2024 Suisun Marsh Vegetation Map Update Solano County, California

October 2025

A Report to the California Department of Water Resources

Prepared by:
Geographical Information Center
North State Planning and Development Collective
California State University, Chico

Malak Saleh, Lead Biologist
Jaclyn Deloach, Biologist Interpreter
Kendra Cote, Biologist Interpreter
John Kelly, Biologist Interpreter
Kristin Quigley, Project Manager
Erik Fintel, Project Manager
Marian Furumi, Biologist Interpreter

California State University Chico
North State Planning and Development Collective

Executive Summary

This report summarizes the methods and results of the 2024 Suisun Marsh triennial vegetation map update. This update by the North State Planning and Development Collective at California State University, Chico, is part of an ongoing triennial vegetation monitoring program for the Suisun Marsh. The project tracks changes in the Suisun Marsh vegetation over time to fulfill specific requirements of the Suisun Marsh Plan of Protection of 1984, the Suisun Marsh Preservation Agreement of 1986, the 2015 Suisun Marsh Preservation Agreement, and associated regulatory permits. This is the eighth update using the current mapping standards originally implemented in 1999. All of the previous vegetation maps from 1999 to 2021 can be viewed and downloaded using the online California Department of Fish and Wildlife (CDFW) Biogeographic Information and Observation System (BIOS); the links to the associated reports are included in the map metadata. For detailed information regarding the history and evolution of this project, see Appendix A in the 2012 update report (Boul and Keeler-Wolf 2016).

The final map covers 91,486 acres, containing vegetation and land use polygons ranging from 0.001 acres to 418 acres and averaging 1.8 acres. The tidally influenced acreage is covered by 13,106 vegetation polygons; 36,392 vegetation polygons cover the leveed acreage.

The primary and secondary Salt Marsh Harvest Mouse (SMHM) habitat types listed in the Bay Delta Conservation Plan (DWR 2013) were used to calculate the potential habitat for SMHM. The 2024 triennial vegetation update suggests there are 50,608 acres of potential habitat in Suisun Marsh, with approximately 76% of this habitat in leveed areas, and the remaining habitat in tidally influenced areas. The leveed areas have seen a 9.6% decrease in potential habitat since 2021, and an overall 18% decrease since 1999 (Appendix F). The tidal areas of the Marsh have seen a 27% increase in potential SMHM habitat since 2021, with an overall 102.5% increase since 1999 (Appendix F). This increase can be attributed to previously leveed habitats becoming tidal due to levee breaks and demolitions. Over the entire marsh (in both tidal and leveed areas combined), potential habitat has decreased by 2.5% since 2021 and by 3.4% since 1999 (Appendix F).

The distribution and spread of non-native plant species of concern were also analyzed across the entire marsh, as well as within each of the four management regions identified in the Suisun Marsh Habitat Management, Preservation, and Restoration Plan. The non-native species of concern include: *Arundo donax, Carpobrotus edulis, Cortaderia selloana, Eucalyptus* spp*., Lepidium latifolium, Phragmites australis,* and *Salsola soda*. Comparisons were made between current distributions and the original 1999 map and the previous 2021 map. The most substantial increase occurred in *Phragmites australis*, the most widespread non-native species of concern in the Marsh. *P. australis* has increased from 693 acres in 1999 to 4,400 acres in 2021, and 5,551 acres in 2024. Full change analysis and discussion of each species can be found further on in this report.

Table of Contents

INTRODUCTION **1**

METHODS **4**

Field Data Collection 4
2024 Aerial Photograph Interpretation, Heads-up Digitizing, and Attributing 4
Mapping Rules 4
Map Attributes 4
Methods for Analysis 5
Accuracy Assessment 7

RESULTS **8**

Mapping 8
Vegetation Change Analysis 8
Salt Marsh Harvest Mouse Habitat *9*
Non-Native Species of Concern *12*

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS **21**

Salt Marsh Harvest Mouse Habitat ..... ***Error! Bookmark not defined.***
Change in Tidal Habitat *21*
Non-Native Species of Concern *23*
Changes in Slough Cover ..... ***Error! Bookmark not defined.***
Future Mapping Efforts 27

LITERATURE CITED **27**

Tables

Table 1: Total acreage and polygons mapped in the 2024 Suisun Map Update **8**
Table 2: Change in Proportions of Salt Marsh Harvest Mouse Habitat from 2021 to 2024 ..... **24**
Table 3: Proportional Cover of Non-Native Species of Concern by Region and Marsh-wide **26**

Figures

Figure 1: Location of the Suisun Marsh study area. **1**
Figure 2: A map showing the four geographic management regions (0-4) in the Suisun Marsh. **7**
Figure 3: The acreage and distribution of potential SMHM habitat **9**
Figure 4: 2024 Salt Marsh Harvest Mouse habitat by region and habitat type (leveed or tidal) **10**
Figure 5: Acreages of the less abundant non-native species of concern from 2015 to 2024. ..... **12**
Figure 6: Acreages of the more abundant non-native species of concern from 2015 to 2024 ..... **13**
Figure 7: Arundo donax distribution by region between 1999, 2015, 2018, 2021, and 2024. ..... **14**
Figure 8: Carpobrotus edulis distribution by region between 1999, 2015, 2018, 2021, and 2024 ..... **15**
Figure 9: Cortaderia selloana distribution by region between 1999, 2015, 2018, 2021, and 2024. ..... **15**
Figure 10: Eucalyptus spp. distribution by region between 1999, 2015, 2018, 2021, and 2024. ..... **16**
Figure 11: Lepidium latifolium distribution by region between 1999, 2015, 2018, 2021, and 2024. ..... **16**
Figure 12: Phragmites australis distribution by region between 1999, 2015, 2018, 2021, and 2024 ..... **17**
Figure 13: Salsola soda distribution by region between 1999, 2015, 2018, 2021, and 2024. ..... **17**

Figure 14: Levee breaks occurred between 2021 and 2024, allowing flooding of previously leveed habitat at Van Sickle Island and Bradmoore Island. 21

Appendices

Appendix A: Suisun Marsh Vegetation Classification and Hierarchy

Appendix B: Vegetation Type Descriptions in Suisun Marsh

Appendix C: Map Classes Used to Map Suisun Marsh

Appendix D: 2024 Vegetation Mapping Attributes and Descriptions

Appendix E: Salt Marsh Harvest Mouse Habitat by Vegetation Mapping Type

Appendix F: Acreage and Acreage Change of Salt Marsh Harvest Mouse Habitat

Appendix G: Acreage and Acreage Change of the Non-Native Species of Concern

Appendix H: Reconnaissance Field Form and Protocol

Introduction

Note: This introduction is credited to CDFW's Vegetation Classification and Mapping Program (VegCAMP_2018).

The Suisun Marsh is located in Solano County, CA, and is part of the San Francisco Bay / Sacramento–San Joaquin River Delta estuary ecosystem (Figure 1). It is one of the largest contiguous brackish marshes remaining in the United States, covering over 69,000 acres of tidal and managed seasonal wetlands. This Marsh is a key wintering area for waterfowl and supports several sensitive plant and animal species. Since 1999, the Marsh has experienced significant variations in salinity conditions, including prolonged droughts. Plant communities can be expected to change over time due to these natural environmental factors, but also from direct management activities such as flooding regime changes, weed control, and plantings, as well as from accidental introductions of invasive weeds and levee breaches.

Figure 1: Location of the Suisun Marsh study area.

As part of the monitoring program in the Plan of Protection for Suisun Marsh and as required in the 1981 US Fish and Wildlife Service Biological Opinion, a Triennial Vegetation Survey is necessary to monitor changes in Salt Marsh Harvest Mouse (SMHM) habitat. The current methodology for this survey was adopted in 1999 (Keeler-Wolf and Vaghti 2000) and uses aerial photography in combination with ground verification to document the overall vegetation composition of the Marsh and to monitor SMHM habitat. The methodology documents the changes in preferred habitat for the SMHM and gathers vegetation information for a variety of other purposes.

This methodology followed the National Vegetation Classification (NVC) standards and resulted in a vegetation classification based on quantitative vegetation sampling (Appendix A). The vegetation classification was used to create vegetation type descriptions (Appendix B) and a mapping classification (Appendix C). While the mapping classification is based on the vegetation classification, the mapping classification is limited by what is discernible from the aerial imagery. It also includes mapping units that are not currently accepted NVC vegetation types and mapping units that represent land use or non-vegetated types. Since the 1999 map, there have been updates in 2000, 2003, 2006, 2009, 2012, 2015, and 2018. This report documents changes based on the 2021 vegetation map update.

As requested by the Department of Water Resources (DWR) and with CDFW Bay Delta Region agreement, for each map update, vegetation change has been analyzed for tidal wetlands, leveed wetlands, and marsh-wide. Tidal wetlands (including muted tidal wetlands) are those areas naturally affected by regular tidal fluctuation. These areas may or may not be vegetated with vascular or non-vascular plants, and may or may not have any evidence of human modification such as ditches, excavations, levees, or berms. The levee-managed wetlands are those areas that are completely enclosed by exterior levees, with water application and drainage controlled through water management infrastructure.

The 2000 remap effort (Vaghti and Keeler-Wolf 2001) was an exploratory change detection study designed to define significant changes in vegetation in the Suisun Marsh ecosystem. Less than 1% of the polygons changed between June 16, 1999, and July 2, 2000. These minor changes included a net loss of 65 acres for *Salicornia pacifica* vegetation types, an 18-acre increase in vegetation dominated by *Lepidium latifolium*, and a 143-acre decrease in Annual Grasses. From this exploratory change detection, it was determined that the map update process would occur every three years.

The 2003 remap effort (Vaghti and Keeler-Wolf 2004) showed a 16.8% change in the vegetation across the entire study area since the 1999 product. Medium Wetland Graminoids, *Bolboschoenus maritimus*, Short Wetland Herbs, Medium Wetland Herbs, and *Bolboschoenus maritimus* – *Salicornia pacifica* were the five types with the greatest increase in acreage. *Distichlis spicata, Salicornia, Distichlis spicata* – Annual Grasses, *Distichlis spicata* – *Salicornia pacifica*, and Open Water were the five types with the greatest decrease in acreage over the study period. Also determined was a 16.7% change in leveed wetland vegetation and a 17.2% change in tidal wetland vegetation.

The 2006 remap study (Boul and Keeler-Wolf 2008) used the 1999 vegetation map as the baseline and followed the 2000 and 2003 change detection methodology. Several vegetation changes found in the 2006 update were of note: 1) a 174% increase in flooded wetlands (due to severe storms resulting in levee breaches), 2) a net loss of 945 acres of *Salicornia pacifica* vegetation types since 1999, 3) a net gain of 780 acres of *Phragmites australis* since 1999, 580 acres of which established since 2003, and 4) acreage decrease or stabilization of several of the non-native species of concern. Several issues with the remapping process and change detection protocol emerged, and VegCAMP suggested changes to the protocol. These were implemented in the 2009 vegetation remap.

The 2009 remap study (VegCAMP 2012) used an updated protocol developed to accommodate advances in available technology and mitigate past inconsistencies; polygon modification was discontinued, and

polygons were instead mapped anew, without using previous linework. The protocol update is discussed in detail in Appendix A in Boul and Keeler-Wolf (2016). The 2009 remap showed that potential Salt Marsh Harvest Mouse habitat (*Salicornia pacifica* dominated vegetation) had increased since 1999 and that two non-native species of concern, *Phragmites australis,* and *Lepidium latifolium*, were still increasing within the Marsh. Interestingly, in the leveed areas of the Marsh, both *Phragmites australis* and *Salicornia pacifica* vegetation seemed to be increasing the most where there had been open water in 2006.

The 2012 remap study (Boul and Keeler-Wolf 2016) showed a marsh-wide 7% increase in potential habitat for SMHM since 2009 and a 1% increase since 1999. By 2012, *Phragmites australis* had increased threefold in acreage since the first map in 1999. The increase was and has been presumed to be in the non-native genotype. Stands dominated by *Lepidium latifolium* showed a marsh-wide decrease in total acreage since 1999, but showed a 63% increase in the tidal habitats of the Marsh.

The 2015 remap study (VegCAMP_2018) showed a marsh-wide 3.9% decrease in potential habitat for SMHM since 2012 and a 7.3% decrease since 2009. From 2012 to 2015, the non-native *Phragmites australis* increased 18.5% marsh-wide, with a total increase of 325% (2,254 acres) since 1999. *Lepidium latifolium* acreage increased by 45% from 2012 to 2015. This remap also evaluated the potential use of satellite imagery instead of high-resolution imagery acquired by DWR for the mapping effort, but determined that the lower-resolution satellite imagery taken at an uncontrolled time of day, year, and tidal stage made it unsuitable for the triennial map update.

The 2018 remap study (GIC 2022) found a 12.4% increase in SMHM habitat since 2015 and a 4.2% increase since 1999. The study found a 46% increase in invasive *Phragmites australis* cover throughout the entire marsh from 2015 to 2018, and a total increase of 520% (3,603 acres) since 1999. *Lepidium latifolium* acreage increased by 90% from 2015 to 2018 but experienced an overall 68% decrease in cover since 1999.

The 2021 remap study showed an overall decrease in SMHM habitat since 2018. Overall, there was a decrease of 2,444 acres (a 5% decrease), with a majority observed in leveed areas, where there was a 2,640-acre decrease, which reflects a 6.6% decrease in leveed habitat. The amount of tidal habitat increased by 196 acres or 2.23%. The findings of the 2021 map indicated there was a 0.9% decrease in habitat since 1999.

This 2024 remap showed an overall decrease in SMHM habitat since 2021. Marsh-wide, there was a decrease of 1,167 acres (2.5%) of potential SMHM habitat (Appendix F). The majority of habitat loss was observed in leveed areas, where there was a 3,615-acre decrease, which reflects a 9.6% decrease in leveed habitat (Appendix F). The amount of tidal habitat increased by 2,448 acres (27%). The findings of the 2024 map indicated there was a 3.4% decrease in habitat since 1999.

Methods

Field Data Collection

This mapping cycle included the collection of 300 reconnaissance points that were collected from May through August of 2024. Map interpreters use these points to discern vegetative signatures and guide mapping type determinations of map polygons. The field data collection form and protocol can be found in Appendix H.

2024 Aerial Photograph Interpretation, Heads-up Digitizing, and Attributing

To create the 2024 Suisun Marsh vegetation map, vegetation was interpreted from a mosaic of the true color imagery that was flown in June 2024. Polygons were delineated using heads-up digitizing (i.e., a photo interpreter manually drew polygons around each stand of vegetation) in Esri's ArcGIS Pro 3.4.0, and polygon attributes were recorded within a file geodatabase.

All attributes were interpreted using the Suisun Marsh 2024 imagery as the base imagery. The photo interpreters obtained information primarily from the 2021 map and 2024 reconnaissance points, which were used during mapping to determine vegetative signatures and the appropriate mapping type for each polygon. Several other imagery sources were used as ancillary data, including 2024 NAIP, 2024 NAIP Color Infrared, all imagery available through Google Earth (including street view), and the 2021 NAIP imagery.

Mapping Rules

Minimum mapping unit (MMU): Typically, the minimum mapping size is 0.25 acres. However, the photo interpreters use their best judgment to determine if a stand below 0.25 acre should be separately delineated. For example, a smaller polygon would be appropriate for any new visible occurrence of a non-native species of concern, such as *Phragmites australis, Arundo donax, Carpobrotus edulis, Eucalyptus* spp., and *Lepidium latifolium*.

Minimum mapping width: There are many long and narrow polygons within the Suisun Marsh study area, most of which are roads, ditches, levees, and sloughs. The minimum mapping width is typically 10 feet; however, if small sections of a stand fell below the minimum width, the polygon was not split.

Map Attributes

The vegetation mapping classification used for this project is based on the vegetation classification created in 1999 (Keeler-Wolf and Vaghti 2000). The names of the mapping units have been updated over the years to reflect current nomenclature and/or current understanding of vegetation classification. The same map classes for the 2024 map that were used for the 2015, 2018, and 2021 maps, with the addition of one new mapping unit (*Bidens cernua - Euthamia occidentalis - Ludwigia palustris* Herbaceous Alliance), which had not been used in previous mapping efforts. This new mapping

unit was added as a result of the 2024 reconnaissance survey data, as this alliance had not been surveyed in past mapping efforts. See Appendix C for a list of all the mapping types.

In addition to the mapping unit, several other attributes are assigned to each polygon. These attributes include percent vegetation cover, average vegetation height, degree of human disturbance, relative cover of invasive species, and habitat type (tidal versus leveed). For more information about each attribute, see Appendix D.

Methods for Analysis

As previously mentioned, DWR and CDFW Bay Delta Region have requested that a change analysis be done for tidal wetlands, leveed (managed) wetlands, and marsh-wide. To determine the areas within the marsh that are tidally influenced versus areas that are leveed (or managed), the 2021 remap habitat attribute was used as a reference. This was determined originally from a shapefile created by CDFW in 2008 (VegCAMP_2018). For the current remap, the polygons that were contained completely within areas that were called tidal habitat in 2021 were given the tidal habitat attribute again, and tidal areas are reverified for each map iteration. Polygons that were completely within the leveed habitat in 2021 were given the leveed habitat attribute after confirmation by a photo interpreter that the general area was still leveed. Additionally, the map was reviewed for levee breaks or levee additions that may have altered the habitat attribute. Sloughs were attributed separately and were not given a habitat type.

The vegetation map was checked for changes in stand-forming non-native species of concern between 1999 and 2024 and between 2021 and 2024. The analysis was performed marsh-wide (total area, leveed habitats, and tidal habitats) and within the four management regions (total area, leveed habitats, and tidal habitats). The non-native species of concern are as follows: *Arundo donax, Carpobrotus edulis, Cortaderia selloana, Eucalyptus* species*, Lepidium latifolium*, *Phragmites australis* (predominantly the non-native strain), and *Salsola soda*. These species are represented by the following mapping units:

Arundo donax Herbaceous Semi-Natural Association
Carpobrotus edulis or Other Ice Plants Herbaceous Semi-Natural Alliance
Cortaderia (jubata, selloana) Herbaceous Semi-Natural Alliance
Eucalyptus (globulus, camaldulensis) Woodland Semi-Natural Alliance
Lepidium latifolium Herbaceous Semi-Natural Alliance
Phragmites australis Herbaceous Alliance
Salsola soda Mapping Unit

At the time of the 2000 and 2003 Suisun Marsh vegetation change detection, less specific information was known about the habitat requirements for the protected Salt Marsh Harvest Mouse (*Reithrodontomys raviventris halicoetes*) in Suisun Marsh. Ten *Salicornia pacifica* (or “pickleweed”) vegetation types or mapping units were collectively considered important habitat for the Salt Marsh Harvest Mouse (SMHM) in 2003 (Vaghti and Keeler-Wolf 2004). Since then, biologists have gained a better understanding of the habitat requirements of the SMHM and have considerably broadened the definition of what is considered SMHM habitat. The vegetation types that are considered SMHM habitat

were updated in both 2013 and 2015. This report and the previous 2021 report use the 2013 habitat types. The updated 2015 habitat types include designating low-, medium-, and high-quality habitat, and will be beneficial to use in future reports, although the change in what is considered habitat will affect true change analysis for future remaps. See Appendix E for the full list of mapping units that are considered potential SMHM habitat in this report.

Vegetation change detection analysis for SMHM habitat and non-native species of concern was performed marsh-wide (separately for the total area, leveed areas, and tidal areas) and for each of the four management regions shown in Figure 2 (separately for the total area, leveed areas, and tidal areas). The percent change (acreage) was calculated using the following formula:

$$\frac{(\text{Current Year Acreage} - \text{Previous Acreage})}{\text{Previous Acreage}} * 100$$

See Appendices F and G for vegetation change in the SMHM habitat and non-native species of concern.

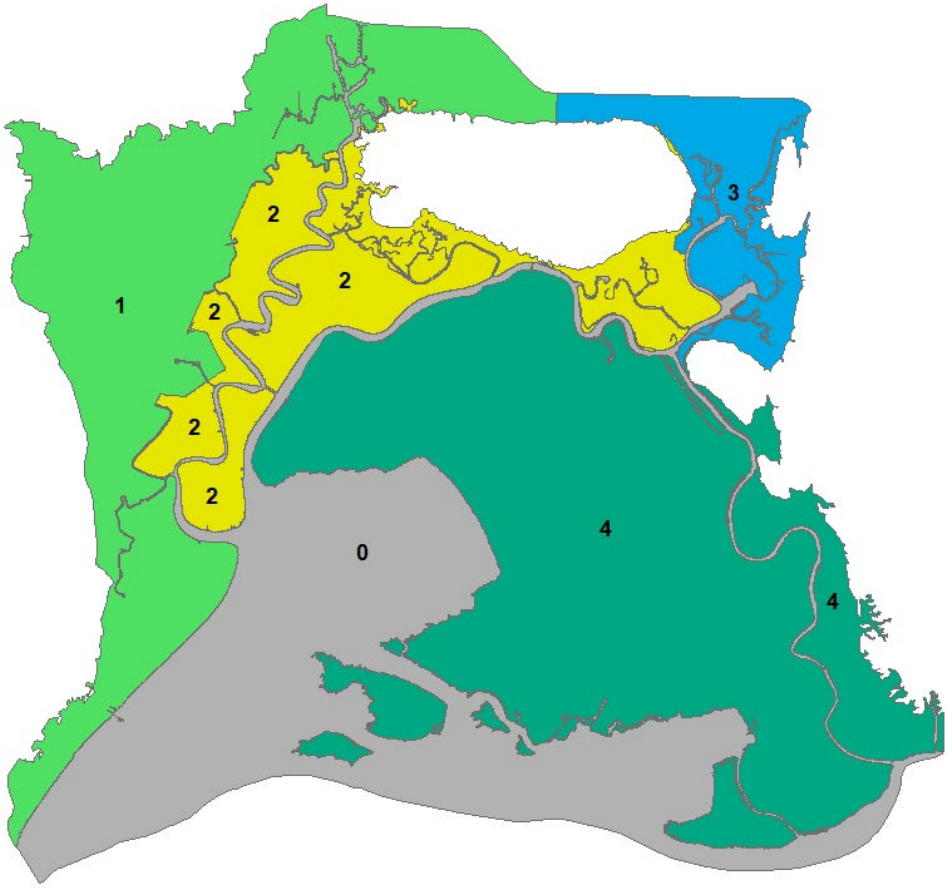


Figure 2: A map showing the four geographic management regions (0-4) in the Suisun Marsh.

'0' refers to areas outside of a defined management region.

Accuracy Assessment

For the 2021 remap, an Accuracy Assessment was not performed due to delays between the imagery flight date (June 2024) and the completion of the map (April 2025). Ideally, due to the fluctuating nature of the Marsh's vegetation, an Accuracy Assessment should be conducted no later than one year after the imagery was taken. A thorough Accuracy Assessment was most recently conducted for the 2015 remap. For detailed methodology and results, see VegCAMP_2018.

Results

Mapping

The mapped project area in 2024 was 91,486 acres, covering the same area as the 2021 mapping effort. The Suisun Bay made up 23.9% of this area, tidal sloughs made up 3.2%, and areas mapped as vegetation or land use (such as roads or development) made up 72.9%. Of the vegetation and land use area, 27.3% was tidally influenced, and the rest was leveed.

The current map consists of 49,531 polygons, while the 2021 map had 39,643 polygons. The total mapped acreage of vegetation changes slightly with each map update due to the tide level at the time the imagery was acquired and channel erosion or accretion since the area was last mapped.

Table 1: Total acreage and polygons mapped in the 2024 Suisun Map Update. This table is based on the values in the "habitat" attribute.

Area mapped as:	Acres	Polygons
Suisun Bay	21,882	1
Sloughs	2,954	32
Tidal vegetation/land use	18,204	13,106
Leveed vegetation/land use	48,446	36,392
Total project area	**91,486**	**49,531**

Vegetation Change Analysis

The changes in Salt Marsh Harvest Mouse habitat and non-native species of concern were analyzed marsh-wide from 2021 to 2024. Changes from 1999 to 2024 are also discussed, and data from the 2015 and 2018 map studies were included for comparison purposes. These year-to-year comparisons are straightforward, as the total area designated as Suisun Marsh has remained static from 1999 to 2024. SMHM habitat and non-native species changes were also analyzed within each of the four management regions.

Salt Marsh Harvest Mouse Habitat

Marsh-wide

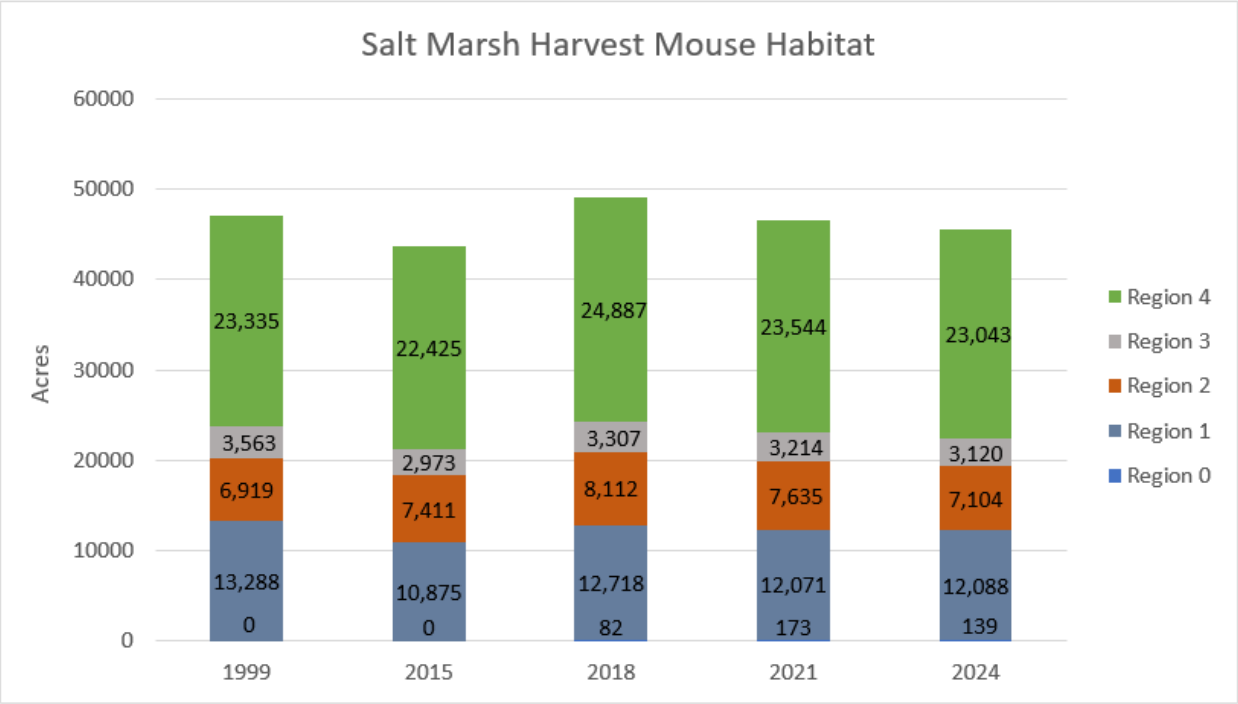


Figure 3: The acreage and distribution across the four management regions for the potential Salt Marsh Harvest Mouse habitat mapped within the Suisun Marsh triennial vegetation maps in 1999, 2015, 2018, 2021, and 2024.

Of the 66,650 acres of vegetation/land use (total area excluding sloughs and Suisun Bay) mapped in the Marsh in 2024, 68% (45,495 acres) is considered potential SMHM habitat, an overall decrease of 3% since 2021 (Figure 3). SMHM habitat comprises 63% of the tidal vegetation/land use areas and 70% of the leveed areas.

Excluding the non-native *Phragmites australis*, which has been used by SMHM and is considered low-quality habitat, there are 39,944 acres of habitat throughout the Marsh. In 2021, Phragmites accounted for 9.5% of SMHM habitat, and in 2024, it accounted for 12%.

There are 11,454.95 acres of SMHM habitat in tidal areas throughout the marsh, an increase of 27% since 2021 and 103% since 1999 (Appendix F). *Schoenoplectus* (*acutus*, *californicus*) mapping units (including *Schoenoplectus* mixed with *Rosa*, wetland herbs, and *Typha*) account for 3,976 acres of tidal habitat (35%, compared to 42% in 2021). *Phragmites* accounts for 3,291 acres of tidal habitat (increasing from 21% to 29% since 2021). *Distichlis* mapping units (including *Distichlis* mixed with annual grasses, *Cotula*, *Juncus*, *Salicornia*, and *Schoenoplectus americanus*) account for 1,374 acres of tidal habitat (12%, compared to 14% in 2021). *Schoenoplectus americanus* mapping units (including when mixed with *Lepidium*) account for 1,438 acres of tidal habitat (decreasing from 15% in 2021, to 13% in 2024). These four vegetation types (*Schoenoplectus acutus/californicus*, *Phragmites, Distichlis*, and *Schoenoplectus americanus*) account for 88% of all tidal habitat acreage in 2024, a decrease of 5% since 2021.

There are 34,040 acres of SMHM habitat in leveed areas throughout the marsh, a decrease of 9.6% since 2021 and a decrease of 17.9% since 1999 (Appendix F). *Salicornia pacifica* mapping units (including *Salicornia* mixed with annual grasses, *Cotula*, *Crypsis*, and *Sesuvium*) account for 13,684 acres of leveed habitat (staying at since 2021). *Distichlis* mapping units account for 6,019 acres of leveed habitat (remaining at 18% since 2021). Mediterranean California Naturalized Annual and Perennial Grassland accounts for 4,989 acres of leveed habitat (15%, compared to 16% in 2021). The California Vernal Pool and Grassland Matrix Group accounts for 658 acres of leveed habitat, or 2% of total leveed habitat. *Phragmites* accounts for 2,260 acres of leveed habitat (remaining at 7% in 2024). *Schoenoplectus* (*acutus*, *californicus*) mapping units account for 1,737 acres of leveed habitat (decreasing from 6% in 2021 to 5% in 2024). These six vegetation types (*Salicornia*, *Distichlis*, grassland, vernal pools, *Phragmites*, and *Schoenoplectus acutus/californicus*) account for 86% of all leveed habitat acreage in 2024 (88% in 2021).

By management region

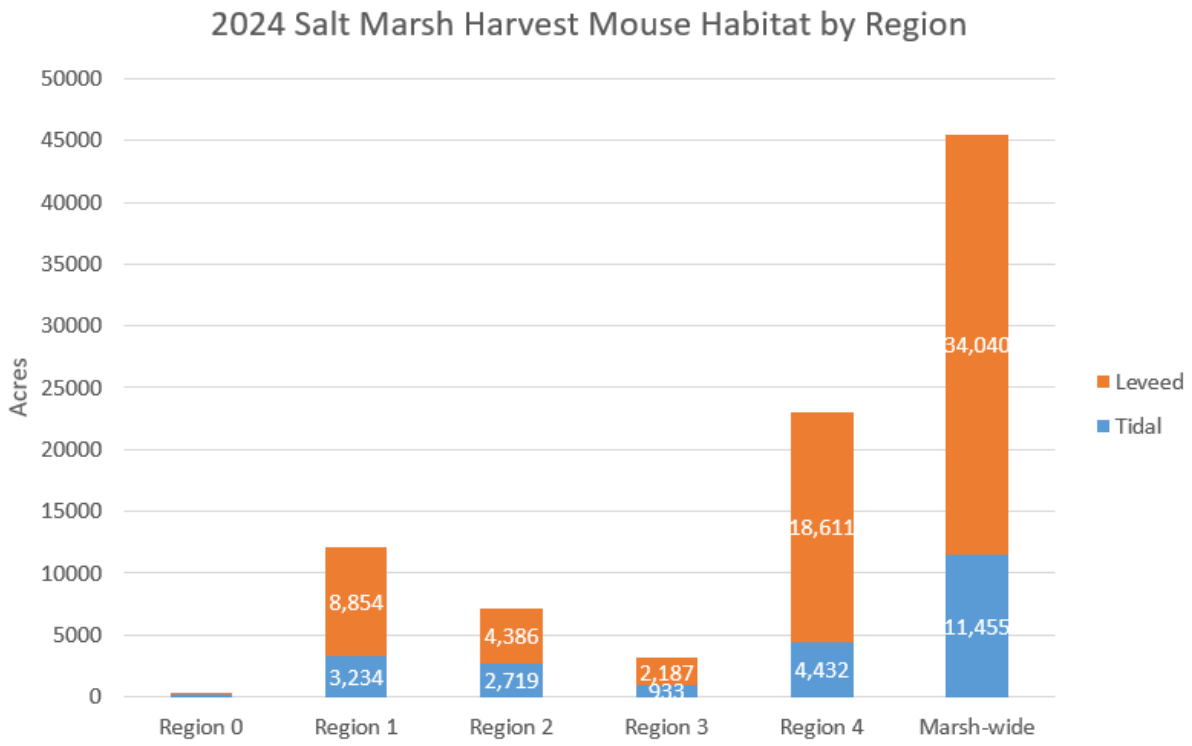


Figure 4: 2024 Salt Marsh Harvest Mouse habitat by region and habitat type (leveed or tidal)

Region 0:

Management Region 0 covers 25,024 acres, the vast majority of which are open water (21,436 acres) and slough cover (2,489 acres). The boundaries of this region contain just 2.26 acres of leveed SMHM habitat and 134 acres of tidal habitat (Figure 4). Tidal habitat in this region has decreased by 19% since

2021, when there were 170 acres of tidal habitat in this region. *Schoenoplectus* (*acutus*, *californicus*) mapping units occupy 95 acres (69%) of the tidal habitat in this region. *Phragmites* accounts for 24 acres (18%) of the habitat in this region.

Region 1:

Management Region 1 covers 18,988 acres. This region contains 12,088 acres (27%) of the SMHM habitat in the Marsh (Figure 3). Habitat in this region has increased by 17 acres since 2021, when there were 12,071 acres. 73% of the SMHM habitat of this region is in the leveed areas (8,854 acres), where it has decreased by 535 acres (6%) since 2021 (Appendix F). In the tidal areas, habitat has seen an increase from 2,682 acres in 2021 to 3,232 acres in 2021 (an increase of 21% over the 3 years). This increase in tidal habitat can be attributed to intentional and unintentional flooding of previously leveed areas. Total SMHM habitat has increased by 0.14% since 1999 in this region. *Phragmites* accounts for 1,230 acres (6.5%) of the habitat in this region (Appendix G).

Region 2:

Management Region 2 covers 9,958 acres. This region contains 7,104 acres (16%) of the SMHM habitat in the Marsh (Appendix F). Habitat has decreased by 7% (530 acres) since 2021, when there were 7,635 acres. 62% of the SMHM habitat of this region is in the leveed areas (4,386 acres), where it has decreased by 1,089 acres (20%) since 2021 (Figure 4). In the tidal areas, habitat has increased from 2,160 acres in 2021 to 2,719 acres in 2024 (a 26% increase). Total SMHM habitat has decreased by 3% since 1999 in this region (Appendix F). *Phragmites* accounts for 756 acres (11%) of the habitat in this region (Appendix G).

Region 3:

Management Region 3 covers 4,720 acres. This region contains 3,120 acres (7%) of the SMHM habitat in the Marsh (Figure 3). Habitat has decreased by 3% (93 acres) since 2021, when there were 3,213 acres (Appendix F). 70% of the SMHM habitat of this region is in the leveed areas (2,187 acres), where it has decreased by 270 acres (11%) since 2021 (Figure 4). In the tidal areas, habitat has increased from 757 acres in 2021 to 933 acres in 2024 (a 23% increase). This increase in tidal habitat can be attributed to flooding of previously leveed areas. Total SMHM habitat has decreased by 12% since 1999 in this region (Appendix F). *Phragmites* accounts for 318 acres (10%) of the habitat in this region (Appendix G).

Region 4:

Management Region 4 covers 32,796 acres. This region contains 23,043 acres (51%) of the SMHM habitat in the marsh (Figure 3). Habitat has decreased by 2% (500 acres) since 2021, when there were 23,543 acres (Appendix F). 81% of the SMHM habitat of this region is in the leveed areas (18,611 acres), where it has decreased by 1,312 acres (8%) since 2021. In the tidal areas, habitat has increased from 3,237 acres in 2021 to 4,432 acres in 2024 (an increase of 37%). This increase in tidal habitat is due to intentional and unintentional flooding of previously leveed areas. Total SMHM habitat has decreased by 1% since 1999 in this region. *Phragmites* accounts for 3,229 acres (14%) of the habitat in this region (Appendix G).

Non-Native Species of Concern

Change detection results for non-native species of concern are presented in Appendix G and are summarized or highlighted in the figure and discussion below.

Marsh-wide

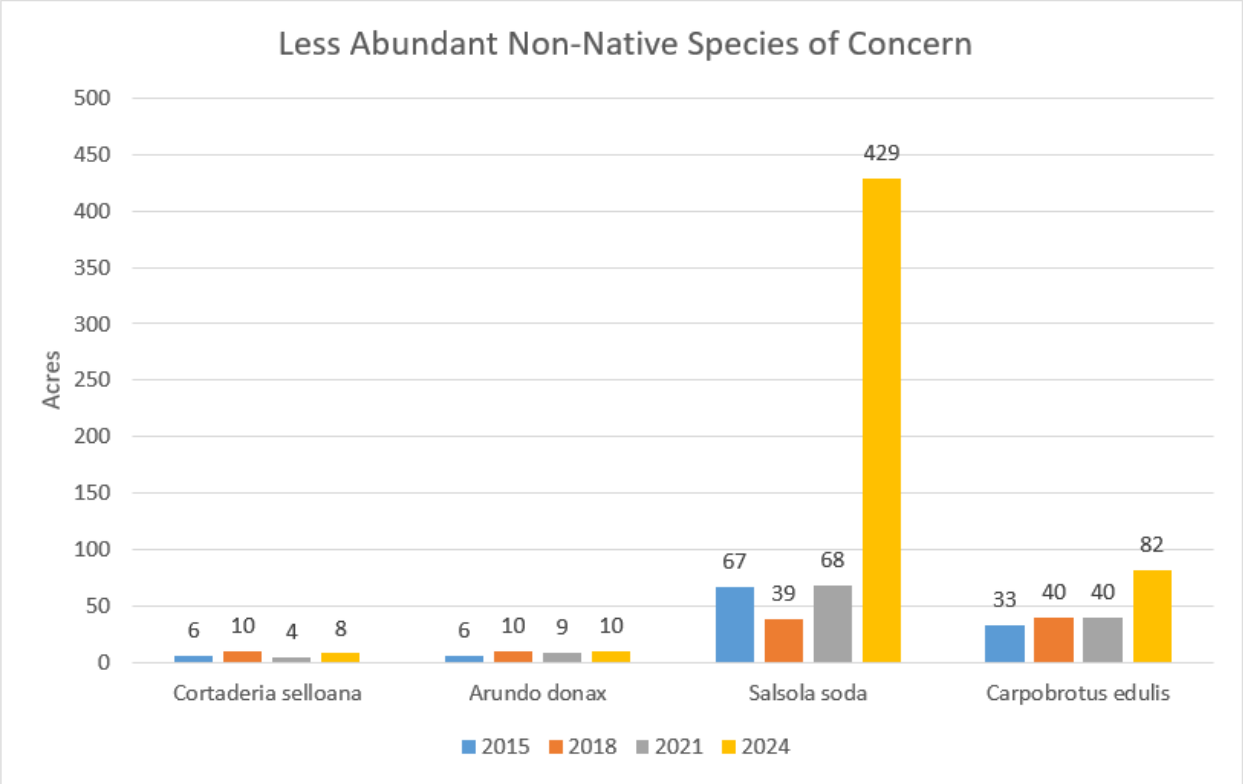


Figure 5: Acreages of the less abundant non-native species of concern between 2015, 2018, 2021, and 2024.

Cortaderia selloana has increased from 4 acres in 2021 to 8 acres in 2024, rising above the 6 acres mapped in 2015 (Figure 5). 3.4 acres occur in leveed areas (a 10% increase since 2021) and the remaining 4.6 acres are in tidal areas (a 115%% increase since 2021).

Arundo donax has increased by 1 acre since 2021 marsh-wide. There are currently 10 total acres; 6 acres are in leveed areas (a 20% increase since 2021), and 4 acres are in tidal areas (remaining the same since 2021). In 1999, there were 4.7 acres total throughout the marsh. There is no minimum mapping unit (MMU) for invasive species, meaning there are mapped polygons of *Arundo donax* that cover less than 0.25 acres.

Of the four "less abundant non-native species of concern," Salsola *soda* has increased by the greatest margin. *Salsola* cover increased from 68 acres in 2021 to 429 acres in 2024 (Figure 6). Over the three-year period, marsh-wide cover of Salsola soda increased by 630%. This is the largest percent change of any non-native species of concern in the Marsh since the 2021 remap. Improvements in both imagery and field data allowed mappers to more easily identify the aerial signature of *Salsola soda,* which in

previous years had been difficult to differentiate from the signature of *Salicornia pacifica.* It may be that Salsola cover was under-reported in previous years due to imagery quality issues.

Carpobrotus edulis increased from 40 acres in 2021 to 82 acres in 2024 (Figure 5). This species has seen a 105% increase over the 3-year period.

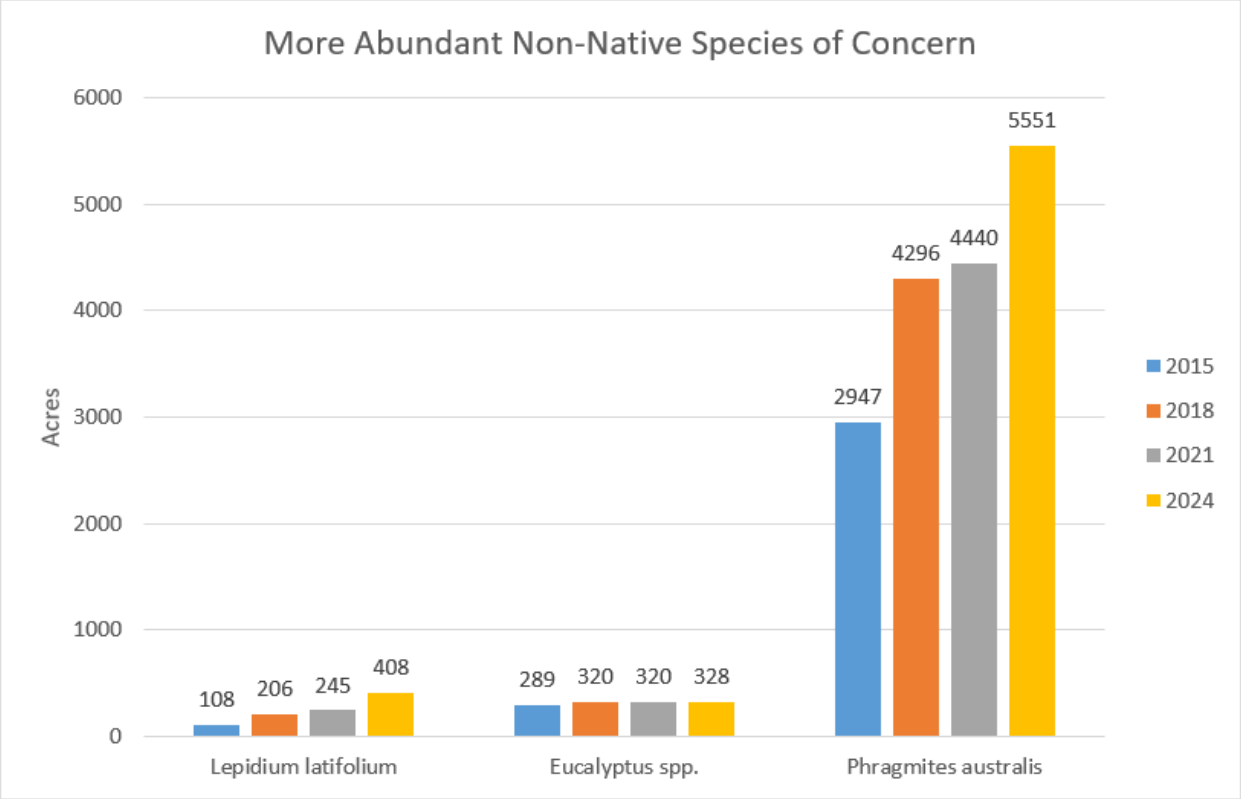


Figure 6: Acreages of the more abundant non-native species of concern between 2015, 2018, 2021, and 2024.

Mapped stands of *Eucalyptus* spp. increased from 208.1 acres in 1999 to 328 acres in 2024, an increase of 63%, with an 8-acre increase from 2021 to 2024 (Appendix G). 287 of the 328 acres occur in leveed areas.

In 2021, there were 245 acres of *L. latifolium* mapped, which increased to 408 acres in 2024, a 60% increase over three years (Figure 6). 328 acres occur in leveed areas and 80 acres occur in tidal areas. In 1999, there were 646.4 acres of the *Lepidium* mapping unit, indicating a 37% decrease overall from 1999 to 2024 (Appendix G).

The non-native variety of *Phragmites australis* is the most widespread non-native species of concern in the marsh (Figure 6). This and the previous mapping efforts do not distinguish between the native and non-native forms; however, what is mapped as the *Phragmites australis* mapping unit is presumed to be the non-native form, which forms dense, monotypic stands. Since 1999, *P. australis* has increased by 801% over the entire marsh, from 693.1 acres in 1999 to 5,551 acres in 2024 (Appendix G). In 2021,

there were 4,296 acres mapped, for an increase of 25% over three years. As of 2024 *P. australis* covered 2,260 acres (4.7%) of the leveed marsh (a 0.1% increase since 2021) and 3,290.8 acres (18.1%) of the vegetation/land use tidal marsh (a 1% increase since 2021).

Non-native species abundance by management region: The change detection results for non-native species of concern are presented in Figures 7-13 as well as in Appendix G and are summarized or highlighted in the discussion below.

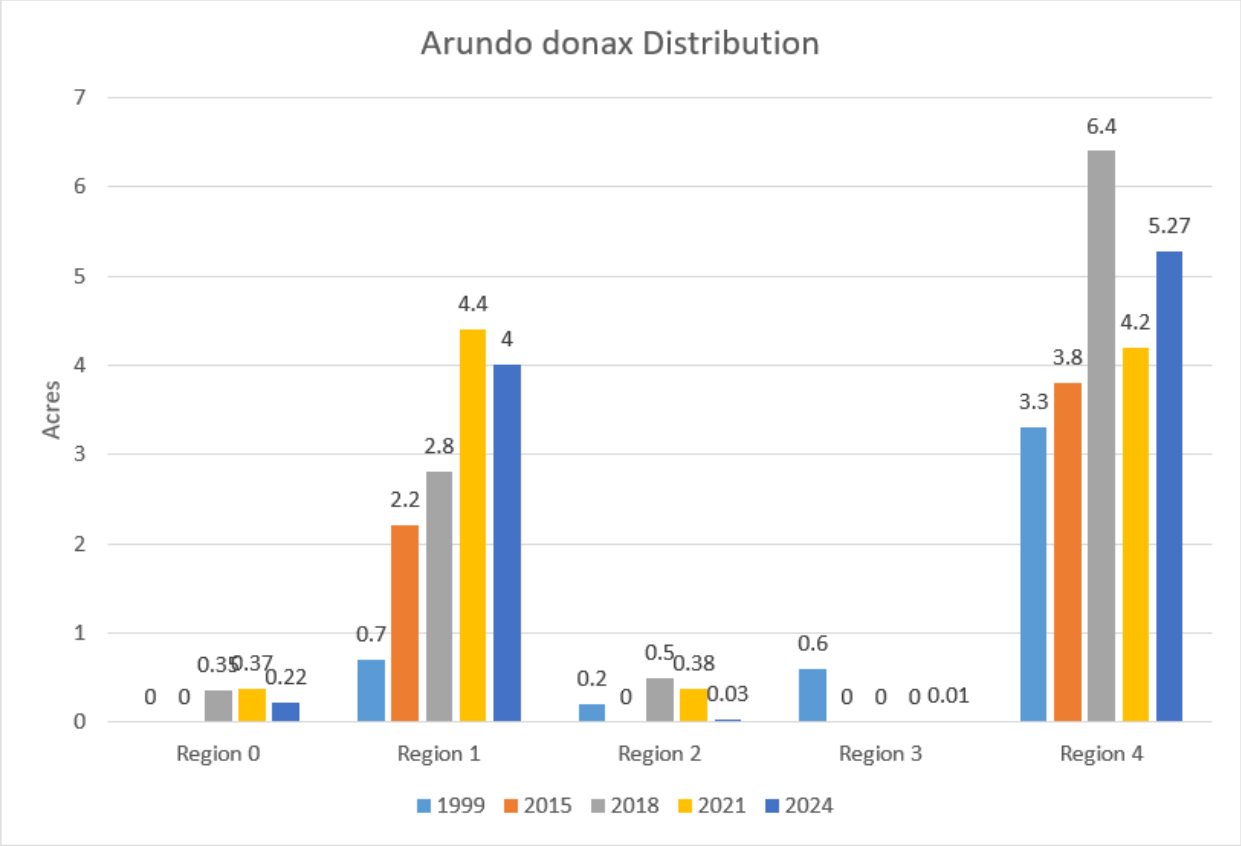


Figure 7: *Arundo donax* distribution by management region between 1999, 2015, 2018, 2021, and 2024.

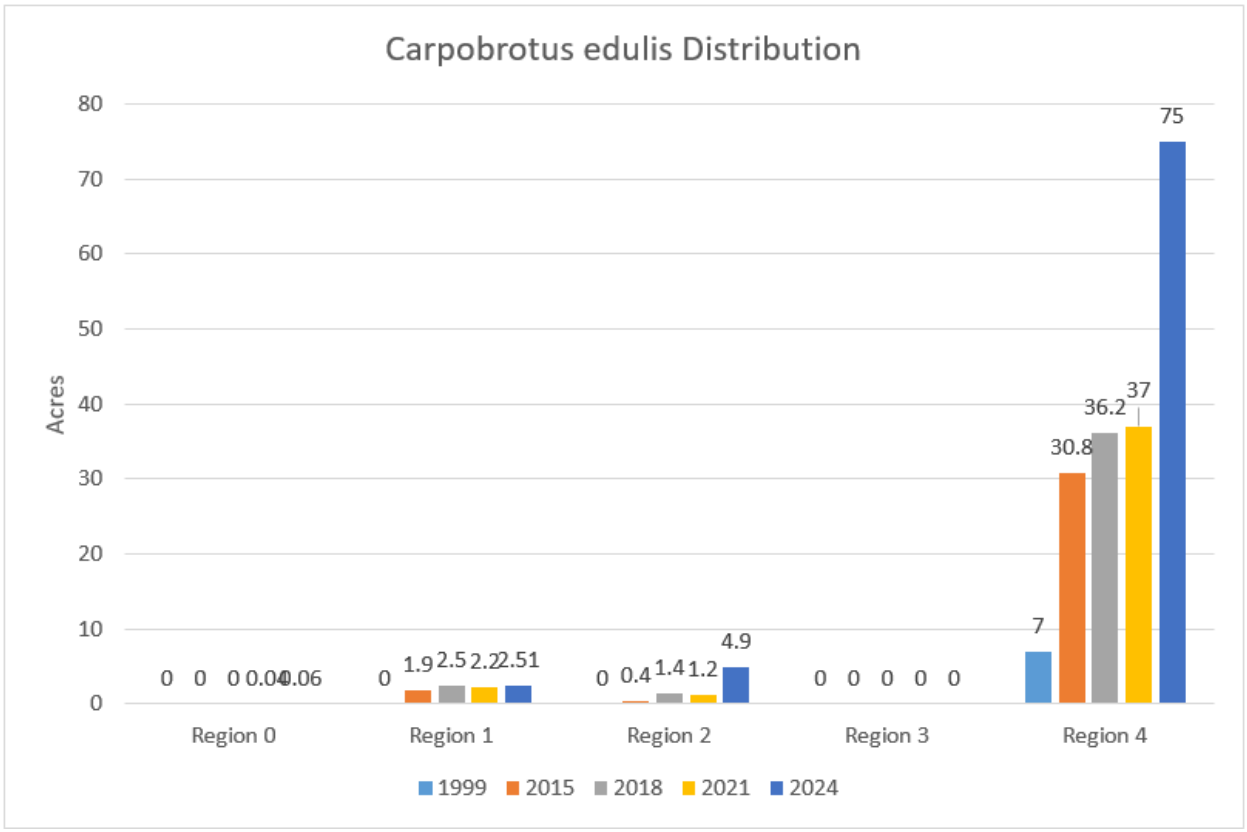


Figure 8: *Carpobrotus edulis* distribution by management region between 1999, 2015, 2018, 2021, and 2024.

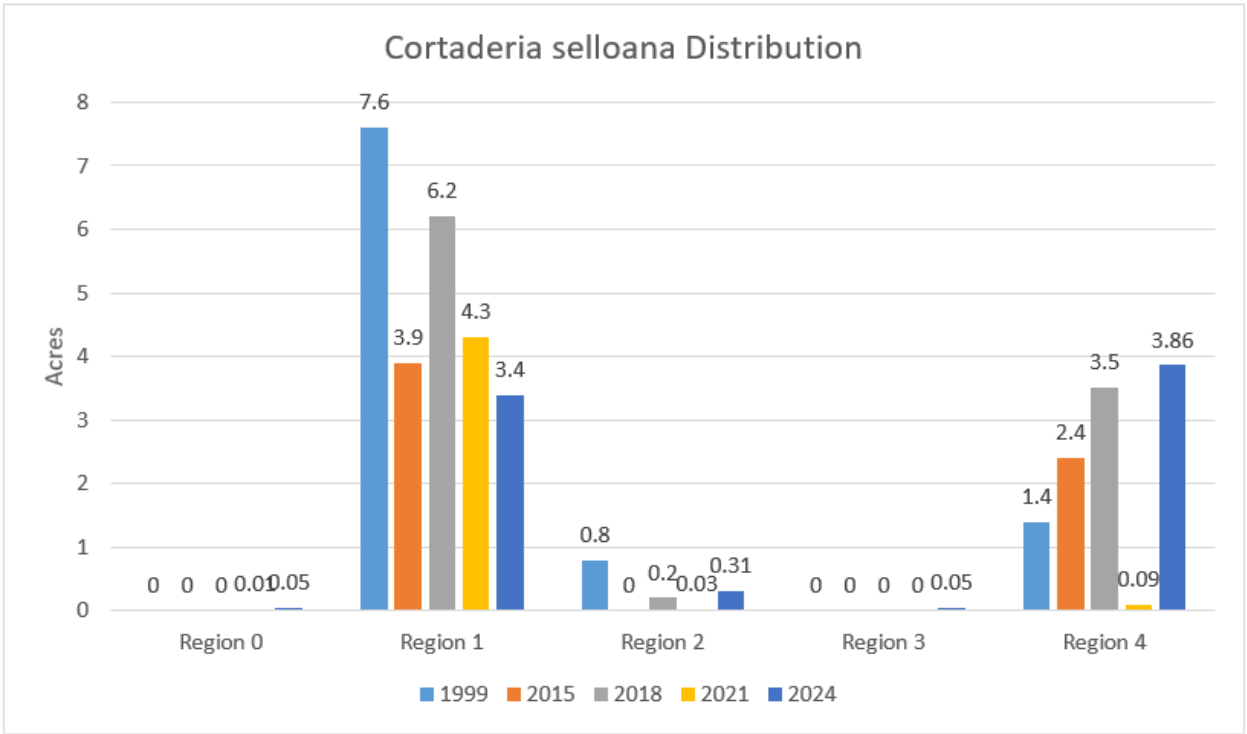


Figure 9: *Cortaderia selloana* distribution by management region between 1999, 2015, 2018, 2021, and 2024.

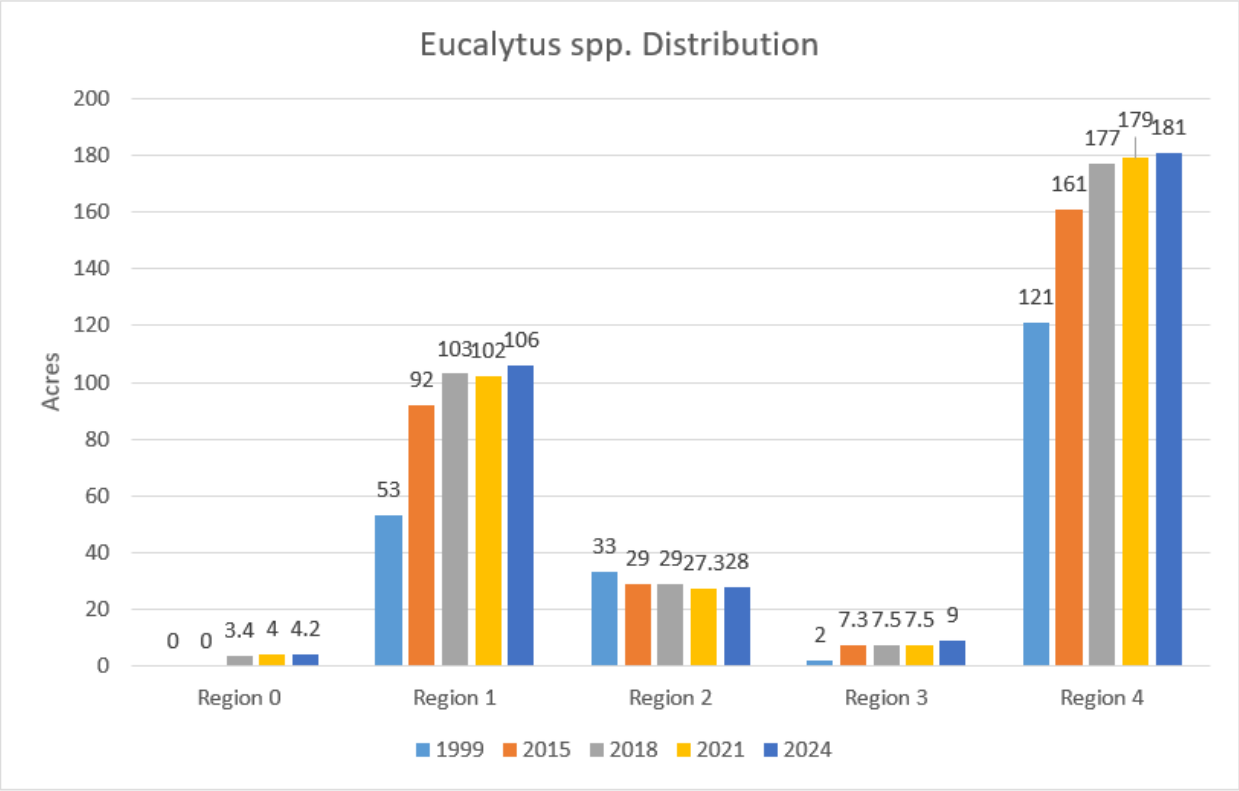


Figure 10: *Eucalyptus* spp. distribution by management region between 1999, 2015, 2018, 2021, and 2024.

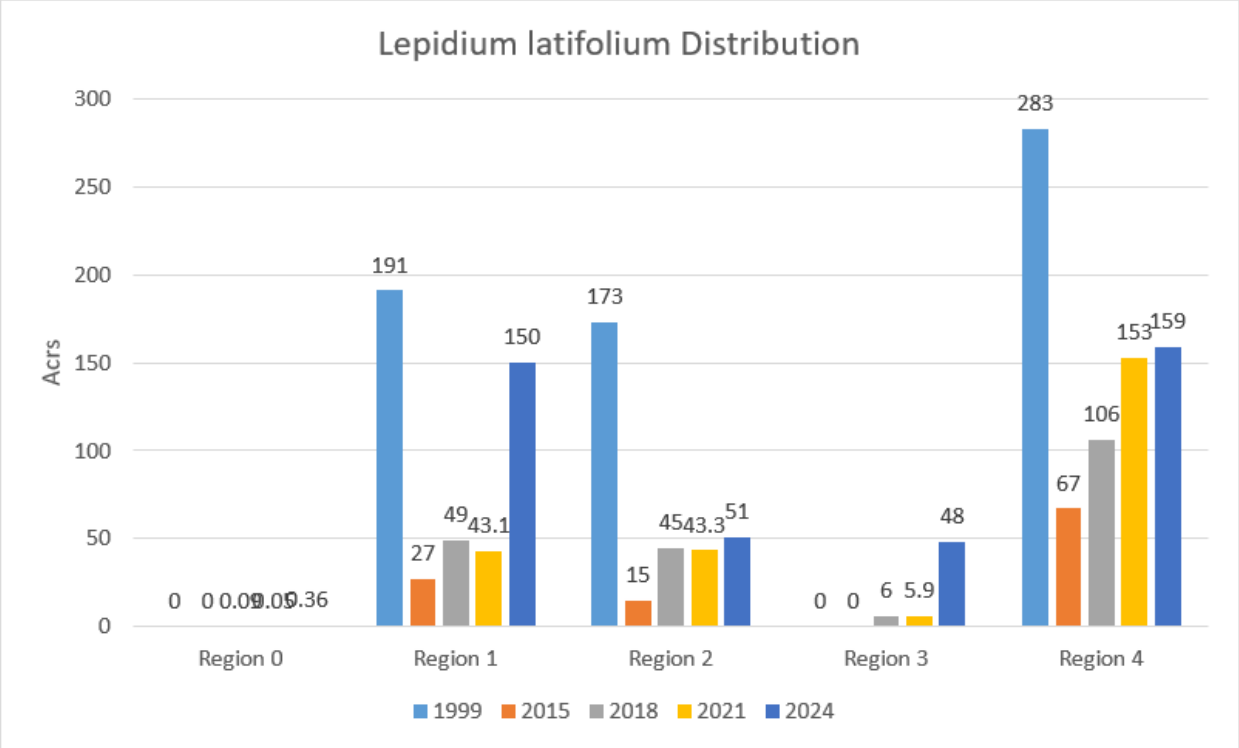


Figure 11: *Lepidium latifolium* distribution by management region between 1999, 2015, 2018, 2021, and 2024.

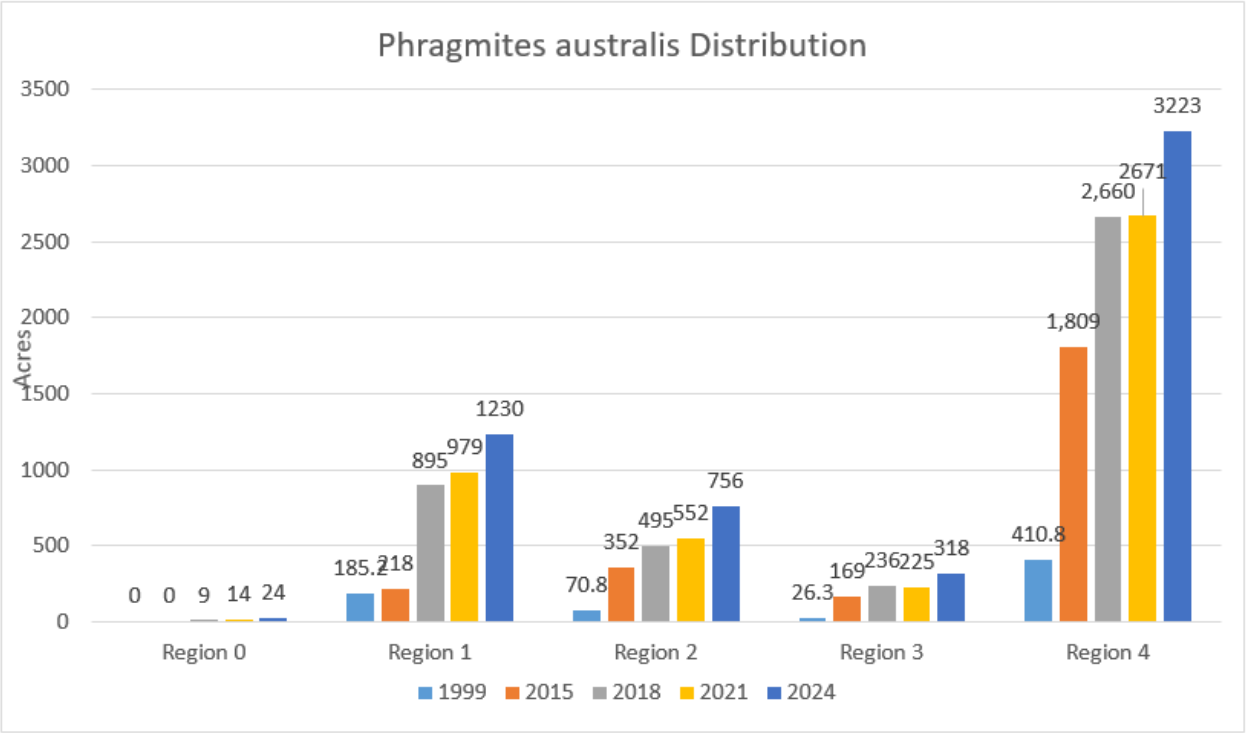


Figure 12: *Phragmites australis* distribution by management region between 1999, 2015, 2018, 2021, and 2024.

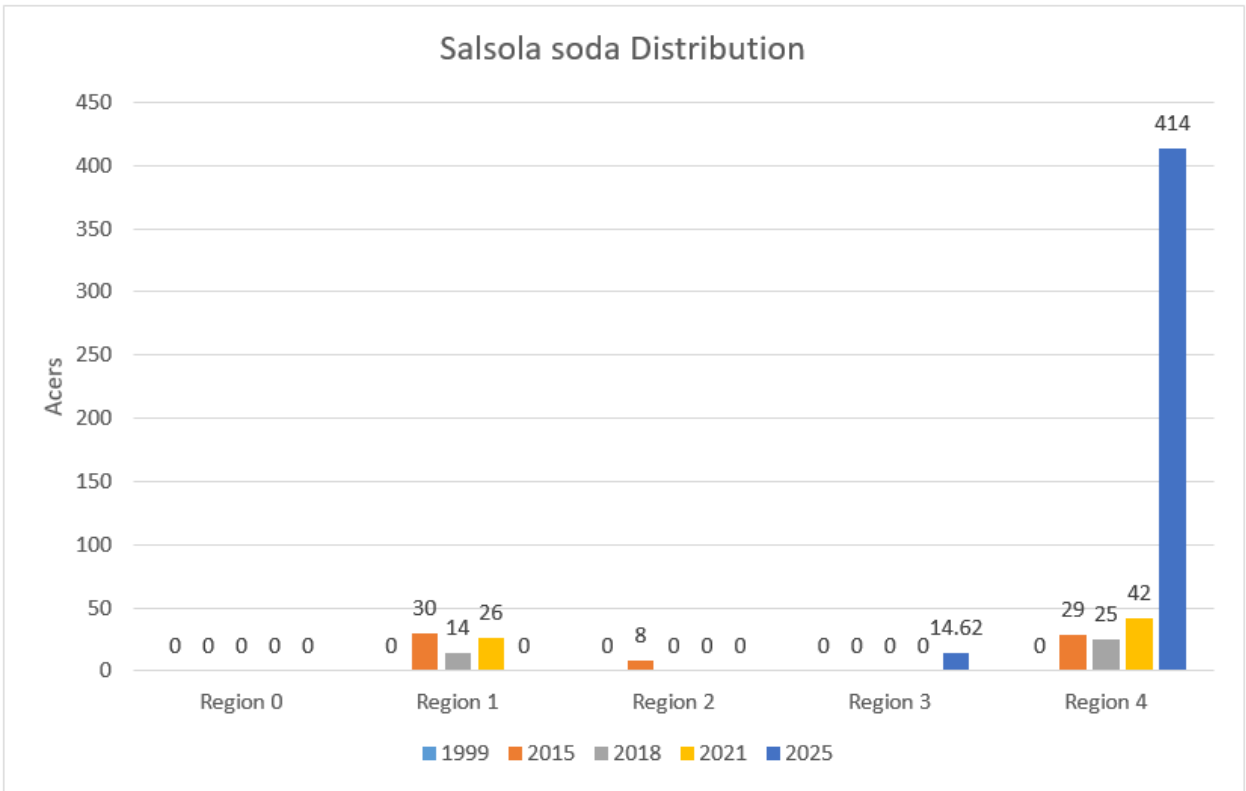


Figure 13: *Salsola soda* distribution by management region between 1999, 2015, 2018, 2021, and 2024.

Region 0:

Management Region 0 covers 25,024 acres (including 23,925 acres of Suisun Bay and sloughs). This region has a total of 300 acres of vegetation.

In 2024 this region included 0.22 acres of *Arundo do*nax, which constitutes 2% of *Arundo donax* in the marsh (Figure 7).

In 2024 there was a 0.06 acre inclusion of *Carpobrotus edulis* in this region, an increase of 0.02 acres since 2021 (Figure 8).

In 2024 there were 0.06 acres included in the region, an increase of 0.04 acres since 2021 (Figure 9).

The cover of *Eucalyptus* spp. increased from 4.0 acres in 2021 to 4.2 acres in 2024 (Figure 10). This is an overall 5% in cover over the 3-year period.

Lepidium latifolium decreased in this region from .05 acres in 2021 to .36 acres in 2024, indicating a 462% increase in cover for this region (Figure 11).

There were 14 acres of *Phragmites australis* throughout the region in 2021, and the cover of *Phragmites* has since increased to 24 acres (Figure 12). This is a 72% increase over the 3-year period.

There was no *Salsola soda* detected in this region in 2024 or previous years.

Region 1:

Management Region 1 covers 18,988 acres (29% of the Marsh, excluding Suisun Bay and sloughs).

42% of the *Arundo donax,* 3% of the *Carpobrotus edulis*, 44% of the *Cortaderia selloana*, 32% of the *Eucalyptus* spp., 18% of the *Lepidium latifolium,* 22% of the *Phragmites australis*, and 37% of the *Salsola soda* occur within this management region.

Arundo donax has increased by 474% in this region since 1999. In the period from 2021 to 2024 there has been a 9% decrease in cover. There has been a 0.41-acre decrease since 2021 (Figure 7).

Carpobrotus edulis has shown a 16% increase from 2.16 acres in 2021 to 2.51 acres in 2024 (Figure 8). No *Carpobrotus* was mapped in this region in 1999.

Cortaderia has decreased by 21% since 2021, from 4.3 acres to 3.4 acres (Figure 9). There has been an overall 55% decrease since 1999 (Appendix G).

Eucalyptus spp. Has remained relatively static in this region since 2021. There has been an increase of 4.2 acres from 102 acres in 2021 to 106.2 acres in 2024, an increase of 4% (Figure 10). There has been an overall 102% increase since 1999 (Appendix G).

Vegetation dominated by *Lepidium latifolium* has decreased by 278% (107 acres) in this region since 2021 (Figure 11). There are currently 150 acres.

Phragmites australis has increased in this region by 1044 acres since 1999 and 250 acres since 2021, for a total of 1,230 acres of *P. australis* in this region in 2024 (Figure 12). *P. australis* cover has increased by 26% over the 3-year period.

Salsola soda decreased to 0 acres in 2024, a 100% decrease since 2021 (Figure 13). All stands in this region, and throughout the Marsh in general, occur in leveed areas.

Region 2:

Management Region 2 covers 9,958 acres (15% of the Marsh, excluding Suisun Bay and sloughs).

0.3% of the *Arundo donax*, 6% of the *Carpobrotus edulis*, 4% of the *Cortaderia selloana*, 8.5% of the *Eucalyptus* spp., 12.5% of the *Lepidium latifolium,* and 14% of the *Phragmites australis* occur within this management region. There were no mapped stands of *Salsola soda*.

There were 0.03 acres of *Arundo donax* in this region in 2024; a 92% decrease since there were 0.38 acres in 2021 (Figure 7).

Carpobrotus edulis has increased from 1.24 acres in 2021 to 4.9 acres in 2021 (Figure 8).

There were 0.03 acres of *Cortaderia selloana* in 2021, and there has been an increase of 0.28 acres for a total of 0.31 acres in 2024 (Figure 9).

There are 28 acres of *Eucalyptus* spp. in this region, an increase of 2% since 2021 (Figure 10).

Vegetation dominated by *Lepidium latifolium* has increased in this region by 18% (7.6 acres) since 2021 (Figure 11). There are currently 44 acres mapped in this region.

Phragmites australis has increased from 551 acres in 2021 to 756 acres in 2024, a 37% increase (Figure 12). Overall, there has been a 968% increase in this region since 1999.

Salsola soda was mapped in this region for the first time in 2015, with 8.2 acres in leveed areas. In 2024, there were no detectable stands present.

Region 3:

Management Region 3 covers 4,720 acres (7% of the Marsh, excluding Suisun Bay and sloughs).

0.1% of the *Arundo donax,* 0.6% of the *Cortederia selloana*, 2.7% of the *Eucalyptus* spp., 12% of the *Lepidium latifolium,* and 5.7% of the *Phragmites australis* were mapped in this region. There were no mapped stands of *Carpobrotus edulis* in this region.

Arundo donax increased from 0 acres mapped in 2021 to 0.01 acres mapped in this region in 2024.

0 acres of *Cortaderia selloana* were mapped in this region in 2021; however, there were 0.05 acres mapped in 2024.

Eucalyptus spp. increased since 2021 from 7.5 acres to 9 acres in 2024 (a 20% increase) (Figure 10).

There are 48 mapped acres of *Lepidium latifolium* in 2024, a 712% increase since 2021, when there were just 5.9 acres in this region (Figure 11).

Phragmites australis is the most abundant species of concern in this region. In the leveed areas, there are 96 acres, a 2% increase since 2021 (Figure 12). There has been a 69% increase in tidal areas, from 131 acres in 2021 to 222 acres in 2024.

Region 4:

Management Region 4 covers 32,796 acres (49% of the Marsh, excluding Suisun Bay and sloughs).

55% of the *Arundo donax,* 91% of the *Carpobrotus edulis*, less than 50% of the *Cortaderia selloana*, 55% of the *Eucalyptus* spp., 39% of the *Lepidium latifolium,* 58% of the *Phragmites australis*, and 97% of the *Salsola soda* occur within this management region.

Arundo donax has decreased from 4.15 acres in 2021 to 5.27 acres in 2024, a 27% decrease for this region (Figure 7).

Carpobrotus edulis has increased from 37 acres in 2021 to 75 acres in 2024, a 104% increase for the region (Figure 8).

Cortaderia selloana cover increased by 3.77 acres overall in this region since 2021 (Figure 9).

Eucalyptus spp. has increased from 179 acres in 2021 to 181 acres in 2024 (Figure 10). 98% of stands occur in leveed areas.

Lepidium latifolium has increased by 4% in this region since 2021, from 153 acres to 158 acres (Figure 11). 97% of stands occur in leveed areas.

Phragmites australis is the most abundant species of concern in this region, covering a total of 3,223 acres. It has increased in tidal areas by 80% (750 acres) since 2021. It has decreased by 11% (199 acres) in the leveed areas of the region since 2021 (Figure 12). It has increased by 684% (2,812 acres) since 1999 (Appendix G).

Salsola soda was mapped at 42 acres in 2021 and has increased since 2021 to 414 acres (Figure 13). All stands occurred in leveed areas. The change from 2021 to 2024 is an 885% increase.

Discussion, Conclusions, and Recommendations

Change in Tidal Habitat

For this mapping effort, mappers took note of levee breaches (both intentional and unintentional) that affect the habitat attribution of vegetation. Mappers found several examples of levee destruction that changed previously leveed habitat into tidal habitat. The newly formed nexus between sloughs and vegetation allows the habitat to be tidally influenced. Figure 14 (next page) illustrates examples of large areas of the marsh where a levee break occurred and flooded previously leveed habitat. Between 2021 and 2024, tidal open water in the marsh increased by 3,395 acres. Almost all this growth in open water cover is due to levee breaks.

Figure 14: Levee breaks occurred between 2021 and 2024, allowing flooding of previously leveed habitat at Van Sickle and Bradmoor Islands. Flooding of Van Sickle Island occurred due to an unplanned levee breach, and flooding of this property is temporary. Bradmoor Island was deliberately flooded for restoration purposes, and the breach will not be repaired in the future.

Van Sickle Island—Unintentional flooding

2021

2024

Bradmoor Island—Intentional flooding

2021

2024

Changes in Slough Cover

This mapping effort yielded a 156-acre increase in slough cover. This change can be attributed to several levee breaks that were identified in the 2024 mapping effort. These levee breaks connected ditches that had previously been leveed to large bodies of tidal open water. When a confluence is created between previously leveed ditches and the open ocean, the ditch becomes a tidally influenced slough. Depending on future levee repairs, this increase could potentially be reversed in the future.

Salt Marsh Harvest Mouse Habitat

Total SMHM habitat has decreased since 2021 (a total decrease of 1,166 acres and 2.5% throughout the marsh), with a majority observed in leveed areas, where there was a 3,615-acre decrease, which reflects a 9% decrease in total leveed SMHM habitat (Appendix F). The amount of total tidal SMHM habitat increased by 2,448 acres or 27%. The large increase in tidal habitat can be attributed to several intentional and unintentional levee breaks that have exposed previously leveed areas to the open water, thus allowing these areas to be "tidally influenced". Changes in proportion of both tidal and leveed habitat were greatest in Region 2, and both habitat types have increased in proportion marshwide (see Table 2).

Since the 2021 remap, there has been a continued decrease in total SMHM habitat. Total SMHM habitat has dipped below 1999 levels when there were 47,105.3 acres, compared to 45,495 acres in 2024. There has been an overall 3.4% decrease in total SMHM habitat since 1999. However, the amount of habitat remains higher than 2015 levels, when there were 43,683 acres of SMHM habitat compared to 45,495 in 2024.

In the 2024 map, several sections of the marsh experienced flooding due to levee breaks. Much of the decrease in SMHM habitat observed over the 3-year period since 2021 can be attributed to levee breaks and flooding discussed in the previous sections.

Table 2: Change in Proportions of Salt Marsh Harvest Mouse Habitat from 2021 to 2024

	Tidal 2021	Tidal 2024	Change in Proportion of Tidal Habitat	Leveed 2021	Leveed 2024	Change in Proportion of Leveed Habitat
Region 0	0.0075167	0.00615	-0.0014	0.34	0.32	-0.02
Region 1	0.76	0.74	-0.02	0.61	0.62	0.00
Region 2	0.95	0.63	-0.31	0.71	0.78	0.06
Region 3	0.74	0.59	-0.15	0.67	0.70	0.03
Region 4	0.73	0.61	-0.12	0.72	0.73	0.02
Marshwide	0.27	0.29	0.02	0.69	0.70	0.02

Non-Native Species of Concern

Phragmites australis is continuing to increase in cover, specifically in tidal areas. Phragmites in tidal areas increased by 1,380.09 acres over the 3 years since 2021, indicating a 72% increase in tidal areas. However, there has been a decrease in *Phragmites* cover located in leveed areas (a reduction of 270 acres and 11%). Overall, Phragmites cover has increased by 1,111 acres and by 25% since 2021. The greatest change in proportion of *Phragmites australis* cover between 2021 and 2024 occurred in Region 2 at +0.0205, and the marsh wide change in proportion was +0.00394 (see table below).

Lepidium latifolium, while at a lower cover level than *Phragmites*, has shown a greater rate of increase in recent years. From 2021 to 2024, *Lepidium* cover increased by 67% (a total of 163 acres). The timing of imagery collection and peak *Lepidium* bloom coincided for this remap project, allowing mappers to more easily identify *Lepidium* for the 2024 map. The greatest change in proportion of *Lepidium latifolium* cover between 2021 and 2024 occurred in Region 3 at +0.0089, and the marsh wide change in proportion was +0.00179 (see Table 3 below).

Salsola soda has made the largest percentage increase in its cover when compared to all other non-native species of concern. Since 2021, *Salsola soda* cover increased by 361 acres and by 528%. This can partially be attributed to improved imagery, which allowed mappers to differentiate between *Salsola* and signatures similar in appearance, such as that of *Salicornia pacifica*. The seeds of *Salsola soda* are distributed by both wind and water, allowing it to rapidly colonize new areas where it previously did not exist. In this re-map and previous maps, *Salsola soda* has been considered a “less abundant non-native species of concern”. Future mapping efforts may consider changing the designation of *Salsola soda* to “more abundant non-native species of concern”. The greatest change in proportion of *Salsola soda* cover between 2021 and 2024 occurred in Region 4 at +0.01135, and the marsh wide change in proportion was +0.00394 (see Table 3 below).

Carpobrotus edulis has doubled in cover since 2021. This 2024 remap delineated 82 acres of Carpobrotus edulis in 2024 compared to 40 acres in 2021 (a 105% increase). Almost all this growth (40 acres) has occurred in leveed areas. The greatest change in proportion of *Carpobrotus edulis* cover between 2021 and 2024 occurred in Region 2 at +0.000368, and the marsh wide change in proportion was +0.000461 (see Table 3 below).

Eucalyptus globulus has shown an 8-acre (2.5%) increase since 2021. This slight increase from 320 acres in 2021 to 328 acres in 2024 can be attributed to expansions of existing *Eucalyptus* stands, as well as the identification and delineation of many additional small stands, which are primarily located in close proximity to large groves of *Eucalyptus*. The greatest change in proportion of *Carpobrotus edulis* cover between 2021 and 2024 occurred in Region 3 at +0.000318, and the marsh wide change in proportion was +0.000087 (see Table 3 below).

Arundo donax and Cortaderia selloana were all originally considered species of concern when mapping began. However, neither of these species have shown increases in coverage (excluding increases due to better imagery) in recent years.

Table 3: Proportional Cover of Non-Native Species of Concern by Region and Marsh-wide

	Region 0			Region 1		
	Region 0 2021	Region 0 2024	Region 0 Change in Proportions	Region 1 2021	Region 1 2024	Region 1 Change in Proportions
Arundo donax	0.00001479	0.00000879	-0.000006	0.000233	0.000212	-0.000022
Carpobrotus edulis	0.00000160	0.00000240	0.000001	0.000114	0.000132	0.000018
Cortaderia selloana	0.00000040	0.00000200	0.000002	0.000228	0.000180	-0.000048
Eucalyptus spp.	0.00015785	0.00016744	0.000010	0.005377	0.005597	0.000220
Lepidium latifolium	0.00000240	0.00001439	0.000012	0.002272	0.007899	0.005627
Phragmites australis	0.00056506	0.00097067	0.000406	0.051564	0.064772	0.013208
Salsola soda	0	0	0	0.001386	0	-0.001386

	Region 2			Region 3		
	Region 2 2021	Region 2 2024	Region 2 Change in Proportions	Region 3 2021	Region 3 2024	Region 3 Change in Proportions
Arundo donax	0.000038	0.000003	-0.000035	0.000000	0.000002	0.000002
Carpobrotus edulis	0.000125	0.000492	0.000368	0.000000	0.000000	0.000000
Cortaderia selloana	0.000003	0.000031	0.000028	0.000000	0.000011	0.000011
Eucalyptus spp.	0.002742	0.002794	0.000052	0.001593	0.001911	0.000318
Lepidium latifolium	0.004347	0.005114	0.000767	0.001256	0.010208	0.008951
Phragmites australis	0.055380	0.075919	0.020539	0.047754	0.067367	0.019612
Salsola soda	0.000000	0.000000	0.000000	0.000000	0.003097	0.003097

	Region 4			Marshwide		
	Region 4 2021	Region 4 2024	Region 4 Change in Proportions	Marshwide 2021	Marshwide 2024	Marshwide Change in Proportions
Arundo donax	0.000127	0.000161	0.000034	0.000102	0.000104	0.000002
Carpobrotus edulis	0.001122	0.002286	0.001164	0.000440	0.000901	0.000461
Cortaderia selloana	0.000003	0.000118	0.000115	0.000049	0.000084	0.000035
Eucalyptus spp.	0.005467	0.005513	0.000047	0.003500	0.003587	0.000087
Lepidium latifolium	0.004655	0.004837	0.000183	0.002679	0.004461	0.001782
Phragmites australis	0.081440	0.098264	0.016825	0.048543	0.060674	0.012131
Salsola soda	0.001282	0.012635	0.011353	0.000747	0.004689	0.003942

Future Mapping Efforts

Improvements in imagery quality and timing have made the 2024 re-map likely more accurate and detailed than previous mapping efforts. Additionally, improvements in reconnaissance data assisted mappers in better identifying vegetation signatures. Mappers identified two potential improvements that could be made to make reconnaissance data even more helpful for future re-maps:

1. **Stand size**: Many of the reconnaissance points taken for the 2024 re-map were taken on stands of less than 0.25 acres in area. In many cases, it is difficult to establish vegetation signatures using examples that are less than 0.25 acres in area, especially when vegetation types are heavily mixing on the ground. For future mapping efforts, data collectors are encouraged to sample large stands for each vegetation type, to assist identification of vegetation types from the aerial imagery.
2. **Sampling of new types**: The 2024 re-map introduced a new mapping alliance, "*Bidens cernua* - *Euthamia occidentalis* - *Ludwigia palustris* Herbaceous Alliance." Because this alliance has not previously been mapped, mappers attempted to identify it based on limited survey data. Future data collection should include more reconnaissance surveys of this type in order to help identify the vegetation signature.

Future mapping efforts could also consider the addition of a "Habitat Quality" attribute to the mapping data. This attribute could help map users and land managers easily filter for and identify polygons that are considered habitat for the SMHM. Adding this attribute could highlight habitat corridors and areas of concern in terms of habitat availability throughout the marsh.

Literature Cited

Baldwin, B.G, D.H. Goldman, D.J. Keil, R. Patterson, T.J. Rosatti and D.H. Wilken, editors. 2012. The Jepson manual: vascular plants of California, second edition. University of California Press, Berkeley.

Boul, R. and T. Keeler-Wolf. 2008. 2006 Vegetation Map Update for Suisun Marsh, Solano County, California. A Report to the California Department of Water Resources. VegCAMP, California Department of Fish and Wildlife, Sacramento, CA.

Boul, R. and T. Keeler-Wolf. 2016. 2012 Vegetation Map Update for Suisun Marsh, Solano County, California. A Report to the California Department of Water Resources. VegCAMP, California Department of Fish and Wildlife, Sacramento, CA.

California Department of Water Resources (DWR). 2013. Bay Delta Conservation Plan. Public Draft. November. Sacramento, CA. Prepared by ICF International (ICF 00343.12). Sacramento, CA.

Congalton, R. and K. Green. 1999. Assessing the accuracy of remotely sensed data: principles and practices. Lewis Publishers, New York.

Federal Geographic Data Committee (FGDC). 2008. National Vegetation Classification Standard, Version 2 FGDC-STD-005-2008 (version 2). Vegetation Subcommittee, FGDC Secretariat, U.S. Geological Survey. Reston, VA. 55 pp. + Appendices.

Foody, G. 2002. Status of land cover classification accuracy assessment. Remote Sens Environ 80:185–201.

Geographical Information Center (GIC). 2022. 2018 Vegetation Map Update for Suisun Marsh Solano County, California. A Report to the California Department of Water Resources. Geographical Information Center, North State Planning and Development Collective, California State University, Chico, CA.

Gopal, S. and C. Woodcock. 1994. Theory and methods for accuracy assessment of thematic maps using fuzzy sets. Photogramm Eng Remote Sens 60:181–188.

Hagen, A. 2003. Fuzzy set approach to assessing similarity of categorical maps. Int J Geogr Inf Sci 17(3):235–249.

Keeler-Wolf, T. and M. Vaghti. 2000. Vegetation Mapping of Suisun Marsh, Solano County – A Report to the California Department of Water Resources. Unpublished administrative report on file at Biogeographic Data Branch, California Department of Fish and Wildlife, Sacramento.

Kincaid, T. and A. Olsen. 2011. survey: Spatial Survey Design and Analysis. R package version 2.2.

Lea, C. and A. Curtis. 2010. Thematic accuracy assessment procedures: National Park Service Vegetation Inventory, version 2.0. Natural Resource Report NPS/2010/NRR—2010/204. National Park Service, Fort Collins, Colorado.

Metzler, J. and S. Sader. 2005. Agreement assessment of spatially explicit regression-derived forest cover and traditional forest industry stand type maps. Photogramm Eng Remote Sens 71(11):1303–1309.

San Francisco Estuary Institute (SFEI). 2011. Bay Area Aquatic Resources Inventory (BAARI) Basemap.

Story, M. and R. Congalton. 1986. Accuracy Assessment: A User's Perspective. Photogrammetric Engineering and Remote Sensing 52:397–399.

Sustaita, D., P. Frinfrock Quickert, L. Patterson, L. Barthman-Thompson, S. Estrella. Salt marsh harvest mouse demography and habitat use in the Suisun Marsh, California. Journal of Wildlife Management 75(6):1498-1507.

USDA NRCS. 2015. The PLANTS Database (http://plants.usda.gov, 4 June 2015). National Plant Data Team, US Department of Agriculture, Natural Resources Conservation Service, Greensboro, NC 27401-4901 USA.

USDA Bureau of Reclamation, U.S. Fish and Wildlife Service, and California Department of Fish and Game. 2013. Suisun Marsh Habitat Management, Preservation and Restoration Plan. May 2013.

Vaghti, M., T. Keeler-Wolf. 2001. Suisun Marsh Vegetation Mapping Change Detection 2000. A Report to the California Department of Water Resources. Wildlife and Habitat Data Analysis Branch, California Department of Fish and Wildlife, Sacramento.

Vaghti, M. and T. Keeler-Wolf. 2004. Suisun Marsh Vegetation Mapping Change Detection 2003. A Report to the California Department of Water Resources. Wildlife and Habitat Data Analysis Branch, California Department of Fish and Wildlife, Sacramento.

Vegetation Classification and Mapping Program (VegCAMP). 2012. 2009 Vegetation map update for Suisun Marsh, Solano County, California. A report to the California Department of Water Resources. VegCAMP, California Department of Fish and Wildlife, Sacramento, CA.

Vegetation Classification and Mapping Program (VegCAMP). 2018. 2015 Vegetation map update for Suisun Marsh, Solano County, California. A report to the California Department of Water Resources. VegCAMP, California Department of Fish and Wildlife, Sacramento, CA.

Appendix A

Suisun Marsh Vegetation Classification and Hierarchy

The vegetation and mapping classification hierarchy of Suisun Marsh is compliant with the United States National Vegetation Classification (USNVC). The vegetation types are listed below within the full eight levels of the USNVC hierarchy. Each type that has been used in any Suisun Marsh map is followed by its mapping code in parentheses.

The original vegetation classification for Suisun Marsh was created in 1999. Since then, a great deal of vegetation work has been done in California, and the state and national hierarchies have been refined. Following the 2015 remap and accuracy assessment, the Suisun Marsh vegetation types were reviewed and modified to match the most current USNVC hierarchy more closely. Some types that were difficult to distinguish on the imagery were aggregated to higher levels of the hierarchy (group or macrogroup level). Some types that were equivalent to current USNVC types were renamed to conform to the current hierarchy. New mapping codes have been assigned to all vegetation types as of the 2015 map; the new codes are listed in parentheses following each type.

Although many alliances and associations from the original classification are equivalent to types in the current USNVC hierarchy, some have no comparable current types. These unmatched vegetation types are labeled “mapping units” and are placed within the appropriate alliances and groups in the hierarchy structure below.

Some of the original mapping units were defined too broadly to fit into the alliance and association levels of the current hierarchy. However, they do approximate some of the upper levels. For instance, although the Medium Upland Graminoids Mapping Unit does not fit into the species-oriented alliance structure, it can be considered part of the Mediterranean California Naturalized Annual and Perennial Grassland Group. These broadly defined mapping units are listed with their corresponding USNVC vegetation types under “Legacy Mapping Units” at the end of the hierarchy.

In the future, when the Suisun Marsh vegetation field data are reanalyzed with a larger data set, the mapping units will either be confirmed as distinct types or renamed to better fit an existing type. In future maps, the broadly defined mapping units will not be used but will be replaced by the corresponding USNVC vegetation types.

The USNVC hierarchy is composed of eight levels, organized into three upper, three middle, and two lower levels as shown below:

Level	**Example**
Upper	-
Level 1 - Class	Forest and Woodland
Level 2 - Subclass	Temperate Forest
Level 3 - Formation	Warm Temperate Forest
Middle	-
Level 4 - Division	Madrean Forest and Woodland
Level 5 - Macrogroup	California Forest and Woodland
Level 6 - Group	Californian Broadleaf Forest and Woodland
Lower	-
Level 7 - Alliance	*Quercus agrifolia*
Level 8 - Association	*Quercus agrifolia / Salix lasiolepis*

Descriptions of vegetation types in the 2015 map can be found in Appendix B.

1. **Forest and Woodland Class**
    a. **Temperate Forest Subclass**
        i. **Warm Temperate Forest Formation (1000000)**
            1. **Madrean Forest and Woodland Division (1100000)**
                a. **California Forest and Woodland Macrogroup (1110000)**
                    i. Californian Broadleaf Forest and Woodland Group[1] (1111000)
                        1. *Quercus agrifolia* Woodland Alliance (1111100)
                            a. *Quercus agrifolia* Association (1111101)
                            b. *Quercus agrifolia / Salix lasiolepis* Association (1111102)
                        2. *Quercus lobata* Woodland Alliance (1111200)
        ii. **Cool Temperate Forest Formation (2000000)**
            1. **North American Introduced Evergreen Broadleaf and Conifer Forest Division (2100000)**
                a. **Introduced North American Mediterranean Woodland and Forest Macrogroup (2110000)**
                    i. no subdivision at group level
                        1. *Eucalyptus (globulus, camaldulensis)* Woodland Semi-Natural Alliance (2110100)
                            a. *Eucalyptus globulus* Semi-Natural Association (2110101)
                        2. *Ailanthus altissima* Woodland Semi-Natural Alliance (2110200)
                b. **Southwestern North American Riparian, Flooded and Swamp Forest Macrogroup (2120000)**
                    i. Southwestern North American Riparian Evergreen and Deciduous Woodland Group[2] (2121000)
                        1. *Salix laevigata* Woodland Alliance (2121100)
                            a. *Salix laevigata / Salix lasiolepis* Association (2121101)
                    ii. Southwestern North American Riparian/Wash Scrub Group (2122000)
                        1. *Salix exigua* Shrubland Alliance (2122100)
                            a. *Salix exigua* Association (2122101)
                        2. *Rosa californica* Shrubland Alliance (2122200)
                            a. *Rosa californica* Association (2122201)
                            b. *Rosa californica – Baccharis pilularis* Association (2122202)
                        3. *Baccharis salicifolia* Shrubland Alliance (2122300)
                    iii. Southwestern North American Introduced Riparian Scrub Group (2123000)
                        1. *Arundo donax* Herbaceous Semi-Natural Alliance (2123100)
                            a. *Arundo donax* Semi-Natural Association (2123101)
                        2. *Tamarix* spp. Shrubland Semi-Natural Alliance (2123200)
        iii. **Temperate Flooded and Swamp Forest Formation (3000000)**
            1. **Western North America Flooded and Swamp Forest Division (3100000)**
                a. **Western Cordilleran Montane–Boreal Riparian Scrub Macrogroup (3110000)**
                    i. Vancouverian Riparian Deciduous Forest Group (3111000)
                        1. *Fraxinus latifolia* Woodland Alliance (3111100)

[1] Formerly named Oaks Mapping Unit

[2] Formerly named Willow Trees Mapping Unit

a. *Fraxinus latifolia* Planted Stands Mapping Unit (3111101)

2. Temperate Flooded and Swamp Forest Mesomorphic Shrub and Herb Vegetation Class
a. Mediterranean Scrub and Grassland Subclass
i. Mediterranean Grassland and Forb Meadow Formation (4000000)
1. California Grassland and Meadow Division (4100000)
a. California Annual and Perennial Grassland Macrogroup (4110000)
i. Mediterranean California Naturalized Annual and Perennial Grassland Group[3] (4111000)
1. *Brassica nigra* and Other Mustards Herbaceous Semi-Natural Alliance (4111100)
a. *Brassica nigra* Semi-Natural Association (4111101)
b. *Raphanus sativus* Semi-Natural Association (4111102)
2. *Bromus (diandrus, hordeaceus) – Brachypodium distachyon* Herbaceous Semi-Natural Alliance (4111200)
3. *Centaurea (solstitialis, melitensis)* Herbaceous Semi-Natural Alliance (4111300)
4. *Conium maculatum – Foeniculum vulgare* Herbaceous Semi-Natural Alliance (4111400)
a. *Conium maculatum* Semi-Natural Association (4111401)
b. *Foeniculum vulgare* Semi-Natural Association (4111402)
5. *Cortaderia (jubata, selloana)* Herbaceous Semi-Natural Alliance (4111500)
6. *Festuca perennis* Herbaceous Semi-Natural Alliance (4111600)
a. *Festuca perennis – Lepidium latifolium* Semi-Natural Association (4111601)
b. *Festuca perennis – Lotus corniculatus* Semi-Natural Association (4111602)
c. *Festuca perennis – Rumex* spp. Mapping Unit (4111603)
d. *Hordeum marinum – Festuca perennis* Mapping Unit (4111604)
7. *Elytrigia pontica* Mapping Unit (4111700)
8. *Agrostis avenacea* Mapping Unit (4111800)
9. *Vulpia* spp*. – Euthamia occidentalis* Mapping Unit (4111900)

3. Mesomorphic Shrub and Herb Vegetation Class
a. Temperate and Boreal Shrubland and Grassland Subclass
i. Temperate Grassland, Meadow, and Shrubland Formation (5000000)
1. **Vancouverian and Rocky Mountain Grassland and Shrubland Division (5100000)**
a. Western North American Temperate Grassland and Meadow Macrogroup (5110000)
i. Vancouverian and Rocky Mountain Naturalized Perennial Grassland Group (5111000)
1. *Phalaris aquatica* Herbaceous Semi-Natural Alliance (5111100)
a. *Phalaris aquatica* Semi-Natural Association (5111101)

b. Vancouverian Lowland Grassland and Shrubland Macrogroup (5120000)
i. Naturalized Non-Native Deciduous Scrub Group (5121000)
1. *Rubus armeniacus* Shrubland Semi-Natural Alliance (5121100)

ii. Temperate and Boreal Scrub and Herb Coastal Vegetation Formation (6000000)
1. Pacific Coast Scrub and Herb Littoral Vegetation Division (6100000)
a. Vancouverian Coastal Dune and Bluff Macrogroup (6110000)
i. California Coastal Evergreen Bluff and Dune Scrub Group[4] (6111000)

[3] Formerly named Annual Grasses/Weeds Mapping Unit
[4] Formerly named Medium Upland Shrubs Mapping Unit

1. *Baccharis pilularis* Shrubland Alliance (6111100)
    a. *Baccharis pilularis* / Annual Grass–Herb Association (6111101)

ii. California–Vancouverian Semi-Natural Littoral Scrub and Herb Vegetation Group (6112000)

1. *Carpobrotus edulis* or Other Ice Plants Herbaceous Semi-Natural Alliance (6112100)

iii. Temperate and Boreal Freshwater Marsh Formation (7000000)

1. Western North American Freshwater Marsh Division (7100000)

a. Western North American Freshwater Marsh Macrogroup (7110000)

i. Arid West Freshwater Emergent Marsh Group[5] (7111000)

1. *Typha (angustifolia, latifolia, domingensis*) Herbaceous Alliance (7111100)
    a. *Typha (angustifolia, latifolia, domingensis)* Association (7111101)
    b. *Typha (angustifolia, latifolia, domingensis)* (dead stalks) Mapping Unit (7111102)
    c. *Typha (angustifolia, latifolia, domingensis) – Echinochloa crus-galli* Association (7111103)
    d. *Typha (angustifolia, latifolia, domingensis) – Distichlis spicata* Association (7111104)
    e. *Typha (angustifolia, latifolia, domingensis) – Phragmites australis* Association (7111105)
    f. *Typha (angustifolia, latifolia, domingensis) – Schoenoplectus americanus* Association (7111106)
2. *Schoenoplectus (acutus, californicus)* Herbaceous Alliance (7111200)
    a. *Schoenoplectus californicus – Schoenoplectus acutus* Association (7111201)
    b. *Schoenoplectus (acutus, californicus)* Mapping Unit (7111202)
    c. *Schoenoplectus (acutus, californicus) – Rosa californica* Association (7111203)
    d. *Schoenoplectus (acutus, californicus)* – Wetland Herbs Mapping Unit (7111204)
3. *Schoenoplectus (acutus, californicus) – Typha (angustifolia, latifolia, domingensis)* Mapping Unit (7111300)
4. *Phragmites australis* Herbaceous Alliance (7111400)
    a. *Phragmites australis* Association (7111401)
    b. *Phragmites australis – Schoenoplectus* spp. Association (7111402)
    c. *Phragmites australis – Xanthium strumarium* Mapping Unit (7111403)
5. *Alisma triviale* Mapping Unit (7111500)

ii. Vancouverian Coastal/Tidal Marsh and Meadow Group (7112000)

1. *Potentilla anserina* Herbaceous Alliance (7112100)

b. Western North America Vernal Pool Macrogroup (7120000)

i. California Vernal Pool and Grassland Matrix Group (7121000)

ii. Californian Mixed Annual/Perennial Freshwater Vernal Pool/Swale Bottomland Group (7121000)

1. *Grindelia (stricta)* Provisional Herbaceous Alliance (7121100)

c. Western North America Wet Meadow and Low Shrub Carr Macrogroup[6] (7130000)

[5] Formerly named Tall Wetland Graminoids Mapping Unit

[6] Formerly named Medium Wetland Graminoids Mapping Unit

i. Californian Warm Temperate Marsh/Seep Group (7131000)
1. *Juncus arcticus (*var*. balticus, mexicanus)* Herbaceous Alliance (7131100)
a. *Juncus arcticus* var*. balticus* Association (7131101)
b. *Juncus arcticus* var*. balticus – Conium maculatum* Association (7131102)
c. *Juncus arcticus* var*. balticus – Lepidium latifolium* Association (7131103)
d. *Juncus arcticus* var*. balticus – Potentilla anserina* Association (7131104)
2. *Leymus triticoides* Herbaceous Alliance (7131200)
3. *Bidens cernua - Euthamia occidentalis - Ludwigia palustris* Herbaceous Alliance (7131300)

ii. Naturalized Warm-Temperate Riparian And Wetland Group (7132000)
1. *Lepidium latifolium* Herbaceous Semi-Natural Alliance (7132100)
2. *Persicaria lapathifolia – Xanthium strumarium* Herbaceous Alliance (7132200)
a. *Persicaria* spp*. – Xanthium strumarium – Echinochloa crus-galli* Mapping Unit (7132201)
3. *Cynodon dactylon – Crypsis* spp. – *Paspalum* spp. Moist Herbaceous Semi-Natural Alliance (7132300)
a. *Crypsis schoenoides* Mapping Unit (7132301)
b. *Cynodon dactylon* Mapping Unit (7132302)
4. *Polypogon monspeliensis* Mapping Unit (7132400)
5. *Rumex* spp. Mapping Unit (7132500)
6. *Salsola soda* Mapping Unit (7132600)

iv. Temperate and Boreal Salt Marsh Formation (8000000)
1. Temperate and Boreal Pacific Coastal Salt Marsh Division (8100000)
a. North American Pacific Coastal Salt Marsh Macrogroup[7] (8110000)
i. Temperate Pacific Tidal Salt and Brackish Meadow Group (8111000)
1. *Bolboschoenus maritimus* Herbaceous Alliance (8111100)
a. *Bolboschoenus maritimus* Association (8111101)
b. *Bolboschoenus maritimus – Salicornia pacifica* Association (8111102)
c. *Bolboschoenus maritimus – Sesuvium verrucosum* Association (8111103)
2. *Distichlis spicata* Herbaceous Alliance (8111200)
a. *Distichlis spicata* Association (8111201)
b. *Distichlis spicata* – Annual Grasses Association (8111202)
c. *Distichlis spicata – Juncus arcticus* var*. balticus (J. arcticus* var*. mexicanus*) Association (8111203)
d. *Distichlis spicata – Lotus corniculatus* Mapping Unit (8111204)
e. *Distichlis spicata – Salicornia pacifica* Association (8111205)
f. *Distichlis spicata – Schoenoplectus americanus* Provisional Association (8111206)
g. *Distichlis spicata – Cotula coronopifolia* Association (8111207)
h. *Distichlis spicata – Bolboschoenus maritimus* Mapping Unit (8111208)
i. *Distichlis spicata – Juncus balticus – Triglochin* spp*. – Glaux maritima* Mapping Unit (8111209)
j. *Lepidium latifolium – Distichlis spicata* Semi-Natural Association (8111210)
3. *Salicornia pacifica (Salicornia depressa)* Herbaceous Alliance (8111300)

[7] Formerly named Short Wetland Graminoids Mapping Unit

a. *Salicornia pacifica* Association (8111301)
b. *Salicornia pacifica* – Annual Grasses Association (8111302)
c. *Salicornia pacifica – Atriplex prostrata* Association (8111303)
d. *Salicornia pacifica – Crypsis schoenoides* Association (8111304)
e. *Salicornia pacifica – Sesuvium verrucosum* Association (8111305)
f. Salicornia pacifica – Echinochloa crus-galli – Polygonum – Xanthium strumarium Association (8111306)
g. *Salicornia pacifica – Cotula coronopifolia* Association (8111307)

4. *Spartina foliosa* Herbaceous Alliance (8111400)

ii. Western North American Disturbed Alkaline Marsh and Meadow Group (8112000)

1. *Atriplex prostrata – Cotula coronopifolia* Herbaceous Semi-Natural Alliance (8112100)
a. *Cotula coronopifolia* Semi-Natural Association (8112101)
b. *Atriplex prostrata* Semi-Natural Association (8112102)
c. *Atriplex prostrata – Distichlis spicata* Semi-Natural Association (8112103)
d. *Atriplex prostrata – Bolboschoenus maritimus* Semi-Natural Association (8112104)
e. *Atriplex prostrata – Sesuvium verrucosum* Semi-Natural Association (8112105)
f. *Atriplex prostrata* – Annual Grasses Semi-Natural Association (8112106)

2. *Sesuvium verrucosum* Herbaceous Alliance (8112200)
a. *Sesuvium verrucosum* Association (8112201)
b. *Sesuvium verrucosum – Distichlis spicata* Association (8112202)
c. *Sesuvium verrucosum – Festuca perennis* Association (8112203)
d. *Sesuvium verrucosum – Cotula coronopifolia* Association (8112204)

3. *Spergularia marina* Provisional Herbaceous Alliance (8112300)
a. *Spergularia marina – Cotula coronopifolia* Mapping Unit (8112301)

2. Western North American Interior Alkali–Saline Wetland Division (8200000)

a. Warm Semi-Desert/Mediterranean Alkali–Saline Wetland Macrogroup (8210000)

i. Southwestern North American Alkali Marsh/Seep Vegetation Group (8211000)

1. *Schoenoplectus americanus* Herbaceous Alliance (8211100)
a. *Schoenoplectus americanus* Association (8211101)
b. *Schoenoplectus americanus – Potentilla anserina* Association (8211102)
c. *Schoenoplectus americanus* – S*choenoplectus californicus – Schoenoplectus acutus* Association (8211103)
d. *Schoenoplectus americanus – Lepidium latifolium* Association (8211104)

ii. Southwestern North American Salt Basin and High Marsh Group (8212000)

1. *Atriplex lentiformis* Shrubland Alliance (8212100)
2. *Frankenia salina* Herbaceous Alliance (8212200)
a. *Frankenia salina* – Annual grasses Mapping Unit *(*8212201)
b. *Frankenia salina – Distichlis spicata* Association (8212202)

4. Hydromorphic Vegetation (Aquatic Vegetation) Class (9000000)

a. Saltwater Aquatic Vegetation Subclass

i. Marine and Estuarine Saltwater Aquatic Vegetation Formation (9100000)

1. Temperate Pacific Saltwater Aquatic Vegetation Division (9110000)

a. Temperate Pacific Intertidal Shore Macrogroup (9111000)

i. Temperate Pacific Intertidal Flat Group (9111100)

1. *Stuckenia (pectinata)* – *Potamogeton* spp. Herbaceous Alliance (9111200)
    a. *Stuckenia pectinata* Association (9111201)
2. *Ruppia (cirrhosa, maritima)* Herbaceous Alliance (9111300)

b. Freshwater Aquatic Vegetation Subclass
i. Freshwater Aquatic Vegetation Formation
1. North American Freshwater Aquatic Vegetation Division (9200000)
a. Western North American Freshwater Aquatic Vegetation Macrogroup (9210000)
i. Naturalized Temperate Pacific Freshwater Vegetation Group (9211000)
1. *Ludwigia (hexapetala, peploides)* Provisional Herbaceous Semi-Natural Alliance (9211100)

5. Agriculture & Developed Vegetation Class
a. Herbaceous Agricultural Vegetation Subclass (9310000)
i. Row & Close Grain Crop Formation (9311000)
ii. Fallow Field and Weed Vegetation Formation (9312000)
1. Cropland Fallow Field Division (9312100)
a. Fallow Field Macrogroup (9312110)

b. Herbaceous & Woody Developed Vegetation Subclass (9410000)
i. Other Developed Vegetation Formation (9411000)
1. Other Developed Vegetation Division (9411100)
a. Tree Developed Vegetation Macrogroup (9411110)
i. Temperate Tree Developed Vegetation Group (9411111)

Non-Vegetation Mapping Units
Bare Ground Mapping Unit (1)
Agriculture (2)
Road / Trails Mapping Unit (4)
Slough Mapping Unit (6)
Tidal Mudflat Mapping Unit (7)
Railroad Track Mapping Unit (8)
Ditch Mapping Unit (9)
Open Water Mapping Unit (11)
Developed Mapping Unit (15)

Legacy Mapping Units

Californian Broadleaf Forest and Woodland Group (1111000)
Oaks Mapping Unit (1111001)
Southwestern North American Riparian Evergreen and Deciduous Woodland Group (2121000)
Willow Trees Mapping Unit (2121001)
Southwestern North American Riparian/Wash Scrub Group (2122000)
Tall Wetland Shrubs Mapping Unit (2122001)
Medium Wetland Shrubs Mapping Unit (2122002)
California Annual and Perennial Grassland Macrogroup (4110000)
Annual Grasses Mapping Unit (4110001)
Mediterranean California Naturalized Annual and Perennial Grassland Group (4111000)
Tall Upland Graminoids Mapping Unit (4111001)
Medium Upland Graminoids Mapping Unit (4111002)
Perennial Grass Mapping Unit (4111003)

Short Upland Graminoids Mapping Unit (4111004)
Tall Upland Herbs Mapping Unit (4111005)
Medium Upland Herbs Mapping Unit (4111006)
Short Upland Herbs Mapping Unit (4111007)
Annual Grasses/Weeds Mapping Unit (4111008)

California Coastal Evergreen Bluff and Dune Scrub Group (6111000)
Medium Upland Shrubs Mapping Unit (6111001)

Arid West Freshwater Emergent Marsh Group (7111000)
Tall Wetland Graminoids Mapping Unit (7111001)
Calystegia sepium – Euthamia occidentalis Mapping Unit (7111002)

Western North America Wet Meadow and Low Shrub Carr Macrogroup (7130000)
Medium Wetland Graminoids Mapping Unit (7130001)

Temperate and Boreal Salt Marsh Formation (8000000)
Wetland Herbs Mapping Unit (8000001)
Tall Wetland Herbs Mapping Unit (8000002)
Medium Wetland Herbs Mapping Unit (8000003)

North American Pacific Coastal Salt Marsh Macrogroup (8110000)
Short Wetland Graminoids Mapping Unit (8110001)
Short Wetland Herbs Mapping Unit (8110002)

Hydromorphic Vegetation (Aquatic Vegetation) Class (9000000)
Floating-leaved Wetland Herbs Mapping Unit (9000001)

Row & Close Grain Crop Formation (9311000)
Cultivated Annual Graminoid Mapping Unit (9311001)

Temperate Tree Developed Vegetation Group (9411111)
Landscape Trees Mapping Unit (9411112)

Developed (15)
Parking Lot Mapping Unit (3)
Structure Mapping Unit (5)
Water Treatment Pond Mapping Unit (13)
Urban Area Mapping Unit (14)

Road / Trails Mapping Unit (4)
Trail Mapping Unit (10)

Appendix B

Suisun Marsh Vegetation Type Descriptions

These descriptions were created for vegetation types mapped in Suisun Marsh in 2015.

These descriptions are intended for use as a guide to the identification of field-based and image interpretation-based vegetation assessments. An example of the type as it is represented in imagery is included with each description. Terms used in the descriptions are defined as follows:

Alliance: Plant communities based on dominant/diagnostic species of the uppermost or dominant stratum. Accepted alliances are part of the USNVC hierarchy.

Association: The most botanically detailed or finest-scale plant community designation based on dominant species and multiple co- or sub-dominant indicator species from any strata. Associations are part of the USNVC hierarchy.

Plant community nomenclature: Species separated by "–" are within the same stratum; species separated by "/" are in different strata. The number that follows some plant community names is the Mapping Code used for labeling plant community polygons for the associated GIS-based plant community map.

Cover: The primary metric used to quantify the importance/abundance of a particular species or a particular vegetation layer within a stand. It is measured by estimating the aerial extent of the living plants, or the bird's-eye view looking from above, for each category. Cover in this mapping project uses the concept of "porosity" or foliar cover rather than "opacity" or crown cover. Thus, field crews are trained to estimate the amount of light versus shade produced by the canopy of a plant or a stratum by considering the amount of shade it casts excluding the openings it may have in the interstitial spaces (e.g., between leaves or branches). This is assumed to provide a more realistic estimate of the actual amount of shade cast by the individual or stratum which, in turn, relates to the actual amount of light available to individual species or strata beneath it. However, as a result, cover estimates can vary substantially between leaf-on versus leaf-off conditions.

Absolute cover: The actual percentage of the surface area of the survey that is covered by a species or physiognomic group (trees, shrubs, herbaceous), as in "*Salicornia pacifica* covers 10% of the area being surveyed." Absolute cover of all species or physiognomic groups, when added together, may total greater than 100%, because this is not a proportional number, and plants can overlap each other. For example, a stand could have 25% tree cover in the upper layer, 40% shrub cover in the middle layer, and 50% herbaceous cover on the ground. However, when aerial interpretation is being used, the maximum absolute value is 100% since lower levels of vegetation cannot be seen through the overstory in aerial photographs.

Relative cover: The percentage of surface area within a survey area that is covered either by one species relative to other species within the same physiognomic stratum (tree, shrub, herbaceous) or one stratum relative to the total vegetation cover in a polygon. Thus, 50% relative cover of *Distichlis spicata* in the herb layer means that *D. spicata* comprises half the cover of all herbaceous species within a stand, while 50% relative shrub cover means that shrubs make up half the cover of all vegetation within a stand. Relative cover values are proportional numbers that, when added together, total 100% for all the species within a stratum or each stratum within a stand of vegetation.

Dominance: Dominance refers to the preponderance of vegetation cover in a stand of uniform composition and site history. It may refer to the cover of an individual species as in "dominated by *Salicornia pacifica*," or it may refer to dominance by a physiognomic group, as in "dominated by herbs." When we use the term in the key, a species is dominant if it is in relatively high cover in each stand, however, see "dominance by layer," below.

Strongly dominant: A species in the dominant life form stratum has 60% or greater relative cover.

Co-dominant: Co-dominance refers to two or more species in a stand with similar cover. Specifically, each species has between 30% to 60% relative cover. For example, in a coastal scrub stand with 5% *Baccharis pilularis*, 4% *Frangula californica*, and 3% *Rubus ursinus* (total 13% shrub cover), technically only the *Baccharis* (5/13 = 39% relative cover) and the *Frangula* (4/13 = 31% relative cover) would be co-dominant because *Rubus* would only have 23% relative cover (3/13 = 23%).

Consistent/Characteristic/Diagnostic species: Should be present in at least 80% of the stands of the type, with no restriction on cover. Relatively even spacing throughout the stand is important particularly in vegetation with low total cover since an even distribution of the diagnostic species is a much better indicator than overall cover. Characteristic species that are evenly distributed are better indicators of a type than species with higher cover and patchy distribution.

Dominance by layer: Tree, shrub, and herbaceous layers are considered physiognomically distinct. A vegetation type is considered to belong to a certain physiognomic group if it is dominated by one layer. Layers are prioritized in order of height. If the tallest layer is dominant and characteristic (see definitions above) across multiple stands of one type, the alliance is usually named by the dominant and/or characteristic species of the tallest layer. Average covers within the dominant layer reflect the "modal" concept of the health/age/environment of a particular vegetation type. For example, a higher average cover of woody plants within a stand not recently affected by disturbance reflects a mode of general availability of water, nutrition, and equitable climate, while lower average cover under similar conditions would reflect lower availability of these things.

Woody plant: A vascular plant species that has a noticeably woody stem (e.g., shrubs and trees). It does not include herbaceous species with woody underground portions such as tubers, roots, or rhizomes.

Tree: A one-stemmed woody plant that normally grows to be greater than 5 meters tall. In some cases, trees may be multi-stemmed (ramified due to fire or other disturbance), but the height of mature plants typically exceeds 5 meters. If less than 5 meters tall, undisturbed individuals of these species are usually single-stemmed. Certain species that can resemble either shrubs or trees (e.g., *Aesculus californica*) are, out of statewide tradition or by the USNVC, called trees. It behooves one to memorize which species are "traditionally" placed in one life form or another. We use the accepted lifeforms in the USNVC or the PLANTS Database (USDA NRCS 2015) to do this.

Shrub: A multi-stemmed woody plant that is usually 0.2–5 meters tall. Definitions are blurred at the low and high ends of the height scales. At the tall end, shrubs may approach tree-size based on disturbance frequencies (e.g., old-growth re-sprouting chaparral species such as *Cercocarpus montanus*, *Fremontodendron californicum*, *Prunus ilicifolia*, and so forth, may frequently attain "tree size," but are still typically multi-stemmed and are considered shrubs in this key). At the short end, woody perennial herbs or sub-shrubs of various species are often difficult to categorize into a consistent life form (e.g., *Eriogonum latifolium, Lupinus chamissonis*); in such instances, we refer to the PLANTS Database or "pick a lane" based on best available definitions.

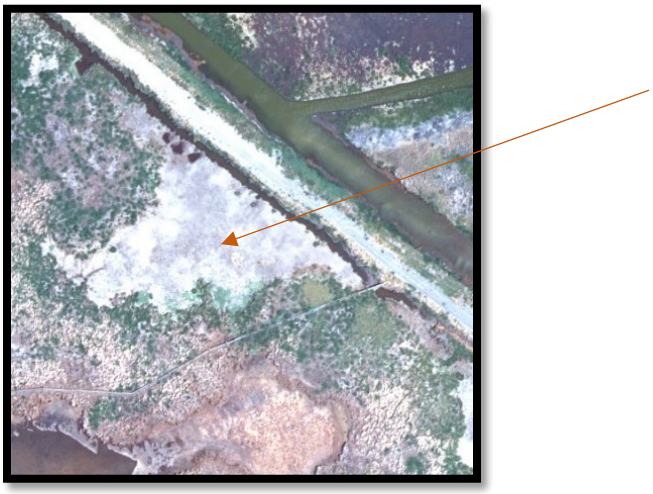
Subshrub: A multi-stemmed plant with noticeably woody stems less than 0.5 meters tall. It may be easily confused with a perennial herb or small shrub. We lump them into the "shrub" category in stand tables and descriptions of vegetation types.

Shrub-characterized vegetation: Shrubs (including sub-shrubs) are evenly distributed throughout the stand, providing a consistent (even if sparse) structural component; the stand cannot be characterized as a tree stand; and one or both of the following criteria are met: (1) shrubs influence the distribution or population dynamics of other plant species; (2) shrubs play an important role in ecological processes within the stand. For this project, shrub alliances have at least 10% absolute shrub cover.

Herbaceous plant: Any species of plant that has no main woody stem development; including grasses, forbs, and perennial species that die back each year.

Herb-characterized vegetation: Herbs are evenly distributed throughout the stand, providing a consistent (even if sparse) structural component and playing an important role in ecological processes within the stand. The stand cannot be characterized as a tree or shrub stand.

Botanical nomenclature: We use the PLANTS Database in vegetation mapping as our standard for botanical names. In certain cases, if a plant is recognized by *The Jepson Manual, second edition* (Baldwin et al. 2012), but not PLANTS Database, we default to the Jepson name.



Bare Ground Mapping Unit

Ground generally has <10% cover of vegetation. Does not include unvegetated tidal flats but does include unvegetated leveed ground such as scraped areas or formerly inundated areas with no vegetation.

Road / Trails Mapping Unit
Includes roads and trails that are wider than the minimum mapping width of 10 feet. May have mown vegetation.

Slough Mapping Unit

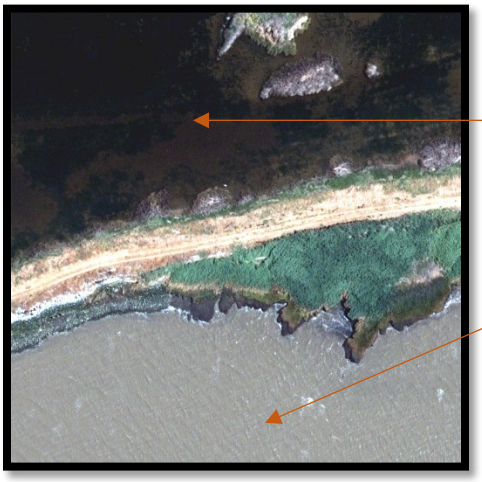
Wide, fully tidal waterways.

Tidal Mudflat Mapping Unit

Tidally exposed mud deposits, generally unvegetated or with a low cover of herbs or algae.

Ditch Mapping Unit

Non-tidal, smaller waterways and graded or maintained permanent or temporary ditches that may or may not contain water at the time of the imagery.



Open Water Mapping Unit

Unchanneled tidal or non-tidal areas of standing water, including Suisun Bay.

Developed Mapping Unit

Includes parking lots, structures, water treatment ponds, and urban areas.

***Quercus agrifolia* Woodland Alliance**

Quercus agrifolia (coast live oak) is dominant or co-dominant in the tree canopy. Typically bordering freshwater creeks at upper reaches of marsh only, making this an uncommon vegetation type in Suisun Marsh.

***Eucalyptus (globulus, camaldulensis)* Woodland Semi-Natural Alliance**

Eucalyptus camaldulensis, Eucalyptus globulus, or other gum trees are dominant in the tree canopy. Planted as trees, groves, and windbreaks; naturalized on uplands and stream courses.

Understories are usually depauperate, though sometimes other non-natives, such as *Hedera helix*, clamber extensively in stands. Seeds of *Eucalyptus* germinate when tree crowns and built-up debris are removed by fire or in other ways.

***Salix laevigata / Salix lasiolepis* Association**

Salix laevigata (red willow) is dominant or co-dominant in the tree or shrub canopy with *S. lasiolepis* (Arroyo willow). Generally found at the edges of the marsh along freshwater creeks.

***Salix exigua* Association**

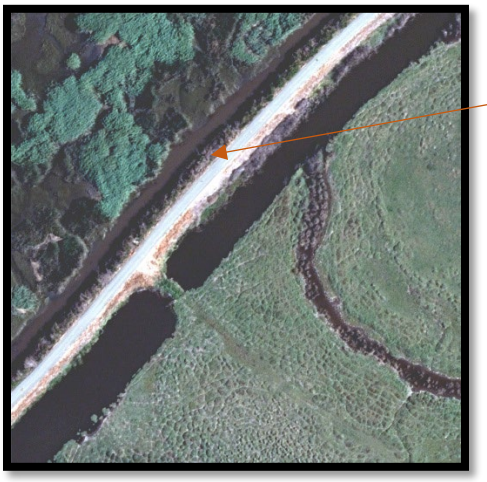
Salix exigua (narrow-leaf willow) is dominant or co-dominant in the shrub canopy with >20% absolute cover.

***Rosa californica* Association**

Rosa californica (California rose) is dominant and conspicuous, often forming narrow briar patches along levees and roads, occasionally in lower-lying portions of marsh.

***Rosa californica – Baccharis pilularis* Association**

Rosa californica (California rose) and *Baccharis pilularis* (coyote brush) co-occur in stand; either species may be dominant, but each has over 5% absolute cover. Often occurs along levees and roads.

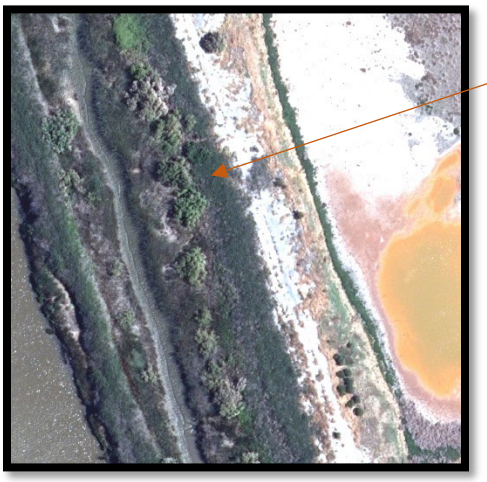


***Baccharis salicifolia* Shrubland Alliance**

One stand strongly dominated by *Baccharis salicifolia* (mule-fat) occurs in the marsh; it was planted at the Blacklock restoration site along the southeastern levee.

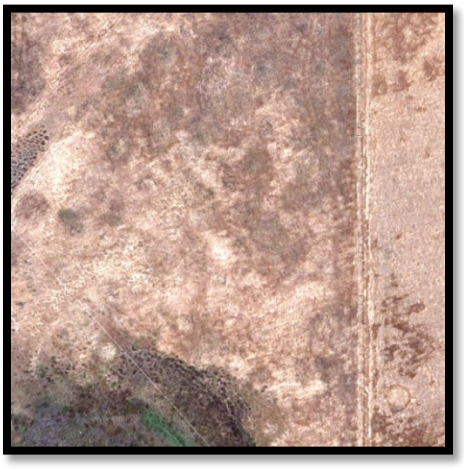
***Arundo donax* Semi-Natural Association**

Clonal dense stands of *Arundo donax* (giant reed), generally small and locally distributed near settlements and roads in the marsh. The signature on the true-color imagery is slightly grayer than *Phragmites australis*, with which it might be confused. *Arundo* is also found in linear stands along roads or ditches more often than *Phragmites*, and the stand edges appear more ragged.



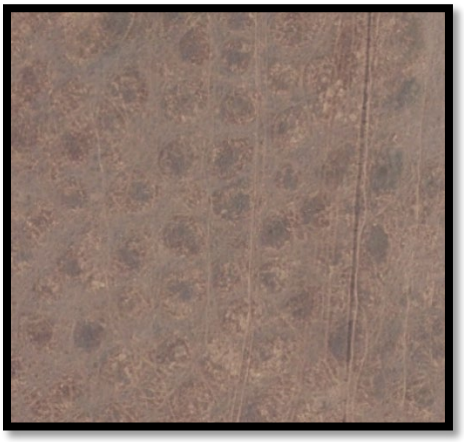
***Tamarix* spp. Shrubland Semi-Natural Alliance**

Stands are dominated by tamarisk, a large, non-native shrub with diffuse habit.



Mediterranean Californian Naturalized Annual and Perennial Grassland Group

Upland grasslands generally are not associated with saturated soil or tidal influence throughout the growing season. Shrubs are generally less than 10% cover or, if more, sub-shrubs are overtopped by the dominant grass or herb species. Dominant species include the grasses *Hordeum murinum, Bromus* spp*., Festuca perennis, Elytrigia pontica,* and *Avena* spp. Also included in this group are stands dominated by weeds such as *Conium maculatum* (poison hemlock), *Foeniculum vulgare* (wild fennel), *Raphanus sativus* (wild radish), and *Brassica nigra* (black mustard).



California Vernal Pool and Grassland Matrix Group

Vernal pools are temporary wetlands that fill with water during the rainy season and dry out in the spring.

***Cortaderia (jubata, selloana)* Semi-Natural Herbaceous Alliance**

Stands dominated by the large, non-native, mound-like *Cortaderia selloana* (pampas grass). Stands are generally small but conspicuous and occur in moist areas in the ecotone between wetlands and uplands. Some stands occur on the outboard sides of levees; however, all stands appear to be near buildings.

***Phalaris aquatica* Semi-Natural Association**
Stands are dominated by the tall bunch grass *Phalaris aquatica* (canary grass). These are usually small stands along levees but may occur in larger upland stands adjacent to the marsh.

***Rubus armeniacus* Shrubland Semi-Natural Alliance**
Vegetation is dominated by the introduced *Rubus armeniacus* (Himalayan berry), often in narrow briar patches along levees and roads in the Marsh. When co-dominant with *Rosa californica* or *Baccharis pilularis,* assign to those alliances.

***Baccharis pilularis* Shrubland Alliance**

***Baccharis pilularis* Shrubland Alliance**
Baccharis pilularis (coyote brush) is dominant to co-dominant with other shrubs such as *Atriplex lentiformis* (big saltbrush). *Rosa californica* (California rose) is typically absent or <<5% absolute cover.

***Baccharis pilularis* / Annual Grass – Herb Association**
Baccharis pilularis (coyote brush) dominates, with an understory that is typically dominated by annual grasses (*Hordeum* spp*., Festuca perennis, Bromus* spp.) and/or annual herbs.

***Carpobrotus edulis* or Other Ice Plants Herbaceous Semi-Natural Alliance**
Vegetation is dominated (>50% relative cover) by perennial non-native *Carpobrotus edulis* (iceplant), generally on levees and areas adjacent to buildings. Most stands are uniform and dense and have a distinct signature, particularly in the CIR imagery, where they are bright pink.

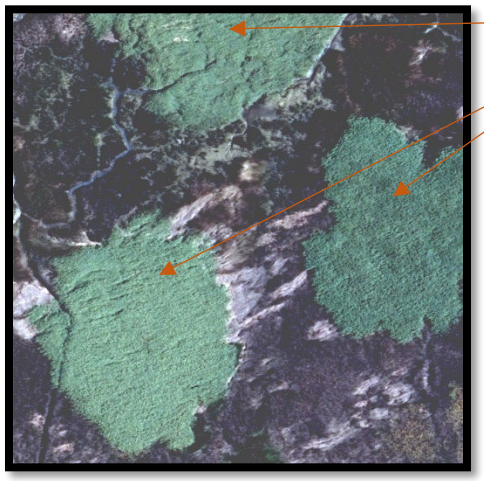
***Typha (angustifolia, latifolia, domingensis)* Herbaceous Alliance**
Stands are dominated by cattail species including *Typha angustifolia, T. latifolia,* and *T. domingensis* (Cattail (narrowleaf, broadleaf, and southern). The distinguishing features of these three species are often blurred in the marsh and there is frequent evidence of hybridization. Different *Typha* species are often found in the same stand and are considered ecologically equivalent. Throughout most of the marsh, narrow-leaved forms (*T. angustifolia/domingensis*) predominate. Often, stands appear to be mostly dead-standing cattails from the previous season, but CIR imagery reveals that they are regenerating.

***Schoenoplectus (acutus, californicus)* Mapping Unit**
Vegetation dominated by *Schoenoplectus californicus* (California bulrush) and/or the ecologically and morphologically similar *Schoenoplectus acutus* (hardstem bulrush). Occasionally *Typha* spp. may occur in equal or higher cover than the *Schoenoplectus* spp., but *Schoenoplectus californicus* or *Schoenoplectus acutus* has at least 10% relative cover**.**

***Schoenoplectus (acutus, californicus) / Rosa californica* Association**
Rosa californica (California rose) is present with *Schoenoplectus californicus* (California bulrush), and/or *Schoenoplectus acutus* (hardstem bulrush). Usually found along levees bordering sloughs and channels, including the intertidal zone.

***Schoenoplectus (acutus, californicus)* – Wetland Herbs Mapping Unit**
Stands dominated by *Schoenoplectus californicus* (California bulrush) and/or *S. acutus* (hardstem bulrush) with an understory of >12% cover that is a varying mixture of mostly native perennial herbs, such as *Euthamia occidentalis, Aster lentus, A. subulatus, Artemisia douglasiana, Baccharis glutinosa, Achillea millefolium*, and *Stachys ajugoides*. May also include *Lepidium latifolium*.

***Schoenoplectus (acutus, californicus) – Typha (angustifolia, latifolia, domingensis)* Mapping Unit**
Stands dominated in the overstory by *Schoenoplectus californicus* (California bulrush) and/or *Schoenoplectus acutus* (hardstem bulrush) with a lower to somewhat higher cover of *Typha angustifolia, T. latifolia*, and/or *T. domingensis*. May have up to 50% relative cover of wetland herbs (*Polygonum, Epilobium, Euthamia,* etc.).



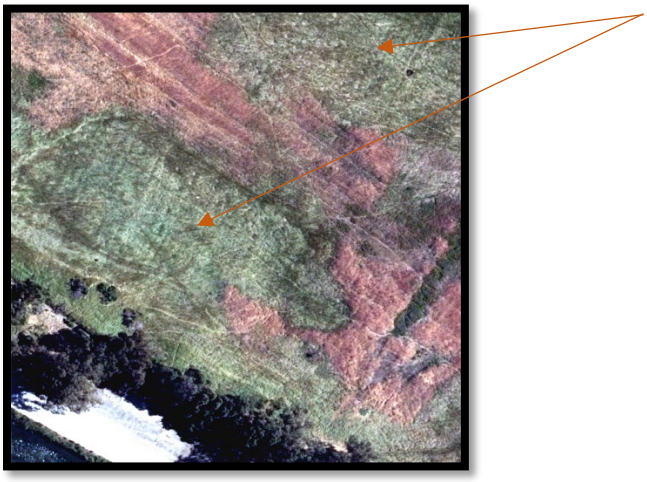
***Phragmites australis* Herbaceous Alliance**
Most of the *Phragmites australis* (common reed) in the marsh is the very densely growing, invasive, non-native form. When *Phragmites* dominates, even when it is mixed with other plants such as *Schoenoplectus*, it is mapped as this type. The signature is very distinct, especially in the CIR imagery, in which it appears hot pink. There is no minimum mapping area for this type.

***Alisma triviale* Mapping Unit**
Vegetation is dominated by *Alisma triviale* (water plantain). Mapping is limited to a pond that receives freshwater drainage along Highway 680.

***Grindelia (stricta)* Provisional Herbaceous Alliance**
Stands dominated by the diffuse perennial herb *Grindelia* spp. (*Grindelia ×paludosa* may be more common in the marsh than previously thought and *Grindelia stricta* less so). May contain a variety of subordinate species, some weedy and some native. Typically found on the edges of wetlands on slightly elevated or drier ground than adjacent vegetation, such as natural or constructed levees, road margins, etc.

Bidens cernua – Euthamia occidentalis – Ludwigia palustris Herbaceous Alliance
Vegetation dominated or co-dominated (>50% relative cover) by *Euthamia occidentalis, Hoita orbicularis, Baccharis douglasii (= B. glutinosa), Bidens* spp., and/or the native herb *Ludwigia palustris.* The signature on true color imagery is often very dark brown. The 2024 remap is the first map to characterize this vegetation type, and more data will be needed in the future to assist mappers in its identification.

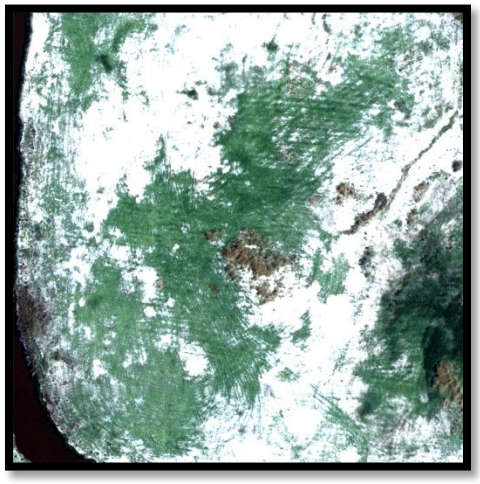
***Juncus arcticus* (var. *balticus, mexicanus)* Herbaceous Alliance**
Vegetation dominated or co-dominated (>30% relative cover) by the stoloniferous (clonal) rush *Juncus arcticus* var. *balticus* (Baltic rush) or *Juncus arcticus* var. *mexicanus* (Mexican rush), often associated with other taller or shorter herbaceous species. Usually in temporarily saturated wetlands not inundated for extensive periods. The signature on true color imagery is often very dark brown or black and its clonal habit is usually obvious.



***Leymus triticoides* Herbaceous Alliance**
Stands dominated (>50% relative cover) by the native *Leymus triticoides* (creeping wild rye). Stands are generally narrow bands of wetland-upland borders including natural ecotones between the *Distichlis spicata* (salt grass) Alliance and naturalized annual grass stands. Also occurs along levee tops and margins of marsh adjacent to vegetation of intermittent flooding zone. Non-natives, such as *Lepidium latifolium* and *Lotus corniculatus*, often invade these stands. Some very large stands, such as on Grizzly Island, may have been planted. The signature is bluer green in comparison to other signatures

***Lepidium latifolium* Herbaceous Semi-Natural Alliance**
Stands dominated by the invasive *Lepidium latifolium* (perennial pepperweed); may occur in temporarily flooded, intermittently flooded, and saturated wetlands, typically in at least slightly saline soils. Appears to be expanding in the marsh and is particularly threatening to native tidal marsh vegetation such as *Schoenoplectus americanus* (three-square), *Juncus arcticus* var. *balticus* (Baltic rush), and *Distichlis spicata* (saltgrass) Alliance stands (as at Rush Ranch). Often stands are at peak flower at the time of the imagery acquisition and so appear mounded and white. CIR imagery shows a very light pink signature.

***Persicaria lapathifolia – Xanthium strumarium* Herbaceous Alliance**
Vegetation of regularly disturbed, winter and vernally wet ponds and fields, usually on fine-grained clay-rich soils. *Xanthium strumarium* (cocklebur), *Persicaria lapathifolia* (common knotweed or willow weed), or other knotweed species are dominant or co-dominant in the herbaceous layer.



***Crypsis schoenoides* Mapping Unit**
Stands dominated by the low annual *Crypsis schoenoides* (swamp timothy). Found in winter and vernally flooded flats and pools. Vegetation is generally scattered, with intervening small to large openings of dry, cracked mud during summer.

***Salsola soda* Mapping Unit**
Stands dominated or co-dominated by *Salsola soda* (opposite-leaf Russian thistle). Large stands originated on the Hill Slough Unit.

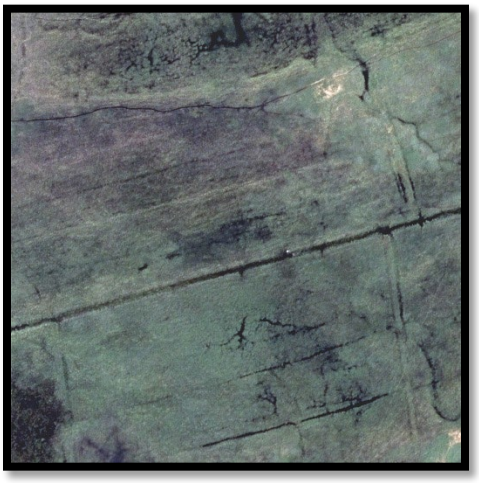
Temperate and Boreal Salt Marsh Formation
This type includes the former wetland herbs mapping unit and is applied when the vegetation is dominated by herbs in a wetland setting that does not have a recognizable signature or is too mixed in species composition to fit into a more specific vegetation type.

***Bolboschoenus maritimus* Herbaceous Alliance**

Vegetation of seasonally wet flats and pond bottoms dominated or co-dominated (>30% relative cover) by *Bolboschoenus maritimus* (alkali bulrush) in the taller herb/graminoid layer. Co-dominant species may include *Distichlis spicata, Salicornia pacifica, Sesuvium verrucosum, Spergularia salina, Typha latifolia,* and/or short herbs or grasses. Some stands also include the similar species *Bolboschoenus robustus* (sturdy bulrush) or hybrids between the two.

***Distichlis spicata* Herbaceous Alliance**

Stands are usually dominated (>50% relative cover) by *Distichlis spicata* (salt grass), or if not dominant, salt grass has higher cover than any other single species. *Distichlis spicata* has a grey-green or yellow-green signature in comparison to *Frankenia salina*, which is more blue-green and occurs in similar settings.



***Distichlis spicata* Association**

Stands strongly dominated by salt grass, *Distichlis spicata,* with no other species greater than 5% cover.

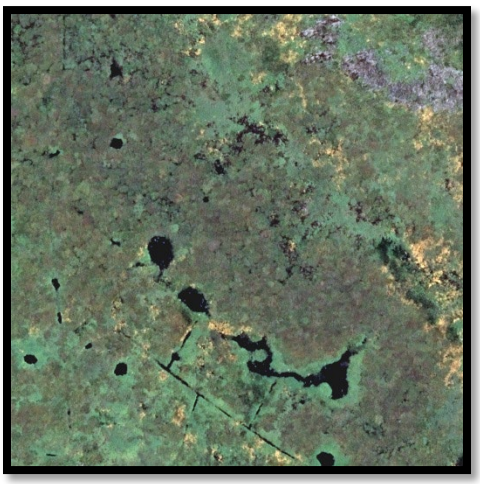
***Distichlis spicata* – Annual Grasses Association**
Stands are composed of a mixture of *Distichlis spicata* (salt grass) and non-native annual grasses. *Distichlis* may be dominant or share dominance (as low as 30% relative cover) with annual grass species, primarily *Polypogon monspeliensis* (rabbit's foot grass), *Festuca perennis* (perennial ryegrass), and/or *Hordeum* spp. (barley). Annuals generally cover at least 10%. Found at the higher marsh margins.

***Distichlis spicata – Juncus arcticus* var. *balticus* (*J. arcticus* var. *mexicanus*) Association**
Stands of *Distichlis spicata* (salt grass), with *Juncus arcticus* var. *balticus or Juncus arcticus* var. *mexicanus* as principal subordinate species (>5% relative cover). *Juncus* should be consistently present throughout the stand but does not need to be the most abundant subordinate species.

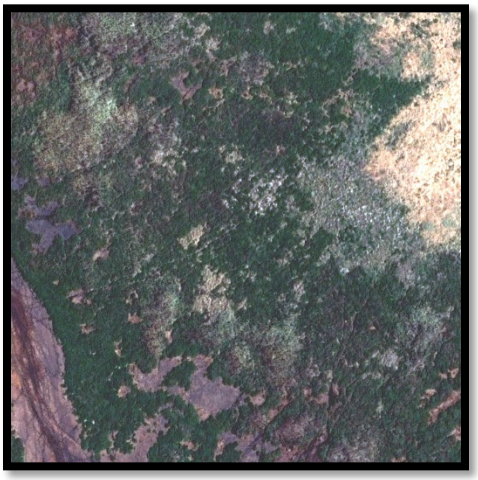
***Distichlis spicata – Salicornia pacifica* Association**
Stands are co-dominated by *Distichlis spicata* (salt grass) and *Salicornia pacifica* (pickleweed), both with 30% to 60% relative cover.

***Distichlis spicata – Schoenoplectus americanus* Provisional Association**
Distichlis spicata (salt grass) is the characteristic grass species with emergent *Schoenoplectus americanus* (three square bulrush) conspicuous, but less than 40% cover. Found in tidal and muted tidal settings with little disturbance.

***Distichlis spicata – Cotula coronopifolia* Association**
Stands of *Distichlis spicata* (salt grass) with the annual *Cotula coronopifolia* (brass buttons) as a subordinate species.



***Distichlis spicata – Juncus balticus – Triglochin* spp. – *Glaux maritima* Mapping Unit**
Distichlis spicata (salt grass) is the major ground cover, associated with a variety of native tidal marsh species including *Juncus balticus*, *Triglochin maritima, Glaux maritima, Jaumea carnosa,* and/or *Limonium californicum.* This type characterizes the most pristine native short tidal marsh habitats.

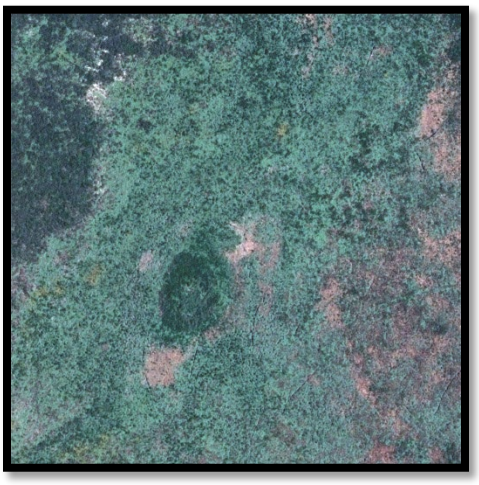


***Salicornia pacifica (Salicornia depressa)* Herbaceous Alliance**
Vegetation dominated (at least 10% cover over a sometimes higher cover of short annual or perennial grasses) by the native perennial salt marsh sub-shrubby or herbaceous *Salicornia pacifica* (pickleweed).

***Salicornia pacifica* Association**
Vegetation is dominated solely by *Salicornia pacifica* (pickleweed), with more than twice as much cover of *Salicornia* than of any other combination of species in the stand.

***Salicornia pacifica* – Annual Grasses Association**
Stand is dominated by *Salicornia pacifica* (pickleweed) with a sparse to dense mixture of annual grasses (*Polypogon, Hordeum, Festuca perennis, Bromus* spp.).

***Salicornia pacifica – Crypsis schoenoides* Association**
Vegetation dominated by *Salicornia pacifica* (pickleweed) mixed with a short intermittent layer of *Crypsis schoenoides* (swamp timothy).



***Salicornia pacifica – Sesuvium verrucosum* Association**
Vegetation dominated or co-dominated by *Salicornia pacifica* (pickleweed) with *Sesuvium verrucosum* (sea purslane) as a main subordinate species (at least 20% relative cover); may also include relatively high cover of *Cotula coronopifolia* (brass buttons).

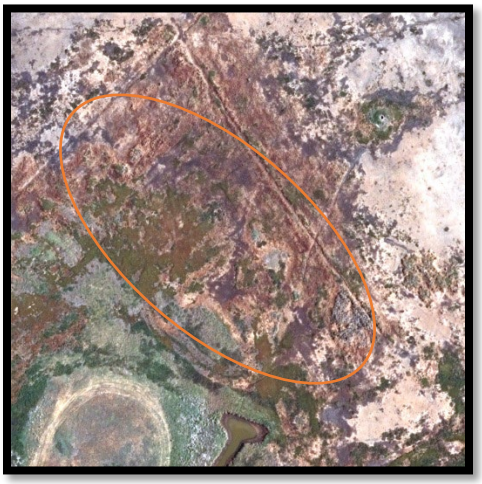
***Salicornia pacifica – Cotula coronopifolia* Association**
Vegetation dominated by *Salicornia pacifica* with an ephemeral annual component of *Cotula coronopifolia* (brass buttons), which may cover enough ground to co-dominate in the early growing season.

***Spartina foliosa* Herbaceous Alliance**

Spartina foliosa was mapped along partially inundated open water along the bay.

***Atriplex prostrata – Cotula coronopifolia* Herbaceous Semi-Natural Alliance**

Stands dominated or characterized by *Atriplex prostrata* (fat hen) and/or *Cotula coronopifolia* (brass buttons). Both species are indicative of disturbed conditions in alkaline or saline wetlands. Both are early seral plants; they may be abundant to sparse from year to year depending on disturbance regime and salinity.



***Cotula coronopifolia* Semi-Natural Association**

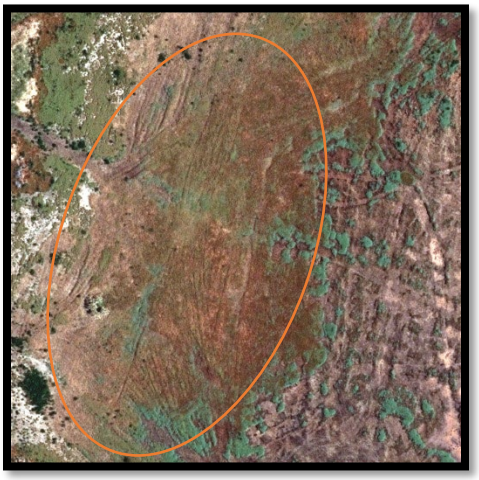
Stands are strongly dominated by *Cotula coronopifolia* (brass buttons) with little or no significant cover from other species. Found on recently inundated, exposed mudflats. When still growing, the CIR imagery signature is a salmon color.

***Sesuvium verrucosum* Herbaceous Alliance**

Sesuvium verrucosum (sea purslane) > 50% relative cover in the herbaceous layer, dominant or co-dominant with *Chenopodium chenopodioides, Cotula coronopifolia, Distichlis spicata, Lolium perenne, Rumex crispus, Rumex pulcher, Salicornia pacifica* and/or *Spergularia marina.*

***Sesuvium verrucosum* Association**

Sesuvium verrucosum (sea purslane) is strongly dominant.

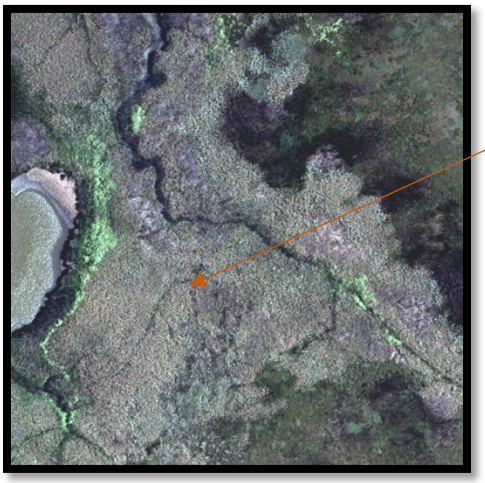


***Spergularia marina* Provisional Herbaceous Alliance**

Stands dominated by *Spergularia marina* (sand spurrey). Found in moist or seasonally flooded alkaline/saline areas, and newly scraped areas exposing mudflats of high salinity.

***Schoenoplectus americanus* Herbaceous Alliance**

Schoenoplectus americanus (three-square bulrush) dominates (>50% relative cover) stand. Co-dominants may include *Distichlis spicata, Juncus arcticus, Schoenoplectus acutus,* and *Schoenoplectus californicus. S. americanus* stands generally occupy portions of the marsh that are saturated, but not permanently flooded, often along the upper reaches of tidally influenced sloughs, creeks, and ditches.



***Schoenoplectus americanus – Lepidium latifolium* Association**

Schoenoplectus americanus (three-square bulrush) is dominant to co-dominant with *Lepidium latifolium* (perennial pepperweed), which may approach *S. americanus* in total cover. Tends to replace native associations of *S. americanus* along small tidal creeks and channels.

***Atriplex lentiformis* Shrubland Alliance**

Scrub dominated by the medium-to-large-sized shrub (up to 4 m in height) *Atriplex lentiformis* (big saltbrush). Generally, occurs in small, linear stands at borders of managed fields and intermittently flooded wetlands, usually associated with annual grasses and non-native herbs. In true color imagery, its signature is very gray in comparison to other shrubs of the same size.

***Frankenia salina* Herbaceous Alliance**

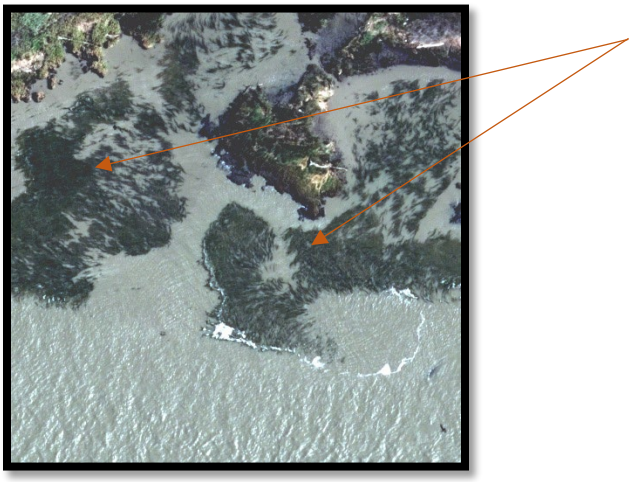
Frankenia salina (alkali heath) is dominant or co-dominant and may have equal or somewhat higher cover of *Distichlis spicata* (salt grass) or annual grasses. Generally found in seasonally moist or intermittently flooded clayey saline soils. *Frankenia* generally has a bluer green color relative to *Distichlis spicata*, which is more yellow-green but often has the same texture in appearance and occurs in similar settings.

***Frankenia salina – Distichlis spicata* Association**

Frankenia salina (alkali heath) and *Distichlis spicata* (saltgrass) co-dominate.

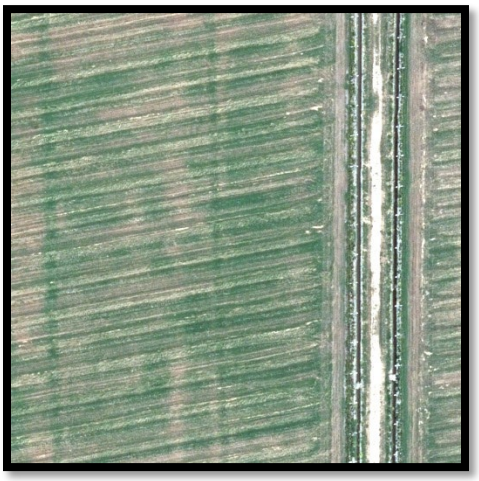
Temperate Pacific Intertidal Flat Group

This group-level mapping unit is used for floating aquatic vegetation that was not identifiable to species on the imagery and which had no field samples to verify its identification.



***Stuckenia pectinata* Association**

Floating masses strongly dominated by *Stuckenia pectinata* (narrow-leaved pondweed) occurring in diked brackish ponds, tidally influenced ditches or sloughs, and at the edges of the open bay.



Row & Close Grain Crop Formation

Upland stands dominated by annual grasses and distinguished by heavily managed site history. Species are various but are planted, mowed, and/or cultivated regularly.

Temperate Tree Developed Vegetation Group

Stands dominated by non-native or planted trees, except *Eucalyptus*, which are mapped as *Eucalyptus (globulus, camaldulensis)* Woodland Semi-Natural Alliance.

Appendix C

Map classes used to map Suisun Marsh

Vegetated map classes are ordered by their Group placement in the Manual of California Vegetation. 2021 map codes are given for each map class.

Group	Map Class (alliance/association)
Southwestern North American Introduced Riparian Scrub Group	
	Arundo donax Herbaceous Semi-Natural Association
	Tamarix spp. Shrubland Semi-Natural Alliance
Southwestern North American Salt Basin and High Marsh Group	
	Atriplex lentiformis Shrubland Alliance
Western North American Disturbed Alkaline Marsh and Meadow Group	
	Atriplex prostrata - Cotula coronopifolia Herbaceous Semi-Natural Alliance
	Cotula coronopifolia Semi-Natural Association
	Sesuvium verrucosum Herbaceous Alliance
	Sesuvium verrucosum Provisional Association
	Spergularia marina Provisional Herbaceous Alliance
California Coastal Evergreen Bluff and Dune Scrub Group	
	Baccharis pilularis / Annual Grass-Herb Association
	Baccharis pilularis Shrubland Alliance
Southwestern North American Riparian/Wash Scrub Group	
	Baccharis salicifolia Shrubland Alliance
Temperate Pacific Tidal Salt and Brackish Meadow Group	
	Bolboschoenus maritimus Herbaceous Alliance
	Distichlis spicata - Annual grasses Association
	Distichlis spicata - Cotula coronopifolia Association
	Distichlis spicata - Juncus arcticus var. balticus (J. arcticus var. mexicanus) Association
	Distichlis spicata - Juncus balticus - Triglochin spp. - Glaux maritima Mapping Unit
	Distichlis spicata - Salicornia pacifica Association
	Distichlis spicata - Schoenoplectus americanus Provisional Association
	Distichlis spicata Association
	Distichlis spicata Herbaceous Alliance
	Salicornia pacifica - Annual Grasses Association
	Salicornia pacifica - Cotula coronopifolia Association
	Salicornia pacifica - Crypsis schoenoides Association
	Salicornia pacifica - Sesuvium verrucosum Association
	Salicornia pacifica (*Salicornia depressa*) Herbaceous Alliance
	Salicornia pacifica Association
	Spartina foliosa Herbaceous Alliance

Group	Map Class (alliance/association)
California-Vancouverian Semi-Natural Littoral Scrub and Herb Vegetation Group	
	Carpobrotus edulis or Other Ice Plants Herbaceous Semi-Natural Alliance
Mediterranean California Naturalized Annual and Perennial Grassland Group	
	Mediterranean California Naturalized Annual and Perennial Grassland Group
	Cortaderia (*jubata, selloana*) Semi-Natural Herbaceous Alliance
	Eucalyptus (*globulus, camaldulensis*) Woodland Semi-Natural Alliance
Southwestern North American Salt Basin and High Marsh Group	
	Frankenia salina - Distichlis spicata Association
	Frankenia salina Herbaceous Alliance
Californian Mixed Annual/Perennial Freshwater Vernal Pool/Swale Bottomland Group	
	Grindelia (*stricta*) Provisional Herbaceous Alliance
California Vernal Pool and Grassland Matrix Group	
	California Vernal Pool and Grassland Matrix Group
Californian Warm Temperate Marsh/Seep Group	
	Bidens cernua – Euthamia occidentalis – Ludwigia palustris Herbaceous Alliance
	Juncus arcticus (var. *balticus, mexicanus*) Herbaceous Alliance
	Leymus triticoides Alliance
Naturalized Warm-Temperate Riparian and Wetland Group	
	Crypsis schoenoides Mapping Unit
	Lepidium latifolium Herbaceous Semi-Natural Alliance
	Persicaria lapathifolia - Xanthium strumarium Herbaceous Alliance
	Salsola soda Mapping Unit
Vancouverian and Rocky Mountain Naturalized Perennial Grassland Group	
	Phalaris aquatica Herbaceous Semi-Natural Association
California Broadleaf Forest and Woodland	
	Quercus agrifolia Woodland Alliance
Row & Close Grain Crop Formation	
	Row and Close Grain Crop Formation
Naturalized Non-Native Deciduous Scrub Group	
	Rubus armeniacus Shrubland Semi-Natural Alliance
Southwestern North American Riparian/Wash Scrub Group	

Group	Map Class (alliance/association)
	Salix exigua Association
	Rosa californica Association
	Rosa californica - Baccharis pilularis Association
Southwestern North American Riparian Evergreen and Deciduous Woodland Group	
	Salix laevigata / *Salix lasiolepis* Association
Southwestern North American Alkali Marsh/Seep Vegetation Group	
	Schoenoplectus americanus - Lepidium latifolium Association
	Schoenoplectus americanus Herbaceous Alliance
Temperate and Boreal Salt Marsh Formation	
	Temperate and Boreal Salt Marsh Formation
Temperate Pacific Intertidal Flat Group	
	Stuckenia pectinata Association
	Temperate Pacific Intertidal Flat Group
Temperate Tree Developed Vegetation Group	
	Temperate Tree Developed Vegetation Group
Arid West Freshwater Emergent Marsh Group	
	Typha (*angustifolia, latifolia, domingensis*) Herbaceous Alliance
	Schoenoplectus (*acutus, californicus*) - *Rosa californica* Association
	Schoenoplectus (*acutus, californicus*) - Wetland Herbs Mapping Unit
	Schoenoplectus (*acutus, californicus*) - *Typha* (*angustifolia, latifolia, domingensis*) Mapping Unit
	Schoenoplectus (*acutus, californicus*) Mapping Unit
	Phragmites australis Herbaceous Alliance
	Alisma triviale Mapping Unit
Non-Vegetation	
	Bare Ground Mapping Unit
	Developed Mapping Unit
	Ditch Mapping Unit
	Open Water Mapping Unit
	Railroad Track Mapping Unit
	Road / Trails Mapping Unit
	Slough Mapping Unit
	Tidal Mudflat Mapping Unit

Appendix D

2024 Vegetation Mapping Attributes and Descriptions

OJECTID_1: Internal feature number

MapClass: The finest level of vegetation type mapped (alliance, association, group, macrogroup, or mapping unit); or land use for polygons that are not natural vegetation.

MapCode: Numeric code corresponding to the MapClass.

PER_HARDWOOD: The total cover of hardwood tree species present in the stand. “0.2” represents hardwood presence at less than 1%.

PER_CONIFER: The total cover of conifer tree species present in the stand. “0.2” represents conifer presence at less than 1%.

PER_TREE: The sum of % hardwood cover and % conifer cover.

PER_SHRUB: The total cover of all shrub species present.

HERB_CODE: The cover of herbaceous species present in a stand, broken into the following classes: <2%, 2-9%, 10-39%, >40% Woody (used when PER_TREE+PER_SHRUB is >40%).

PER_TOTAL: The total combined cover of % tree + % shrub + average of the herbaceous cover by class

HT_CODE: Average height of the dominant vegetation within the polygon, in meters, broken into the following classes: <1 m, 1-5 m, 5-20 m, 20-50 m

SIZE_CATEGORY: Used only for tree mapping types, the average diameter at breast height of the trees present within the stand, broken into the following classes:
Saplings (1-6”), Pole (6-11”), Small (11-24”), Medium-Large (>24”).

ISOLATED_TREE: A “Y” indicates a total tree cover of >0% and <5%.

RESTORATION: A “Y” indicates that this polygon is within the whole property boundary (i.e., tidal and upland elevations) of a tidally restored site that was permitted as a tidal restoration project. Restoration refers to the conversion of managed/leveed wetlands into tidal wetlands by intentionally breaching levees and/or removing hydrological barriers to reintroduce natural tidal flows. Details describe whether the polygon falls in a project that tiered off the Suisun Marsh Habitat Management, Preservation, and Restoration Plan (classified as an “SMP Restoration Project”) or not (classified as a “non-SMP Restoration Project”). The year that the site was tidally restored is also included.

CLEARING_DISTURBANCE: The percent of the polygon that has been affected by human disturbance (including disking, plowing, and mowing), broken into the following classes:
No Disturbance = <5%, Minimal Disturbance = 5-25%, Moderate Disturbance = 25-50%, High Disturbance = >50%

INVASIVE_PLANT: The percent of the polygon that is covered by invasive species, broken into the following classes:
No Invasive = <5%, Low Invasive = 5-25%, Moderate Invasive = 25-50%, High Invasive = >50%

Comments_Final: Comments from the photo interpreter about an individual polygon

Habitat:
Tidal (1): Tidal wetlands (including muted tidal) are those areas naturally affected regularly by tidal fluctuation. The area may or may not be vegetated with vascular or non-vascular plants and may or may not have any evidence of human modification such as ditches, excavations, interrupted levees, berms, etc.
Leveed (2): leveed wetlands are those areas that are completely enclosed and are restricted from natural tidal influence.
Slough (3): Generally applied to the wide, naturally occurring (at least not linear) waterways affected by tides.

Unique_ID: Unique identifier for each polygon.

MCVName: Names will be the same as the ones used in the Manual of California Vegetation and California Natural Community List. These standardized names correspond as much as possible to the National Vegetation Classification System. Classes for human land use or otherwise unvegetated land were drawn from the California Wildlife Habitat Relationship.

MCVLevel: The standardized level of the vegetation description in the Manual of California Vegetation corresponding with levels of the National Vegetation Classification System.

CalVegType: A crosswalk to the CalVeg vegetation system. Note that there may be a one-to-many relationship between CalVeg and NVCS.

CalVegCode: The two-letter code for the crosswalked CalVeg vegetation system. Note that there may be a one-to-many relationship between CalVeg and NVCS.

CWHRType: A crosswalk to the California Wildlife Habitat Relationships (CWHR) system. Note that there is usually a one-to-many relationship between CWHR and NVCS.

CWHRCode: The three-letter code for the crosswalked CWHR habitat type. Note that there is usually a one-to-many relationship between CWHR and NVCS.

GlobalRank: The global rarity rank of the plant community (only for polygons mapped to the alliance level).

G1: Fewer than 6 viable occurrences and/or 2000 acres worldwide;
G2: 6-20 viable occurrences and/or 2000-10,000 acres worldwide;
G3: 21-100 viable occurrences and/or 10,000-50,000 acres worldwide;
G4: Greater than 100 viable occurrences and/or greater than 50,000 acres worldwide;
G5: Community demonstrably secure due to secure worldwide abundance.

StateRank: The state rarity rank of the plant community (only for polygons mapped to the alliance level).

S1: Fewer than 6 viable occurrences and/or 2000 acres statewide;
S2: 6-20 viable occurrences and/or 2000-10,000 acres statewide;
S3: 21-100 viable occurrences and/or 10,000-50,000 acres statewide;
S4: Greater than 100 viable occurrences and/or greater than 50,000 acres statewide;
S5: Community demonstrably secure due to secure statewide abundance.

Sensitive: Rarity of the vegetation type. Alliances and associations with state ranks of S1-S3 and global ranks of G1-G3 are considered sensitive.

Y – Sensitive
N – Not Sensitive

CaCode: California Natural Community Codes - unique code assigned to alliances and associations.

MCVAlliance: The Manual of California Vegetation (MCV)-compliant alliance (if applicable) which contains this vegetation type.

MCVGroup: The MCV-compliant group (if applicable) which contains this vegetation type.

MCVMacrogroup: The MCV-compliant macrogroup (if applicable) which contains this vegetation type.

Community_Link: The link to the alliance in the Manual of California Vegetation Online.

Ortho_NAIP_Year: All imagery for this mapping effort was flown in 2018.

Shape_Length: Length of the polygon, in meters.

Shape_Area: Area of the polygon, in meters squared.

Acres: The area of a polygon in acres

Hectares: The area of a polygon in hectares

Appendix E

Salt Marsh Harvest Mouse habitat by vegetation mapping type

Note: some mapping types at group level and higher could not be rated as potential habitat.

Mapping Code	Mapping type	Potential Habitat
1	Bare Ground Mapping Unit	No
2	Agriculture	No
4	Road / Trails Mapping Unit	No
6	Slough Mapping Unit	No
7	Tidal Mudflat Mapping Unit	No
8	Railroad Track Mapping Unit	No
9	Ditch Mapping Unit	No
11	Open Water Mapping Unit	No
15	Developed Mapping Unit	No
1000000	**Warm Temperate Forest Formation**	No
1100000	**Madrean Forest and Woodland Division**	No
1110000	**California Forest and Woodland Macrogroup**	No
1111000	Californian Broadleaf Forest and Woodland Group	No
1111100	*Quercus agrifolia* Alliance	No
1111101	*Quercus agrifolia* Association	No
1111102	*Quercus agrifolia / Salix lasiolepis* Association	No
1111200	*Quercus lobata* Alliance	No
2000000	**Cool Temperate Forest Formation**	No
2100000	**North American Introduced Evergreen Broadleaf and Conifer Forest Division**	No
2110000	**Introduced North American Mediterranean Woodland and Forest Macrogroup**	No
2110100	*Eucalyptus (globulus, camaldulensis)* Semi-Natural Alliance	No
2110101	*Eucalyptus globulus* Semi-Natural Association	No
2110200	*Ailanthus altissima* Semi-Natural Alliance	No
2120000	**Southwestern North American Riparian, Flooded and Swamp Forest Macrogroup**	No
2121000	Southwestern North American Riparian Evergreen and Deciduous Woodland Group	No
2121100	*Salix laevigata* Alliance	No
2121101	*Salix laevigata / Salix lasiolepis* Association	No
2122000	Southwestern North American Riparian/Wash Scrub Group	Not rated
2122100	*Salix exigua* Alliance	No
2122101	*Salix exigua* Association	No
2122200	*Rosa californica* Alliance	Yes
2122210	*Rosa californica* Association	Yes
2122212	*Rosa californica – Baccharis pilularis* Association	Yes
2122300	*Baccharis salicifolia* Shrubland Alliance	Yes

Mapping Code	Mapping type	Potential Habitat
2123000	Southwestern North American Introduced Riparian Scrub Group	No
2123100	*Arundo donax* Semi-Natural Alliance	No
2123101	*Arundo donax* Semi-Natural Association	No
2123200	*Tamarix* spp. Shrubland Semi-Natural Alliance	No
3000000	**Western North America Flooded and Swamp Forest Division**	No
3100000	**Western Cordilleran montane–boreal riparian scrub Macrogroup**	No
3111000	Vancouverian Riparian Deciduous Forest Group	No
3111100	*Fraxinus latifolia* Alliance	No
3111101	*Fraxinus latifolia* Planted Stands Mapping Unit	No
4000000	**Mediterranean Grassland and Forb Meadow Formation**	Not rated
4100000	**California Grassland and Meadow Division**	Not rated
4110000	**California Annual and Perennial Grassland Macrogroup**	Not rated
4111000	Mediterranean California Naturalized Annual and Perennial Grassland Group	Yes
4111100	*Brassica nigra* and Other Mustards Semi-Natural Alliance	No
4111101	*Brassica nigra* Semi-Natural Association	No
4111102	*Raphanus sativus* Semi-Natural Association	No
4111200	*Bromus (diandrus, hordeaceus) – Brachypodium distachyon* Semi-Natural Alliance	Yes
4111300	*Centaurea (solstitialis, melitensis)* Semi-Natural Alliance	No
4111400	*Conium maculatum – Foeniculum vulgare* Semi-Natural Alliance	No
4111401	*Conium maculatum* Semi-Natural Association	No
4111402	*Foeniculum vulgare* Semi-Natural Association	No
4111500	*Cortaderia (jubata, selloana)* Semi-Natural Herbaceous Alliance	No
4111600	*Festuca perennis* Semi-Natural Alliance	Yes
4111601	*Festuca perennis – Lepidium latifolium* Semi-Natural Association	Yes
4111602	*Festuca perennis – Lotus corniculatus* Semi-Natural Association	Yes
4111603	*Festuca perennis – Rumex* spp. Mapping Unit	Yes
4111604	*Hordeum marinum – Festuca perennis* Mapping Unit	Yes
4111700	*Elytrigia pontica* Mapping Unit	Yes
4111800	*Agrostis avenacea* Mapping Unit	Yes
4111900	*Vulpia* spp. *– Euthamia occidentalis* Mapping Unit	Yes
5000000	**Temperate Grassland, Meadow, and Shrubland Formation**	Not rated
5100000	**Vancouverian and Rocky Mountain Grassland and Shrubland Division**	Not rated
5110000	**Western North American Temperate Grassland and Meadow Macrogroup**	Not rated
5111000	Vancouverian and Rocky Mountain Naturalized Perennial Grassland Group	Not rated
5111100	*Phalaris aquatica* Herbaceous Semi-Natural Alliance	Yes

Mapping Code	Mapping type	Potential Habitat
5111101	*Phalaris aquatica* Herbaceous Semi-Natural Association	Yes
5120000	**Vancouverian Lowland Grassland and Shrubland Macrogroup**	Not rated
5121000	Naturalized Non-Native Deciduous Scrub Group	Not rated
5121100	*Rubus armeniacus* Shrubland Semi-Natural Alliance	Yes
6000000	**Temperate and Boreal Scrub and Herb Coastal Vegetation Formation**	Not rated
6100000	**Pacific Coast Scrub and Herb Littoral Vegetation Division**	Not rated
6110000	**Vancouverian Coastal Dune and Bluff Macrogroup**	Not rated
6111000	California Coastal Evergreen Bluff and Dune Scrub Group	Not rated
6111100	*Baccharis pilularis* Shrubland Alliance	Yes
6111101	*Baccharis pilularis* / Annual Grass-Herb Association	Yes
6112000	California–Vancouverian Semi-Natural Littoral Scrub and Herb Vegetation Group	No
6112100	*Carpobrotus edulis* or Other Ice Plants Herbaceous Semi-Natural Alliance	No
7000000	**Temperate and Boreal Freshwater Marsh Formation**	Not rated
7100000	**Western North American Freshwater Marsh Division**	Not rated
7110000	**Western North American Freshwater Marsh Macrogroup**	Not rated
7111000	Arid West Freshwater Emergent Marsh Group	Not rated
7111100	*Typha (angustifolia, domingensis, latifolia*) Herbaceous Alliance	No
7111101	*Typha (angustifolia, latifolia, domingensis)* Association	No
7111102	*Typha (angustifolia, latifolia, domingensis)* (dead stalks) Mapping Unit	No
7111103	*Typha (angustifolia, latifolia, domingensis) – Echinochloa crus-galli* Association	No
7111104	*Typha (angustifolia, latifolia, domingensis) – Distichlis spicata* Association	No
7111105	*Typha (angustifolia, latifolia, domingensis) – Phragmites australis* Association	Yes
7111106	*Typha (angustifolia, latifolia, domingensis) – Schoenoplectus americanus* Association	Yes
7111200	*Schoenoplectus (acutus, californicus)* Alliance	Yes
7111201	*Schoenoplectus californicus – Schoenoplectus acutus* Association	Yes
7111202	*Schoenoplectus (acutus, californicus)* Mapping Unit	Yes
7111203	*Schoenoplectus (acutus, californicus) / Rosa californica* Provisional Association	Yes
7111300	*Schoenoplectus (acutus, californicus) – Typha (angustifolia, latifolia, domingensis)* Mapping Unit	Yes
7111400	*Schoenoplectus (acutus, californicus)* – Wetland Herbs Mapping Unit	Yes
7111401	*Calystegia sepium – Euthamia occidentalis* Mapping Unit	No
7111500	*Phragmites australis* Herbaceous Alliance	Yes
7111501	*Phragmites australis* Association	Yes

Mapping Code	Mapping type	Potential Habitat
7111502	*Phragmites australis – Schoenoplectus* spp. Association	Yes
7111503	*Phragmites australis – Xanthium strumarium* Mapping Unit	No
7111600	*Alisma triviale* Mapping Unit	No
7112000	Vancouverian Coastal/Tidal Marsh and Meadow Group	Not rated
7112100	*Potentilla anserina* Alliance	Yes
7120000	**Western North America Vernal Pool Macrogroup**	Not rated
7121000	Californian Mixed Annual/Perennial Freshwater Vernal Pool/Swale Bottomland Group	Not rated
7121000	California Vernal Pool and Grassland Matrix Group	Yes
7121100	*Grindelia (camporum, stricta)* Provisional Herbaceous Alliance	Yes
7130000	**Western North America Wet Meadow and Low Shrub Carr Macrogroup**	Not rated
7131000	Californian Warm Temperate Marsh/Seep Group	Not rated
7131300	Bidens cernua – Euthamia occidentalis – Ludwigia palustris Herbaceous Alliance	Yes
7131100	*Juncus arcticus (*var*. balticus, mexicanus)* Herbaceous Alliance	Yes
7131101	*Juncus arcticus* var*. balticus* Association	Yes
7131102	*Juncus arcticus* var*. balticus – Conium maculatum* Association	Yes
7131103	*Juncus arcticus* var*. balticus – Lepidium latifolium* Association	Yes
7131104	*Juncus arcticus* var*. balticus – Potentilla anserina* Association	Yes
7131200	*Leymus triticoides* Alliance	Yes
7132000	Naturalized Warm-Temperate Riparian And Wetland Group	Yes
7132100	*Lepidium latifolium* Herbaceous Semi-Natural Alliance	Yes
7132200	*Persicaria lapathifolia – Xanthium strumarium* Provisional Herbaceous Alliance	Yes
7132201	*Polygonum* spp*. – Xanthium strumarium – Echinochloa crus-galli* Mapping Unit	Yes
7132300	*Cynodon dactylon – Crypsis* spp. *– Paspalum* spp. Moist Semi-Natural Alliance	Yes
7132301	*Crypsis schoenoides* Mapping Unit	Yes
7132302	*Cynodon dactylon* Mapping Unit	No
7132400	*Polypogon monspeliensis* Mapping Unit	Yes
7132500	*Rumex* spp. Mapping Unit	Yes
7132600	*Salsola soda* Mapping Unit	No
8000000	**Temperate and Boreal Salt Marsh Formation**	Not rated
8100000	**Temperate and Boreal Pacific Coastal Salt Marsh Division**	Not rated
8110000	**North American Pacific Coastal Salt Marsh Macrogroup**	Not rated
8111000	Temperate Pacific Tidal Salt and Brackish Meadow Group	Not rated
8111100	*Bolboschoenus maritimus* Herbaceous Alliance	Yes
8111101	*Bolboschoenus maritimus* Association	Yes

Mapping Code	Mapping type	Potential Habitat
8111102	*Bolboschoenus maritimus – Salicornia pacifica* Association	Yes
8111103	*Bolboschoenus maritimus – Sesuvium verrucosum* Association	Yes
8111200	*Distichlis spicata* Herbaceous Alliance	Yes
8111201	*Distichlis spicata* Association	Yes
8111202	*Distichlis spicata* – Annual Grasses Association	Yes
8111203	*Distichlis spicata – Juncus arcticus* var. *balticus (J. arcticus* var. *mexicanus*) Association	Yes
8111204	*Distichlis spicata – Lotus corniculatus* Mapping Unit	No
8111205	*Distichlis spicata – Salicornia pacifica* Association	Yes
8111206	*Distichlis spicata – Schoenoplectus americanus* Provisional Association	Yes
8111207	*Distichlis spicata – Cotula coronopifolia* Association	Yes
8111208	*Distichlis spicata – Bolboschoenus maritimus* Mapping Unit	Yes
8111209	*Distichlis spicata – Juncus balticus – Triglochin* spp. *– Glaux maritima* Mapping Unit	Yes
8111210	*Lepidium latifolium – Distichlis spicata* Semi-Natural Association	Yes
8111300	*Salicornia pacifica (Salicornia depressa)* Herbaceous Alliance	Yes
8111301	*Salicornia pacifica* Tidal Association	Yes
8111302	*Salicornia pacifica* – Annual Grasses Association	Yes
8111303	*Salicornia pacifica – Atriplex prostrata* Association	Yes
8111304	*Salicornia pacifica – Crypsis schoenoides* Association	Yes
8111305	*Salicornia pacifica – Sesuvium verrucosum* Association	Yes
8111306	*Salicornia pacifica – Echinochloa crus-galli – Polygonum – Xanthium strumarium* Association	Yes
8111307	*Salicornia pacifica – Cotula coronopifolia* Association	Yes
8111400	*Spartina foliosa* Herbaceous Alliance	Yes
8112000	Western North American Disturbed Alkaline Marsh and Meadow Group	Not rated
8112100	*Atriplex prostrata – Cotula coronopifolia* Herbaceous Semi-Natural Alliance	Yes
8112101	*Cotula coronopifolia* Semi-Natural Association	Yes
8112102	*Atriplex prostrata* Semi-Natural Association	Yes
8112103	*Atriplex prostrata – Distichlis spicata* Semi-Natural Association	Yes
8112104	*Atriplex prostrata – Bolboschoenus maritimus* Semi-Natural Association	Yes
8112105	*Atriplex prostrata – Sesuvium verrucosum* Semi-Natural Association	Yes
8112106	*Atriplex prostrata* – Annual Grasses Semi-Natural Association	Yes
8112200	*Sesuvium verrucosum* Herbaceous Alliance	Yes
8112201	*Sesuvium verrucosum* Association	Yes
8112202	*Sesuvium verrucosum – Distichlis spicata* Association	Yes
8112203	*Sesuvium verrucosum – Festuca perennis* Association	Yes
8112204	*Sesuvium verrucosum – Cotula coronopifolia* Association	Yes
8112300	*Spergularia marina* Provisional Herbaceous Alliance	No
8112301	*Spergularia marina – Cotula coronopifolia* Mapping Unit	No
8200000	**Western North American Interior Alkali–Saline Wetland Division**	Not rated

Mapping Code	Mapping type	Potential Habitat
8210000	**Warm Semi-Desert/Mediterranean Alkali–Saline Wetland Macrogroup**	Not rated
8211000	Southwestern North American Alkali Marsh/Seep Vegetation Group	Not rated
8211100	*Schoenoplectus americanus* Herbaceous Alliance	Yes
8211101	*Schoenoplectus americanus* Association	Yes
8211102	*Schoenoplectus americanus – Potentilla anserina* Association	Yes
8211103	*Schoenoplectus americanus – Schoenoplectus californicus – Schoenoplectus acutus* Association	Yes
8211104	*Schoenoplectus americanus – Lepidium latifolium* Association	Yes
8212000	Southwestern North American Salt Basin and High Marsh Group	Not rated
8212100	*Atriplex lentiformis* Shrubland Alliance	Yes
8212200	*Frankenia salina* Herbaceous Alliance	Yes
8212201	*Frankenia salina* – Annual grasses Mapping Unit	Yes
8212202	*Frankenia salina – Distichlis spicata* Association	Yes
9000000	**Hydromorphic Vegetation (Aquatic Vegetation) Class**	No
9100000	**Marine and Estuarine Saltwater Aquatic Vegetation Formation**	No
9110000	**Temperate Pacific Saltwater Aquatic Vegetation Division**	No
9111000	**Temperate Pacific Intertidal Shore Macrogroup**	No
9111100	Temperate Pacific Intertidal Flat Group	No
9111200	*Stuckenia (pectinata) – Potamogeton* spp. Alliance	No
9111201	*Stuckenia pectinata* Association	No
9111300	*Ruppia (cirrhosa, maritima)* Herbaceous Alliance	No
9200000	**North American Freshwater Aquatic Vegetation Division**	No
9210000	**Western North American Freshwater Aquatic Vegetation Macrogroup**	No
9211000	Naturalized Temperate Pacific Freshwater Vegetation Group	No
9211100	*Ludwigia (hexapetala, peploides)* Provisional Herbaceous Semi-Natural Alliance	No
9310000	**Herbaceous Agricultural Vegetation Subclass**	No
9311000	**Row & Close Grain Crop Formation**	No
9312000	**Fallow Field and Weed Vegetation Formation**	No
9312100	**Cropland Fallow Field Division**	No
9312110	**Fallow Field Macrogroup**	No
9410000	**Herbaceous & Woody Developed Vegetation Subclass**	No
9411000	**Other Developed Vegetation Formation**	No
9411100	**Other Developed Vegetation Division**	No
9411111	Temperate Tree Developed Vegetation Group	No

Appendix F

Acreage and acreage change of Salt Marsh Harvest Mouse habitat in Suisun Marsh within the tidal, leveed, and whole region, within the four management regions and marsh-wide in 1999, 2015, 2018, and 2021.

Tidal SMHM Habitat

Region	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Management Region 0	N/A	N/A	79.08	169.65	136.76	N/A	N/A	90.57	-32.89	N/A	N/A	114.53%	-19.39%
Management Region 1	1529.3	2329.6	2683.9	2,682.17	3234.43	1,705.13	354.3	-1.73	552.26	111.50%	15.21%	-0.06%	20.59%
Management Region 2	1360.8	2088.6	2137.1	2,160.90	2718.69	1,357.89	48.5	23.8	557.79	99.79%	2.32%	1.11%	25.81%
Management Region 3	448.9	597.3	652	757.2	933.10	484.20	54.7	105.2	175.90	107.86%	9.16%	16.13%	23.23%
Management Region 4	2316.5	2643.9	3258.3	3,236.60	4431.99	2,115.49	614.4	-21.7	1195.39	91.32%	23.24%	-0.67%	36.93%
Marsh-wide	5655.5	7659.4	8810.3	9,006.52	11454.95	5,799.45	1150.9	196.22	2448.43	102.55%	15.03%	2.23%	27.19%

Leveed SMHM Habitat

Region	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Management Region 0	N/A	N/A	2.99	3.7	2.26	N/A	N/A	0.71	-1.44	N/A	N/A	23.75%	-38.92%
Management Region 1	11758.5	8545	10033.7	9,388.90	8,853.99	-2,904.51	1488.7	-644.8	-534.91	-24.70%	17.42%	-6.43%	-5.70%
Management Region 2	5558.4	5321.9	5975.4	5,474.20	4,385.65	-1,172.75	653.5	-501.2	-1088.55	-21.10%	12.28%	-8.39%	-19.89%
Management Region 3	3114.1	2375.6	2654.9	2,456.40	2,186.89	-927.21	279.3	-198.5	-269.51	-29.77%	11.76%	-7.48%	-10.97%
Management Region 4	21018.8	19780.7	21628.7	20,307.30	18,611.30	-2,407.50	1848	-1321.4	-1696.00	-11.45%	9.34%	-6.11%	-8.35%
Marsh-wide	41449.8	36023.1	40295.7	37,655.50	34,040.32	-7,409.48	4272.6	-2640.2	-3615.18	-17.88%	11.86%	-6.55%	-9.60%

Marsh-wide SMHM Habitat

Region	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Management Region 0	N/A	N/A	82.07	173.4	139.01668	N/A	N/A	91.33	-34.3833181	N/A	N/A	111.28%	-19.83%
Management Region 1	13287.8	10874.6	12707.6	12,071.10	12,088.42	-1,199.38	1833	-636.5	17.320164	-9.03%	16.86%	-5.01%	0.14%
Management Region 2	6919.3	7410.5	8112.5	7,635.10	7,104.34	185.04	702	-477.4	-530.7584	2.67%	9.47%	-5.88%	-6.95%
Management Region 3	3562.9	2972.9	3306.8	3,213.60	3,119.99	-442.91	333.9	-93.2	-93.612	-12.43%	11.23%	-2.82%	-2.91%
Management Region 4	23335.4	22424.5	24887	23,543.90	23,043.30	-292.10	2462.5	-1343.1	-500.6039	-1.25%	10.98%	-5.40%	-2.13%
Marsh-wide	47105.3	43682.5	49106	46,662	45,495	-1,610.03	5423.5	-2444	-1166.7266	-3.42%	12.42%	-4.98%	-2.50%

Appendix G

Acreage and acreage change of the non-native species of concern in Suisun Marsh within the tidal, leveed, and whole region, within the four management regions and marsh-wide in 1999, 2015, 2018, 2021, and 2024.

Management Region 0—Tidal Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	N/A	N/A	0.3	0.31	0.2	N/A	N/A	0.01	-0.11	N/A	N/A	3.33%	-35.48%
Carpobrotus edulis Association	N/A	N/A	0	0.04	0	N/A	N/A	0.04	-0.04	N/A	N/A	N/A	-100.00%
Cortaderia selloana Association	N/A	N/A	0.02	0.01	0.05	N/A	N/A	-0.01	0.04	N/A	N/A	-62.87%	507.66%
Eucalyptus spp.	N/A	N/A	0.21	0.42	0.67	N/A	N/A	0.22	0.25	N/A	N/A	105.36%	58.92%
*Lepidium latifolium**	N/A	N/A	0.08	0.01	0.17	N/A	N/A	-0.07	0.16	N/A	N/A	-87.50%	1600.00%
Phragmites australis	N/A	N/A	9.01	13.61	23.8	N/A	N/A	4.60	10.19	N/A	N/A	51.00%	74.92%
Salsola soda Provisional Alliance	N/A	N/A	0	0	0	N/A	N/A	0	0.00	N/A	N/A	N/A	N/A

Management Region 0—Leveed Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	N/A	N/A	0.05	0.06	0.01	N/A	N/A	0.01	-0.05	N/A	N/A	20.55%	-84.44%
Carpobrotus edulis Association	N/A	N/A	0	0	0.06	N/A	N/A	0	0.06	N/A	N/A	N/A	N/A
Cortaderia selloana Association	N/A	N/A	0	0	0	N/A	N/A	0	0.00	N/A	N/A	N/A	N/A
Eucalyptus spp.	N/A	N/A	3.21	3.53	3.51	N/A	N/A	0.32	-0.02	N/A	N/A	9.89%	-0.62%
*Lepidium latifolium**	N/A	N/A	0.01	0.05	0.19	N/A	N/A	0.04	0.14	N/A	N/A	363.68%	251.76%
Phragmites australis	N/A	N/A	0.34	0.53	0.49	N/A	N/A	0.19	-0.04	N/A	N/A	55.30%	-8.17%
Salsola soda Provisional Alliance	N/A	29.9	0	0	0	N/A	N/A	0	0.00	N/A	N/A	N/A	N/A

Management Region 0—Region-wide Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	N/A	N/A	0.35	0.37	0.22	N/A	N/A	0.02	-0.15	N/A	N/A	5.93%	-41.22%
Carpobrotus edulis Association	N/A	N/A	0	0.04	0.06	N/A	N/A	0.04	0.02	N/A	N/A	N/A	50.00%
Cortaderia selloana Association	N/A	N/A	0.02	0.01	0.05	N/A	N/A	-0.01	0.04	N/A	N/A	-50.00%	400.00%
Eucalyptus spp.	N/A	N/A	3.42	3.95	4.19	N/A	N/A	0.53	0.24	N/A	N/A	15.62%	5.98%
*Lepidium latifolium**	N/A	N/A	0.09	0.06	0.36	N/A	N/A	-0.03	0.30	N/A	N/A	-30.15%	462.37%
Phragmites australis	N/A	N/A	9.35	14.14	24.29	N/A	N/A	4.79	10.15	N/A	N/A	51.16%	71.78%
Salsola soda Provisional Alliance	N/A	29.9	0	0	0	N/A	N/A	0	0	N/A	N/A	N./A	N/A

Management Region 1—Tidal Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	0.00	2.20	1.00	2.34	1.66	1.66	-1.20	1.34	-0.68	N/A	-0.55	0.57	-0.29
Carpobrotus edulis Association	0.00	1.90	0.00	0.00	0.50	0.50	-1.90	0.00	0.50	N/A	-1.00	N/A	N/A
Cortaderia selloana Association	0.00	0.30	1.00	0.48	1.00	1.00	0.70	-0.52	0.52	N/A	2.33	-1.07	1.07
Eucalyptus spp.	0.00	0.90	0.30	0.79	0.86	0.86	-0.60	0.49	0.07	N/A	-0.67	0.62	0.09
*Lepidium latifolium**	31.60	7.00	14.35	7.32	53.74	22.14	7.35	-7.03	46.42	0.70	1.05	-0.96	6.34
Phragmites australis	102.80	454.60	587.20	589.55	851.96	749.16	132.60	2.35	262.41	7.29	0.29	0.00	0.45
Salsola soda Provisional Alliance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	N/A	N/A

Management Region 1—Leveed Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	0.7	0	1.8	2.09	2.36	1.66	1.8	0.29	0.27	237.14%	N/A	16.11%	12.92%
Carpobrotus edulis Association	0	0	2.5	2.16	2.01	2.01	2.5	-0.3365737	-0.1534263	N/A	N/A	-13.46%	-7.09%
Cortaderia selloana Association	7.6	3.6	5.2	3.84	2.40	-5.20	1.6	-1.3576447	-1.4423553	-68.42%	44.44%	-26.11%	-37.54%
Eucalyptus spp.	52.6	91	102.6	101.31	105.41	52.81	11.6	-1.2886278	4.0986278	100.40%	12.75%	-1.26%	4.05%
*Lepidium latifolium**	159	20.2	34.6	35.81	96.24	-62.76	14.4	1.2142448	60.425755	-39.47%	71.29%	3.51%	168.72%
Phragmites australis	82.4	162.4	307.8	389.53	377.92	295.52	145.4	81.733588	-11.613588	358.64%	89.53%	26.55%	-2.98%
Salsola soda Provisional Alliance	0	29.9	13.9	26.32	0.00	0.00	-16	12.415018	-26.315018	N/A	-53.51%	89.32%	-100.00%

Management Region 1— Region-wide Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	0.7	2.2	2.8	4.43	4.02	3.32	0.6	1.63	-0.41	474.29%	27.27%	58.21%	-9.26%
Carpobrotus edulis Association	0	1.9	2.5	2.16	2.51	2.51	0.6	-0.34	0.3465737	N/A	31.58%	-13.46%	16.02%
Cortaderia selloana Association	7.6	3.9	6.2	4.33	3.41	-4.19	2.3	-1.87	-0.9155829	-55.13%	58.97%	-30.23%	-21.17%
Eucalyptus spp.	52.6	91.8	103	102.10	106.28	53.68	11.2	-0.90	4.1824373	102.05%	12.20%	-0.88%	4.10%
*Lepidium latifolium**	190.6	27.2	49	43.14	149.99	-40.61	21.8	-5.86	106.85185	-21.31%	80.15%	-11.96%	247.70%
Phragmites australis	185.2	617.1	895	979.09	1229.89	1044.69	277.9	84.09	250.80199	564.09%	45.03%	9.40%	25.62%
Salsola soda Provisional Alliance	0	29.9	13.9	26.32	0.00	0.00	-16	12.42	-26.315018	N/A	-53.51%	89.32%	-100.00%

Management Region 2—Tidal Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	0.2	0	0	0	0	-0.2	0	0	0	-100.00%	N/A	N/A	N/A
Carpobrotus edulis Association	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
Cortaderia selloana Association	0.8	0	0.02	0.03	0.03	-0.77	0.02	0.01	0	-96.25%	N/A	50.00%	0.00%
Eucalyptus spp.	3.2	2.2	2	6.16	24.11	20.91	-0.2	4.16	17.95	653.44%	-9.09%	208.00%	291.40%
*Lepidium latifolium**	52.9	9.5	14.9	11.99	6.67	-46.23	5.4	-2.91	-5.32	-87.39%	-9.09%	-19.53%	-44.37%
Phragmites australis	17.2	125.8	183.2	235.03	501.75	484.55	57.4	51.83	266.72	2817.15%	44.12%	28.29%	113.48%
Salsola soda Provisional Alliance	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A

Management Region 2—Leveed Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	0	0	0.5	0.38	0.03	0.03	0.5	-0.12	-0.35	N/A	N/A	-23.78%	-92.13%
Carpobrotus edulis Association	0	0.4	1.4	1.24	4.90	4.90	1	-0.16	3.66	N/A	250%	-11.53%	295.63%
Cortaderia selloana Association	0	0	0	0	0.28	0.28	0	0.00	0.28	N/A	N/A	N/A	N/A
Eucalyptus spp.	29.7	27	26.8	21.14	3.70	-26.00	-0.2	-5.66	-17.44	-87.54%	-0.74%	-21.11%	-82.50%
*Lepidium latifolium**	120.3	4.6	30.1	31.30	44.26	-76.04	25.5	1.20	12.96	-63.21%	554.35%	3.97%	41.42%
Phragmites australis	53.6	226.1	311.9	316.44	254.25	200.65	85.8	4.54	-62.19	374.35%	37.95%	1.46%	-19.65%
Salsola soda Provisional Alliance	0	8.2	0	0	0	0.00	-8.2	0.00	0.00	N/A	-100%	N/A	N/A

Management Region 2— Region-wide Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	0.2	0	0.5	0.38	0.03	-0.17	0.5	-0.12	-0.35	-85%	N/A	-23.78%	-92.13%
Carpobrotus edulis Association	0	0.4	1.4	1.24	4.90	4.90	1	-0.16	3.66	N/A	250%	-11.53%	295.63%
Cortaderia selloana Association	0.8	0	0.02	0.03	0.31	-0.49	0.02	0.01	0.28	-61%	N/A	50.00%	933.33%
Eucalyptus spp.	32.8	29.2	28.9	27.30	27.82	-4.98	-0.3	-1.60	0.52	-15%	-0.34%	-5.53%	1.90%
*Lepidium latifolium**	173.3	14.1	45	43.29	50.93	-122.37	30.9	-1.71	7.64	-71%	205.40%	-3.81%	17.66%
Phragmites australis	70.8	351.9	495.1	551.47	756.00	685.20	143.2	56.37	204.53	968%	39.90%	11.39%	37.09%
Salsola soda Provisional Alliance	0	8.2	0	0.00	0.00	0.00	-8.2	0.00	0.00	N/A	-100%	N/A	N/A

Management Region 3—Tidal Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	0.6	0	0	0	0	-0.6	0	0	0	-100%	N/A	N/A	N/A
Carpobrotus edulis Association	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
Cortaderia selloana Association	0	0	0	0	0.05	0.05	0	0	0.05	N/A	N/A	N/A	N/A
Eucalyptus spp.	0	0.2	0.36	0.41	0.76	0.76	0.16	0.05	0.35	N/A	80.00%	13.89%	85.37%
*Lepidium latifolium**	0	0	0	0.03	3.83	3.83	0	0.03	3.8	N/A	N/A	N/A	12666.67%
Phragmites australis	1.2	31.6	100.6	131.35	221.73	220.53	69	30.75	90.38	18377.50%	218.35%	30.57%	68.81%
Salsola soda Provisional Alliance	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A

Management Region 3—Leveed Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	0	0	0	0	0.01	0.01	0	0	0.01	N/A	N/A	N/A	N/A
Carpobrotus edulis Association	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
Cortaderia selloana Association	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
Eucalyptus spp.	1.6	7.1	7.2	7.11	8.26	6.66	0.1	-0.09	1.15	416.25%	1.41%	-1.25%	16.17%
*Lepidium latifolium**	0	0	5.8	5.9	44.35	44.35	5.8	0.1	38.45	N/A	N/A	1.72%	651.69%
Phragmites australis	25.1	137	135.5	94.05	96.25	71.15	-1.5	-41.45	2.2	283.47%	51.93%	-30.59%	2.34%
Salsola soda Provisional Alliance	0	0	0	0	14.62	14.62	0	0	14.62	N/A	N/A	N/A	N/A

Management Region 3— Region-wide Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	0.6	0	0	0	0.01	-0.59	0	0	0.01	-98%	N/A	N/A	N/A
Carpobrotus edulis Association	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
Cortaderia selloana Association	0	0	0	0	0.05	0.05	0	0	0.05	N/A	N/A	N/A	N/A
Eucalyptus spp.	1.6	7.3	7.5	7.52	9.02	7.42	0.2	0.02	1.5	463.75%	2.74%	0.27%	19.95%
*Lepidium latifolium**	0	0	5.8	5.93	48.18	48.18	5.8	0.13	42.25	N/A	N/A	2.24%	712.48%
Phragmites australis	26.3	168.5	236.1	225.4	317.97	291.67	67.6	-10.7	92.57	1109.01%	40.12%	-4.53%	41.07%
Salsola soda Provisional Alliance	0	0	0	0	14.62	14.62	0	0	14.62	N/A	N/A	N/A	N/A

Management Region 4—Tidal Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	1.1	0.1	2.2	1.66	1.98	0.88	2.1	-0.54	0.32	80.00%	2200%	-24.55%	19.28%
Carpobrotus edulis Association	1.6	0.1	0	0.23	1.96	0.36	-0.1	0.23	1.73	22.50%	-100.00%	N/A	N/A
Cortaderia selloana Association	1.2	2.2	2.8	0.09	3.2	2	0.6	-2.71	3.11	166.67%	27.27%	-96.79%	3455.56%
Eucalyptus spp.	9.5	4.5	4.2	6.11	14.76	5.26	-0.3	1.91	8.65	55.37%	-6.67%	45.48%	141.57%
*Lepidium latifolium**	18.7	0	3.3	3.05	16.12	-2.58	3.3	-0.25	13.07	-13.80%	N/A	-7.58%	428.52%
Phragmites australis	240.4	570.8	984.8	941.23	1,691.61	1451.21	414	-43.57	750.38	603.66%	72.53%	-4.42%	79.72%
Salsola soda Provisional Alliance	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A

Management Region 4—Leveed Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	2.1	3.7	4.3	2.49	3.29	1.19	0.6	-1.81	0.8	56.67%	16.22%	-42.09%	32.13%
Carpobrotus edulis Association	5.5	30.7	36.2	36.56	73	67.5	5.5	0.36	36.44	1227.27%	17.92%	0.99%	99.67%
Cortaderia selloana Association	0.2	0.2	0.7	0	0.66	0.46	0.5	-0.7	0.66	230.00%	250.00%	-100.00%	N/A
Eucalyptus spp.	111.6	156	173	173.17	166.06	54.46	17	0.17	-7.11	48.80%	10.90%	0.10%	-4.11%
*Lepidium latifolium**	263.8	66.7	102.5	149.6	142.52	-121.28	35.8	47.1	-7.08	-45.97%	53.67%	45.95%	-4.73%
Phragmites australis	170.4	1238.6	1675.4	1,729.66	1,531.06	1360.66	436.8	54.26	-198.6	798.51%	35.27%	3.24%	-11.48%
Salsola soda Provisional Alliance	0	28.9	25.2	42.05	414.38	414.38	-3.7	16.85	372.33	N/A	-12.80%	66.87%	885.45%

Management Region 4— Region-wide Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	3.3	3.8	6.4	4.15	5.27	1.97	2.6	-2.25	1.12	59.70%	68.42%	-35.16%	26.99%
Carpobrotus edulis Association	7	30.8	36.2	36.79	74.96	67.96	5.4	0.59	38.17	970.86%	17.53%	1.63%	103.75%
Cortaderia selloana Association	1.4	2.4	3.5	0.09	3.86	2.46	1.1	-3.41	3.77	175.71%	45.83%	-97.43%	4188.89%
Eucalyptus spp.	121.1	160.5	177.2	179.28	180.81	59.71	16.7	2.08	1.53	49.31%	10.40%	1.17%	0.85%
*Lepidium latifolium**	282.5	66.7	105.8	152.65	158.65	-123.85	39.1	46.85	6	-43.84%	58.62%	44.28%	3.93%
Phragmites australis	410.8	1809.4	2660.2	2670.89	3,222.67	2811.87	850.8	10.69	551.78	684.49%	47.02%	0.40%	20.66%
Salsola soda Provisional Alliance	0	28.9	25.2	42.05	414.38	414.38	-3.7	16.85	372.33	N/A	-12.80%	66.87%	885.45%

Marsh-wide—Tidal Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	1.9	2.3	3.5	4.32	3.86	1.96	1.2	0.82	-0.46	103%	52.17%	23.43%	-10.65%
Carpobrotus edulis Association	1.6	2	0	0.27	2.46	0.86	-2	0.27	2.19	54%	-100.00%	N/A	811.11%
Cortaderia selloana Association	2	2.5	3.85	0.61	4.33	2.33	1.35	-3.24	3.72	117%	54.00%	-84.16%	609.84%
Eucalyptus spp.	12.7	7.7	7.1	13.89	41.17	28.47	-0.6	6.79	27.28	224%	-7.79%	95.63%	196.40%
*Lepidium latifolium**	103.3	16.5	32.6	22.4	80.55	-22.75	16.1	-10.2	58.15	-22%	97.58%	-31.29%	259.60%
Phragmites australis	361.6	1182.8	1864.7	1910.77	3,290.86	2929.26	681.9	46.07	1380.09	810%	57.65%	2.47%	72.23%
Salsola soda Provisional Alliance	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A

Marsh-wide—Leveed Vegetation

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	2.8	3.7	6.6	5.03	5.7	2.9	2.9	-1.57	0.67	103.57%	78.38%	-23.79%	13.32%
Carpobrotus edulis Association	5.5	31	40.2	39.96	79.98	74.48	9.2	-0.24	40.02	1354.18%	29.68%	-0.60%	100.15%
Cortaderia selloana Association	7.8	3.8	5.85	3.84	3.35	-4.45	2.05	-2.01	-0.49	-57.05%	53.95%	-34.36%	-12.76%
Eucalyptus spp.	195.4	281.1	312.9	306.27	286.95	91.55	31.8	-6.63	-19.32	46.85%	11.31%	-2.12%	-6.31%
*Lepidium latifolium**	543.1	91.5	173.1	222.66	327.57	-215.53	81.6	49.56	104.91	-39.69%	89.18%	28.63%	47.12%
Phragmites australis	331.6	1764.2	2431.1	2530.22	2,259.97	1928.37	666.9	99.12	-270.25	581.53%	37.80%	4.08%	-10.68%
Salsola soda Provisional Alliance	0	67	39.1	68.36	429	429	-27.9	29.26	360.64	N/A	-41.64%	74.83%	527.56%

Marsh-wide—Total Non-Native Species of Concern

Species	1999 Acres	2015 Acres	2018 Acres	2021 Acres	2024 Acres	1999-2024 Change	2015-2018 Change	2018-2021 Change	2021-2024 Change	1999-2024 Percent Change	2015-2018 Percent Change	2018-2021 Percent Change	2021-2024 Percent Change
Arundo donax Association	4.7	6.1	10.1	9.35	9.56	4.86	4	-0.75	0.21	103.40%	65.57%	-7.43%	2.25%
Carpobrotus edulis Association	7	33.1	40.2	40.23	82.44	75.44	7.1	0.03	42.21	1077.71%	21.45%	0.07%	104.92%
Cortaderia selloana Association	9.8	6.3	9.7	4.45	7.68	-2.12	3.4	-5.25	3.23	-21.63%	53.97%	-54.12%	72.58%
Eucalyptus spp.	208.1	288.8	320	320.16	328.13	120.03	31.2	0.16	7.97	57.68%	10.80%	0.05%	2.49%
*Lepidium latifolium**	646.4	108	205.7	245.06	408.12	-238.28	97.7	39.36	163.06	-36.86%	90.46%	19.13%	66.54%
Phragmites australis	693.1	2947	4295.8	4440.99	5,550.84	4857.74	1348.8	145.19	1109.85	700.87%	45.77%	3.38%	24.99%
Salsola soda Provisional Alliance	0	67	39.1	68.36	429	429	-27.9	29.26	360.64	N/A	-41.64%	74.83%	527.56%

Appendix H

Reconnaissance Field Form and Protocol

RECON FIELD FORM - SUISUN MARSH (May 27, 2015)

Recorder:	**Other Surveyors:**	**Date:**	**Return?** ☐
Waypoint ID:	**Location Name:**		
	GPS Name _____ **Projected? Yes / No / Base / Digitized**		
	If Yes, enter: **Bearing (°):** _____ **Distance (m):** _____ **Inclination (°):** _____		
UID:	If Yes or Digitized, enter: **Base Waypoint ID:** _____		
	Base UTMs / **Projected** UTMs (circle one)		
	UTME ___ ___ ___ ___ ___ ___ **UTMN** ___ ___ ___ ___ ___ ___ ___ **PDOP: +/-**		
Stand Size (acres): <0.25 0.25-0.5 0.5-1 1-2 2-5 >5	**Camera:** **Photos:**		
Field Alliance/Association name:			
Comments:			

% Cover: Tree_____ Shrub_____ Herb_____ Total Veg_____ **Veg Ht (m):** <0.5 0.5-1 1-2 2-5 5-10 >10 **Disturb:** N/A Low Med High

Strata	Species	% cover		Strata	Species	% cover		Strata	Species	% cover

Recorder:	**Other Surveyors:**	**Date:**	**Return?** ☐
Waypoint ID:	**Location Name:**		
	GPS Name _____ **Projected? Yes / No / Base / Digitized**		
	If Yes, enter: **Bearing (°):** _____ **Distance (m):** _____ **Inclination (°):** _____		
UID:	If Yes or Digitized, enter: **Base Waypoint ID:** _____		
	Base UTMs / **Projected** UTMs (circle one)		
	UTME ___ ___ ___ ___ ___ ___ **UTMN** ___ ___ ___ ___ ___ ___ ___ **PDOP: +/-**		
Stand Size (acres): <0.25 0.25-0.5 0.5-1	**Camera:** **Photos:**		

1-2 2-5 >5	

Field Alliance/Association name:

Comments:

% Cover: Tree_____ Shrub_____ Herb_____ Total Veg_____ **Veg Ht (m):** <0.5 0.5-1 1-2 2-5 5-10 >10 **Disturb:** N/A Low Med High

Strata	Species	% cover		Strata	Species	% cover		Strata	Species	% cover

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE PROTOCOL FOR
RECONNAISSANCE FIELD FORM

Definitions of fields in the form

I. LOCATIONAL/ENVIRONMENTAL DESCRIPTION

Recorder: The full name of the recorder should be provided for the first field form for the day. On successive forms, initials can be recorded.

Other Surveyors: The full name of each person assisting should be provided for the first field form for the day. On successive forms, initials of each person assisting can be recorded.

Date: Date of the sampling.

Return?: Check this box if team members should return to this spot at a later date to take a recon or RA/relevé. This can be used if the phenology is not conducive to identification of the major species, or if there is not enough time to take the survey.

Waypoint ID: The waypoint number assigned by a Global Positioning System (GPS) unit when marking and storing a waypoint for the sample location.

UID: The ID number of a reference point or polygon that this reconnaissance describes.

Location Name: The name of the property, park, or location within large holdings (like USFS or BLM properties).

GPS name: The name/number assigned to the GPS unit.

Projected? Yes / No / Base / Digitized: Circle the appropriate option:

> **Yes** - The point is a projected, or offset point. The surveyor used a bearing and distance to project the point to match what they are describing with the survey.
>
> **No** - The surveyors are in the vegetation they are describing and the point is where the observer was standing for photographs. This location can also be used as a base location for an offset survey.
>
> **Base** - Base point only. This is where a surveyor was standing when taking an offset survey to describe vegetation not at that point. No plant data or vegetation descriptions are associated with this location. However, cardinal photos taken at this point will be stored in a directory of this name.
>
> **Digitized** – An offset point was created on the GPS unit without taking bearing and distance readings. This option should only be used when the imagery on the GPS unit is unique and unmistakable.

Bearing (°): The compass bearing from the Base point to the Projected point.

Distance (m): The distance in meters from the Base point to the Projected point, determined by use of a range finder.

Inclination (°): The vertical offset from the Base point to the Projected point.

Base Waypoint ID: For a projected or digitized point, this is the location where the surveyor was standing when the information was collected. Cardinal photographs will be taken at this point and will

be stored on the computer under this ID. Photographs of the stand vegetation will be taken from this point and will be stored on the computer under the Projected point's ID.

Base / Projected UTMs: If the point is projected or digitized, circle whether the coordinates of the base point or the offset point have been recorded. These will generally be for the offset point.

PDOP: The accuracy of the GPS location. Record the error reading from the GPS unit.

GPS coordinates: Record easting (**UTME**) and northing (**UTMN)** from a GPS unit.

Stand Size: Estimate the size of the entire stand in which the sample is taken and circle the appropriate range. As a measure, one acre is similar in size to a football field.

Camera/Photos: Write the name camera, JPG numbers, and direction of the photos. Take four photos in the main cardinal directions (N, E, S, W) clockwise from the north, from the GPS location. This symbol can be used to indicate the cardinal photos:  . If additional photos are taken in other directions, please note the JPG numbers and a description of each photo.

II. HABITAT AND VEGETATION DESCRIPTION

Field Alliance/Association name: Name of alliance or association following the most recent Suisun Marsh classification, using scientific nomenclature, *e.g., Quercus agrifolia*. An alliance is based on the dominant or diagnostic species of the stand and usually reflects the uppermost and/or dominant height stratum. A dominant species covers the greatest area. A diagnostic species is consistently found in some vegetation types but not others.

Please note: The field-assessed alliance name may not exist in the present classification, in which case you can provide a new alliance name in this field.

Comments: Briefly describe the stand age/seral stage, disturbance history, nature and extent of land use, and other site environmental and vegetation factors that will aid in the mapping effort.

% Cover:

Tree: The total cover of all the trees taking into consideration the porosity, or the holes, in the vegetation. This is an estimate of the absolute tree cover, disregarding the overlap1 of individual trees.

Shrub: The total cover of all the shrubs taking into consideration the porosity, or the holes, in the vegetation. This is an estimate of the absolute shrub cover, disregarding the overlap of individual shrubs.

Herb: The total cover of all the herbs taking into consideration the porosity, or the holes, in the vegetation. This is an estimate of the absolute herbaceous cover, disregarding the overlap1 of individual herbs.

Total Veg: The total cover of all vascular vegetation taking into consideration the porosity, or the holes, in the vegetation. This is an estimate of the absolute vegetation cover, disregarding the overlap1 of the various tree, shrub, and/or herbaceous layers and species.

Veg Ht (m): Modal height for all vegetation. Estimate the mean height and circle the appropriate height range.

Disturb.: Estimate the amount of disturbance in the stand from human activity, such as roads, trails, disking, tilling, clearing, etc.

N/A = not applicable for this polygon type
Low = 0-33% of polygon affected by disturbance

Med = 34-66% of polygon affected by disturbance
High = >67% of polygon affected by disturbance

Species List and Coverage

List the species that are dominant or that are characteristically consistent throughout the stand. This list is used if there is some uncertainty in the field-assessed alliance name, so the most common species should be listed. In the interests of time and efficiency, this species list should not be exhaustive.

Strata:

T = Tree. A woody perennial plant that has a single trunk.

A = SApling. 1" - <6" dbh and young in age, OR small trees that are <1" dbh, are clearly of appreciable age and are kept short by repeated browsing, burning, or other disturbance. Includes trees that are re-sprouting from roots or stumps following fire, logging, or other disturbance. These re-sprouts may exhibit a shrubby form, with multiple small trunks, but are species that are generally considered trees. If a majority of the trunks are >6" dbh, then the re-sprouts would be recorded under the "Tree" stratum.

E = SEedling. A tree species clearly of a very young age that is < 1" dbh or has not reached breast height. This applies only to trees propagating from seed; re-sprouts are not recorded here even if they meet the size requirements.

S = Shrub. A perennial, woody plant, that is multi-branched and doesn't die back to the ground every year.

H = Herb. An annual or perennial that dies down to ground level every year.

N = Non-vascular. Includes moss, lichen, liverworts, hornworts, cryptogammic crust, and algae.

When one or more tree species are regenerating, the Tree, Seedling, and/or Sapling strata may be noted on the same line, e.g.:

Strata	**Species**	**%Cover**	C
T/A/E	Quercus douglasii	40/<1/<1	C

Species: Use Jepson Manual nomenclature. When uncertain of an identification (which you intend to confirm later) use parentheses to indicate what part of the determination needs to be confirmed. For example, you could write out *Brassica* (*nigra*) if you are sure it is a *Brassica* but you need further clarification on the specific epithet.

% cover: provide the % absolute aerial cover for each species listed. All species percent covers may total over 100% because of overlap.

Collections: If a species collection is made, it should be indicated in the blank column next to "% cover" with a "C" (for collected). If the species is later keyed out, cross out the species name or description and write the keyed species name in pen on the datasheet. Do not erase what was written in the field, because this information can be used if specimens get mixed up later. If the specimen is then thrown out, add a "T" to the "C" in that column (CT = thrown out after confirmation) or cross out the "C". If the specimen is kept but is still not confidently identified, add a "U" to the "C" (CU = collected and unconfirmed). In this case, the unconfirmed species epithet should be put in parentheses [e.g. *Hordeum (murinum)*]. If the specimen is kept and is confidently identified, add a "C" to the existing "C" (CC =

collected and confirmed). If the specimen is later deposited in an herbarium, add a “D” to the existing “C” (CD = collected and deposited) and note the receiving herbarium.