San Francisco Estuary
Invasive *Spartina* Project
2010
Monitoring Report

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Cover Photos: Photo point monitoring photos from Subarea 13e: Whale's Tail South Fluke show the decline of invasive *Spartina alterniflora x foliosa* hybrid and the return of native marsh vegetation (dominated by perennial pickleweed, as seen in lower photo) in response to invasive *Spartina* control efforts coordinated by the ISP. Hybrid *Spartina* can be seen encroaching into the channel in 2006. Regrowth remains in 2008, and by 2010 no hybrid *Spartina* is visible at this photo point location.

Cover designed by Stephanie Ericson.

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CONTENTS

TABLES

FIGURES

INTRODUCTION

The San Francisco Estuary Invasive *Spartina* Project was established by the California Coastal Conservancy, in partnership with the U.S. Fish and Wildlife Service, in 2000 in response to the invasion of hybridized non-native *Spartina* into the marshes and mudflats of the San Francisco Estuary (referred to as Estuary or Bay throughout this report).

In the last several decades, four non-native cordgrasses, including *Spartina alterniflora* (Atlantic cordgrass), *S. densiflora* (Chilean cordgrass), *S. anglica* (English cordgrass), and *S. patens* (saltmeadow cordgrass), were introduced to the Estuary. Each of these species is known to be an aggressive invader outside of its native range, and each has demonstrated varying degrees of invasiveness since establishing in the Estuary. The Army Corps of Engineers introduced *S. alterniflora* in Pond 3A near the Alameda Flood Control Channel in the early 1970s with the intention of restoring marsh vegetation. The introduced cordgrass established successfully at this site and was subsequently transplanted into other restoration sites around the Bay. *Spartina densiflora* and *S. anglica* were introduced at Creekside Park in Corte Madera, where they were intentionally planted in a park design. The history of the introduction of *Spartina patens* to the Estuary is unknown. To date it has been found at only one site – Benicia State Recreation Area's Southampton Marsh.

Both *S. alterniflora* and *S. densiflora* hybridized with native *S. foliosa* (Daehler and Strong 1996, Ayres et al. 2003, Ayres et al. 2008a). Offspring of *S. alterniflora x foliosa* hybrids backcrossed with the parent species and with one another, producing an extremely robust and fertile "hybrid swarm," which has invaded habitat throughout the Estuary, threatening the ecological integrity of the Estuary's existing and potential future restored tidal wetlands and mudflats (Daehler and Strong 1996, Goals Project 1999, Ayres et al. 2003, State Coastal Conservancy 2003, Ayres et al. 2004b, Ayres et al. 2008a).

The purpose of the ISP is to implement a coordinated, region-wide program to control and eventually eradicate *S. alterniflora* and their hybrids as well as other non-native *Spartina* species from the Estuary.

As part of its regional program, the ISP conducts annual monitoring to track and map the extent and rate of spread of nonnative *Spartina*, to inform the ISP's Control Program, and to monitor the efficacy of treatment efforts. This report presents the results of region wide inventory monitoring conducted by the ISP in 2010.

Since its inception, the ISP has collaborated with researchers at the UC Davis *Spartina* Lab (the lab of Professor Donald Strong). The *Spartina* Lab conducts research regarding the hybridization of introduced *Spartina* species with the native *S. foliosa* and developed genetic markers for such work, including RAPD and microsatellite markers. Until 2008, the State Coastal Conservancy contracted with the UC Davis *Spartina* Lab to analyze *Spartina* samples for species identification using Random Amplified Polymorphic DNA (RAPD) markers. RAPD markers were subsequently dropped from the analysis due to the inability to identify a commercial lab to perform RAPD testing, concerns regarding the reproducibility of results between different laboratories, and concerns regarding the ability to accurately identify late-generation hybrids using the limited number of RAPD primers available. Beginning in 2009, the ISP contracted with commercial labs to perform genetic testing using microsatellite markers, also referred to as simple sequence repeat (SSR) markers.

Treatment efforts began with small-scale manual removal in 2002 and 2003. In 2004, the herbicide glyphosate was applied at most treated sites, and testing of aerial applications of the herbicide imazapyr began at a few trial locations. The ISP Control Program has coordinated annual region-wide *Spartina* control efforts using the highly effective herbicide imazapyr in aerial and ground-based applications from 2005 to present, with full-scale treatment beginning in 2006. Treatment methods are generally described in the ISP's Programmatic EIS/R (State Coastal Conservancy 2003). Specific treatment approaches are described in site-specific control plan prepared for each site (ISP 2004, 2005, Grijalva et al. 2008, 2011). *Spartina* treatment operations are reported annually by the ISP Control Program (Grijalva 2004, Grijalva and Kerr 2006, Grijalva et al. 2008, Grijalva and Kerr 2011). This report also presents the results of the photo point monitoring data collected by the ISP since 2006 to assess the efficacy of control efforts.

1. INVENTORY MONITORING

1.1 INENTORY BACKGROUND

1.1.1 Inventory Monitoring

The ISP began Estuary-wide inventory monitoring in 2000, with annual monitoring of all sites beginning in 2004. The original geographic scope of monitoring efforts was limited to the bayward side of most major highways due to staff constraints (see Hogle et al. 2008). Since 2006 all potential invasive *Spartina* habitat identified within the San Francisco Estuary, Bolinas, Point Reyes and Tomales Bay has been surveyed by the ISP or its partners. This includes annual surveys of over 50,000 acres of tidal marsh and mudflat throughout the Estuary and Outer Coast areas.

Inventory monitoring is conducted for two purposes: to track change in the extent and net cover of the infestation over time for purposes of analysis and reporting, and to locate and map patches of invasive *Spartina* to inform management and coordination of field operations by the ISP Control Program.

Monitoring methods have included field-based and helicopter-based monitoring using global positioning system (GPS) as well as digitizing of aerial imagery in a Geographic Information System (GIS). Aerial imagery interpretation became inappropriate in 2007, when treatment success was great enough that the relatively small patches of regrowth were no longer detectable even with the use of high resolution imagery (see Hogle and Olofson Environmental Incorporated 2011).

1.1.2 Treatment Surveys

The ISP employed four treatment monitoring interns in 2010, following up on the successful pilot project initiated in 2009 to conduct monitoring of treatment activities. These surveys, termed “treatment surveys”, served to help guide treatment at the patch level, and allowed the documentation of treatment at the patch level. Treatment information is helpful monitoring efforts in subsequent years; since regrowth of treated *Spartina* is often stunted and can be difficult to identify or distinguish from native *Spartina*, knowledge of patch-level treatment activities provides additional evidence which is helpful for the identification of *Spartina* within a patch.

1.2 INVENTORY METHODS

ISP field biologists have conducted inventory monitoring between May and December annually since 2004, with the majority of monitoring completed between mid-June and mid-October. Mapping-grade GPS units (Trimble GeoXT 2008 models) were used to collect point, line and polygon data containing *Spartina* species and percent cover data using ArcPad software in 2010. Field sites were accessed using the least destructive, most efficient, thorough, and cost-effective methods possible for each site, and included walking, boating, kayaking and helicopter. Binoculars were used to help identify plants at a distance. GPS features were offset when necessary using a laser rangefinder and compass to determine distance and direction from observer. Details of inventory monitoring methods are described in the ISP Quality Assurance Document (QAD) (Hogle et al. 2008).

1.2.1 Species Identification

Species mapped included *S. alterniflora x foliosa* hybrids ("hybrids"), *S. densiflora*, *S. densiflora* x *foliosa*, *S. anglica*, and *S. patens*. Although some pure *S. alterniflora* plants may still exist in the Estuary, the project assumed that this is unlikely due to the documented pollen swamping and superior invasiveness of the *S. alterniflora x foliosa* hybrids compared to the *S. alterniflora* parents (Anttila et al. 1998, Ayres et al. 2004a, Ayres et al. 2004b). Project biologists did not attempt to distinguish between pure *S. alterniflora* and *S. alterniflora x foliosa* hybrids, but lumped these together for the purposes of monitoring and treatment, referring to them as *S. alterniflora x foliosa*, *S. alterniflora*/hybrids or simply "hybrids".

Reporting *Spartina* Area

Two methods are used to measure and report area of non-native *Spartina*, "**net area**" and "**treatment area**".

"Net area" refers to the actual amount of the *Spartina*, and is calculated to represent the coverage as if all non-native *Spartina* plants were contiguous (i.e., compacted onto one discrete area). Net area is not very useful for planning and management purposes, as it does not give an accurate picture of the marsh area that will need to be treated or monitored.

For this purpose, "treatment area" is used. Treatment area is the area requiring treatment. Gross area is the area of all GIS features recorded, and is calculated using GIS and a point/line-buffering strategy. Cover class categories are used to define the net and treatment area of *Spartina* within gross areas.

The measurement of "treatment area" was developed by the ISP in 2008, and has proved extremely useful for planning and management purposes.

Species were identified based on a number of considerations including morphology, location, phenology, and/or past years' lab results. Field staff used drop-down menus in their GPS data forms to record their species identification (based on any of the above factors) as well as their level of confidence associated with that identification for each feature. Confidence level choices included: lower, moderate or high confidence. Ambiguous plants were either identified to species and given a lower field-identification confidence, or identified as "unknown *alterniflora*/hybrid or *foliosa*", "unknown *densiflora*/hybrid" or "unknown *anglica*/*alterniflora* hybrid".

Samples were collected for genetic testing, to compare field-identification with lab-identification. Where logistically possible, samples were collected for genetic testing of ambiguous individuals. Samples of plants identified by field staff with moderate to high confidence were also sampled for genetic testing throughout each season. In 2010, these samples from patches of high confidence field identification were collected to be used as controls for the genetic testing or were collected with the intention of testing the comparability of lab results to field identifications.

1.2.2 Treatment Area

Monitoring efforts included the recording of a "treatment cover" value for each GPS feature recorded (see *Reporting *Spartina* Area* box), as initiated by the ISP in 2008. Capturing this value allowed calculation of an estimate of the area requiring treatment, thereby allowing the ISP Control Program to more accurately plan for treatment activities. Cover classes were used for estimation of the percent of each patch requiring treatment, so the resulting sum in "treatment area" for a site has a minimum, mean, and maximum value based on the minimum, mean, and maximum of the cover class category.

1.2.3 Treatment Surveys

Beginning in 2009, ISP monitoring staff began conducting treatment surveys at a small subset of sites (approximately 12 sites). In 2010, this effort was expanded to 157 subareas. Four interns were hired, and two clapper rail biologists were trained as *Spartina* biologists, for a total of six additional field staff employed to conduct 2010 *Spartina* monitoring. Even with these additional staff, staffing constraints prevented full treatment surveys at many of those sites where ISP monitoring staff and/or interns were present during and/or immediately following treatment.

During treatment surveys, monitoring staff kept up with, guided, or lagged behind treatment crews. When lagging behind, staff were able to record what was or was not treated based on observance of the blue dye (Blazon Blue) added to the herbicide used at sites treated with herbicide. This method was necessary when there were fewer monitoring staff than treatment crews, or when treatment crews were moving more quickly than data could be recorded. At sites treated with manual control methods, treatment was generally slower and monitoring staff could more easily keep up with treatment crews.

Monitoring data was "checked out" onto GPS units using ArcPad software, and customized forms were used to record treatment survey information, primarily whether and how a patch was treated. Treatment methods recorded included sprayed (with imazapyr herbicide), dug, tarped, or other.

1.2.4 Mapping Methods

Field-based monitoring was conducted by using GPS units with customized ArcPad software to map point, line, polygon and grid features and associated attributes to document the location, extent and density of individual patches of invasive *Spartina*. All four feature types may be used during surveys, so that the resulting GIS data includes point, line, polygon and grid features which must all be viewed together for a complete representation of field-mapped *Spartina*. The minimum size for a feature is a 5 cm-radius point; there is no maximum size for a feature. Grid sizes were based on ease of access and level of precision required by the Control Program, and included 10x10 meter grids (for mapping *Spartina densiflora* at Creekside Park) and 25x25 meter grids at smaller sites. Field staff used GPS to navigate to the center of each grid cell, and then recorded *Spartina* cover information for the grid cell. When used throughout this report, the term "feature" may refer to a GPS-collected point, line or polygon feature, a digitized polygon, or a polygon "grid" feature, as described above.

Modes of access included foot, boat, and helicopter, as described in the 2008-9 Monitoring Report (Hogle and Olofson Environmental Incorporated 2011).

1.2.5 Inventory Boundary

During the winter of 2009-2010, the Monitoring Program underwent a comprehensive effort to update and identify new potential habitat boundaries using high resolution aerial imagery in a GIS. The resultant new, potential habitat boundaries were then field-checked during the 2010 field season and given attributes to indicate whether or not they contained potential invasive *Spartina* habitat. Inventory boundaries were updated throughout the season to track which areas were surveyed and which remained to be surveyed. A baywide map of 2010 Inventory Boundaries is shown in **Figure 1**.

1.2.6 GPS Field Data

Using ArcPad, we were able to view all relevant spatial data for a site using our GPS unit in the field. During a survey, staff were able to view and navigate to the exact locations where invasive *Spartina* had been mapped in the past and query the information associated with these locations while in the field. ArcPad also allowed us to check out other data from our GIS to bring into the field as well, such as inventory boundary layers which guide the extent of our survey area at each site. ArcPad data entry forms were further customized for the 2010 season, improving the efficiency of data collection.

1.2.7 Data Processing and Editing

Inventory data was checked in from ArcPad to an ArcGIS geodatabase, then checked and edited for location and attribute accuracy in a GI*S*. All GPS features were checked for positional and attribute accuracy in ArcMap by the same individuals who collected the data.

Genetic results from microsatellite tests were linked to the point layer indicating where genetic samples were collected then overlaid onto the inventory data once results were analyzed, in May 2010. Final species determinations for features associated with specific DNA samples were based on a review of lab identification results and a cross-check of field photos and attributes recorded by the biologist who collected the data.

1.2.8 Map Presentation

The ISP has recently developed methods to display not only the locations of invasive *Spartina*, but also the "footprint" of invasive *Spartina* using a GI*S*. In maps designed to clearly show the locations of all invasive *Spartina* mapped within a site, features are not displayed to scale. In these location maps, the perimeter of line, polygon and grid features are displayed to scale but without regard for density of invasive *Spartina* within these features. Point features are non-dimensional in location maps, and are displayed without regard for patch size or density. In past years, location maps were the only style of maps created by the ISP for display of *Spartina* inventory monitoring data.

New for this report, the ISP developed scale-dependent GIS layers to allow display of the spatial extent and density of invasive *Spartina* <u>to scale</u> based on the relative cover of invasive *Spartina* within each patch. Data are displayed using scale-dependent dot density layers based on net invasive *Spartina* area calculations for each feature in a GI*S*. This presentation displays the on-the-ground "footprint" of invasive *Spartina*, and allows comparison of invasion levels between different sites and different spatial scales.

1.3 INVENTORY ANALYSIS METHODS

Summary statistics of *Spartina* inventory monitoring data were calculated by converting all data to polygon data. This was done by buffering lines by width and points by diameter values recorded in the field at time of data collection.

For regional analysis, models were created using ArcGIS Model Builder to clip these summary polygons by regional boundaries, calculate minimum, mean and maximum net and treatment area per clipped feature, then sum net area and treatment area (see Box in Section 1.1 above) by species within each region. Minimum, average (mean) and maximum area values were calculated based on the cover class ranges used to record net and treatment cover during inventory monitoring (<1%, 1-5%, 5-9%, 10-19%, 20-29%...90-99%, 100%).

Designation of mapped locations as new populations was determined in ArcGIS by selecting those patches of invasive *Spartina* mapped in 2010 that were greater than 500 m – 1 km from any invasive *Spartina* of the same species mapped in past years.

Results are reported in acres and/or square meters. This combination of standard and metric units is an artifact of the units of measurement used by the ISP Control Program and past monitoring reports (acres) and the units of measurement used during patch-level monitoring efforts (square meters). Summary data are presented in standard units for large areas and square meters for small areas so as to maintain consistency in presentation from past years and for the ease of those who collect and use this data on a regular basis.

1.4 RESULTS

1.4.1 Baywide Inventory Results

A total of approximately 50,000 acres of potential *Spartina* habitat were surveyed in 2010 (**Figure 1**), and approximately 85 net acres of invasive *Spartina* were mapped. **Table 1** provides the area of invasive *Spartina* mapped at each treatment site.

The invasive *Spartina* continues to be distributed throughout the project area. **Figures 2-26** show a detail of each of the 25 treatment sites (as delineated by the ISP Control Program), and the non-native *Spartina* mapped there. The first map of each site (figure a) is not to scale, but rather is designed to clearly show the locations of all invasive *Spartina* mapped within a site. The maps that follow for each site (figure b, c, and/or d) display the spatial extent and density of invasive *Spartina* to scale based on the relative cover of invasive *Spartina* within each patch, displayed using scale-dependent dot density layers based on net invasive *Spartina* area calculations for each feature in a GIS. (See section 1.2.8 Map Presentation, above, for more information on data displays and map development.)

1.4.2 Steady Baywide Decline

The approximate 85 net acres of invasive *Spartina* remaining in 2010 represents a baywide decline of 46% since 2009, and a 90% reduction since full-scale treatment began in 2005 (**Table 2**, **Figures 27**, **28**). This represents a 4% increase in the rate of annual decline seen in the previous season (a decline of 42% between 2008 and 2009) and documents the continued progress of treatment towards the goal of invasive *Spartina* eradication in the Bay area.

We estimate a 33% decline in area requiring treatment between 2009 and 2010 (**Table 3**). Estimated acres requiring treatment have declined from 431 in 2008, to 323 acres in 2009, to 218 in 2010. These estimates of acres requiring treatment are based on the mean value of the treatment cover class ranges recorded in the field by staff for individual *Spartina* features during inventory monitoring, and include all species of invasive *Spartina*. These numbers differ from net area, as explained in the box *Reporting *Spartina* Area* above.

For analysis and reporting purposes, the ISP follows the bay region divisions defined by the Baylands Ecosystem Habitat Goals Report (Goals Project 1999), with the South Bay further subdivided into Northern South Bay and Southern South Bay at the Highway 84 Dumbarton Bridge. As shown in **Tables 2** and **3**, annual trends have mirrored those of the baywide decline within the Suisun Bay, Central Bay and the Northern South Bay regions. Declines have not been as rapid in the Southern South Bay compared to baywide trends.

In those areas where populations of invasive *Spartina* are small, annual summary data is especially sensitive to discoveries of even small new populations. New discoveries of invasive

Spartina populations led to increases in net area in the Outer Coast since both 2005 and 2009. In the North Bay, new populations have been discovered, leading to an increase in net area since 2005. Control of these new populations led to a decline between 2009 and 2010, but this rate of decline is not as rapid as seen in other regions because more new populations were discovered in 2010.

1.4.3 Trends Vary By Subarea

The ISP Control Program divides its 25 treatment sites into 174 subareas for logistical and reporting purposes. **Table 4** provides a summary of net area of invasive *Spartina* within each site and subarea by species, a summary of total net area and total treatment area of all combined invasive *Spartina* species, and grand totals of these values at the bottom of the table.

Change in net area of invasive *Spartina* within sites and subareas between 2009 and 2010, and between the height of the baywide infestation (2005) and 2009 is presented in **Table 5**. Change varies greatly by subarea. While overall baywide net acres were reduced by 46% between 2009 and 2010, reductions reached up to 99% in many subareas. However, net area of invasive *Spartina* did not decline but even increased in other subareas. Extensive descriptions of treatment activities at each subarea can be found in the Annual ISP Treatment Reports written and compiled by the ISP Control Program, and can serve to explain some of this variability in trends by subarea.

1.4.4 Species Updates

Spartina alterniflora x foliosa

The most abundant and widespread invasive *Spartina* in the Bay area, *S. alterniflora x foliosa* ("hybrids") covered 216 of the total 217 acres requiring treatment throughout the Bay, and made up 84 out of the total 85 net acres of invasive *Spartina* (**Tables 6** and **7**). Net area of hybrids declined by approximately 46% between 2009 and 2010 in response to coordinated treatment efforts, down from 804 acres at the height of the infestation in 2005 (**Figures 29**, **30**). This corresponded to a 33% decline in area requiring treatment from 2009 to 2010 (**Table 3**).

Net areas of 2010 hybrid populations within ISP subareas are shown by location and size in **Figure 31**.

Morphologies, phenologies, growth characteristics and other phenotypic characteristics can vary widely between individual *Spartina alterniflora x foliosa* hybrids (Callaway and Josselyn 1992, Anttila et al. 1998, Daehler et al. 1999, Ayres et al. 2004a, Ayres et al. 2008b). Some plants are easy to identify, while others can be extremely difficult to distinguish from *S. foliosa*. Due to this difficulty, level of confidence in field identification is recorded during monitoring.

As in past years, the vast majority of hybrid acres mapped contained plants identified in the field with high confidence in 2010 (94%), about 4% of the plants were identified as hybrids with moderate confidence, around 1% were identified with low confidence, and a few plants (< 0.1% in terms of acreage) were mapped in the field as possible hybrids, to be determined based on genetic testing and/or monitoring over time.

New populations of hybrids and possible hybrids were detected in several locations around the Bay in 2010 (**Figure 32**). New populations are defined as patches further than one kilometer away from patches mapped in any previous year, and/or located in areas never before surveyed by the ISP. Populations identified as possible hybrids will be monitored for expansion and subjected to genetic testing in 2011.

Spartina densiflora

Spartina densiflora remains the second most abundant and widespread species of invasive *Spartina* in the Bay area, but populations are declining rapidly in response to control efforts. In 2010, only 0.84 acres required treatment of *S. densiflora* populations, down from 2.8 acres in 2009. Net acres were down to 0.35 acres in 2010 (**Figures 33, 34**).

Locations of 2010 *S. densiflora* populations are shown in **Figure 35**. Several new populations of *S. densiflora* were found in 2010 as shown in **Figure 36**, including the first population of *S. densiflora* to be discovered in the South Bay. This new population was discovered in a channel adjacent to Maple Street, near Redwood Creek, that had previously gone undetected. This isolated patch of fewer than 20 *S. densiflora* plants was found in a muted tidal stream bank under a bank of riparian and upland trees and growing among a mix of brackish and upland plants.

Spartina densiflora x foliosa

Spartina densiflora x foliosa hybrids were field-identified at a number of sites in 2010 (**Figure 37**), but no genetic testing was performed to test these field identifications. With the transition to microsatellite genetic testing, the ISP has focused genetic testing exclusively on detection of hybridity between *S. foliosa* and *S. alterniflora*. Thus the two new *S. densiflora x foliosa* populations identified in **Figure 36** are based on field-identification only and have not been subjected to genetic testing. Regardless of exact genetic identity, patches identified as having morphological characteristics indicative of hybridity with *S. densiflora* are slated for treatment.

S. alterniflora x densiflora x foliosa

No plants were identified *S. alterniflora x densiflora x foliosa* in 2010. As with *S. densiflora x foliosa*, discussed above, no genetic testing was performed in 2010 to assist in the identification of *S. alterniflora x densiflora x foliosa*.

Spartina patens

Spartina patens remained restricted to Southampton Marsh at Benicia State Recreation Area (**Figure 37**), where monitoring shows net area to be down from past years to <100 square meters remaining.

Spartina anglica

Spartina anglica remains restricted to Corte Madera's Creekside Park (**Figure 37**), where monitoring shows net area to be down 71%, from 310 square meters in 2009 to 89 square meters in 2010.

1.5 DISCUSSION

1.5.1 Expanded Treatment Surveys

The expansion of treatment surveys from 12 to 157 subareas in 2010 demonstrates the value placed on these surveys by the ISP. The increased thoroughness and accuracy of treatment at the patch level facilitated by treatment surveys led to the detection and treatment of many small patches of invasive *Spartina* that might have otherwise gone undetected. Because untreated patches can quickly expand and set seed, this expanded effort in ensuring thorough treatment and its documentation is expected to lead to a shorter timeframe within which *Spartina* eradication can be completed. This presumption assumes that follow-up treatment can continue with this same or greater level of effort, and can be performed during the summer months for maximum herbicide efficacy, in all subsequent years.

1.5.2 Continued Reduction

Survey results showing continued, dramatic declines in baywide net acreage of invasive *Spartina* since the height of the infestation. At the peak of the infestation, in 2005, the ISP mapped an estimated 809 net acres (327 hectares) of invasive *Spartina* throughout the Bay and outer coast areas. By 2010, only 85 net acres (34 net hectares) remained (**Figure 27**).

These results confirm our subjective observations that invasive *Spartina* populations declined significantly since the ISP began using the highly effective herbicide imazapyr at most sites. Photo monitoring (described in section 3 of this report) has also documented this visible decline (for example, see **Figures 38 through 43)**.

1.5.3 Caveats to Monitoring Data

Estimates of acres requiring treatment as calculated by the Monitoring Program data do not necessarily represent the acreage actually treated or deemed to require treatment by the ISP Control Program or partners performing treatment. (For information on acres actually treated, see the ISP Control Program Reports.) Discrepancies between years and between observers can result from the following scenarios.

(1) Inventory mapping may take place significantly earlier in the year than treatment. Identification of hybrid plants can be more difficult earlier in the season (prior to flowering), and if monitoring is conducted too early, some hybrid plants may not yet be tall enough to be visible. Thus, monitoring staff may under-map an area. In such a circumstance, if treatment crews go to the site later in the season, they will likely notice and treat more invasive *Spartina* than was previously mapped. If a full treatment survey takes place during treatment, these additional patches can be documented. If not, the site may remain "under-mapped" in a given year.

(2) The difficulty of identifying invasive *Spartina* with less obvious hybrid morphologies can lead to differences in those patches identified as invasive *Spartina* and treated by partners and their contractors versus those patches mapped as invasive *Spartina* by the ISP Monitoring Program. Even in situations where there are no concerns of hybrid identification, differences in the ability to accurately detect, identify and treat or map plants can differ among individuals. It is thus not surprising if differences arise in this situation, where differentiation between native and hybrid plants adds additional challenge to consistency in patch evaluation between individuals. When treatment surveys are conducted by more experienced ISP biologists, their presence can assist with the identification of these difficult plants. When inventory monitoring has been conducted prior to a treatment survey, the inventory data can assist the ISP biologist/intern in guiding treatment crews to previously-mapped patches requiring treatment.

(3) Inventory mapping may be conducted by field staff unfamiliar with the morphology of *Spartina foliosa* at a particular site, resulting in the misidentification of *Spartina* species at that site. This can lead to either the over- or under-mapping of invasive *Spartina* at a site. Although steps are taken to avoid this situation, including the checkout of past years' data onto GPS units for each site and extensive training and pairing of new staff with experienced staff, this situation can happen, especially at difficult sites (such as those in the Southern South Bay where *S. foliosa* is often extremely robust). When mapping is conducted prior to treatment, review of mapped data to inform treatment planning can alert the ISP Control Program to possible problems with the collected data, so that these issues can be addressed and resolved prior to treatment.

1.6 CONCLUSIONS

1.6.1 Monitoring Surveys

Improvements to the efficiency of data collection and processing has made monitoring survey information more accessible to the Control Program. The increased difficulty in detection of hybrid plants has made monitoring more time-consuming and difficult than in past years. The Monitoring Program will continue to use and improve customizations to the software used on GPS units to bring all past years' information into the field so as to inform inventory monitoring navigation and decision-making.

ISP biologists will continue to search diligently for previously undetected potential habitat, both in the field and using aerial imagery in the office.

1.6.2 Treatment Surveys

Treatment surveys proved valuable to both the Monitoring and Control Programs by improving the accuracy and thoroughness of treatment and thus improving the long-term efficiency of control efforts. Survey data also helped to reduce discrepancies between mapped versus treated acres by better integrating monitoring and treatment efforts.

The ISP will consider expanding its Control Monitor Internship program by one person (from 4 to 5 interns) to help conduct more thorough treatment surveys in 2011. The cost of the required increase in monitoring staff should ultimately be offset in the long term by the increased thoroughness of treatment activities facilitated by this integrated approach to monitoring and treatment. More thorough annual treatment effort at a site should lead to a reduction in the time to eradication of invasive *Spartina* at that site.

The Monitoring Program will continue to develop more efficient methods of data collection to allow for faster data collection during treatment surveys. This should help improve the speed at which treatment surveys can be conducted and help reduce the time required to edit data after a survey.

2. GENETIC TESTING

2.1 BACKGROUND

2.1.1 RAPD Testing

From 2000 to 2008, the ISP contracted with the lab of Dr. Don Strong at the University of California, Davis (also referred to as the UC Davis *Spartina* Lab) to conduct RAPD-based genetic testing to determine hybridity of collected *Spartina* samples. The RAPD markers used by the ISP for identification of *S. foliosa*, *S. alterniflora S. densiflora*, *S. anglica* and their hybrids were developed within Dr. Strong's lab (Daehler and Strong 1997, Ayres et al. 1999, Ayres and Strong 2001, Ayres et al. 2008a). The ISP relied on these RAPD tests to confirm taxonomic field identification and to test for hybridity of those plants that are difficult to identify based on field characteristics.

2.1.2 Microsatellite Testing

In 2009 the ISP transitioned to the use of microsatellite markers, also referred to as simple sequence repeat (SSR) markers, for genetic testing to help determine the species composition of individual *Spartina* samples. SSR markers were chosen by collaborator and UC Davis PhD candidate Laura Feinstein from the suite of available SSR markers previously developed by UC Davis researchers (Blum et al. 2004, Sloop et al. 2006). Markers were selected based on their power to distinguish native from hybrid plants, based on SSR screens of *S. foliosa* and *S. alterniflora x foliosa* hybrids performed by Drs. Sloop and Blum during initial marker development. Markers were additionally validated by Dr. Sloop and Feinstein using the results of subsequent genetic analyses of San Francisco Bay hybrid *Spartina* (Sloop et al. 2009, 2011) and review of unpublished genetic screenings by Dr. Bando (2007) of additional *S. foliosa* sampled from Baja, Mexico, and from Northern California populations.

In 2009, ten microsatellite markers were tested and eight were used in the final results analysis (Hogle and Olofson Environmental Incorporated 2011). Samples were sent to a commercial lab in Colorado (STA Labs) for DNA extraction and testing of ten microsatellite markers. The ISP analyzed the microsatellite data with the assistance of plant geneticist Dr. Emma Jack, with whom the ISP contracted to consult on methodologies and data analysis. Dr. Jack worked with the ISP to perform the analysis of microsatellite results from STA Labs and to interpret these results. Eight of the ten marker results were used in the data analysis in 2009.

The results from 2009 indicated that the experimental set up conducted by STA laboratories could be optimized to obtain better data. In addition the lack of control samples used for the 2009 season made interpretation of results difficult. Three areas of the experimental set up were identified for further optimization: 1) to standardize the plant tissues collection protocol to improve DNA quality; 2) to analyze the specificity and sensitivity of the primers selected to minimize errors in the primers; and 3) to run samples of high confidence *Spartina foliosa* and high confidence hybrid taken from marshes in the San Francisco Estuary as controls to better cluster plants into the ancestral populations. These three optimization procedures are discussed below.

In 2010 Dr. Jack developed a new protocol for plant collection and storage in order to reduce degradation of plant samples and to increase the purity of extracted DNA. This involved stipulating initial washing and drying of samples followed by either refrigeration at a controlled 20°

C or freezing of the sample at a controlled -20 ° C. In addition, field biologists stopped using permanent marker pens to label the tissue samples, to prevent any potential chemical reaction with the marker pen ink and the chemicals involved in DNA extraction that may degrade the DNA.

The full suite of microsatellite (SSR) primers developed by Blum et al., 2004 and Sloop et al., 2006 were analyzed for suitability in the 2010 experiments. The analysis consisted of examining the specificity of the primers and their sensitivity. Specificity of a primer set is related to whether the primers are binging only the sequences that we want to detect (i.e. SPAR 08), or if they also bind to additional (random) sequences in the genome. If the primer binds to a lot of sequences, or even unrelated sequences, they were deemed insufficient to identify hybrid plants from *foliosa* plants, and were eliminated from the 2010 microsatellite analysis. The sensitivity of the SSR primers is related to whether or not the primers detect the sequences that are assumed to be specific to the *S. alterniflora* genome. This analysis was conducted as outlined in Stover and Cavalcanti (2009) by Dr. Jack.

Of the thirty-six (36) potential *Spartina* SSR markers, fifteen performed well in the analysis and were used in 2010.

Twenty-four (24) samples of of field-identified *S. foliosa* were collected from areas believed to be free of invasive *Spartina*, 26 samples of field-identified *S. alterniflora x foliosa* hybrids and 6 samples of *S. alterniflora* from Boston, Massachusetts were submitted as controls. All of these samples were run in 2010 and the size of the alleles produced, were used to compare to allele sizes of unknown samples as species controls. In addition, Dr Jack selected two samples to be run in every experiment as internal controls, one *S. foliosa* (sample 0831S03) and one *S. alterniflora x foliosa* hybrid (sample 0902A03).

2.1.3 SCAR Marker Development

The ISP contracted with Dr. Jack to convert eleven (11) of the RAPD markers historically used by UC Davis to sequence characterized amplified region (SCAR) markers (**Appendix 1**). This work was pursued in order to determine if use of SCAR markers could increase the efficiency and predictability of the RAPD assay. If these markers prove useful, they could possibly be an alternative or additional method for genetic analysis.

2.2 METHODS

2.2.1 Collection Methods

A total of 563 samples were collected and tested with microsatellite primers in 2010. These included 120 samples collected for a special study at Cooley Landing (Hogle 2011), twenty samples collected as controls of pure *S. foliosa* or pure *S. alterniflora*, and twenty samples for which GPS data and related attribute data was not collected or is missing (such as for some of the species-specific control samples, including the *S. alterniflora* from Boston). The remainder (403 samples) were collected to confirm or assist in the identification of tested *Spartina* as *S. foliosa* or hybrid to inform monitoring results and control efforts; these samples were collected throughout the project area (**Figures 44** through **48**).

Leaf samples were collected in the field and stored following the protocol developed by Dr. Jack (2010) and specified in the contract with UCLA Human Genomics Lab. Samples were kept in controlled 20 or -20°C conditions until being sent overnight on ice to the UCLA Human Genomics Laboratory. Upon arrival, all samples were unpacked, their condition assessed and frozen at -20 ° until DNA extraction occurred. All 15 markers chosen for this analysis produced reliable and repeatable results all of were used in the final results analysis presented in this report.

2.2.2 Lab Methods

The UCLA Human Genomics Lab followed the Promega DNA extraction methods following the manufacturer's instructions. The DNA was then tested for its concentration and purity using (260/280) spectrophotometric readings that determines the amount of protein contaminating the samples

Prior to running the 15 SSR markers, UCLA researchers tested the reaction efficiency and size of the marker produced to compare to the expected size described by Blum et al. (2004) and Sloop et al. (2006) to check the results from the database analysis. All primers produced markers in the expected size range. The primers used in the 2010 analysis are presented in **Table 8**.

The UCLA lab identified and re-ran specific primers on individual samples as needed to correct problems such as missing data, and requested that the last nonzero alleles reported be used as the final value in the ISP's results analysis. Due to the polyploid nature of *S. foliosa* and *S. alterniflora*, the UCLA lab identified and reported results for up to six markers (i.e. six alleles) per primer for each sample. Results were reported in the tab-delimited text file format output from Genemapper (ABI Biosystems).

2.2.3 Results Analysis Methods

Parameters and Ploidy

The microsatellite loci were amplified using PCR and fluorescently labeled primers. The dye labeled products are identified by fluorescence detection. The size and genotype of alleles was conducted by UCLA using GeneMapper® Software Version 4.0 as per the manufacturer's instructions (Applied Biosystems, 2010).

Genotyped alleles were then analyzed using the free software package *structure* which uses a clustering method to investigate population structure in genetic data. This software can be used to assign individuals to populations and to study hybrid zones (Pritchard et al. 2000). This software is used by the UC Davis for microsatellite analysis, and was used by the ISP for analysis of 2009 microsatellite data.

We performed *structure* analysis using the same parameters used in our 2009 analysis. As in 2009, we used an admixture model with no population prior and including all samples collected in the current year. We set K=2 set to model two clusters, corresponding to *S. foliosa* or *S. alterniflora*. We were able to determine the species corresponding to cluster 1 and cluster 2 based on the values of the control samples (*S. foliosa* sample and *S. alterniflora*) which *structure* consistently assigned to cluster 1 or cluster 2. We also analyzed correspondence between high confidence field ID samples (controls) with their assigned clusters to confirm cluster assignment.

New in 2010, we input data in three different formats to compare the model's interpretations of different diploid versus polyploid results. Although *S. alterniflora* and *S. foliosa* are hexaploid species, the selected microsatellites are assumed to behave as diploid markers (Blum et al. 2004). In 2010, we asked the UCLA lab to analyze and report their results with an acknowledgment of the hexaploid nature of these species; thus we received data for up to six alleles per marker for each sample. We compared two different methods of allele selection for analysis of the data as diploid, and we ran an analysis of the polyploid data using all six alleles. Results of these three data input methods were compared to assess sensitivity of the model to these different inputs.

For the diploid interpretation, for all samples where three or more alleles were reported for a primer, two of these alleles were selected for analysis. In one analysis, the two markers corresponding to the lowest base pair sizes were selected. This conformed to the data as they were reported (in ascending order of size). In an alternative analysis, the two markers corresponding to the highest peaks were selected for input into structure.

For the polyploid interpretation, all markers reported, up to six alleles per primer, were input into structure.

Validity of Methods

Three methods were used to assess the validity of the 2010 genetics testing methods. (1) Genetics consultant Dr. Emma Jack interpreted the statistics output by structure. (2) Duplicate samples were analyzed for consistency in structure output. Duplicate sample analysis was performed by replacing final nonzero results with nonzero results from earlier runs for all primers rerun within the 245 samples for which any reruns were performed.

Correspondence to Field ID

Results from those samples collected as *S. foliosa* controls were reviewed to determine a maximum threshold value for inferred *S. alterniflora* ancestry expected to be found in putatively pure *S. foliosa*.

The relationship of field identification to *structure* results was analyzed by tabulating the number of samples for which microsatellite data provided evidence to support or contradict field identification. Separate tabulations were conducted for the 243 samples collected baywide and the 120 samples collected for the Cooley Landing study.

The Cooley Landing study was conducted specifically to assess the correspondence of phenotypic characteristics to microsatellite results, and thus is not directly comparable to the baywide collection effort conducted in 2010 or in past years. In the Cooley study, a stratified random sampling design was employed in which 60 samples were selected from each species, as identified in the field by ISP biologists based on phenotypic characteristics, and within this 20 samples each were collected from plants identified with low, moderate, or high field ID confidence. To allow an unbiased measure of phenotypic characteristics to microsatellite data, plant field identification at this site was intentionally *not* based on proximity to plants with obvious hybrid characteristics. Thus, the comparison of field identification to microsatellite evidence at this site is informative but cannot be accurately compared with other baywide and past years' efforts where proximity to hybrid clones can weigh heavily on field identifications.

2.3 RESULTS

A diversity of alleles was found during multiple runs of the two internal control samples for the majority of primers used. These data are presented in **Table 9**.

The diversity of alleles found in all samples, their frequency within the polyploid dataset, and their correspondence to *S. foliosa* or *S. alterniflora*, as calculated by *structure*, are presented in **Table 10**. Based on the review of structure results from those samples collected as *S. foliosa* controls and other samples field-identified as *S. foliosa* with high confidence, a threshold of

>15% inferred *S. alterniflora* ancestry based on polyploid analysis was determined to be appropriate for identification of hybrids.

Of the 423 samples collected outside of the Cooley Landing study, 79% of the field identifications were supported by microsatellite evidence. (**Table 11**, **Figures 44 and 45**). Of the 23 samples that were too difficult to identify in the field (where field ID was recorded as unknown), microsatellite data inferred a lack of hybridity for 21 of these samples (**Figure 46**). Only 8% of samples were identified as hybrids in the field but were found to have no evidence of hybridity based on microsatellite data (**Figure 47**). Likewise, only 8% of samples were identified as natives in the field but were found to have evidence of hybridity based on microsatellite data (**Figure 48**).

Within the Cooley Landing study, microsatellite evidence supported the field identification of 71% of the 120 samples collected (**Table 12**; Hogle 2011).

2.4 DISCUSSION

The high degree of contradiction between field identification of *S. foliosa* and inferred genetic evidence of hybridity in 2009 led to concerns regarding the validity of the 2009 RAPD and microsatellite testing results. Modifications to techniques were employed in 2010 to address these concerns, including the collection of greater numbers of control samples and the increase from 8 to 15 primers analyzed. As shown in **Table 13**, genetic testing provided supporting evidence (that is, a lack of evidence of hybridity) for 88% of those samples field-identified as *S. foliosa* in 2010. This is up from 58% in 2009, and is more in line with the percentages expected by project staff, based on past years' results using different genetic tests.

Genetic evidence supported the field identification of a full 79% of those 423 samples collected baywide, supporting the view within the project that the genetic methods used in 2010 appear to be reliable based on comparison with field identifications.

The greater agreement between genetic evidence and field identification between the data sets of 2009 and 2010 is likely also, in part, an artifact of the greater number of samples collected as "controls" to assist in the *structure* cluster analysis and the fewer number of samples collected for genetic testing overall in 2010.

Analysis of genetic results to inform final species designations within sites while using GIS for final data review confirmed the improved perceived reliability of 2010 genetic results by ISP biologists.

2.5 CONCLUSION

In situations where field identification is unclear, reliable genetic results can be an important tool to aide in the decision-making process of the Invasive *Spartina* Project and its partners. Genetic results informed the final species determinations of hundreds of *Spartina* features recorded in 2010, which in turn informs the treatment of these patches of *Spartina*.

The expanded the number of microsatellite markers analyzed and the collection of many more putatively pure *S. foliosa* samples and many more putative *S. alterniflora x foliosa* hybrids with phenotypes indicative of hybridity, appears to have greatly assisted with the analysis of microsatellite results in 2010 and thus with the reliability of these results.

The continued use of the genetic techniques employed in 2010 will be an asset to the project by providing such assistance in situations where field identification is especially challenging. Use of the 15 selected microsatellite markers appears to be helpful in both in confirming field-based species identifications and in assisting with the identification of those plants which are difficult to identify in the field. The collection and testing of putatively pure *S. foliosa* and *S. alterniflora x foliosa* hybrids should be continued at the rate performed in 2010, so as to inform the 2011 *structure* analysis.

The ISP endeavors to identify and apply the most appropriate methods of genetic analysis to meet our monitoring objectives. The ISP will continue to investigate SCAR markers as a potential, cost-effective alternative or additional method for genetic analysis. In addition, the ISP will stay appraised of research by the UC Davis *Spartina* lab and others which may lead to the development of other suitable methods of genetic analysis in the future.

3. PHOTO POINT MONITORING

3.1 BACKGROUND

Photos were taken at 146 permanent photo point locations within 21 control program areas starting in 2006 to assess and document efficacy twice per season. Sites for photo point monitoring were selected to encompass a range of marsh types and treatment methods, and were located within 70 control program subareas. Photos were taken early enough in the spring to allow the Control Program to assess the upcoming effort required at each site, and were taken again late enough in the summer to assess initial impact of current-year control efforts.

3.2 METHODS

Photo point monitoring took place beginning in late May following the protocol described in the QAD. Photos were taken at all photo point locations, with exact points relocated using GPS and compass directions, and with print-outs of past year's photos used to ensure the correct angle and horizon level in the camera view-frame. Two images were photographed at each location. Final images were selected and cropped as necessary in the office to allow for the best match of horizon and view extent so as to allow for ease in comparability between years.

Photo point images were shared with ISP Control Program Field Operations Managers within several days of data acquisition and used to inform field operations planning on an as-needed basis.

3.3 RESULTS

Photo point monitoring was used by the ISP Control Program to quickly assess and plan for the upcoming treatment season. Photo monitoring was completed at 57 sites, with a total of 136 photos taken at each of two rounds. Digital photos are saved to the ISP server, where they are organized by photo point to allow ease of viewing change over time using photo-viewing software. Photo points are also available for public viewing on the web, through Google Maps and Picassa Web Albums, at http://g.co/maps/xj67d. Examples of photos from 2006-2010, and maps illustrating 2010 *Spartina* inventory data overlaid with photo point locations are presented for five locations in this report (**Figure 38**). These locations were selected to show a diversity of sites and a diversity of treatment efficacy as evidenced by the photos. These include Subarea 2h: Greco Island South (**Figure 39**), Subarea 6b: Emeryville Crescent West (**Figure 40**), Subarea 7b: Oro Loma Marsh - west (**Figure 41**), Subarea 13e: Whale's Tail South Fluke (**Figure 42**), and Subarea 18e: Sam Trans Peninsula (**Figure 43**). Note: Corresponding net area, treatment area and treatment efficacy for these subareas can be looked up in **Tables 4 and 5**.

3.4 DISCUSSION

The information on site-specific efficacy collected through photo point monitoring was used by the ISP Control Program to plan for field operations. This photo monitoring effort is also strengthening the documentation of observed efficacy of *Spartina* treatment efforts throughout the Bay, and is documenting the resulting restoration of marsh vegetation or open mudflat at many sites.

3.5 CONCLUSION

Photo point monitoring has proven to be an efficient and effective method of monitoring and capturing information regarding the results of treatment, including passive restoration of tidal marsh and mudflat. Photo point monitoring will be continued into the future by the ISP Monitoring Program.

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TABLES

Table 1. Estimated Net Acres of Invasive *Spartina* in 2010 by Site

Site Number and Name	Estimated Total Net Acres (All Invasive *Spartina*)	Estimated Total Acres Requiring Treatment (All Invasive *Spartina*)
1: Alameda Flood Control Channel	0.95	4.38
2: Bair/Greco Islands	30.56	92.55
3: Blackie's Pasture	<¼ acre (79 m^2)	<¼ acre (397 m^2)
4: Corte Madera Creek Complex	0.80	1.93
5: Coyote Creek/ Mowry Complex	8.65	18.53
6: Emeryville Crescent	<¼ acre (807 m^2)	0.79
7: Oro Loma Marsh	0.81	2.73
8: Palo Alto Baylands	1.37	2.66
9: Pickleweed Park	<¼ acre (168 m^2)	<¼ acre (250 m^2)
10: Point Pinole Marshes	<¼ acre (725 m^2)	0.33
11: Southampton Marsh	<¼ acre (452 m^2)	<¼ acre (684 m^2)
12: Southeast San Francisco	<¼ acre (222 m^2)	<¼ acre (745 m^2)
13: Whale's Tail Complex	0.71	1.53
15: South Bay Marshes	2.10	3.99
16: Cooley Landing Salt Pond Restoration	3.15	7.97
17: Alameda/San Leandro Bay Complex	18.28	34.35
18: Colma Creek San Bruno Marsh Complex	1.59	4.15
19: West San Francisco Bay	4.29	11.03
20: San Leandro/Hayward Shoreline	3.74	12.23
21: Ideal Marsh	1.91	5.68
22: Two Points Complex	4.55	10.26
23: Marin Outliers	0.37	1.17
24: Petaluma River	<¼ acre (135 m^2)	<¼ acre (188 m^2)
25: Outer Coast	<¼ acre (139 m^2)	<¼ acre (195 m^2)
26: North San Pablo Bay	0.28	0.58
GRAND TOTAL	85 acres	219 acres

Table 2. Change in Net Area of Invasive *Spartina* within ISP Bay Regions: 2005, 2009, 2010.

ISP Region	2005	2009	2010	05-10 decline	09-10 decline
Outer Coast	0.34 m^2	38 m^2	139 m^2	increase (139 m^2)	increase (101 m2)
North Bay	0.8 ac	6 ac	5 ac	increase (4 ac)	23%
Suisun Bay	0.6 ac	0.1 ac	0.1 ac	82%	21%
Central Bay	170 ac	49 ac	24 ac	86%	51%
Northern South Bay	624 ac	90 ac	44 ac	93%	51%
Southern South Bay	13 ac	14 ac	12 ac	13%	14%
Grand Total	809 ac	159 ac	85 ac	90%	46%

Table 3. Change in Area Requiring Treatment within ISP Bay Regions: 2008 - 2010.

ISP Region	2008	2009	2010	08-10 decline	09-10 decline
Outer Coast	64 m^2	110 m^2	196 m^2	increase (132 m^2)	increase (86 m^2)
North Bay	491 m^2	822 m^2	779 m^2	increase (3 ac)	8%
Suisun Bay	250 ac	198 ac	133 ac	increase (289 m^2)	5%
Central Bay	127 ac	79 ac	49 ac	61%	38%
Northern South Bay	250 ac	198 ac	133 ac	47%	33%
Southern South Bay	46 ac	33 ac	25 ac	47%	26%
Grand Total	431 ac	323 ac	218 ac	49%	33%

Table 4. Estimated 2010 Net Acres by Species and Total Net Acres and Acres Requiring Treatment by Subarea.

Subarea	*Spartina* Coverage by Species (acres)					All Invasive Spartina Cover (acres)	
	anglica	*patens*	*densiflora x foliosa*	*alterniflora x foliosa*	*densiflora*	Net area	Treatment area
1a: Channel Mouth				<¼ acre (219 m²)		<¼ acre (219 m²)	<¼ acre (472 m²)
1b: Lower Channel				0.67		0.67	3.1
1c: Upper Channel				<¼ acre (539 m²)		<¼ acre (539 m²)	0.91
1d: Upper Channel - Union City Blvd to I-880				<¼ acre (26 m²)		<¼ acre (26 m²)	<¼ acre (163 m²)
1e: Strip Marsh No. of Channel Mouth				<¼ acre (310 m²)		<¼ acre (310 m²)	<¼ acre (619 m²)
1f: Pond 3-AFCC				<¼ acre (18 m²)		<¼ acre (18 m²)	<¼ acre (199 m²)
1: Alameda Flood Control Channel Total				0.95		0.95	4.38
2a: Belmont Slough/Island, North Point, Bird Island, Steinberger Sl/Redwood Shores				2.06		2.06	7.42
2b: Steinberger Sl South, Corkscrew Slough, Redwood Creek North				1.78		1.78	6.8
2c: B2 North Quadrant				17.87		17.87	41.58
2d: B2 South Quadrant - Rookery				1.81		1.81	10.52
2e: West Point Slough NW				0.25		0.25	0.75
2f: Greco Island North				2.12		2.12	8.83
2g: West Point Slough SW and East				0.6		0.6	2.4
2h: Greco Island South				1.52		1.52	5.88
2i: Ravenswood Slough & Mouth				1.15		1.15	3.77
2j: Ravenswood Open Space Preserve				<¼ acre (873 m²)		<¼ acre (873 m²)	0.81
2k: Redwood Creek and Deepwater Slough Restoration				0.85		0.85	3.28
2l: Inner Bair				0.31		0.31	0.47

Table 4. Estimated 2010 Net Acres by Species and Total Net Acres and Acres Requiring Treatment by Subarea. (continued)

	Spartina Coverage by Species (acres)					All Invasive Spartina Cover (acres)	
Subarea	***anglica***	***patens***	***densiflora x foliosa***	***alterniflora x foliosa***	***densiflora***	**Net area**	**Treatment area**
2m: Pond B3 (Middle Bair)				<¼ acre (29 m^2)		<¼ acre (29 m^2)	<¼ acre (130 m^2)
2: Bair/Greco Islands Total				30.56		30.56	92.55
3a: Blackie's Creek (above bridge)			<¼ acre (0.24 m^2)	<¼ acre (16 m^2)	<¼ acre (3 m^2)	<¼ acre (19 m^2)	<¼ acre (73 m^2)
3b: Blackie's Creek Mouth			<¼ acre (1 m^2)	<¼ acre (56 m^2)	<¼ acre (3 m^2)	<¼ acre (60 m^2)	<¼ acre (324 m^2)
3: Blackie's Pasture Total	<¼ acre (1 m^2)			<¼ acre (72 m^2)	<¼ acre (6 m^2)	<¼ acre (79 m^2)	<¼ acre (397 m^2)
4a: Corte Madera Marsh Reserve				<¼ acre (110 m^2)	<¼ acre (6 m^2)	<¼ acre (116 m^2)	<¼ acre (187 m^2)
4b: College of Marin Study Area				<¼ acre (2 m^2)	<¼ acre (19 m^2)	<¼ acre (21 m^2)	<¼ acre (7 m^2)
4c: Piper Park East			<¼ acre (2 m^2)	<¼ acre (0.08 m^2)	<¼ acre (1 m^2)	<¼ acre (4 m^2)	<¼ acre (9 m^2)
4d: Piper Park West			<¼ acre (<1 m^2)		<¼ acre (1 m^2)	<¼ acre (1 m^2)	<¼ acre (3 m^2)
4e: Larkspur Ferry Landing Area				<¼ acre (4 m^2)	<¼ acre (0.01 m^2)	<¼ acre (4 m^2)	<¼ acre (15 m^2)
4f: Riviera Circle				<¼ acre (6 m^2)	<¼ acre (155 m^2)	<¼ acre (160 m^2)	<¼ acre (270 m^2)
4g: Creekside Park	<¼ acre (89 m^2)		<¼ acre (71 m^2)	<¼ acre (4 m^2)	<¼ acre (658 m^2)	<¼ acre (822 m^2)	0.59
4h: Upper Corte Madera Creek (Above Bon Air Rd)			<¼ acre (7 m^2)	<¼ acre (84 m^2)	<¼ acre (5 m^2)	<¼ acre (95 m^2)	<¼ acre (205 m^2)
4i: Lower Corte Madera Creek (Bon Air Rd to HWY 101)			<¼ acre (12 m^2)	<¼ acre (127 m^2)	<¼ acre (40 m^2)	<¼ acre (179 m^2)	<¼ acre (364 m^2)
4j: Corte Madera Creek Mouth (Below HWY 101)			<¼ acre (1 m^2)	0.34	<¼ acre (439 m^2)	0.45	1.08
4k: Boardwalk Number One (Arkites)			<¼ acre (0.35 m^2)		<¼ acre (4 m^2)	<¼ acre (4 m^2)	<¼ acre (12 m^2)
4: Corte Madera Creek Complex Total	<¼ acre (183 m^2)			0.43	0.33	0.8	1.93
5a: Mowry Marsh-Newark Slough to Calaveras Point				4.86		4.86	9.27
5b: Dumbarton/Audubon				1.55		1.55	3.38
5c: Newark Slough				0.39		0.39	0.99

Table 4. Estimated 2010 Net Acres by Species and Total Net Acres and Acres Requiring Treatment by Subarea. (continued)

Subarea	*Spartina* Coverage by Species (acres)					All Invasive Spartina Cover (acres)	
	anglica	*patens*	*densiflora x foliosa*	*alterniflora x foliosa*	*densiflora*	Net area	Treatment area
5d: LaRiviere Marsh				1.2		1.2	3.16
5e: Mayhew's Landing				<¼ acre (349 m^2)		<¼ acre (349 m^2)	0.28
5f: Coyote Creek- Alameda County				<¼ acre (49 m^2)		<¼ acre (49 m^2)	<¼ acre (182 m^2)
5g: Cargill Pond (W Hotel)				0.53		0.53	1.31
5h: Plummer Creek Mitigation				<¼ acre (95 m^2)		<¼ acre (95 m^2)	<¼ acre (375 m^2)
5: Coyote Creek/ Mowry Complex Total				8.65		8.65	18.53
6a: Emeryville Crescent East				<¼ acre (294 m^2)		<¼ acre (294 m^2)	<¼ acre (647 m^2)
6b: Emeryville Crescent West				<¼ acre (513 m^2)		<¼ acre (513 m^2)	0.63
6: Emeryville Crescent Total				<¼ acre (807 m^2)		<¼ acre (807 m^2)	0.79
7a: Oro Loma Marsh-East				0.26		0.26	0.93
7b: Oro Loma Marsh-West				0.54		0.54	1.8
7: Oro Loma Marsh Total				0.81		0.81	2.73
8: Palo Alto Baylands				1.37		1.37	2.66
8: Palo Alto Baylands Total				1.37		1.37	2.66
9: Pickleweed Park			<¼ acre (0.08 m^2)	<¼ acre (67 m^2)	<¼ acre (5 m^2)	<¼ acre (168 m^2)	<¼ acre (250 m^2)
9: Pickleweed Park Total			<¼ acre (0.08 m^2)	<¼ acre (164 m^2)	<¼ acre (5 m^2)	<¼ acre (168 m^2)	<¼ acre (250 m^2)
10a: Whittel Marsh				<¼ acre (14 m^2)	<¼ acre (0.2 m^2)	<¼ acre (14 m^2)	<¼ acre (28 m^2)
10b: Southern Marsh				<¼ acre (339 m^2)	<¼ acre (0.01 m^2)	<¼ acre (339 m^2)	<¼ acre (497 m^2)
10c: Giant Marsh			<¼ acre (0.08 m^2)	<¼ acre (372 m^2)		<¼ acre (372 m^2)	<¼ acre (815 m^2)
10: Point Pinole Marshes Total			<¼ acre (0.08 m^2)	<¼ acre (725 m^2)	<¼ acre (0.21 m^2)	<¼ acre (725 m^2)	0.33
11: Southampton Marsh		<¼ acre (32 m^2)		<¼ acre (422 m^2)		<¼ acre (452 m^2)	<¼ acre (684 m^2)
11: Southampton Marsh Total		<¼ acre (32 m^2)		<¼ acre (422 m^2)		<¼ acre (454 m^2)	<¼ acre (684 m^2)

Table 4. Estimated 2010 Net Acres by Species and Total Net Acres and Acres Requiring Treatment by Subarea. (continued)

	Spartina Coverage by Species (acres)					All Invasive Spartina Cover (acres)	
Subarea	*anglica*	*patens*	*densiflora x foliosa*	*alterniflora x foliosa*	*densiflora*	Net area	Treatment area
12a: Pier 94				<¼ acre (14 m^2)		<¼ acre (14 m^2)	<¼ acre (37 m^2)
12b: Pier 98/Heron's Head				<¼ acre (11 m^2)		<¼ acre (11 m^2)	<¼ acre (71 m^2)
12c: India Basin				<¼ acre (0.41 m^2)		<¼ acre (0.41 m^2)	<¼ acre (1 m^2)
12d: Hunters Point Naval Reserve				<¼ acre (56 m^2)		<¼ acre (56 m^2)	<¼ acre (335 m^2)
12e: Yosemite Channel				<¼ acre (77 m^2)		<¼ acre (77 m^2)	<¼ acre (117 m^2)
12f: Candlestick Cove				<¼ acre (62 m^2)		<¼ acre (62 m^2)	<¼ acre (179 m^2)
12g: Crissy Field				<¼ acre (0.47 m^2)		<¼ acre (0.47 m^2)	<¼ acre (2 m^2)
12h: Yerba Buena Island				<¼ acre (0.08 m^2)		<¼ acre (0.08 m^2)	<¼ acre (1 m^2)
12i: Mission Creek				<¼ acre (0.41 m^2)		<¼ acre (0.41 m^2)	<¼ acre (3 m^2)
12: Southeast San Francisco Total				<¼ acre (222 m^2)		<¼ acre (222 m^2)	<¼ acre (745 m^2)
13a: Old Alameda Creek North Bank				<¼ acre (28 m^2)		<¼ acre (28 m^2)	<¼ acre (97 m^2)
13b: Old Alameda Creek Island				<¼ acre (148 m^2)		<¼ acre (148 m^2)	<¼ acre (664 m^2)
13c: Old Alameda Creek South Bank				<¼ acre (69 m^2)		<¼ acre (69 m^2)	<¼ acre (212 m^2)
13d: Whale's Tail North Fluke				<¼ acre (551 m^2)		<¼ acre (551 m^2)	0.26
13e: Whale's Tail South Fluke				0.26		0.26	0.42
13f: Cargill Mitigation Marsh				<¼ acre (367 m^2)		<¼ acre (367 m^2)	<¼ acre (877 m^2)
13g: Upstream of 20 Tide Gates				<¼ acre (20 m^2)		<¼ acre (20 m^2)	<¼ acre (92 m^2)
13h: Eden Landing-North Creek				<¼ acre (178 m^2)		<¼ acre (178 m^2)	<¼ acre (301 m^2)
13i: Eden Landing-Pond 10				<¼ acre (14 m^2)		<¼ acre (14 m^2)	<¼ acre (30 m^2)
13j: Eden Landing-Mt Eden Creek				<¼ acre (88 m^2)		<¼ acre (88 m^2)	<¼ acre (332 m^2)
13k: Eden Landing Reserve South				<¼ acre (208 m^2)		<¼ acre (208 m^2)	<¼ acre (422 m^2)
13l: Eden Landing Reserve North				<¼ acre (162 m^2)		<¼ acre (162 m^2)	<¼ acre (370 m^2)

Table 4. Estimated 2010 Net Acres by Species and Total Net Acres and Acres Requiring Treatment by Subarea. (continued)

	Spartina Coverage by Species (acres)					All Invasive Spartina Cover (acres)	
Subarea	***anglica***	***patens***	***densiflora x foliosa***	***alterniflora x foliosa***	***densiflora***	**Net area**	**Treatment area**
13: Whale's Tail Complex Total				0.71		0.71	1.53
15a: South Bay Marshes - Santa Clara County				1.48		1.48	2.52
15b: Faber/Laumeister Marsh				<¼ acre (608 m^2)		<¼ acre (608 m^2)	0.42
15c: Shoreline Regional Park at Mountain View				0.55		0.55	1.05
15: South Bay Marshes Total				2.1		2.1	3.99
16: Cooley Landing (Ravenswood Open Space Preserve)				3.14		3.14	7.97
16: Cooley Landing Restoration Total				3.14		3.14	7.97
17a: Alameda Island South (Elsie, Crown, Crab Cove)				<¼ acre (444 m^2)		<¼ acre (444 m^2)	0.39
17b: Bay Farm				<¼ acre (15 m^2)		<¼ acre (15 m^2)	<¼ acre (116 m^2)
17c: Arrowhead Marsh				11.47		11.47	18.83
17d: MLK Regional Shoreline/Garretson Point				1.68		1.68	2.61
17e: San Leandro Creek				<¼ acre (714 m^2)		<¼ acre (714 m^2)	0.54
17f: Oakland Inner Harbor				0.28		0.28	0.56
17g: Coast Guard Island				<¼ acre (34 m^2)		<¼ acre (34 m^2)	<¼ acre (181 m^2)
17h: MLK Marsh				3.39		3.39	8.76
17i: Coliseum Channels				0.35		0.35	0.84
17j: Fan Marsh				0.28		0.28	0.62
17k: Airport Channel				<¼ acre (157 m^2)		<¼ acre (157 m^2)	<¼ acre (417 m^2)
17l: Doolittle Pond				<¼ acre (171 m^2)		<¼ acre (171 m^2)	<¼ acre (700 m^2)
17m: Alameda Island East (Aeolian Club & East Shore)				0.43		0.43	0.83

Table 4. Estimated 2010 Net Acres by Species and Total Net Acres and Acres Requiring Treatment by Subarea. (continued)

Subarea	*Spartina* Coverage by Species (acres)					All Invasive Spartina Cover (acres)	
	anglica	*patens*	*densiflora x foliosa*	*alterniflora x foliosa*	*densiflora*	Net area	Treatment area
17: Alameda/San Leandro Bay Compl. Total				18.28		18.28	34.35
18a: Colma Creek				<¼ acre (60 m^2)		<¼ acre (60 m^2)	<¼ acre (225 m^2)
18b: Navigable Slough				<¼ acre (206 m^2)		<¼ acre (206 m^2)	<¼ acre (613 m^2)
18c: Old Marina				<¼ acre (33 m^2)		<¼ acre (33 m^2)	<¼ acre (72 m^2)
18d: Inner Harbor				<¼ acre (155 m^2)		<¼ acre (155 m^2)	<¼ acre (199 m^2)
18e: Sam Trans Peninsula				0.71		0.71	1.01
18f: Confluence Marsh				<¼ acre (287 m^2)		<¼ acre (287 m^2)	0.28
18g: San Bruno Marsh				0.68		0.68	2.51
18h: San Bruno Creek				<¼ acre (85 m^2)		<¼ acre (85 m^2)	<¼ acre (319 m^2)
18: Colma Cr. San Bruno Marsh Compl. Total				1.59		1.59	4.15
19a: Brisbane Lagoon				<¼ acre (474 m^2)		<¼ acre (474 m^2)	<¼ acre (743 m^2)
19b: Sierra Point				<¼ acre (68 m^2)		<¼ acre (68 m^2)	<¼ acre (201 m^2)
19c: Oyster Cove				<¼ acre (106 m^2)		<¼ acre (106 m^2)	<¼ acre (429 m^2)
19d: Oyster Point Marina				<¼ acre (6 m^2)		<¼ acre (6 m^2)	<¼ acre (42 m^2)
19e: Oyster Point Park				<¼ acre (4 m^2)		<¼ acre (4 m^2)	<¼ acre (27 m^2)
19f: Point San Bruno				<¼ acre (742 m^2)		<¼ acre (742 m^2)	0.55
19g: Seaplane Harbor				<¼ acre (42 m^2)		<¼ acre (42 m^2)	<¼ acre (94 m^2)
19h: SFO				0.4		0.4	0.97
19i: Mills Creek Mouth				0.27		0.27	0.49
19j: Easton Creek Mouth				<¼ acre (459 m^2)		<¼ acre (459 m^2)	<¼ acre (848 m^2)
19k: Sanchez Marsh			<¼ acre (138 m^2)	0.3	<¼ acre (1 m^2)	0.33	0.74
19l: Burlingame Lagoon				<¼ acre (361 m^2)		<¼ acre (361 m^2)	0.33

Table 4. Estimated 2010 Net Acres by Species and Total Net Acres and Acres Requiring Treatment by Subarea. (continued)

Subarea	*Spartina* Coverage by Species (acres)					All Invasive Spartina Cover (acres)	
	anglica	*patens*	*densiflora x foliosa*	*alterniflora x foliosa*	*densiflora*	Net area	Treatment area
19m: Fisherman's Park				<¼ acre (0 m^2)		<¼ acre (0 m^2)	<¼ acre (0.12 m^2)
19n: Coyote Point Marina/Marsh				<¼ acre (551 m^2)		<¼ acre (551 m^2)	0.43
19o: San Mateo Creek/Ryder Park				<¼ acre (216 m^2)		<¼ acre (216 m^2)	<¼ acre (489 m^2)
19p: Seal Slough Mouth				2.53		2.53	6.75
19q: Foster City				<¼ acre (6 m^2)		<¼ acre (6 m^2)	<¼ acre (62 m^2)
19r: Anza Lagoon				<¼ acre (6 m^2)		<¼ acre (6 m^2)	<¼ acre (61 m^2)
19s: Maple Street Channel					<¼ acre (35 m^2)	<¼ acre (35 m^2)	<¼ acre (73 m^2)
19: West San Francisco Bay Total		<¼ acre (138 m^2)		4.25	<¼ acre (35 m^2)	4.29	11.03
20a: Oyster Bay Regional Shoreline				<¼ acre (664 m^2)		<¼ acre (664 m^2)	0.59
20b: Oakland Metropolitan Golf Links				0.27		0.27	0.86
20c: Dog Bone Marsh				<¼ acre (105 m^2)		<¼ acre (105 m^2)	<¼ acre (362 m^2)
20d: Citation Marsh				0.48		0.48	1.3
20e: East Marsh				<¼ acre (71 m^2)		<¼ acre (71 m^2)	<¼ acre (266 m^2)
20f: North Marsh				0.57		0.57	1.43
20g: Bunker Marsh				0.35		0.35	1.34
20h: San Lorenzo Creek & Mouth				0.39		0.39	1.26
20i: Bockmann Channel				<¼ acre (7 m^2)		<¼ acre (7 m^2)	<¼ acre (18 m^2)
20j: Sulphur Creek & 20k Hayward				<¼ acre (4 m^2)		<¼ acre (4 m^2)	<¼ acre (9 m^2)
20l: Johnson's Landing				<¼ acre (15 m^2)		<¼ acre (15 m^2)	<¼ acre (44 m^2)
20m: Cogswell Marsh, Quadrant A				<¼ acre (539 m^2)		<¼ acre (539 m^2)	0.28
20n: Cogswell Marsh, Quadrant B				0.58		0.58	2.87
20o: Cogswell Marsh, Quadrant C				<¼ acre (995 m^2)		<¼ acre (995 m^2)	1.16

Table 4. Estimated 2010 Net Acres by Species and Total Net Acres and Acres Requiring Treatment by Subarea. (continued)

	***Spartina* Coverage by Species (acres)**					**All Invasive Spartina Cover (acres)**	
Subarea	***anglica***	***patens***	***densiflora x foliosa***	***alterniflora x foliosa***	***densiflora***	**Net area**	**Treatment area**
20p: Hayward Shoreline Outliers				<¼ acre (3 m^2)		<¼ acre (3 m^2)	<¼ acre (21 m^2)
20q: San Leandro Shoreline Outliers				<¼ acre (884 m^2)		<¼ acre (884 m^2)	0.69
20r: Oakland Airport Shoreline and Channels				<¼ acre (167 m^2)		<¼ acre (167 m^2)	<¼ acre (861 m^2)
20s: H.A.R.D. Marsh				<¼ acre (38 m^2)		<¼ acre (38 m^2)	<¼ acre (90 m^2)
20t: San Leandro Marina				<¼ acre (14 m^2)		<¼ acre (14 m^2)	<¼ acre (45 m^2)
20u: Estudillo Creek Channel				<¼ acre (777 m^2)		<¼ acre (777 m^2)	<¼ acre (948 m^2)
20v: Howard Landing Canal				<¼ acre (45 m^2)		<¼ acre (45 m^2)	<¼ acre (292 m^2)
20w: Triangle marsh				<¼ acre (1 m^2)		<¼ acre (1 m^2)	<¼ acre (3 m^2)
20: San Leandro/Hayward Shoreline Total				3.74		3.74	12.23
21a: Ideal Marsh North				0.89		0.89	2.49
21b: Ideal Marsh South				1.02		1.02	3.19
21: Ideal Marsh Total				1.91		1.91	5.68
22a: Wildcat Marsh				0.42		0.42	0.74
22b: San Pablo Marsh				3.88		3.88	8.90
22c: Rheem Creek Area				<¼ acre (323 m^2)		<¼ acre (323 m^2)	<¼ acre (719 m^2)
22d: Stege Marsh				<¼ acre (162 m^2)		<¼ acre (162 m^2)	<¼ acre (359 m^2)
22e: Hoffman Marsh				<¼ acre (0.01 m^2)		<¼ acre (0.01 m^2)	<¼ acre (0.02 m^2)
22f: Richmond/Albany Shoreline				<¼ acre (470 m^2)	<¼ acre (3 m^2)	<¼ acre (474 m^2)	0.35
22: Two Points Complex Total				4.55	<¼ acre (3 m^2)	4.55	10.26
23a: Brickyard Cove				<¼ acre (0.47 m^2)		<¼ acre (0.47 m^2)	<¼ acre (3 m^2)
23b: Beach Drive				<¼ acre (766 m^2)		<¼ acre (766 m^2)	0.68
23c: Loch Lomond Marina				<¼ acre (83 m^2)	<¼ acre (0.33 m^2)	<¼ acre (84 m^2)	<¼ acre (139 m^2)

Table 4. Estimated 2010 Net Acres by Species and Total Net Acres and Acres Requiring Treatment by Subarea. (continued)

Subarea	*Spartina* Coverage by Species (acres)					All Invasive Spartina Cover (acres)	
	anglica	*patens*	*densiflora x foliosa*	*alterniflora x foliosa*	*densiflora*	Net area	Treatment area
23d: San Rafael Canal Mouth North				<¼ acre (159 m^2)	<¼ acre (0.33 m^2)	<¼ acre (159 m^2)	<¼ acre (278 m^2)
23e: Muzzi & Martas Marsh				<¼ acre (124 m^2)	<¼ acre (2 m^2)	<¼ acre (126 m^2)	<¼ acre (318 m^2)
23f: Paradise Cay				<¼ acre (3 m^2)	<¼ acre (12 m^2)	<¼ acre (15 m^2)	<¼ acre (35 m^2)
23g: Greenwood Beach Road/Harbor			<¼ acre (5 m^2)		<¼ acre (1 m^2)	<¼ acre (6 m^2)	<¼ acre (13 m^2)
23h: Strawberry Point			<¼ acre (4 m^2)	<¼ acre (20 m^2)	<¼ acre (2 m^2)	<¼ acre (26 m^2)	<¼ acre (62 m^2)
23i: Strawberry Cove				<¼ acre (26 m^2)		<¼ acre (26 m^2)	<¼ acre (247 m^2)
23j: Bothin Marsh				<¼ acre (63 m^2)		<¼ acre (63 m^2)	<¼ acre (223 m^2)
23k: Sausalito				<¼ acre (8 m^2)		<¼ acre (8 m^2)	<¼ acre (28 m^2)
23l: Starkweather Park			<¼ acre (0.01 m^2)		<¼ acre (1 m^2)	<¼ acre (1 m^2)	<¼ acre (1 m^2)
23m: Novato				<¼ acre (14 m^2)		<¼ acre (14 m^2)	<¼ acre (23 m^2)
23n: Triangle Marsh				<¼ acre (203 m^2)	<¼ acre (33 m^2)	<¼ acre (236 m^2)	<¼ acre (596 m^2)
23o: China Camp				<¼ acre (13 m^2)		<¼ acre (13 m^2)	<¼ acre (37 m^2)
23: Marin Outliers Total			<¼ acre (9 m^2)	0.36	<¼ acre (51 m^2)	0.37	1.17
24a: Upper Petaluma River- Upstream of Grey's Field				<¼ acre (105 m^2)		<¼ acre (105 m^2)	<¼ acre (143 m^2)
24b: Grey's Field				<¼ acre (0.47 m^2)		<¼ acre (0.47 m^2)	<¼ acre (1 m^2)
24c: Petaluma Marsh				<¼ acre (30 m^2)		<¼ acre (30 m^2)	<¼ acre (44 m^2)
24: Petaluma River Total				<¼ acre (135 m^2)		<¼ acre (135 m^2)	<¼ acre (188 m^2)
25a: Tom's Point, Tomales					<¼ acre (3 m^2)	<¼ acre (3 m^2)	<¼ acre (7 m^2)
25b: Limantour Estero				<¼ acre (133 m^2)		<¼ acre (133 m^2)	<¼ acre (180 m^2)
25c: Drakes Estero				no data		no data	no data
25d: Bolinas Lagoon, North				<¼ acre (3 m^2)		<¼ acre (3 m^2)	<¼ acre (6 m^2)

Table 4. Estimated 2010 Net Acres by Species and Total Net Acres and Acres Requiring Treatment by Subarea. (continued)

	Spartina Coverage by Species (acres)					All Invasive Spartina Cover (acres)	
Subarea	***anglica***	***patens***	***densiflora x foliosa***	***alterniflora x foliosa***	***densiflora***	**Net area**	**Treatment area**
25e: Bolinas Lagoon, South				<¼ acre (0.07 m^2)		<¼ acre (0.07 m^2)	<¼ acre (1 m^2)
25: Outer Coast Total				<¼ acre (135 m^2)	<¼ acre (3 m^2)	<¼ acre (139 m^2)	<¼ acre (195 m^2)
26a: White Slough/Napa River				<¼ acre (9 m^2)		<¼ acre (9 m^2)	<¼ acre (18 m^2)
26b: San Pablo Bay NWR and Mare Island			<¼ acre (0.05 m^2)	<¼ acre (818 m^2)	<¼ acre (5 m^2)	<¼ acre (823 m^2)	0.36
26c: Sonoma Creek				<¼ acre (284 m^2)		<¼ acre (284 m^2)	<¼ acre (840 m^2)
26d: Sonoma Baylands				<¼ acre (21 m^2)		<¼ acre (21 m^2)	<¼ acre (28 m^2)
26: North San Pablo Bay Total			<¼ acre (0.05 m^2)	0.28	<¼ acre (5 m^2)	0.28	0.57
GRAND TOTAL	<¼ acre (89 m^2)	<¼ acre (32 m^2)	<¼ acre (243 m^2)	84 acres	0.36 acres	85 acres	218 acres

Table 5. Change in Net Acres of invasive *Spartina*: 2005-2010 and 2009-2010.

Subsite	2005-2010 Decrease	2009-2010 Decrease
1a: Channel Mouth	99%	80%
1b: Lower Channel	99%	88%
1c: Upper Channel	99%	76%
1d: Upper Channel - Union City Blvd to I-880	100%	37%
1e: Strip Marsh No. of Channel Mouth	99%	increase (204 m^2)
1f: Pond 3-AFCC	100%	96%
1: Alameda Flood Control Channel Total	99%	85%
2a: Belmont Sl, North Pt, Bird Isl, Steinberger Sl/Redwd Shore	81%	57%
2b: Steinberger Sl South, Corkscrew Sl, Redwood Cr North	77%	57%
2c: B2 North Quadrant	59%	increase (8.79 ac)
2d: B2 South Quadrant - Rookery	90%	42%
2e: West Point Slough NW	56%	increase (486 m^2)
2f: Greco Island North	74%	50%
2g: West Point Slough SW and East	88%	82%
2h: Greco Island South	90%	70%
2i: Ravenswood Slough & Mouth	91%	51%
2j: Ravenswood Open Space Preserve	78%	increase (287 m^2)
2k: Redwood Creek and Deepwater Slough Restoration	55%	71%
2l: Inner Bair	increase (872 m^2)	increase (760 m^2)
2m: Pond B3 (Middle Bair)	n/a	new in 2010
2: Bair/Greco Islands Total	76%	22%
3a: Blackie's Creek (above bridge)	98%	86%
3b: Blackie's Creek Mouth	94%	80%
3: Blackie's Pasture Total	96%	82%
4a: Corte Madera Marsh Reserve	82%	23%
4b: College of Marin Study Area	84%	increase (7 m^2)
4c: Piper Park East	92%	73%
4d: Piper Park West	97%	89%
4e: Larkspur Ferry Landing Area	99%	92%
4f: Riviera Circle	90%	70%
4g: Creekside Park	91%	78%
4h: Upper Corte Madera Creek (Above Bon Air Rd)	95%	14%
4i: Lower Corte Madera Creek (Bon Air Rd to HWY 101)	89%	70%
4j: Corte Madera Creek Mouth (Below HWY 101)	12%	28%

Table 5. Change in Net Acres of invasive *Spartina*: 2005-2010 and 2009-2010 (continued).

Subsite	2005-2010 Decrease	2009-2010 Decrease
4k: Boardwalk Number One (Arkites)	97%	92%
4: Corte Madera Creek Complex Total	82%	59%
5a: Mowry Marsh-Newark Slough to Calaveras Point	increase (0.67 ac)	increase (2.14 ac)
5b: Dumbarton/Audubon	54%	48%
5c: Newark Slough	88%	51%
5d: LaRiviere Marsh	72%	64%
5e: Mayhew's Landing	94%	48%
5f: Coyote Creek- Alameda County	increase (13 m²)	increase (44 m²)
5g: Cargill Pond (W Hotel)	increase (0.41 ac)	increase (0.46 ac)
5h: Plummer Creek Mitigation	n/a	increase (71 m²)
5: Coyote Creek/ Mowry Complex Total	48%	14%
6a: Emeryville Crescent East	90%	71%
6b: Emeryville Crescent West	79%	increase (44 m²)
6: Emeryville Crescent Total	85%	45%
7a: Oro Loma Marsh-East	95%	83%
7b: Oro Loma Marsh-West	99%	81%
7: Oro Loma Marsh Total	98%	82%
8: Palo Alto Baylands	increase (0.78 ac)	increase (522 m²)
8: Palo Alto Baylands Total	increase (0.78 ac)	increase (522 m²)
9: Pickleweed Park	increase (66 m²)	increase (65 m²)
9: Pickleweed Park Total	increase (66 m²)	increase (65 m²)
10a: Whittel Marsh	98%	increase (5 m²)
10b: Southern Marsh	increase (265 m²)	increase (250 m²)
10c: Giant Marsh	increase (75 m²)	increase (187 m²)
10: Point Pinole Marshes Total	32%	increase (442 m²)
11: Southampton Marsh	83%	21%
11: Southampton Marsh Total	83%	21%
12a: Pier 94	88%	20%
12b: Pier 98/Heron's Head	91%	92%
12c: India Basin	100%	100%
12d: Hunters Point Naval Reserve	98%	95%
12e: Yosemite Channel	99%	79%
12f: Candlestick Cove	95%	91%
12g: Crissy Field	37%	68%

Table 5. Change in Net Acres of invasive *Spartina*: 2005-2010 and 2009-2010 (continued).

Subsite	2005-2010 Decrease	2009-2010 Decrease
12h: Yerba Buena Island	97%	97%
12i: Mission Creek	n/a	97%
12: Southeast San Francisco Total	98%	92%
13a: Old Alameda Creek North Bank	100%	93%
13b: Old Alameda Creek Island	100%	83%
13c: Old Alameda Creek South Bank	100%	increase (30 m^2)
13d: Whale's Tail North Fluke	99%	64%
13e: Whale's Tail South Fluke	98%	increase (495 m^2)
13f: Cargill Mitigation Marsh	100%	increase (313 m^2)
13g: Upstream of 20 Tide Gates	99%	increase (14 m^2)
13h: Eden Landing-North Creek	n/a	increase (79 m^2)
13i: Eden Landing-Pond 10	n/a	73%
13j: Eden Landing-Mt Eden Creek	n/a	85%
13k: Eden Landing Reserve South	n/a	52%
13l: Eden Landing Reserve North	n/a	new in 2010
13: Whale's Tail Complex Total	99%	38%
15a: South Bay Marshes - Santa Clara County	increase (347 m^2)	increase (0.29 ac)
15b: Faber/Laumeister Marsh	increase (415 m^2)	53%
15c: Shoreline Regional Park at Mountain View	15%	increase (0.36 ac)
15: South Bay Marshes Total	increase (306 m^2)	increase (0.47 ac)
16: Cooley Landing (Ravenswood Open Space Preserve)	47%	64%
16: Cooley Landing Salt Pond Restoration Total	47%	64%
17a: Alameda Island South (Elsie, Crown, Crab Cove)	99%	96%
17b: Bay Farm	100%	96%
17c: Arrowhead Marsh	50%	increase (0.78 ac)
17d: MLK Regional Shoreline/Garretson Point	89%	31%
17e: San Leandro Creek	94%	increase (3 m^2)
17f: Oakland Inner Harbor	79%	34%
17g: Coast Guard Island	100%	92%
17h: MLK Marsh	29%	12%
17i: Coliseum Channels	87%	increase (728 m^2)
17j: Fan Marsh	96%	90%
17k: Airport Channel	98%	75%

Table 5. Change in Net Acres of invasive *Spartina*: 2005-2010 and 2009-2010 (continued).

Subsite	2005-2010 Decrease	2009-2010 Decrease
17l: Doolittle Pond	90%	67%
17m: Alameda Island East (Aeolian Club & East Shore)	89%	69%
17: Alameda/San Leandro Bay Complex Total	78%	27%
18a: Colma Creek	100%	97%
18b: Navigable Slough	98%	95%
18c: Old Marina	100%	99%
18d: Inner Harbor	99%	94%
18e: Sam Trans Peninsula	92%	69%
18f: Confluence Marsh	98%	93%
18g: San Bruno Marsh	96%	80%
18h: San Bruno Creek	99%	95%
18: Colma Creek San Bruno Marsh Complex Total	97%	85%
19a: Brisbane Lagoon	96%	82%
19b: Sierra Point	96%	96%
19c: Oyster Cove	98%	79%
19d: Oyster Point Marina	100%	98%
19e: Oyster Point Park	100%	99%
19f: Point San Bruno	91%	increase (527 m^2)
19g: Seaplane Harbor	99%	98%
19h: SFO	93%	67%
19i: Mills Creek Mouth	82%	9%
19j: Easton Creek Mouth	90%	93%
19k: Sanchez Marsh	51%	1%
19l: Burlingame Lagoon	92%	79%
19m: Fisherman's Park	100%	100%
19n: Coyote Point Marina/Marsh	96%	61%
19o: San Mateo Creek/Ryder Park	95%	38%
19p: Seal Slough Mouth	92%	27%
19q: Foster City	100%	96%
19r: Anza Lagoon	100%	48%
19s: Maple Street Channel	n/a	new in 2010
19: West San Francisco Bay Total	93%	56%
20a: Oyster Bay Regional Shoreline	96%	88%
20b: Oakland Metropolitan Golf Links	32%	56%

Table 5. Change in Net Acres of invasive *Spartina*: 2005-2010 and 2009-2010 (continued).

Subsite	2005-2010 Decrease	2009-2010 Decrease
20c: Dog Bone Marsh	99%	47%
20d: Citation Marsh	95%	86%
20e: East Marsh	95%	increase (35 m^2)
20f: North Marsh	92%	89%
20g: Bunker Marsh	97%	89%
20h: San Lorenzo Creek & Mouth	98%	64%
20i: Bockmann Channel	99%	83%
20j: Sulphur Creek & 20k Hayward Landing	n/a	increase (3 m^2)
20l: Johnson's Landing	100%	increase (7 m^2)
20m: Cogswell Marsh, Quadrant A	99%	91%
20n: Cogswell Marsh, Quadrant B	99%	93%
20o: Cogswell Marsh, Quadrant C	99%	86%
20p: Hayward Shoreline Outliers	100%	94%
20q: San Leandro Shoreline Outliers	70%	30%
20r: Oakland Airport Shoreline and Channels	96%	94%
20s: H.A.R.D. Marsh	81%	increase (8 m^2)
20t: San Leandro Marina	increase (2 m^2)	64%
20u: Estudillo Creek Channel	increase (135 m^2)	increase (696 m^2)
20v: Howard Landing Canal	100%	66%
20w: Triangle marsh	increase (<1 m^2)	increase (<1 m^2)
20: San Leandro/Hayward Shoreline Total	98%	86%
21a: Ideal Marsh North	95%	4%
21b: Ideal Marsh South	84%	18%
21: Ideal Marsh Total	92%	11%
22a: Wildcat Marsh	increase (0.39 ac)	increase (274 m^2)
22b: San Pablo Marsh	increase (3.39 ac)	21%
22c: Rheem Creek Area	n/a	88%
22d: Stege Marsh	increase (132 m^2)	27%
22e: Hoffman Marsh	100%	100%
22f: Richmond/Albany Shoreline	77%	48%
22: Two Points Complex Total	increase (3.48 ac)	27%
23a: Brickyard Cove	99%	95%
23b: Beach Drive	43%	24%
23c: Loch Lomond Marina	57%	67%

Table 5. Change in Net Acres of invasive *Spartina*: 2005-2010 and 2009-2010 (continued).

Subsite	2005-2010 Decrease	2009-2010 Decrease
23d: San Rafael Canal Mouth North	increase (152 m^2)	42%
23e: Muzzi & Martas Marsh	increase (47 m^2)	39%
23f: Paradise Cay	99%	73%
23g: Greenwood Beach Road/Harbor	91%	94%
23h: Strawberry Point	91%	74%
23i: Strawberry Cove	n/a	81%
23j: Bothin Marsh	n/a	25%
23k: Sausalito	97%	93%
23l: Starkweather Park	n/a	98%
23m: Novato	55%	63%
23n: Triangle Marsh	increase (198 m^2)	increase (192 m^2)
23o: China Camp	n/a	new in 2010
23: Marin Outliers Total	63%	37%
24a: Upper Petaluma River- Upstream of Grey's Field	n/a	increase (46 m^2)
24b: Grey's Field	n/a	94%
24c: Petaluma Marsh	n/a	increase (29 m^2)
24: Petaluma River Total		increase (67 m^2)
25a: Tom's Point, Tomales	increase (3 m^2)	increase (<1 m^2)
25b: Limantour Estero	n/a	increase (100 m^2)
25c: Drakes Estero	n/a	n/a
25d: Bolinas Lagoon, North	n/a	increase (2 m^2)
25e: Bolinas Lagoon, South	n/a	91%
25: Outer Coast Total	increase (138 m^2)	increase (102 m^2)
26a: White Slough/Napa River	n/a	increase (6 m^2)
26b: San Pablo Bay NWR and Mare Island	n/a	27%
26c: Sonoma Creek	n/a	increase (244 m^2)
26d: Sonoma Baylands	n/a	new in 2010
26: North San Pablo Bay Total	n/a	5%

Table 6. Estimated Net Acres Baywide in 2010.

Species	Estimated Net Acres		
	Minimum	Average	Maximum
S. alterniflora/hybrid	68	84	97
S. densiflora	0.26	0.35	0.44
S. densiflora hybrid	0.053	0.060	0.065
S. anglica	0.017	0.022	0.026
S. patens	0.006	0.008	0.010
All invasive *Spartina*	68	85	98

Table 7. Estimated Acres Requiring Treatment Baywide in 2010.

Species	Estimated Acres Requiring Treatment		
	Minimum	Average	Maximum
S. alterniflora/hybrid	192	216	234
S. densiflora	0.70	0.84	0.96
S. densiflora hybrid	0.111	0.115	0.118
S. anglica	0.067	0.071	0.075
S. patens	0.032	0.035	0.037
All invasive *Spartina*	193	217	235

Table 8. Primers for 2010 SSR Analysis (markers developed by Blum et al. 2004 and Sloop et al. 2006).

Primer	Forward sequence (5'-3')	Reverse sequence (5'-3')
Spar 02	GAAGGACGAGTCTCATTTGG	GGCTGCCCCTGTTTCACG
Spar 08	CTAAGGTCCCAAACGACGAC	GCGACGAGCGAGGATTTAC
Spar 10	CGCAAAACGAAACCTTGTTC	AGGCTGCTGGACTGACATCT
Spar 15	ATTTGCTGCTTTTGGTAGAC	GTAGAACAATGGAAGAATGC
Spar 16	CTTCCTGCTTGAATTGGTAG	ACATCGGTGGCAGTAGTAAC
Spar 17	TACTTTGGTGTTTGCTTTATC	GAGTTAGAGGAGTTATTGCTG
Spar 18	AACTTCTTGTTCTGGGATTG	TAGGGAGATAGGACTGGACTG
Spar.20	ACCGTGCCTCAGCTACTG	GGTGTTTCCTCGCATAGATC
Spar 21	TGATGCTGTTTCTACCACCTTTAC	CCTCGTCCTCCGTTTTTG
Spar 22	ACTGGTCGGTATGGATGCACTGGTCGGTATGGATGC	ATGAGGTCGGTCGTTGTAGC
Spar 24	TTACACTTGACCTTCTCATC	GAAACGACTACAGCAATAAG
Spar 26	TTCAACTGGCGTAGTGATTCC	AACATTTCCGACTGGTAGAGC
Spar 27	CATCAAAAGCAAGAGGA	GACACCAACGGAACTG
Spar 31	GATCGGACAACTCTATGGAC	CCAGAAGAAAGTACACAAAG
Spar 32	TGGGAACACTTATCAACAATGG	AGGTGGAGACAACGGAGCAG

Table 9. Allelic diversity found in multiple runs of the two internal control samples.

S. foliosa internal control

Primer	Allele	Occurrences
SPAR2	200 218 220	14 1 1
SPAR8	199	16
SPAR10	348	10
SPAR15	272 275 277 279	4 6 3 7
SPAR16	385 387	7 7
SPAR17	380	16
SPAR18	185 187 191 203	1 1 1 6
SPAR20	178	12
SPAR21	232 234	13 1
SPAR22	393 397 411	6 1 3
SPAR24	176 179 198 200	2 7 7 6
SPAR26	270	14
SPAR27	321 329 335	11 1 1
SPAR31	201 245	1 9
SPAR32	450 452	4 6

S. alterniflora x foliosa internal control

Primer	Allele	Occurrences
SPAR2	200 208 220	4 2 12
SPAR8	193 199 220	9 10 1
SPAR10	348 350 358	7 1 6
SPAR15	272 275	1 15
SPAR16	387 391	16 2
SPAR17	380 384	19 1
SPAR18	191	12
SPAR20	178 180	8 6
SPAR21	232	16
SPAR22	391 393 397 401 411 415	1 7 6 1 5 4
SPAR24	176 179 198 204	1 8 8 7
SPAR26	270 284 292	8 7 1
SPAR27	321	16
SPAR31	201 213 241	1 2 8
SPAR32	452	14

Table 10. Allelic diversity found in 2010 samples. Estimated Frequencies and Confidence Level from *structure* output. Frequency in 2010 polyploid dataset tabulated by ISP from 2010 results.

Primer	Alleles	Estimated Frequency in S. foliosa	Estimated Frequency in S. alterniflora	Confidence Level of Estimated Frequencies	Frequency in 2010 polyploid dataset
SPAR02	200	0.938	0.037	0.122	809
13 alleles	208	0.05	0.573	0.266	160
5.5% missing data	202	0.008	0	0.038	4
	212	0.002	0	0.038	1
	196	0.001	0	0.034	3
	198	0	0.008	0.049	2
	204	0	0.204	0.104	52
	206	0	0.002	0.035	1
	210	0	0.032	0.066	6
	214	0	0.037	0.065	10
	216	0	0.006	0.047	2
	218	0	0.013	0.055	3
	220	0	0.088	0.08	18
SPAR08	199	0.923	0.269	0.187	842
14 alleles	201	0.065	0.002	0.047	37
4.6% missing data	203	0.008	0	0.04	4
	197	0.004	0.021	0.078	8
	183	0	0.016	0.057	7
	185	0	0.106	0.076	43
	187	0	0.005	0.044	3
	189	0	0.04	0.059	12
	193	0	0.321	0.117	104
	205	0	0.032	0.061	5
	207	0	0.05	0.065	8
	211	0	0.108	0.074	16
	220	0	0.029	0.059	5
SPAR10	348	0.994	0.047	0.131	731
12 alleles	342	0.003	0.011	0.077	4
20.4% missing data	336	0.002	0	0.038	1
	344	0	0.04	0.069	14
	346	0	0.023	0.063	7
	350	0	0.218	0.117	38
	352	0	0.428	0.176	69
	354	0	0.034	0.074	6
	356	0	0.002	0.041	1
	358	0	0.182	0.113	25
	360	0	0.014	0.061	2

Table 10. Allelic diversity found in 2010 samples (continued).

Primer	Alleles	Estimated Frequency in S. foliosa	Estimated Frequency in S. alterniflora	Confidence Level of Estimated Frequencies	Frequency in 2010 polyploid dataset
SPAR15	272	0.341	0.002	0.056	389
8 alleles	275	0.26	0.505	0.252	310
17.9% missing data	279	0.135	0.147	0.155	110
	277	0.133	0.228	0.183	149
	281	0.094	0.066	0.122	62
	283	0.029	0.017	0.09	18
	285	0.006	0.033	0.094	10
	270	0.003	0.001	0.047	6
SPAR16	387	0.991	0.457	0.367	864
8 alleles	385	0.007	0.001	0.045	12
8.9% missing data	393	0.002	0.008	0.081	2
	379	0	0.028	0.072	17
	381	0	0.019	0.066	10
	383	0	0.155	0.127	64
	389	0	0.064	0.09	12
	391	0	0.268	0.152	47
SPAR17	380	0.987	0.475	0.436	907
7 alleles	376	0.008	0.001	0.051	6
10.8% missing data	382	0.005	0.005	0.081	6
	374	0	0.009	0.061	2
	384	0	0.13	0.115	26
	386	0	0.066	0.092	12
	388	0	0.313	0.164	51
SPAR18	203	0.86	0.035	0.123	423
10 alleles	185	0.055	0.003	0.065	91
36.4% missing data	189	0.048	0.003	0.064	76
	205	0.018	0.001	0.045	7
	199	0.015	0.001	0.048	17
	193	0.002	0.062	0.112	14
	191	0.001	0.467	0.21	87
	187	0	0.298	0.163	61
	195	0	0.121	0.111	32
	211	0	0.01	0.059	1

Table 10. Allelic diversity found in 2010 samples (continued).

Primer	Alleles	Estimated Frequency in S. foliosa	Estimated Frequency in S. alterniflora	Confidence Level of Estimated Frequencies	Frequency in 2010 polyploid dataset
SPAR20	178	0.991	0.031	0.161	874
9 alleles	182	0.006	0.005	0.086	5
4.4% missing data	176	0.003	0.002	0.066	4
	174	0	0.001	0.042	1
	180	0	0.758	0.281	161
	184	0	0.121	0.133	23
	186	0	0.033	0.084	9
	188	0	0.037	0.086	9
	190	0	0.011	0.061	2
SPAR21	232	0.983	0.681	0.361	973
11 alleles	230	0.015	0.003	0.058	23
7.1% missing data	234	0.001	0.02	0.07	3
	228	0	0.005	0.05	3
	236	0	0.14	0.106	24
	238	0	0.031	0.068	4
	240	0	0.01	0.052	2
	242	0	0.008	0.05	1
	246	0	0.01	0.049	2
	248	0	0.087	0.088	13
	252	0	0.007	0.046	1
SPAR22	411	0.698	0.125	0.121	403
15 alleles	393	0.178	0.144	0.125	481
12.3% missing data	397	0.124	0.044	0.09	97
	389	0	0.015	0.046	10
	391	0	0.014	0.046	9
	395	0	0.035	0.052	24
	399	0	0.086	0.072	48
	401	0	0.132	0.077	46
	403	0	0.003	0.035	2
	407	0	0.016	0.046	7
	409	0	0.003	0.038	2
	413	0	0.015	0.048	6
	415	0	0.131	0.071	29
	417	0	0.135	0.072	33
	419	0	0.102	0.063	25

Table 10. Allelic diversity found in 2010 samples (continued).

Primer	Alleles	Estimated Frequency in S. foliosa	Estimated Frequency in S. alterniflora	Confidence Level of Estimated Frequencies	Frequency in 2010 polyploid dataset
SPAR24	198	0.798	0.274	0.187	476
10 alleles	179	0.165	0.212	0.163	545
3.9% missing data	176	0.016	0.015	0.082	51
	194	0.01	0.043	0.094	22
	200	0.009	0.077	0.11	20
	188	0.001	0.018	0.072	7
	191	0.001	0.008	0.068	8
	173	0	0.002	0.038	1
	185	0	0.158	0.091	51
	204	0	0.193	0.096	33
SPAR26	270	0.987	0.182	0.126	912
18 alleles	268	0.004	0.001	0.041	6
4.3% missing data	274	0.004	0.001	0.039	2
	265	0.003	0.002	0.045	3
	296	0.002	0	0.033	1
	272	0	0.03	0.062	7
	276	0	0.152	0.068	28
	280	0	0.002	0.038	1
	282	0	0.021	0.042	4
	284	0	0.102	0.071	19
	286	0	0.015	0.043	3
	288	0	0.024	0.055	10
	290	0	0.07	0.059	14
	292	0	0.126	0.068	24
	294	0	0.007	0.044	1
	298	0	0.223	0.075	39
	300	0	0.027	0.052	4
	306	0	0.015	0.039	3
SPAR27	321	0.99	0.266	0.208	891
11 alleles	327	0.01	0.1	0.137	35
4.6% missing data	311	0	0.082	0.086	30
	323	0	0.028	0.069	6
	329	0	0.21	0.097	55
	331	0	0.045	0.07	10
	335	0	0.048	0.07	9
	337	0	0.155	0.089	35
	339	0	0.035	0.065	6
	347	0	0.023	0.061	5
	349	0	0.007	0.048	1

Table 10. Allelic diversity found in 2010 samples (continued).

Primer	Alleles	Estimated Frequency in S. foliosa	Estimated Frequency in S. alterniflora	Confidence Level of Estimated Frequencies	Frequency in 2010 polyploid dataset
SPAR31	241	0.372	0.229	0.16	311
14 alleles	237	0.236	0.001	0.043	196
8.5% missing data	245	0.204	0.064	0.121	143
	233	0.084	0.001	0.046	85
	247	0.04	0.005	0.061	22
	227	0.038	0.002	0.049	52
	201	0.02	0.001	0.039	49
	249	0.004	0.015	0.08	4
	213	0.001	0.106	0.107	35
	231	0.001	0	0.033	2
	199	0	0.024	0.05	16
	207	0	0.087	0.069	30
	211	0	0.455	0.102	124
	215	0	0.008	0.04	1
SPAR32	450	0.863	0.349	0.419	724
3 alleles	452	0.135	0.651	0.534	203
17.8% missing data	456	0.002	0.001	0.047	1

Table 11. 2010 Microsatellite Results from Baywide Collection Effort.

Field ID	Microsatellite evidence	Number of Samples	Percent of Total
S. alterniflora/hybrid	S. alterniflora/hybrid	99	23%
S. foliosa	S. foliosa	236	56%
S. foliosa	S. alterniflora/hybrid	33	8%
S. alterniflora/hybrid	S. foliosa	32	8%
Unknown	S. alterniflora/hybrid	2	0.5%
Unknown	S. foliosa	21	5%
	Total:	423	samples

Table 12. 2010 Microsatellite Results from Cooley Landing Study.

<table>
<tr><th>Field ID</th><th>Field ID confidence</th><th>Microsatellite evidence</th><th>Number of Samples</th><th>Percent of Total</th></tr>
<tr><td rowspan="6">S. alterniflora/hybrid</td><td rowspan="2">low</td><td>S. alterniflora/hybrid</td><td>9</td><td>8%</td></tr>
<tr><td>S. foliosa</td><td>10</td><td>8%</td></tr>
<tr><td rowspan="2">moderate</td><td>S. alterniflora/hybrid</td><td>10</td><td>8%</td></tr>
<tr><td>S. foliosa</td><td>10</td><td>8%</td></tr>
<tr><td rowspan="2">high</td><td>S. alterniflora/hybrid</td><td>19</td><td>16%</td></tr>
<tr><td>S. foliosa</td><td>2</td><td>2%</td></tr>
<tr><td rowspan="6">S. foliosa</td><td rowspan="2">low</td><td>S. alterniflora/hybrid</td><td>4</td><td>3%</td></tr>
<tr><td>S. foliosa</td><td>17</td><td>14%</td></tr>
<tr><td rowspan="2">moderate</td><td>S. alterniflora/hybrid</td><td>4</td><td>3%</td></tr>
<tr><td>S. foliosa</td><td>15</td><td>13%</td></tr>
<tr><td rowspan="2">high</td><td>S. alterniflora/hybrid</td><td>5</td><td>4%</td></tr>
<tr><td>S. foliosa</td><td>15</td><td>13%</td></tr>
<tr><td></td><td></td><td>Total:</td><td>120</td><td>samples</td></tr>
</table>

Table 13. Summary of field identifications and evidence from genetic testing, 2003-2010.

Samples of varying field ID and lab ID confidence levels (low-high) are combined in this table. Changes in types of marker (RAPD, SSR) and primers used each year are discussed in relevant annual reports.

Field ID	Year and Method	Number of Samples	Genetic Evidence			
			S. alterniflora x foliosa		S. foliosa	
S. foliosa	2003 RAPD	0	0	0%	0	0%
	2004 RAPD	127	18	14%	109	86%
	2005 RAPD	84	4	5%	80	95%
	2006 RAPD	81	18	22%	63	78%
	2007 RAPD	458	76	17%	382	83%
	2008 RAPD	491	99	20%	392	80%
	2009 RAPD	185	77	42%	108	58%
	2009 SSR	444	185	42%	259	58%
	2010 SSR	269	33	12%	236	88%
Unknown	2003 RAPD	227	89	39%	138	61%
	2004 RAPD	104	74	71%	30	29%
	2005 RAPD	36	6	17%	30	83%
	2006 RAPD	57	21	37%	36	63%
	2007 RAPD	133	45	34%	88	66%
	2008 RAPD	31	10	32%	21	68%
	2009 RAPD	18	14	78%	4	22%
	2009 SSR	34	20	59%	14	41%
	2010 SSR	23	2	9%	21	91%
S. alterniflora x foliosa	2003 RAPD	44	44	100%	0	0%
	2004 RAPD	112	109	97%	3	3%
	2005 RAPD	117	67	57%	50	43%
	2006 RAPD	202	161	80%	41	20%
	2007 RAPD	289	136	47%	153	53%
	2008 RAPD	423	231	55%	192	45%
	2009 RAPD	105	75	71%	30	29%
	2009 SSR	301	214	71%	87	29%
	2010 SSR	131	99	76%	32	24%