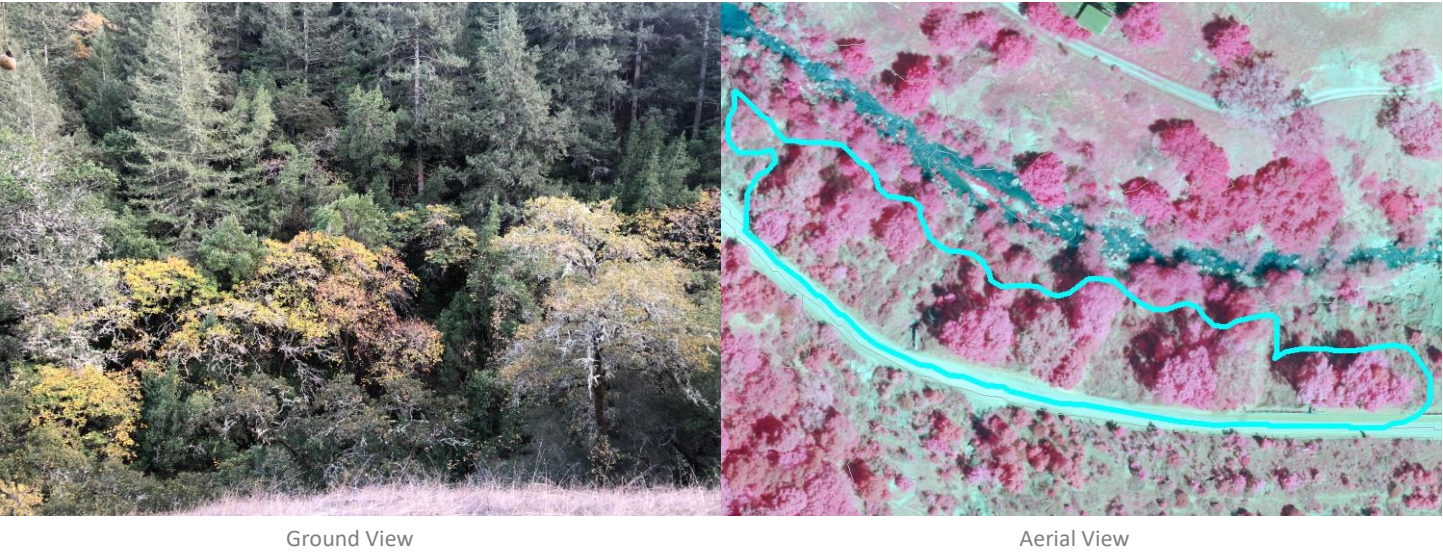
Stands in Sonoma County are rare; only one was accessible on public land. However, at least one other *Abies grandis* stand exists uphill from the access road to the Gualala River campground off Highway 1 (Keeler-Wolf, personal observation). Trees in this stand are significantly larger than those in the sampled stand at Salt Point State Park.

Most Abundant Species: *Abies grandis*

Distribution / Location:

This class is very rare and limited in Sonoma County. Only one stand that met the project minimum mapping units was identified. This stand is located near the coast just east of Highway 1 north of Salt Point State Park.

Acres mapped countywide:	2	Global/State Rarity Rank:	G4/S2
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed



NVC Association(s):

Acer macrophyllum Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, *Acer macrophyllum* is dominant or co-dominant in the tree canopy with *Abies concolor*, *Alnus rhombifolia*, *Alnus rubra*, *Calocedrus decurrens*, *Cornus nuttallii*, *Picea sitchensis*, *Pseudotsuga menziesii*, *Quercus chrysolepis*, *Quercus kelloggii*, *Quercus lobata*, *Sequoia sempervirens*, *Taxus brevifolia*, and *Umbellularia californica*.

This alliance occurs in habitats with different moisture regimes, from moist stream terraces to dry talus, but it attains its best development on deep alluvial soils. The best developed stands are scattered along alluvial river terraces, in adjacent side drainages, and at springs along slopes. The species is extremely flood tolerant; it is the only hardwood encountered commonly at low elevation in Pacific Northwest coniferous forests in both steep upland slopes and riparian habitats. At the southern portion of its range, in southern and central California, it is usually riparian (Minore and Zasada 1990, Uchytel 1989a).

Sonoma County
Most *Acer macrophyllum* stands in Sonoma County are consistent with this description.

Most Abundant Species: *Acer macrophyllum*, *Fraxinus latifolia*, *Quercus chrysolepis*

Distribution / Location:

This class can be found scattered throughout Sonoma county, mostly north of the Russian River, throughout the Mayacamas, and along alluvial river terraces.

Acres mapped countywide:	709	Global/State Rarity Rank:	G4/S3
Accuracy Assessment Map Sites:	6	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	9	Producer's Accuracy:	89%



Ground View

Aerial View

NVC Association(s): Adenostoma fasciculatum -Arctostaphylos manzanita Assoc., Adenostoma fasciculatum -Arctostaphylos stanfordiana / Salvia sonomensis Provisional Assoc., Adenostoma fasciculatum -Diplacus aurantiacus Assoc., Adenostoma fasciculatum Association, Adenostoma fasciculatum Serpentine Assoc.

Description:

Statewide (Sawyer et al. 2009)
In this map class, Adenostoma fasciculatum is dominant in the shrub canopy with Adenostoma sparsifolium, Arctostaphylos glandulosa, Arctostaphylos manzanita, Arctostaphylos viscida, Ceanothus spp., Diplacus aurantiacus, Eriodictyon californicum, Eriogonum fasciculatum, Hesperoyucca whipplei, Heteromeles arbutifolia, Quercus berberidifolia, Quercus wislizeni, Salvia apiana, Salvia leucophylla, Salvia mellifera, and Toxicodendron diversilobum. Emergent trees may be present at low cover.

This alliance occurs across cismontane California in a variety of topographic settings from coastal bluffs to steep, lower montane slopes. In stands older than 60 years of age, little new growth is produced as dead stem biomass increases. In earlier treatments, several chaparral series were assigned to mixed alliances other than Adenostoma fasciculatum when other shrubs were co-dominant (Sawyer and Keeler-Wolf 1995). Following extensive review and the analysis of many more plots, most mixed stands where another indicator species is either strongly dominant or co-dominant with A. fasciculatum were treated as part of other alliances. The few exceptions include the Adenostoma fasciculatum – Salvia mellifera and Adenostoma fasciculatum – Salvia apiana Alliances.

Sonoma County
Adenostoma fasciculatum stands tend to mix with low cover of several Arctostaphylos species.

Most Abundant Species: Adenostoma fasciculatum

Distribution / Location:

In Sonoma County, this map class is located primarily in the interior, away from cool coastal summer air masses. Most of these inland stands are located on steep, south-facing slopes. The few stands that are close to the coast tend to be on serpentine or on extremely steep, south-facing, rocky slopes over 1000 ft.

Acres mapped countywide:	12,716	Global/State Rarity Rank:	G5/S5
Accuracy Assessment Map Sites:	46	User's Accuracy:	74%
Accuracy Assessment Reference Sites:	45	Producer's Accuracy:	73%

Map Class: Aesculus californica Alliance

Common Name: California Buckeye Alliance



Ground View

Aerial View

NVC Association(s): Aesculus californica / Toxicodendron diversilobum / Moss Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Aesculus californica is dominant or co-dominant in the tree canopy with Fraxinus dipetala, Heteromeles arbutifolia, Pinus sabiniana, Prunus ilicifolia, Quercus wislizeni, and Umbellularia californica.

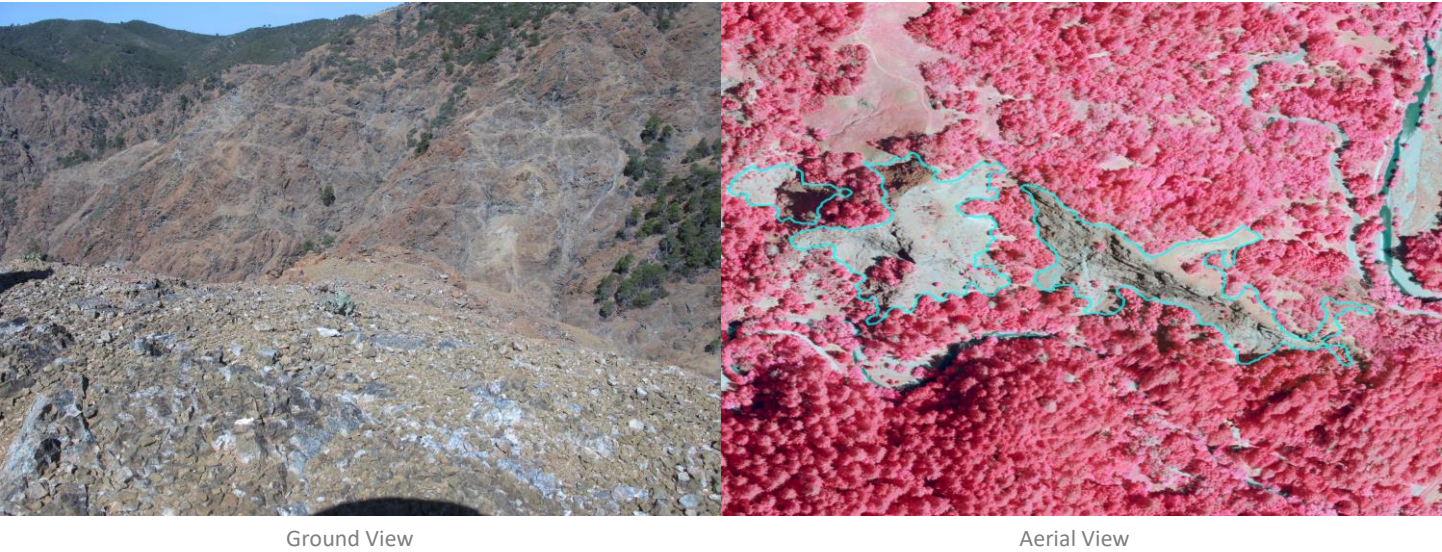
Stands tend to be small and often occur in relatively mesic concavities inland or on steep lower to mid slopes in coastal areas. They intermix with stands of many chaparral and woodland alliances at low elevations.

Most Abundant Species: Aesculus californica

Distribution / Location:

In Sonoma County, this class is located inland from the main summer fog belt and occurrences are most common in the vicinity of Lake Sonoma, where the maps class is found on concave slopes.

Acres mapped countywide:	441	Global/State Rarity Rank:	G3/S3
Accuracy Assessment Map Sites:	2	User's Accuracy:	50%
Accuracy Assessment Reference Sites:	1	Producer's Accuracy:	100%



NVC Association(s): Eriogonum luteolum – Streptanthus morrisonii Provisional Association

Description:

Statewide
In this map class, species composition of this newly defined alliance is variable, but usually includes one or more species of Allium (especially Allium falcifolium and A. cratericola), annual or perennial Eriogonum spp., and Streptanthus spp. Cover is typically sparse, generally < 5%, and is characterized by annual and perennial herbs and low sub-shrubs. Other larger woody shrub species are widely scattered and may include Quercus durata, Arctostaphylos spp., and Ceanothus spp. (particularly C. jepsonii or C. cuneatus). Occasional emergent trees of Hesperocyparis spp., Pinus sabiniana, P. attenuata, or P. jeffreyi may be present.

Stands are restricted to serpentine, peridotite, dunite, or other ultramafic substrates that are characteristically high in magnesium and low in calcium, and often include chromium, nickel, mercury, and other chemically harsh elements. The combination of a substrate toxic to most plants and a location on frequently unstable talus or scree slopes (often called barrens) makes these landscapes poorly vegetated, but rich in serpentine-tolerant endemic plants. All major serpentine regions within the state contain such barrens. However, there is insufficient vegetation data to characterize all of them.

Sonoma County
The provisional association found in Sonoma County is characterized by two species found largely in the serpentine belts of the North Coast Ranges of California, Eriogonum luteolum var. luteolum and Streptanthus morrisonii. In addition to the nominate species, this association also contains Eriogonum cedrorum, an endemic known only from The Cedars locality. Other widespread species of the alliance, such as Asclepias solanoana and Allium falcifolium, also occur in stands of the Eriogonum luteolum – Streptanthus morrisonii Provisional Association.

Most Abundant Species: Allium falcifolium, Eriogonum spp.

Distribution / Location:

In Sonoma County, this class is most common and extensive in and around the The Cedars. It also occurs throughout interior Sonoma County on areas of serpentine. Because it is difficult to map from imagery, this class was mapped only where it was observed in the field.

Acres mapped countywide:	1,119	Global/State Rarity Rank:	G2G3?/S2S3?
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class:

Ammophila arenaria Semi-Natural Alliance

Common Name:

European Marram Grass Semi-Natural Alliance



NVC Association(s):

Ammophila arenaria Semi-Natural Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Ammophila arenaria is dominant in the herbaceous layer. Emergent shrubs may be present at low cover, including Baccharis pilularis or Lupinus arboreus.

Ammophila arenaria is now the predominant vegetation type in many dune systems along the Pacific coast from Ventura County to British Columbia. Many habitat changes occur with its presence: dune stabilization, alteration of dune morphology, reduction in native stands of the Abronia latifolia – Ambrosia chamissonis, Leymus mollis, and other alliances, and a reduction in habitat for both rare animals (e.g., snowy plover, Charadrius alexandrinus) and rare plants (e.g., Erysimum menziesii ssp. eurekaense and Layia carnosa, both listed as California rare plants with a rank of 1B.1). See Apteckar 2000, Boyd 1992, Pickart and Barbour 2007, and Pickart and Sawyer 1998.

Most Abundant Species: Ammophila arenaria

Distribution / Location:

In Sonoma County, this class dominates the large coastal dune-field at Bodega State Beach and occurs in other patches along the coast south of the Russian River.

Acres mapped countywide:	439	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Annual Cropland

Common Name: NA



Ground View

Aerial View

NVC Association(s): NA

Description:

In this map class, the area is an irrigated annual cropland (e.g., vegetable crops) as observed in the Fall, 2013 imagery.

Most Abundant Species: NA

Distribution / Location:

Annual croplands can be found scattered across many valley areas of Sonoma County. The largest annual croplands are located in the Santa Rosa Plain.

Acres mapped countywide:	1,235	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	31	User's Accuracy:	94%
Accuracy Assessment Reference Sites:	30	Producer's Accuracy:	97%



Ground View

Aerial View

NVC Association(s): Arbutus menziesii – Quercus agrifolia Association, Arbutus menziesii – Umbellularia californica – Quercus kelloggii Association, Arbutus menziesii – Umbellularia californica Provisional Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Arbutus menziesii is dominant or co-dominant in the tree canopy with Acer macrophyllum, Notholithocarpus densiflorus, Pseudotsuga menziesii, Quercus agrifolia, Quercus chrysolepis, Quercus kelloggii, Quercus wislizeni, and Umbellularia californica.

Arbutus menziesii groves have traditionally been considered part of the “mixed evergreen forest” and not treated as a separate type (Sawyer 2007). Although A. menziesii is common as a secondary species in many forest types, it does form distinctive stands of high cover worthy of recognition in parts of the state that have relatively snow-free winters but upwards of 100 cm of annual precipitation. Stands in northern parts of the state mix with those of the Pseudotsuga menziesii – Notholithocarpus densiflorus Alliance.

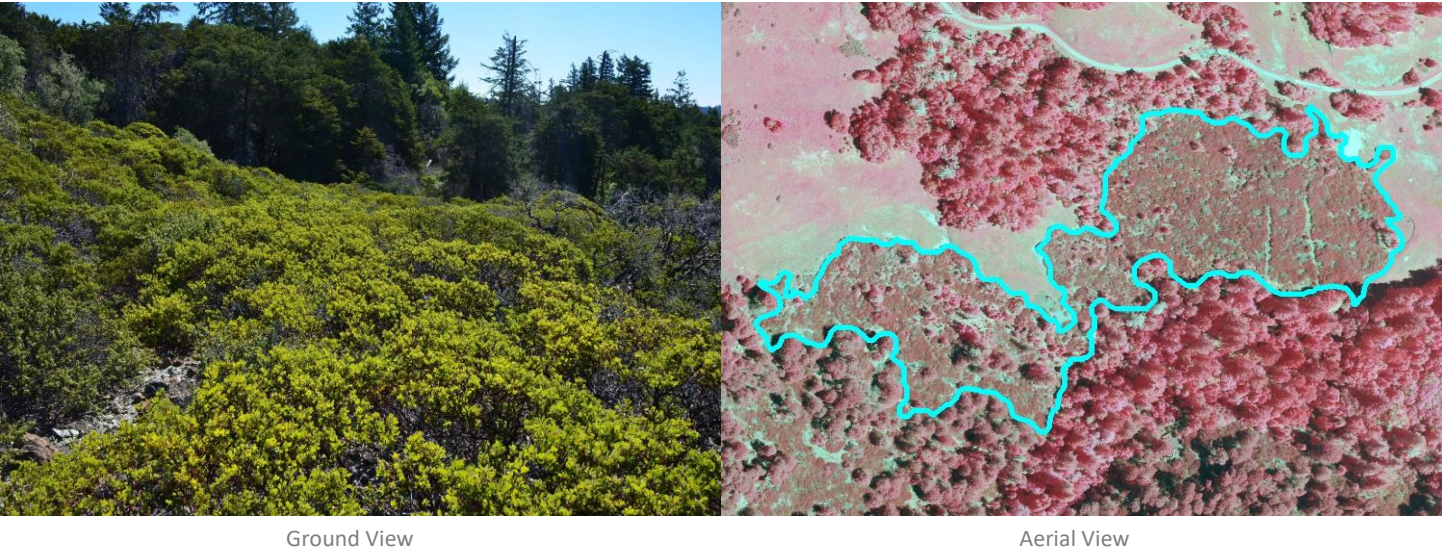
Sonoma County
Stands are ecologically intermediate between those of the Umbellularia californica and Quercus agrifolia Alliances. They tend to segregate from Umbellularia californica stands by occurring on upper slopes and convexities, and they tend to occur in somewhat more mesic settings than stands of Quercus agrifolia.

Most Abundant Species: Arbutus menziesii, Quercus kelloggi, Quercus agrifolia, Umbellularia californica

Distribution / Location:

This class is particularly abundant in the northern and eastern portions of county - especially around Lake Sonoma. Stands often occur on upper slopes.

Acres mapped countywide:	20,903	Global/State Rarity Rank:	G4/S3
Accuracy Assessment Map Sites:	27	User's Accuracy:	74%
Accuracy Assessment Reference Sites:	27	Producer's Accuracy:	78%



NVC Association(s):

Arctostaphylos bakeri Provisional Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, *Arctostaphylos bakeri* or *A. montana* is dominant or co-dominant in the shrub canopy with *Adenostoma fasciculatum*, *Ceanothus cuneatus*, *Ceanothus jepsonii*, *Diplacus aurantiacus*, *Eriodictyon californicum*, *Frangula californica* ssp. *tomentella*, *Garrya elliptica*, *Heteromeles arbutifolia*, *Quercus durata*, and *Toxicodendron diversilobum*. Emergent trees may be present at low cover, including *Hesperocyparis sargentii*, *Pseudotsuga menziesii*, *Quercus wislizeni*, or *Umbellularia californica*.

Arctostaphylos bakeri ssp. *bakeri* and *A. bakeri* ssp. *sublaevis* are serpentine endemics; they are listed as California rare plants with ranks of 1B.1 and 1B.2, respectively. Both are restricted to serpentine outcrops in the lower North Coast Ranges of Sonoma County (Best et al. 1996). Stands of *Arctostaphylos montana* ssp. *montana* and *A. montana* ssp. *ravenii* are not found in Sonoma County; they are only known to occur in Marin and San Francisco Counties, respectively, but are similar in setting and composition to *Arctostaphylos bakeri* stands.

Sonoma County
The stands at both The Cedars and Harrison Grade tend to be on upper slopes adjacent to *Hesperocyparis sargentii* Alliance stands.

Most Abundant Species: *Arctostaphylos bakeri* ssp. *bakeri*, *Arctostaphylos bakeri*, *Quercus durata*

Distribution / Location:

In Sonoma County, this class occurs in the Harrison Grade-Camp Meeker area southeast of Monte Rio on the Russian River and at The Cedars.

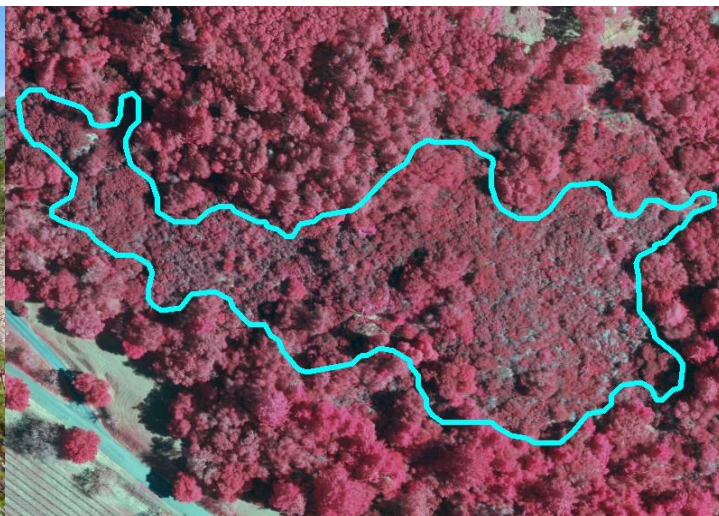
Acres mapped countywide:	954	Global/State Rarity Rank:	G2/S2
Accuracy Assessment Map Sites:	6	User's Accuracy:	83%
Accuracy Assessment Reference Sites:	7	Producer's Accuracy:	86%

Map Class: Arctostaphylos (canescens, manzanita, stanfordiana) A. glandulosa Mapping Unit

Common Name: Manzanita (Hoary, Common, Stanford's) Eastwood's Manzanita



Ground View



Aerial View

NVC Association(s): Arctostaphylos canescens Provisional Association, Arctostaphylos manzanita Provisional Association, Arctostaphylos stanfordiana Provisional Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Arctostaphylos canescens, A. manzanita and/or A. stanfordiana dominate or co-dominate in the shrub canopy with Adenostoma fasciculatum, Arctostaphylos auriculata, Arctostaphylos glandulosa, Arctostaphylos stanfordiana, Arctostaphylos viscida, Baccharis pilularis, Ceanothus spp., Diplacus aurantiacus, Eriodictyon californicum, Heteromeles arbutifolia, Lotus scoparius, Pickeringia montana, Quercus berberidifolia, and Quercus wislizeni. Emergent trees may be present at low cover, including Pinus attenuata, Pseudotsuga menziesii, Quercus chrysolepis, Quercus douglasii, or Quercus wislizeni.

Arctostaphylos canescens appears as a dominant or co-dominant with other chaparral species, forming small stands within a matrix of chaparral and conifers. Arctostaphylos manzanita is a variable species with six subspecies: ssp. elegans, ssp. glaucescens, ssp. laevigata, ssp. manzanita, ssp. roofii, and ssp. wieslanderi (Parker et al. 2007, 2012). The most widely ranging subspecies is ssp. manzanita, and it occurs in many chaparral and woodland types. The other subspecies have smaller ranges. This alliance includes stands of ssp. laevigata and ssp. manzanita. Arctostaphylos stanfordiana has three subspecies, two of which, ssp. decumbens and ssp. raichei, are listed as California rare plants with a rank of 1B.1.

Sonoma County

Most stands of Arctostaphylos manzanita are small and are usually topographically associated with upper slopes in transitional settings between grassland and oak woodland. Evidence of recent fire or clearing disturbance is common in these stands. This suggests that A. manzanita typically acts as an individual species, associated with local disturbance (clearing, fire, etc.) in Quercus garryana woodlands or mixed Douglas-fir – oak woodlands, and only rarely forms significant stands in the county.

In contrast, most pure or mixed stands of Arctostaphylos stanfordiana and A. canescens are larger and tend to associate with extensive old growth chaparral and associated stands of closed-cone conifers or Pinus sabiniana.

Most Abundant Species: Arctostaphylos manzanita, Arctostaphylos stanfordiana, Arctostaphylos canescens

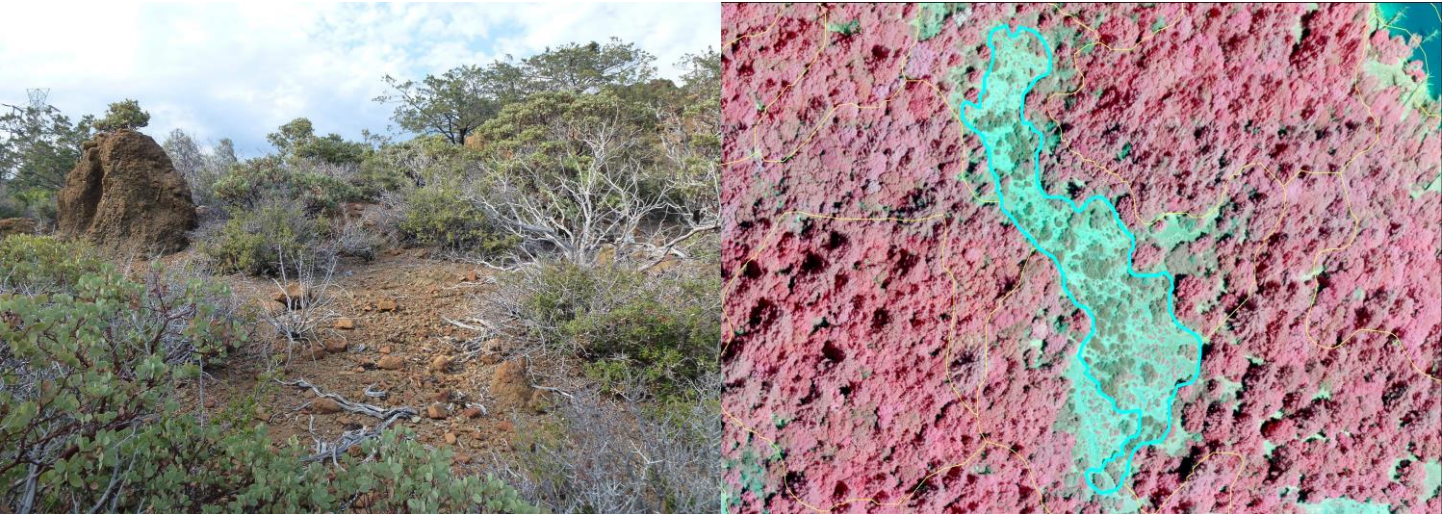
Distribution / Location:

This map class occurs throughout Sonoma County, away from the immediate coast and the Petaluma Gap. Occurrence is most extensive in the Eastern part of the County, especially in the Mayacamas mountains.

Acres mapped countywide:	7,317	Global/State Rarity Rank:	G3/S3
Accuracy Assessment Map Sites:	26	User's Accuracy:	81%
Accuracy Assessment Reference Sites:	27	Producer's Accuracy:	78%

Map Class: Arctostaphylos viscida Alliance

Common Name: Whiteleaf Manzanita Alliance



Ground View

Aerial View

NVC Association(s): Arctostaphylos viscida – Ceanothus jepsonii Provisional Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Arctostaphylos viscida is dominant or co-dominant in the shrub canopy with Adenostoma fasciculatum, Amelanchier alnifolia, Arctostaphylos manzanita, Arctostaphylos mewukka, Arctostaphylos myrtifolia, Arctostaphylos patula, Ceanothus cordulatus, Ceanothus cuneatus, Ceanothus integerrimus, Ceanothus velutinus, Garrya fremontii, Holodiscus discolor, and Quercus berberidifolia. Emergent trees may be present at low cover, including Pinus attenuata, Pinus ponderosa, Pinus sabiniana, or Pseudotsuga menziesii.

In the many portions of its range, stands of Arctostaphylos viscida are transitional to montane forest or woodland types. Some stands persist for over 100 years. Arctostaphylos viscida grows under a wide range of conditions as a result of the species' high ecological plasticity. Three subspecies are recognized in the Jepson Manual (ssp. mariposa, ssp. pulchella, and ssp. viscida), and hybrids with A. canescens and A. patula are known. Arctostaphylos viscida ssp. mariposa grows in the central and southern Sierra Nevada; A. viscida ssp. pulchella grows in the Klamath Mountains and North Coast Ranges; and A. viscida ssp. viscida grows in the Cascades, Klamath Mountains, and Sierra Nevada. Arctostaphylos viscida ssp. pulchella regularly forms stands on serpentine substrates in Colusa, Glenn, Mendocino, Napa, and Tehama Counties. Alexander et al. (2007) recognized Arctostaphylos viscida ssp. pulchella as a separate alliance endemic to serpentine. However, sampling has been minimal in the range of the species and all forms of A. viscida are included in this alliance at this time.

Sonoma County

This class is heavily concentrated north and east of the Austin Creek State Recreational Area and restricted to xeric serpentine sites. When found in association with North Coast Range endemic manzanita species, such as Arctostaphylos bakeri or A. stanfordiana, it appears in the more xeric exposures.

Most Abundant Species: Arctostaphylos viscida ssp. pulchella, Arctostaphylos viscida

Distribution / Location:

This map class was uncommon in Sonoma County and occurred on serpentine substrates on dry sites in interior parts of the county.

Acres mapped countywide:	521	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:	6	Producer's Accuracy:	33%

Map Class: Baccharis pilularis Alliance

Common Name: Coyotebrush Alliance



Ground View



Aerial View

NVC Association(s): Baccharis pilularis – Frangula californica – Rubus spp. Provisional Assoc., Baccharis pilularis – Toxicodendron diversilobum Assoc., Baccharis pilularis / Annual Grass – Herb Assoc., Baccharis pilularis / Danthonia californica Assoc., Baccharis pilularis / Deschampsia cespitosa Assoc., Baccharis pilularis / Nassella pulchra Assoc., Baccharis pilularis / Native Grass (Mixed) Assoc.

Description:

Statewide (Sawyer et al. 2009)

In this map class, Baccharis pilularis is dominant or co-dominant in the shrub canopy with Artemisia californica, Ceanothus thyrsiflorus, Corylus cornuta, Diplacus aurantiacus, Eriogonum fasciculatum, Eriophyllum staechadifolium, Frangula californica, Garrya elliptica, Gaultheria shallon, Holodiscus discolor, Lotus scoparius, Lupinus arboreus, Morella californica, Rubus ursinus, Salvia apiana, Salvia leucophylla, and Toxicodendron diversilobum. Emergent trees may be present at low cover, including Pinus muricata, Pseudotsuga menziesii, Quercus agrifolia, or Umbellularia californica.

Stands can be transitory to forest and woodland types or persistent for a long time (Heady et al. 1977). Seedlings of Baccharis pilularis invade grasslands in the central coast, forming stands when grazing and fire decrease (McBride and Heady 1968). Older, shady stands are transitional to forest types with Pinus muricata, Pseudotsuga menziesii, Quercus agrifolia, and Umbellularia californica (Grams et al. 1977, McBride 1974). Baccharis pilularis invades recently logged land in northern California well away from the coast. B. pilularis also invades coastal dunes stabilized by Ammophila arenaria or Lupinus arboreus (Pickart and Sawyer 1998).

The core of diverse, older stands of Baccharis pilularis lies along the coast from Monterey County to Sonoma County. For example, Borchert et al. (2004) identify a Baccharis pilularis Alliance in the northern Santa Lucia Range, where they sampled mid- to late-seral stands (with >25 years since fire).

Sonoma County

The Baccharis pilularis Alliance has several associations. Mixed shrub stands in the vicinity of the coast are floristically and structurally diverse. These stands persist for relatively long periods of time, especially on headlands and coastal bluffs. Coastal stands with a native grass understory are common along coastal bluffs and represent woody succession on former native coastal prairie sites.

Most Abundant Species: Baccharis pilularis, Toxicodendron diversilobum

Distribution / Location:

This class occurs throughout the county but is most common on coastal bluffs on the southern Sonoma coast between Bodega Bay and Fort Ross.

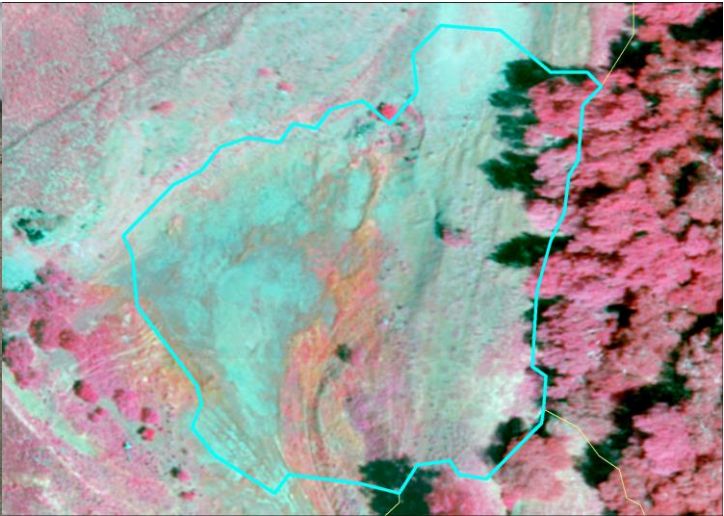
Acres mapped countywide:	9,295	Global/State Rarity Rank:	G5/S5
Accuracy Assessment Map Sites:	29	User's Accuracy:	86%
Accuracy Assessment Reference Sites:	28	Producer's Accuracy:	89%

Map Class: Barren & Sparsely Vegetated

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

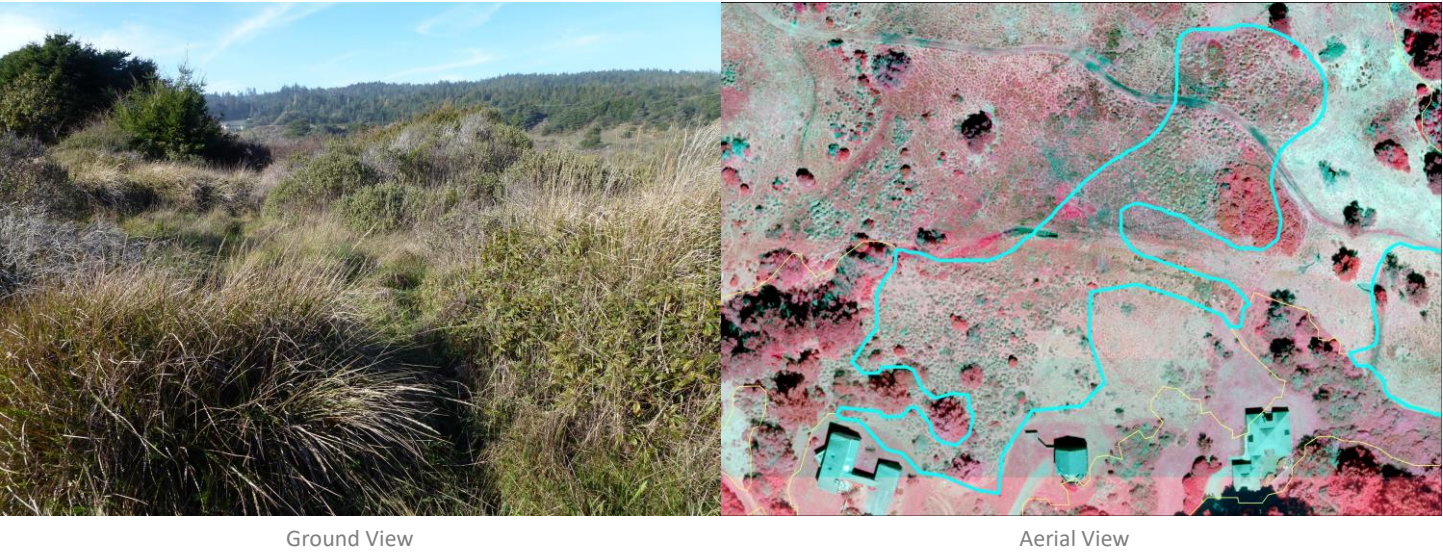
In this map class, vegetation is sparse. This class primarily is composed of bare earth, sand, or rock. It occurs as gravel bars along waterways, as beaches on the coast, and as rocky and cliffy areas.

Most Abundant Species: NA

Distribution / Location:

This map class mostly consists of sandy or rocky areas adjacent to main water bodies such as the Pacific Ocean, Russian River, and Lake Sonoma. A large portion of Sonoma coast is barren due to the prominence of sandy beaches or rocky shorelines.

Acres mapped countywide:	4,971	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	32	User's Accuracy:	90%
Accuracy Assessment Reference Sites:	30	Producer's Accuracy:	93%



NVC Association(s):

Calamagrostis nutkaensis / Baccharis pilularis Association

Description:

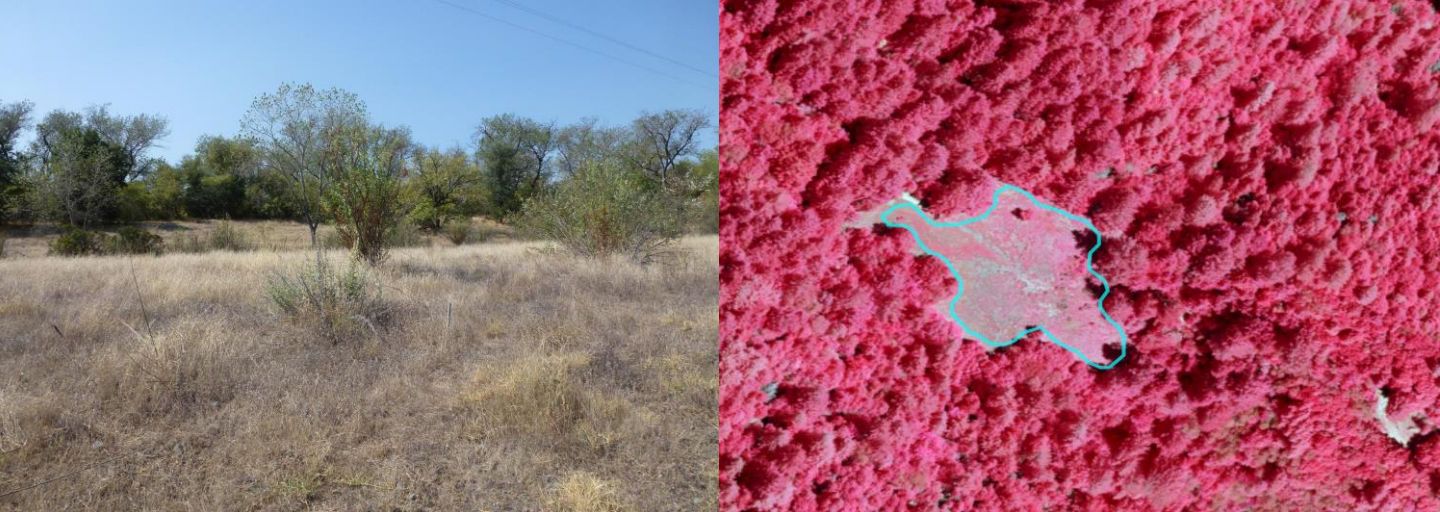
Statewide (Sawyer et al. 2009)
Calamagrostis nutkaensis is dominant or co-dominant in the herbaceous layer with Anthoxanthum odoratum, Artemisia suksdorfii, Elymus glaucus, Festuca arundinacea, Festuca rubra, Heracleum maximum, Holcus lanatus, and Pteridium aquilinum. Emergent trees and shrubs may be present at low cover, including Picea sitchensis, Baccharis pilularis, Gaultheria shallon, Rubus spp., or Vaccinium ovatum. Often considered part of the coastal prairie (Bartolome 1994, Hektner and Foin 1977), the alliance occupies the coastal terraces and mixes with the Danthonia californica and Deschampsia cespitosa Alliances at a fine scale. The alliance also occurs in freshwater swales, depressions, and springs, mixed with other wetland herbaceous types. It forms tall grasslands on moist coastal bluffs at the southern extent of its range. On the broad scale, Calamagrostis nutkaensis stands mix with forested stands of the Alnus rubra and Picea sitchensis Alliances, and shrublands of the Baccharis pilularis, Lupinus arboreus, Salix hookeriana, and Rubus spp. Alliances.

Sonoma County
All Calamagrostis nutkaensis stands sampled in the county occur within 1 km of the coast and are typically on exposed coastal terraces. In some cases, such as at Ft. Ross State Park, stands have colonized formerly cultivated or mowed fields. The Calamagrostis nutkaensis individuals are usually taller than the associated Baccharis pilularis shrubs and concentrate fog drip, thus enhancing their local moisture conditions through condensation. In some instances, Calamagrostis nutkaensis stands occur as mesic openings surrounded by Pinus muricata forest. In such conditions the co-dominant species may be the locally restricted Veratrum fimbriatum (fringed corn-lily), which is listed as a California rare plant with a rank of 4.3.

Most Abundant Species: Calamagrostis nutkaensis, Veratrum fimbriatum

Distribution / Location:
In Sonoma County, this class occurs within 1 km of the coast typically on exposed coastal terraces. In some cases, such as at Ft. Ross State Park, stands have colonized formerly cultivated or mowed fields.

Acres mapped countywide:	109	Global/State Rarity Rank:	G4/S2
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed



Ground View

Aerial View

NVC Association(s): California Annual Herb/Grass Group, California Perennial Grasslands Group

Description:

In this map class, native and non-native grasslands occur in dry to seasonally moist settings in the interior areas east of the coastal grasslands. The map class includes vegetation characterized by, but not limited to, *Avena*, *Brassica*, *Bromus*, *Centaurea*, *Cynosurus*, *Elymus glaucus*, *Eschscholzia*, *Lasthenia californica*, *Lolium*, *Nassella*, *Melica*, *Plantago erecta*, *Pteridium aquilinum*, *Vulpia microstachys*, and *Plagiobothrys nothofulvus*.

Most Abundant Species: *Multiple herbaceous species*

Distribution / Location:

This map class occurs widely throughout Sonoma County.

Acres mapped countywide:	236,947	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	3	User's Accuracy:	67%
Accuracy Assessment Reference Sites:	1	Producer's Accuracy:	50%

Map Class:

California Coastal Evergreen Bluff and Dune Scrub Group

Common Name:

NA



Ground View

Aerial View

NVC Association(s):

Lupinus arboreus Alliance, Lupinus chamissonis - Ericameria ericoides Alliance

Description:

In this map class, *Ericameria ericoides*, *Lupinus arboreus*, and/or *L. chamissonis* dominate or co-dominate the shrub canopy. *Baccharis pilularis* may also co-dominate. These stands tend to have an understory dominated by non-native grasses such as *Bromus diandrus*, which presumably benefit from the nitrogenous build up beneath these nitrogen-fixing shrubs. Stands commonly occur adjacent to *Baccharis pilularis* shrubland, and native and non-native perennial coastal grasslands.

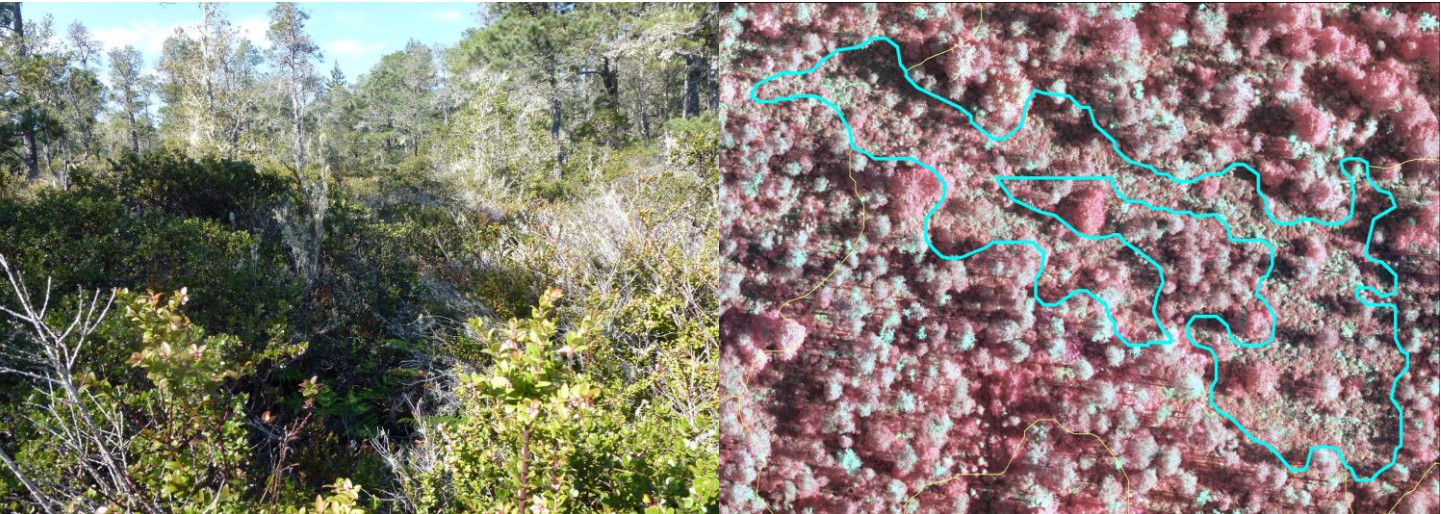
Most Abundant Species:

Ericameria ericoides, *Lupinus arboreus*, *L. chamissonis*

Distribution / Location:

Stands are found on coastal dunes and bluffs and are limited to salty, rocky, or sandy settings immediately adjacent to the open coast.

Acres mapped countywide:	604	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:	11	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	13	Producer's Accuracy:	85%



Ground View

Aerial View

NVC Association(s): Arctostaphylos (nummularia, sensitiva) Alliance

Description:

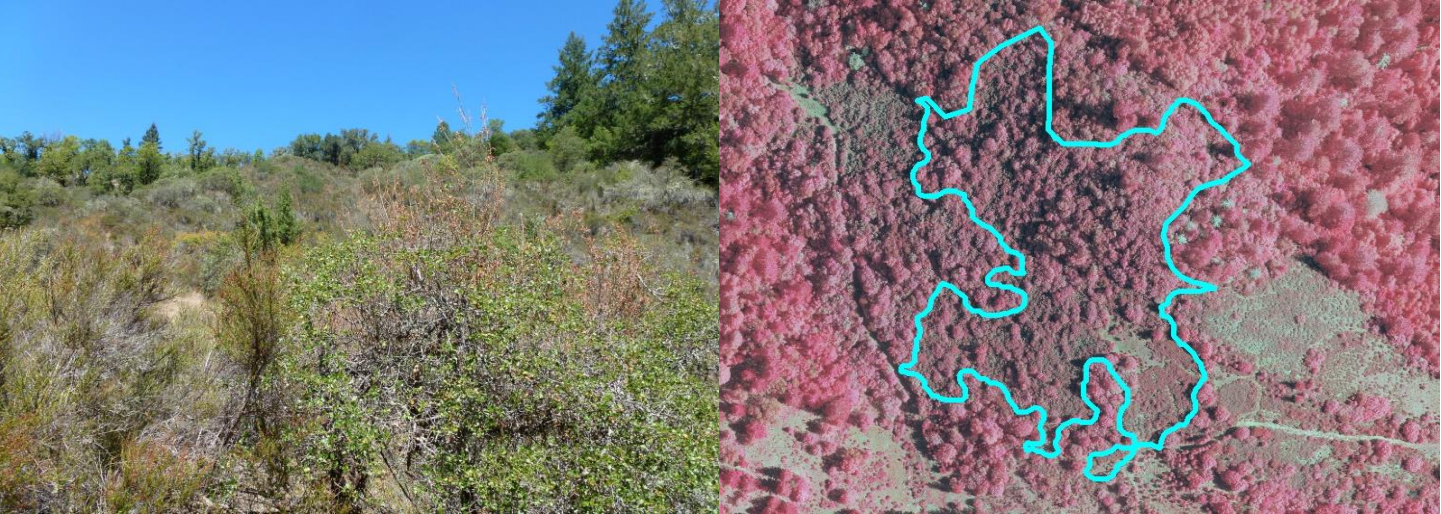
In this map class, shrub canopy is dominated by *Arctostaphylos nummularia* ssp. *nummularia*. *Gaultheria shallon* and/or *Vaccinium ovatum* may co-dominate. *Arctostaphylos columbiana*, *Chrysolepis chrysophylla* var. *minor*, *Pinus muricata*, and *Pteridium aquilinum* are often present in these coastal shrublands. Stands of the *Arctostaphylos (nummularia, sensitiva)* Alliance are only known from Gualala Ridge and are associated with very old oligotrophic marine terrace soils that also support *Pinus muricata* stands. Bishop pine and glossy-leaf manzanita are ecologically related in this area. *Arctostaphylos nummularia* stands may persist for many decades, or re-establish from seed banks, following the senescence and death of overstory *Pinus muricata*. In adjacent southern Mendocino County near Gualala, examples of the *Arctostaphylos nummularia* ssp. *nummularia* Association may occur adjacent to *Hesperocyparis pygmaea* stands.

Most Abundant Species: *Arctostaphylos nummularia* ssp. *Nummularia*, *Gaultheria shallon*, *Vaccinium ovatum*

Distribution / Location:

This uncommon, habitat-specific class is limited to a few areas oligotrphic marine terrace soils just east of the Sonoma Coast. The best-developed occurrences of this map class are found at Salt Point State Park.

Acres mapped countywide:	70	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed



Ground View

Aerial View

NVC Association(s):

Cercocarpus montanus Alliance, Quercus berberidifolia Alliance, Quercus berberidifolia - Adenostoma fasciculatum Alliance

Description:

In this map class, shrub canopy is dominated or co-dominated by *Cercocarpus montanus* and/or *Quercus berberidifolia*. *Adenostoma fasciculatum* may also be present as a co-dominant. *Diplacus aurantiacus* and *Toxicodendron diversilobum* are often present.

Most Abundant Species: *Cercocarpus montanus*, *Quercus berberidifolia*, *Adenostoma fasciculatum*

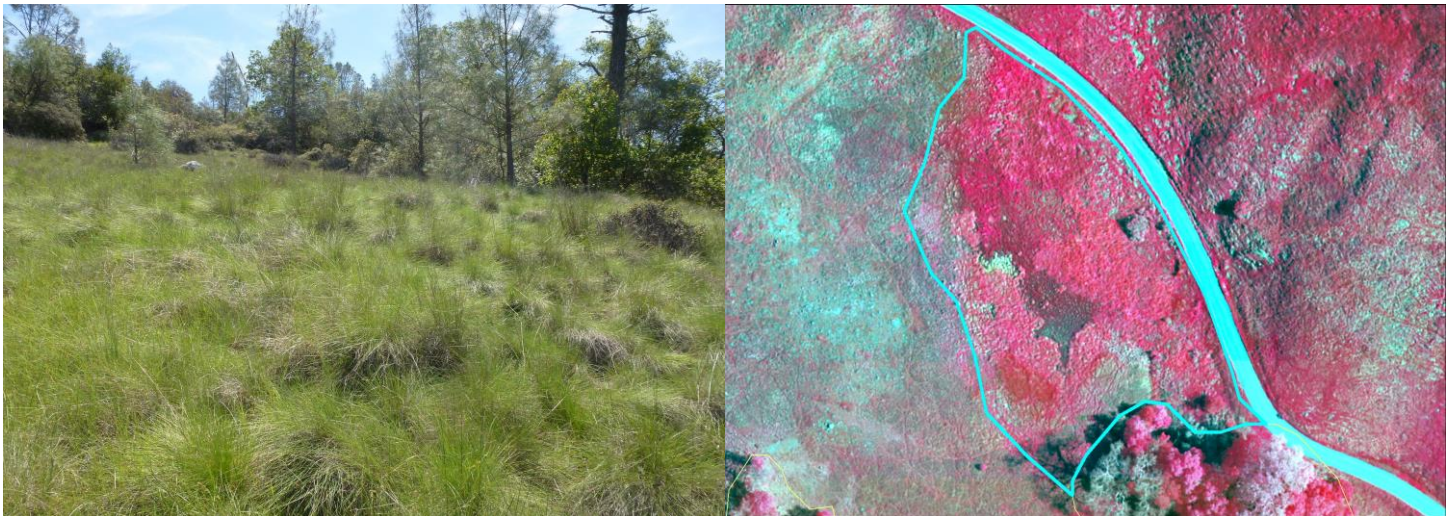
Distribution / Location:

This class was mapped at mid-high elevations of the Mayacamas, in southeastern and south-central Sonoma County.

Acres mapped countywide:	1,312	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:	9	User's Accuracy:	56%
Accuracy Assessment Reference Sites:	5	Producer's Accuracy:	80%

Map Class: Carex serratodens Provisional Alliance

Common Name: Bifed Sedge Provisional Alliance



Ground View

Aerial View

NVC Association(s): Carex serratodens Provisional Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Carex serratodens is dominant or co-dominant in the herbaceous layer with Achillea millefolium, Asclepias fascicularis, Deschampsia danthonioides, Hordeum brachyantherum, Juncus arcticus, Juncus bufonius, Juncus occidentalis, Lotus purshianus, Mimulus guttatus, and Sisyrinchium bellum. Emergent shrubs may be present at low cover, including Baccharis pilularis or Frangula californica.

Carex serratodens stands appear on wet-to-moist serpentine substrates (Alexander et al. 2007). They occur in gently sloping seeps, broad meadows, and narrow riparian stringers with a mixture of serpentinetolerant species, including endemics.

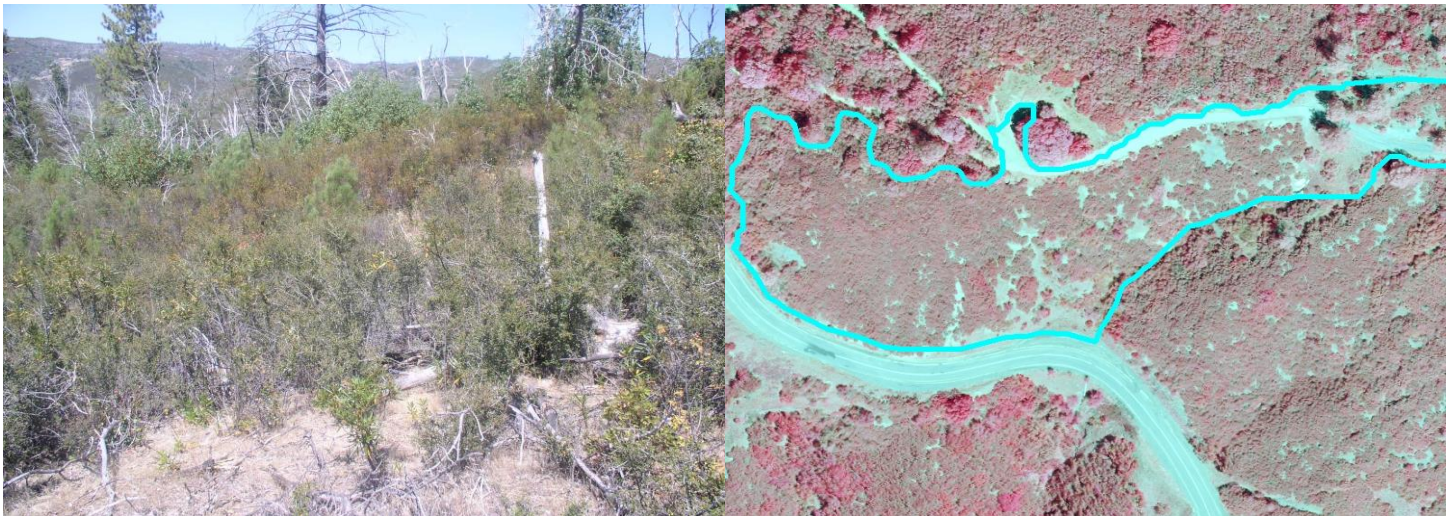
Sonoma County
All stands sampled in the county occur on ultramafic (serpentine) substrates and either exist on seeps, springs, or slump ponds associated with landslides. Depending upon the size of the stand, adjacent vegetation may be other wetland or meadow alliances such as Juncus (effusus, patens) or Carex (pansa, praegracilis), or serpentine-tolerant upland grassland or herbaceous types such as Nassella spp. – Melica spp., Lasthenia californica – Plantago erecta – Vulpia microstachys, or Festuca idahoensis.

Most Abundant Species: Carex serratodens

Distribution / Location:

This class is uncommon in Sonoma County and difficult to discern on imagery. It was mapped where it was observed in the field in interior, northern Sonoma County.

Acres mapped countywide:	3	Global/State Rarity Rank:	G3/S3
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed



Ground View

Aerial View

NVC Association(s): Ceanothus cuneatus – Adenostoma fasciculatum Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Ceanothus cuneatus is dominant or co-dominant in the shrub canopy with Adenostoma fasciculatum, Arctostaphylos glauca, Arctostaphylos manzanita, Arctostaphylos patula, Arctostaphylos tomentosa, Ceanothus integerrimus, Cercocarpus montanus, Eriogonum fasciculatum, Garrya fremontii, Hesperoyucca whipplei, Heteromeles arbutifolia, Quercus berberidifolia, Quercus john-tuckeri, Rhus ovata, and Salvia mellifera. Emergent trees may be present at low cover, including Calocedrus decurrens, Juniperus californica, Pinus jeffreyi, Pinus ponderosa, Pinus sabiniana, Quercus douglasii, or Quercus wislizeni.

Ceanothus cuneatus occurs as an understory shrub in various forest and woodland types in northern California, and it is present as a secondary species in many chaparral alliances in southern California. Self-perpetuating stands are typically restricted to rocky, harsh exposures or substrates. Many stands establish after fire and they form an important part of the chaparral in northern and central California. Ceanothus cuneatus stands are often dense, with interlocking crowns that may contain abundant deadwood. Ceanothus cuneatus may also form open stands with much bare ground.

Mixed stands with co-dominant Adenostoma fasciculatum are common in the central coast and inner North Coast Ranges, and occur more sporadically in the Sierra Nevada and in southern California. These mixed stands occur on a variety of exposures along steep lower to upper slopes. Substrates are usually sedimentary and metamorphic. Because of ecological overlap between mixed and pure Ceanothus cuneatus stands, the former practice of segregating them into separate series or alliances has been discontinued. There are five varieties of Ceanothus cuneatus (Fross and Wilken 2006).

Sonoma County

A single widespread association (Ceanothus cuneatus – Adenostoma fasciculatum) is represented in all stands sampled. All Ceanothus cuneatus stands are associated with relatively large, mappable patches of chaparral, both on and off serpentine soils.

Most Abundant Species: Ceanothus cuneatus, Adenostoma fasciculatum

Distribution / Location:

This class occurs throughout the Mayacamas in northeastern Sonoma County, with notably large stands just east of Black Mountain. Mapped occurrences in Sonoma County are typically above 1,500 feet in elevation.

Acres mapped countywide:	1,576	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	13	User's Accuracy:	77%
Accuracy Assessment Reference Sites:	20	Producer's Accuracy:	70%

Map Class: Ceanothus oliganthus Alliance

Common Name: Hairy Ceanothus Alliance



Ground View

Aerial View

NVC Association(s): Ceanothus oliganthus Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Ceanothus oliganthus is dominant or co-dominant in the shrub canopy with Adenostoma fasciculatum, Adenostoma sparsifolium, Arctostaphylos glandulosa, Ceanothus megacarpus, Ceanothus tomentosus, Heteromeles arbutifolia, Quercus berberidifolia, Rhus ovata, Salvia mellifera, Toxicodendron diversilobum, and Xylococcus bicolor. Emergent trees may be present at low cover, including Calocedrus decurrens, Juglans californica, Pseudotsuga macrocarpa, Quercus agrifolia, Quercus chrysolepis, Quercus wislizeni, or Umbellularia californica.

Stands of Ceanothus oliganthus tend to occur as small, localized patches after recent fire disturbance, and they senesce after about 30-40 years. These stands occur on northerly slopes or adjacent to riparian areas in southern California, and they occur on a wide range of slopes and exposures in central California.

Sonoma County

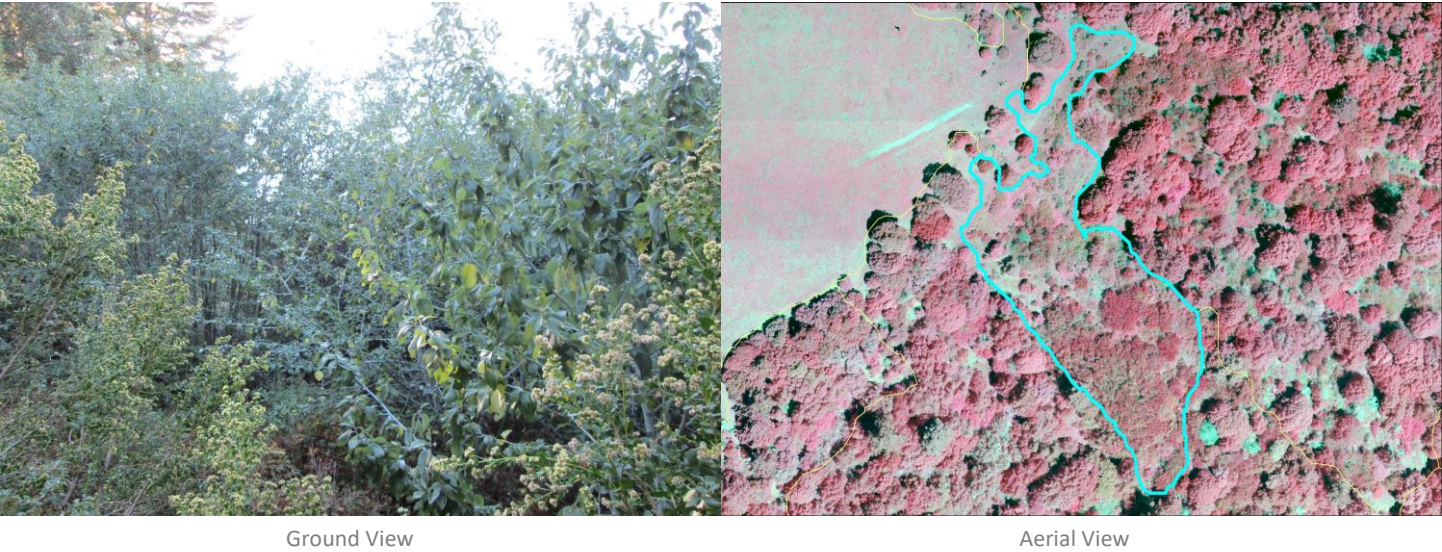
Although Ceanothus oliganthus is a common shrub in post-fire chaparral in other parts of the county (e.g., The Geysers), only one stand was sampled meeting the definition of the alliance. That stand was very small and was associated with an old cleared site adjacent to a dirt road. Following recent fires it is possible that more Ceanothus oliganthus stands will be identified in Sonoma County.

Most Abundant Species: Ceanothus oliganthus

Distribution / Location:

Ceanothus oliganthus occurs in a few small stands in the Mayacamas in northeastern Sonoma County.

Acres mapped countywide:	180	Global/State Rarity Rank:	G3/S3
Accuracy Assessment Map Sites:	5	User's Accuracy:	60%
Accuracy Assessment Reference Sites:	5	Producer's Accuracy:	40%



NVC Association(s): Ceanothus incanus Provisional Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, *Ceanothus thyrsiflorus* is dominant or co-dominant in the shrub canopy with *Adenostoma fasciculatum*, *Arctostaphylos manzanita*, *Baccharis pilularis*, *Ceanothus incanus*, *Ceanothus integerrimus*, *Ceanothus velutinus*, *Gaultheria shallon*, *Heteromeles arbutifolia*, *Lupinus arboreus*, *Quercus berberidifolia*, *Rubus ursinus*, *Toxicodendron diversilobum*, and *Vaccinium ovatum*. Emergent conifer trees may be present at low cover.

The most extensive *Ceanothus thyrsiflorus* stands establish after logging or burning in the outer Coast Ranges of central and northern California. These stands persist for a few decades and are seral to stands of the *Pinus muricata*, *Pseudotsuga menziesii* – *Notholithocarpus densiflorus*, and *Sequoia sempervirens* Alliances. Stands on exposed coastal headlands persist for long periods and are frequently associated with *Baccharis pilularis* and *Lupinus arboreus* Alliance shrublands.

Sonoma County

Stands assigned to the *Ceanothus thyrsiflorus* Alliance are small and uncommon in Sonoma County. Those sampled are associated with small openings due to logging or clearing in forests of the *Pseudotsuga menziesii* – *Notholithocarpus densiflorus* Alliance. All of the sampled stands are less than an acre in size and they may best be considered a seral community within recent clearings of Douglas-fir or related forests. All three sampled stands are dominated by *Ceanothus incanus*, a large shrub ecologically and taxonomically related to *Ceanothus thyrsiflorus*. Until further sampling takes place, the physical and ecological similarity of *Ceanothus incanus* to *C. thyrsiflorus* justifies the temporary placement of these three stands into the *Ceanothus thyrsiflorus* Alliance. Individuals of *Ceanothus thyrsiflorus* do occur in Sonoma County, particularly close to the coast. However, no stands of *C. thyrsiflorus* have been observed or sampled in Sonoma County to date.

Most Abundant Species: Ceanothus incanus

Distribution / Location:

In Sonoma County, this class occurs infrequently in small stands. The map class occurs in the northwestern part of the county, in clearings or logged areas amidst conifer or mixed conifer-hardwood forests.

Acres mapped countywide:	336	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed



Ground View

Aerial View

NVC Association(s): Corylus cornuta/Polystichum munitum

Description:

Corylus cornuta var. californica is dominant in shrub canopy with Holodiscus discolor; Marah fabaceus, Ribes sanguineum, Rubus parviflorus, R. ursinus, Toxicodendron diversilobum, and Vaccinium ovatum. Shrubs < 5m; canopy is continuous. Herbaceous layer is sparse.

Most Abundant Species: Corylus cornuta

Distribution / Location:

This class is limited to a few locations where it was observed in the field just inland from the coast along the Russian River.

Acres mapped countywide:	40	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Developed

Common Name: NA



Ground View

Aerial View

NVC Association(s): NA

Description:

In this map class, area is a manmade developed area greater than 0.2 acres. Areas were considered developed if they contain significant man-made impervious cover or are highly altered by man. Highly altered areas include lawns, heavily landscaped garden and patio areas, bocce courts, tennis courts, sport courts, developed horse riding arenas, baseball fields, soccer fields, swimming pools, and playground areas.

Most Abundant Species: NA

Distribution / Location:

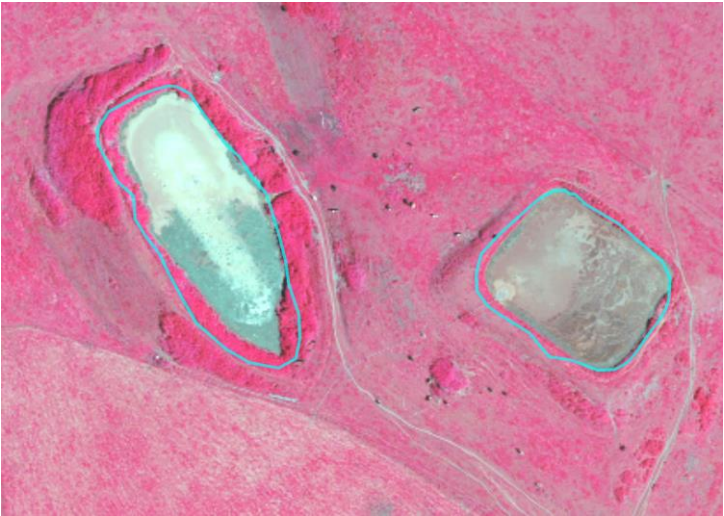
The developed map class occurs throughout Sonoma County but is concentrated in the county's urban and suburban areas.

Acres mapped countywide:	24,527	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	35	User's Accuracy:	97%
Accuracy Assessment Reference Sites:	35	Producer's Accuracy:	97%

Map Class: Dry Stock Pond

Common Name: NA

No Image
Available



Ground View

Aerial View

NVC Association(s): NA

Description:

This map class is a dry stock pond as observed in the fall, 2013 imagery.

Most Abundant Species: NA

Distribution / Location:

Small stock ponds are scattered throughout Sonoma County. The largest concentration of ponds is in the large valley areas of the county, such as the Santa Rosa Plain.

Acres mapped countywide:	145	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Eriodictyon californicum - Lupinus albifrons Alliance

Common Name: Yerba Santa - Silver Lupine Alliance



NVC Association(s): Eriodictyon californicum / Herbaceous Association, Lupinus albifrons Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, the two nominate species of this alliance were given separate alliance status in Sawyer et al. (2009). Recently, the peer review panel of the NVC suggested merging them into a single alliance; the new convention is followed here. Eriodictyon californicum or Lupinus albifrons dominates or co-dominates in the shrub canopy with Adenostoma fasciculatum, Ceanothus cuneatus, Diplacus aurantiacus, Eriogonum fasciculatum, Eriophyllum confertiflorum, Hesperoyucca whipplei, Lotus scoparius, Sambucus nigra, Senecio flaccidus, and Toxicodendron diversilobum. Emergent trees may be present at low cover, including Pinus sabiniana, Quercus douglasii, or Quercus wislizeni.

Lupinus albifrons and Eriodictyon californicum regularly form stands in recently burned chaparral, in grazed or cleared shrublands, or in other disturbed areas. In the Sierra Nevada foothills, these seral stands become invaded by other shrubs or by trees as the stands age, and they transition to Ceanothus cuneatus shrublands or Quercus douglasii or Q. wislizeni woodlands if not disturbed further (Klein et al. 2007). Lupinus albifrons forms stands on stabilized dunes on the Channel Islands of southern California. Although the Lupinus albifrons shrub is relatively short-lived, the stands reestablish from a persistent seed bank. Other stand-forming species of Eriodictyon (E. crassifolium, E. trichocalyx) are currently considered part of this alliance.

Sonoma County
Stands of this alliance fall into two distinct categories: those dominated by Lupinus albifrons and those dominated by Eriodictyon californicum. The five samples of Eriodictyon californicum / Herbaceous Association all occur far inland (more than 30 km from the coast) and are usually adjacent to stands of mature chaparral. The stands dominated by Lupinus albifrons are often surrounded by grassland rather than chaparral, and may occur either close to the coast or far inland.

Most Abundant Species: Eriodictyon californicum, Lupinus albifrons

Distribution / Location:

This uncommon class occurs in interior Sonoma County on dry, disturbed areas and is sometimes associated with serpentine substrates.

Acres mapped countywide:	76	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Eucalyptus (globulus, camaldulensis) Semi-natural Alliance

Common Name: Eucalyptus (Blue Gum, River Red Gum) Semi-natural Alliance



Ground View

Aerial View

NVC Association(s): NA

Description:

Eucalyptus globulus, E. camaldulensis or other gum is dominant in the tree canopy. Eucalyptus was planted and is non-native.

Most Abundant Species: *Eucalyptus globulus*, *Eucalyptus camaldulensis*

Distribution / Location:

This alliance is found throughout Sonoma County. The largest stands are found in the southern part of the county in the Petaluma Gap, where Eucalyptus trees were planted extensively as windbreaks.

Acres mapped countywide:	2,924	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	27	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	26	Producer's Accuracy:	100%

Map Class: Forest Sliver

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

Forest slivers are areas of forest and woodland between 1/2 acre and 1 acre in size that are surrounded by a non-forested map class.

Most Abundant Species: NA

Distribution / Location:

Throughout Sonoma County

Acres mapped countywide:	4,000	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Gaultheria shallon - Rubus (ursinus)
Provisional Alliance

Common Name: Salal - California blackberry Provisional Alliance



NVC Association(s): Gaultheria shallon – Rubus spp. Provisional Association, Rubus ursinus Association

Description:

Statewide
In this map class, the two nominate species of this alliance were segregated from the Rubus spp. Alliance in Sawyer et al. (2009) based on suggestions from the peer review panel of the NVC. The new convention is followed here: Rubus ursinus or Gaultheria shallon dominates solely or co-dominate, forming various mixtures in the shrub canopy with Baccharis pilularis, Garrya elliptica, Gaultheria shallon, Heracleum maximum, Lonicera involucrata, Marah oreganus, Morella californica, Ribes menziesii, Sambucus racemosa, Toxicodendron diversilobum, and Vaccinium ovatum. Emergent trees may be present at low cover, including Picea sitchensis, Pinus muricata, or Pseudotsuga menziesii.

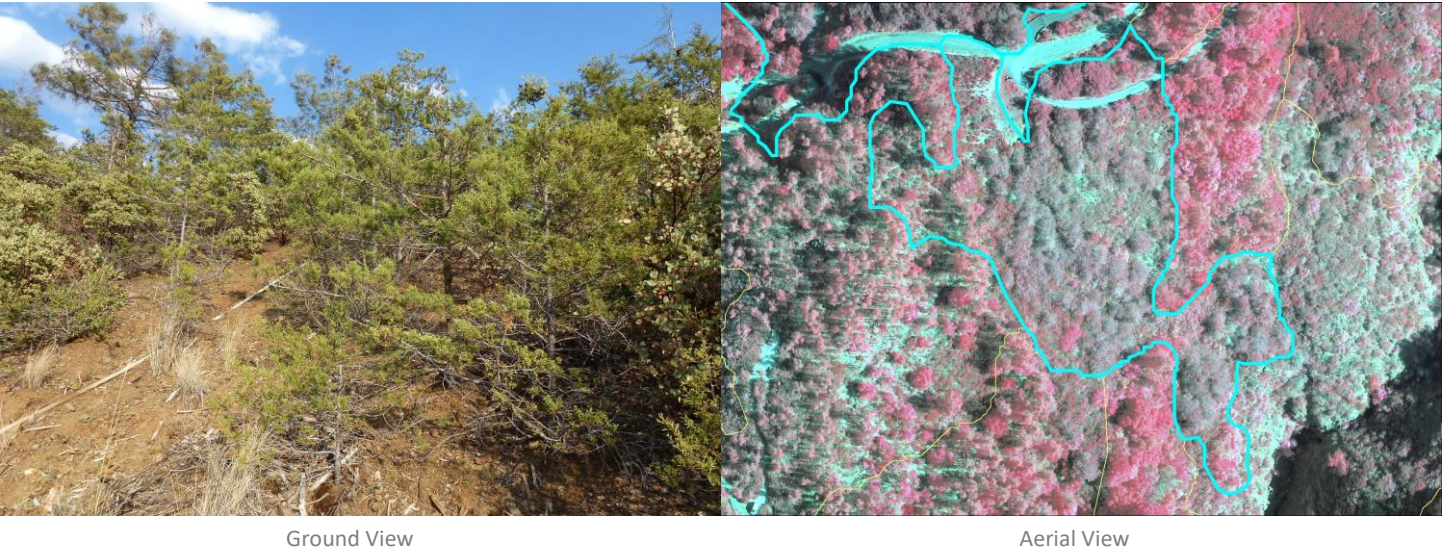
Stands of Rubus ursinus, which were previously thought to be part of a mixed Rubus Alliance (Sawyer et al. 2009), have recently been reconsidered as two different alliances (Morella californica – Rubus spectabilis and Gaultheria shallon – Rubus (ursinus) Provisional Alliances). Rubus ursinus and Gaultheria shallon are both widespread, low, sprawling shrubs found in mesic woodlands and forests in the coastal areas of central and northern California. Both species tend to emerge from forest or woodland cover on exposed coastal bluffs or in coastal grasslands.

Sonoma County
In Sonoma County, two provisional associations have been defined from the plot data. The Gaultheria shallon – Rubus spp. This association is often adjacent to and intermingled with stands of Calamagrostis nutkaensis. The Rubus ursinus Association is often found along old fencelines in coastal pastures or formerly grazed coastal grasslands classified within the Holcus lanatus – Anthoxanthum odoratum Alliance. The Rubus ursinus Association tends to have mixtures of grasses and graminoid species.

Most Abundant Species: Rubus ursinus, Gaultheria shallon, Rubus parviflorus

Distribution / Location:
Mappable stands of this class are limited to a few small coastal patches between Sonoma Coast State Beach and Bodega Bay, with additional occurrences at Forst Ross State Historic Park. The map class occurs more extensively on the landscape, but occurrences are below this project's 1-acre minimum mapping unit.

Acres mapped countywide:	325	Global/State Rarity Rank:	G4/S3
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed



NVC Association(s): Hesperocyparis macnabiana / Arctostaphylos viscida Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Hesperocyparis macnabiana is dominant in the tree canopy with Hesperocyparis sargentii, Pinus attenuata, and Pinus sabiniana. Shrubs may include Arctostaphylos viscida.

This is the most abundant and widespread cypress in the state (Griffin and Critchfield 1972). Several large stands are scattered throughout northern California, mostly on serpentine or volcanic rocks (Alexander et al. 2007, Barbour 2007). The genus Cupressus is now restricted to the Old World; cypresses in California belong to the genus Hesperocyparis (Bartel et al. 2003, Little 2006, Adams et al. 2009, Terry et al. 2012).

Most Abundant Species: Hesperocyparis macnabiana

Distribution / Location:

This class is very uncommon in Sonoma County - it is mapped in a few serpentine locations in the Mayacamas.

Acres mapped countywide:	22	Global/State Rarity Rank:	G3/S3
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Hesperocyparis macrocarpa Semi-Natural Alliance

Common Name: Monterey Cypress Semi-Natural Alliance



Ground View

Aerial View

NVC Association(s): Hesperocyparis macrocarpa Provisional Semi-Natural Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Hesperocyparis macrocarpa, a non-native conifer, is dominant or co-dominant in the tree canopy with Pinus radiata.

Most Abundant Species: Hesperocyparis macrocarpa

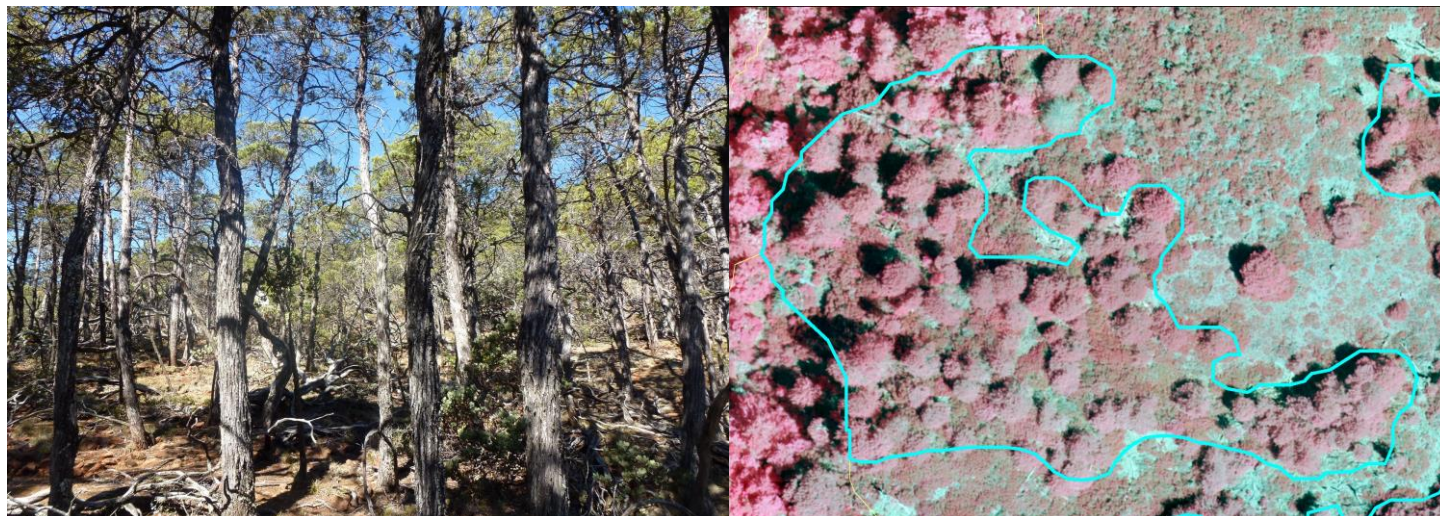
Distribution / Location:

This class is located along portions of Sonoma coast where it has been planted along roads and near structures as windbreaks.

Acres mapped countywide:	522	Global/State Rarity Rank:	G1/S1
Accuracy Assessment Map Sites:	2	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	2	Producer's Accuracy:	100%

Map Class: Hesperocyparis sargentii Alliance

Common Name: Sargent's Cypress Alliance



Ground View

Aerial View

NVC Association(s): Hesperocyparis sargentii / Ceanothus jepsonii – Arctostaphylos spp. Provisional Association, Hesperocyparis sargentii / Quercus durata (Mesic) Provisional Association, Hesperocyparis sargentii Riparian Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Hesperocyparis sargentii is dominant in the tree canopy with Hesperocyparis macnabiana, Pinus attenuata, Pinus sabiniana, Pseudotsuga menziesii, Quercus wislizeni, and Umbellularia californica.

Hesperocyparis sargentii is an abundant and widespread cypress with two centers of distribution. The northern stands, centered in the San Francisco Bay area and southern North Coast Ranges, may contain H. macnabiana and species of Arctostaphylos. Hesperocyparis macnabiana tends to grow on upper slopes, and H. sargentii often grows on lower slopes and in ravines. The upland stands of H. sargentii in the North Coast Ranges are associated with shallow water tables or impeded drainage (Alexander et al. 2007). The southern stands, centered in the Santa Lucia Mountains, are more purely Hesperocyparis sargentii. There are genetic differences between the two centers (Bartel et al. 2003).

Most Abundant Species: *Hesperocyparis sargentii*

Distribution / Location:

In Sonoma County, this class forms extensive stands at The Cedars. There are also significant occurrences throughout the Mayacamas and in western Sonoma County near Occidental.

Acres mapped countywide:	6,833	Global/State Rarity Rank:	G3/S3
Accuracy Assessment Map Sites:	11	User's Accuracy:	82%
Accuracy Assessment Reference Sites:	10	Producer's Accuracy:	90%

Map Class: Intensively Managed Hayfield

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

In this map class, area is an intensively managed hayfield that is mechanically turned over every year.

Most Abundant Species: NA

Distribution / Location:

This class occurs in the southern part of Sonoma County with very large occurrences adjacent to San Pablo Bay. This class also occurs just east of Rohnert Park and near Petaluma.

Acres mapped countywide:	16,302	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	35	User's Accuracy:	83%
Accuracy Assessment Reference Sites:	30	Producer's Accuracy:	97%

Map Class: Irrigated Pasture

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

In this map class, area is an irrigated pasture that appears green in the fall, 2013 imagery.

Most Abundant Species: NA

Distribution / Location:

Irrigated pasture occurs throughout the county, but the preponderance of the map class occurs in the Santa Rosa Plain, around Petaluma, and in the Petaluma gap.

Acres mapped countywide:	3,125	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	26	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	30	Producer's Accuracy:	87%



NVC Association(s): Juncus arcticus (var. balticus, mexicanus) Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Juncus arcticus var. balticus or Juncus arcticus var. mexicanus is dominant or co-dominant in the herbaceous layer with Achillea millefolium, Argentina egedii, Bolboschoenus robustus, Bromus diandrus, Carex spp., Conium maculatum, Deschampsia cespitosa, Distichlis spicata, Eleocharis acicularis, Geum macrophyllum, Iris missouriensis, Juncus effusus, Juncus phaeocephalus, Lepidium latifolium, Leymus cinereus, Poa pratensis, Ranunculus alismifolius, Schoenoplectus pungens, Sporobolus airoides, Taraxacum officinale, and Trifolium longipes. Emergent trees and shrubs may be present at low cover.

Botanists have treated the circumboreal Juncus arcticus (var. balticus, mexicanus) complex in a plethora of ways. The online Jepson Interchange (2015) uses Juncus balticus ssp. ater and J. mexicanus for these two varieties, while the PLANTS Database (USDA-NRCS 2015) uses the name J. arcticus ssp. Littoralis for var. balticus, and J. mexicanus is given species rank. We follow the Flora of North America treatment (Brooks and Clements 2000) that recognizes Juncus arcticus with four varieties, of which two (balticus and mexicanus) occur in California.

Sonoma County
Compared to the Juncus (effusus, patens) Alliance, stands of Juncus arcticus (var. balticus, mexicanus) are generally found in locations that are more regularly moist during the growing season. However they may occur adjacent to stands of the J. (effusus, patens) Alliance.

Most Abundant Species: Juncus arcticus

Distribution / Location:
This class was mapped in a few locations where it was observed in the field. The three mapped stands were wet areas adjacent to seeps, ponds, or riparian bottomlands.

Acres mapped countywide:	10	Global/State Rarity Rank:	G5/S4
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Major Roads

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

In this map class, area is a major road. Major paved road polygons (highways and some major arterial roads) were included in the vegetation map, but minor paved roads and dirt roads were not included. Tukman Geospatial worked with the Sonoma Ag + Open Space to determine exactly which roads and what type of roads to include.

Most Abundant Species: NA

Distribution / Location:

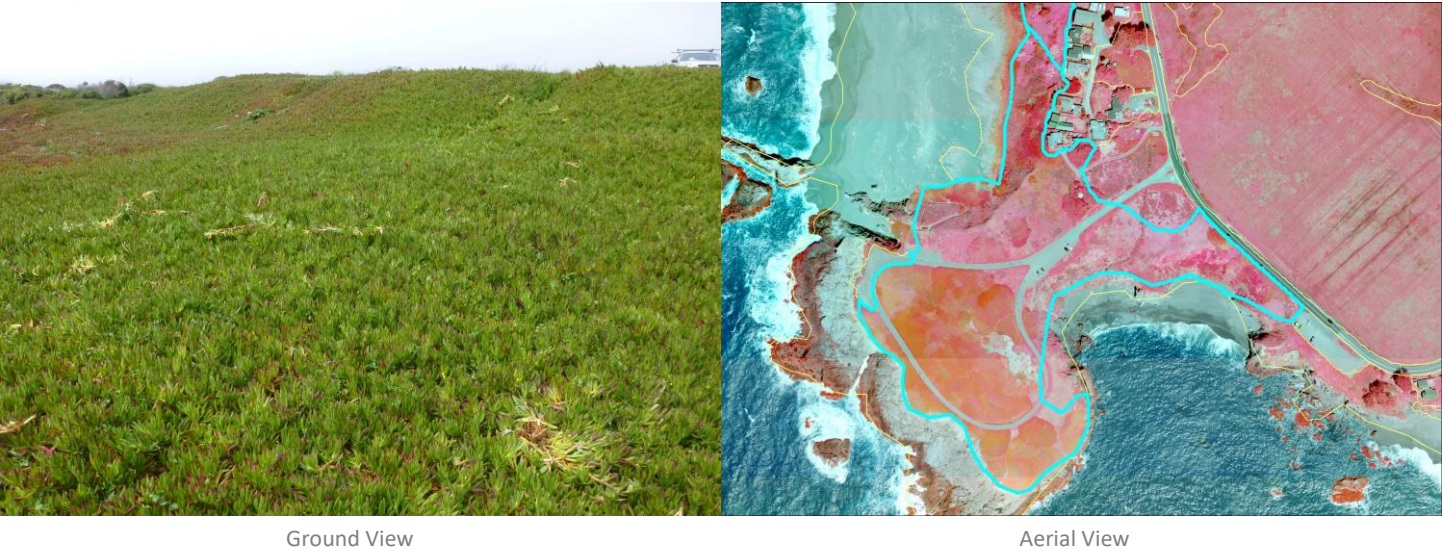
Throughout Sonoma County.

Acres mapped countywide:	3,404	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Mesembryanthemum spp. - Carpobrotus spp.

Common Name: Iceplant

Provisional Alliance



NVC Association(s):

Carpobrotus (edulis) Provisional Semi-Natural Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Carpobrotus chilensis, C. edulis, Mesembryanthemum, or other ice plant taxa are dominant in the herbaceous layer. At least eight invasive ice plant taxa grow in California: Aptenia cordifolia, Carpobrotus edulis, C. chilensis, Conicosia pugioniformis, Drosanthemum floribundum, Malephora crocea, Mesembryanthemum crystallinum, and M. nodiflorum.

Carpobrotus edulis is a ground-hugging succulent perennial that forms impenetrable mats covering large areas. This ice plant has been widely planted for soil stabilization and landscaping. The success of C. edulis is due particularly to its tolerance of a wide range of soil moisture and nutrient conditions, and to its dispersal by mammals (D’Antonio 1993). This species is often confused with C. chilensis, a smaller, less aggressive ice plant with magenta flowers. The two species hybridize, and the hybrids are invasive as well.

Aptenia cordifolia grows in disturbed places and on the margins of coastal wetlands (Kitz 2000a). Conicosia pugioniformis, a short-lived succulent, has narrow leaves and does not form clonal mats. It is most abundant in open patches on dunes and in recently disturbed areas (Albert and D’Antonio 2000). The uncommon Drosanthemum floribundum is a mat-forming shrub. Malephora crocea is a prostrate shrub with linear leaves, common in coastal southern California (DiTomaso and Healy 2007). Mesembryanthemum crystallinum and M. nodiflorum invade coastal bluffs and interior alkaline wetlands in southern California (Randall 2000).

Most Abundant Species:

Carpobrotus

Distribution / Location:

In Sonoma County, this class is located in mats of Carpobrotus edulis or C. chilensis scattered along coastal bluffs along the coast.

Acres mapped countywide:	163	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed



Ground View

Aerial View

NVC Association(s):

Western Cordilleran Montane-Boreal Mesic Wet Meadow Group, Vancouverian and Rocky Mountain Naturalized Perennial Grassland Group, Western Cordilleran Montane Moist Graminoid Meadow Group, Vancouverian Coastal Grassland Group

Description:

In this map class, native and non-native coastal grasslands are dominated or co-dominated by *Agrostis gigantea*, *A. stolonifera*, *Calamagrostis nutkaensis*, *Deschampsia cespitosa*, *Danthonia californica*, *Eryngium armatum*, *Festuca arundinacea*, *Holcus lanatus*, *Hordeum brachyantherum*, *Nassella pulchra*, and/or *Phalaris aquatica*. Mapping of this herbaceous lifeform occurred within a “coastal grasslands mask,” created using Sonoma County's coastal grasslands map and ancillary GIS layers.

Most Abundant Species: *Multiple herbaceous species*

Distribution / Location:

This map class is located along the entire Sonoma coast.

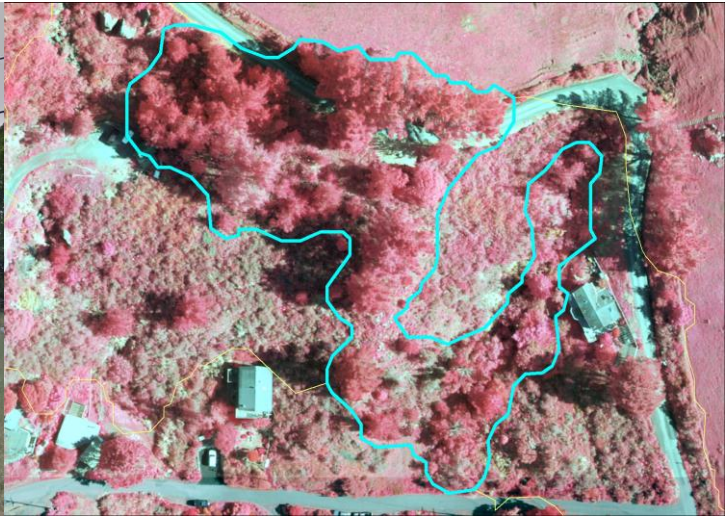
Acres mapped countywide:	25,195	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	2	User's Accuracy:	0%
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Non-native Forest & Woodland

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

In this map class, non-native forest is defined as stands dominated by non-native, ornamental, or landscaping trees. Common non-native trees in Sonoma County include Eucalyptus, Pinus radiata, and Hesperocyparis macrocarpa. These three species are mapped to their respective alliances in the vegetation map; other non-native and ornamental genera are mapped to this generic non-native tree class.

Most Abundant Species: Several non-native tree species

Distribution / Location:

Though it occurs throughout the county, this class is often occurs in suburban and exurban areas.

Acres mapped countywide:	5,269	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	35	User's Accuracy:	94%
Accuracy Assessment Reference Sites:	35	Producer's Accuracy:	94%

Map Class: Non-native Shrub

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

In this map class, stands are dominated by non-native, ornamental, or landscaping shrubs.

Most Abundant Species: *Several non-native shrub species*

Distribution / Location:

This class occurs in small patches throughout the county in suburban and exurban settings.

Acres mapped countywide:	1,166	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	14	User's Accuracy:	64%
Accuracy Assessment Reference Sites:	9	Producer's Accuracy:	100%

Map Class:

North American Pacific Coastal Salt Marsh Macrogroup

Common Name:

NA



NVC Association(s):

NA

Description:

In this map class, areas are dominated or co-dominated by *Bolboschoenus* spp., *Distichlis* spp., *Sarcocornia* spp., and/or *Spartina* spp. Salt marsh areas for San Pablo Bay adapted from SFEI's Bay Area Aquatic Resource Inventory (BAARI) Basemap.

Most Abundant Species: *Bolboschoenus* spp., *Distichlis* spp., *Sarcocornia* spp.

Distribution / Location:

This class is limited to the tidal salt marshes adjacent to Bodega Bay and San Pablo Bay.

Acres mapped countywide:	7,985	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	29	User's Accuracy:	97%
Accuracy Assessment Reference Sites:	27	Producer's Accuracy:	100%

Map Class: Notholithocarpus densiflorus Alliance

Common Name: Tanoak Alliance



Ground View

Aerial View

NVC Association(s): Notholithocarpus densiflorus – Arbutus menziesii Association, Notholithocarpus densiflorus Provisional Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Notholithocarpus densiflorus is dominant or co-dominant in the tree canopy with Acer macrophyllum, Alnus rubra, Arbutus menziesii, Calocedrus decurrens, Chamaecyparis lawsoniana, Chrysolepis chrysophylla, Cornus nuttallii, Pinus coulteri, Pinus lambertiana, Pseudotsuga menziesii, Quercus agrifolia, Quercus chrysolepis, Quercus kelloggii, Sequoia sempervirens, Torreya californica, Tsuga heterophylla, and Umbellularia californica.

Stands of this alliance and others that contain N. densiflorus are often referred to as mixed evergreen forest (Sawyer 2006, 2007), but Bingham’s (1999) study found that stands dominated by N. densiflorus differed significantly in species composition and environmental conditions from stands containing N. densiflorus with other evergreens. Cooper’s (1922) original concept of the mixed evergreen forest described mixed hardwood stands in the Santa Lucia Mountains. Munz (1959) and Whittaker (1960) expanded the term “mixed evergreen” to include Pseudotsuga menziesii – Notholithocarpus densiflorus stands. Forest ecologists have used the name “Lithocarpus densiflorus series” or “Notholithocarpus densiflorus Alliance” to refer to stands that have a low to moderate presence of conifers, such as Pseudotsuga menziesii or Sequoia sempervirens (e.g., Atzet and Wheeler 1982, Jimerson et al. 1996). The National Vegetation Classification (NVC) places such stands in the Pseudotsuga menziesii – Notholithocarpus densiflorus or Sequoia sempervirens Alliances. Our concept of the Notholithocarpus densiflorus Alliance is one with minimal conifer cover and the main cover provided by tanoak with a variable proportion of other hardwoods. The shrub form of Notholithocarpus densiflorus (var. echinoides) has its own alliance.

Sonoma County

Sudden oak death (Phytophthora ramorum) has decimated many stands of this alliance throughout much of coastal and central parts of Sonoma County. High elevation stands near Mt. Saint Helena, which are above the summer fog level, have not been affected as of 2014.

Most Abundant Species: Notholithocarpus densiflorus, Pseudotsuga menziesii, Arbutus menziesii Association

Distribution / Location:

This alliance is widespread and occurs in large stands in the northwest portion of Sonoma County, west of the Russian River and north of the Petaluma Gap. Notholithocarpus does not tolerate a persistent marine layer and does not occur along the immediate coast. In eastern Sonoma County, this alliance occurs in isolated areas of the Mayacamas.

Acres mapped countywide:	21,099	Global/State Rarity Rank:	G4/S3
Accuracy Assessment Map Sites:	28	User's Accuracy:	89%
Accuracy Assessment Reference Sites:	33	Producer's Accuracy:	85%



Ground View

Aerial View

NVC Association(s): NA

Description:

In this map class, area is a nursery or ornamental horticulture area as observed in the fall, 2013 imagery.

Most Abundant Species: NA

Distribution / Location:

Nursery or ornamental horticultural areas are uncommon on the landscape. The class was mapped where it occurred, mainly as nurseries near urban areas.

Acres mapped countywide:	103	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Orchard or Grove

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

In this map class, area is an orchard or grove of fruit or nut trees as observed in the fall, 2013 imagery.

Most Abundant Species: NA

Distribution / Location:

The orchards and grove class is found across Sonoma County's valley regions. The largest orchards and the highest concentration of orchards is in and around Sebastopol.

Acres mapped countywide:	3,918	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	31	User's Accuracy:	97%
Accuracy Assessment Reference Sites:	33	Producer's Accuracy:	91%

Map Class: Perennial Agriculture

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

In this map class, area is a perennial cropland (e.g., lavender, berries, Christmas trees, rhododendron) as observed in the fall, 2013 imagery.

Most Abundant Species: NA

Distribution / Location:

Perennial agriculture was mapped in a small number of locations throughout Sonoma County.

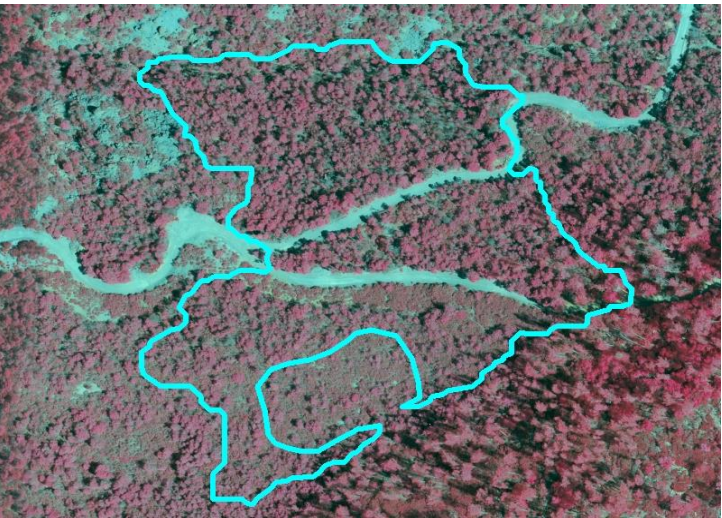
Acres mapped countywide:	227	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Pinus attenuata Alliance

Common Name: Knobcone Pine Alliance



Ground View



Aerial View

NVC Association(s): Pinus attenuata / Arctostaphylos (manzanita, canescens) Provisional Association, Pinus attenuata / Arctostaphylos viscida Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Pinus attenuata is dominant or co-dominant in the tree canopy with Arbutus menziesii, Juniperus occidentalis, Notholithocarpus densiflorus, Pinus contorta, Pinus coulteri, Pinus monticola, Pinus radiata, Pinus sabiniana, Pseudotsuga menziesii, Quercus chrysolepis, and Quercus wislizeni.

Stands of Pinus attenuata typically occur on nutrient-deficient soils with and without dense understories (Minnich 2007). They tend to vary regionally in size and occurrence; the trees in many stands are dense, forming closed canopies, while in other stands, trees are scattered and canopies are open. Associated vegetation is often chaparral, but in some regions, the surrounding vegetation includes coniferous forests, montane chaparral, and oak woodlands. Individual Pinus attenuata trees often emerge through shrub canopies in stands of many chaparral alliances.

Sonoma County

In Sonoma County, the Pinus attenuata Alliance is usually associated with extensive stands of chaparral and is less often associated with Pseudotsuga menziesii and several species of Quercus. Some Pinus attenuata stands are located on serpentine.

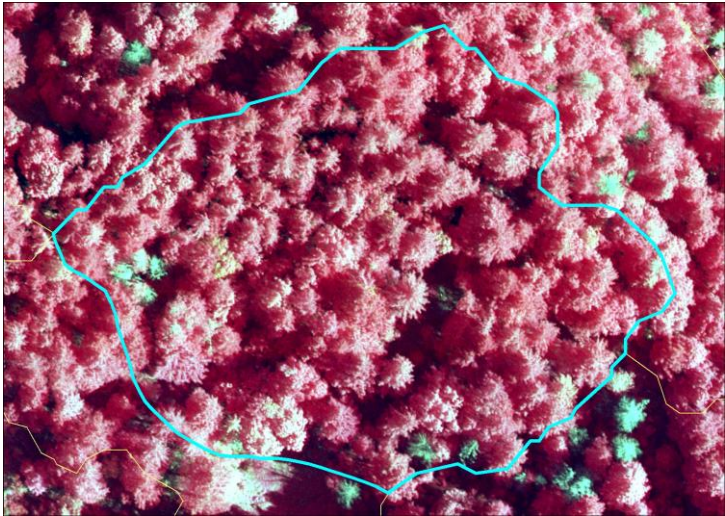
Most Abundant Species: Pinus attenuata

Distribution / Location:

This class occurs in eastern Sonoma County throughout the Mayacamas. It is often interspersed with extensive stands of chaparral.

Acres mapped countywide:	4,546	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	14	User's Accuracy:	86%
Accuracy Assessment Reference Sites:	17	Producer's Accuracy:	82%

No Image
Available



Ground View

Aerial View

NVC Association(s):

Pinus lambertiana - Pinus contorta ssp. Contorta/Quercus vaccinifolia-Notholithocarpus densiflorus var. echinoides

Description:

In this map class, *Pinus lambertiana* is dominant in the tree canopy. *Pseudotsuga menziesii* is often present. *Lithocarpus densiflorus* and other hardwoods are also common as understory components. Because of its limited geographic occurrence, stands of this type were not encountered or sampled by CNPS field crews. As a result, there are not descriptions or stand tables for this map class.

Most Abundant Species: *Pinus lambertiana*

Distribution / Location:

This class is limited to far northwestern Sonoma County, where it occurs in a small number of stands. *Pinus lambertiana* is present throughout northern Sonoma County, but - except for in a few areas near the Mendocino County border - rarely dominates the stands where it occurs.

Acres mapped countywide:	689	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:	2	User's Accuracy:	0%
Accuracy Assessment Reference Sites:	0	Producer's Accuracy:	not assessed



Ground View

Aerial View

NVC Association(s):

Pinus muricata – Hesperocyparis pigmaea Provisional Association, Pinus muricata / Vaccinium ovatum Provisional Association, Pinus muricata Provisional Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, *Pinus muricata* is dominant or co-dominant in the tree canopy with *Abies grandis*, *Arbutus menziesii*, *Hesperocyparis pigmaea*, *Notholithocarpus densiflorus*, *Pinus contorta* ssp. *bolanderi*, *Pinus contorta* ssp. *contorta*, *Pinus radiata*, *Pseudotsuga menziesii*, *Quercus agrifolia*, *Quercus tomentella*, *Sequoia sempervirens*, *Tsuga heterophylla*, and *Umbellularia californica*.

Pinus muricata grows on the mainland from Santa Barbara to Humboldt Counties, as well as on the Santa Cruz and Santa Rosa islands (Barbour 2007). It grows in areas with spring and summer fog, which is important to its survival (Cope 1993e). In the La Purisima Hills in Santa Barbara County, *Pinus muricata* stands occur on diatomaceous mudstone and are surrounded by chaparral (Cole 1980, Vogl et al. 1977). Those in the western Santa Ynez Mountains and near Erendira in Baja California also exist in chaparral. *Pinus muricata* stands on the Channel Islands differ in species composition from one another and from stands on the mainland (Philbrick and Haller 1977). In Humboldt and Mendocino Counties, *P. muricata* commonly occurs on shallow, poorly drained soils and mixes with *Hesperocyparis pigmaea*, *Pinus contorta*, *Pseudotsuga menziesii*, and *Sequoia sempervirens* (Westman and Whittaker 1975).

Most Abundant Species: *Pinus muricata*

Distribution / Location:

This class is exclusive to the northern portions of the Sonoma County coast, north of the Russian River, where it occurs on coastal terraces.

Acres mapped countywide:	2,747	Global/State Rarity Rank:	G3/S3
Accuracy Assessment Map Sites:	24	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	26	Producer's Accuracy:	96%



NVC Association(s): Pinus ponderosa – Pseudotsuga menziesii Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Pinus ponderosa and Pseudotsuga menziesii are co-dominant in the tree canopy with Abies concolor, Arbutus menziesii, Calocedrus decurrens, Pinus jeffreyi, Pinus lambertiana, Quercus chrysolepis, Quercus garryana, and Quercus kelloggii.

The ecological literature has applied the term mixed conifer forest to stands where Pinus ponderosa and Pseudotsuga menziesii share canopy dominance. Bingham (1999) developed a region-wide alliance-level classification for late seral forests based on relationships between species composition and major environmental gradients. Stands where Pinus ponderosa and Pseudotsuga menziesii shared dominance segregated significantly from other alliances. Stands are particularly extensive in the northern Coast Ranges, Klamath Mountains, and northern Sierra Nevada, where one to all the five mixed conifer trees (Abies concolor, Calocedrus decurrens, Pinus lambertiana, Pinus ponderosa, and Pseudotsuga menziesii) may be present, but only Pinus ponderosa and Pseudotsuga menziesii combined have high tree canopy cover. Stands of this alliance fall compositionally and environmentally between the central and southern Sierran stands of the Pinus ponderosa – Calocedrus decurrens Alliance and the coastal stands of the Pseudotsuga menziesii – Notholithocarpus densiflorus Alliance (Sawyer 2007).

Sonoma County
In Sonoma County, Pinus ponderosa – Pseudotsuga menziesii stands are rare and those that have been identified have a history of logging. This alliance appears to be restricted to the higher elevations of the northeastern part of the county, near The Geysers.

Most Abundant Species: Pinus ponderosa

Distribution / Location:

This class has limited coverage in Sonoma County and occurs at a few higher elevation areas in the Mayacamas. The largest stands occur in northeast Sonoma County along the Lake County border above 2,000 feet in elevation.

Acres mapped countywide:	830	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	2	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	4	Producer's Accuracy:	100%



Ground View

Aerial View

NVC Association(s): Pinus radiata Provisional Semi-Natural Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Pinus radiata is dominant or co-dominant in the tree canopy with Acer macrophyllum, Alnus rhombifolia, Arbutus menziesii, Hesperocyparis goveniana, Notholithocarpus densiflorus, Pinus attenuata, Pinus muricata, Pseudotsuga menziesii, Quercus agrifolia, Quercus wislizeni, Salix lasiolepis, Salix scouleriana, and Sequoia sempervirens.

Pinus radiata plantations exist in the state and worldwide, but natural stands exist in only three disjunct areas in mainland California: near Año Nuevo, on the Monterey Peninsula, and at Cambria. Additional populations occur on Cedros and Guadalupe islands off central Baja California. Variations in age structure and species composition are high among the three mainland populations (Barbour 2007, Jones and Stokes Associates 1994b, 1996, Rogers 2002, Stephens et al. 2004, White 1999). Cylinder (1995) describes links between marine terrace conditions and Pinus radiata success. His proposed types suggest that stands dominated by Pinus radiata have similar species composition but differ structurally on each terrace.

It is difficult to differentiate between natural and planted tree regeneration in stands that have been reproducing along the coast of Central California. Nevertheless, the total area currently occupied by P. radiata is probably no more than 8000 ha (Rogers 2002). Because of this species’ economic status and rarity, we know much about the species genetically (Rogers 2002).

Sonoma County

All Pinus radiata stands in Sonoma County are derived from plantings.

Most Abundant Species: Pinus radiata

Distribution / Location:

The largest stands of Pinus radiata in Sonoma County are planted windbreaks along the coast. The alliance also occurs throughout the county in small, planted stands.

Acres mapped countywide:	317	Global/State Rarity Rank:	G1/S1
Accuracy Assessment Map Sites:	2	User's Accuracy:	0%
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Pinus sabiniana / Quercus durata Provisional Alliance

Common Name: California Foothill Pine / Leather Oak Provisional Alliance



Ground View



Aerial View

NVC Association(s): Pinus sabiniana / Quercus durata Provisional Association, Pinus sabiniana / Arctostaphylos viscida Association

Description:

Statewide (Sawyer et al. 2009)

Pinus sabiniana is dominant or co-dominant in the tree canopy with Aesculus californica, Juniperus californica, Juniperus occidentalis, Pinus coulteri, Quercus chrysolepis, and Quercus wislizeni.

This extensive alliance occupies rough foothill slopes, intermixed with stands of chaparral (Allen-Diaz et al. 2007, Sawyer 2007). The northernmost California stand of this widespread species on serpentine is along the Salmon River in the Klamath Mountains (Griffin and Critchfield 1972); the range of the species extends into southern Oregon. Pinus sabiniana is a common and important member of stands of the Quercus douglasii Alliance. In the Pinus sabiniana Alliance, Quercus douglasii may be present only at low cover; mixed stands are placed in the Q. douglasii Alliance. Pinus sabiniana also occurs as an emergent over chaparral in many shrubland alliances.

Sonoma County

Pinus sabiniana stands are associated with serpentine and occur primarily over shrubby understories.

Most Abundant Species: Pinus sabiniana, Quercus durata

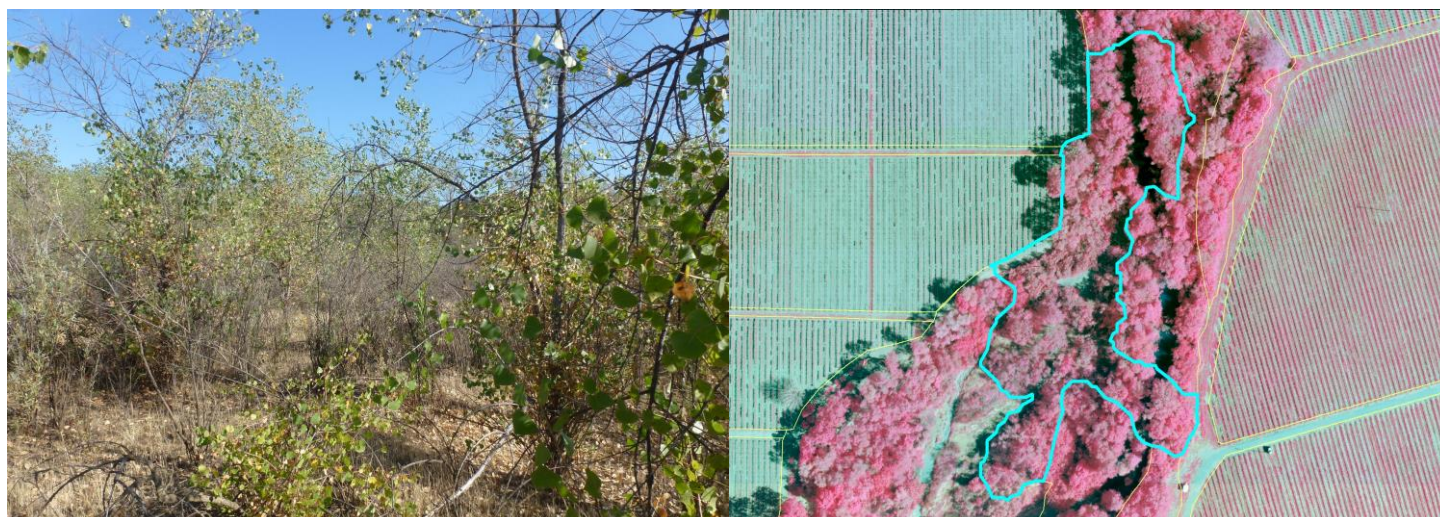
Distribution / Location:

In Sonoma County, this class occurs in the northeast part of county, mainly east of Lake Sonoma and in the northern Mayacamas. Some small stands also exist in the Southern Mayacamas. Stands are associated with serpentine and often occur over shrubby understories dominated by Quercus durata.

Acres mapped countywide:	2,064	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	28	User's Accuracy:	93%
Accuracy Assessment Reference Sites:	25	Producer's Accuracy:	100%

Map Class: Populus fremontii Alliance

Common Name: Fremont Cottonwood Alliance



Ground View

Aerial View

NVC Association(s): Populus fremontii – Acer negundo Association, Populus fremontii / Salix exigua Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Populus fremontii is dominant or co-dominant in the tree canopy with Acer negundo, Fraxinus latifolia, Juglans hindsii, Juglans hindsii xregia, Platanus racemosa, Quercus agrifolia, Salix exigua, Salix gooddingii, Salix laevigata, Salix lasiolepis, Salix lucida ssp. lasiandra, and Salix lutea.

The Populus fremontii Alliance is found in riparian settings and may dominate stands or mix with other trees. Some uncertainty exists about the proper classification of mixed stands of Populus fremontii and Salix gooddingii. Vaghti (2003) places these in the P. fremontii Alliance; Hickson and Keeler-Wolf (2007), in a larger survey from the Sacramento Delta, suggest that they are better placed in the Salix gooddingii Alliance. Furthermore, uncertainty exists about mixed stands of Populus fremontii and Platanus racemosa. Klein and Evens (2005) and Evens and San (2005) place co-dominant stands in a mixed alliance, but Sawyer et al. (2009) place them in the Platanus racemosa Alliance. In southern California, Populus fremontii occurs in mixed stands with Salix laevigata and other willows (S. lucida and S. lasiolepis), Quercus agrifolia, and Juglans californica (Klein and Evens 2005, Stillwater Sciences and URS 2007).

Sonoma County

Populus fremontii stands are similar to many northern California stands that are found along rivers and larger creeks in the foothills and Great Valley.

Most Abundant Species: Populus fremontii, Juglans hindsii

Distribution / Location:

Populus fremontii occurs in perennial riparian areas throughout the county, but not along the coast. The most extensive stands of this map class are found along the main stem Russian River and Dry Creek.

Acres mapped countywide:	2,273	Global/State Rarity Rank:	G4/S3
Accuracy Assessment Map Sites:	15	User's Accuracy:	93%
Accuracy Assessment Reference Sites:	31	Producer's Accuracy:	68%



NVC Association(s): Pseudotsuga menziesii – Notholithocarpus densiflorus Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Notholithocarpus densiflorus and Pseudotsuga menziesii are co-dominant in the tree canopy with Acer macrophyllum, Arbutus menziesii, Calocedrus decurrens, Chamaecyparis lawsoniana, Chrysolepis chrysophylla, Pinus lambertiana, Pinus ponderosa, Quercus chrysolepis, Quercus kelloggii, Taxus brevifolia, and Umbellularia californica.

Ecologists have used the term “mixed evergreen forest” in referring to stands in this and several other alliances (Sawyer 2007). However, Bingham (1999) found that stands where Pseudotsuga menziesii and Notholithocarpus densiflorus shared dominance segregated significantly in species composition and environmental conditions from those where Pseudotsuga menziesii shared dominance with other trees (see the Abies concolor – Pseudotsuga menziesii, Pinus ponderosa – Pseudotsuga menziesii, and Pseudotsuga menziesii Alliances).

Sonoma County
Notholithocarpus densiflorus has been decimated by sudden oak death. Due to this disease, Pseudotsuga menziesii – Notholithocarpus densiflorus stands are rapidly being converted to the Pseudotsuga menziesii Alliance.

Most Abundant Species: Notholithocarpus densiflorus, Pseudotsuga menziesii

Distribution / Location:

This alliance is widespread and occurs in large stands in the northwest portion of Sonoma County, west of the Russian River and north of the Petaluma Gap. Notholithocarpus does not tolerate a persistent marine layer and does not occur along the immediate coast. In eastern Sonoma County, this alliance occurs in isolated areas of the Mayacamas.

Acres mapped countywide:	14,343	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	17	User's Accuracy:	65%
Accuracy Assessment Reference Sites:	26	Producer's Accuracy:	54%



Ground View

Aerial View

NVC Association(s): Pseudotsuga menziesii – Arbutus menziesii Association, P. menziesii – Quercus agrifolia Association, P. menziesii – Quercus chrysolepis Association, P. menziesii – Umbellularia californica / Polystichum munitum Association, P. menziesii – Umbellularia californica Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Pseudotsuga menziesii is dominant or co-dominant in the tree canopy with Abies concolor, Acer macrophyllum, Alnus rhombifolia, Arbutus menziesii, Calocedrus decurrens, Chamaecyparis lawsoniana, Chrysolepis chrysophylla, Cornus nuttallii, Pinus contorta, Pinus jeffreyi, Pinus lambertiana, Quercus agrifolia, Quercus chrysolepis, Quercus garryana, Quercus kelloggii, and Sequoia sempervirens.

The ecological literature applies the term “Douglas fir forest” to stands of varying species composition (Fites-Kaufman et al. 2007, Sawyer 2006, 2007). Bingham (1999) developed a region-wide alliance-level classification for late-seral-stage forests based on relationships between species composition and major environmental gradients. Stands dominated by Pseudotsuga menziesii segregated significantly from other alliances. This alliance is mainly a middle-elevation one in California. Abies concolor may be a component of the understory and a secondary species of tree canopy.

The complex relationship between Pseudotsuga menziesii and other conifers and hardwoods throughout northern California has led to the recognition of four additional alliances, defined by the combinations of co-dominants: the Abies concolor – Pseudotsuga menziesii Alliance, the Pseudotsuga menziesii – Calocedrus decurrens Alliance, the Pseudotsuga menziesii – Notholithocarpus densiflorus Alliance, and the Pinus ponderosa – Pseudotsuga menziesii Alliance. Other combinations, such as in the case of the Pseudotsuga menziesii – Quercus chrysolepis Association, are included in this Pseudotsuga menziesii Alliance.

Most Abundant Species: Pseudotsuga menziesii, Quercus agrifolia, Arbutus menziesii, Umbellularia californica

Distribution / Location:

The Pseudotsuga menziesii Alliance is the most extensive coniferous alliance in the county. It occurs on both the west and east sides of the Santa Rosa Basin and can be found at both near the coast and at the county's highest elevations. It grows across a range of conditions.

Acres mapped countywide:	98,244	Global/State Rarity Rank:	G5/S4
Accuracy Assessment Map Sites:	46	User's Accuracy:	85%
Accuracy Assessment Reference Sites:	46	Producer's Accuracy:	74%

Map Class: Quercus (agrifolia, douglasii, garryana, kelloggii, lobata, wislizeni) Alliance

Common Name: Oak (California Live, Blue, Oregon White, California Black, Valley, Scrub



Ground View

Aerial View

NVC Association(s): Quercus agrifolia – Quercus garryana – Quercus kelloggii Provisional Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Quercus agrifolia, Quercus douglasii, Quercus garryana, Quercus kelloggii, Quercus lobata and/or Quercus wislizeni are co-dominant in the tree canopy with Aesculus californica, Arbutus menziesii, Pinus sabiniana, Pseudotsuga menziesii, and Umbellularia californica.

Allen et al. (1989, 1991) recognized a mixed oak series with 10 subseries; they based the subseries on the species composition of the woody plants since they lacked information on the herbaceous species. Their definition was followed in the 1995 edition of the Manual of California Vegetation (MCV) (Sawyer et al. 1995) and the subseries were listed as associations.

A careful study of the key (Allen et al. 1989, 1991) permitted some of the subseries to be placed in other alliances if the definitions allow the characteristic oak be co-dominant. For example, “valley oak and blue oak are co-dominant; coast live oak is present” becomes the Quercus lobata – Quercus douglasii Association in the Quercus lobata Alliance. The Quercus wislizeni – Quercus douglasii – Pinus sabiniana Association was placed in the Quercus wislizeni Alliance because the third tree is not an oak. However, some subseries remain within this alliance when three or more oaks co-dominate.

Sonoma County

Allen et al. did not analyze mixed stands with Quercus garryana. Hence, the single association defined is a newly described representative of the mixed oak alliance.

Most Abundant Species: Quercus agrifolia, Quercus garryana, Quercus kelloggii, Quercus douglasii, Quercus lobata

Distribution / Location:

In Sonoma County, this class is widespread and common, but occur mostly inland and away from the immediate coast.

Acres mapped countywide:	42,192	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	39	User's Accuracy:	76%
Accuracy Assessment Reference Sites:	29	Producer's Accuracy:	83%



Ground View

Aerial View

NVC Association(s): Quercus agrifolia – Arbutus menziesii – Umbellularia californica Association, Quercus agrifolia / Grass Association, Quercus agrifolia / Toxicodendron diversilobum Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Quercus agrifolia is dominant or co-dominant in the tree canopy with Acer macrophyllum, Acer negundo, Arbutus menziesii, Juglans californica, Platanus racemosa, Populus fremontii, Quercus douglasii, Quercus engelmannii, Quercus kelloggii, Quercus lobata, Salix lasiolepis, and Umbellularia californica.

Stands of this extensive alliance vary from upland savannas and woodlands to bottomland, riparian forests with closed tree canopies (Allen-Diaz et al. 2007). Genetic variation is high in the species, with two main recognized varieties. Most plants represent Quercus agrifolia var. agrifolia; plants recognized as Quercus agrifolia var. oxyadenia in the Peninsular Ranges of southern California have hairs completely covering the lower leaf surfaces (Roberts 1995). Quercus agrifolia hybrids include Quercus xganderi (Q. agrifolia var. oxyadenia x Q. kelloggii) in San Diego County and Quercus xchasei (Q. agrifolia var. agrifolia x Q. kelloggii) in Monterey and Santa Cruz Counties. The species also hybridizes with Quercus dumosa, Q. lobata, and Q. wislizeni to varying degrees (Kathleen et al. 2002, Dodd et al. 1993, Brophy and Parnell 1974). A shrub form, Quercus agrifolia var. frutescens, may only represent frequently burned or salt-spray-pruned plants.

Most Abundant Species: Quercus agrifolia

Distribution / Location:

In Sonoma County, this class is very widespread and covers the range from mesic woodlands to relatively dry, open woodlands with grassy understories. It is more common in the interior parts of the county but is one of the few Quercus species that occurs very close to the immediate coast.

Acres mapped countywide:	44,158	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	33	User's Accuracy:	76%
Accuracy Assessment Reference Sites:	29	Producer's Accuracy:	83%



Ground View

Aerial View

NVC Association(s):

Quercus chrysolepis – Arbutus menziesii Provisional Association, Quercus chrysolepis – Quercus wislizeni Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Quercus chrysolepis is dominant or co-dominant in the tree canopy with Abies concolor, Acer macrophyllum, Arbutus menziesii, Calocedrus decurrens, Notholithocarpus densiflorus, Pinus coulteri, Pinus lambertiana, Pinus monophylla, Pinus ponderosa, Pseudotsuga macrocarpa, Pseudotsuga menziesii, Quercus garryana var. garryana, Quercus kelloggii, Quercus wislizeni, and Umbellularia californica.

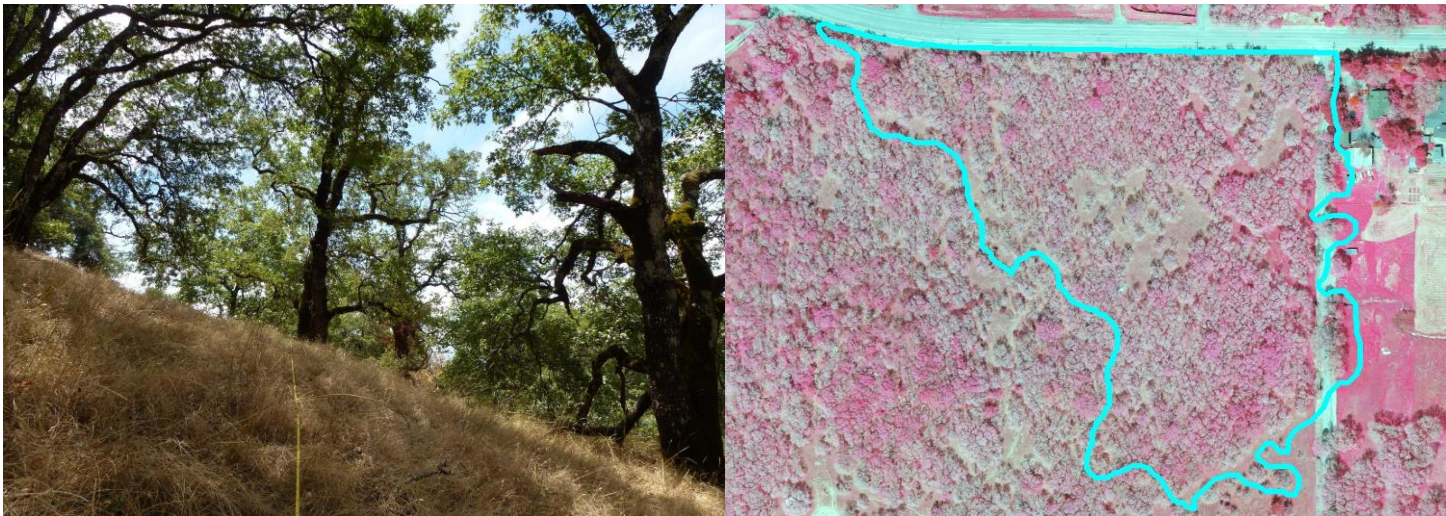
Quercus chrysolepis grows on the east side of the Sierra Nevada, in the Mojave Desert, and in most of cismontane California at middle and upper elevations (Griffin and Critchfield 1972). Quercus chrysolepis is present in many different alliances and it shares dominance with several other tree species in this alliance (Allen-Diaz et al. 2007). Most Quercus chrysolepis stands that are free of recent major disturbance have trees of all sizes and all ages (Tirmenstein 1989b, Thornburgh 1990b).

Most Abundant Species: Quercus chrysolepis

Distribution / Location:

In Sonoma County, this alliance is best represented in the interior portions of the county, typically at least seven miles from the coast and at slightly higher elevation ranges than other Quercus classes.

Acres mapped countywide:	10,438	Global/State Rarity Rank:	G5/S5
Accuracy Assessment Map Sites:	17	User's Accuracy:	71%
Accuracy Assessment Reference Sites:	27	Producer's Accuracy:	67%



Ground View

Aerial View

NVC Association(s): Quercus xepingii / Grass Provisional Association, Quercus douglasii – Quercus agrifolia Association, Quercus douglasii / Arctostaphylos manzanita / Herbaceous Association, Quercus douglasii / Grass Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Quercus douglasii is dominant or co-dominant in the tree canopy with Aesculus californica, Juniperus californica, Pinus sabiniana, Quercus agrifolia, Quercus lobata, and Quercus wislizeni.

The Quercus douglasii Alliance, in its varied forms, is one of the most extensive and conspicuous vegetation types in the state. In some cases, oak savannas of Quercus douglasii trees are scattered across the landscape, and in other cases, trees of mixed composition form a closed tree canopy. Genetic variation is high in the species. Environmental factors controlling this variation include moisture availability, substrate, fire, and other disturbances (Allen-Diaz and Bartolome 1992, Allen-Diaz et al. 2007, Keeley 2002c). Named Quercus douglasii hybrids include those with Q. john-tuckeri (Quercus xalvordiana), Q. garryana (Quercus xepingii), and Q. lobata (Quercus xjolonensis) (Griffin and Critchfield 1972).

Sonoma County
Stands of Quercus douglasii are commonly composed of hybrids with Q. garryana (Quercus xepingii), which are sometimes difficult to distinguish from either parent species. Most typical blue oak stands with blue-green foliage occur in the southeastern portion of the county. Those stands composed of many hybrid oaks and occupying relatively xeric inland sites have also been placed in this alliance.

Most Abundant Species: Quercus douglasii

Distribution / Location:

This class occurs in eastern portions of Sonoma County in the hills rising from Sonoma Valley in the south, the Santa Rosa plain in the central part of the county, and on both sides of the Alexander Valley in the north.

Acres mapped countywide:	8,062	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	26	User's Accuracy:	88%
Accuracy Assessment Reference Sites:	34	Producer's Accuracy:	82%



NVC Association(s):

Quercus durata – Adenostoma fasciculatum Provisional Association, Quercus durata – Ceanothus jepsonii Provisional Association, Quercus durata – Heteromeles arbutifolia / Umbellularia californica Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Quercus durata is dominant or co-dominant in the shrub canopy with Adenostoma fasciculatum, Arctostaphylos glandulosa, Arctostaphylos glauca, Arctostaphylos pungens, Arctostaphylos viscida, Ceanothus jepsonii, Cercocarpus montanus, Eriodictyon californicum, Fremontodendron californicum, Garrya condonii, Heteromeles arbutifolia, Quercus berberidifolia, Quercus wislizeni, and Umbellularia californica. Emergent trees may be present at low cover, including Hesperocyparis macnabiana, Hesperocyparis sargentii, Juniperus californica, Pinus attenuata, or Pinus sabiniana.

Stands of this alliance have high fidelity to serpentine or other ultramafic substrates (Alexander et al. 2007, Kruckeberg 1984), typically occupying mesic sites, including north-facing slopes. Quercus durata includes two varieties: var. durata and var. abriensis. This alliance mainly describes Quercus durata var. durata, which grows on serpentine substrates in the Coastal Ranges and the foothills of the Sierra Nevada. The southern variety, Q. durata var. gabrielensis, occupies barren gneiss-derived soils in the San Gabriel Mountains.

Sonoma County
Quercus durata stands in Sonoma County are entirely restricted to serpentine soils, as is common for this alliance throughout its range. The three associations of this alliance occupy different ecological settings: the Quercus durata – Heteromeles arbutifolia / Umbellularia californica Association is the most mesic and is found on northerly facing slopes; the most xeric is the relatively uncommon Quercus durata – Adenostoma fasciculatum Provisional Association. The most widespread Quercus durata association in the county is the Quercus durata – Ceanothus jepsonii Provisional Association. It is newly defined from the data in this project, but probably extends eastward and northward in the Inner North Coast Ranges on serpentine soils. Occasionally, individuals of Quercus durata occur as members of other chaparral alliances (e.g., Q. wislizeni (shrub) or Q. berberidifolia Alliance stands) growing on volcanic or metamorphic substrates.

Most Abundant Species: Quercus durata, Adenostoma fasciculatum

Distribution / Location:

In Sonoma County, this class extends eastward and northward in the Inner North Coast Ranges but is limited to serpentine soils.

Acres mapped countywide:	3,864	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	36	User's Accuracy:	83%
Accuracy Assessment Reference Sites:	26	Producer's Accuracy:	96%



Ground View

Aerial View

NVC Association(s):

Quercus garryana – Umbellularia californica – Quercus (agrifolia, kelloggii) Provisional Association,
Quercus garryana / (Cynosurus echinatus – Festuca californica) Provisional Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, *Quercus garryana* var. *garryana* is dominant or co-dominant in the tree canopy with *Juniperus occidentalis*, *Pinus jeffreyi*, *Pinus ponderosa*, *Pinus sabiniana*, *Pseudotsuga menziesii*, *Quercus chrysolepis*, *Quercus kelloggii*, and *Umbellularia californica*.

Both forest and woodland *Quercus garryana* stands contain the tree form of the species (var. *garryana*). Trees grow on a wide variety of sites, and can be over-topped by conifers on productive sites. Stands typically occupy unproductive, exposed, dry, or temporarily wet locations (Griffin 1977, Howard 1992j, Stein 1980a). They occur primarily in northwestern California, which has higher rainfall than other locations with oaks in the state (Jimerson and). Both native and non-native grasses make up the understory on most sites (Sawyer 2006). The shrub form of *Quercus garryana* (var. *fruticosa*) is treated in a separate alliance.

Sonoma County

Stands may be partially composed of hybrids between *Quercus garryana* and *Quercus douglasii* (*Q. xepingii*). Stands containing hybrids with leaf and ecological characteristics similar to *Quercus garryana* are common in the vicinity of Lake Sonoma and elsewhere inland; they are classified here as members of the *Quercus garryana* Alliance.

Most Abundant Species: *Quercus garryana*

Distribution / Location:

This class is widespread in interior Sonoma County, where it occurs on a variety of sites. In southern Sonoma County, it is limited to the eastern part of county far away from coastal influences. In north part of county it is most concentrated east of Lake Sonoma.

Acres mapped countywide:	49,370	Global/State Rarity Rank:	G4/S3
Accuracy Assessment Map Sites:	45	User's Accuracy:	78%
Accuracy Assessment Reference Sites:	40	Producer's Accuracy:	85%



Ground View

Aerial View

NVC Association(s): Quercus kelloggii – Arbutus menziesii – Quercus agrifolia Association, Quercus kelloggii – Pseudotsuga menziesii – Umbellularia californica Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Quercus kelloggii is dominant or co-dominant in the tree canopy with Abies concolor, Arbutus menziesii, Calocedrus decurrens, Pinus attenuata, Pinus ponderosa, Pseudotsuga menziesii, Quercus agrifolia, Quercus chrysolepis, Quercus garryana, Quercus lobata, and Umbellularia californica.

The range of Quercus kelloggii is sufficiently wide that it mixes with many species in many alliances (Gaman and Casey 2002), though it tends to occur in higher elevations than most tree oaks other than Quercus chrysolepis. The Quercus kelloggii Alliance occurs from the foothills to mid-montane elevations, from the Coast Ranges to the Klamath Mountains and the western Sierra Nevada (Barbour et al. 2007a). Conifers replace Quercus kelloggii on productive sites in the absence of fire. Conifer replacement is slower or lacking on unproductive sites (Howard 1992I). Stands commonly have Pinus ponderosa, Pinus sabiniana, and less commonly Pinus jeffreyi. Mixed cismontane stands with Pinus ponderosa are currently placed in this alliance, despite the conifer’s greater height.

Sonoma County

Sonoma County Quercus kelloggii stands are scattered and are typically small. They may be associated with stands of the Mixed Oak Alliance.

Most Abundant Species: Quercus kelloggii, Umbellularia californica

Distribution / Location:

Quercus kelloggii stands are found throughout Sonoma County. The largest stands are found in the higher elevations of the northern Mayacamas and in the highlands just to the west of Lake Sonoma. Smaller stands are found throughout the county, especially on gentler north facing slopes and on ridges.

Acres mapped countywide:	8,007	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	20	User's Accuracy:	85%
Accuracy Assessment Reference Sites:	28	Producer's Accuracy:	75%



Ground View

Aerial View

NVC Association(s): Quercus lobata – Fraxinus latifolia / (Vitis californica) Association, Quercus lobata – Quercus agrifolia / Grass Association, Quercus lobata / Grass Association, Quercus lobata / Rubus ursinus – Rosa californica Provisional Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Quercus lobata is dominant or co-dominant in the tree canopy with Acer negundo, Alnus rhombifolia, Fraxinus latifolia, Juglans hindsii, Juglans hindsii xregia, Platanus racemosa, Populus fremontii, Quercus agrifolia, Quercus douglasii, Quercus kelloggii, Quercus wislizeni, Salix gooddingii, and Salix lasiolepis. Shrubs and lianas may include Aristolochia californica or Vitis californica.

Quercus lobata is endemic to California, and stands vary from open savannas to closed-canopy forests (Allen-Diaz et al. 2007). Riparian and upland forests of Quercus lobata occur in the deep, rich soil typical of floodplains and valley floors. Riparian Quercus lobata stands typically exist on higher portions of the floodplain than do stands of Populus fremontii and willows (Holstein 1984, Vaghti and Greco 2007). The Quercus lobata forests currently found in California are only remnants of what once existed in the Central Valley, other valleys, and foothill locations (Allen-Diaz et al. 2007).

Sonoma County

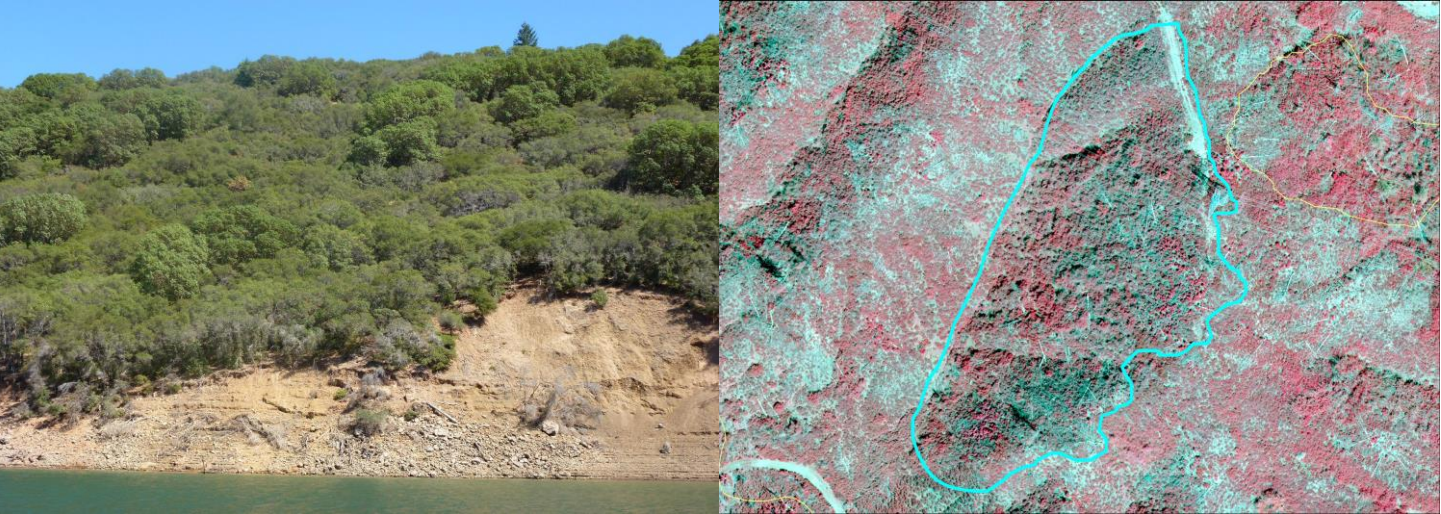
Quercus lobata stands in Sonoma County include both riparian and upland associations.

Most Abundant Species: Quercus lobata, Prunus latifolia, Quercus wislizeni, Quercus kelloggii

Distribution / Location:

This class is abundant throughout county but scattered widely in small stands. The largest stands are found in wide valleys with deep soils, but Quercus lobata stands are found throughout the county's hilly terrain in small upland valleys and on topographical benches.

Acres mapped countywide:	12,304	Global/State Rarity Rank:	G3/S3
Accuracy Assessment Map Sites:	36	User's Accuracy:	69%
Accuracy Assessment Reference Sites:	32	Producer's Accuracy:	84%



Ground View

Aerial View

NVC Association(s):

Quercus wislizeni - Ceanothus oliganthus Provisional Association, Quercus wislizenia var. frutescens Provisional Association

Description:

In this map class, *Quercus wislizeni* is dominant or co-dominant in the shrub canopy with *Adenostoma fasciculatum*, *Arctostaphylos glandulosa*, *Arctostaphylos glauca*, *Ceanothus cuneatus*, *Ceanothus leucodermis*, *Ceanothus oliganthus*, *Cercocarpus montanus*, *Frangula californica*, *Hesperoyucca whipplei*, *Heteromeles arbutifolia*, *Prunus ilicifolia*, *Quercus berberidifolia*, *Quercus chrysolepis*, *Rhamnus ilicifolia*, and *Toxicodendron diversilobum*. Emergent trees may be present at low cover, including *Aesculus californica*, *Juniperus californica*, *Pinus attenuata*, *Pinus coulteri*, or *Pinus sabiniana*. *Quercus wislizeni* is a widespread and common species in shrublands, forests, and woodlands of the state. The shrubby stands included in this alliance may represent the distinct *Quercus wislizeni* var. *frutescens* or *Q. wislizeni* trees affected by age-related limited height growth or fire regime. White and Sawyer (1995) consider many southern California *Quercus wislizeni* shrublands to be the result of frequent resprouting after fires.

Most Abundant Species: *Quercus wislizeni* var *frutescens*, *Ceanothus oliganthus*, *Arctostaphylos manzanita*

Distribution / Location:

All stands occur inland at least 15 km from the coast, and stands of both tree and shrub forms have often been observed to be adjacent to one another – the tree stands lying on lower, protected slopes and the shrub stands on middle to upper slopes.

Acres mapped countywide:	1,234	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:	7	User's Accuracy:	57%
Accuracy Assessment Reference Sites:	11	Producer's Accuracy:	36%



NVC Association(s): Quercus wislizeni – Arbutus menziesii / Toxicodendron diversilobum Association

Description:

Statewide (Sawyer et al. 2009)
In this map class, Quercus wislizeni var. wislizeni is dominant or co-dominant in the tree canopy with Aesculus californica, Arbutus menziesii, Notholithocarpus densiflorus, Pinus sabiniana, Quercus chrysolepis, Quercus douglasii, and Quercus kelloggii.

Stands of this extensive alliance vary from savannas to closed forests, but they commonly form woodlands (Allen-Diaz et al. 2007). There appears to be less genetic variation in Quercus wislizeni than in other evergreen oaks in the state (Nixon 2002). The tree form (var. wislizeni) is distinguished from the shrub form (var. frutescens), but form and height may be only the result of high fire frequencies (White and Sawyer 1995). The species hybridizes with other oaks. The most commonly encountered hybrid is the deciduous Quercus xmorehus (Q. kelloggii x Q. wislizeni).

Sonoma County
There is confusion indistinguishing the Quercus wislizeni (tree) Alliance from the Quercus wislizeni var. frutescens (shrub) Alliance. Recent and recurring fires in stands of formerly tree-sized Quercus wislizeni give the affected stands a shrubby look, and they are classified under the Quercus wislizeni (shrub) Alliance. Quercus wislizeni stands may occur immediately adjacent to mesic chaparral stands of Quercus berberidifolia, Cercocarpus montanus, and shrubby Aesculus californica; they are assigned to the Quercus wislizeni (tree) Alliance if the individuals are in the tree form in spite of their close proximity to shrub alliances.

The majority of all Quercus wislizeni stands sampled in Sonoma County appear to be “tree” stands.

Most Abundant Species: Quercus wislizeni

Distribution / Location:

Abundant class which occurs throughout the north part of county with most concentrated areas in northeast part of county in the Mayacamas. Stands occur inland at least 15 km from the coast. There is significant overlap with the Q. wislizeni (shrub) Alliance. The elevation range of sampled sites is 368 to 1083 ft.

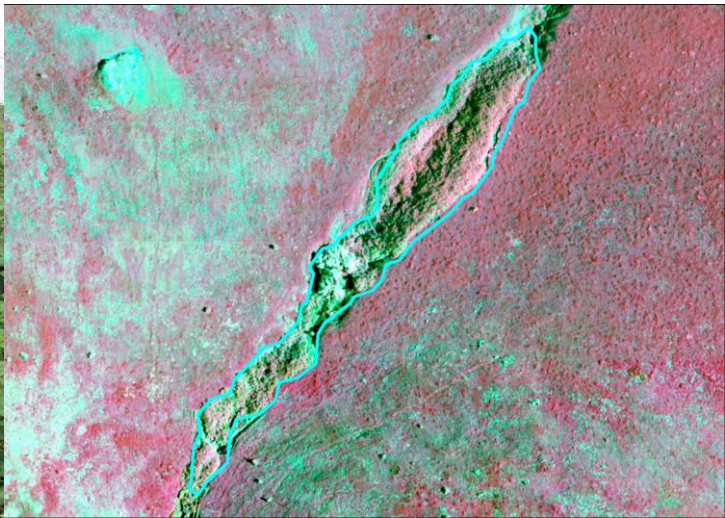
Acres mapped countywide:	12,898	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:	23	User's Accuracy:	57%
Accuracy Assessment Reference Sites:	21	Producer's Accuracy:	62%

Map Class: Rubus armeniacus Alliance

Common Name: Himalayan Blackberry Alliance



Ground View



Aerial View

NVC Association(s): Rubus armeniacus Semi-Natural Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Rubus armeniacus is dominant or co-dominant in the shrub canopy. Emergent trees may be present at low cover, including Populus fremontii, Quercus agrifolia, Quercus lobata, or Salix spp.

Rubus armeniacus grows in riparian habitats, mesic clearings, disturbed areas, and stock ponds throughout cismontane California. The native Rubus ursinus and non-native R. armeniacus have similar ecologies, and these species sometimes intermix. On the north California coast, Rubus ursinus forms extensive stands lacking R. armeniacus, but they remain unsampled. Stands dominated by the aggressive Rubus armeniacus are extensive in many areas in northern California, but they remain of little interest to land managers.

The native blackberry (Rubus ursinus) and rose brambles (Rosa californica, R. nutkana, and R. woodsii) are classified as separate alliances from the Rubus armeniacus type because of their differences in nativity and regional distributions.

Most Abundant Species: Rubus armeniacus

Distribution / Location:

In Sonoma County, this map class tends to be associated with riparian areas and moist pastures with recently reduced grazing pressure. Although most Rubus armeniacus stands in the state are considered riparian, Sonoma County’s cooler coastal stands may be located in upland mesic settings.

Acres mapped countywide:	551	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:	9	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	13	Producer's Accuracy:	77%



Ground View

Aerial View

NVC Association(s): Sequoia sempervirens – Acer macrophyllum – Umbellularia californica Assoc., S. sempervirens – Notholithocarpus densiflorus / Vaccinium ovatum Assoc., S. sempervirens – Pseudotsuga menziesii – N. densiflorus Prov. Assoc., S. sempervirens – P. menziesii – U. californica Assoc., S. sempervirens – U. californica Assoc., S. sempervirens / Oxalis oregana Assoc., S. sempervirens / W. fimbriata Rip. Assoc.

Description:

Statewide (Sawyer et al. 2009)

In this map class, Sequoia sempervirens is dominant or co-dominant in the tree canopy with Abies grandis, Acer macrophyllum, Alnus rubra, Arbutus menziesii, Chrysopsis chrysophylla, Notholithocarpus densiflorus, Picea sitchensis, Pseudotsuga menziesii, Tsuga heterophylla, and Umbellularia californica.

Sequoia sempervirens occurs in moist coastal areas with heavy summer fog. Stands generally occur below 600 meters in elevation, from southern Oregon to the Santa Lucia Mountains in central California. Scattered stands also occur along streams, springs, seeps, and sheltered moist locations up to about 975 meters elevation, where they usually occur as mixed hardwood forests (Sawyer 2006, 2007). Sequoia sempervirens is probably limited in its northern extent by freezing temperatures and in its southern extent by low winter rainfall (Lanner 1999).

Ecologists differentiate forests on alluvial streamside terraces, where Sequoia sempervirens is usually the dominant canopy tree, from those in upland settings, where Sequoia sempervirens shares the canopy with other conifers and with hardwood trees (NatureServe 2007a). However, these differences are best understood when the associations are placed in three geographic regions (Sawyer et al. 2000b). Tsuga heterophylla plays an important role in the northern forest region, and it is absent from the other two regions, where Notholithocarpus densiflorus plays an important role.

Sonoma County

Sequoia sempervirens stands in Sonoma County are represented by seven associations, varying from riparian habitats and river terraces to mid- and upper-slope positions.

Most Abundant Species: Sequoia sempervirens, Pseudotsuga menziesii, Arbutus menziesii, Notholithocarpus densiflorus

Distribution / Location:

This very widespread forest class is concentrated along the coastal regions of northwest and west central Sonoma County with less continuous stands extending east to the Alexander Valley and eastern Sonoma County. Habitat varies from riparian locations along river terraces to mid to upper slope positions.

Acres mapped countywide:	104,169	Global/State Rarity Rank:	G3/S3
Accuracy Assessment Map Sites:	46	User's Accuracy:	74%
Accuracy Assessment Reference Sites:	38	Producer's Accuracy:	84%

Map Class: Southwestern North American Riparian
Evergreen and Deciduous Woodland Group

Common Name: NA



Ground View



Aerial View

NVC Association(s): Acer negundo Alliance, Juglans hindsii and Hybrids Alliance, Salix laevigata Alliance

Description:

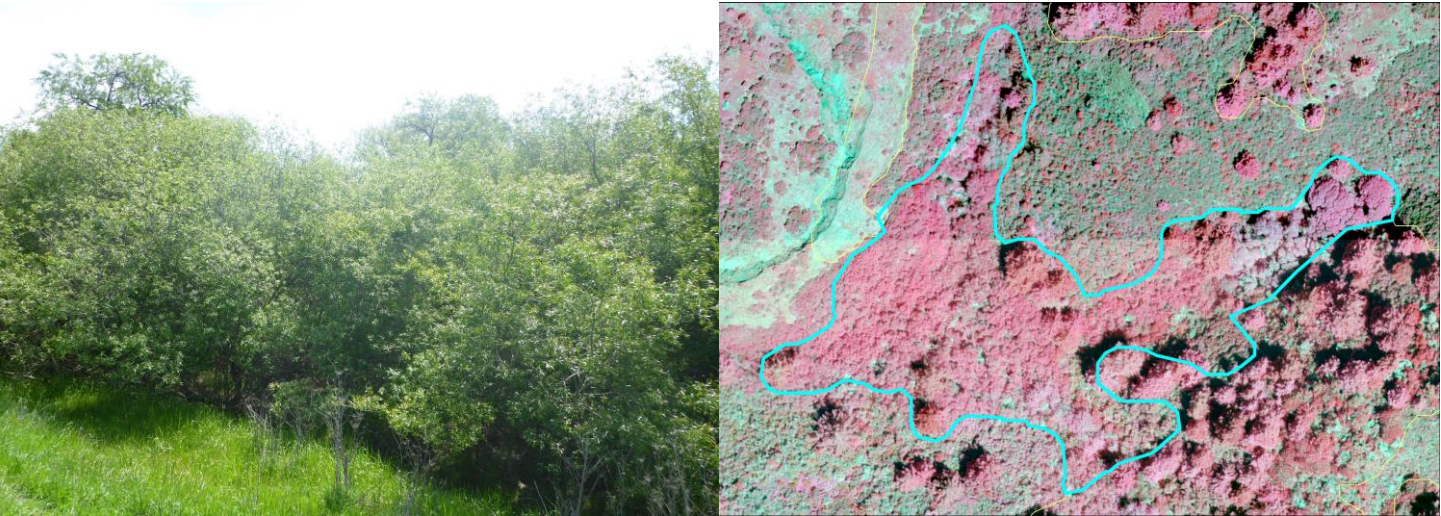
In this map class, tree canopy is dominated or co-dominated by the following riparian species: Populus fremontii, Acer negundo, Juglans hindsii (and hybrids), and/or Salix laevigata. Vegetation commonly found in permanently moist or riparian settings, where subsurface water is available all year. Populus fremontii has less than 5% absolute cover and is not dominant or codominant in the stand.

Most Abundant Species: Acer negundo, Juglans hindsii, Salix laevigata

Distribution / Location:

This riparian class is common along many of the creeks in the Alexander Valley, along the Russian River, and in the Laguna de Santa Rosa and the Santa Rosa Plain.

Acres mapped countywide:	2,980	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:	24	User's Accuracy:	67%
Accuracy Assessment Reference Sites:	25	Producer's Accuracy:	64%



Ground View

Aerial View

NVC Association(s):

Frangula californica - Rhododendron occidentale Alliance, Salix breweri Alliance, Salix exigua Alliance, Sambucus nigra Alliance, Salix lasiolepis Alliance

Description:

In this map class, shrub canopy is dominated or co-dominated by the following mainly riparian species: *Frangula californica*, *Rhododendron occidentale*, *Salix breweri*, *Salix exigua*, *Salix melanopsis*, *Sambucus nigra*, *Salix lasiolepis*. *Rubus* spp. or *Baccharis pilularis* often occurs as a co-dominant shrub. This group is commonly found in permanently moist or riparian settings, where sub-surface water is available all year.

Note: in stands greater than 5 meters tall that met the compositional definition of this alliance, mappers labelled to this group.

Most Abundant Species:

Frangula californica, *Rhododendron occidentale*, *Salix breweri*, *Salix exigua*, *Salix melanopsis*, *Sambucus nigra*, *Salix lasiolepis*

Distribution / Location:

This riparian class occurs in permanently moist areas throughout Sonoma County. Located in many creeks and wetlands throughout the county.

Acres mapped countywide:	3,538	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:	30	User's Accuracy:	87%
Accuracy Assessment Reference Sites:	32	Producer's Accuracy:	81%

Map Class: Tidal Panne

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

This map class was used to map areas of tidal mudflat that were not-inundated at the time of the collection of the 2013 imagery.

Most Abundant Species: NA

Distribution / Location:

This class is limited to the tidally influenced areas around San Pablo Bay in the far southern part of Sonoma County.

Acres mapped countywide:	967	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Toxicodendron diversilobum Alliance

Common Name: Pacific Poison-oak Alliance



Ground View

Aerial View

NVC Association(s): Toxicodendron diversilobum – Baccharis pilularis Provisional Association

Description:

Statewide (Sawyer et al. 2009)

In this map class, Toxicodendron diversilobum is dominant in the shrub canopy with Artemisia californica, Baccharis pilularis, Diplacus aurantiacus, Heteromeles arbutifolia, Keckiella cordifolia, Malosma laurina, Philadelphus lewisii, Rhamnus ilicifolia, Rubus parviflorus, Salvia leucophylla, Salvia mellifera, and Sambucus nigra. Emergent trees may be present at low cover, including Juglans californica or Quercus agrifolia.

Sampling in this alliance requires care. Nonetheless, people have sampled it in a variety of settings in southern and central California, from the immediate coastline to dry inland foothills of the Sierra Nevada. Some coastal stands are nearly pure, persistent, and have relatively low diversity. However, some stands are likely to be a consequence of past and frequent fire disturbance, and these can have a high diversity of native herbs and emergent trees. Toxicodendron diversilobum grows throughout cismontane California and is found in many low-elevation alliances.

Sonoma County

Stands of the Toxicodendron diversilobum Alliance overlap with mesic coastal scrub of the Baccharis pilularis and Frangula californica – Rhododendron occidentale Alliances.

Most Abundant Species: Toxicodendron diversilobum

Distribution / Location:

Poison oak often occurred in small patches below the minimum mapping unit of 1-acre. A few mappable stands did occur within a few kilometers of the coast, especially on moist sheltered slopes between the Russian River mouth and Bodega Bay.

Acres mapped countywide:	24	Global/State Rarity Rank:	G4/S4
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed



Ground View

Aerial View

NVC Association(s):

Umbellularia californica – Acer macrophyllum Assoc., Umbellularia californica – Notholithocarpus densiflorus Assoc., Umbellularia californica – Pseudotsuga menziesii / Rhododendron occidentale Assoc., Umbellularia californica – Quercus agrifolia Provisional Assoc., Umbellularia californica (Pure – Coastal) Provisional Assoc. Umbellularia californica / Polystichum munitum Assoc.

Description:

Statewide (Sawyer et al. 2009)
Umbellularia californica is dominant or co-dominant in the tree or tall shrub canopy with Acer macrophyllum, Aesculus californica, Alnus rhombifolia, Alnus rubra, Arbutus menziesii, Corylus cornuta, Juglans californica, Notholithocarpus densiflorus, Pinus sabiniana, Platanus racemosa, Pseudotsuga menziesii, Quercus agrifolia, Quercus chrysolepis, Quercus wislizeni, and Sequoia sempervirens.

In many cases, Umbellularia californica is the only tree species in older stands with few shrubs and herbs present (McBride 1974). Stands occur near the coast and inland in both mesic and riparian settings, usually in a patchwork with stands of other evergreen forest or chaparral alliances. Coastal stands have characteristically wind-pruned trees or shrubs, and both coastal and inland stands typically have dense, clonally sprouted plants. The stands may be shrubby, as on ultramafic soils such as in the western Klamath Mountains, or they may be trees within a larger matrix of chaparral, as in central and southern California. Historically productive stands were cleared for agriculture and residential development (Stein 1990b).

Most Abundant Species: Umbellularia californica

Distribution / Location:

In Sonoma County, this class has a wide range occurring from riparian settings, inland, and wind-blown upper slopes near the ocean. The elevation range of sampled sites is 88 to 2098 ft.

Acres mapped countywide:	46,834	Global/State Rarity Rank:	G4/S3S4?
Accuracy Assessment Map Sites:	32	User's Accuracy:	88%
Accuracy Assessment Reference Sites:	29	Producer's Accuracy:	76%

Map Class: Urban Window

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

In this map class the area is inside of the “Urban Window.” The urban window encompasses fully developed areas that are part of an urban core. The urban window does not include large city parks and riparian corridors that cross urban areas. The urban window was defined by impervious surface analysis of the fall, 2013 imagery.

Most Abundant Species: NA

Distribution / Location:

These are the population centers including Santa Rosa, Windsor, Rohnert Park, Cotati, Sebastopol, Healdsburg, Cloverdale, Petaluma, and Sonoma, and Oakmont.

Acres mapped countywide:	42,577	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed



Ground View

Aerial View

NVC Association(s): Morella californica - Rubus spectabilis Alliance, Salix sitchensis Alliance

Description:

In this map class, shrub canopy is dominated by Salix sitchensis, Morella californica, Rubus parviflorus, and/or Rubus spectabilis. Stands may be small and are generally found close to the coast on moist or wet soils such as along coastal or low elevation streams, lagoons. A variety of trees and shrubs may be present, including Acer, Alnus, Fraxinus, Salix, and Rubus.

Most Abundant Species: Salix sitchensis, Morella californica, Rubus parviflorus

Distribution / Location:

This group is limited to the narrow coastal strip along the entire Sonoma coast. Found on moist and wet soils, in riparian areas and wetlands.

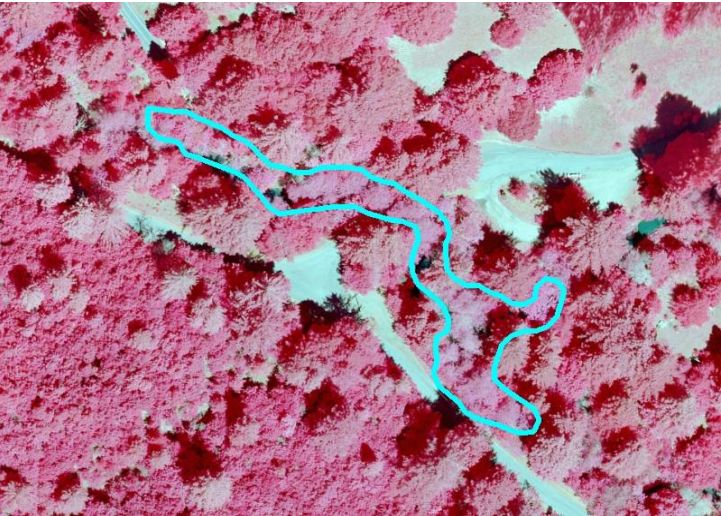
Acres mapped countywide:	278	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:	17	User's Accuracy:	82%
Accuracy Assessment Reference Sites:	15	Producer's Accuracy:	87%

Map Class: Vancouverian Riparian Deciduous Forest Group

Common Name: NA



Ground View



Aerial View

NVC Association(s): Alnus rhombifolia Alliance, Alnus rubra Alliance, Fraxinus latifolia Alliance, Salix lucida Alliance

Description:

In this map class, tree canopy is dominated or co-dominated by the following species: Alnus rhombifolia, Alnus rubra, Fraxinus latifolia, and Salix lucida. Acer macrophyllum and/or Umbellularia californica may be co-dominant.

Most Abundant Species: Alnus rhombifolia, Alnus rubra, Fraxinus latifolia, Salix lucida

Distribution / Location:

This class occurs throughout Sonoma County in riparian zones. It can be found on along the channels and on the flood plains of many of Sonoma County's perennial creeks and rivers.

Acres mapped countywide:	7,571	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:	68	User's Accuracy:	75%
Accuracy Assessment Reference Sites:	49	Producer's Accuracy:	90%



Ground View

Aerial View

NVC Association(s): *Abronia latifolia* - *Ambrosia chamissonis* Alliance, *Leymus mollis* Alliance

Description:

In this map class, native species, including *Abronia latifolia*, *Ambrosia chamissonis*, *Artemisia pycnocephala*, and/or *Leymus mollis* are dominant or co-dominant on dunes or bluffs. Plants are adapted to salt spray, wind and shifting sands and are, thus, capable of colonizing relatively unstable and sterile substrates.

Most Abundant Species: *Abronia latifolia*, *Ambrosia chamissonis*, *Artemisia pycnocephala*, *Leynus mollis*

Distribution / Location:

This small class is limited to a few patches on the coast on dunes or bluffs. Specific spots include Salmon Beach, Wright Beach, and Goat Rock Beach within Sonoma Coast State Beach area.

Acres mapped countywide:	24	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Vineyard

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

In this map class, area is a vineyard as observed in the Fall, 2013 imagery.

Most Abundant Species: NA

Distribution / Location:

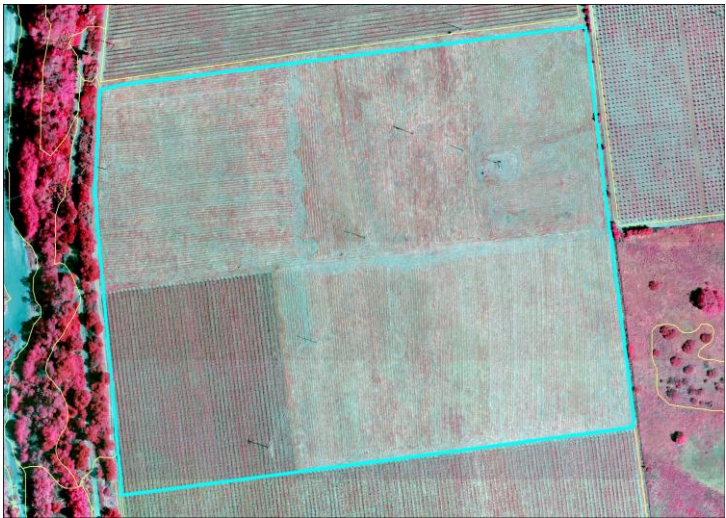
Although vineyards are planted throughout Sonoma County the largest concentrations are south of Sonoma (Carneros), throughout the Sonoma Valley, and throughout the Russian River and Alexander Valleys.

Acres mapped countywide:	62,930	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	30	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	32	Producer's Accuracy:	94%

Map Class: Vineyard Replant

Common Name: NA

No Image
Available



Ground View

Aerial View

NVC Association(s): NA

Description:

In this map class, area is a vineyard completely cleared for replanting. To be considered a "Vineyard Replant," an area must be planted with mature vines on the 2011 orthos and appear cleared in the 2013 orthos. If there is evidence that the area is being converted to another crop or land use, a bare land or herbaceous label is applied.

Most Abundant Species: NA

Distribution / Location:

Isolated occurrences in same locations as vineyards (see Vineyard).

Acres mapped countywide:	1,226	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed



Ground View

Aerial View

NVC Association(s): NA

Description:

In this map class, water covers the area as it appears in the fall, 2013 high resolution imagery.

Most Abundant Species: NA

Distribution / Location:

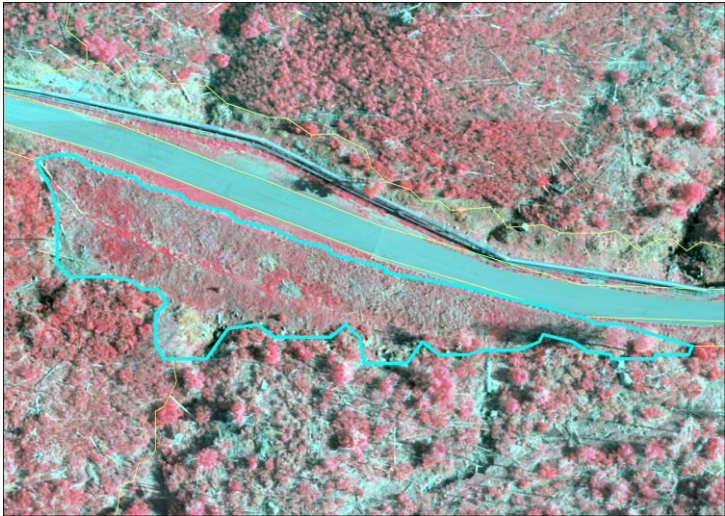
Major waterbodies in Sonoma County include San Pablo Bay wetlands, Petaluma River, Russian River, Lake Sonoma, and bays/inlets adjacent to Pacific Ocean.

Acres mapped countywide:	18,109	Global/State Rarity Rank:	NA
Accuracy Assessment Map Sites:	30	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	31	Producer's Accuracy:	97%

Map Class: Western Dry Upland Perennial Grassland Group

Common Name: NA

No Image Available



Ground View

Aerial View

NVC Association(s): Elymus (elymoides, multisetus) Provisional Alliance, Festuca idahoensis Alliance

Description:

In this map class, native, relatively drier, cool-temperate grasslands were dominated, co-dominated, or characterized by the following perennial grasses: Bromus carinatus, Elymus elymoides, E. glaucus, E. multisetus, Festuca californica, and/or F. idahoensis.

Most Abundant Species: Bromus carinatus, Elymus elymoides, E. glaucus, E. multisetus, Festuca californica, and/or F. idahoensis

Distribution / Location:

Just a single plot in the Mayacama Mountains near Lake County border.

Acres mapped countywide:	1	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class: Western North America Vernal Pool
Macrogroup

Common Name: NA



Ground View



Aerial View

NVC Association(s): NA

Description:

This map class includes depressional pools or vernally influenced marshes dominated by *Eleocharis macrostachya*, *Lasthenia glaberrima*, or *Pleuropogon californicus*. Vernal pool delineations for the Santa Rosa Plain were adapted and refined from the San Francisco Estuary Institute’s North Coast Aquatic Resource Inventory dataset.

Most Abundant Species: *Eleocharis macrostachya*, *Lasthenia glaberrima*, *Pleuropogon californicus*

Distribution / Location:

This class is mostly limited to the Santa Rosa Plain, where it occurs in complexes across throughout the low-lying areas of the plain. There are a few additional occurrences of this macrogroup in the Valley of the Moon.

Acres mapped countywide:	919	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:	1	User's Accuracy:	100%
Accuracy Assessment Reference Sites:	1	Producer's Accuracy:	100%

Map Class:

Western North American Freshwater Aquatic Vegetation Macrogroup

Common Name:

NA

No Image Available



Ground View

Aerial View

NVC Association(s):

NA

Description:

In this map class, floating aquatic vegetation dominates water surfaces. Azolla, Brasenias, Ceratophyllum, Lemna, Ludwigia, and/or Nuphar occur on the surfaces of streams, ponds or lakes in the fall, 2013 imagery.

Most Abundant Species: Multiple herbaceous species

Distribution / Location:

The largest occurrences of this macrogroup are in the Laguna de Santa Rosa. The map class occurs throughout the county, especially in lowlands where still water occurs and in and around the Santa Rosa Plain.

Acres mapped countywide:	359	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed

Map Class:

Western North American Freshwater Marsh Macrogroup

Common Name:

NA



NVC Association(s):

NA

Description:

In this map class, the mapping team mapped marsh and wet meadow vegetation evident in the fall, 2013 imagery. Stands dominated by *Argentina* spp., *Carex pansa*, *Carex obnupta*, *Carex praegracilis*, *Juncus effusus*, *Juncus lescurii*, *Juncus patens*, *Oenanthe* spp., *Schoenoplectus* spp., *Scirpus microcarpus* spp., and/or *Typha* spp.

Most Abundant Species:

Typha spp., *Juncus effusus*, *Juncus lescurii*, and/or *Juncus patens*, *Schoenoplectus acutus*, *Carex obnupta*, *Scirpus microcarpus*

Distribution / Location:

This class is found throughout many lowland and marsh areas throughout Sonoma County. The largest stands are located in southern Sonoma County.

Acres mapped countywide:	7,402	Global/State Rarity Rank:	Not ranked
Accuracy Assessment Map Sites:		User's Accuracy:	not assessed
Accuracy Assessment Reference Sites:		Producer's Accuracy:	not assessed