2009
Vegetation Map Update For
Suisun Marsh,
Solano County, California

A Report to the California Department of Water Resources

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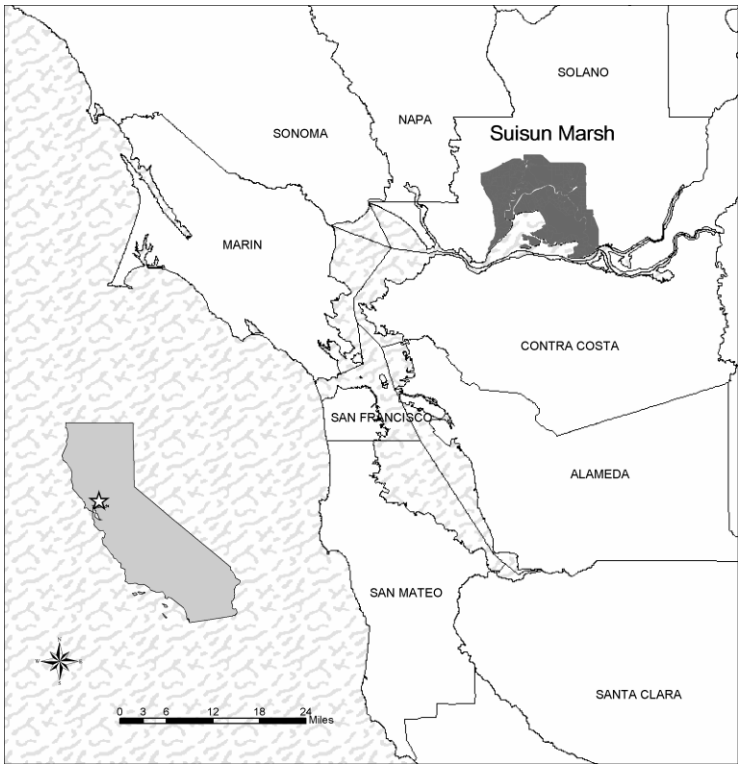

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Executive Summary

This report summarizes the methods and results of the 2009 Suisun Marsh vegetation map update. This is part of an ongoing monitoring project that the Biogeographic Data Branch (BDB) of the California Department of Fish and Game (CDFG), in collaboration with the Department of Water Resources (DWR) and the CDFG Bay Delta Region (BDR), started in 1999 to track changes in the Suisun Marsh vegetation over time. This is the fourth update since the original map was made in 1999. The first update, conducted in 2000, is summarized in *Vegetation Mapping of Suisun Marsh, Solano County: A Report to the California Department of Water Resources* (Keeler-Wolf et al. 2000). The second update, done three years later in 2003, is summarized in *Suisun Marsh Vegetation Mapping Change Detection 2003* (Vaghti and Keeler-Wolf 2004). The 2006 update is not yet available to the public.

The final 2009 vegetation map contains 16,199 polygons covering 70,277 acres. They polygons range from 0.01 acres to 2,862 acres and average 4.33 acres. 2,524 vegetation polygons, or 8,322 acres, are tidally influenced and 13,625 polygons, or 57,980 acres, are not naturally affected by tide. This map update shows that potential Salt Marsh Harvest Mouse habitat (*Salicornia virginica* dominated vegetation) has increased since 1999 and that two non-native species of concern, *Phragmites australis* and *Lepidium latifolium*, are still increasing within the marsh. Interestingly, in the leveed areas of the marsh, both *Phragmites australis* and *Salicornia virginica* vegetation seem to be increasing the most where, in 2006, there was open water.

Introduction

Background

The Suisun Marsh 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 a number of sensitive plant and animal species. In 1977 the Suisun Marsh Preservation Act was enacted and required that the marsh be managed for its wildlife resources. Consequently, the Plan of Protection for the Suisun Marsh (Plan of Protection) was developed. In 1981 the U.S. Fish and Wildlife Service produced a Section 7 Biological Opinion for the Plan of Protection. Their Biological Opinion accepted the monitoring program in the Plan of Protection and added specific conservation measures to protect the federally listed salt marsh harvest mouse (SMHM) habitat.

As part of the monitoring program in the Plan of Protection, a Triennial Vegetation Survey was developed to document the overall vegetation composition of the marsh and to monitor SMHM habitat by the use of aerial photography in combination with ground verification. Prior to the final Plan of Protection, a baseline vegetation survey was conducted in 1981. However, since completion of the Suisun Marsh Salinity Control Gates as described in the Plan of Protection was delayed until 1988, the 1988 vegetation survey was the closest to the start of facility operations. The Triennial Vegetation Survey was conducted in Suisun Marsh in 1981, 1988, 1991, and 1994 to document any changes in vegetation composition over time.

There were concerns about the methodology used and the lack of useful maps from the 1988, 1991, and 1994 surveys. In 1996 an interagency technical committee was convened to review the current survey methodology and recommend a more detailed monitoring system for vegetation changes in the marsh. Consequently, in July 1997 the committee agreed to implement a new survey methodology for the 1998 vegetation survey.

The new methodology and results for the 1999 survey are described in detail in *Vegetation Mapping of Suisun Marsh, Solano County: A Report to the California Department of Water*

Resources (Keeler-Wolf *et al*. 2000). The survey methodology is designed to meet the goal of documenting changes in preferred habitat for the SMHM as well as to gather vegetation information to be used for a variety of other purposes. These may include correlating management activities with vegetation changes, gathering data to support the use of a GIS format that will allow queries and overlaying of additional information, and creation of a base map for future studies. This methodology is based on work by the Department of Fish and Game, Wildlife and Habitat Data Analysis Branch (now Biogeographic Data Branch) Vegetation Classification and Mapping Program (VegCAMP) and has been widely used throughout the state.

In 2000 an exploratory change detection study was implemented (Vaghti & Keeler-Wolf 2001). The goals of the change analysis were to define significant change for vegetation in the Suisun Marsh ecosystem, quantify and spatially identify such changes, improve map accuracy, and make recommendations for future revisions of the map to best support management efforts for endangered species habitat, waterfowl and other wildlife. Given that the 2000 map update was conducted only one year after the 1999 baseline map was created, the changes detected were relatively minor. Less than 1% of the polygons were shown to have changed between June 16, 1999 and July 2 2000. These minor changes include a net loss of 65 acres for *Salicornia virginica* 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 showed a 16.8% change across the entire study area since the 1999 product. "Medium Wetland Graminoids, *Scirpus maritimus*, Short Wetland Herbs, Medium Wetland Herbs and *S. maritimus/Salicornia virginica* were the five types with the greatest increase in acreage. *Distichlis spicata*, *Salicornia*, *Distichlis*/Annual Grasses, *Distichlis/Salicornia*, 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.

The 2006 remap and change detection used the 1999 vegetation map as the baseline and followed the 2000 and 2003 change detection methodology. Several vegetation changes found in this 2006 update are of note: 1) The 174% increase in flooded wetlands (due to sever storms resulting levee breaches), 2) the net loss of 945 acres of *Salicornia virginica* vegetation types since 1999, 3) the net gain of 780 acres of the invasive form of *Phragmites australis* since 1999, 580 acres of which have established since 2003, and 4) the acreage decrease or stabilization of several of the non-native species of concern. These are discussed in more detail in the draft 2006 update report (Boul and Keeler-Wolf 2009). Aside from the changes in vegetation that were detected in the 2006 Suisun marsh remap, several issues with the remapping process and change detection protocol were brought to light. Due to these findings VegCAMP suggested that changes to the protocol be made and implemented for the 2009 vegetation remap. These changes and reasoning behind them are discussed below.

Changing the re-map protocol

There were several reasons for changing the map update and vegetation change detection protocol: 1) inconsistencies in imagery orthorectification, 2) unforeseen flaws in the original protocol, and 3) advances in available technology. In order to explain the changes to the protocol, the old method must be explained first.

Past protocol (2000-2006)

To create the 2006 vegetation map a copy of the 2003 vegetation polygon shapefile was made and then modified for the 2003-2006 change detection. The new shapefile was linked to a new 2006 Access table for data entry. For consistency the attributes and vegetation types for the

2006 change detection remained the same as in 2003. When a change in size or shape of a polygon was detected, it was cut using the "Cut Polygon Features" task and merged using the "Merge" option in ArcMap.

The following changes were considered significant and consistently interpretable, and were updated:

- A greater than 20% change in acreage of an exiting small polygon (< 0.5-1 acre)
- A greater than 10% change in acreage of a mid-sized polygon (1-5 acres)
- A greater than 5% change in a large polygon (>5 acres)
- A type conversion of a vegetation polygon dominated by perennial species. Type conversion as defined here, occurs when a previously mapped vegetation type dominated by perennial species has changed based on the decision rules set forth in the vegetation mapping unit key defined in the Suisun Marsh Vegetation Mapping Report (Table 5), or when an annual species dominated vegetation type is converted to a perennial vegetation type.
- A persistent physical change has altered any vegetation polygon and partially or entirely replaced it with a non-vegetated area (non-vegetated areas include buildings, dredged ditches, new levees, roads, or other human engineered structures).
- A change in management style, which includes a conversion or restoration from an actively managed situation (annual burning, disking, plowing, flooding, or other management practice which annually disturbs the vegetation) to a passively or non-managed situation.

The following changes were considered non-significant and/or unreliably interpretable and were not assessed:

- Conversions of one annual vegetation type to another annual type were not considered because of the vagaries of climate on annual vegetation.
- Polygons that are regularly heavily managed by annual burning, disking, flooding, or other means were not considered. These changes, unless they show some direction (e.g., from passive management to active, or vice versa), are considered regular management perturbations and maintain the same general vegetation pattern through regular disturbance.

2009 protocol

To create the 2009 map the vegetation was interpreted from the 2009 aerial imagery and polygons were digitizing using heads-up digitizing (I.e. a photo interpreter manually drew polygons around each stand of vegetation) in ArcMAP 9.3 and recorded within an empty Microsoft Access Persoanl Geodatabase. Because this new protocol starts with an empty GIS data file and is not based on the manipulation of an already existing shapefile several of the mapping rules and attributes used in the old protocol that referred to the manipulation of a shapefile no longer apply (see section above and Appendix 1).

Justification for the change in protocol

Inconsistencies in imagery orthorectification. In preparation for the 2009 updating process the imagery flown specifically for the Suisun Marsh mapping from 1999 through 2009 was compared with the intention of summarizing a consistent time series of change over the 4 intervals (1999-2000, 2000-2003, 2003-2006, 2006-2009). However, VegCAMP staff noticed that none of the datasets matched up spatially. The 2006 and 2009 imagery were very close to each other but were about 7 meters off from the 2009 orthomosaics provided by the National Agriculture Imagery Program (NAIP), which was considered the most regionally accurate standard. The 1999

imagery was very close to the 2009 NAIP and the 2003 Suisun imagery was approximately 15 meters shifted from all the other imagery sets. Because the past protocol included making a copy of the previously updated shapefile (which matched the imagery for the time) and updating it according to the new imagery (which was shifted 7 to 15m from the previous imagery), errors were compounded. The non-linear shift in imagery would confound a number of useful analyses such as description of individual shifts in size and shape of stands of different marsh vegetation, or trends in number and acreage of different types of marsh habitat within and between different marsh management zones.

Unforeseen flaws in the original protocol. Following is the protocol used for the original 1999 vegetation polygon delineation: "Using light tables, delineations were drawn with a .2 mm water-soluble pen (Uniball Microroller) directly on mylar sheets taped to the diapositives." These were then scanned and rubber sheeted to create a digital version. At the time (1999), this was the standard method used for delineating and digitizing vegetation polygons. This process created some discrepancies between the shapefile and the imagery. The "rubber sheeting" process resulted in inconsistent shifts in the line work that have been perpetuated throughout the life of the project and further complicated by the imagery orthorectification shifts.

Advances in available technology. Today there is much more spatially accurate georeferenced imagery that can be used directly in a GIS. Now, instead of the extra time-consuming and error-compounding step of first delineating manually and then scanning and correcting the drawn polygons, we can digitize polygons directly over the imagery in a computer. By adopting the new protocol of remapping from scratch every time, we eliminate the types of errors that compound with each update.

Implementation of an adaptive protocol that allows for future advances in technology: When envisioning a protocol for a project that will potentially last for many, many years we must consider the inevitable change in technology and our understanding of vegetation. A few of the major effects that changing technology has had on this project has already been discussed above and there will be more that arise in the future. There have also been shifts in our understanding of vegetation classification and how that translates to a mapping classification (Appendix 2). For this reason it is important to have an adaptable protocol. It needs to be a protocol that does not build on the previous version so as not to get caught using old technology or ideas just because "that's what we did before". By creating a separate and distinct vegetation map for each update we are still able to compare the shapefiles from year to year while freeing us up to use the most current information and technology available.

Testing efficiency: In exploring the changes to the protocol, VegCAMP performed a time efficiency test. Using ArcMap 9.3, a portion of the marsh (~230 acres) was mapped the old way (cutting and merging pieces of old polygons until the new polygons look fairly close to the current vegetation boundaries) and the same portion was mapped from scratch. The thinking was that it may take longer to map from scratch, but it would be more spatially accurate, it would look better, and we can stop compounding errors.

What was learned: It was quicker, easier, more concise and more accurate to draw polygons from scratch. It is much slower and more difficult to cut many portions of a polygon and merge them with other various polygons than to just draw the polygon the way the photo interpreter sees it. In addition, just as you set a minimum map unit size based on time and money available, the photo interpreter must also limit the number of cuts and merges for the same reason. So, not only did the old protocol prove to be more time consuming, but the resulting vegetation map had inconsistent "sloppy" looking line-work.

Summary of effects of this decision: In order to plan for more accurate comparisons that are more independent of improving technologies we made the decision to discontinue the further modification of polygons that were created with a spatially inaccurate base map. The benefit is that there will no longer be an ever-compounding issue of using incorrectly referenced original

information and partially modified polygons to make all future comparisons. However, the short term negative effect will be that the 2009 map cannot be directly compared to the previous editions on a polygon-by-polygon basis. Starting with a "clean slate" for the 2009 remap, with the most accurate delineations, we would have to work backwards and modify all 3 previous iterations of the map, essentially de-coupling the original map produced in 2000 from the following individual updates. This will take time and money, but should ultimately provide a more valuable long-term time sequence. However, it will be possible to immediately compare changes in acreage and numbers of polygons of different vegetation classes over the 4 editions of the map (see results and discussion sections, to follow).

2009 Methods

2009 Field Data Collection

At least 4 days of pre- or post-map reconnaissance to assist in photo signature interpretation was conducted by VegCAMP staff once the 2009 imagery was received. This field data gave us the vegetation type, cover, and height for 308 polygons.

2009 Aerial Photograph Interpretation

The vegetation photo interpretation for the 2009 Suisun Marsh re-map was based on true color imagery that was flown at 1:7200 on June 15, 2009. VegCAMP first received this imagery on March 22, 2010 as 73 individual flight line photos. As described in the "Justification for the change in protocol" section (page 9), it was discovered that the orthorectification process resulted in a spatial shift by as much as 10 meters when compared to the 2009 NAIP imagery. This discovery resulted in a reprocessing of the imagery to create a more spatially accurate data set. The reprocessed imagery was received by VegCAMP on October 14, 2010.

Improvement of spatial accuracy in the 2009 aerial images

The aerial photography captured in June 2009 covering the Suisun Marsh area was post-processed using ground control points that were used for previously captured aerial photography of this area. The horizontal position for a ground control point was determined by matching a permanent residual feature identified on a photograph, such as a bridge abutment or cross-roads, with that same feature shown on USGS 7.5-minute quadrangle topographic map (quad map); the vertical position was interpolated using the contours on the quad maps. The USGS quad map's horizontal accuracy standard requires that the positions of 90 percent of all points tested must be accurate within 1/50th of an inch (0.05 centimeters) on the map. At 1:24,000 scale, 1/50th of an inch is 40 feet (12.2 meters). Likewise, the vertical accuracy standard requires that the elevation of 90 percent of all points tested must be correct within half of the contour interval. On a map with a contour interval of 10 feet, the map must correctly show 90 percent of all points tested within 5 feet (1.5 meters) of the actual elevation. This method was sufficient for doing comparative studies among the several collections of aerial photography captured on a three-year cycle.

However, when horizontal positions for features shown in the georeferenced orthomosaic created from the 2009 aerial photography were compared to positions of the same features identified in NAIP, differences as large as 10 meters were discovered. The absolute accuracy specification for NAIP requires 95 percent of well-defined points to be within 6 meters of true ground and is therefore more rigorous than the original standards. Although these differences fell within the accuracy specifications for control derived from the quad maps, they were outside those for NAIP.

Although topography is subtle in the largely flat marsh, it is extremely important to obtain both horizontal and vertical accuracy to properly depict correct position of narrow channels, ditches, and subtle elevational distinctions that influence tides, ponding, and vegetation. For the purposes of their vegetation studies, the staff of the CDFG and DWR- Division of Environmental Services (DES) requested that a method be devised to raise the level of absolute positional accuracy for the 2009 Suisun Marsh aerial photography.

The method that was employed was for staff from the DWR's Mapping & Photogrammetry Section to measure the positions of permanent residual features identified both in photographs and on the ground using Garmin 76CSx handheld GPS units. The published accuracy for these units is typically less than 5 meters. A total of 51 control points were measured and used to reprocess the imagery, which resulted in an orthomosaic that closely agrees with NAIP digital orthorectified quarter quadrangle (DOQQ) aerial photography.

The reprocessed 2009 imagery was received by VegCAMP on October 14, 2010, at which point the photo interpretation began. Several other imagery sources were used as ancillary data including the 2009 NAIP, 2009 NAIP CIR, all the imagery available through the ImmageConnect data Library, and the 1999, 2003, and 2006 Suisun Marsh imageries. The 2006 Suisun Marsh vegetation map was also referred to often. All of the polygons were drawn using heads-up digitizing in ArcMAP 9.3 starting with an empty Microsoft Access Persoanl Geodatabase. For each polygon the vegetation type, disturbance level, and overall vegetation cover and vegetation height was estimated (Appendix 1). The area in acres for each polygon was calculated using the ArcGIS 9.3 "Calculate Geometry" tool.

Methods for Analysis

As requested by DWR and with Bay-Delta Region agreement, the vegetation within Suisun Marsh was broken into two different categories; leveed wetlands and tidal wetlands. 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 or berms etc. The leveed wetlands are those areas that are completely enclosed and are totally restricted to any natural tidal influence.

To determine changes in vegetation within the Marsh in tidally influenced areas versus leveed (or managed) areas a habitat shapefile (Suisun_Regions_habitats_ver2) that was created by CDFG in 2008 was used as a reference. This file was created using the 2003 San Francisco Estuary Institutes (SFEI) EcoAtlas as a base layer with input from local experts to refine it. However, due to its coarse scale and poor spatial accuracy when compared to the 2009 Suisun imagery and vegetation map, a simple "clip" in ArcMap 9.3 could not be preformed. To determine the tidal areas in 2009 the polygons that were contained completely within the "tidal" habitat polygons from the 2008 CDFG shapefile were given a habitat attribute of "1" (meaning they were definitely tidal). Those polygons that intersected the outline of the "tidal" habitat polygons from the 2008 CDFG Suisun_Regions_habitats_ver2 shapefile were examined by the photo interpreter to determine if they were tidally influenced or leveed and attributed accordingly. Sloughs were given a habitat attribute of "3". All other polygons were considered leveed and therefore given a habitat attribute of "2".

To determine the tidal areas in 2006, the polygons that were contained completely within the "tidal" habitat polygons from the 2009 vegetation shapefile were given a habitat attribute of "1" (meaning they were definitely tidal). Those polygons that intersected the outline of the "tidal" habitat polygons from the 2009 vegetation shapefile were examined by the photo the interpreter to determine if they were tidally influenced or leveed and attributed accordingly. Sloughs were given a habitat attribute of "3". All other polygons were considered leveed and therefore given a habitat attribute of "2". The Blacklock parcel was excluded from the 2006 tidal areas because the levees had not yet been breached at the time the imagery was flown. Everything that was not tidal was considered leveed (unless it was a slough).

The percent change (acreage) for each vegetation type within the entire marsh, within the tidally influenced areas and the leveed areas, was calculated for 2006 to 2009 using the following formula:

$$\frac{(\text{2009 Acreage} - \text{2006 Acreage})}{\text{2006 Acreage}} * 100$$

The polygons were also analyzed for changes from 2006 to 2009 in nine non-native stand-forming species of concern (e.g., species that when dominant can be mapped as semi-natural vegetation as per Sawyer et al 2009) marsh-wide, within the tidal and leveed areas of the marsh as well as the changes within the 5 management zones within the marsh (Figure 1). The nine non-native species of concern are as follows: *Arundo donax, Carpobrotus edulis, Centaurea solstitialis, Conium maculatum, Cortaderia selloana, Eucalyptus* species, *Foeniculum vulgare, Lepidium latifolium,* and *Phragmites australis* (presumably the non-native strain). These species are represented by 18 vegetation mapping units where at least one of these species occurs as a dominant or co-dominant. These mapping units are: (1) *Arundo donax*; (2) *Carpobrotus edulis*; (3) *Centaurea solstitialis*; (4) *Conium maculatum* (generic); (5) *Juncus balticus – Conium maculatum*; (6) *Cortaderia selloana*; (7) *Eucalyptus* (generic); (8) *Eucalyptus globulus*; (9) *Foeniculum vulgare*; (10) *Lepidium latifolium* (generic); (11) *Lepidium - Distichlis spicata*; (12) *Scirpus americanus - Lepidium latifolium*; (13) *Juncus balticus - Lepidium*; (14) *Lolium multiflorum*

- Lepidium latifolium; (15) *Phragmites australis*; (16) *Phragmites australis - Scirpus (acutus or californicus)*; (17) *Phragmites australis - Xanthium strumarium*; and (18) *Typha* spp. - *Phragmites australis.*

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 SMHM in Suisun Marsh. The ten *Salicornia virginica* (SAVI, or "pickleweed") vegetation types or mapping units were collectively considered important habitat for the SMHM in 2003. These include: (1) *Scirpus maritimus/Salicornia*; (2) *Distichlis spicata/Salicornia*; (3) *Salicornia*; (4) *Salicornia*/Annual Grasses; (5) *Salicornia/Atriplex triangularis*; (6) *Salicornia/ Crypsis schoenoides*; (7) *Salicornia/Sesuvium verrucosum*; (8) *Salicornia*; (9) *Salicornia/Echinochloa crus-galli Polygonum lapathifolium-Xanthium strumarium*; and (10) *Salicornia/Cotula coronopifolia.* Since then, the CDFG-BDR and DWR conducted a 2 year study (2002-2004) to gain a better understanding of "demographic performance and habitat use of salt marsh harvest mice (*Reithrodontomys raviventris halicoetes*) in the Suisun Marsh" (Sustaita *et al.* 2011). It was determined that, in addition to vegetation dominated by *Salicornia virginica*, microhabitats dominated by mixed wetland species also support SMHM. However, mixed-vegetation-dominated habitat as defined by Sustaita *et al*. (2009) (various native and non-native species, other than pickleweed and upland grasses, such as fat hen, saltgrass, Baltic rush, and Olney's three-square bulrush) has not been directly translated to one or more of the vegetation associations or alliances defined in Keeler-Wolf and Vaghti (2000). This is due to different methods for classification. In general, the mixed wetland species category of Sustaita is defined generally as vegetation not strongly dominated by *Salicornia virginica* and not strongly dominated by upland (non wetland) herbaceous species. Therefore, until more specific SMHM data is collected, we will be unable to analyze for changes in any vegetation other than *Salicornia virginica* vegetation in regard to changes SMHM habitat.

For this report *Salicornia virginica* vegetation was examined to determine changes marsh-wide, within the tidal and leveed areas of the marsh as well as the changes within the 5 management zones within the marsh (Figure 1).

See Appendix 3 for a cross-walk between the vegetation types that were mapped versus the types that were used for the analysis for changes in the vegetation from 2006 to 2009. There are three main circumstances for using different types for analysis than what was mapped: 1) several mapped types were lumped into a "Weedy" type for analysis due to being annual types that are considered non-significant and/or unreliably interpretable; 2) several of the non-native species of concern dominated in more than one mixed vegetation type and were analyzed as one type (the same was done for the *Salicornia virginica* types; and 3) a few generic mapping units were mapped in 2006 that were not mapped in 2009. For analysis these last types were put into a "best guess" type (e.g., "Tall Wetland Graminoids" mapped in 2006 were analyzed as "*Scirpus (californicus* or *acutus)-Typha* sp.").

Figure 1 - Suisun Marsh in Solano County, California showing the five management zones.

Results

The final 2009 vegetation map contains 16,197 polygons, which is 40% fewer polygons than the 2006 vegetation map (26,950 polygons). After clipping the mapped areas to the project boundary, in 2009 the total acreage mapped was 68,957and in 2006 the total acreage mapped was 68,846. The minimal discrepancy (111 acres) between the mapping areas has nothing to do with a change in the actual acreage of the marsh, rather there are several fringe upland polygons that were not mapped in the 2006 (and earlier) vegetation update that were mapped in 2009. So for analysis, there was no comparison made where there was not overlap between the two maps.

Salicornia virginica[1] Vegetation **(Refer to Table 1, 3 and 4)**

Marsh wide there was an overall increase of 2853 acres, or 23.8%, in vegetation dominated by *Salicornia virginica* from 2006 to 2009 (Table 1). Since 1999 the *Salicornia virginica* vegetation has increase by 1904.9 acres or almost 15% (Table 1). The majority of the increase from 2006 to 2009 occurred within the leveed areas of the marsh (2694 acres), however the *Salicornia virginica* vegetation also increased in the tidal areas of the marsh by almost 23% (Table 1), with a net increase of 159 acres (Table 4).

Within the five management zones (Figure 1) *Salicornia virginica* vegetation increased in all but Zone 1 (Table 3), where it decreased 7.5%. Most of this loss was due to the conversion of *Salicornia virginica* to bare ground (Table 3). Zone 3 had the greatest increase in *Salicornia virginica* vegetation, up by 159% since 2006 (Table 3). It should be noted that since 2000, the general trend for *Salicornia virginica* in the marsh has been to disappear in the areas that have been inundated and then to reemerge after the water is removed, so there does not seem to be an overall reduction in the type.

Non-Native Species of Concern **(Refer to Table 2, 5, and 6)**

From 2006 to 2009 there was a 37%, or 1045.6 acres, increase in the nine non-native species of concern over the entire marsh. In the tidal areas of the marsh there was a 30% increase from 2006 (853 acres) to 2009 (1114 acres) and in the leveed areas there was a 17% increase from 2006 (2389 acres) to 2009 (2786 acres). Several types show an overall decrease in acreage: *Arundo donax, Carpobrotus edulis, Centaurea* sp, *Cortaderia selloana*, and *Foeniculum vulgare*. Only three types show an increase: *Eucalyptus* sp., *Lepidium latifolium*, and *Phragmites australis*.

Since 1999 *Phragmites australis* has continued to increase by 24% to 57% every three years, increasing by almost 1500 acres or 173% (Table 2). *Phragmites australis* increased by 47.7%, or 761.6 acres, over the entire marsh (Table 2) from 2006 to 2009. Most of this increase occurred within the leveed areas of the marsh (643.9 acres) where 164 acres of *Phragmites australis* is now growing where there was open water in 2006 (Table 5). From 2006 to 2009 *Lepidium latifolium* increased by 339 acres or 57.6% marsh-wide (Table 2). However, since 1999 *L. latifolium* has decreased by 3.5% marsh-wide (Table 2). From 2006 to 2009 it continued to decrease in the leveed areas by 9.3%, but doubled in acreage in the tidal areas of the marsh. The area covered by *Eucalyptus* species increased by 22.9% marsh-wide, up by 49.5 acres since

[1] According to The Jepson Manual: Higher Plants of California, First[t] Edition, .Salicornia virginica is the scientific name for pickle weed Note that all species nomenclature within the report is taken from The Jepson Manual: Higher Plants of California, First Edition. Appendix 2 is a crosswalk to the updated scientific names for Salicornia virginica (Salicornia pacifica) and the other species relevant to this project according to The Jepson Manual: Vascular Plants of California, Second Edition.

2006 (Table2). Most of this increase occurred within the leveed areas (26.8 acres) while there was only a 5 acre increase of *Eucalyptus* species in the tidal areas.

Within the five management zones *Phragmites australis* increased in all of them, however in zone 1 there was only a 2.2 acre (>1%) increase from 2006 to 2009 (Table 6). At an increase of 434.1 acres, zone 5 received the greatest increase in *Phragmites australis* from 2006 to 2009 (Table 6 cont.). *Lepidium latifolium* showed a decrease of 133.5 acres in zone 4, but an increase in all the other zones (Table 6). Zones 2 and 4 had the greatest *Eucalyptus* sp. acreage expansion from 2006 to 2009, increasing by 17.7 and 14.5 acres respectively. In zones 1, 3, and 5 *Eucalyptus* sp. either decreased or increased by less than 5 acres. All other species of concern decreased in acreage (or increased by <1 acre) within all management zone (Table 6).

Table 1 - The change (acres) in the vegetation dominated by Salicornia virginica from 2006 to 2009 and 1999 to 2009 within the Suisun Marsh marsh-wide and within the tidal and leveed areas.

	Marsh-Wide					Tidal (acres)				Leveed			
Vegetation Name	**1999**	**2006**	**2009**	**% Δ 2006 to 2009**	**% Δ 1999 to 2009**	**2006**	**2009**	**Δ 2006 to 2009**	**% Δ 2006 to 2009**	**2006**	**2009**	**Δ 2006 to 2009**	**% Δ 2006 to 2009**
Scirpus maritimus - S. virginica	534.1	805.8	674.5	-16.3	26.3	6.1	3.0	-3.1	-50.6	799.8	671.6	-128.2	-16.0
Distichlis spicata - S. virginica	2383.7	2253.4	3558.6	57.9	49.3	37.0	132.9	96.0	259.7	2216.4	3425.7	1209.2	54.6
Salicornia virginica	6052.9	4524.5	7548.3	66.8	24.7	10.2	63.1	52.8	516.4	4514.2	7485.3	2971.0	65.8
S. virginica - Annual Grasses	2282.4	2748.4	1916.2	-30.3	-16.0	18.5	27.1	8.6	46.1	2729.8	1889.1	-840.7	-30.8
S. virginica - Atriplex triangularis	623.0	530.0	40.3	-92.4	-93.5	1.8	0.0	-1.8	-100.0	528.2	40.3	-487.9	-92.4
S. virginica - Crypsis	2.1	2.1	4.8	124.2	124.2	0.0	0.0	0.0	0.0	2.1	4.8	2.6	124.2
S. virginica - Sesuvium	120.6	95.5	236.6	147.7	96.1	0.0	0.0	0.0	0.0	95.5	236.6	141.1	147.7
Salicornia (generic)	551.5	667.4	0.0	-100.0	-100.0	2.4	0.0	-2.4	-100.0	665.1	0.0	-665.1	-100.0
S. virginica - Polygonum-Xanthium-Echinochloa	106.4	109.2	688.6	530.4	547.0	0.0	1.2	1.2	100	109.2	687.5	578.2	529.3
S. virginica - Cotula	262.6	234.8	156.3	-33.4	-40.5	0.0	7.7	7.7	0.0	234.8	148.6	-86.1	-36.7
Total	**12919.4**	**11971.1**	**14824.3**	**23.8**	**14.7**	**76.0**	**234.9**	**159.0**	**209.2**	**11895.2**	**14589.4**	**2694.2**	**22.6**

Table 2: The change (acres) in the vegetation dominated by the nine species of concern (SOC) from 2006 to 2009 and 1999 to 2009 within the Suisun Marsh marsh-wide and within the tidal and leveed areas.

	Marsh-wide					Tidal					Leveed				
Vegetation Name	**Acres 1999**	**Acres 2006**	**Acres 2009**	**% Δ 2006 to 2009**	**% Δ 1999 to 2009**	**Acres 1999**	**Acres 2006**	**Acres 2009**	**% Δ 2006 to 2009**	**% Δ 1999 to 2009**	**Acres 1999**	**Acres 2006**	**Acres 2009**	**% Δ 2006 to 2009**	**% Δ 1999 to 2009**
Arundo donax	4.7	23.0	0.8	-96.4	-82.4	0.9	18.5	0.0	-100.0	-100.0	3.9	5.2	0.8	-84.11	-78.56
Carpobrotus edulis	7.0	7.3	0.0	-100.0	-100.0	0.2	0.4	0.0	-100.0	-100.0	6.8	7.0	0.6	-90.9	-90.7
Centaurea (generic)	76.9	29.6	0.6	-97.9	-99.2	4.1	0.0	0.0	0.0	-100.0	72.8	55.1	0.0	-100	-100
Conium maculatum	310.5	265.4	237.1	-10.7	-23.6	10.7	0.9	0.0	-100.0	-100.0	299.8	347.3	238.0	-31.47	-20.61
Cortaderia selloana	9.8	6.7	6.1	-9.7	-37.6	0.9	2.2	2.3	3.2	155.5	8.9	7.8	3.8	-50.81	-56.95
Eucalyptus globulus	209.9	216.7	266.2	22.9	26.8	19.4	5.4	10.5	95.1	-46.0	189.6	230.2	257.0	11.644	35.55
Foeniculum vulgare	140.9	92.8	76.0	-18.1	-46.1	12.3	11.5	4.3	-62.6	-65.2	128.6	114.7	75.4	-34.32	-41.4
Lepidium latifolium	960.8	588.3	926.9	57.6	-3.5	166.3	210.4	421.4	100.3	153.5	797.3	583.5	528.9	-9.346	-33.66
Phragmites australis	863.7	1596.0	2357.6	47.7	173.0	327.0	604.0	675.8	11.9	106.6	536.6	1038.8	1682.3	61.95	213.5

Table 3: The net change (in acres) of the vegetation types that the *Salicornia virginica* (SAVI) vegetation has changed into [loss of SAVI indicated with the negative sign (-)] and has changed from (acreage gain of SAVI) from 2006 to 2009 within the five management zones of Suisun Marsh. The yellow highlighted cells indicate the vegetation types that displaced the most acreage of SAVI or have been replaced by the most SAVI since 2006.

	SAVI Net Change 2006 to 2009									
	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5	
VegName	Net Change	Total % Change	Net Change	Total % Change	Net Change	Total % Change	Net Change	Total % Change	Net Change	Total % Change
Bare Ground	-446.1		-275.9		-37.4		-369.3		140.9	
Conium maculatum	0.5		-3.6		0.1		9.7		-0.2	
Distichlis (generic)	8.2		1.5		3.1		85.5		40.8	
Distichlis spicata	41.3		43.6		-16.9		28.0		39.7	
Distichlis/Juncus	5.3		-5.8		-0.8		8.7		-1.3	
Distichlis/Lotus	1.8		0.4		0.4		6.5		0.1	
Distichlis/S. americanus	0.6		27.5		28.9		1.8		0.0	
Distichlis/S. maritimus	1.5		15.5		7.8		33.6		22.3	
Distichlis-Juncus-Triglochin-Glaux	-0.5		-4.0		17.1		-3.0		-4.0	
Ditch	-29.1		-27.0		7.7		-31.8		17.6	
Elytrigia pontica	0.0		3.1		0.0		-0.1		4.0	
Fallow Disced Field	0.0		-20.8		0.0		3.1		1.5	
Frankenia (generic)	0.0		-6.0		-1.0		3.0		4.2	
Juncus balticus	0.7		1.5		0.7		14.4		9.6	
Lepidium (generic)	-18.0		-2.8		2.7		10.4		16.5	
Lotus corniculatus	1.5		4.0		1.6		14.0		1.2	
Medium Wetland Graminoids	0.5		132.3		127.5		103.1		51.1	
Medium Wetland Herbs	18.6		75.3		25.2		27.4		25.5	
Open Water	22.2		163.0		475.8		122.5		716.3	
Phragmites australis	-3.7		-16.9		2.1		10.1		-13.5	
Salicornia (generic)	0.0		0.0		0.0		0.0		0.0	
Scirpus (californicus or *acutus)/Rosa*	-2.9		-16.1		0.1		1.2		-0.2	
Scirpus (californicus or acutus)-Typha sp.	-0.3		4.1		9.4		17.0		29.4	
Scirpus americanus (generic)	-2.5		7.0		5.7		-1.4		0.0	
Scirpus californicus/S. acutus	0.0		0.9		9.7		9.2		22.2	
Scirpus maritimus	26.1		115.5		109.6		212.1		128.9	
Scirpus maritimus/Sesuvium	0.8		0.0		9.4		31.3		0.7	
Short Wetland Herbs	97.3		-13.7		-1.5		43.6		12.5	
Tidal Mudflat	-7.1		-7.8		0.0		-3.3		-2.2	
Typha angustifolia/Distichlis	1.8		-33.7		12.9		-35.9		13.7	
Typha angustifolia/Polygonum-Xanthium-Echinochloa	1.0		-11.9		8.4		1.8		3.9	
Typha angustifolia/S. americanus	1.0		-29.6		15.4		6.1		0.5	
Typha species (generic)	33.5		-9.4		9.1		38.7		31.9	
Weedy	40.4		209.3		50.1		62.6		16.5	
Wetland Herbs	18.5		0.0		0.0		-0.1		0.0	
Total	**-191.1**	**-7.5**	**316.4**	**10.1**	**891.2**	**159.6**	**468.2**	**11.3**	**1341.4**	**88.0**

Table 4: The net change (in acres) of the vegetation types that the *Salicornia virginica* (SAVI) vegetation has changed into [loss of SAVI indicated with the negative sign (-)] and has changed from (acreage gain of SAVI) from 2006 to 2009 within the tidal and leveed areas of Suisun Marsh. The yellow highlighted cell indicates the vegetation types that converted the most acerage to SAVI since 2006.

	SAVI Net Change 2006 to 2009	
VegName	**Tidal**	**Leveed**
Agrostis avenacea	0	7.4
Baccharis/Annual Grasses	0	0.2
Bare Ground	-0.1	-983.3
Conium maculatum	0	6.5
Distichlis (generic)	0	139.2
Distichlis spicata	1.5	131.1
Distichlis/Juncus	2.7	3.3
Distichlis/Lotus	1.5	7.7
Distichlis/S. americanus	32.4	26.4
Distichlis/S. maritimus	0	83.7
Distichlis-Juncus-Triglochin-Glaux	27.6	-22.1
Ditch	0.2	-61.7
Elytrigia pontica	0	7.0
Fallow Disced Field	0.8	-17.0
Open Water	-0.8	1515.2
Foeniculum vulgare	0	2.0
Frankenia (generic)	0	0.2
Juncus balticus	0	26.9
Lepidium (generic)	-1.1	9.9
Lotus corniculatus	0	22.4
Medium Upland Herbs	0	8.4
Medium Wetland Graminoids	6.2	408.3
Medium Wetland Herbs	0	171.9
Phragmites australis	21.6	-43.5
Salicornia virginica	0.9	-0.9
Scirpus (californicus or *acutus)/Rosa*	-3.4	-14.6
Scirpus (californicus or *acutus)*/Wetland Herb	0.8	1.9
Scirpus (californicus or acutus)-Typha sp.	0.1	59.6
Scirpus americanus (generic)	6.8	2.0
Scirpus californicus/S. acutus	0.1	41.8
Scirpus maritimus	1.2	593.7
Scirpus maritimus/Sesuvium	0	42.1
Short Wetland Herbs	0	138.2
Tidal Mudflat	0	-20.5
Typha angustifolia/Distichlis	4.0	-49.2
Typha angustifolia/Polygonum-Xanthium-Echinochloa	1.1	2.2
Typha angustifolia/S. americanus	11.9	-18.5
Typha species (generic)	1.3	98.5
Weedy	39.7	350.3
Total	**159.0**	**2689.4**

Table 5: The net change (in acres) of the vegetation types that the species of concern (SOC) vegetation has changed into [loss of SOC indicated with the negative sign (-) and changed from (acreage gain of SOC) from 2006 to 2009 within the tidal and leveed areas of the Suisun Marsh management. (2006 SOC was mapped to X vegetation type in 2009 = - SOC acreage in 2009. 2009 SOC was mapped to X vegetation type in 2006 = +SOC acreage in 2009. Add them together to get the net change of SOC by X vegetation type in 2009.)

	Net Change (acres) - Tidal								Net Change (acres) - Leveed								
VegName	**Arundo donax**	**Carpobrotus edulis**	**Conium maculatum**	**Cortaderia selloana**	**Eucalyptus sp**	**Foeniculum vulgare**	**Lepidium (generic)**	**Phragmites australis**	**Arundo donax**	**Carpobrotus edulis**	**Centaurea (generic)**	**Conium maculatum**	**Cortaderia selloana**	**Eucalyptus sp**	**Foeniculum vulgare**	**Lepidium (generic)**	**Phragmites australis**
Arundo donax	0	0	0	0.3	0	0	0.1	0	0	0	0	0	0	0	0	0	0
Baccharis/Annual Grasses	0	0	0	0	0	-1.9	-2.2	-0.6	-0.3	0	0	-14.5	0	-2.6	-10.9	-5.6	-1.9
Bare Ground	0	0	0	0	0	0	-0.2	0.8	-0.1	-0.5	-3.0	-7.0	0	-1.3	-0.1	-9.0	-18.2
Centaurea (generic)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.4	0.1
Conium maculatum	0	0	0	-0.1	0	0	0	1.1	0	0	0	0	-0.1	0.7	0.8	7.5	3.9
Distichlis (generic)	0	0	0	0	0	0	0.2	0.1	0	0	0	2.0	0	2.0	0	3.2	11.5
Distichlis spicata	0	0	0	0	0	0	0.6	0.4	0	0	0	-0.1	0	0.7	-1.9	12.2	25.1
Distichlis/Juncus	0	0	0	0	0	0	1.8	-1.9	0	0	0	-4.2	0	0.2	-1.1	-19.0	1.4
Distichlis/S. americanus	0	0	0	0	0	0	19.1	3.6	0	0	0	5.3	0	-0.2	0	4.3	5.7
Distichlis/S. maritimus	0	0	0	0	0	0	0.2	0	0	0	0	-1.5	0	0	0	-1.6	14.7
Distichlis-Juncus-Triglochin-Glaux	0	0	0	0	0	0	6.9	0.4	0	0	0	-7.9	0	0	0	-3.3	-11.5
Eucalyptus sp.	0	0	0	0	3.7	0	0	0.3	0	0.3	0	-0.7	0	0	-0.3	-1.0	-0.2
Foeniculum vulgare	0	0	0	0	0	0	0.2	1.1	0	0	0	-0.8	0	0.3	0	5.5	-0.1
Juncus balticus	0	0	0	0	0	0	0.8	0.0	0	0	0	27.2	0	0.2	0	2.1	13.0
Lepidium (generic)	-0.1	0	0	0	0	-0.5	1.4	-3.5	0	0	-5.4	-7.5	0	1.0	-5.5	0	-2.2
Medium Wetland Graminoids	0	0	0	0	0	0	0	0.3	0	0	0.0	2.1	0	0.2	2.4	0.4	25.9
Medium Wetland Herbs	0	0	0	0	0.2	0	1.2	0.3	0	0	0.0	0.3	0	0.7	0	1.4	22.2
Open Water	0	0	0	0	0	0.1	0.1	3.2	-0.2	0	-0.1	10.7	0	36.8	0.2	49.9	164.7
Phragmites australis	0	0	-0.6	0	0	-0.2	3.6	5.7	0	0	-0.1	-3.9	0	0.2	0.1	2.2	0.0
Salicornia (generic)	0	0	0	-0.3	0	-0.1	1.1	-22.3	0	0	-3.1	-6.5	-0.3	-2.7	-2.0	-10.0	41.6
Scirpus (californicus or *acutus)/Rosa*	-0.1	0	0	0	-0.1	-1.0	4.3	9.8	0	0	0	-0.2	0	0.3	-0.4	3.4	0
Scirpus (californicus or acutus)/Wetland Herb	-14.2	0	0	0	0.4	0	5.6	0.9	0	0	0	0.4	0	0.3	0	0.1	-2.1
Scirpus (californicus or acutus)-Typha sp.	-1.3	-0.1	0	0.4	-1.0	-0.2	15.3	6.6	-0.4	-0.1	0	-0.7	0	1.0	2.4	3.9	51.7
Scirpus americanus (generic)	0	0	0	0	0	0	17.5	4.5	0	0	0	0.8	0	0.1	0	4.3	2.5
Scirpus americanus/Potentilla	0	0	0	0	0	-0.1	24.4	-4.6	0	0	0	0.0	0	0.0	0	0.4	0.0
Scirpus californicus/S. acutus	-0.3	0	0	0.4	0.1	-1.3	7.0	28.3	0.1	0	0	0.7	0	2.9	0	2.1	38.2
Scirpus maritimus	0	0	0	0	0	0	0	0.8	0	0	0	0.5	0	0.1	4.0	0.3	42.6
Typha angustifolia/Distichlis	0	0	0	-0.7	0	0	6.7	-29.2	0	0	0	-4.9	-0.7	0.3	-0.7	13.8	3.0
Typha angustifolia/Polygonum-	0	0	0	0	0	0	4.0	2.4	0	0	0	2.3	0	0.6	-0.4	-4.8	17.1

Xanthium-Echinochloa																	
Typha angustifolia/S. americanus	0	0	0	0.2	0	0	47.8	6.5	0	0	0	0.3	0	-0.8	1.2	7.0	7.8
Typha species (generic)	-0.2	0	0	0	1.1	0	30.8	37.2	-0.4	0	0	6.3	0	2.2	-1.6	5.0	64.0
Weedy	0	0	-0.2	-3.2	0	3.5	-0.4	0.2	-0.7	0	-40.0	-57.8	-3.2	6.6	-1.0	-102.1	112.5
Total	**-18.5**	**-0.4**	**-0.9**	**-5.5**	**5.2**	**-7.2**	**211.8**	**80.3**	**-3.4**	**-6.3**	**-54.9**	**-100.8**	**-7.7**	**49.5**	**-37.6**	**-34.2**	**649.4**

Table 6: The net change (in acres) of the vegetation types that the species of concern (SOC) vegetation has changed into [loss of SOC indicated with the negative sign (-) and changed from (acreage gain of SOC) from 2006 to 2009 within the five Suisun Marsh management zones. (2006 SOC was mapped to X vegetation type in 2009 = - SOC acreage in 2009. 2009 SOC was mapped to X vegetation type in 2006 = +SOC acreage in 2009. Add them together to get the net change of SOC by X vegetation type in 2009.)

	Net Change in acres																				
	Zone 1						Zone 2								Zone 3						
VegName	Centaurea (generic)	Conium maculatum	Eucalyptus sp	Foeniculum vulgare	Lepidium (generic)	Phragmites australis	Arundo donax	Centaurea (generic)	Conium maculatum	Cortaderia selloana	Eucalyptus sp	Foeniculum vulgare	Lepidium (generic)	Phragmites australis	Arundo donax	Centaurea (generic)	Conium maculatum	Cortaderia selloana	Eucalyptus sp	Foeniculum vulgare	Lepidium (generic)	Phragmites australis
Bare Ground	0	0	0	0	0	2.5	0	0	0	0	0	0	0.9	0	0	0	0	0	0.5	0	0	2.8
Carpobrotus edulis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centaurea (generic)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.4	0
Conium maculatum	0	0	0	0	0	0	0	0	0	0	0	0.6	5.2	-1.0	0	0	0	0	0	0.5	0	0.7
Cortaderia selloana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distichlis (generic)	0	0	0	0	0	1.5	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0
Distichlis spicata	0	0	0	0	9.2	10.8	0	0	0	0	0	0	20.8	4.7	0	0	0.8	0	0	0	1.1	1.8
Distichlis/Juncus	0	0	0	0	-1.5	-2.0	0	0	0	0	0	0	1.0	2.7	0	0	0	0	0	0	-2.0	-1.0
Distichlis-Juncus-Triglochin-Glaux	0	0	0	0	0	0	0	0	0	0	0	0	-5.3	-1.2	0	0	0	0	0	0	-1.9	-0.6
Distichlis/S. americanus	0	0	0	0	7.2	4.5	0	0	0.7	0	0	0	8.7	5.2	0	0	0.8	0	0	0	8	0
Distichlis/S. maritimus	0	0	0	0	0	0.8	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0
Distichlis-Juncus-Triglochin-Glaux	0	0	0	0	0	0.8	0	0	0	0	0	0	6.7	0	0	0	0	0	0	0	5.3	0.8
Ditch	0	-1.4	-0.6	0	-0.7	-0.7	0	0	-2.1	0	-1.1	-4.3	-4.3	-1.4	0	0	0	0	0	0	0.5	-2.5
Elytrigia pontica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.8	0	0
Eucalyptus sp	0	0	0	0	0	0	0	0	0	0	0	0	-0.6	0	0	0	0	0	0	0	0	0
Foeniculum vulgare	0	0	0	0	0	-0.9	0	0	-0.6	0	0	0	4.1	0	0	0	-0.5	0	0	0	0	0
Juncus balticus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9
Lepidium (generic)	0	0	0	0	0	-7.6	0	0	-5.2	0	0.6	-4.1	0	1.6	0	-5.4	0	0	0	0	0	-0.9
Medium Wetland Graminoids	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	2.4	0	4.6
Medium Wetland Herbs	0	0	0	0	0	0	0	0	0	0	0	0	0	3.0	0	0	0	0	0	0	0	3.2
Open Water	0	0	0	0	0	-15.8	0	0	2.2	0	34.3	1.0	10.0	12.5	0	0	0.7	0	0	0	5.1	17.8
Phragmites australis	0	0	0	1	8	0	0	0	1.0	0	0	0	-1.6	0	0	0	-0.7	0	0	0	0.9	0
Road	0	0	1.1	0	2.7	3.4	0	0	0	0	0	6.4	15.5	1.6	0	0	0	0	0	1.2	0	1.1
Rosa californica	0	0	0	0	0.6	3.0	0	0	0	0	0	0.9	2.7	0	0	0	0	0	0	0	0	0
Rosa/Baccharis	0	0	0	0	-0.5	0	0	0	-6.3	0	0	-9.9	-1.5	-0.7	0	0	0	0	0	0	0	0
Salicornia (generic)	0	-0.5	0	-0.7	18.0	3.7	0	0	3.6	0	-1.8	1	2.8	16.9	0	-3.0	0	0	0	0	-2.7	-2.1
Scirpus (californicus or *acutus)/Rosa*	0	0	0	0	2.0	8.6	0	0	0	0	0	0	3.4	0.8	0	0	0	0	0	0	0	0
Scirpus (californicus or *acutus)*/Wetland Herb	0	0	0	0	0	2.7	0	0	0	0	0	0	2.5	0.9	-14.0	0	0	0	0	0	0	-3.3

Scirpus (californicus or *acutus)-Typha* sp.	0	0	0	1.6	5.4	-3.3	0	0	0	0	0	0.9	4.6	10.6	-1.7	0	-1.4	0	0	0	0	9.9
Scirpus americanus (generic)	0	0	0	0	5.3	6.7	0	0	0	0	0	0	10.6	1.0	0	0	0	0	0	0	5.5	0.8
Scirpus americanus/Potentilla	0	0	0	0	-1.1	-2.7	0	0	0	0	0	0	23.2	-0.5	0	0	0	0	0	0	2.7	-1.4
Scirpus californicus/S. acutus	0	0	0	0	0	0	0	0	0	0	0	-1.6	2.6	4.5	0	0	0	0	0	0	2.1	7.4
Scirpus maritimus	0	0	0	0	0	1	0	0	0.6	0	0	2.4	0	6.2	0	0	0	0	0	0	0	2.1
Slough	0	0	0.9	0	1.5	8.7	0	0	0	0	1.9	0	9.1	0.6	0	0	0	0	0	0	2.3	0.8
Typha angustifolia/Distichlis	0	0	0	0	-1.7	-20.2	0	0	-0.8	-0.7	0	0	11.9	6.3	0	0	0	0	0	0	6.0	7.3
Typha angustifolia/Polygonum-Xanthium-Echinochloa	0	0	0	0	4.3	3.1	0	0	0	0	0.6	0	-2.5	0.7	0	0	0	0	0	0	0	4.8
Typha angustifolia/S. americanus	0	0	0	0	7.6	7.3	0	0	0	0	-0.9	0	24.6	19.4	0	0	0	0	0	0.7	12.8	-15.1
Typha species (generic)	0	0	0	1.6	10.4	3.6	0	0	-1.2	0	0	-2.1	6.6	8.7	0	0	0	0	0	0	4.0	8.2
Weedy	-4.2	-2.5	0.6	-1.0	8.0	12.0	0	-22.7	-10.3	-3.2	-7.0	4.0	-7.7	3.1	0	-13.3	-5.4	0	0	13.5	13.9	-4.2
Total	**-6.1**	**-5.7**	**-3.0**	**0.1**	**79.6**	**2.2**	**-1.1**	**-24.7**	**-31.6**	**-5.4**	**17.7**	**-22.6**	**140.1**	**96.1**	**-18.7**	**-24.3**	**-9.1**	**0.6**	**0.5**	**14.7**	**66.3**	**39.5**

Table 6 cont.: The net change (in acres) of the vegetation types that the species of concern (SOC) vegetation has changed into [loss of SOC indicated with the negative sign (-) and changed from (acreage gain of SOC) from 2006 to 2009 within the five Suisun Marsh management zones. (2006 SOC was mapped to X vegetation type in 2009 = - SOC acreage in 2009. 2009 SOC was mapped to X vegetation type in 2006 = +SOC acreage in 2009. Add them together to get the net change of SOC by X vegetation type in 2009.)

	Net Change in acres													
	Zone 4								Zone 5					
VegName	Arundo donax	Carpobrotus edulis	Conium maculatum	Cortaderia selloana	Eucalyptus sp	Foeniculum vulgare	Lepidium (generic)	Phragmites australis	Arundo donax	Conium maculatum	Eucalyptus sp	Foeniculum vulgare	Lepidium (generic)	Phragmites australis
Bare Ground	0	0	0	0	0	0	0.8	11.5	0	1.1	0	0	0	8
Carpobrotus edulis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centaurea (generic)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conium maculatum	0	0	0	0	0.5	0	5.0	4.5	0	0	0	0	-2.5	0
Cortaderia selloana	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Distichlis (generic)	0	0	1.0	0	1.2	0	0	4.9	0	0.9	0.8	0	0	4.9
Distichlis spicata	0	0	3.3	0	1.3	0	0	5.5	0	0	0	0	1.1	11.7
Distichlis/Juncus	0	0	2.5	0	0	0	-7.4	-2.7	0	-6.7	0	0	-7.4	2.5
Distichlis-Juncus-Triglochin-Glaux	0	0	-6.3	0	0	0	0	-1.8	0	-1.7	0	0	-1.7	-8.9
Distichlis/S. americanus	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0
Distichlis/S. maritimus	0	0	0	0	0	0	0	4.9	0	0	0	0	0	7.5
Distichlis-Juncus-Triglochin-Glaux	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0
Ditch	0	-2.0	-9.3	0	2.6	-0.5	-5.4	3.1	0	-1.2	0	-0.8	6.3	18.2
Elytrigia pontica	0	0	-1.1	0	0	-1.1	-5.6	-2.2	0	0	0	0	0	0
Eucalyptus sp	0	0	-0.5	0	0	0	-0.5	0	0	0	0	0	0	0
Foeniculum vulgare	0	0	0	0	0	0	1.0	1.5	0	0	0	0	0	0
Juncus balticus	0	0	16.8	0	0	0	0.8	6.1	0	11.6	0	0	1.9	6.7
Lepidium (generic)	0	0	-5.0	0	0.5	-1.0	0	1.8	0	2.5	0	0	0	0
Medium Wetland Graminoids	0	0	1.5	0	0	0	0	9.3	0	0.6	0	0	0	9.4
Medium Wetland Herbs	0	0	0.8	0	0.7	0	1.3	4.4	0	0	0	0	3.2	12.9
Open Water	0	0	-0.9	0	0.8	-0.9	-1.0	10.9	0	8.8	0	0	35.2	131.8
Phragmites australis	0	0	-4.5	0	0	-1.5	-1.8	0	0	0	0	0	0	0
Road	0	0	1.0	0	4.5	0	0	2.0	0	0.6	0.5	0	1.0	4.3
Rosa californica	0	0	0	0	1.0	0	0	1.7	0	0	0	0	0.8	1.2
Rosa/Baccharis	0	0	0	-0.7	0	0	0	-0.1	0	-1.8	0	-1.2	-1.4	0
Salicornia (generic)	0	0	-9.7	0	-1.0	-1.2	-10.4	-10.1	0	0	0	-0.7	-16.5	13.5
Scirpus (californicus or *acutus)/Rosa*	0	0	0	0	0	0	1.1	1.3	0	0	0	0	1.5	1.7
Scirpus (californicus or acutus)/Wetland Herb	0	0	0	0	0	0	3.5	2.6	0	0	-0.6	0	-0.6	-5.6
Scirpus (californicus or *acutus)-Typha* sp.	0	0	2.0	0	-1.5	0	4.6	4.6	0	-2.1	0	0	3.9	48.8
Scirpus americanus (generic)	0	0	0.6	0	0	0	0.0	2.0	0	0	0	0	0	0
Scirpus americanus/Potentilla	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scirpus californicus/S. acutus	0	0	0.7	0	1.3	0	0	9.2	0	0	0	0	4.1	34.3
Scirpus maritimus	0	0	0	0	0	1.6	0	20.7	0	0.8	0	0	0	20.7
Slough	0	0	0	0	0	0	0.7	1.0	0	0	0	0	0	0.8
Typha angustifolia/Distichlis	0	0	-3.3	0	0	0	0	-25.2	0	-1.1	0	0	3.2	5.4
Typha angustifolia/Polygonum-Xanthium-Echinochloa	0	0	0	0	0	0	0	7.2	0	2.9	0	0	-2.9	3.5
Typha angustifolia/S. americanus	0	0	0	0	0	0	0.7	0	0	0	0	0	9.1	2.5
Typha species (generic)	0	0	2.9	0	1.0	-1.1	2.0	27.6	0	3.9	1.6	0	10.0	51.7
Weedy	0	0	-27.8	0	12.6	-7.6	-93.3	52.1	0	-11.7	1.4	-2.8	-20.4	51.5
Total	**-0.9**	**-6.8**	**-54.5**	**-0.4**	**14.5**	**-22.2**	**-133.5**	**142.6**	**-1.7**	**-8.0**	**4.7**	**-12.8**	**12.3**	**434.1**

Discussion, Conclusions and Recommendations

Due to the levee breeches and heavy rainfall in 2006, it isn't surprising that a majority of the increase in *Salicornia virginica* vegetation from 2006 to 2009 occurred mostly in the leveed areas of the marsh where there was "Open Water" in 2006. This accounts for an increase of 1515 acres of *Salicornia virginica* vegetation from 2006 to 2009 (Table 4). The same pattern can be seen for the increase of *Phragmites australis* in the leveed areas of the marsh. Here, *Phragmites australis* has encroached onto 164 acres where there was open water in 2006 (Table 5). The decrease of 983 acres of *Salicornia virginica* vegetation within the leveed areas due to an increase in bare ground tended to occur where the polygon had a disturbance level of medium or high. Of the 744 polygons that were *Salicornia virginica* vegetation in 2006 and shifted to bare ground in 2009, 505 of them had a disturbance level of medium or high. See Appendices 4 and 5 for tables from the 2006 report showing changes in *Salicornia virginica* and *Phragmites australis* vegetation from 2003 to 2006 and 1999 to 2006.

Conclusions

The change in protocol used for the 2009 vegetation map update proved to be well worth it as far as map accuracy, quality, and efficiency of production. However, because the 2006 vegetation shapefile is not as spatially accurate as the 2009 vegetation map it is recommended that future analyses involving raster data of a vegetation map from 2006 or earlier wait until the layers are reprocessed using the same field control points that the DWR's Mapping & Photogrammetry Section used for the 2009 Suisun Marsh imagery. It is also recommended that these same points be used when processing all future imagery flown specifically for this project.

Literature Cited

Boul, R., D. Hickson, and T. Keeler-wolf. 2007. The Vegetation of Suisun Marsh, Solano County, California: First Permanent Plot Resample Study 1999 cvs. 2006. Unpublished administrative report on file at Biogeographic Data Branch, California Department of Fish and Game, Sacramento.

Boul, R. and T. Keeler-wolf. 2008. The 2006 Vegetation Map Update For Suisun Marsh, Solano County, California. Unpublished administrative report on file at Biogeographic Data Branch, California Department of Fish and Game, Sacramento.

Keeler-Wolf, T., M. Vaghti and A. Kilgore. 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 Game, Sacramento.

Sustaita, D., P. Finfrock Quickert, L. Patterson, L. Barthman-Thompson, and S. Estrella. 2011. Salt Marsh Harvest Mouse Demography and Habitat Use in the Suisun Marsh. Journal of Wildlife Management,75(6):1498-1507.

Vaghti, M., T. Keeler-Wolf. 2001. Suisun Marsh Vegetation Mapping: Change Detection 2000. Unpublished administrative report on file at Wildlife and Habitat Data Analysis Branch, California Department of Fish and Game, Sacramento.

Vaghti, M. and T. Keeler-Wolf. 2004. Suisun Marsh Vegetation Mapping Change Detection 2003. Unpublished administrative report on file at Biogeographic Data Branch, California Department of Fish and Game, Sacramento

Monroe, M, Olofson PR, Collins JN, Grossinger RM, Haltiner J, Wilcox C. 1999. Baylands Ecosystem Habitat Goals. Goals Project. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U. S. Environmental Protection Agency, San Francisco, Calif./S.F. Bay Regional Water Quality Control Board, Oakland, California

Appendix 1 - Crosswalk of the mapping attributes used for the 2006 and 2009 Suisun Marsh vegetation maps.

Map attributes		Definition
2006	**2009**	
ChngeCls06	N/A	Change is size class of polygon since 2003; 0=none, 1= (5-10%), 2=(10-20%), 3=(20-50%), 4=(>50%), 999=new or eliminated
ChngeVeg06	N/A	0=no change in vegetation type from 2003 to 2006; 1=change
PolyID_06	PolyID_2009	Unique polygon identifier in 2009
Cover_06	Cov_2009	Assessed total vegetation cover class in 2009; 0=N/A, 1=(<2%), 2=(2-10%), 3=(10-25%), 4=(25-50%), 5=(50-75%), 6=(>75%)
Dist_06	Dist_2009	Assessed disturbance class in 2009; 0=N/A, 1=Not evident, 2=Low, 3=Medium, 4=High
Ht_06	Ht_2009	Assessed vegetation height class in 2009; 0=N/A, 1=(<0.5m), 2=(0.5-1m), 3=(1-2m), 4=(2-5m), 5=(5-10m), 6=(>10m)
PolySize06	Poly_size_2009	Size class of polygon in 2009; 1=(<1ac), 2=(1-5ac), 3=(>5ac)
Notes_06	Notes_2009	2009 Notes
ID_06	ID_2009	How assessment was determined in 2009: P=photo interpretation, R=reconnaissance, S06=sampled in 2006 (Relevé), U=updated, FC=Field checked (post map)
Veg_06	Veg_2009	Assessed vegetation code in 2009
PolyArea06	Area_Acres	Area (in acres) of each polygon in 2009

Appendix 2 - The vegetation types and mapping units used to map Suisun Marsh. Old vegetation types and map units (left) are cross-walked to more recent vegetation names on the right. "Mu" is mapping unit (i.e., not a true vegetation classification unit). The Jepson Manual Higher Plants of California, First Edition has been the sources for the species nomenclature for this project until The Jepson Manual: Vascular Plants of California, Second Edition is officially released in January 2012.

Mapping Code	Vegetation Name 1999-2006	Vegetation Name as of 2009
1	Bare Ground	Bare Ground mu
2	Fallow Disced Field	Fallow Disced Field mu
3	Parking Lot	Parking Lot mu
4	Road	Road mu
5	Structure	Structure mu
6	Slough	Slough mu
7	Tidal Mudflat	Tidal Mudflat mu
8	Railroad Track	Railroad Track mu
9	Ditch	Ditch mu
10	Trail	Trail mu
11	Open Water	Open Water mu
12	Freshwater Drainage	Freshwater Drainage mu
13	Water Treatment Pond	Water Treatment Pond mu
14	Urban Area	Urban Area mu
101	Tall Wetland Graminoids	Tall Wetland Graminoids mu
102	*Arundo donax*	*Arundo donax*
103	*Phragmites australis*	*Phragmites australis*
104	*Phragmites/Scirpus*	*Phragmites australis-Schoenoplectus* spp.
105	*Phragmites/Xanthium*	*Phragmites australis-Xanthium strumarium*
112	*Scirpus americanus/Potentilla*	*Schoenoplectus americanus-Potentilla anserina*
113	*Scirpus americanus/S. Californicus-S. acutus*	*Schoenoplectus americanus-Schoenoplectus (acutus, californicus)*
114	*Scirpus americanus* (generic)	*Schoenoplectus americanus*
116	*Scirpus californicus/S. acutus*	*Schoenoplectus (acutus, californicus)*
120	*Typha angustifolia/Polygonum-Xanthium-Echinochloa*	*Typha angustifolia-Polygonum* sp.*-Xanthium strumarium-Echinochloa crus-galli*
121	*Typha angustifolia/S. americanus*	*Typha angustifolia-Schoenoplectus americanus*
123	*Typha species* (generic)	*Typha* spp.
125	*Typha angustifolia* (dead stalks)	*Typha angustifolia* (dead stalks)
126	*Typha angustifolia/Distichlis*	*Typha angustifolia-Distichlis spicata*
127	*Scirpus americanus/Lepidium*	*Schoenoplectus americanus-Lepidium latifolium*
129	*Typha angustifolia/Phragmites*	*Typha angustifolia/Phragmites australis*
130	Medium Wetland Graminoids	Medium Wetland Graminoids mu
132	*Juncus balticus*	*Juncus balticus*
133	*Juncus balticus/Conium*	*Juncus balticus-Conium maculatum*
134	*Juncus balticus/Lepidium*	*Juncus balticus-Lepidium latifolium*
135	*Juncus balticus/Potentilla*	*Juncus balticus-Potentilla anserina*
137	*Scirpus maritimus*	*Bolboschoenus maritimus*
138	*Scirpus maritimus/Salicornia*	*Bolboschoenus maritimus-Salicornia virginica*
139	*Scirpus maritimus/Sesuvium*	*Bolboschoenus maritimus-Sesuvium verrucosum*
140	Short Wetland Graminoids	Short Wetland Graminoids mu
141	*Distichlis spicata*	*Distichlis spicata*

142	*Distichlis*/Annual Grasses	*Distichlis spicata*-Annual grasses
145	*Distichlis/Juncus*	*Distichlis spicata-Juncus balticus*
147	*Distichlis/Lotus*	*Distichlis spicata-Lotus corniculatus*
148	*Distichlis/Salicornia*	*Distichlis spicata-Salicornia virginica*
149	*Distichlis/S. americanus*	*Distichlis spicata-Schoenoplectus americanus*
153	*Distichlis/Cotula*	*Distichlis spicata-Cotula coronopifolia*
154	*Distichlis/S. maritimus*	*Distichlis spicata-Bolboschoenus maritimus*
155	*Crypsis schoenoides*	*Crypsis schoenoides*
156	*Distichlis* (generic)	*Distichlis spicata* (generic)
157	*Scirpus (californicus* or *acutus)-Typha sp.*	*Schoenoplectus (acutus, californicus)-Typha* sp.
158	*Scirpus (californicus* or *acutus)*/Wetland Herb	*Schoenoplectus (acutus, californicus)*-Wetland herbs
160	*Distichlis-Juncus-Triglochin-Glaux*	*Distichlis spicata-Juncus balticus-Triglochin* sp.*-Glaux maritima*
161	*Cynodon dactylon*	*Cynodon dactylon*
162	*Scirpus (californicus* or *acutus)/Rosa*	*Schoenoplectus (acutus, californicus)-Roca californica*
202	*Cortaderia selloana*	*Cortaderia selloana*
210	Medium Upland Graminoids	Medium Upland Graminoids mu
211	*Elytrigia pontica*	*Elytrigia pontica*
215	*Leymus* (generic)	*Leymus* (generic)
218	*Lolium* (generic)	*Lolium* (generic)
220	*Lolium/Lepidium*	*Lolium multiflorum-Lepidium latifolium*
222	*Lolium/Rumex*	*Lolium multiflorum-Rumex* sp.
223	*Phalaris aquatica*	*Phalaris aquatica*
225	Cultivated Annual Graminoid	Cultivated Annual Graminoid mu
226	Perennial Grass	Perennial Grass
227	Annual Grasses/Weeds	Annual Grasses/Weeds
228	*Agrostis avenacea*	*Agrostis avenacea*
230	Short Upland Graminoids	Short Upland Graminoids mu
231	Annual Grasses generic	Annual Grasses generic
232	*Bromus spp/Hordeum*	*Bromus sp.-Hordeum* sp.
234	*Hordeum/Lolium*	*Hordeum sp.-Lolium multifloum*
235	*Vulpia/Euthamia*	*Vulpia/Euthamia*
238	*Polypogon monspeliensis* (generic)	*Polypogon monspeliensis* (generic)
300	Wetland Herbs	Wetland Herbs mu
301	Tall Wetland Herbs	Tall Wetland Herbs mu
310	Medium Wetland Herbs	Medium Wetland Herbs mu
311	*Atriplex triangularis*	*Atriplex triangularis*
312	*Atriplex/Distichlis*	*Atriplex triangularis-Distichlis spicata*
315	*Atriplex/S. maritimus*	*Atriplex triangularis-Bolboschoenus maritimus*
316	*Atriplex/Sesuvium*	*Atriplex triangularis-Sesuvium verrucosum*
317	*Frankenia/Agrostis*	*Frankenia salina-Agrostis*
318	*Frankenia/Distichlis*	*Frankenia salina-Distichlis spicata*
320	*Frankenia* (generic)	*Frankenia salina* (generic)
321	*Grindelia stricta* var *stricta*	*Grindelia stricta* var. *stricta*
323	*Lepidium/Distichlis*	*Lepidium latifolium-Distichlis spicata*
324	*Lepidium* (generic)	*Lepidium latifolium* (generic)
329	*Polygonum-Xanthium-Echinochloa*	*Polygonum* spp.*-Xanthium strumarium-Echinochloa crus-galli*

330	*Calystegia/Euthamia*	*Calystegia sepium-Euthamia occidentalis*
336	*Rumex* (generic)	*Rumex* spp. (generic)
337	*Atriplex*/Annual Grasses	*Atriplex triangularis*-Annual Grasses
338	*Potentilla anserina* (generic)	*Potentilla anserina* (generic)
339	*Atriplex triangularis*(generic)	*Atriplex triangularis* (generic)
340	Short Wetland Herbs	Short Wetland Herbs mu
342	*Cotula coronopifolia*	*Cotula coronopifolia*
344	*Lotus corniculatus*	*Lotus corniculatus*
346	*Salicornia virginica*	*Salicornia pacifica*
347	*Salicornia*/Annual Grasses	*Salicornia pacifica*-Annual Grasses
348	*Salicornia/Atriplex*	*Salicornia pacifica-Atriplex triangularis*
350	*Salicornia/Crypsis*	*Salicornia pacifica-Crypsis*
356	*Salicornia/Sesuvium*	*Salicornia pacifica-Sesuvium verrucosum*
357	*Sesuvium verrucosum*	*Sesuvium verrucosum*
358	*Sesuvium/Distichlis*	*Sesuvium verrucosum-Distichlis spicata*
359	*Sesuvium/Lolium*	*Sesuvium verrucosum-Lolium multiflorum*
360	*Spergularia/Cotula*	*Spergularia-Cotula coronopifolia*
361	*Salicornia* (generic)	*Salicornia* (generic)
364	*Salicornia/Polygonum-Xanthium-Echinochloa*	*Salicornia virginca-Polygonum-Xanthium-Echinochloa*
365	*Salicornia/Cotula*	*Salicornia pacifica-Cotula coronopifolia*
371	*Potamogeton pectinatus*	*Potamogeton pectinatus*
401	Upland Herbs	Upland Herbs mu
402	*Conium maculatum*	*Conium maculatum*
403	*Foeniculum vulgare*	*Foeniculum vulgare*
405	*Raphanus sativus* (generic)	*Raphanus sativus* (generic)
406	*Brassica nigra* (generic)	*Brassica nigra* (generic)
410	Medium Upland Herbs	Medium Upland Herbs mu
413	*Centaurea* (generic)	*Centaurea* (generic)
421	*Carpobrotus edulis*	*Carpobrotus edulis*
502	*Salix exigua*	*Salix exigua*
514	*Atriplex lentiformis* (generic)	*Atriplex lentiformis* (generic)
601	Medium Upland Shrubs	Medium Upland Shrubs mu
603	*Baccharis*/Annual Grasses	*Baccharis pilularis* /Annual Grasses
604	*Rosa californica*	*Rosa californica*
605	*Rosa/Baccharis*	*Rosa californica-Baccharis pilularis*
606	*Rubus discolor*	*Rubus discolor*
700	Willow Trees	Willow Trees
702	*Salix laevigata/S. lasiolepis*	*Salix laevigata/Salix lasiolepis*
705	*Salix lasiolepis/Quercus agrifolia*	*Salix lasiolepis/Quercus agrifolia*
800	*Eucalyptus*	*Eucalyptus* mu
801	*Eucalyptus globulus*	*Eucalyptus globulus*
900	Oaks	Oaks mu
901	*Quercus agrifolia*	*Quercus agrifolia*
903	*Quercus lobata*	*Quercus lobata*
910	Landscape Trees	Landscape Trees mu
911	*Ailanthus altissima*	*Ailanthus altissima*
912	*Fraxinus latifolia*	*Fraxinus latifolia*

Appendix 3 - A cross-walk between the vegetation types that were mapped within the Suisun Marsh (Mapped Type) versus the types that were used for the analysis for changes in the vegetation from 2006 to 2009. Those mapped types that were lumped into the "Weedy" type for analysis are annual types that are considered non-significant and/or unreliably interpretable. Several of the non-native species of concern dominated in more than one mixed vegetation type and were analyzed as one type. The same was done for the Salicrnia virginica types. Also, there are a few generic mapping units that were mapped in 2006 and were not mapped in 2009; For analysis these types were put into a "best guess" type (example: "Tall Wetland Graminoides" mapped in 2006 were analyzed as "Scirpus (californicus or acutus)-Typha sp." for the 2006/2009 change detection).

Mapped Code	Mapped Type	Code for analysis	Type Used For Analysis
1	Bare Ground	1	Bare Ground
2	Fallow Disced Field	2	Fallow Disced Field
3	Parking Lot	3	Parking Lot
4	Road	4	Road
5	Structure	5	Structure
6	Slough	6	Slough
+7	Tidal Mudflat	7	Tidal Mudflat
8	Railroad Track	8	Railroad Track
9	Ditch	9	Ditch
10	Trail	4	road
11	Open Water	11	Open Water
12	Freshwater Drainage	12	Freshwater Drainage
13	Water Treatment Pond	13	Water Treatment Pond
14	Urban Area	14	Urban Area
101	Tall Wetland Graminoids	157	Scirpus (californicus or acutus)-Typha sp.
102	*Arundo donax*	102	*Arundo donax*
103	*Phragmites australis*	103	*Phragmites australis*
104	*Phragmites/Scirpus*	103	*Phragmites australis*
105	*Phragmites/Xanthium*	103	*Phragmites australis*
112	*Scirpus americanus/Potentilla*	112	*Scirpus americanus/Potentilla*
113	*Scirpus americanus/S. Californicus-S. acutus*	113	*Scirpus americanus/S. Californicus-S. acutus*
114	*Scirpus americanus* (generic)	114	*Scirpus americanus* (generic)
116	*Scirpus californicus/S. acutus*	116	*Scirpus californicus/S. acutus*
120	*Typha angustifolia/Polygonum-Xanthium-Echino*	120	*Typha angustifolia/Polygonum-Xanthium-Echino*
121	*Typha angustifolia/S. americanus*	121	*Typha angustifolia/S. americanus*
123	*Typha species* (generic)	123	*Typha species* (generic)
125	*Typha angustifolia* (dead stalks)	123	*Typha species* (generic)
126	*Typha angustifolia/Distichlis*	126	*Typha angustifolia/Distichlis*
127	*Scirpus americanus/Lepidium*	324	*Lepidium (generic)*
129	*Typha angustifolia/Phragmites*	103	*Phragmites australis*
130	Medium Wetland Graminoids	130	Medium Wetland Graminoids
132	*Juncus balticus*	132	*Juncus balticus*
133	*Juncus balticus/Conium*	402	*Conium maculatum*
134	*Juncus balticus/Lepidium*	324	*Lepidium* (generic)
135	*Juncus balticus/Potentilla*	135	*Juncus balticus/Potentilla*
137	*Scirpus maritimus*	137	*Scirpus maritimus*
138	*Scirpus maritimus/Salicornia*	361	*Salicornia* (generic)
139	*Scirpus maritimus/Sesuvium*	139	*Scirpus maritimus/Sesuvium*
140	Short Wetland Graminoids	140	Short Wetland Graminoids
141	*Distichlis spicata*	141	*Distichlis spicata*
142	*Distichlis*/Annual Grasses		Weedy

145	*Distichlis/Juncus*	145	*Distichlis/Juncus*
147	*Distichlis/Lotus*	147	*Distichlis/Lotus*
148	*Distichlis/Salicornia*	361	*Salicornia* (generic)
149	*Distichlis/S. americanus*	149	*Distichlis/S. americanus*
153	*Distichlis/Cotula*		Weedy
154	*Distichlis/S. maritimus*	154	*Distichlis/S. maritimus*
155	*Crypsis schoenoides*		Weedy
156	*Distichlis* (generic)	156	*Distichlis* (generic)
157	*Scirpus (californicus* or *acutus)-Typha* sp.	157	*Scirpus (californicus* or *acutus)-Typha* sp.
158	*Scirpus (californicus* or *acutus)/Wetland Herb*	158	*Scirpus (californicus* or *acutus)*/Wetland Herb
160	*Distichlis-Juncus-Triglochin-Glaux*	160	*Distichlis-Juncus-Triglochin-Glaux*
161	*Cynodon dactylon*	227	Annual Grasses/Weeds
162	*Scirpus (californicus or acutus)/Rosa*	162	*Scirpus (californicus* or *acutus)/Rosa*
202	*Cortaderia selloana*	203	*Cortaderia selloana*
210	Medium Upland Graminoids	227	Annual Grasses/Weeds
211	*Elytrigia pontica*	211	*Elytrigia pontica*
215	*Leymus* (generic)	226	Perennial Grass
218	*Lolium* (generic)		Weedy
220	Lolium/Lepidium		Weedy
222	Lolium/Rumex		Weedy
223	Phalaris aquatica	223	*Phalaris aquatica*
225	Cultivated Annual Graminoid		Weedy
226	Perennial Grass	226	Perennial Grass
227	Annual Grasses/Weeds		Weedy
228	Agrostis avenacea	228	*Agrostis avenacea*
230	Short Upland Graminoids		Weedy
231	Annual Grasses generic		Weedy
232	Bromus spp/Hordeum		Weedy
234	Hordeum/Lolium		Weedy
235	Vulpia/Euthamia		Weedy
238	Polypogon monspeliensis (generic)		Weedy
300	Wetland Herbs	300	Wetland Herbs
301	Tall Wetland Herbs	301	Tall Wetland Herbs
310	Medium Wetland Herbs	310	Medium Wetland Herbs
311	*Atriplex triangularis*		Weedy
312	*Atriplex/Distichlis*		Weedy
315	*Atriplex/S. maritimus*		Weedy
316	*Atriplex/Sesuvium*		Weedy
317	*Frankenia/Agrostis*	320	*Frankenia* (generic)
318	*Frankenia/Distichlis*	320	*Frankenia* (generic)
320	*Frankenia* (generic)	320	*Frankenia* (generic)
321	*Grindelia stricta* var. *stricta*	321	*Grindelia stricta* var. *stricta*
323	*Lepidium/Distichlis*	324	*Lepidium* (generic)
324	*Lepidium* (generic)	324	*Lepidium* (generic)
329	*Polygonum-Xanthium-Echinochloa*		Weedy
330	*Calystegia/Euthamia*	330	*Calystegia/Euthamia*
336	*Rumex* (generic)		Weedy
337	*Atriplex*/Annual Grasses		Weedy
338	*Potentilla anserina* (generic)	338	*Potentilla anserina* (generic)
339	*Atriplex triangularis* (generic)		Weedy
340	Short Wetland Herbs	340	Short Wetland Herbs
342	*Cotula coronopifolia*		Weedy

344	*Lotus corniculatus*	344	*Lotus corniculatus*
346	*Salicornia virginica*	361	*Salicornia* (generic)
347	*Salicornia*/Annual Grasses	361	*Salicornia* (generic)
348	*Salicornia*/Atriplex	361	*Salicornia* (generic)
350	*Salicornia*/Crypsis	361	*Salicornia* (generic)
356	*Salicornia*/Sesuvium	361	*Salicornia* (generic)
357	*Sesuvium verrucosum*		Weedy
358	*Sesuvium/Distichlis*		Weedy
359	*Sesuvium/Lolium*		Weedy
360	*Spergularia/Cotula*		Weedy
361	*Salicornia* (generic)	361	*Salicornia* (generic)
364	*Salicornia/Polygonum-Xanthium-Echinochloa*	361	*Salicornia* (generic)
365	*Salicornia/Cotula*	361	*Salicornia* (generic)
371	*Potamogeton pectinatus*	371	*Potamogeton pectinatus*
401	Upland Herbs		Weedy
402	*Conium maculatum*	402	*Conium maculatum*
403	*Foeniculum vulgare*	403	*Foeniculum vulgare*
405	*Raphanus sativus* (generic)		Weedy
406	*Brassica nigra* (generic)		Weedy
410	Medium Upland Herbs	410	Medium Upland Herbs
413	*Centaurea* (generic)	413	*Centaurea* (generic)
421	*Carpobrotus edulis*	421	*Carpobrotus edulis*
502	*Salix exigua*	502	*Salix exigua*
514	*Atriplex lentiformis* (generic)	514	*Atriplex lentiformis* (generic)
601	Medium Upland Shrubs	601	Medium Upland Shrubs
603	*Baccharis*/Annual Grasses	603	*Baccharis*/Annual Grasses
604	*Rosa californica*	604	*Rosa californica*
605	*Rosa/Baccharis*	605	*Rosa/Baccharis*
606	*Rubus discolor*	606	Rubus discolor
700	Willow Trees	700	Willow Trees
702	*Salix laevigata/S. lasiolepis*	702	*Salix laevigata/S. lasiolepis*
705	*Salix lasiolepis/Quercus agrifolia*	705	*Salix lasiolepis/Quercus agrifolia*
800	*Eucalyptus*	800	*Eucalyptus* sp
801	*Eucalyptus globulus*	800	*Eucalyptus* sp
900	Oaks	900	Oaks
901	*Quercus agrifolia*	901	*Quercus agrifolia*
903	*Quercus lobata*	903	*Quercus lobata*
910	Landscape Trees	910	Landscape Trees
911	*Ailanthus altissima*	911	*Ailanthus altissima*
912	*Fraxinus latifolia*	912	*Fraxinus latifolia*

Appendix 4: The net change (in acres) of the vegetation types that the *Salicornia viginica* (SAVI) vegetation types changed into [loss of SAVI indicated with the negative sign (-)] and changed from (acreage gain of SAVI) in 2003 to 2006 and 1999 to 2006

Veg Code	Vegetation Name	SAVI Net Change 2003 to 2006	SAVI Net Change 1999 to 2006
1	Bare Ground	28.43	-14.15
2	Fallow Disced Field	43.73	-24.74
3	Parking Lot	0	-0.19
4	Road	0	5.58
6	Slough	0	0.92
9	Ditch	-4.27	-3.33
11	Open Water	-1029.42	-1259.48
101	Tall Wetland Graminoids	5	-9.95
103	Phragmites australis	-21.31	-40.64
104	Phragmites/Scirpus	-5.65	-15.88
114	Scirpus americanus (generic)	5.49	5.99
116	Scirpus californicus/S. acutus	0	-1.11
120	Typha angustifolia/Polygonum-Xanthium-Echinochloa	6.51	7.05
121	Typha angustifolia/S. americanus	2.66	5.19
123	Typha species (generic)	63.48	32.86
125	Typha angustifolia (dead stalks)	-5.55	-16.47
126	Typha angustifolia/Distichlis	-7.65	-9.9
129	Typha angustifolia/Phragmites	0.98	-11.3
130	Medium Wetland Graminoids	70.56	-199.06
132	Juncus balticus	0	3.45
133	Juncus balticus/Conium	0	-3.8
137	Scirpus maritimus	89.56	-48.79
139	Scirpus maritimus/Sesuvium	2.2	2.56
140	Short Wetland Graminoids	0	-3.69
141	Distichlis spicata	103.71	284.64
142	Distichlis/Annual Grasses	-23.65	73.68
145	Distichlis/Juncus	15.51	20.02
147	Distichlis/Lotus	0	6.71
149	Distichlis/S. americanus	-8.6	1.66
153	Distichlis/Cotula	6.73	13.82
154	Distichlis/S. maritimus	5.34	-1.79
155	Crypsis schoenoides	0	-4.34
156	Distichlis (generic)	22.43	9.39
157	Scirpus (californicus or acutus)-Typha sp.	-5.64	6.36
160	Distichlis-Juncus-Triglochin-Glaux	-0.82	8.46
161	Cynodon dactylon	0	-0.54
210	Medium Upland Graminoids	0	3.21
211	Elytrigia pontica	0	-0.93
218	Lolium (generic)	1.39	1.39
220	Lolium/Lepidium	0	2.84
223	Phalaris aquatica	0	3.61
226	Perennial Grass	0	-0.92
227	Annual Grasses/Weeds	22.23	5.92

230	Short Upland Graminoids	0	1.16
231	Annual Grasses generic	-52.65	-15.06
238	Polypogon monspeliensis (generic)	4.41	5.6
310	Medium Wetland Herbs	25.06	-111.23
311	Atriplex triangularis	59.21	66.21
312	Atriplex/Distichlis	6.34	21.64
315	Atriplex/S. maritimus	0	0.63
316	Atriplex/Sesuvium	-2.53	-2.53
318	Frankenia/Distichlis	5.27	5.27
320	Frankenia (generic)	1.91	5.21
323	Lepidium/Distichlis	4.66	0
324	Lepidium (generic)	31.42	13.8
329	Polygonum-Xanthium-Echinochloa	12.72	22.82
337	Atriplex/Annual Grasses	1.52	4.88
339	Atriplex triangularis(generic)	0	-1.16
340	Short Wetland Herbs	20.14	-171.38
342	Cotula coronopifolia	16.15	36.15
344	Lotus corniculatus	2.86	4.92
357	Sesuvium verrucosum	9.82	22.63
358	Sesuvium/Distichlis	0	0.71
371	Potamogeton pectinatus	0	8.66
401	Upland Herbs	1.49	-1.95
402	Conium maculatum	2.08	-1.23
403	Foeniculum vulgare	-2.82	0
410	Medium Upland Herbs	0	-1
603	Baccharis/Annual Grasses	0	4.22
801	Eucalyptus globulus	-2.1	-4.21

Appendix 5: The net change (in acres) of the vegetation types that the Phragmites australis (PHAU) vegetation types changed into [loss of PHAU indicated with the negative sign (-)] and changed from (acreage gain of PHAU) in 2003 to 2006 and 1999 to 2006.

Veg Code	Vegetation Name	PHAU Net Change 2003 to 2006	PHAU Net Change 1999 to 2006
1	Bare Ground	2.65	-5.45
3	Parking Lot	0	0.88
6	Slough	0	2.96
9	Ditch	-12.07	0
11	Open Water	-20.64	3.73
101	Tall Wetland Graminoids	6.65	-4.64
113	Scirpus americanus/S. Californicus-S. acutus	0	0.97
114	Scirpus americanus (generic)	8.34	14.01
116	Scirpus californicus/S. acutus	11.32	25.93
120	Typha angustifolia/Polygonum-Xanthium-Echinochloa	3.03	19.17
121	Typha angustifolia/S. americanus	3.60	17.04
123	Typha species (generic)	90.99	95.19
125	Typha angustifolia (dead stalks)	0.52	0.52
126	Typha angustifolia/Distichlis	1.05	1.26
130	Medium Wetland Graminoids	33.82	-17.85
132	Juncus balticus	7.06	6.66
134	Juncus balticus/Lepidium	3.09	0
135	Juncus balticus/Potentilla	0	1.74
137	Scirpus maritimus	46.58	38.60
138	Scirpus maritimus/Salicornia	1.35	1.00
141	Distichlis spicata	39.83	64.16
142	Distichlis/Annual Grasses	-0.58	7.83
145	Distichlis/Juncus	1.14	1.14
147	Distichlis/Lotus	0.88	5.59
148	Distichlis/Salicornia	6.59	14.99
149	Distichlis/S. americanus	-1.77	-0.17
153	Distichlis/Cotula	0	1.98
154	Distichlis/S. maritimus	12.76	7.61
156	Distichlis (generic)	3.89	4.35
157	Scirpus (californicus or acutus)-Typha sp.	18.31	51.31
158	Scirpus (californicus or acutus)/Wetland Herbs	1.54	-6.38
162	Scirpus (californicus or acutus)/Rosa	0	2.91
227	Annual Grasses/Weeds	3.88	6.15
228	Agrostis avenacea	0	1.75
231	Annual Grasses generic	-3.26	0
238	Polypogon monspeliensis (generic)	0	0.73
310	Medium Wetland Herbs	15.80	-24.34
311	Atriplex triangularis	2.50	3.35
312	Atriplex/Distichlis	0	4.10
315	Atriplex/S. maritimus	0	3.43
323	Lepidium/Distichlis	0	1.37
324	Lepidium (generic)	3.46	0.32

329	Polygonum-Xanthium-Echinochloa	51.32	75.81
330	Calystegia/Euthamia	0	-3.93
337	Atriplex/Annual Grasses	0	1.17
339	Atriplex triangularis(generic)	2.11	2.09
340	Short Wetland Herbs	2.35	-9.07
342	Cotula coronopifolia	0.74	4.19
344	Lotus corniculatus	0.76	0.76
346	Salicornia virginica	7.89	19.68
347	Salicornia/Annual Grasses	-12.06	-8.82
348	Salicornia/Atriplex	-0.62	2.40
357	Sesuvium verrucosum	0	2.25
361	Salicornia (generic)	3.40	18.14
364	Salicornia/Polygonum-Xanthium-Echinochloa	2.38	0
365	Salicornia/Cotula	0	3.39
401	Upland Herbs	6.75	6.75
403	Foeniculum vulgare	7.66	6.81
405	Raphanus sativus (generic)	3.79	3.79
604	Rosa californica	0	0.52
606	Rubus discolor	0	1.13