SAN FRANCISCO ESTUARY INVASIVE SPARTINA PROJECT

Revegetation Program

2013-2014 Installation Report
and
2014-2015 Revegetation Plan
San Francisco Estuary Invasive Spartina Project

Revegetation Program

2013-2014 Installation Report
and
2014-2015 Revegetation Plan

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Cover Photographs: Invasive Spartina Project

Clockwise from top center: Top: Spartina foliosa plots along the Alameda Creek channel edge soon after installation in 2012. Plugs of 3-5 stems were planted in groups and surrounded by rope caging to protect against grazing geese. Spartina foliosa, once abundant within this channel, had been completely displaced over a 10-year period by invasive Hybrid Spartina; Bottom Right: the same Spartina foliosa plots 2 ½ years later (2014) are beginning to provide a substantial band of habitat along the channel and are a source of Spartina foliosa seed throughout the region; Bottom Left: Newly planted Grindelia stricta seedlings, marked by orange flags, are barely visible along this small channel in Alameda Creek in 2012. The area shown had been dominated by hybrid Spartina just a few years previous, and the pickleweed (Sarcocornia pacifica) shown here rebounded rapidly once the tall hybrid Spartina was eradicated; Top Left: 2 ½ years after planting (2014), the Grindelia stricta plants are well established and beginning to add critical habitat structure and refuge for wildlife.
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1 INTRODUCTION

The Coastal Conservancy initiated the ISP Revegetation Program in 2011 to implement components of the San Francisco Estuary Invasive Spartina Project California Clapper Rail Habitat Enhancement, Restoration, and Monitoring Plan (Olofson Environmental, January 2012). This five-year plan was prepared to comply with specific requirements of the U.S. Fish and Wildlife Service (USFWS 2011, Zaremba et al. August 2011; Hull, Raabe, Solvesky, pers. comm. September 15, 2011; Raabe memo November 28, 2011), with the broad objective of rapidly establishing habitat features to benefit California Ridgway’s rail (formerly California clapper rail1). The plan focused improvements at strategic locations near where recent removal of non-native cordgrass (hybrid Spartina alterniflora × foliosa or S. densiflora) had caused decreases in local California Ridgway’s rail populations, and included reintroduction of S. foliosa into regions where it had been extirpated or radically reduced by the spread and eradication of hybrid S. alterniflora × foliosa.

The Revegetation Program completed a first season of planting in the winter of 2011-2012 (“Year 1”), with additional plantings completed in the winters of 2012-2013 and 2013-2014 (“Year 2” and “Year 3”, respectively). The program is now preparing for the fourth planting season in the winter of 2014-2015, which will be “Year 4”. Program objectives, the plans for years 1, 2, and 3, and the reports of planting completed in years 1 and 2, have been reported previously (Olofson Environmental, January 2012, May 2012, October 2013; Lewis and Thornton, September 2013, October 2014). This document reports planting as it was completed in Year 3, and presents the plans for Year 4.

1 The Fifty-fifth Supplement to the Ornithologists’ Union Check-list of North American Birds changed the name of the rail subspecies “California Clapper Rail” (Rallus longirostris obsoletus) to “California Ridgway’s Rail” (Rallus obsoletus obsoletus) (Chesser et al., 2014).
2 OVERVIEW OF PLANTING COMPLETED IN YEAR 3 (WINTER 2013-2014)

The main objective of the Invasive Spartina Project (ISP) Revegetation Program is to install native tidal marsh plants that enhance foraging, roosting and nesting cover as well as high tide refuge cover for the California Ridgway’s rail (Olofson Environmental, Inc., 2012). During Year 3, over 53,500 native tidal marsh plants were planted at 28 sites (Table 1 and Figure 1). The primary species planted in Year 3 included Grindelia stricta, Spartina foliosa and, at select sites, Distichlis spicata. These plant species continued to be the focus of the revegetation effort in Year 3, as they grow taller than other native salt marsh plants, providing more vertical structure for cover, and are important components of native marshes that have populations of California Ridgway’s rail. Spartina foliosa planting occurred in low elevation areas including mudflats, the transition between mudflats and the marsh plain, salt pans, and along marsh channels. Grindelia stricta (and D. spicata) planting occurred at mid- to high-marsh elevations along marsh plain channels as well as in higher elevation areas that exist in the marsh interior (e.g., berms and/or higher elevation islands).

Table 1. Forty-one 2011-2015 ISP Revegetation Sites

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Notes:
1Revegetation conducted by Save The Bay
2Revegetation conducted by ISP and Save The Bay
3Revegetation conducted by Friends of Corte Madera Creek Watershed
4Revegetation conducted by Romberg Tiburon Center, UC Davis and ISP
5Revegetation conducted by ISP and Friends of Corte Madera Creek Watershed
6High tide refuge island(s)
Figure 1. Twenty-five 2013-2014 ISP Revegetation Program Sites
Plans for Year 3 originally called for approximately 74,000 plants to be outplanted (Olofson Environmental 2013). That number was lowered during the planting season primarily due to decreased propagation bed production of *S. foliosa*. The same number of sites and revegetation areas planned for *S. foliosa* were planted but with fewer blocks of *S. foliosa* than originally anticipated. In addition, several sites that had been originally planned for Year 3 were subsequently dropped as a result of hybrid *Spartina* expansion at sites where no treatment was occurring and/or because of low survivorship of previous plantings at the restoration sites. Areas that were dropped included North and Dog Bone marshes at Robert’s Landing, and MLK Restoration Marsh and San Leandro Creek within the East Bay Regional Park District’s Martin Luther King Jr. Regional Shoreline. One other site, Johnson’s Landing (part of the East Bay Regional Park District’s Hayward Regional Shoreline), was dropped due to concerns that erosion occurring along the bayward edge could reduce the long term value of plantings for habitat creation. A site that was not initially proposed was later added as a tidal marsh revegetation demonstration site for public outreach and education. This site, Mt. Eden Creek Marsh/Mt. Eden Creek Muted Marsh, is located adjacent to successful Save The Bay upland transition zone plantings at the main public access point to the Eden Landing Ecological Reserve.

### 2.1 Planting Designs

The basic planting designs used in Year 3 were similar to the previous years’ designs (Figures 2 and 3).

*Grindelia stricta*

The basic *G. stricta* design is used for two different planting zones: along marsh plain channel edges and on higher elevation berms and islands (*Figure 2*). In 2013-2014, the number of *G. stricta* plants planned per patch was increased from 10 to 20 plants. At select sites with less plant diversity, *Distichlis spicata* was included in the patch design. At four sites, where *G. stricta* was planted on higher elevation berms and islands, some plants were caged with plastic mesh tree seedling protector tubes to protect the plants from grazing by herbivores (e.g., geese or rabbits).

Tidal marsh channels selected for planting were typically smaller channels that were estimated to be at the appropriate elevation for successful plant establishment based on several criteria (e.g., existing vegetation). The basic patch measured one meter wide by four and one-half meters in length and included two rows of plants that followed the natural curvature of marsh channels or berms. One row of plants was located approximately 0.25–1.0 meters from the channel edge and a second (outer) row was located 0.5 meters further from the channel edge. These patches were distributed throughout the marsh plain along appropriate channels to enhance habitat for as many Ridgway’s rail as possible. Typically, both sides of a channel were planted with patches to provide roosting and nesting cover on both sides.
Distichlis spicata

*Distichlis spicata* was planted as part of *G. stricta* patches at sites and planting areas where there was limited existing *D. spicata*, with the idea that *D. spicata* would grow up into the *G. stricta* and further increase the amount of vertical cover. In 2013-2014, a new propagation and potting technique was tested that included one to two *D. spicata* ramets in each one-gallon pot of *G. stricta* (termed “combo” pot) with the idea that transporting one pot with two species would increase planting efficiency.

Spartina foliosa

In previous years, *Spartina foliosa* was planted in lower elevation areas that included mudflats, the transition between mudflats and the marsh plain, and along marsh channels. In Year 3, *S. foliosa* planting designs included two additional habitat types: salt pans and the outer bay-front edge of marshes at the transition to lower elevation bay mudflats. These areas were selected to explore additional habitat types where *S. foliosa* occurs naturally, especially at revegetation sites with otherwise low planting survivorship.

During the first two years of the program, *S. foliosa* planting designs tested the survivorship and growth rate of eight different donor source populations. Monitoring results indicated that both survivorship and growth rate varied by source and by site. Two to three years after installation, the multi-species plots had grown together, and the original sources were no longer identifiable. In order to track different source populations over longer time periods, a new planting design was used in Year 3 that included single source and mixed source blocks, each containing four plots of *S. foliosa*, planted in close proximity to each other. Because survivorship was found
to be variable by source at different sites, all sites in Year 3 were planted with four different sources because there could be variable rates of survivorship for the different sources under different site conditions.

The basic _S. foliosa_ plot design of five plugs from the same source population planted together (Figure 3) was used for all plantings and repeated in different configurations depending on site-specific conditions. Several different planting designs (multiples of the basic plot design in different configurations) were designed to evaluate source population performance and the efficacy of caging. At each site, the four source populations were selected for planting based on several considerations including prior performance at either that site or at sites with similar conditions.

One of two caging designs, PVC-rope cage or plastic mesh cage, was applied to prevent herbivores (e.g., Canada goose, _Branta canadensis_) from accessing the plantings from either under or over the cage. The PVC-rope cage was used extensively to protect plantings in most areas, while plastic mesh caging was used for specific conditions where rope caging was not appropriate, such as narrow channel banks and benches. The PVC-rope cage design was square or rectangular in shape and used 4-6 PVC poles to surround multiples of the basic _S. foliosa_ plot. The PVC poles were linked and tied with 2-3 rope lines around the perimeter of the planting area. At all sites at least half of the blocks (each containing one to multiple _S. foliosa_ plots) were caged, and at several sites all plantings were caged. Where blocks of _S. foliosa_ were planted in salt pans, “trimming” of plugs was conducted during installation as another method to improve survivorship and prevent herbivory. Trimming entailed clipping the tops of the leaves to reduce visibility of plugs, reduce transplant shock, and to promote root growth.

As in Year 2, plastic mesh cages were constructed as a square with plastic mesh fabric attached to four PVC poles at each corner. Each plastic mesh cage surrounded one _S. foliosa_ plot (five

Figure 3. Schematic of basic planting design for _S. foliosa_ plots in Year 3. All five plugs are from the same source population.
plugs from same source population) and was pushed into the substrate to prevent herbivores (e.g., crabs) from digging under the cage. Typically each plot protected with a plastic mesh cage was paired with an uncaged plot.

Also as in Year 2, it was anticipated that approximately one-half of the S. foliosa cages would be removed one year after installation to continue to test how long caging may be required to establish S. foliosa patches that can withstand herbivory pressure. Results from 2014 monitoring will indicate whether plantings continue to survive if caging is removed one year after installation or if some caging should remain in place for a longer period of time.

ISP Biologist W. Thornton and her research colleagues continue to examine other factors that may influence S. foliosa survivorship (e.g., elevation) and those results will be reported elsewhere.

Uncontrolled Hybrid Spartina

Another consideration when choosing sites for revegetation is the proximity to uncontrolled hybrid Spartina. There are currently 10 sites where hybrid Spartina is not controlled, 9 of these 10 sites are located in the East Bay between the San Mateo and Dumbarton bridges.

Grindelia stricta has been planted and will continue to be planted at several sites with uncontrolled hybrid Spartina. Planting locations selected at these sites avoid existing hybrid Spartina for two reasons. One reason to avoid hybrid Spartina is to minimize the risk that the plantings will be outcompeted by hybrid Spartina. The second reason is that hybrid Spartina patches may be providing habitat for rails and, because treatment can occur within three meters of plantings to protect the plantings from encroachment, these areas need to be avoided.

Selecting sites for S. foliosa reintroduction, with the presence of uncontrolled hybrid Spartina in the Bay, must be conducted with caution. For example, if Spartina foliosa is planted near uncontrolled hybrid Spartina, cross-pollination could occur that could produce fertile hybrid seed. To guide the reintroduction effort, ISP staff developed a protocol that includes detailed information on the collection, genetic testing, propagation, outplanting and monitoring of S. foliosa that occurs as part of the program (Appendix 1, Olofson Environmental, May 2012). Spartina foliosa planting sites are selected based on two main considerations: 1) presence of limited to no existing S. foliosa in the area that could provide propagules for rapid recolonization, and 2) hybrid Spartina is close to local eradication. Monitoring at sites where S. foliosa has been planted occurs several times per year per the protocol to ensure that hybrid Spartina does not invade planted areas.

High Tide Refuge Islands

In Year 3, 16 islands were constructed by the Conservancy, H.T. Harvey & Associates, and Hanford ARC to enhance high tide refuge habitat for California Ridgway’s rail at ISP revegetation
sites (Table 1). These islands were planted with *G. stricta* and *D. spicata* as well as locally collected “sod” that included native marsh species such as *Salicornia pacifica* and *D. spicata*. Detailed design and construction information for the high tide refuge islands is included in the 2012-2013 Installation Report and 2013-2014 Revegetation Plan (2013) as well as H.T. Harvey & Associates reports (2013a and b).

### 2.2 Methods

As in Year 2, Year 3 plants were propagated in a commercial native plant nursery and delivered by contractors to the revegetation site for outplanting. Three pot sizes were used for *G. stricta*: D40 (Deepot 40, 40 cubic inches of soil), one-gallon (180 cubic inches of soil), and Treeband 4 (TB4, 160 cubic inches of soil). Compared to one-gallon pots, TB4s hold a similar amount of soil, but are longer and narrow, and thus have additional space for deeper roots. They were tested in Year 3 to determine if they might be less difficult for contractors to transport and plant than one-gallon pots. Twenty-five percent of the D40 size *G. stricta* was salt hardened in the nursery, and these were installed at 10 sites to continue to assess the value of salt hardening.

Nearly all *S. foliosa* planted in Year 3 was propagated in nursery beds according to Program protocols (Thornton 2012), and then outplanted at revegetation sites as plugs. All nursery *S. foliosa* beds were salt hardened prior to outplanting. One exception to the nursery propagation occurred at Mt. Eden Creek Marsh/Mt. Eden Creek Muted Marsh, where *S. foliosa* plants were directly transplanted to the site from genetically tested source populations at Golden Gate Fields and Port Sonoma Marina, again following the Program protocols. This was not initially planned, but was implemented to augment total plant numbers when it was observed that the *S. foliosa* beds had not produced as many plugs as were needed.

At most sites, *S. foliosa* was planted in plugs with an average of three stems per plug. For two sites (Whale’s Tail North and Whale’s Tail South) where establishment of *S. foliosa* along channels was the primary objective and survivorship had previously been low, larger plugs, with an average of 5-10 stems/plug, were installed. Larger plugs were used with the idea that these plants would have more resources to withstand transplant shock. Larger plugs were also installed at a third site (Cogswell A) where establishment of *S. foliosa* along channels was also a primary objective and *S. foliosa* at that site had not been planted in that habitat type before.

### 2.3 Lessons Learned through Year 3 and Recommendations for Year 4

Monitoring of Year 1 and Year 2 plantings was conducted during the fall of 2013. Detailed information on monitoring results and analyses are discussed in Lewis and Thornton (2013 and 2014). Appendix 2 provides the report on the 2013 (post-Year 2) revegetation monitoring, and select summary results are included in the recommendations that follow.
Plant survivorship for Year 1 and Year 2 plantings varied by species, site, and installation treatment. For plants installed in Year 1, the mean survivorship for *S. foliosa* was 46%, which surpassed the Program's target survivorship goal of 40%. Survivorship by site was as high as 94%. Overall, Year 1 marsh plain *G. stricta* survivorship was 32%, with several sites having survivorship of over 50%. For plants installed in Year 2, the mean survivorship for *S. foliosa* was 36% (with a high of 66%). Mean survivorship for *G. stricta* installed in Year 2 was 55% (with a high of 86 percent). For detailed results from both years of monitoring, refer to Olofson Environmental (2012) and Lewis and Thornton (2013 and 2014). Figures 4 and 5 show examples of plantings after two growing seasons. Survivorship monitoring for Year 3 will occur in fall 2014, and while it may inform final plans for Year 4 planting, the results will be reported in a subsequent document.

**Pot Size**

Across sites for Year 2 plantings, overall survivorship of *G. stricta* grown in one-gallon pots was significantly higher than in D40 pots. At the site level, however, 12 out of 19 sites showed no significant difference in survivorship between the two pot sizes. At a subset of sites, *G. stricta* plant volume was measured after one season of growth and plants that were planted as one-gallons were found to have significantly greater volume than D40s. The advantage of D40 pots is less weight and easier transport during planting (D40s are carried in plant trays, gallons are carried individually) resulting in a more efficient planting effort. As gallons were found to result in higher survivorship and greater plant volume, it is recommended that they continue to be used despite requiring more planting effort.
Figure 4. Right: Two year old plantings of S. foliosa along the Alameda Flood Control Channel.

Figure 5. Below: Program Manager Jeanne Hammond, monitoring two year old plantings of G. stricta at Cogswell Marsh, Hayward.
TB4s, which hold a similar amount of soil as one-gallon pots, were tested in Year 3 to see if they might be less difficult to transport and plant than were gallons. During installation, however, it was found that TB4s were more difficult to transport due to the tall, narrow stature of the pot and that there was an increased likelihood of plant damage (i.e., pots falling over). Therefore, TB4s are not recommended for future planting.

**Spartina foliosa Plug Size**

The *Spartina foliosa* planting design in Year 2 used a plug size of approximately 5 stems per plug. In Year 3, plugs with an average of three stems per plug were used at most sites to allow planting across a larger area. However, at important sites where survivorship had previously been low, larger plugs, with an average of 5-10 stems per plug, were installed with the idea that larger plugs would help improve survivorship and rate of growth. Using a larger plug size may be a tradeoff between covering a smaller area with denser plants more quickly, and planting a larger area that may take additional time to achieve the same density. This may be useful to consider in some situations.

**Spartina foliosa Direct Transplants**

Direct transplanting of plants from a genetically-tested source population to a revegetation site was used at some sites in Year 1, and again at one location in Year 3. This approach may raise concerns regarding the increased potential for transplanting a hybrid *Spartina* plant or introducing invertebrates or other pests to revegetation sites. Field crews collecting, transporting, and installing the direct transplants in Year 1 reported increased difficulty with managing the loose and muddy plugs from one site, and the survivorship of plants installed this way was significantly lower. Direct transplant between locations should not be relied on as a regular practice, although there might be times when it is warranted. One idea that is under consideration is to collect small amounts of *S. foliosa* from established planted areas for planting in new areas at the same site. Plants that are transferred between recently-established *S. foliosa* patches and adjacent unvegetated areas must be genetically tested.

**Spartina foliosa Donor Source**

The effect of *S. foliosa* donor source population on survivorship and growth rate at different sites was found to be variable for both Year 1 and 2 plantings. Which sources will be most successful at a specific site is not known given our current level of understanding, and it is recommended that multiple sources continue to be planted at each revegetation site to increase the likelihood of survivorship and establishment of a plot.

**Salt Hardening**

A test of Year 2 plantings found that salt hardening of *G. stricta* plants prior to outplanting had a positive effect on survivorship at most sites. All *S. foliosa* plugs have been salt hardened prior
to outplanting in all three years of the program. Salt hardening of both *G. stricta* and *S. foliosa* is recommended to continue for 2014-2015.

**Caging**

In Year 2, caging of *G. stricta* plants was limited to higher elevation berm and island areas within the interior of the marsh. At one out of the four sites where comparisons were possible, caging had a significant positive effect on survivorship. In Year 3, caging was again tested at four sites, but data has not yet been analyzed. With the continued drought, it is likely that planting on the higher, dryer areas where caging was found useful will be very limited in Year 4. Due to the significant cost of materials and added labor associated with installation and removal of caging, it should only be considered for those sites where herbivory is expected.

In Year 2 tests, rope caging to protect *S. foliosa* plugs was found to have a significant positive effect on survivorship at three sites, and on plant height at two sites. Plastic mesh caging was used in areas with either high wave action or along narrow channel banks and monitoring results from one site indicate that caging had a significant positive effect on survivorship; no uncaged plots survived. Caging of *S. foliosa* plugs occurred at all sites in Year 3, with all plugs caged at some sites, and half of the plugs caged at other sites to test whether caging had an effect on survivorship. Initial observations at sites continue to show increased survival with caging. Caging of *S. foliosa* should be continued to protect plants from herbivory.

**Spartina foliosa** Trimming

Trimming of plant leaves at the time of plug installation was tested in Year 3 in certain habitat types as an additional method to minimize herbivory and reduce transplant shock. Trimming was tested based on two ideas: 1) that herbivory could be minimized by reducing the amount of visible green on newly planted plugs and 2) that transplant shock could be reduced by redirecting resources to the roots from the leaves. Trimming is a relatively easy treatment to implement, and if it is shown to effectively reduce herbivory or transplant shock, it is recommended for future use.

**Effects of Invasive Spartina Pressure at Revegetation Sites**

The continued presence of uncontrolled hybrid *Spartina* at multiple sites around the Bay has increased the invasion pressure at revegetation sites. As the uncontrolled hybrid *Spartina* plants at these sites expand and produce increasing numbers of seed, this pressure will continue to increase. Monitoring efforts to locate and treat new seedlings will continue to be extremely important, especially at *S. foliosa* reintroduction sites, in order to ensure that revegetation sites are not re-infested. Reintroduction sites for *S. foliosa* need to be re-evaluated on a yearly basis to assess the latest information on presence of hybrid *Spartina* at or near the site.

At some sites with uncontrolled hybrid *Spartina, G. stricta* is actively planted in un-infested areas, with the idea that established plants would provide native habitat support for rail when
treatment at the site resumes. Hybrid *Spartina* is actively encroaching on these areas in some places and treatment of the allowed 3-meter buffer around plantings has been necessary. Hybrid *Spartina* is also actively expanding into areas where *Grindelia stricta* plants exist naturally at these sites, and appears to be overwhelming and likely outcompeting these plants. As long as comprehensive *Spartina* monitoring and treatment continues, it is recommended that planting of both species continues at revegetation sites with caution, especially for *S. foliosa*.

**Wave Attenuation**

Wave attenuation may be needed at some sites in order to establish *S. foliosa*. At Elsie Roemer, research has found that caging increased survivorship, but survivorship still remains low compared to other sites. An additional wave attenuation treatment was installed at this site in Year 3 that involved placement of bamboo close together in roughly an L-shape to form a barrier on the bayward side of the plantings. Preliminary observations suggest that survivorship is still low, but there may be some positive effect. This treatment is time consuming, and thus expensive to install, and it has a high visual impact on the marsh. While repeating this method may not be warranted, information gathered from this test may lead to improved methods with higher efficacy.

**Planting Elevation**

In Year 2, elevation data was collected for *G. stricta* plantings at two sites. Results indicated that elevation had a significant effect on survivorship. It is recommended that elevation data be collected for a selection of sites to achieve a better understanding of the influence of elevation on survivorship across many sites. Data should particularly be collected at sites where survivorship is otherwise unexplainably low. Marsh elevation may need to be correlated with site-specific tidal elevations to determine inundation period, which may have more influence on plant performance.

**Watering**

*Grindelia stricta* plants installed along a berm at the B2 South site at Bair Island in Year 3 received a watering treatment a few days after installation. Access to this site required an airboat outfitted with a water tank. No analysis was conducted to determine the added benefit of watering. Watering should continue to be considered and tested as a method to increase plant survivorship, particularly with the ongoing drought, although cost and access issues may make this method difficult.
3 OVERVIEW OF PLANS FOR YEAR 4 (WINTER 2014-2015)

The ISP expects to install more than 60,000 plants at 27 sites in the coming season (Figure 6). Most of the proposed revegetation sites have been planted 1-3 times in different areas as part of this program. In addition, several new revegetation sites are proposed for planting, including the Deepwater Slough and Corkscrew Slough sites at Don Edwards NWR’s Bair Island; the Eden Landing Ecological Reserve’s Ponds E8A, E9, and E8X, and North Creek; and the East Bay Regional Park District’s Hayward Regional Shoreline at Johnson’s Landing. These sites will be evaluated during groundtruthing to determine if suitable and accessible areas exist for revegetation.

Native tidal marsh species to be planted as part of this program will include Grindelia stricta, Spartina foliosa, and at select sites, Distichlis spicata. Grindelia stricta planting will occur at mid-to high-marsh elevations along marsh plain channels as well as in higher elevation areas in the marsh interior, such as berms and higher elevation islands. Spartina foliosa planting will occur in low elevation areas including mudflats, the transition between mudflats and the marsh plain, salt pans, and along marsh channels.

As in previous years, plants will be propagated in a commercial native plant nursery and be delivered by contractors to the revegetation sites. Pot sizes for G. stricta and D. spicata will be similar to those used in Year 3. Grindelia stricta will be propagated in D40 and one-gallon pots. The TB4 size pot tested in Year 3 will not be planted in 2014-2015. The “combo” one-gallon pot that contains both a G. stricta plant and two ramets of D. spicata will be used again as a way to decrease the number of pots transported and planted at a site. Distichlis spicata will also continue to be transported in gallon pots and planted in selected G. stricta patches. Thirty percent of the D40 size G. stricta plants will be salt hardened in the nursery prior to outplanting.

To prepare for Year 4 planting, S. foliosa was again collected from source populations and grown out in the nursery prior to planting, following program protocols (Thornton, 2012). Forty beds were initially propagated from eight established source locations and one new location (Tennessee Valley, Marin County), to produce an estimated 53,000 stems for outplanting. However, in October 2014, mid-season monitoring and genetic testing of the beds revealed a hybrid Spartina plant present in one of them. Following protocol, the hybrid plant was immediately removed, the six beds containing plants from the same source population (Alviso Slough) were destroyed, and the source location was removed from future use by the program (Hammond and Olofson, memo, 2014). Spartina foliosa will again be planted as plugs with an estimated average of three stems per plug, and all propagation beds will undergo salt hardening before outplanting. For a map of source population locations for all years of the program, refer to Appendix 3.
Figure 6. 2014-2015 Revegetation Sites
Planting designs for Year 4 are similar to the previous years’ designs. For schematics of the planting designs, refer to Appendix 1. One slight variation to the patch planting design for *G. stricta* along marsh plain channels will be to increase, from 0.25 m to 1.0 m, the estimated maximum distance from the channel edge that plants can be planted. This increased distance was determined based on continued observation of erosion along channel edges at some sites. Anecdotal observations also indicated that, at some sites where the elevation is appropriate, existing *G. stricta* grows up to several meters away from channel edges. The program may make additional slight modifications to planting designs based on site-specific conditions. Site assessment to select planting locations is anticipated to occur during the months of October to January.

Drought conditions are expected to continue through the 2014-2015 planting season. Site assessments and planning will consider the likelihood that higher elevation areas such as berms and islands within the marsh plain may require supplemental watering for plants to become established.

Construction of an additional 21 high tide refuge islands is proposed at three locations, including Palo Alto Baylands, Corte Madera Ecological Reserve at Muzzi Marsh, and Bair Island at Corkscrew and Deepwater sloughs (H.T. Harvey & Associates pers. comm.).
4 SITE-SPECIFIC YEAR 3 INSTALLATION REPORTS AND YEAR 4 PLANS

The following sections include brief site descriptions, Year 3 (Winter 2013-2014) plant installation information, and the proposed site plans for Year 4 (Winter 2014-2015).

4.1 Alameda Flood Control Channel (AFCC) and Pond 3

Alameda Flood Control Channel Mouth, Lower & Upper

The Alameda Flood Control Channel (AFCC) is a large flood control channel located in Newark, California that is managed by the Alameda County Flood Control and Water Conservation District (Figure 7). The channel is lined with broad benches of accreted sediment that function as a tidal marsh plain. Much of this channel was previously lined with dense stands of non-native cordgrass, which now have been significantly controlled. The levees on both sides of the channel are also multi-use trails that are part of the San Francisco Bay Trail, Alameda Creek Regional Trail and Coyote Hills Regional Park (East Bay Regional Park District).

In areas where extensive treatment of non-native Spartina occurred, perennial pickleweed (Sarcocornia pacifica) rebounded quickly and is now abundant. Prior to planting efforts, however, two important components of a native marsh were either very limited (G. stricta) or missing completely (S. foliosa). Overall survivorship of G. Stricta and S. foliosa plantings in Years 1 and 2 was high at this site, with 58-68% survivorship for G. stricta and 66-67% survivorship for S. foliosa.

Year 3 (2013-2014) Installation

As in previous years, S. foliosa was planted on the wide bench located along the main channel edge, and G. stricta patches were planted along smaller channels that run perpendicular to the main channel. Twenty patches of G. stricta (400 D40s) were installed, nine of which included two gallons of D. spicata each (each gallon divided into 4 ramets). Over 1,100 plugs of S. foliosa were planted from four source populations, including Seminary Cove, Starkweather Cove, Port Sonoma Marina, and Permanente Creek. The planting design included clusters of 12 blocks planted in the same area, with half of the blocks caged and half uncaged. Each block contained four of the basic planting plots shown in Figure 3. Eight of the twelve blocks were planted each with plots from a single source, and four of the 12 blocks had plots from all four sources.


Approximately 300 G. stricta plants (15 patches) will be planted along smaller side channels, and 600 plugs of S. foliosa will be planted along the main channel. Given the good survivorship to date for both S. foliosa and G. stricta, planting will be focused on areas with conditions similar to previous years.
Figure 7. Year 1 to Year 3 Completed Planting Map at Alameda Flood Control Channel (AFCC) and Pond 3
California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

This site is accessible using drivable levees on both sides of the channel and access for planting can be by truck and foot.

**AFCC Pond 3**

AFCC Pond 3, or Ecology Marsh, is located on the northern side of the flood control channel described above in the City of Newark, and is part of the Newark Unit of the Don Edwards SFBNWR (Figure 7). Pond 3 was the location of the first intentional planting (ca. 1976) of *S. alterniflora* by the U.S. Army Corps of Engineers as part of a dredge sediment reuse and tidal marsh restoration effort. Pond 3 is a former salt pond that lacks significant channelization and is primarily vegetated with perennial pickleweed. This marsh is bordered on the north, south, and east by levees, and by the bay to the west.

A considerable amount of non-native *Spartina* treatment has occurred at this site since 2005. In areas where treatment occurred, non-native *Spartina* has been successfully removed and perennial pickleweed is now abundant, however, *Grindelia stricta* is still limited. Prior to ISP planting efforts, there was no *S. foliosa* present at this site.

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 12 patches (240 plants) of *G. stricta* were planted at this site, expanding planting in the same areas as Year 2 (Figure 6). Approximately 200 plugs of *S. foliosa* from the same four source populations as AFCC (Seminary Cove, Starkweather Cove, Port Sonoma Marina, and Permanente Creek) were planted at Pond 3 and protected using rope cages.


Pond 3 is part of Phase 2 planning efforts for the South Bay Salt Pond Project, and is under consideration for construction to widen a channel as a tidal outlet for upstream ponds to be breached (J. Bourgeois pers. comm.). Because of the uncertainty with future plans for the site, the planting effort in Year 4 will be limited to 200 *G. stricta* plants.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

This site is accessible using a drivable levee that runs along the south side of the site and access for planting can be by truck and foot.

**4.2 Greco Island**

Greco Island is the largest area of fairly undisturbed, historic tidal marsh in the South Bay. Portions of the island were developed into salt works in the early 1900s, which reverted back to tidal marsh by the 1950s. Greco Island is part of the West Bay Unit of the Don Edwards SFBNWR and is located just southeast of Bair Island and Redwood Creek in Redwood City, California. The
island is bordered to the south by Bedwell Bayfront Park in the City of Menlo Park, California. As a relatively undisturbed tidal marsh, Greco Island has extensive channel networks that are lined with S. foliosa and, in the southern part of the island, wide bands of G. stricta as well. Treatment has removed most of the non-native Spartina from the site and the native marsh is relatively intact. The northern portion of the island is less populated with G. stricta, and plantings have been focused in this area.

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 100 patches (2,000 plants) of G. stricta were planted at this site, with planting expanded into areas to the east and south of areas planted in Years 1 and 2 (Figure 8).


Approximately 3,000 plants (G. stricta and D. spicata) in 130 patches are planned for installation at Greco Island in Year 4. Plant survivorship in Years 1 and 2 was low in some areas of the site, and analysis of limited data showed that planting elevation may have had a significant effect (Lewis and Thornton 2014). Based on these results, new plantings will be focused in higher elevation areas at this site.

California Ridgway’s rails are present at this site, with one of the highest density populations located in the southern portion of the site (McBroom 2014). Every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

Access to Greco Island requires a boat. Typically, an airboat is used to ensure accessibility during all tide heights.

**4.3 Bair Island**

The ISP revegetation sites on Bair Island are part of a 3,000 acre phased, large-scale restoration project managed as part of the West Bay Unit of the Don Edwards SFBNWR. The tidal marshes of Bair Island were diked in the late 1800s and early 1900s for agriculture. Bair Island is essentially three islands that are separated by large sloughs (Corkscrew and Smith sloughs). All three islands were used for salt production from the 1940s until 1965. Tidal marsh restoration began in the late 1970s. ISP revegetation sites at Bair Island (Figure 9) are primarily part of Outer Bair Island which was restored through a series of planned and unplanned breaches during the late 1970s and early 1980s. These sites have extensive channelization with mature tidal marsh vegetation, including abundant S. foliosa. Hybrid Spartina is also present, but effective treatment has significantly reduced its presence, with the exception of B2 North East, which is not currently approved for treatment. Planting efforts at Bair Island sites have focused on areas that are appropriate for G. stricta, but where currently there is little or no Grindelia present.
Figure 8. Year 1 to Year 3 Completed Planting at Greco Island
Figure 9. Bair Island Complex Year 1 to Year 3 Completed Planting, High Tide Refuge Island Locations, and Year 4 New ISP Revegetation Sites
Bair Island - B2 North West

B2 North West is a section of Bair Island located adjacent to the bay front and to Steinberger Slough, but separated by remnant levees (Figure 10). B2 North (both West and East) has abundant *S. foliosa* lining marsh channels. B2 North East is directly to the east of this site and, in addition to abundant *S. foliosa*, has a significant amount of hybrid *Spartina*. B2 North East was not treated in 2011-2012. In 2013 and 2014, seed suppression treatment (aerial spraying of herbicide at reduced concentration to stop seed production) was conducted.

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 51 patches (1,020 plants) of *G. stricta* were planted at this site, with planting expanded into areas to the east of areas planted in Years 1 and 2 (Figure 10). Year 1 planting survivorship was low, at 5%; however, Year 2 planting survivorship was high, at 61%. This is likely due to several factors including more informed selection of planting location in Year 2 based on previous experience, and the planting of more mature nursery plants with better developed roots. Planting locations selected in Year 3 were informed by survivorship data from Years 1 and 2.

Three high tide refuge islands were also constructed and planted with both *G. stricta* and *D. spicata* at B2 North in Year 3 (one in B2 North West and two in B2 North East, H.T. Harvey & Associates 2014b).


Approximately 1,300 plants (*G. stricta* and *D. spicata*) in 65 patches are planned for installation at B2 North West in Year 4. Planting will continue in previously planted areas with higher survivorship, and will be expanded into other areas with suitable elevation.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

Access to Bair Island requires a boat. Typically, an airboat is used to ensure accessibility during all tide heights.

Bair Island - B2 North - South of Boardwalk

B2 North - South of Boardwalk is located to the south of B2 North West and East and is separated from these sites by a large slough channel and PG&E transmission line and boardwalk that cross the marsh from the northwest to the southeast. This site was planted for the first time in Year 3.

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 83 patches (1,660 plants) of *G. stricta* were planted at this site in the areas shown on Figure 11.
Figure 10. Year 1 to Year 3 Completed Planting and High Tide Refuge Island Locations Map at B2 North West
Figure 11. Year 3 Completed Planting at B2 North - South of Boardwalk

Approximately 1,700 plants (G. stricta and D. spicata) in 85 patches are planned for installation at B2 North – South of Boardwalk in Year 4. Planting will continue in previously planted areas with higher survivorship, and will be expanded into other areas with suitable elevation.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

Access to Bair Island requires a boat. Typically, an airboat is used to ensure accessibility during all tide heights.

Bair Island - B2 South

B2 South is a 62-acre diked area located to the east of B2 North East. This site experiences damped, or muted, tidal action via several breaches in the remnant levees that completely surround it. Channelization is limited to several larger channels that are primarily the result of borrow ditch construction (i.e., straight channels that run adjacent to the levees). Perennial pickleweed is abundant, however, G. stricta and S. foliosa are uncommon. This site was planted for the first time in Year 3.

Year 3 (2013-2014) Installation

In Year 3 of the program, 38 patches (760 plants) of G. stricta were planted at this site in the areas shown on Figure 12. G. stricta patches were planted in the marsh plain and at an appropriate elevation along the remnant levee.


Approximately 900 plants (G. stricta and D. spicata) in 45 patches are planned for installation at B2 South in Year 4. Planting will continue in previously planted areas with higher survivorship, and will be expanded into other areas with suitable elevation.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

Access to Bair Island requires a boat. Typically, an airboat is used to ensure accessibility during all tide heights.

Deepwater Slough – New 2014-2015 Site

The Deepwater Slough revegetation site is bounded on the north and west sides by Deepwater Slough and to the east by the deep water channel of Redwood Creek. A PG&E transmission line and boardwalk runs northeast to southwest and roughly bisects the site (Figure 9). Perennial pickleweed is abundant, and S. foliosa is common on most channel complexes at this site. Planting at this site will focus on areas with appropriate elevation that are lacking G. stricta. This site will be planted for the first time in Year 4.
Figure 12. Year 3 Completed Planting at B2 South

Approximately 760 plants (*G. stricta*) in 38 patches are planned for installation at Deepwater Slough in Year 4.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

Access to Bair Island requires a boat. Typically, an airboat is used to ensure accessibility during all tide heights.

Corkscrew Slough—New 2014-2015 Site

The Corkscrew Slough revegetation site consists of two marsh areas adjacent to Corkscrew Slough – one area northwest of the slough, and one smaller “peninsula” area on the south side (*Figure 9*). Perennial pickleweed is abundant, and *S. foliosa* is common on most channel complexes at this site. Planting at this site will focus on areas with appropriate elevation that are lacking *G. stricta*. This site will be planted for the first time in Year 4.


Approximately 900 plants (*G. stricta* and *D. spicata*) in 37 patches are planned for installation at Corkscrew Slough in Year 4.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

Access to Bair Island requires a boat. Typically, an airboat is used to ensure accessibility during all tide heights.

4.4 Bird Island

Bird Island is located adjacent to the mouth of Belmont Slough in Redwood City (*Figure 13*). The island is located on the bayfront and separated from adjacent urban development by a shallow, wide channel on the south side. Perennial pickleweed is abundant and *S. foliosa* lines the extensive channels that typically run north to south on the island. A high tide refuge island was constructed here in Year 2 of the program, and plantings on the marsh plain began in Year 3.

Year 3 (2013-2014) Installation

In Year 3 of the program, 26 patches (520 plants) of *G. stricta* were planted at this site (*Figure 13*) at the eastern end of the island.


Approximately 1,300 plants (*G. stricta* and *D. spicata*) in 45 patches are planned for installation at Bird Island in Year 4.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.
Figure 13. Year 3 Completed Planting and Year 2 High Tide Refuge Island Location at Bird Island
Access to Bair Island requires a boat. Typically, an airboat is used to ensure accessibility during all tide heights.

### 4.5 Hayward Regional Shoreline: Cogswell, Triangle and H.A.R.D. Marshes

ISP revegetation sites located at the East Bay Regional Park District’s Hayward Regional Shoreline include the Cogswell and Oro Loma marshes as well as Triangle, H.A.R.D. and Johnson’s Landing (Figure 14). These sites are all fairly young restoration marshes that were restored to tidal action during the peak of the hybrid *Spartina* invasion and consequently were heavily invaded. Hybrid *Spartina* colonized these sites first and outcompeted other native marsh vegetation. Treatment has now successfully controlled hybrid *Spartina*, and perennial pickleweed is abundant in areas that have reached the appropriate elevation. Other native marsh species are limited at these sites and ISP planting has primarily focused on *G. stricta* at all sites and *S. foliosa* at several sites.

**Cogswell A**

Cogswell A is the northernmost quadrant of the Cogswell Marsh (Figure 14). Cogswell Marsh was opened to tidal action in 1980 and was one of the first restoration sites to become highly invaded by invasive hybrid *Spartina*. Cogswell A is currently the only quadrant of the Cogswell Marsh that is approved for treatment.

Cogswell A has undergone consistent yearly hybrid *Spartina* control since 2005, and while perennial pickleweed is now abundant, native marsh plant diversity is low. Several components of a native marsh are either very limited (*G. stricta*), or missing completely (*S. foliosa*). In 2006-2007, *G. stricta* was planted in the northeast corner of Cogswell A, and while these plantings were not formally monitored, the presence of mature *G. stricta* only in this area of the site indicates that plantings had high survivorship. Year 1 and Year 2 plantings at this site focused on *G. stricta* patches, and also included upland transition zone plantings located around the perimeter of two islands within this site. Plant survivorship for Year 1 and Year 2 *G. stricta* plantings ranged from 44% to 64%. Survivorship for upland transition zone plantings was 43% after two seasons. Year 2 also included experimental planting of *S. foliosa* along the bayfront edge. Due to continued uncontrolled hybrid *Spartina* adjacent to this site, no future *S. foliosa* plantings are currently planned for this site.
Figure 14. Year 1 to Year 3 Completed Planting, High Tide Refuge Island Locations, and Year 4 New Revegetation Site at the Hayward Regional Shoreline
Year 3 (2013-2014) Installation

In Year 3 of the program, 49 patches of *G. stricta* and 820 plugs of *S. foliosa* (over 2,300 plants total) were planted at this site (Figure 14). *G. stricta* patches were distributed throughout the marsh in areas not previously planted. Blocks of two plots of *S. foliosa* were planted along interior channels, with one plot in each block surrounded by plastic mesh caging, and one plot left uncaged. Blocks of eight plots of *S. foliosa* were also planted within salt pans, using rope caging on half of the plots and leaving half uncaged. Source populations planted at this site include Starkweather, Napa River, Seminary Cove and Golden Gate Fields. Half of the *S. foliosa* plots at this site were trimmed (i.e., upper portion of leaves were cut off).


Approximately 1,300 plants (*G. stricta* and *D. spicata*) in 65 patches are planned for installation at Cogswell A in Year 4. Planting will be distributed throughout the marsh in areas that were not planted previously, and will likely include the edges of larger channels. Due to concerns over the spread of hybrid *Spartina* from Cogswell B and C (sites not approved for treatment), *S. foliosa* will not be planted at Cogswell A in Year 4.

California Ridgway’s rails are present at this site and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

The perimeter of this site is drivable levee, and access to the site for planting is by truck and foot.

Cogswell B

Cogswell B is the easternmost quadrant of Cogswell Marsh (Figure 14). Cogswell Marsh was opened to tidal action in 1980 and was one of the first restoration sites to become highly invaded by invasive hybrid *Spartina*. Like Cogswell A, this site initially underwent substantial hybrid *Spartina* treatment, however, no treatment has occurred since 2011. Areas where hybrid Spartina was removed now have abundant perennial pickleweed, however, *G. stricta* is very limited at this site. Due to the continuing significant presence of hybrid *Spartina*, which is once again spreading rapidly at the site, *G. stricta* planting has focused on areas where hybrid *Spartina* is not present, and is implemented with caution with the knowledge that plantings could be outcompeted. Planting was initiated at Cogswell B in Year 2 and survivorship was high, at 56%.

Year 3 (2013-2014) Installation

In Year 3 of the program, 69 patches (over 1,700 plants) of *G. stricta* were planted at this site (Figure 14). Year 1 plantings survivorship was low (5%), however, Year 2 plantings survivorship was high (61%).

Three high tide refuge islands were also constructed and planted with both *G. stricta* and *D. spicata* at Cogswell B in Year 3 (H.T. Harvey & Associates 2014b).

Approximately 1,000 plants (*G. stricta* and *D. spicata*) in 50 patches are planned for installation at Cogswell B in Year 4. Planting will continue in previously planted areas with higher survivorship, and will be expanded into other areas with suitable elevation, while avoiding hybrid *Spartina*.

California Ridgway’s rails are present at this site and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

The perimeter of this site is drivable levee and access to the site for planting will be primarily by truck and foot. A Jon boat may be used at high tide to cross a large channel located along the west side of the quadrant in order to more efficiently move plants and crew to the “island” in the center of Cogswell B.

**Cogswell C**

Cogswell C is the southwestern quadrant of Cogswell Marsh (Figure 14). Cogswell Marsh was opened to tidal action in 1980 and was one of the first restoration sites to become highly invaded by invasive hybrid *Spartina*. Like Cogswell A and B, this site initially received substantial hybrid *Spartina* treatment, however, no treatment has occurred since 2011. Areas where hybrid *Spartina* was removed now have abundant perennial pickleweed, however, *G. stricta* is very limited at this site. Due to the continuing significant presence of hybrid *Spartina*, *G. stricta* planting has focused on areas where hybrid *Spartina* is not present and is implemented with caution with the knowledge that plantings could be outcompeted. Year 1 and 2 plant survivorship for *G. stricta* after two seasons ranged from 42% to 55%, respectively.

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 40 patches (over 800 plants) of *G. stricta* were planted at this site (Figure 14).

Three high tide refuge islands were also constructed and planted with both *G. stricta* and *D. spicata* at Cogswell C in Year 3 (H.T. Harvey & Associates 2014b).


Approximately 1,000 plants (*G. stricta* and *D. spicata*) in 50 patches are planned for installation at Cogswell C in Year 4. Planting will continue in previously planted areas with higher survivorship, and will be expanded into other areas with suitable elevation, while avoiding hybrid *Spartina*.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

The perimeter of this site is drivable levee and access to the site for planting will be primarily by truck and foot.
Triangle Marsh

Triangle Marsh is a small restoration marsh located just north of Cogswell A, with the two sites separated by two levees and a channel (Figure 14). The triangular-shaped marsh is bounded by a capped landfill to the east and separated from the bay to the west by a levee which includes the San Francisco Bay Trail. This site is the property of the Hayward Area Recreation & Park District and is managed as part of the Hayward Regional Shoreline. The site has damped, or muted, hydrology and only receives tidal water via culverts that enter the marsh at the northern end. While proximate to Cogswell Marsh, Triangle Marsh was never heavily infested with hybrid *Spartina* and the site has received successful hybrid *Spartina* treatment since 2005. *G. stricta* is very limited at this site and no *S. foliosa* is present in the area. This site was planted for the first time in Year 3.

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 15 patches of *G. stricta* and 440 plugs of *S. foliosa* (over 740 plants total) were planted at this site (Figure 14). Plots of *S. foliosa* were planted along interior channels and within salt pans and all plantings were protected with rope caging. Source populations planted at this site include Starkweather, Port Sonoma Marina, Permanente Creek and Golden Gate Fields. Half of the *S. foliosa* plots at this site were trimmed (i.e., upper portion of leaves were cut off).


Approximately 1,100 plants, including 25 patches of *G. stricta* (including *D. spicata*) and 400 plugs of *S. foliosa*, are planned for installation at Triangle Marsh in Year 4. Due to the small size of this site and limited opportunity for planting locations, some plants may be reallocated to others sites if suitable planting locations are not located during groundtruthing.

California Ridgway’s rails have been detected sporadically at this marsh, with the last detection during surveys in 2011. Given the three years since detection and the low number of rails detected (one individual) this site may be planted during a later planting date (after February 1).

The perimeter of this site is drivable levee and access to the site for planting will be by truck and foot.

**HARD Marsh**

The Hayward Area Recreation and Park District Marsh (HARD Marsh) is located just south of Cogswell Marsh, just to the north of the San Mateo Bridge, and is adjacent to the Hayward Shoreline Interpretive Center (Figure 14). The Bay Trail runs along the southern edge of the marsh. This site is the property of the Hayward Area Recreation & Park District and is managed as part of the Hayward Regional Shoreline. HARD Marsh was restored to tidal action in 2002. Much of the marsh is wide, open mudflats at low tide, and the vegetation that has colonized appropriate areas is primarily perennial pickleweed. Several remnant higher elevation berms function as islands that extend north-south into the marsh interior.
While proximate to Cogswell Marsh, HARD Marsh was only moderately infested with hybrid *Spartina* and the site has received successful hybrid *Spartina* treatment since 2005. *G. stricta* is very limited at this site and no *S. foliosa* is present in the area. This site was planted for the first time in Year 3.

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 42 patches of *G. stricta* (including *D. spicata*) and 1,145 plugs of *S. foliosa* (over 2,000 plants total) were planted at this site (**Figure 14**). Patches of *G. stricta* were planted on higher elevation berms that function as islands. Plots of *S. foliosa* were planted primarily on mudflat areas and on the transition areas between mudflat and marsh plain. A few plots were located along channels. Half of the plantings were protected with rope caging, and half were left uncaged). Source *S. foliosa* populations planted at this site include Coyote Creek, Seminary Cove, Starkweather Cove, and Port Sonoma Marina. At this site, half of the *S. foliosa* plots were trimmed (i.e., upper portion of leaves were cut off).


Over 2,700 plants including 45 patches of *G. stricta* (including *D. spicata*) and 1,500 plugs of *S. foliosa* are planned for installation at HARD Marsh in Year 4. Due to the low elevation of the marsh plain, planting of *G. stricta* patches will likely be limited to higher elevation areas along remnant berms. Plots of *S. foliosa* will continue to be planted throughout the site in areas with appropriate elevation.

As expected for a recently restored marsh, California Ridgway’s rails have only been detected sporadically at this marsh (one detection in 2012, no detections in 2013 or 2014). Given the low number of rails detected (one individual detected) this site may be planted during a later planting date (after February 1).

The perimeter of this site is drivable levee and access to the site for planting will be by truck and foot.

**4.6 Hayward Regional Shoreline: Oro Loma**

Oro Loma Marsh is a restoration marsh located at the northern end of Hayward Regional Shoreline (**Figure 14**). The site is bordered to the north by a sewage treatment plant (Oro Loma Sanitary District), and to the south by Sulphur Creek. The San Francisco Bay Trail runs along the levee that separates this marsh from the bay. A levee that separated Oro Loma East and West was partly removed to restore tidal flow between the two sites in 1997. During construction, the site was graded to include channels and higher elevation mounds or “refugial islands”, primarily on the west side of the marsh. The eastern side of the marsh is generally higher in elevation, has more stable substrate, and more developed marsh vegetation, including extensive stands of *G. stricta*. The recently restored mudflats in the western portion of this site were heavily invaded by hybrid *Spartina* and treatment has been ongoing at this site since 2005. Plant survivorship in Oro Loma East for Year 1 and 2 ranged from 34% (after two seasons) to
78%, respectively. Survivorship in Oro Loma West was lower than Oro Loma East for Year 1 and 2 and ranged from 28% (after two seasons) to 50%, respectively.

**Oro Loma East**

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 36 patches of *G. stricta* (including *D. spicata*) were planted (over 900 plants total) at this site (**Figure 14**). Planting areas in Year 3 expanded on areas that were previously planted in Years 1 and 2.


Over 1,000 plants including 50 patches of *G. stricta* (including *D. spicata*) are planned for installation at Oro Loma East in Year 4. Planting will continue in previously planted areas with higher survivorship, and will be expanded into other areas with suitable elevation.

California Ridgway’s rails are present at this site in low numbers, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

The site is bordered by drivable levees and access to the site for planting will primarily be by truck and foot. The mudflats are quite soft in areas, and require experience in marsh walking as well as gear such as hip waders. Both an airboat and a Jon boat have been used to facilitate delivery of plants and installation crew.

**Oro Loma West**

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 11 patches of *G. stricta* (220 plants total) were planted at this site (**Figure 14**). The general elevation of the marsh plain is still too low to support *G. stricta* in most areas. Because of this, appropriate planting locations were limited to the higher elevation refuge islands.


An estimated 20 patches of *G. stricta* (400 plants total) are planned for installation at Oro Loma West in Year 4. Due to the low elevation of the marsh plain, planting of *G. stricta* patches will likely continue to be limited to the higher elevation refuge islands.

California Ridgway’s rails are present at this site in low numbers, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

The site is bordered by drivable levees and access to the site for planting will primarily be by truck and foot. The mudflats are quite soft in areas, and require experience in marsh walking as well as gear such as hip waders. An airboat has been used to facilitate delivery of plants and installation crew at this site.
4.7 Eden Landing Ecological Reserve

All the revegetation sites included in this section are part of the 5,000 acre Eden Landing Ecological Reserve, which is managed by the California Department of Fish and Wildlife (CDFW) and located just south of the San Mateo Bridge in Hayward, California (Figure 15). The core of the Reserve includes the former Baumberg Tract salt ponds that are now part of the South Bay Salt Pond Restoration Project. Hybrid Spartina invaded the Reserve as in other locations, however, treatment has been very effective here. As most of the sites are young restoration marshes (except for the two Whale’s Tail sites) most sites have abundant perennial pickleweed in areas that have restored to the appropriate marsh plain elevation but are lacking in other native marsh species. Planting at these sites has included G. stricta where there is opportunity, and at one site, upland transition zone plantings. The main focus of planting is to introduce S. foliosa to provide propagules that will help establish cordgrass throughout this complex of future marshes.

Whales Tail North

Whales Tail North is an older, restored marsh bounded between the recently re-engineered mouth of Mt. Eden Creek to the north and the mouth of Old Alameda Creek to the south (Figure 15). On the east side is a recently graded levee that separates the site from two newly breached former salt ponds (Ponds E8A and E9). Across Old Alameda Creek to the south is Whale’s Tail South. These two older mature restoration sites are named for their shapes, which resemble the two flukes of a whale’s tail. Both sites were formerly diked areas that were restored to tidal action in the 1940s by unintentional breaches that were not repaired.

As a mature restoration marsh, Whale’s Tail North has a well-developed marsh plain primarily vegetated with perennial pickleweed and an extensive network of marsh plain channels with abundant G. stricta in some areas. This site had no S. foliosa prior to ISP planting efforts due to invasion by hybrid Spartina, which outcompeted any native S. foliosa.

Year 1 and 2 plant survivorship for G. stricta ranged from 43% (after two seasons) to 83%, respectively. In Year 1 and 2, survivorship of S. foliosa plantings was very low (0 and 18%, respectively).

Year 3 (2013-2014) Installation

In Year 3 of the program, 10 patches of G. stricta and 1,215 plugs of S. foliosa (over 1,400 plants total) were planted at this site (Figure 15). Patches of G. stricta were planted along channel edges. Plots of S. foliosa were planted in three different habitat types in order to increase the chances of survivorship: 1) on channel edges (all protected by plastic mesh caging), 2) on the
Figure 15. Year 1 to 3 Completed Planting and Year 4 New Revegetation Sites Map at the Eden Landing Ecological Reserve
bayfront edge of the marsh, and 3) in salt pans (half protected by rope caging). Source *S. foliosa* populations planted at this site include Alviso Slough, Seminary Cove, Golden Gate Fields and Napa River. Trimming was conducted on half of the *S. foliosa* plots planted in both salt pans and on the bayfront edge of the marsh (i.e., upper portion of leaves were cut off).


Over 1,700 plants including 35 patches of *G. stricta* (including *D. spicata*) and 900 plugs of *S. foliosa* are planned for installation at Whale’s Tail North in Year 4. Due to previous low survivorship, plots of *S. foliosa* will continue to be targeted in different habitat types throughout the site in areas with appropriate elevation to increase the chance of survivorship.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

A boat is required to access this site due to a breach at the northeast corner of the marsh. A number of boats have been used for access including a Jon boat, kayaks and an Achilles Inflatable two-chamber pontoon boat. As in previous years, plant delivery is anticipated to be by airboat one day prior to planting. Plants will be staged along the remnant levee on the east side of the marsh plain. The site also has numerous channels that need to be crossed throughout the marsh plain.

**Whales Tail South**

Whales Tail South is an older, restored marsh bounded between the mouth of Old Alameda Creek to the north and by former salt ponds to the south (*Figure 15*). To the east is a former salt pond restored to tidal action in 1998, known as Cargill Mitigation Marsh. Across Old Alameda Creek to the north is Whale’s Tail North. As a mature restoration marsh, Whales Tail South has a well-developed marsh plain primarily vegetated with perennial pickleweed and an extensive network of interior channels with abundant *G. stricta* in some areas. This site had no *S. foliosa* prior to ISP planting efforts due to invasion by hybrid *Spartina*, which outcompeted native *S. foliosa*.

Year 1 and 2 plant survivorship for *G. stricta* ranged from 21% (after two seasons) to 75%, respectively. Survivorship for upland transition zone plantings was 65% after two seasons. For Year 1 and 2 plantings, survivorship of *S. foliosa* plantings was very low (0 and 9%, respectively).

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 43 patches of *G. stricta* and 1,575 plugs of *S. foliosa* (over 2,900 plants total) were planted at this site (*Figure 15*). Patches of *G. stricta* were planted along channel edges. Plots of *S. foliosa* were planted in three different habitat types in order to increase the chances of survivorship: 1) on channel edges (half protected by plastic mesh caging), 2) on the bayfront edge of the marsh, and 3) in salt pans (half protected by rope caging). Source *S. foliosa* populations planted at this site include Coyote Creek, Golden Gate Fields, Starkweather Cove,
and Napa River. Trimming was conducted on half of the *S. foliosa* plots planted in both salt pans and on the bay front edge of the marsh (i.e., upper portion of leaves were cut off).


Over 2,300 plants including 45 patches of *G. stricta* (including *D. spicata*) and 900 plugs of *S. foliosa* are planned for installation at Whale’s Tail South in Year 4. Due to previous low survivorship, plots of *S. foliosa* will continue to be planted in different habitat types throughout the site, in areas with appropriate elevation, to increase the chance of survivorship.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

Access to the northwestern part of the site is via a drivable levee. This site is also partly accessed via a walkable levee on the east side of the marsh. However, numerous channels need to be crossed to completely access the marsh plain. In Year 2 of the program, a new temporary wooden foot bridge was constructed by the plant installation crew to facilitate access across a breach in the levee and provide easier access to the marsh interior.

**Cargill Mitigation Marsh**

Cargill Mitigation Marsh is a 49-acre former solar salt production evaporator pond that was restored to be completely tidal in 1998. The site is bounded to the north by a levee along the Old Alameda Creek channel, on the west by Whale’s Tail South, and to the east and south by former salt production ponds (*Figure 15*). The site is surrounded by levees, with two breach points on the western levee that drain the site into Whale’s Tail South. Once opened to tidal action, the site became heavily invaded by hybrid *Spartina*. Treatment of hybrid *Spartina* has been very successful at this site, allowing for the reintroduction of *S. foliosa* here. Cargill was planted for the first time in Year 2 of the program. As a young restoration marsh, some of the site is likely still at too low an elevation to support marsh plain vegetation, however, perennial pickleweed is rapidly becoming abundant in some areas, and portions of the marsh appear to be at an elevation appropriate for *G. stricta*. Much of the site appears to be at an appropriate elevation for *S. foliosa*. Year 2 plant survivorship for *G. stricta* plantings was 77%. Year 2 survivorship of *S. foliosa* plantings was very low (8%).

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 25 patches of *G. stricta* (including *D. spicata*) and 830 plugs of *S. foliosa* (over 1,400 plants total) were planted at this site (*Figure 15*). Patches of *G. stricta* were planted along channel edges. Plots of *S. foliosa* were planted primarily in two different habitat types: 1) mudflats, and 2) in salt pans. All plantings were protected by rope caging. Source *S. foliosa* populations planted at this site include Coyote Creek, Golden Gate Fields, Starkweather Cove, and Napa River.

Over 1,800 plants including 30 patches of *G. stricta* and 1,200 plugs of *S. foliosa* are planned for installation at Cargill in Year 4. Due to low survivorship, plots of *S. foliosa* will continue to be planted in different habitat types throughout the site, and in areas with appropriate elevation to increase the chance of survivorship.

California Ridgway’s rails have not been detected during surveys at this site in recent years, thus planting can take place after February 1, if necessary.

The site is bordered by levees that can be accessed by truck and foot. The marsh interior and mudflats are quite soft in areas, and thus require experience in marsh walking as well as gear such as hip or chest waders, especially for planting *S. foliosa*.

North Creek Marsh

North Creek Marsh is a former salt pond located in the northeastern portion of Eden Landing that was restored in 2006 (Figure 15). This timing coincided with high hybrid *Spartina* infestation levels in the Eden Landing area, and the site was immediately invaded. Effective hybrid *Spartina* control has occurred there since 2008, and the area is now suitable for the reintroduction of *S. foliosa*. Because restoration is still in the early stages, the site is primarily channel and mudflat, with rapidly expanding areas of perennial pickleweed in the upper mudflats. The site lacks a developed marsh plain and has low native marsh species diversity.

Elevation data collected at this site indicates that the majority of the site is at an appropriate elevation for *S. foliosa* plantings. With little existing *S. foliosa* within the Eden Landing Ecological Reserve, this site would serve as a propagule source for restoration sites throughout the Reserve.

Year 1 and 2 plant survivorship for *G. stricta* ranged from 22% to 34%, respectively. In Year 1 and 2, survivorship of *S. foliosa* plantings was 57% (after two seasons) and 46%, respectively.

Year 3 (2013-2014) Installation

In Year 3 of the program, 34 patches of *G. stricta* (including *D. spicata*) and over 1,180 plugs of *S. foliosa* (over 1,970 plants total) were planted at this site (Figure 15). Patches of *G. stricta* were planted along channel edges and along a bordering levee. Plots of *S. foliosa* were planted in both mudflat areas and transitional areas between mudflat and marsh plain elevation. Half of the plantings were protected by rope caging. Source *S. foliosa* populations planted at this site include Alviso Slough, Port Sonoma Marina, Starkweather Cove, and Napa River.


Approximately 2,400 plugs of *S. foliosa* are planned for installation at North Creek Marsh in Year 4. Patches of *G. stricta* are not planned for installation in Year 4 due to lack of suitable planting elevations in the marsh plain.
As a young restoration site, California Ridgway’s rail are not expected to be present (and have not been detected during surveys) until the marsh plain reaches an elevation that can support native marsh vegetation at a density and with sufficient vertical structure to be suitable. Thus planting can take place during the breeding season, after January 31, if necessary.

The site is bordered by levees that can be accessed by truck and foot. The levee on the west side of the marsh is all-weather and accessible during rain. Use of the access road on the east side requires dry weather and, because it is restricted in width and functions as a public trail, cannot have any vehicles parked along it. The marsh interior and mudflats are quite soft in areas, and thus require experience in marsh walking as well as gear such as hip or chest waders, especially for planting *S. foliosa*.

**Mt. Eden Creek**

As part of Phase 1 of the South Bay Salt Pond Restoration Project, the mouth of Mt. Eden Creek was re-engineered, and an adjacent salt pond (E9) was breached so that it flows into Mt. Eden Creek near the mouth. The creek runs more or less east-west between multiple former salt ponds in the northern part of the Reserve (Figure 15). The creek is bounded by levees on both sides, with an expanse of marsh plain, vegetated primarily with perennial pickleweed, on the south side near the mouth. A former creek channel separates this marsh plain from a large open mudflat area. Treatment of hybrid *Spartina* along Mt. Eden Creek has been effective, and this site is now appropriate for *S. foliosa* reintroduction.

Year 1 and 2 plant survivorship for *G. stricta* ranged from 29% (after two seasons) to 69%, respectively. For Year 1 and 2 plantings, survivorship of *S. foliosa* was 30% (after two seasons) and 35%, respectively.

**Year 3 (2013-2014) Installation**

In Year 3 of the program, seven patches of *G. stricta* (including *D. spicata*) and 1,200 plugs of *S. foliosa* (over 1,380 plants total) were planted (Figure 15). Patches of *G. stricta* were planted along channel edges. Plots of *S. foliosa* were planted in both mudflat areas and transitional areas between mudflat and marsh plain elevation. Half of the plantings were protected by rope caging. Source *S. foliosa* populations planted at this site include Napa River, Permanente Creek, Seminary Cove and Napa River.


Approximately 1,480 plants, including 10 patches of *G. stricta* (including *D. spicata*) and 1,200 plugs of *S. foliosa*, are planned for installation at Mt. Eden Creek in Year 4.

California Ridgway’s rails have not been detected at this site during the last three years of surveys (2012 through 2014); however, there have been detections of low numbers of birds in some years prior to that. Given the three years since detection and the previous low density of rails, this site is proposed for planting during the early breeding season (after February 1).
The site is bordered to the south by a levee that can be accessed by truck and foot. The mudflats are quite soft in areas, and thus require experience in marsh walking as well as gear such as hip waders, especially for planting *S. foliosa*.

**Mt. Eden Creek Marsh and Mt. Eden Creek Muted Marsh**

Mt. Eden Creek Marsh and Mt. Eden Creek Muted Marsh are located in the northern part of the Eden Landing Ecological Reserve at the upstream end of Mt. Eden Creek (*Figure 15*). The upland transition zone area that borders this site to the west has been extensively planted by Save The Bay. Mt. Eden Creek Marsh and Mt. Eden Creek Muted Marsh are separated by a drivable levee that includes the culvert through which tidal waters enter the muted marsh. While these very young restoration sites will not likely support California Ridgway’s rail in the short-term, establishing *S. foliosa* here will provide propagules for restoration sites throughout the Reserve. Additionally, given the location immediately inside the Reserve’s main public access point, the site could function as a demonstration site for public outreach about the ISP Revegetation Program and specifically for *S. foliosa* plantings. This site was planted for the first time in Year 3 of the program.

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 960 plugs of *S. foliosa* were planted at this site (*Figure 15*). Plots of *S. foliosa* were planted along the perimeter of this site, which is primarily a large mudflat. Half of the plantings were protected with rope caging, with half left uncaged. Source *S. foliosa* populations planted at this site include Coyote Creek, Port Sonoma Marina, Golden Gate Fields, and Napa River.


Approximately 1,200 plugs of *S. foliosa* are planned for installation at Mt. Eden Creek Marsh and Mt. Eden Creek Muted Marsh in Year 4. Due to the low elevation of this site in general, plots of *S. foliosa* will continue to be planted around the perimeter.

As expected for a recently restored marsh, California Ridgway’s rails have not been detected at this site. Rails are not expected to be present until the marsh plain reaches an elevation that can support native marsh vegetation at a density and with sufficient vertical structure to be suitable. This site is thus designated as a “late” planting site that may be planted after February 1.

The site is bordered on several sides by drivable levee and access to the site for planting will be by truck and foot.

**Ponds E8A, E9, E8X and North Creek—New 2014-2015 Sites**

Ponds E8A, E9, and E8X are recently breached former salt ponds restored to tidal action in 2012-13. North Creek was restored to tidal action in 2006, and is the entry point for tidal waters entering North Creek Marsh and the eastern breaches of E8A and E8X (*Figure 15*).

Approximately 1,600 plugs of *S. foliosa* are proposed for installation at these sites in Year 4. These sites are scheduled to be the final planting sites for this season, so plant material will be allocated here depending on remaining availability.

As newly breached restoration sites with primarily open mudflat habitat, California Ridgway's rails are not expected to be present, and planting can take place during rail breeding season (i.e., after February 1).

Access to these sites will be primarily by boat – likely Jon boat or airboat. A drivable levee is located along the northern edge of ponds E9 and E8X which may be used for access to these sites during planting and potentially for boat launching. Because these are new sites for the revegetation program, access routes will be determined during groundtruthing.

### 4.8 Robert’s Landing

The Robert’s Landing Complex (also known as the San Leandro Shoreline Marshlands) in the City of San Leandro, includes four ISP revegetation sites: Citation Marsh, North Marsh, Bunker Marsh, and San Lorenzo Creek Mouth (Figure 16). Citation, North, and Bunker Marshes are restoration marshes that were restored in the mid-1990s. None of the Robert’s Landing marshes are currently approved for hybrid *Spartina* treatment. San Lorenzo Creek Mouth and North Marsh were not planted in Year 3 of the program, and will not be planted in Year 4 for several reasons, including the lack of planting opportunities, and low *G. stricta* survivorship.

**Citation Marsh**

Citation Marsh is the easternmost marsh at Robert’s Landing and is bordered by residential development and railroad tracks to the east, North Marsh to the west, and a paved portion of the San Francisco Bay Trail to the south (Figure 16). The marsh plain is vegetated primarily with perennial pickleweed, and there is one main north-south channel that bisects the site. On the west side of the channel is a large mudflat area, and on the east of the channel, in the southeastern portion of the marsh, are several large salt pans. Upland areas on the marsh plain include
Figure 16. Year 2 and Year 3 Completed Planting and Year 3 High Tide Refuge Island Locations at Robert’s Landing
several islands with primarily ruderal vegetation. Tidal flow is regulated with tide gates along the main channel in two locations, and as a result, portions of the marsh plain are infrequently inundated. Hybrid *Spartina* was treated at this site until 2011, however, no treatment has occurred since 2011 in the northern half of the site. In areas where treatment has continued, hybrid *Spartina* has been successfully removed and perennial pickleweed is abundant, but *G. stricta* is still limited. Planting of *G. stricta* was initiated at Citation Marsh in Year 2 of the program, and survivorship was 86%.

**Year 3 (2013-2014) Installation**

In Year 3 of the program, 31 patches of *G. stricta* (including *D. spicata*) were planted (over 650 plants total) at this site (Figure 16). Planting in Year 3 expanded on areas that were previously planted in Year 2.


An estimated 1,300 plants (65 patches of *G. stricta*) are planned for installation at Citation Marsh in Year 4. Plantings will continue in areas that were previously planted and expand to adjacent areas found to be at appropriate elevation during groundtruthing.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

The western side of this site is levee, and to the south is a paved section of the San Francisco Bay Trail and thus access to the site for planting can be by truck and foot. In addition, a Jon boat was used in Year 3 of the program to transport plants and installation crew to the planting areas using the main channel. This method of transport will be used again in Year 4.

**Bunker Marsh**

Bunker Marsh is the southwest portion of the Robert’s Landing restoration area and is surrounded by levees with an outlet to the south that drains to San Lorenzo Creek (Figure 16). This marsh is bordered by North Marsh to the north, East Marsh to the east, the bay front to the west, and San Lorenzo Creek to the south.

Hybrid *Spartina* was treated at this site until 2011, however, since then no *Spartina* treatment has been conducted. In areas where treatment occurred and hybrid *Spartina* was successfully removed, perennial pickleweed is abundant. *G. stricta* is also present along the main channel. A fairly wide and continuous upland transition zone, vegetated primarily with native plants, exists along the eastern side of the marsh.

Planting was initiated at Bunker Marsh in Year 2 of the program and survivorship of *G. stricta* for Year 2 was 56%.
**Year 3 (2013-2014) Installation**

In Year 3 of the program, 19 patches of *G. stricta* (including *D. spicata*) were planted (over 500 plants total) at this site *(Figure 16)*. Planting areas in Year 3 expanded on areas that were previously planted in Year 2.


An estimated 660 plants (33 patches of *G. stricta*) are planned for installation at Bunker Marsh in Year 4. Planting will continue in previously planted areas, and will be expanded into other areas with suitable elevation.

California Ridgway’s rails are present at this site, and every effort shall be made to complete plantings prior to the breeding season, which begins on February 1.

This site is bordered to the north by a paved section of the San Francisco Bay Trail and by levees on the west and east sides, and thus access to the site for planting will be by truck and foot.

### 4.9 San Leandro Bay

ISP revegetation sites in San Leandro Bay are small, lower elevation marsh fragments located in a highly urbanized area. The small marsh fragments present around San Leandro Bay today are all that remains of an extensive marsh complex that existed in this area historically. Arrowhead Marsh, MLK Restoration Marsh, and Damon Marsh are all part of the Martin Luther King Jr. Regional Shoreline managed by the East Bay Regional Park District in Oakland, California *(Figure 17)*. These sites are located between I-880 and Oakland Airport in a commercial and light industrial area that borders San Leandro Bay. Paved sections of the San Francisco Bay Trail border all of these sites. The Elsie Roemer Bird Sanctuary is located on the southwest edge of the City of Alameda and is managed as part of the Crown Memorial State Beach by the East Bay Regional Park District.

Several of the revegetation sites in San Leandro Bay are not currently approved for hybrid *Spartina* treatment (Damon Marsh, the eastern side of Arrowhead Marsh, and MLK Restoration Marsh). Damon Marsh and MLK Restoration Marsh were not planted in Year 3 of the program for several reasons, including the continuing presence of extensive hybrid *Spartina*, lack of planting opportunities, and low *G. stricta* survivorship from previous plantings. In Year 4 of the program, these sites as well as Arrowhead Marsh will not be planted for the same reasons.

**Arrowhead Marsh**

Arrowhead Marsh is a 47-acre marsh that supports a dense population of California Ridgway’s rails. Arrowhead Marsh was heavily invaded by non-native *Spartina* and, because of the high density population of Ridgway’s rails there, *Spartina* treatment was phased to reduce immediate habitat loss. The eastern half of the marsh was treated only for seed suppression (to stop seed production with reduced loss of vegetative cover), while the western half underwent
Figure 17. Year 1 to Year 3 Completed Planting and Year 2 and 3 High Tide Refuge Island Locations Map
full herbicide treatment to kill the hybrid *Spartina*. After several years of successful control, hybrid *Spartina* had been mostly removed from the western side of the marsh and several native plant species had colonized. In 2012, all treatment on the eastern half of Arrowhead Marsh was discontinued. With hybrid *Spartina* now uncontrolled on the eastern half of the marsh, invasion pressure on the west side has become severe and is slowing the passive native revegetation.

From 2010 to 2012, Save The Bay (STB), with logistical assistance from the ISP, installed native plants including *G. stricta* and *Triglochin maritima*, in the western portion of Arrowhead Marsh.

**Year 3 (2013-2014) Installation**

ISP initiated work at Arrowhead Marsh in Year 3, planting 30 patches (600 plants) of *G. stricta* (Figure 17). Areas planted in Year 3 expanded on areas that were previously planted by STB in Year 2.

Two high tide refuge islands were also constructed and planted with both *G. stricta* and *D. spicata* on the western side of Arrowhead Marsh in Year 3 (H.T. Harvey & Associates 2014b).


Due to continued low survivorship at this site, likely due to low elevation on the western side of Arrowhead Marsh, *G. stricta* is only successfully establishing in a few locations, and additional planting opportunities are extremely limited. As the focus of this program is to plant *G. stricta* and *S. foliosa*, with *G. stricta* plantings proving unsuccessful and *S. foliosa* planting being precluded due to the presence of uncontrolled hybrid *Spartina*, this site will not be planted in Year 4.

**Elsie Roemer**

Elsie Roemer Bird Sanctuary is located on the southwestern side of Alameda Island at the mouth of San Leandro Bay (Figure 17). This narrow, linear strip marsh extends along the shoreline, with the very narrow eastern portion managed by the City of Alameda and the slightly wider western portion managed primarily by the East Bay Regional Park District. The narrow fringe of vegetation is primarily perennial pickleweed with other native marsh species at the upper edge including *G. stricta*. The upper marsh edge is bordered by public trail and primarily ruderal vegetation. At the bayward edge of the marsh, sandy mudflats extend south toward the San Leandro Channel. At the peak of infestation, a dense hybrid *Spartina* meadow advanced out onto the mudflats, increasing the width of the marsh temporarily. The marsh itself is relatively new, accreting and expanding over the last several decades. Treatment of hybrid *Spartina* has occurred since 2005, and has been very successful, allowing the site to be selected for experimental reintroduction of *S. foliosa* in 2010.

In 2006, *G. stricta* was planted at this site by the ISP as part of a project that involved the construction of three marsh plain channels with the goal to temporarily enhance habitat for Ridgway’s rail during hybrid *Spartina* control. From 2010-2013, the site was planted with modest amounts of *S. foliosa* by researcher W. Thornton. In 2013, W. Thornton and collaborators from
UC Davis evaluated a number of metrics potentially influencing S. foliosa survivorship and establishment (Thornton in prep.). ISP continued with S. foliosa plantings in Year 3. Survivorship of S. foliosa plantings at this site has been generally low (Year 2 survivorship was 14%), likely due to several factors including high wave action and herbivory.

Year 3 (2013-2014) Installation
ISP planted 525 plugs of S. foliosa at Elsie Roemer in Year 3 (Figure 17), expanding on areas that were previously planted in Year 2. Plots of S. foliosa were planted at different elevations and protected using rope caging (half caged, half uncaged). In addition to rope caging, a wave attenuation treatment, in which bamboo was placed in front of plantings to form an L-shaped wall, was tested in 2014. This site was the last site planted in Year 3, and remaining available plant material from the propagation beds was used, resulting in a mix of S. foliosa source populations.

Approximately 600 plugs of S. foliosa are planned for installation at Elsie Roemer in Year 4. Due to previous low survivorship here, specific elevations for planting will be selected and wave attenuation and caging treatments will again be used in an effort to improve survivorship.

California Ridgway’s rails have not been detected at this site in recent years and planting can take place during rail breeding season (i.e., after February 1).

A city street and public trail runs the length of the area proposed for planting, so Elsie Roemer access will be by foot.
5 REFERENCES


Personal Communications


John Bourgeois, South Bay Salt Pond Project, California Coastal Conservancy, Oakland, CA.

H.T. Harvey & Associates, July 22, 2014. ISP Refuge Island Planning Meeting held at Coastal Conservancy office, Oakland, CA.

Debra Ayres, University of California Davis, Davis, CA.

Steve Bobzien, East Bay Regional Park District, Hayward, CA.

APPENDIX 1:

ISP Revegetation Program

Year 4 Revegetation Planting Designs

**Figure 1.** General Patch Design for *Grindelia stricta*. Each patch includes 20 *G. stricta* plants planted in two rows as shown (orange circles). In selected patches, two one-gallon pots of *Distichlis spicata* are planted as shown (brown triangles).

**Figure 2.** Patch Design for *Grindelia stricta* planted on higher elevation berms and islands in the marsh interior. Each patch includes 20 *G. stricta* plants planted in two rows as shown (orange circles). In selected patches, two one-gallon pots of *Distichlis spicata* are planted as shown (brown triangles).
Figure 3. Basic planting design for *Spartina foliosa* termed a plot. Each plot includes five plant plugs (green circles) from the same source population. This basic planting design was replicated in groups of two, four, six and eight during Year 1 to 3. These groups of plots are called a block and cages are constructed around blocks. In Year 4, blocks of four and six plots will be planted.

Figure 4. *Spartina foliosa* planting design with blocks of four plots, caged and uncaged. Each block has four plots, all from different source populations. Each plot has five plugs from the same source population. Other planting designs planned for Year 4 include the same design as above with one source population planted in all four plots for the two paired caged and uncaged blocks.
Figure 5. *Spartina foliosa* planting design with blocks of six plots, caged and uncaged. Each block has six plots, all from different source populations. Each plot has five plugs from the same source population.
APPENDIX 2:

Analysis of 2013 Revegetation Monitoring Data
APPENDIX 2: ANALYSIS OF 2013 REVEGETATION MONITORING DATA

San Francisco Estuary Invasive Spartina Project
Analysis of 2013 Revegetation Monitoring Data

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REPORT OVERVIEW

This report presents the analysis of monitoring data collected in the fall of 2013 for revegetation plantings installed by the Invasive Spartina Project (ISP) during the winters of 2011-2012 and 2012-2013. In addition to general survivorship information, this report assesses the influence of environmental factors and planting methods on plant survivorship. Other measurements of plant health are also examined, depending on the plant species. This report is divided into five sections. Section One provides a brief introduction to the revegetation program. Sections Two, Three, and Four provide detailed analysis results for the monitoring of native Pacific cordgrass (Spartina foliosa) plantings, marsh gumplant (Grindelia stricta) plantings, and upland transition zone plantings, respectively. Section Five provides recommendations for adaptive management actions in future years based on the results of this year’s monitoring. For more detailed information on the revegetation program, please refer to the California Clapper Rail Habitat Enhancement, Restoration, and Monitoring Plan (Olofson Environmental, Inc. 2012a) and the 2012-2013 California Clapper Rail Habitat Enhancement Plan (Olofson Environmental, Inc. 2012b).

1. INTRODUCTION

The ISP initiated a tidal marsh revegetation program in 2011 to rapidly enhance habitat for the endangered California Ridgway’s rail (Rallus obsoletus obsoletus)¹. The first major installation of native plants for the program began during the winter of 2011-2012. Additional plantings were installed during the winters (primarily from December through March) of 2012-2013 and 2013-2014. Within this report, we will refer to plantings completed in the winter of 2011-2012 as “Year 1” plantings, and those completed in the winter of 2012-2013 as “Year 2” plantings. Since the monitoring reported herein was completed in the fall of 2013, plantings completed in the winter of 2013-2014 (“Year 3”) are not included.

During Year 1 of the program, ISP and partners planted approximately 62,000 plants (counting S. foliosa as plugs) at sites around San Francisco Bay. In Year 2 of the program, ISP and partners planted approximately 103,000 plants. This monitoring report summarizes only data collected for plantings installed by the ISP.

With the goal of enhancing Ridgway’s rail habitat, three marsh elevation zones (low marsh, mid- and high-marsh, and upland transition zone) were planted during Year 1 and Year 2. Native S. foliosa was planted in the low to mid-marsh to provide Ridgway’s rail nesting substrate and foraging habitat. Spartina foliosa was planted at sites where both sufficient control of invasive hybrid S. alterniflora × foliosa has occurred and where S. foliosa is not present. Grindelia stricta was planted in the mid-marsh plain to provide nesting and roosting substrate and in the high marsh to provide high tide refuge for Ridgway’s rail. Grindelia stricta has been planted at all revegetation sites. Upland transition zone vegetation was planted at three sites to provide high tide refuge for Ridgway’s rail.

This report also briefly summarizes the results from monitoring of Year 1 plantings that occurred in the fall of 2012 (one growing season after planting). Complete results from the 2012 monitoring are reported in Lewis and Thornton (2013). Monitoring of Year 1 plantings occurred again in the fall of 2013 and those results are included in this report. Survivorship of Year 1 plantings for all species varied greatly among sites and among habitat types within each site. Results specific to S. foliosa

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¹ This subspecies was previously called the California clapper rail (Rallus longirostris obsoletus), until changed in 2014 by the American Ornithologists’ Union (Chesser et al. 2014)
indicate that native cordgrass propagated in nursery beds may have higher survivorship than cordgrass directly transplanted from donor source sites. Caging also improves plant survivorship, however, partner research with San Francisco State University’s Romberg Tiburon Center (RTC) found caging effects to be site specific. Results specific to Year 1 *G. stricta* plantings included (1) larger pot sizes generally had significantly higher survivorship than smaller pot sizes, (2) there was no significant difference in survivorship between the inner row and outer row of plantings, (3) differences in survivorship between planting zones varied by site, and (4) existing plant species may function as indicators of a location’s quality as a planting location for *G. stricta*. Monitoring results of the Year 1 upland transition zone plantings indicated that survivorship varied significantly among planted species. In addition, as part of the planting design, a constant distance was maintained between the inner and outer row of plants in a plot which influenced the elevation at which the outer row was planted. As a result, the outer row was often planted at a less suitable elevation for those species, which may have resulted in lower survivorship.

Informed by the results of the 2012 monitoring, the revegetation program expanded during the second winter (Year 2). In Year 2, the exploration of site-specific factors that influence establishment rates of both *S. foliosa* and *G. stricta* continued. For example, the relationship between planting elevations and survivorship was explored. In addition to increasing the number of *S. foliosa* plugs planted, the number of *S. foliosa* donor sources was increased to eight, and the performance of these eight sources relative to each other was monitored. Caging efforts for *S. foliosa* were expanded and the efficacy of two different types of caging (a rope cage and a plastic mesh cage) was explored. Other Year 2 treatments specific to *S. foliosa* looked at the influence of plug size and planting method (i.e., plugs planted with either burlap or bamboo for protection and anchoring) on plug survivorship. The effects of salt hardening, pot size and caging on *G. stricta* survivorship in the marsh plain were tested.

Mapping and monitoring of all plots was conducted using handheld mapping grade GPS units (Trimble Yuma 2, Trimble GeoXT, Juniper Archer + XF101). All data were collected in customized forms in ArcPad. Quality control was performed in ArcGIS 9.3 and all analyses were carried out using JMP statistical software (JMP, Version 11. SAS Institute Inc.).

## 2. SPARTINA FOLIOSA

### 2.1 OVERVIEW

In both the Year 1 and Year 2 planting seasons, *S. foliosa* designs tested multiple different transplant and planting techniques. The factors tested varied both by year and by site and changes to planting designs were made based on field observations and survivorship monitoring results. This adaptive management approach was developed in response to the relatively limited recent literature on native cordgrass restoration in San Francisco Estuary and the highly sensitive nature of native cordgrass restoration (Olofson Environmental, Inc. 2012a).

In Planting Year 1, *S. foliosa* was planted at six restoration marshes. Year 1 planting designs focused on improving restoration techniques by looking at the effect of transplant source, donor site, rope caging, restoration site, and planting amendments. During Year 1, planting designs were modified mid-season in an effort to decrease the amount of time needed for planting and field mapping. The basic design for Year 2 plantings was developed during the last planting efforts of the Year 1 field season. As a result, only three field sites (North Creek Marsh, Whales Tail North, and Whales Tail South) from the Year 1 field season were planted with methods analogous to those used during the Year 2 field season.
Spartina foliosa planting efforts quintupled in Year 2 (see Appendix I for a site list and numbers). Year 2 planting designs and the number of plugs installed at each site were informed by Year 1 survivorship. With the help of ISP’s Technical Advisory Committee, the following five main questions regarding planting S. foliosa were developed and explored during Year 2:

1. Do donor sources have different survivorship and growth rates?
2. To what extent does caging influence survivorship and growth rates of S. foliosa plantings?
3. Does initial plug size, subjective appearance (vigor), or height correlate with survivorship or growth characteristics?
4. Do anchoring treatments (burlap or bamboo) improve survivorship?
5. Do planting location (elevation), planting site, and caging interact?

As a result, five planting designs were developed for Year 2 plantings, with each design targeted to help answer one or more of the questions listed above.

This report documents findings from the 2013 monitoring of both Year 1 and Year 2 plantings. The majority of Year 1 plots were monitored during the fall of 2013 for survivorship. Year 1 plots at one site, North Creek Marsh, were monitored in early summer 2013 for both survivorship and growth metrics that included tiller number, stem number, stem width, and flower production. Year 2 plantings were monitored at all sites during fall of 2013 for both survivorship and growth metrics.

2.2 DESIGN AND OVERALL RESULTS

The basic planting unit for S. foliosa planting designs included a grouping of five plugs, termed a plot, as shown in Figure 1. Each plot was then planted with other plots in a block (typically 2, 4 or 8 plots). Plots were planted uniformly (same donor source or experimental treatment) and survivorship and growth metrics used for statistical analyses were calculated on averages of the five plugs planted into a plot (see Figure 1).

Each plot was individually flagged and mapped by ISP biologists prior to plant installation. During mapping, data was recorded on habitat type, vegetation proximity, sediment conditions, and proximity to channels for each plot. During installation, previously mapped plots were updated with data collected at the plot-level that included initial stem number, number of tillers, heights, and field notes.

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2Question 5 was developed as part of a collaboration with T. Grosholz (University of California at Davis), L. Feinstein (University of California at Davis) and W. Thornton (San Francisco State University’s Romberg Tiburon Center). Because this experiment is ongoing, results are not given in this report.

3 Three sites planted in 2011-2012 were not planted using a plot-based design (Alameda Flood Control Channel, Mt. Eden Creek, and Old Alameda Creek). For these sites, the only metric reported in this document is survivorship.
Monitoring of Year 1 plantings indicated that site and planting location within site were the strongest predictors of survivorship (see Lewis and Thornton 2012). In Year 2, planting designs were implemented that considered factors specific to a site, with five planting designs developed to target site-specific goals. Table 1 highlights *S. foliosa* installation differences between the two field seasons.

Table 1. Overview of differences in installation methods, planting numbers and planting designs in Year 1 and Year 2

<table>
<thead>
<tr>
<th>Factor</th>
<th>Planting Year 1 (Winter 2011-2012)</th>
<th>Planting Year 2 (Winter 2012-2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plugs Planted</td>
<td>Approximately 1,700 plugs&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Approximately 8,700 plugs&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Site Number</td>
<td>6 restoration sites</td>
<td>9 restoration sites</td>
</tr>
<tr>
<td>Basic Planting Unit</td>
<td>5 plugs per plot or 9 plugs per plot</td>
<td>5 plugs per plot</td>
</tr>
<tr>
<td>Cage Type</td>
<td>2-tiered rope caging only&lt;sup&gt;3&lt;/sup&gt;</td>
<td>3-tiered rope caging and plastic mesh caging</td>
</tr>
<tr>
<td>Donor Source</td>
<td>2 sources: Port Sonoma Marina and Golden Gate Fields.</td>
<td>8 sources: Port Sonoma Marina, Golden Gate Fields, Alviso Slough, Coyote Creek, Permanente Creek, Starkweather Marsh, Seminary Marsh, and Napa River.</td>
</tr>
<tr>
<td>Planting Amendments</td>
<td>Bamboo, Rock, Burlap</td>
<td>Burlap, Bamboo</td>
</tr>
<tr>
<td>Transplant Type</td>
<td>Direct transplants and nursery propagated donor material</td>
<td>Nursery propagated only</td>
</tr>
</tbody>
</table>

1. This total only includes ISP planting totals for Year 1. Research partners at RTC planted an additional 550 plugs during Year 1. All sources for this research were direct transplants.
2. This total includes Elsie Roemer (RTC partner research). Plants that were used at this site came from The Watershed Nursery in Richmond, California.
3. Plastic mesh caging (Vexar) was used in RTC partner research in Year 1 and informed the use of plastic mesh caging in Year 2.

### 2.3 DESIGN AND RESULTS FOR YEAR 1 (WINTER 2011-2012) PLANTINGS

#### 2.3.1 Monitoring Method

In 2013, most Year 1 planting blocks were only monitored for survivorship. All planting blocks at sites except North Creek Marsh were monitored in the late summer or early fall of 2013. North Creek Marsh
was monitored from May-June of 2013. In addition to early monitoring, this site was monitored for additional metrics including total stem (culm) number, stem height, and tiller number.

2.3.2 Overall Survivorship

Aggregating all sites, the mean survivorship of Year 1 plantings monitored in summer and fall of 2013 was 36.5%. This is a slight decline from the previous year’s 40.4% survivorship. Both Alameda Flood Control Channel and Mt. Eden Creek experienced no changes in total plug survivorship (Table 2). At North Creek Marsh there was a slight decline in survivorship and field observations suggested that decline was related to the low elevation of some plantings. At Old Alameda Creek, surviving blocks experienced a 50% decline, anecdotally this decline is also likely occurring at the lowest elevation plots. At the Whale’s Tail Complex, all remaining plants (n=4) died. Year 1 plantings at the two sites within the Whale’s Tail Complex were not caged, which may partly explain low survivorship.

Table 2. Survivorship of Year 1 (Winter 2011-2012) plantings. This table documents changes in Year 1 survivorship between the 2012 and 2013 monitoring events.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Number of Plugs Planted Year 1</th>
<th>Surviving Plugs in 2012</th>
<th>Survivorship in 2012</th>
<th>Surviving Plugs in 2013</th>
<th>Survivorship in 2013</th>
<th>% Change in Survivorship 2012 to 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alameda Flood Control Channel (AFCC)</td>
<td>327</td>
<td>220</td>
<td>67%</td>
<td>220</td>
<td>67%</td>
<td>0%</td>
</tr>
<tr>
<td>Old Alameda Creek (OAC)</td>
<td>351</td>
<td>81</td>
<td>23%</td>
<td>41</td>
<td>12%</td>
<td>-11%</td>
</tr>
<tr>
<td>Mount Eden Creek (MEC)</td>
<td>94</td>
<td>28</td>
<td>30%</td>
<td>28</td>
<td>30%</td>
<td>0%</td>
</tr>
<tr>
<td>North Creek Marsh (NCM)</td>
<td>605</td>
<td>363</td>
<td>60%</td>
<td>342</td>
<td>57%</td>
<td>-3%</td>
</tr>
<tr>
<td>Whale’s Tail Complex (North and South)</td>
<td>352</td>
<td>4</td>
<td>1%</td>
<td>0</td>
<td>0%</td>
<td>-1%</td>
</tr>
</tbody>
</table>

During 2013 monitoring, North Creek Marsh was the only site for which plot-level metrics beyond survivorship were appropriate to collect. At Old Alameda Creek and the Whale’s Tail complex survivorship was too low, and at Alameda Flood Control Channel and Mount Eden Creek plugs had expanded and coalesced to the point that observers were unable to determine which original plugs remained. By fall of 2013, the plantings at North Creek Marsh had coalesced as well, and this site was also not monitored on a per plot basis. Year 1 plantings will be monitored for metrics that describe plant expansion during the fall of 2014.

2.3.3 Results Specific to Year 1 Plantings at North Creek Marsh

There was a slight decline in survivorship at North Creek Marsh between the 2011 and 2012 monitoring events (3%). However, surviving S. foliosa plots rapidly expanded during this same time period. During the Year 1 planting effort, 2,542 stems were counted at installation (~20 stems per plot). During September 2012 monitoring, total stems had increased by 5% at this site. By the summer of 2013, there was an 80% increase in total stem number with 4,572 stems counted at this site (an average of 37 stems per plot).
The Year 1 planting design at North Creek Marsh looked at the influence on planting success of rope caging, planting method (i.e., burlap wrapped around the plug prior to planting), and direct transplants compared with nursery-propagated plant material. Generalized mixed modelling was used to determine what factors that were manipulated or recorded had a significant effect on *S. foliosa* stem number. The set of factors that resulted in the model with the lowest Akaike information criterion (AIC) score (and thus best explained variation in the data set) were caging, month of monitoring, and donor source.

**Caging**

During Year 1 planting, half of the planting blocks at North Creek were caged (n=10) using a 2-tiered rope design and half were uncaged (i.e., controls). During 2012 monitoring, there was a significant difference in survivorship between caged and uncaged blocks (Wilcoxon p<.01). During the 2013 monitoring event, differences in survivorship of the Year 1 plantings persisted, but did not increase between caged and uncaged plots. There were still persistent differences in stem number between caged and uncaged plots in 2013. **Figure 2** shows changes in mean stem count during four monitoring events for both caged and uncaged plots. The differences in mean stem count were normally distributed during the final round of monitoring between caged and uncaged plots, thus a paired t-test was run. A paired t-test found caging to be a significant factor on mean stem number at North Creek Marsh (p <.01).
**Donor Source**

*Spartina foliosa* plugs were collected from two donor sites in Year 1: Golden Gate Fields and Port Sonoma Marina. For each of these donor sites some plugs, referred to as nursery plugs, were propagated at a local native plant nursery⁴, and then planted into the revegetation sites five to seven months later. For comparison, some plugs, referred to as direct transplants, were also transplanted directly to the restoration site from the donor source after collection. Direct transplants were only planted into caged plots. Lewis and Thornton (2013) showed there were strong effects of transplant donor source on survivorship, with nursery-propagated plants having higher overall survivorship and varying significantly from Golden Gate Fields and Port Sonoma Marina direct transplants. However, when calculating differences in mean stem number for the 2012-2013 report, we found that both direct transplants from Port Sonoma Marina and Golden Gate Fields were planted at a statistically different lower stem density (Figure 3), which may have influenced the survivorship results for the previous year. In order to account for this, we ran an analysis of variance on change in stem number from initial planting to date of monitoring. Post hoc comparisons found there were no significant differences between the growth rate of nursery plants and direct transplants from Golden Gate Fields. However,

⁴ The primary native plant nursery for the program in 2012 and 2013 was The Watershed Nursery in Richmond, California. Unless otherwise noted, any mention of “nursery” refers to The Watershed Nursery.
there was a difference between the direct transplants from Port Sonoma Marina and the other three sources (direct transplants from Golden Gate Fields and nursery plants from Golden Gate Fields and Port Sonoma Marina).

**Interaction between Caging and Treatment Type**

Since caging was a strong predictor of performance, two separate analyses were conducted to look at the impact of nursery source and burlap packaging on caged and uncaged plots. No effect was observed for either of these treatments on caged plots. However, both of these treatments were found to be significant predictors of performance in uncaged plots using a paired t-test. **Figure 4** shows that nursery plants from Port Sonoma Marina had higher stem densities than Golden Gate Fields \((p=0.031)\).
Figure 4. Stem number of Year 1 (Winter 2011-2012) plantings at North Creek Marsh by nursery plant source. This graph only shows uncaged plots. Nursery plant source was found to be a significant predictor of stem number.

Figure 5. Stem number of Year 1 (Winter 2011-2012) plantings at North Creek Marsh using burlap packaging. This graph only shows uncaged plots. Container type was found to be a significant predictor of stem number in uncaged plots.
2.4 DESIGN AND OVERALL RESULTS FOR YEAR 2 (WINTER 2012-2013) PLANTINGS

2.4.1 Monitoring Method

Year 2 plantings were monitored in fall of 2013, and over 95 percent of plots (over 1,700 plots) were monitored (Table 3). For each monitored plot the following data was collected: number of surviving plugs (out of 5), total number of live stems (culms), height (in centimeters) of the tallest stem in each plug, number of tillers greater than 25 centimeters away from the center of originating plug, the distance of the furthest tiller away (minimum of 26 centimeters away), and the number of inflorescences produced. In addition to the fall 2013 monitoring event, several sites were also monitored in the spring and summer of 2013. This additional monitoring was made possible by research partnerships with San Francisco State University’s Romberg Tiburon Center and the University of California at Davis.

2.4.2 Statistical Method

Unless otherwise noted, data on the number of plugs surviving, flowers produced, and tillers counted were modeled with a zero-inflated Poisson distribution. Data on maximum and average culm heights as well as culm width were modeled assuming normal distribution of data. A generalized linear modeling approach was used and the model with the lowest AIC value was accepted. When significant differences were found in models, post-hoc comparisons were used to identify differences. All statistical analyses were conducted using JMP analytical software. An alpha level of 0.05 was considered significant. All graphs, unless otherwise noted, were constructed using 95% confidence intervals.

2.4.3 Overall Survivorship and Growth Rate

Aggregating all the sites, the mean survivorship of plots was 36.4% – nearly identical to Year 1 survivorship (36.5%). Alameda Flood Control Channel had the highest survivorship at 65.9%, and North Creek Marsh had the second highest survivorship at 46.5%. More than half of the S. foliosa plugs planted in Year 2 were planted at these two sites, and their relatively high survivorship rates tend to raise the mean survivorship for all sites (Table 3 and Figure 6).
Table 3. Summary of Year 2 number of plugs monitored, survivorship, and stem numbers.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Number of Plots</th>
<th>Total Number of Plugs</th>
<th>Mean Survivorship (%)</th>
<th>Mean Number of Stems per Plug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alameda Flood Control Channel (AFCC)</td>
<td>238</td>
<td>1190</td>
<td>65.9</td>
<td>60.9</td>
</tr>
<tr>
<td>Cargill Mitigation Marsh (CAMI)</td>
<td>166</td>
<td>830</td>
<td>8.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Cogswell Marsh (COGS)</td>
<td>64</td>
<td>320</td>
<td>26.3</td>
<td>10.4</td>
</tr>
<tr>
<td>Elsie Roemer (ERL)</td>
<td>96</td>
<td>480</td>
<td>14.0</td>
<td>3.4</td>
</tr>
<tr>
<td>Mount Eden Creek (MEC)</td>
<td>179</td>
<td>895</td>
<td>34.6</td>
<td>16.2</td>
</tr>
<tr>
<td>North Creek Marsh (NCM)</td>
<td>705</td>
<td>3525</td>
<td>46.5</td>
<td>35.3</td>
</tr>
<tr>
<td>Pond 3 (Pond 3)</td>
<td>10</td>
<td>50</td>
<td>8.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Whale's Tail North (WTN)</td>
<td>80</td>
<td>400</td>
<td>18.5</td>
<td>5.4</td>
</tr>
<tr>
<td>Whale's Tail South (WTS)</td>
<td>165</td>
<td>825</td>
<td>8.7</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>1703</strong></td>
<td><strong>8515</strong></td>
<td><strong>36.4</strong></td>
<td></td>
</tr>
</tbody>
</table>

1. Elsie Roemer plantings were part of a collaboration with T. Grosholz (University of California at Davis), L. Feinstein (University of California at Davis) and W. Thornton (San Francisco State University’s Romberg Tiburon Center) during Year 2 and totals from this site are not reflected in 2012-2013 planning documents.

2. At Pond 3, all plantings were uncaged.

Figure 6. Year 2 survivorship in fall of 2013. Site codes are abbreviated here, see Table 3 for site list.

Although our target of 40% survivorship for Year 2 plantings was not reached, there was a 33% increase in planted material at monitored plots due to plant expansion. The initial stem count conducted after planting for monitored plots was over 33,000 stems of *S. foliosa*. By fall 2013, stems counted during monitoring numbered over 44,000. However, growth primarily occurred at North Creek Marsh and the Alameda Flood Control Channel. **Figure 7** shows both the initial average stem number per plug, and the average stem number of surviving plugs during fall monitoring. It is important to note that this table does not represent a plot average, but rather marks the growth rate of
surviving plugs. Four sites (Alameda Flood Control Channel, Mt. Eden Creek, North Creek Marsh, and Cogswell) had significant increases in average stem count from initial planting (Wilcoxon p<0.05).

![Figure 7](image.png)

Figure 7. Average size of plugs in terms of stem number at planting and during October 2013 monitoring. Site codes are abbreviated here, see Table 3 for site list.

In order to determine which of the factors that were manipulated or recorded had a significant effect on *S. foliosa* survivorship, a model was generated using generalized linear regression. The resulting model included site, habitat type, caging, initial stem number, presence of vegetation, donor source (Alviso Slough, Napa River, Starkweather Marsh, and Coyote Creek), and substrate. Factors that were not found to be informative for *S. foliosa* survivorship included number of burrows, channel slope, tiller number, and initial stem height. As some treatments were only initiated at a few sites, these treatments were not included in the model. The factors excluded include caging type, wave action treatment, and absolute elevation effect on survivorship.

Five different habitat types were planted at the nine restoration sites in 2012-2013. Habitat type is highly correlated with site, with each site only having one to three of the habitat types noted in Figure 8. However, habitat type was found to be a significant predictor of survivorship (Kruskal-Wallis p<0.001). Two habitat types (channels under six meters and shoreline habitats) had significantly lower survivorship than the other three defined habitat types (Figure 8).
2.5 RESULTS FOR YEAR 2 (2012-2013) BY PLANTING DESIGN

2.5.1 Overview of Designs

Five planting designs were developed in Year 2 to help answer the questions outlined in Section 2.1. These designs were then tailored to restoration site constraints. For example, at sites with high survivorship, donor sources differences were evaluated to determine if certain sources had faster growth rates. At sites with low survivorship, planting designs were used that explored whether this was due to environmental factors or herbivory. Each planting design was planted at a minimum of two sites, with one site being North Creek Marsh (included as a control for design type). As Year 1 results indicated the greatest cause of variability in survivorship was planting location, all target treatments were randomized and planted in close proximity to each other. This approach, known as a randomized block design, improved the ability to detect differences in target treatments by including all treatments in a given block.

The planting designs were developed to answer five main questions that were developed with the help of the ISP Technical Advisory committee (Section 2.1).

2.5.2 Study Design 1: Donor Source Effect

Do donor sources have different survivorship and growth rates?

In Year 2, *S. foliosa* source material for outplanting was expanded to eight donor populations. All eight donor marshes were genetically tested and collected from during the spring of 2012. Collected plugs were then planted into nursery beds, to be grown under ideal conditions for a full growing season, in order to amplify the amount of plant material available for outplanting. Source material was collected from geographically distinct areas with three of the donor sources from the far South Bay (Alviso Slough, Coyote Creek, and Permanente Creek), three of the donor sources from isolated pocket marshes in the Central Bay (Seminary Marsh, Starkweather Marsh, and Golden Gate Fields), and two of the donor populations from the far North Bay (Port Sonoma Marina and Napa River). While the two sources used in Year 1 plantings (Golden Gate Fields and Port Sonoma Marina) exhibited fairly similar growth characteristics at both the source marsh and in the nursery beds, the new sources were observed...
to perform very differently in the nursery beds, in terms of bed density and stem height. See Appendix I for donor source information. See Thornton and Boyer (2013) for nursery performance information.

Between January and February 2013, plants in the nursery beds were outplanted at two marshes (Alameda Flood Control Channel and North Creek Marsh). All eight sources were planted into blocks, with planting position within the block randomized. Blocks were then protected using rope caging (Figure 9). Thirty blocks (1,200 plugs) were planted at each site, for a total of 60 blocks (2,400 plugs).

Figure 9. Year 2 (Winter 2012-2013) all source planting design planted at North Creek Marsh and Alameda Flood Control Channel. Each plot is shown in a different color indicating a difference donor source.

Blocks were then monitored quarterly through November 2013 for survivorship, growth rates, flower production, and stems heights. Analyses found at least one source varied significantly from the others on all of the above metrics (Kruskal-Wallis p<0.001). However, site was again found to be the strongest predictor of plant performance when data was modeled. Consequently, each site was analyzed separately.

For both sites, the Alviso Slough source produced significantly more stems than the other sources. This source also had the highest survivorship, produced the fewest flowers, and had the shortest culm height and narrowest culm width. For both sites, Starkweather Marsh and Coyote Creek had the lowest survivorship and growth rates. Figure 10 and Figure 11 show survivorship at North Creek Marsh and the Alameda Flood Control Channel.
Alviso Slough was the shortest of the sources during the initial planting event of Year 2. Because of the shorter, slighter stem size, Alviso Slough plants were planted at higher stem density than other sources to create a more substantial planting. Figure 12 shows this trend at North Creek Marsh. Confidence intervals were not shown on these graphs, but Starkweather Marsh, Alviso Slough, and Permanente Creek were all found to be statistically different from other sources in growth response. Alameda Flood Control Channel plantings showed the same trends, but were not included here.
Figure 12: Year 2 (Winter 2012-2013) plot stem number by monitoring date at North Creek Marsh. Confidence intervals are not shown on this graph, but during the final round of monitoring Alviso Slough, Permanente Creek and Starkweather Marsh were statistically different from all other sources.

Figure 13. Year 2 (Winter 2012-2013) average stem heights by source in October 2013 at North Creek Marsh. Alviso Slough is significantly different than other sources (p=.02). Site codes are abbreviated here, see Table 3 for site list.

While Alviso Slough did perform better for the metrics of survivorship and plant expansion, this source produced fewer flowers and remained the shortest in terms of culm height (Figure 13). When considering potential for rail habitat enhancement (i.e., better cover), plant height as well as stem density are important (Figure 14 and Figure 15).
Figure 14. Year 2 (Winter 2012-2013) number of flowers per *S. foliosa* stem by source planted at Alameda Flood Control Channel. Monitoring occurred in October 2013.

Figure 15. Year 2 (Winter 2012-2013) number of flowers per *S. foliosa* stem by source planted at North Creek Marsh. Monitoring occurred in October 2013.
2.5.3 Study Designs 2 and 3: Rope and Plastic Mesh Caging Effects

*To what extent does rope caging and plastic mesh caging improve survivorship?*

In Year 1, only one revegetation site was tested for the effectiveness of rope caging over the duration of the growing season. Partner research at five sites found caging needs to be site specific. In Year 2, the rope cage design was modified to include a 3-tiered roping strategy, and the effectiveness of rope caging was tested at three sites.

A smaller 0.5 meter cage that only protected five plants was developed to be used at high wave action shorelines and along narrow channel banks. This cage had walls made out of a durable plastic mesh (netting) material. In Year 2, this netting was 1/8 inch gauge and purchased from Memphis Netting and Twine. In previous reporting documents, this type of caging has been referred to as Vexar caging. This refers to the first material used for caging in partner research (Conwed Global Netting Solutions under the marketed Vexar™ brand). In this report, these cages will be referred to simply as plastic mesh. In Year 2, ISP piloted the use of plastic mesh cages at four restoration sites. Three of the sites were part of a larger study detailed in Appendix II.

The effectiveness of rope caging was tested at three sites, and the effectiveness of plastic mesh caging at four sites. At three of the mesh caging sites, the interaction between plastic mesh caging and marsh elevations was tested. This study design is explained in Appendix II.

The effect of rope caging on plant survivorship was tested at three sites. For each site, five blocks of caged *S. foliosa* were paired with five blocks of uncaged *S. foliosa*. Each block contained 40 native *S. foliosa* plugs from multiple donor sources. Even with this relatively small sample size, caging was found to be an explanatory variable in a general linear model (p<0.001). At North Creek Marsh and Cogswell Marsh caging also had a significant effect on plant height (p<0.001) with plants in cages producing taller stems (Figure 16). In this model both site and source were significant predictors of survivorship (Figure 17).
Figure 16. Effect of caging on Year 2 (Winter 2012-2013) *S. foliosa* plantings stem height at three sites. Monitoring occurred in October 2013. Site codes are abbreviated here, see Table 3 for site list.

Figure 17. Effect of caging on Year 2 (Winter 2012-2013) *S. foliosa* survivorship. Site codes are abbreviated here, see Table 3 for site list.
At Whale’s Tail North, planting efforts targeted narrow channels not suitable for rope caging. For this site, a 0.5 m² plastic mesh cage was used to protect a plot of five plugs. An unprotected plot of five plugs was placed within three meters of the caged plot. Distance varied between plots so that both plots could be planted at similar elevations. There was a sample size of 40 (400 total plugs) used for this design. Only one uncaged plot survived at this site (Figure 18).

Figure 18. Effect of caging on S. foliosa survivorship at Whale's Tail North

2.5.4 Study Design 4: Planting Method

Can anchoring treatments (burlap or bamboo) improve survivorship?

Does initial plug size, appearance, or height correlate with survivorship or growth characteristics?

Several weak trends were observed in Year 1 results including: (1) the effect that initial stem number had on plug survivorship and (2) the effect of the anchoring treatments burlap (described in Year 1 methods) and bamboo (a method in which S. foliosa is anchored to a bamboo stake) on survivorship.

In order to further look at the anchoring capabilities of burlap and bamboo, in Year 2 both a high wave action site (Mt. Eden Creek) and a low wave action site (North Creek Marsh) were planted. We planted three sources (Alviso Slough, Napa River, and Starkweather Marsh) into 12 plot blocks that were protected using rope caging. For each source, four plots were planted into the block (Figure 19). In one of the four plots, all five plugs were anchored to bamboo. In another of the four plots, all five plugs were wrapped in burlap. The other two plots for each source were planted without any special preparation to act as controls. Within a week of planting, the following data were collected from each plot: total number of live culms, height (in centimeters) of the tallest culm, and number of tillers.
For the control plots ("bare root"), individual plugs were monitored. Plugs were numbered 1 to 5 in a "Z" formation, and either the first plug was staked (North Creek Marsh) or the first or second plug was starred on a data sheet to indicate which was oriented closer to the channel (Mt. Eden Creek). Each plug had the following additional data collected: total number of live culms, number of live culms taller than 40 centimeters, height (in centimeters) of the tallest culm, and initial plug vigor. Vigor was scored on a 9 point scale (0 indicating that no culms were living) that broadly took into account (in the following order), appearance, average size of each culm, and number of culms. For consistency, all data up to this point were taken by one observer.

Fall monitoring data collection followed the general protocol for bamboo and burlap plots. For control (bare root) plots, each plug had the following additional data taken for it: total number of live culms and number of live culms taller than 40 centimeters.

The data that resulted from this planting design was difficult to interpret because both site and sources responded differently to treatments (with Alviso Slough responding differently from the other two sources). Due to the fact that Alviso Slough also performed differently from all other sources in the donor source experiment, Alviso Slough was analyzed separately from Napa River and Starkweather Marsh.

There was no effect of bamboo on stem number by source or by site. Figure 20 shows stem count monitoring results for the bamboo treatment by site (Mt. Eden Creek p=0.067, North Creek Marsh p=0.52).

For both the Napa River and Starkweather Marsh sources, there was a positive effect of burlap on stem counts at North Creek Marsh (p=0.034 and p=0.045, respectively). However, while there was a significant relationship for burlap and Napa River stem counts at Mt. Eden Creek (p=0.041), there was not a relationship between burlap and Starkweather Marsh stem counts at this site (Figure 21). There was no effect of burlap on Alviso Slough stem numbers at either site.
Figure 20. Effect of bamboo planting method on Year 2 (Winter 2012-2013) *S. foliosa* stem number at two sites. Monitoring occurred October 2013. Site codes are abbreviated here, see Table 3 for site list.

Figure 21. Effect of burlap planting method on Year 2 (Winter 2012-2013) *S. foliosa* stem number by site and source at two sites. Monitoring occurred in October 2013. Site codes are abbreviated here, see Table 3 for site list.

No correlation was found between initially planted stem number and monitored stem number the following October at Mt. Eden Creek. At North Creek Marsh, there was a weak relationship between
initially planted stem numbers and stem numbers counted the following October (Figure 22, $R^2=.11$, $p=.02$). However, this relationship was driven by the Alviso Slough source. When the Alviso Slough donor source was removed from data analysis there was no relationship between initial stem number and monitored stem number the following October. Therefore, Alviso Slough plots were analyzed separately. Alviso Slough plantings responded differently from the other two sources in this planting design. Napa River and Port Sonoma Marina plantings were not found to be statistically different from each other and so they are combined.

Figure 22. Correlation between initial stem number planted in Year 2 (Winter 2012-2013) and number of stems for two sites. Monitoring occurred during October 2013.

The regression shown in Figure 22 included all monitored plantings regardless of survivorship. The result suggests that planting location rather than plug number is more important for initial survivorship at these sites. In order to determine if plug number influenced growth rate or surviving plugs, a regression was done on only plugs with at least one stem present in October. Again, the only source for which a trend emerged was Alviso Slough (Figure 23, $R^2=.20$).
Regression analyses also found slight negative correlations between initial stem height and monitored stem number and between vigor assessments and stem number. An analysis of plant vigor included all sources, and found that plants that were predicted to have low survivorship (2-4) had the highest rates of survivorship and stem growth. Plants that were tall and robust rated higher on the vigor scale. However, this does not correlate to mean stem number during monitoring in October 2013 (Figure 24).


2.6 SUMMARY

Results from monitoring both years of plantings showed that site and planting location within site are the most important predictors of native cordgrass planting success. Sites with uniform mudflats and wide channel banks had the highest establishment rates. Plantings on smaller second-order channels and on bayfront edges had much lower establishment rates. At restoration sites with minimal mudflats and no wide channel banks, more experimentation may be required in order to increase survivorship. Research has also found strong effects of caging at some marshes. As strong but variable effects of caging between marshes have been found, it is recommended that caging continue to be used at sites with evidence of high grazing pressure (typically Canada Goose, *Branta canadensis*). Plastic mesh caging also appeared to be beneficial at sites with high potential for erosion or wave action. Methods of stabilizing sediment at these sites should be further explored. Donor source was found to be a strong driver of both survivorship and growth rate (based on stem counts). As donor sources were found to perform differently, multiple donor sources will be used at each site and a minimum of three donor sources will be used when evaluating treatments. The planting method of burlap packaging of plugs may have a positive effect on plant performance, but it is time consuming to prepare. This planting approach is recommended only for sites where survivorship is low. The planting method of bamboo did not have an effect on outplanting success and this method is not recommended for use by this program. Plug size was found to be weakly correlated with plant survivorship. However, this was not as strong as a predictor as planting location for plant survivorship. Thus, if resources are limited, planting in more locations may be more important than planting larger plugs to increase success. Finally, second year monitoring at North Creek Marsh found trends that were not discernible during first year monitoring. Thus, it is recommended that sites continue to be monitored regularly.
3. GRINDELIA STRICTA

3.1 OVERVIEW
In both years, multiple sizes of G. stricta pots were planted, with larger pots expected to provide larger above- and below-ground plant biomass. In Year 1, gallon pots (180 cubic inches of soil), D-16 pots (16 cubic inches), and “stubby” pots (7 cubic inches) were used. In Year 2, gallon pots and D-40 pots (40 cubic inches) were used. For both years, we tested the effect of pot size on survivorship and volume of G. stricta plants. In Year 1, all plantings were salt hardened. For Year 2, only 25 percent of the plants were salt hardened. During Year 2, to test whether salt hardening increased survivorship, salt hardened plants were mixed with non-salt hardened plants at four sites. At some sites, caging was tested for mound/berm plantings as a means of reducing herbivory. At these sites, some G. stricta patches were caged and some G. stricta patches were not caged. Typically, caging was alternated every other patch, leaving half of the patches caged and half uncaged. In Year 2, while flagging locations for installation of G. stricta patches, field staff recorded plant species that were already growing in each patch location. Correlations between presence of plant species and G. stricta survivorship were examined to determine which plant species may function as indicators for quality of G. stricta planting locations. Following survivorship monitoring, elevation data was collected (using an RTK or real-time kinematic satellite GPS unit) at two sites to examine correlations between elevation and survivorship.

3.2 DESIGN AND RESULTS FOR YEAR 1 (WINTER 2011-2012) PLANTINGS
The primary objective for monitoring the Year 1 plantings was to determine whether trends observed in the first year of monitoring continued into the second year and whether the more robust plantings of Year 1 were reaching a volume at which they might begin to provide habitat. For more information on the results of first year monitoring of the Year 1 plantings, please reference Appendix 1 of the 2011-2013 Installation Report and 2013-2014 Revegetation Plan: Analysis of 2012 Revegetation Monitoring Data (Lewis and Thornton 2013).

3.2.1 Planting Design
During the Year 1 planting season, G. stricta were planted in patches of ten plants in two rows, each row containing five plants. Along each row plants were planted 1.0 meter apart from one another and the two rows were 0.25 meters apart from one another. Plants were planted into two zones: the marsh plain, where plantings were along the edges of channels to provide nesting and high tide refuge habitat for Ridgway’s rail, and on mounds or berms which are areas of higher ground that are less frequently inundated that could provide refuge for Ridgway’s rail during both normal high tide and extreme high tide events. For marsh plain plantings, the row of plants that was closer to the channel was referred to as the inner row and for the mound and berm plantings the row of plants which was lower in elevation was referred to as the inner row. During Year 1, the inner rows of all plantings were 0.25 meters from the channel edge and the outer rows were planted 0.5 meters from the channel edge for all marsh plain plantings. For all mound and berm plantings, the inner row was considered to be the row that was at a lower elevation and the outer row was considered to be the row at a higher elevation. The biologist who was flagging an area to be planted selected the proper elevation for the lower, inner row based on their knowledge of G. stricta planting requirements. The outer, higher row was placed 0.5 meters from the inner row.
3.2.2 Monitoring Method

For the Year 1 *G. stricta* plantings, only the plantings which had 50% or greater survivorship during the 2012 monitoring were monitored during 2013. At each of these patches, total survivorship was monitored and morphology data (e.g., height and width) was collected for each of the three largest plants. Plots that were originally planted in Year 1 but then replanted in Year 2 were excluded from analysis, and these are addressed by a different analysis (see Section 3.4.1). During the second year of monitoring it was found that reliably identifying whether any individual plant pertains to the inner row or the outer row was no longer possible.

3.2.3 Results of 2013 Monitoring – Change in Survivorship from Year 1

At each of the monitored plots, surviving plants were counted during 2013 monitoring. These were compared with the survivorship data for each plot taken during 2012 monitoring. Sites where less than 10 plots were monitored during 2013 were excluded from analysis due to small sample size. Difference in survivorship from one year to the next was found to be normally distributed and paired t-tests were used to compare survivorship between the two years. Alameda Flood Control Channel (AFCC), Cogswell A, Cogswell C, Greco Island, and Whale’s Tail South had significant declines in *G. stricta* survivorship from 2012 to 2013. Mt. Eden Creek, Oro Loma East, and Whale’s Tail North had no significant change in survivorship between the two years. Oro Loma West had a statistically significant increase in survivorship from 2012 to 2013 (Figure 25 and Table 3). This is likely due to plants that visually appeared to have died during the first year of monitoring but were found to have survived in 2013. It should be noted that in some sites, particularly Oro Loma East, Oro Loma West, and Mt. Eden Creek, this analysis is based on a very small sample size and therefore, it may be difficult to extrapolate this limited data set into a characterization of an entire site. Despite the decline in survivorship seen at some sites, the majority of these sites continue to have survivorship higher than 40% after two years. The decrease in survivorship as plants reach a larger size may be partially attributed to intraspecific competition among the *G. stricta* plants as one reaches a considerably larger size than its neighbor. Due to the relatively small size of plants installed during Year 1, it is also likely that some of the plants were outcompeted by the canopy of perennial pickleweed (*Salicornia pacifica*) during the intervening growing season. Plants installed during subsequent years were considerably taller, which should reduce the negative impacts of *S. pacifica* canopy on *G. stricta* plantings.

Table 3. Change in *G. stricta* survivorship from 2012 to 2013

<table>
<thead>
<tr>
<th>Site</th>
<th>Mean Change In Survivorship</th>
<th>p value</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFCC</td>
<td>-10.00</td>
<td>0.0014</td>
<td>47</td>
</tr>
<tr>
<td>Cogswell A</td>
<td>-10.73</td>
<td>&lt;0.0001</td>
<td>82</td>
</tr>
<tr>
<td>Cogswell C</td>
<td>-8.21</td>
<td>0.0355</td>
<td>28</td>
</tr>
<tr>
<td>Greco Island</td>
<td>-12.17</td>
<td>0.0008</td>
<td>46</td>
</tr>
<tr>
<td>Mt. Eden Creek</td>
<td>no significant change</td>
<td>0.8269</td>
<td>24</td>
</tr>
<tr>
<td>Oro Loma East</td>
<td>no significant change</td>
<td>0.8477</td>
<td>19</td>
</tr>
<tr>
<td>Oro Loma West</td>
<td>10.50</td>
<td>0.0387</td>
<td>20</td>
</tr>
<tr>
<td>Whale's Tail North</td>
<td>no significant change</td>
<td>0.0803</td>
<td>132</td>
</tr>
<tr>
<td>Whale's Tail South</td>
<td>-20.53</td>
<td>&lt;0.0001</td>
<td>57</td>
</tr>
</tbody>
</table>
3.2.4 Plant Volume

Total plant volume was measured as a way to assess the function of planted *G. stricta* plots as potential rail habitat (e.g., available nesting and roosting cover). Volumes were examined in an attempt to identify early differences in *G. stricta* volume among sites and pot sizes. Height and width of each of the three largest plants in each plot were measured in the field. As it was no longer possible to state with certainty which plants were originally planted in the inner row and which were planted in the outer row, plots were compared based on whether or not each plot had gallons planted into it. The heights and widths were then converted into a measure of volume. Plots with less than three survivors were excluded from analysis. There is concern that assessing the volume of the largest three plants in each plot where there are a variable number of survivors may allow survivorship to stochastically influence total volume even though the number of plants measured remained constant. To account for this, a stepwise generalized linear model was run with site, number of survivors in 2013, and whether each plot contained gallons or stubbies entered as potential factors influencing total volume of the largest three plants. The model with the lowest AIC score included site, number of survivors in 2013, and whether each plot contained gallons, however, this model excluded whether each plot contained stubbies. In this model, both presence of gallons within each plot and the number of survivors in 2013 had a significant positive effect on volume, likely due to the aforementioned stochastic effects.
2012 monitoring, gallon pots were found to have significantly higher survivorship than D-40 pots. There is therefore a strong likelihood that differences in the volume found using this method are largely a product of the stochastic effects of a larger number of gallon pots surviving. With this large caveat, there were significant differences in mean total volume among sites (Kruskal-Wallis p<0.0001, Figure 26). The effect of gallons on volume varied among sites (Figure 27). At Whale’s Tail North, presence of gallons had a significant positive effect on volume (Kolmogorov-Smirnov p=0.0022). At Whale’s Tail South, there was a trend toward a positive effect of gallons on volume, but it fell short of statistical significance (p=0.0524). There was no apparent effect of gallons on volume at Cogswell A (Kolmogorov-Smirnov p=0.3879) or Greco Island (Kolmogorov-Smirnov p=0.2260). We will continue to monitor the effect of gallons on survivorship in future years, with modifications to the monitoring protocol to eliminate the interference of the aforementioned stochastic effects.
Figure 26. Mean total volume of largest three *G. stricta* plants in each plot by site.

Figure 27. Total volume of largest three *G. stricta* plants by site and by whether plots contain gallon pots.
3.3 DESIGN AND OVERALL RESULTS FOR YEAR 2 (WINTER 2012-2013)

3.3.1 Planting Design

As during the previous year, during the Year 2 planting season, *G. stricta* was planted in plots of ten plants in two rows, each row containing five plants (Figure 28). Along each marsh plain row plants were planted 1.0 meter apart from one another and the two rows were 0.25 meters apart from one another. For the marsh plain plantings during Year 2, the placement of the inner row of each planting was between approximately 0.25 meters and 0.5 meters from the channel edge, as deemed appropriate by field staff. In the mound and berm plantings, the inner row of each planting was placed as deemed appropriate by biologists based on their knowledge of *G. stricta* planting requirements and the outer row was placed 0.5 meters from the inner row. The majority of *G. stricta* planted during Year 2 were salt hardened. However, to test the efficacy of salt hardening in improving survivorship, at sections of Bunker Marsh, North Marsh, Greco Marsh, and Cogswell B, non-salt hardened plants were planted in the marsh plain. In these sections, pairs of salt-hardened and non-salt hardened plots were planted in an alternating pattern to make certain that they were evenly distributed spatially. In some of the mound and berm planting areas, the efficacy of caging as a method of reducing herbivory and increasing survivorship was tested. In these areas, plots were alternately caged or uncaged. For further information on planting design, please reference the 2012-2013 California Clapper Rail Habitat Enhancement Plan.

![Figure 28. Year 2 (Winter 2012-2013) G. stricta marsh plain planting design](image-url)
3.3.2 Monitoring Method

A power analysis was performed with the previous year’s data in order to determine the target number of patches that needed to be monitored in order to capture a confidence interval for survivorship that had less than a 10% margin of error in either direction. This target number for monitoring (N) was exceeded at all sites. All patches were monitored for survivorship. At Bair B2 North, Cogswell A, Mt. Eden Creek, and Whale’s Tail South, plantings were also monitored for morphological data, with measurements of height and width of each plant taken in order to calculate volume.

3.3.2 Overall Survivorship

Aggregating all sites, overall survivorship was 54.6%, which exceeds the program target goal of 40% survivorship. Overall survivorship was considerably higher than the previous year’s survivorship of 31.6%. At 15 of the 20 sites where G. stricta was planted, survivorship exceeded the target of 40% (Table 4 and Figure 29). Three sites (Damon Marsh, MLK Restoration, and North Marsh) fell considerably below our target (these sites had 10% survivorship or less). It is possible that these sites lack suitable locations for planting G. stricta, whether due to inappropriate elevation, soil characteristics, or competitive exclusion by hybrid S. alterniflora x foliosa. Greco Island and North Creek Marsh fell somewhat below our target survivorship (30% and 34% respectively). To determine what factors that were manipulated or recorded had a significant effect of G. stricta survivorship, a stepwise generalized linear regression was conducted. The resulting model included site, planting zone, salt hardening, caging, pot size, presence of S. foliosa, presence of existing G. stricta, presence of alkali heath (Frankenia salina), presence of saltgrass (Distichlis spicata), presence of Jaumea carnosa, and presence of alkali Russian thistle (Salsola soda). Factors that were not found to be informative for G. stricta survivorship included nursery source, presence of S. alterniflora x foliosa, presence of S. pacifica, presence of seaside alkali grass (Puccinellia maritima), presence of California sea lavender (Limonium californicum), presence of Algerian sea lavender (Limonium ramossissum), and presence of fat-hen (Atriplex prostrata). While presence of hybrid S. alterniflora x foliosa did not turn out to be informative to the model, it is possible that, because hybrid Spartina was much more abundant near the plantings at Damon Marsh than at any other site, the effect of hybrid Spartina was lost in the site effect of Damon Marsh.

Table 4. Survivorship of G. stricta plots by site (Year 2 plantings)

<table>
<thead>
<tr>
<th>Site</th>
<th>Mean Survivorship (%)</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
<th>N (plots monitored)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFCC</td>
<td>76.25</td>
<td>68.33</td>
<td>84.17</td>
<td>40</td>
</tr>
<tr>
<td>AFCC Pond 3</td>
<td>75.00</td>
<td>67.18</td>
<td>82.82</td>
<td>20</td>
</tr>
<tr>
<td>Bair B2 North</td>
<td>61.00</td>
<td>54.30</td>
<td>67.70</td>
<td>100</td>
</tr>
<tr>
<td>Bunker</td>
<td>55.87</td>
<td>45.40</td>
<td>66.34</td>
<td>46</td>
</tr>
<tr>
<td>Cargill</td>
<td>77.71</td>
<td>69.59</td>
<td>85.84</td>
<td>35</td>
</tr>
<tr>
<td>Citation</td>
<td>85.82</td>
<td>81.12</td>
<td>90.52</td>
<td>55</td>
</tr>
<tr>
<td>Cogswell A</td>
<td>64.46</td>
<td>59.68</td>
<td>69.24</td>
<td>130</td>
</tr>
<tr>
<td>Cogswell B</td>
<td>56.44</td>
<td>52.66</td>
<td>60.21</td>
<td>289</td>
</tr>
<tr>
<td>Cogswell C</td>
<td>55.06</td>
<td>50.36</td>
<td>59.76</td>
<td>176</td>
</tr>
<tr>
<td>Damon</td>
<td>10.24</td>
<td>4.26</td>
<td>16.22</td>
<td>42</td>
</tr>
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</table>
## APPENDIX 2: ANALYSIS OF 2013 REVEGETATION MONITORING DATA

<table>
<thead>
<tr>
<th>Location</th>
<th>Greco</th>
<th>MLK Restoration</th>
<th>Mt. Eden Creek</th>
<th>North</th>
<th>North Creek Marsh</th>
<th>Oro Loma East</th>
<th>Oro Loma West</th>
<th>San Lorenzo Creek Mouth</th>
<th>Whale's Tail North</th>
<th>Whale's Tail South</th>
<th>Overall</th>
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<tbody>
<tr>
<td></td>
<td>29.95</td>
<td>6.84</td>
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<td></td>
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<td>29.15</td>
<td>72.92</td>
<td>43.01</td>
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<td></td>
<td>33.86</td>
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<td>38.52</td>
<td>83.19</td>
<td>56.66</td>
<td>90.89</td>
<td>89.25</td>
<td>83.72</td>
<td>56.21</td>
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<tr>
<td></td>
<td>190</td>
<td>19</td>
<td>127</td>
<td>52</td>
<td>206</td>
<td>113</td>
<td>122</td>
<td>42</td>
<td>49</td>
<td>52</td>
<td>1905</td>
</tr>
</tbody>
</table>

Figure 29. Survivorship of Year 2 (Winter 2012-2013) *G. stricta* by site
3.4 RESULTS FOR YEAR 2 (2012-2013) BY PLANTING DESIGN

3.4.1 Survivorship of Year 1 (Winter 2011-2012) Planting Patches that were Replanted in Year 2 (Winter 2012-2013)

The differences between survivorship in 2012 and survivorship in 2013 were normally distributed, therefore a series of paired t tests were used to compare differences in survivorship between the two years. At all sites except Greco Island, there was a significant increase in survivorship after replantings were conducted (Figure 30). At Greco Island, there was no significant difference in survivorship between the two years. While replanting during Year 2 resulted in an increase in survivorship, the method of replanting directly into the previous year’s plot was logistically complicated during both installation and monitoring. Therefore, in future years we will not be replanting directly into existing plots.

![Figure 30](image)

Figure 30. Survivorship of Year 1 (Winter 2011-2012) plots that were replanted in Year 2 (Winter 2012-2013) by site

3.4.2 Planting Zone Effect

At Cargill Mitigation Marsh, Cogswell B, Cogswell C, and Mt. Eden Creek, there were substantial numbers of *G. stricta* planted in both the marsh plain zone and the mound and berm zone. Distribution was non-normal and at some sites variances were unequal according to Levene’s test, therefore differences between survivorship of the marsh plain and the mound and berm plantings were examined within each site using Kolmogorov-Smirnov tests (Figure 31). At Cogswell B, there was significantly higher survivorship for the marsh plain plantings than the mound and berm plantings (p=0.0308), but there was no significant difference in survivorship between the two zones at Cargill Mitigation Marsh (p=0.2393), Cogswell C (p=0.8158), or Mt. Eden Creek (p=0.5583).
3.4.3 Salt Hardening Effect

We tested the effect of salt hardening on *G. stricta* survivorship at four sites: Bunker Marsh, Citation Marsh, Cogswell B, and Greco Island. Within a section of each of these sites, we planted paired plots of salt hardened and non-salt hardened D-40 pots of *G. stricta*. Pairs of plots were located in close geographic proximity, typically on either side of a channel. The number of plots varied by site: Bunker Marsh had 19 plots of each treatment, Citation Marsh had 20, Cogswell B had 32, and Greco Island had 39. Conditions including elevation, soils, and existing plant community varied enough between each plot within a pair that it was determined that a pairwise comparison would be inappropriate. Because distribution of survivorship was non-normal at all sites and the two treatments had unequal variances at Citation Marsh and at Greco Island, a nonparametric one-sided Kolmogorov-Smirnov test was used to compare survivorship of the two treatments within each site (Figure 32). Salt hardened plots were found to have significantly higher survivorship at Bunker Marsh (p=0.0344), Citation Marsh (p=0.0002), and Greco Island (p=0.0318). At Cogswell B, however, no significant difference in survivorship between the two treatments was observed (p=0.2597). Speculatively, the lack of effect of salt hardening on *G. stricta* survivorship at Cogswell B could be due to the fact that Cogswell was planted much earlier in the winter and received early winter rains shortly after planting that may have reduced the shock of planting into saline soil. The 2013-2014 *G. stricta* plantings will continue to test the effect of salt hardening on survivorship.
Both the effect of pot size on *G. stricta* survivorship and the effect of pot size on *G. stricta* mean plant volume were examined. While survivorship was monitored at all sites, plant volume was only monitored at Bair B2 North, Cogswell A, Mt. Eden Creek, and Whale’s Tail South. The two pot sizes of *G. stricta* for comparison were D-40 pots and gallon pots. While many plots contained D-40 pots in both rows, mixed pot size plots contained one row of gallons and one row of D-40s, typically alternating what was planted on the outer row and what was planted on the inner row. Because these gallon-containing mixed pot size plots were often preferentially planted into the areas that were considered to be the most ideal during ground truthing, it was inappropriate to compare mixed pot size plots with plots that exclusively contained D-40 pots. Therefore, comparisons between survivorship and volume of the two pot sizes were made using a pairwise comparison of survivorship between the two rows among the mixed plots. Because the differences in survivorship and plant volume between the two pot sizes were determined by graphical analysis to be normally distributed, pairwise t-tests were used as the basis of comparison between the two pot sizes.

In the aggregation of all plots, gallons had a higher survivorship (56.12%) than D-40s (51.20%) and this relationship was statistically significant (p<0.0001). This relationship was true both for the plantings in the marsh plain (p<0.0001) and the plantings on mounds and berms (p=0.0063). The pattern is less apparent, however, when examining individual sites. Of the 19 sites where gallons were planted, 12 sites did not show a significant difference in survivorship between the two pot sizes.
Gallons had significantly higher survivorship at six sites: Alameda Flood Control Channel (p=0.0437, n=35), Cogswell A (p<0.0001, n=84), Cogswell B (p<0.0001, n=72), Mt. Eden Creek (p=0.02222, n=100), North Creek Marsh (p=0.0209, n=57), and Whale’s Tail North (p=0.0045, n=37). At Oro Loma East, D40s were found to have significantly higher survivorship than gallons (p=0.0093, n=35).

Gallons also had significantly greater volume than D-40s. This was found to be true at all sites where volume was monitored including Bair B2 North (p=0.0450, n=10), Cogswell A (p=0.0002, n=75), Mt. Eden Creek (p=0.0001, n=43), and Whale’s Tail South (p<0.0001, n=38) as shown on Figure 33.

![Figure 33](image-url)

Figure 33. Mean volume of G. stricta plants by pot size and site

### 3.4.5 Caging Effect

Caging was used exclusively for mound and berm plantings. At some sites, all plants were caged, but to test the effect of caging on survivorship, caging was tested at four sites: Cogswell B, Mt. Eden Creek, North Creek Marsh, and Oro Loma West. At these sites, some plots were caged and others were left without cages. To remove the potential confounding factor of pot size, only D-40 plots were included in this analysis. At all sites, survivorship data was not normally distributed but Levene’s tests showed no evidence of unequal variance between the caged and uncaged treatments, therefore a chi-square approximation Wilcoxon ranked sum test was used to examine differences between the two treatments within each site (Figure 34). At North Creek Marsh, caged plants had significantly higher survivorship than uncaged plants (p<0.0001). At Cogswell B, there was a slight trend toward greater survivorship of the caged plants, but this was not statistically significant (p=0.0884). However, at Mt. Eden Creek, there was a trend toward greater survivorship in the uncaged plants, though this also fell
short of statistical significance (p=0.0534). At Oro Loma West, there was no difference in survivorship between caged plants and uncaged plants (p=0.6700).

Figure 34. Effect of caging on *G. stricta* survivorship

### 3.4.6 Existing Vegetation Effect

Due to the high degree of variation in site conditions, plant conditions, and planting method, vegetation was looked at in the context of the generalized linear model described in Section 3.3.2. Plant species that were determined to be informative to survivorship were included in a generalized linear model which also included site, planting zone, salt hardening, caging, and pot size. Presence of *S. foliosa* was found to have a negative effect on *G. stricta* survivorship. This is likely due to *S. foliosa* functioning as an indicator of an elevation that is lower than what is ideal for *G. stricta*. Previously, existing *G. stricta*, *F. salina*, *D. spicata*, *J. carnosa*, and *S. soda* were found to have a positive effect on the survivorship of *G. stricta* plantings (Table 5). From the previous year’s monitoring results, it was known that *F. salina* and *J. carnosa* had a positive correlation with survivorship and that *S. foliosa* had a negative correlation with survivorship. For Year 1 plantings, *S. pacifica* also had a negative correlation with survivorship; the lack of negative correlation between *S. pacifica* presence and *G. stricta* survivorship in the Year 2 plantings may be due to the greater height of the plantings that was above the level of the *S. pacifica* canopy or may simply be an artifact of the ubiquity of *S. pacifica* at these sites. Otherwise, results from Year 2 monitoring reinforce and expand upon the results of Year 1 monitoring.
Table 5 Effect of existing plant species on *G. stricta* Year 2 plantings survivorship

<table>
<thead>
<tr>
<th>Species</th>
<th>Effect on <em>G. stricta</em> Survivorship</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Spartina foliosa</em></td>
<td>-3.57%</td>
<td>1.96</td>
</tr>
<tr>
<td><em>Grindelia stricta</em></td>
<td>+5.44%</td>
<td>3.01</td>
</tr>
<tr>
<td><em>Frankenia salina</em></td>
<td>+2.54%</td>
<td>1.08</td>
</tr>
<tr>
<td><em>Distichlis spicata</em></td>
<td>+4.28%</td>
<td>1.65</td>
</tr>
<tr>
<td><em>Jaumea carnosa</em></td>
<td>+4.32%</td>
<td>1.12</td>
</tr>
<tr>
<td><em>Salsola soda</em></td>
<td>+8.12%</td>
<td>3.26</td>
</tr>
</tbody>
</table>

3.4.7 Elevation Effect

At two sites, Bunker Marsh and Greco Island, elevation measurements were taken on a subset of *G. stricta* patches using a Leica CS-15 RTK unit. Elevation data were recorded at plots planted with both salt hardened and non-salt hardened plants for the salt hardening study. At each plot, elevations were taken at both the lowest point and the highest point planted within that plot. The mean of these two elevation measurements was the basis of subsequent analysis. The effect of elevation on *G. stricta* survivorship was analyzed using a generalized linear model. In a model that incorporated only the effect of elevation on *G. stricta* survivorship, elevation was found to have a significant effect on survivorship (p<0.0001) and to explain a large portion of the variance in survivorship (R² = 0.5055). When a model incorporated both elevation and salt hardening, somewhat more of the variance in survivorship was explained (R² = 0.6085), but a model incorporating only salt hardening explained relatively little variance in survivorship (R² = 0.1556, Figure 35).

Figure 35. Effect of elevation on *G. stricta* survivorship
5.5 SUMMARY

Sites (such as Damon Marsh and MLK Restoration) which exhibited particularly low survivorship of Year 2 plantings may not be suited to further planting of *G. stricta* unless there are available suitable planting locations (potentially as a result of sufficient control of *S. alterniflora x foliosa* infestation). Results from monitoring the Year 2 plantings demonstrate that salt hardening may be an effective means to increase survivorship at some sites. Caging does not appear to have a strong effect on *G. stricta* survivorship. Use of caging should be considered only for those sites where herbivory might have a strong negative effect on survivorship. Existing plant species continued to have a correlation with *G. stricta* survivorship, reinforcing that several “indicator” species are a good proxy for habitat quality. The results of the Year 2 monitoring expanded our understanding of indicator species. The use of indicator species is part of the current protocol for selecting planting locations and the function of indicator species should be reviewed every year with all biologists who are engaged in field selection of planting locations. Larger pot sizes increased first year survivorship and mean plant volume, and may increase second year plant volume. While use of larger pots and the use of salt hardening seem beneficial to *G. stricta* survivorship, the cost per plant is higher; therefore decisions regarding pot size should be looked at in an overall cost/benefit framework. Elevation plays a strong role in survivorship of *G. stricta* and an understanding of proper planting elevations at each site has the potential to greatly improve survivorship. It is recommended that RTK elevation data for *G. stricta* plots be collected for a wider selection of sites to achieve a better understanding of the influence of elevation on survivorship across many sites. This knowledge may be combined with existing elevation datasets to select ideal planting areas within each site prior to ground truthing. The methods used to monitor the Year 1 plantings during their second planting year resulted in data that is somewhat difficult to interpret. Morphological data collected during subsequent years preferably would include all living plants within a subset of plots (i.e., smaller number) rather than data on a subset of plants at a larger number of plots.
4. UPLAND TRANSITION ZONE

4.1 OVERVIEW

During both Year 1 and Year 2, three sites had upland transition zone plantings installed. The Year 2 upland transition zone plantings may be considered to be replantings of the Year 1 upland transition zone plantings. Since there was relatively low survivorship in the upland transition zone during Year 1, the Year 2 upland transition zone plantings were planted directly on top or adjacent to the Year 1 plantings. Results of the 2013 upland transition zone monitoring were analyzed for survivorship by site and for differences in survivorship among upland transition zone plant species.

4.2 DESIGN AND OVERALL RESULTS

4.2.1 Planting Design

Each upland transition zone plot contained ten plants, planted in two rows of five. The lower elevation inner row contained five *G. stricta* plants and the higher elevation outer row contained a mixture of three species: one *G. stricta* plant, two California sagebrush (*Artemisia californica*) plants, two marsh baccharis (*Baccharis douglasii*) plants and 18 ramets of *D. spicata* (Figure 36). For the Year 1 upland transition zone plantings, the distance between the two rows was held at a constant one meter, but slope appeared to have some effect on survivorship. This was likely due to the changes in slope changing the elevation into which the upper row was planted. Therefore, during Year 2, the distance between the two rows was allowed to vary as much as deemed appropriate by field staff in order to plant outer row plants at an appropriate elevation. The Year 2 upland transition zone plantings at both Bair B2 North and Whale’s Tail South both received watering treatments during the winter they were planted.

![Figure 36. Year 2 (Winter 2012-2013) Upland Transition Zone planting design](image-url)
4.2.2 Survivorship By Site

At all sites, overall survivorship for the upland transition zone plantings exceeded the 40% survivorship goal. There were significant differences among sites in total upland transition zone plant survivorship (Van der Waeden p<0.0001, Table 6), in survivorship of the inner *G. stricta* row of plants (Van der Waeden p<0.0001), and in survivorship of the outer mixed species row of plants (Van der Waeden p<0.0001, Figure 37).

Table 6 Survivorship of Upland Transition Zone Plantings

<table>
<thead>
<tr>
<th>Site</th>
<th>Overall %</th>
<th>Inner (G. stricta) Row %</th>
<th>Outer (Mixed species) Row %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bair B2 North</td>
<td>56.62</td>
<td>66.09</td>
<td>46.96</td>
</tr>
<tr>
<td>Cogswell A</td>
<td>43.21</td>
<td>70.19</td>
<td>16.23</td>
</tr>
<tr>
<td>Whale's Tail South</td>
<td>64.89</td>
<td>90.38</td>
<td>34.55</td>
</tr>
</tbody>
</table>

Figure 37. Survivorship of Upland Transition Zone plantings

4.2.3 Survivorship By Species

Examining the individual species that comprise the outer row, there were significant differences among sites in survivorship of outer row *G. stricta* (Van der Waeden p<0.0001), in survivorship of *A. californica* (Van der Waeden p<0.0001), and in survivorship of *B. douglasii* (Van der Waeden p=0.0127, Figure 38). In addition to overall survivorship numbers varying among sites, patterns of
outer row species’ survivorship were different at the three different sites. Survivorship of *G. stricta* in the outer row was considerably lower at Cogswell A than at either Bair B2 North or at Whale’s Tail South. At Cogswell A, *A. californica* had far lower survivorship than the other two species, but at Whale’s Tail South, *A. californica* had far higher survivorship than the other two species. Survivorship of *B. douglasii* was much higher at Bair B2 North than at Cogswell A, with survivorship at Whale’s Tail South somewhere between the two. It is possible that the watering treatments applied to Bair B2 North and Whale’s Tail South increased survivorship of *A. californica* relative to Cogswell A.

Figure 38. Survivorship of species in outer row by site

**4:3 SUMMARY**

We do not currently have any plans to plant in the upland transition zone in the coming years. However, any future upland transition zone plantings may be informed by the differences among sites in survivorship of each of these species in order to select site-appropriate planting palettes. The experience of monitoring the upland transition zone plots also suggests that changes in planting and mapping design, such as mapping plantings as larger plots, may improve monitoring field efficiency. Because it is suspected that watering treatments improved survivorship at two of the three sites, any future upland transition zone plantings should be considered for watering if budget, time and access allow.
5. PROGRAM MANAGEMENT RECOMMENDATIONS

5.1 OVERALL RECOMMENDATIONS

1. For all revegetation efforts, site and planting location within site are the most important predictors of planting success. It is recommended that ISP continue to have planting designs that consider site-specific factors.

2. Using existing established plants can aid in selecting suitable planting locations during ground-truthing and it is recommended that existing vegetation continues to be used as a guide.

3. Elevation appears to play a strong role in survivorship of both *S. foliosa* and *G. stricta*, and an understanding of proper planting elevation at each site has the potential to greatly improve survivorship. It is recommended that RTK elevation data be collected for a wider selection of sites to achieve a better understanding of the influence of elevation on survivorship across many sites. It is recommended that use of this device first be expanded at sites where target survivorship goals have not been met.

4. Use of caging should be considered for those sites where herbivory might have a strong negative impact on survivorship.

5.2 SPARTINA FOLIOSA

1. Sites with uniform mudflats and wide channel banks had the highest establishment with much lower establishment rates for second order channels and on bayfront edges. At revegetation sites that do not have mudflats or wide channel banks, more experimentation may be needed in order to increase survivorship.

2. Strong effects of caging have been found at some marshes. However, these cage effects vary by marsh. It is recommended that caging continue to be used at sites with high grazing pressure (typically by Canada Goose).

3. Plastic mesh (Vexar) caging appeared to be beneficial at sites with erosion or wave action concerns. It is recommended that methods of stabilizing sediment in these areas be further explored. However, this method of caging is much less cost effective than rope caging, and thus, it should only be used when rope caging is not appropriate.

4. Donor source is a strong driver of survivorship and growth rate. Donor sources also behaved differently in some experiments. It is thus recommended that at least three donor sources be used in all experimental treatments and that multiple donors are used at each site. It is also recommended that donor sources continue to be monitored in order to ensure that they achieve heights that are suitable for providing habitat that can support California Ridgway’s rail.

5. The planting method of burlap packaging can have a positive effect on plant performance. However, this method is time consuming. It is recommended that this approach only be attempted at sites where survivorship is low.

6. The planting method of bamboo did not have an effect on outplanting success. It is recommended that this method not be employed in the future.

7. Plug size was weakly correlated with plant survivorship. However, this was not as strong of a predictor as planting location for plant survivorship. Thus, if resources are limited, planting in more locations, rather than planting larger plugs may increase success.

8. Finally, second year monitoring at North Creek Marsh found trends that were not discernible during the first year monitoring event. Thus, it is recommended that sites continue to be monitored regularly.
5.2 GRINDELIA STRICTA

1. Sites (such as Damon Marsh and MLK Restoration) that exhibited particularly low survivorship of Year 2 plantings may not be suited to further planting of *G. stricta* unless there are appropriate planting locations (potentially as a result of sufficient control of *S. alterniflora* x *foliosa* infestation).

2. Salt hardening may be an effective means to increase survivorship at some sites. This is being further tested in the 2013-2014 plantings.

3. Caging does not appear to have a strong effect on *G. stricta* survivorship. Use of caging should be considered only for those sites where herbivory might have a strong negative impact on survivorship.

4. Existing plant species continued to be correlated with *G. stricta* survivorship, reinforcing that those “indicator” species are a good proxy for planting location quality. The use of indicator species is part of the current protocol for selecting planting locations and the function of indicator species should be reviewed every year with all biologists who are engaged in field selection of planting locations.

5. Larger pot sizes increase first year survivorship and mean plant volume, and may increase second year plant volume. While use of larger pots and the use of salt hardening seem beneficial to *G. stricta* survivorship, the cost per plant is higher and decisions regarding pot size should be looked at in an overall cost/benefit framework.

6. The methods used to monitor the Year 1 *G. stricta* plantings during their second planting year resulted in data that is somewhat difficult to interpret. If morphology data is monitored during subsequent years, it would be better to take morphology data on all living plants within a smaller number of plots than to take morphology data on a subset of plants at a larger number of plots.

5.3 UPLAND TRANSITION ZONE

We do not currently have any plans to plant in the upland transition zone in the coming years. However, any future upland transition zone plantings may be informed by the differences among sites in survivorship of each of these species in order to select site-appropriate planting palettes.
6. REFERENCES


APPENDIX I:

Spartina foliosa Donor Source Information
APPENDIX 2: ANALYSIS OF 2013 REVEGETATION MONITORING DATA
APPENDIX I: DONOR SOURCE INFORMATION

Purpose of Document
This document provides a brief description of the eight sites that were selected as donor populations for *S. foliosa* restoration efforts in Year 1 (winter 2011-2012) and Year 2 (winter 2012-2013). Figure 1 provides a map of site locations. All donor populations were genetically sampled to confirm that collection occurred in pure *S. foliosa* stands. Sites were chosen based on several considerations including distance from known hybrid *Spartina*, abundance of potential donor material, and California Ridgway’s rail presence (locations chosen for collection were not known to support nesting California Ridgway’s rail).

In Year 1, two sources (Golden Gate Fields and Port Sonoma Marina) were planted in six restoration marshes. In Year 2, eight sources (Golden Gate Fields, Port Sonoma Marina, Alviso Slough, Permanente Creek, Coyote Marsh, Seminary Marsh, Starkweather Marsh, and Napa River) were planted at nine restoration marshes. Table 1 itemizes donor sources planted at each restoration site. Half of the *S. foliosa* plants from Year 1 and all of *S. foliosa* plants for Year 2 were propagated in nursery beds prior to outplanting in order to amplify restoration material and reduce impact to donor marshes.

Central Bay and South Bay Locations

Golden Gate Fields Marsh: Albany, CA
Golden Gate Fields is a four-acre pocket marsh with muted tidal action that is isolated from the City of Albany shoreline by a two-lane road. Tidal waters flow into this marsh through two culverts. The marsh is a meadow of *S. foliosa* mixed with *Salicornia pacifica* (perennial pickleweed). No hybrid *Spartina* has ever been detected within this marsh. This site was chosen due to the location in the central Bay and proximity to ISP restoration sites. The site was also chosen because annual surveys have not detected presence of California Ridgway’s rail.

Permanente Creek: Mountain View, CA
The collection area for this site is a one-meter-wide band of *S. foliosa* located along the narrow upstream reach of Permanente Creek that is bordered by golf course on both sides. *S. foliosa* grows tall at this site likely due to golf course and urban runoff that is typically low in salinity and high in nitrogen. The collection area was over 1000 meters from known hybrid *Spartina* and has been genetically sampled since 2008. The upstream reach of Permanente Creek where collection occurred is unsuitable habitat for California Ridgway’s rail.

Alviso Slough: Don Edwards San Francisco Bay National Wildlife Refuge, CA
The collection area for this site is a one-half- to one-meter-wide band of *S. foliosa* that occurs along the upstream reach of Alviso Slough. The collection area is brackish as indicated by the co-occurrence of *S. foliosa* and sedge species such as *Bolboschoenus maritimus*. The collection area was located 1,000 meters upstream from the nearest known hybrid *Spartina*. Although this site was not expected to have California Ridgway’s rail, ISP conducted a survey prior to collection to verify that no rail were present.

Coyote Creek: Don Edwards San Francisco Bay National Wildlife Refuge, CA
The collection area at this site consists of a three-meter-wide band of *S. foliosa* along the south bank of Coyote Creek just east of Artesian Slough/Mallard Slough. *S. foliosa* grows in a uniform and almost continuous band along the creek bank at this location. The collection area was located 800 meters...
upstream from the nearest known hybrid *Spartina* location. Due to the upstream location of the collection area, salinity levels are lower and *Bolboschoenus maritimus* co-occurs with *S. foliosa*. 2012 rail surveys conducted by USFWS did not detect Ridgway’s rail at the site, however, ISP conducted a survey prior to collection to verify that Ridgway’s rail were not present. Under Refuge staff direction, prior to collection, ISP also conducted a survey for western snowy plover (*Charadrius nivosus nivosus*) along the levee access route out to the collection area.

**North Bay Locations**

**Port Sonoma Marina: Sonoma, CA**

The collection area at this site was originally dredged to be a marina (adjacent to the current Port Sonoma Marina near the mouth of the Petaluma River) but is not currently in use. *S. foliosa* that occurs at this site is rapidly colonizing the area, grows uniformly and has long rhizomes. The collection area was located over 1,000 meters from the nearest known hybrid *Spartina*.

**Starkweather Marsh: Marin, CA**

Starkweather Marsh is a 15-year-old restoration marsh with muted tidal flows via two underground culverts that connect to San Francisco Bay. No hybrid *Spartina* has been detected at this site, however, there was a sizeable *S. densiflora* infestation. The *S. densiflora* invasion has significantly decreased and the marsh is currently vegetated primarily with *S. pacifica* and a wide band of *S. foliosa* in a ring around a central mudflat. Observation of the wide band of *S. foliosa* indicates that it is rapidly expanding. Due to the small size, surrounding developed land uses and distance to other marshes, this marsh is unlikely to support breeding Ridgway’s rail. ISP surveys at this site have not detected Ridgway’s rail.

**Seminary Cove: Marin, CA**

Seminary Cove (also known as Strawberry Marsh) is a small bounded historic marsh adjacent to Highway 101 in Tiburon. This relatively small marsh has a complex channel network allowing full tidal exchange through a wide breach in an outboard levee. The site has many ponds, covering about 30% of the site. Observed salinity in these ponds is higher than seawater for most of year. A short form of native *S. foliosa* and *S. pacifica* occur throughout the marsh. Due to the small size, surrounding developed land uses and distance to other marshes, this marsh is unlikely to support breeding Ridgway’s rail. ISP has conducted yearly rail surveys at this site with no detections.

**Napa River: Napa, CA**

Several collection areas were selected along the Napa River, each consisting of a five to 10-meter-wide band of *S. foliosa* that extended for 50 to 100 meters located on the outboard edge of the west bank of the river. *S. foliosa* occurs in these areas as dense, uniform linear patches. Collection areas along the river are over 2,000 meters upstream from the nearest known hybrid *Spartina* location. However, the site is relatively fresh and far from restoration sites. Additionally, this site required collection by boat. While it is easiest to see *S. foliosa* collection areas at low tide, a higher tide is necessary to gain access to these sites by boat. Collection areas were located in narrow linear areas bounded by levee on one side and the wide Napa River on the other and distant from expansive marsh plain habitat and therefore the collection areas were not anticipated to provide nesting habitat for California Ridgway’s rail.
Figure 1: Collection sites for *S. foliosa*.
Table 7: Donor source and site information for of Year 1 (Winter 2011-2012) and Year 2 (Winter 2012-2013) plantings.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Number of plugs planted Year 1</th>
<th>Sources planted Year 1* (Winter 2011-2012)</th>
<th>Number of plugs planted Year 2</th>
<th>Sources planted Year 2** (Winter 2012-2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alameda Flood Control Channel (AFCC)</td>
<td>327</td>
<td>Golden Gate (Nursery), Golden Gate (Direct), Sonoma (Nursery), Sonoma (Direct)</td>
<td>1200</td>
<td>Alviso Slough, Coyote Creek, Golden Gate, Napa River, Permanente Creek, Seminary Marsh, Port Sonoma Marina, and Starkweather Marsh</td>
</tr>
<tr>
<td>Cargill Mitigation (CAMI)</td>
<td>Not planted</td>
<td>Not planted</td>
<td>830</td>
<td>Coyote Creek, Golden Gate, Napa River, Seminary Marsh</td>
</tr>
<tr>
<td>Cogswell Marsh (COGS)</td>
<td>Not planted</td>
<td>Not planted</td>
<td>400</td>
<td>Coyote Creek, Golden Gate, Napa River, Seminary Marsh</td>
</tr>
<tr>
<td>Elsie Roemer (ERL)</td>
<td>Not planted</td>
<td>Not planted</td>
<td>480</td>
<td>Seminary Marsh and Port Sonoma Marina</td>
</tr>
<tr>
<td>Mount Eden Creek (MEC)</td>
<td>94</td>
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<td>905</td>
<td>Alviso Slough, Napa River, and Starkweather Marsh</td>
</tr>
<tr>
<td>North Creek Marsh (NCM)</td>
<td>605</td>
<td>Golden Gate (Nursery), Golden Gate (Direct), Sonoma (Nursery), Sonoma (Direct)</td>
<td>3560</td>
<td>Alviso Slough, Coyote Creek, Golden Gate, Napa River, Permanente Creek, Seminary Marsh, Port Sonoma Marina, and Starkweather Marsh</td>
</tr>
<tr>
<td>Old Alameda Creek (OAC)</td>
<td>351</td>
<td>Golden Gate (Nursery), Golden Gate (Direct), Sonoma (Nursery), Sonoma (Direct)</td>
<td>Not planted</td>
<td>Not planted</td>
</tr>
<tr>
<td>Pond 3 (Pond 3)</td>
<td>Not planted</td>
<td>Not planted</td>
<td>50</td>
<td>Seminary Marsh, Port Sonoma Marina, and Starkweather Marsh</td>
</tr>
<tr>
<td>Whale's Tail North (WTN)</td>
<td>150</td>
<td>Golden Gate (Nursery), Sonoma (Nursery)</td>
<td>400</td>
<td>Golden Gate and Permanente Creek</td>
</tr>
<tr>
<td>Whale's Tail South (WTS)</td>
<td>165</td>
<td>Golden Gate (Nursery), Sonoma (Nursery)</td>
<td>825</td>
<td>Seminary Marsh and Port Sonoma Marina</td>
</tr>
<tr>
<td>Totals</td>
<td>1692</td>
<td>0</td>
<td>8650</td>
<td></td>
</tr>
</tbody>
</table>

*Year 1:
Some plugs, referred to as direct transplants, were transplanted to revegetation sites from the donor source directly after collection. Some plugs, referred to as nursery plugs, were propagated at The Watershed Nursery (in Richmond) and then planted at revegetation sites five to seven months later.

**Year 2: All plugs were propagated at The Watershed Nursery prior to outplanting.
APPENDIX II:

Design 5 Preliminary Results
APPENDIX II: DESIGN 5 PRELIMINARY RESULTS

INTRODUCTION

How do Site, Elevation, and Herbivory Affect Native Pacific Cordgrass (Spartina foliosa) Establishment?

METHODS

RESULTS

CONCLUSIONS

1. Restoration success was greatest at North Creek Marsh.
2. Survival was greatest at higher tidal elevations across the range (Figs. 2, 3).
3. Site and herbivory factors are significant at one site only (Westley Field, Table 3). Measurements of effects of water, soil characteristics are in progress.

APPENDIX II: DESIGN 5 PRELIMINARY RESULTS

Research Summary

Whitney Thornton, Laura Feinstein, Courteney Hahn, and Edwin Grosholz

Restoring native cordgrass (Spartina foliosa) in a critical step towards eradication of invasive hybrid cordgrass in San Francisco Bay, California. Invasive hybrid cordgrass changes habitat structure, alters physical processes, and threatens native biodiversity. Site and herbivory factors were identified as important factors in restoration success.

Restoration Design

- Study the success of hybrid cordgrass eradication
- Evaluate the effects of herbivory
- Evaluate the effects of tidal elevation

Restoration Monitoring

- Salt marshes
- Flats
- Marsh and tidal flat
- Field tests

Final reports were published in 2013.

SOURCES:

San Francisco Bay Conservation and Development Commission
U.S. Geological Survey
U.S. Fish and Wildlife Service
APPENDIX 3:

ISP Revegetation Program

*Spartina foliosa* Source Populations in the
San Francisco Estuary
MAP OF SPARTINA FOLIOSA SOURCE POPULATIONS

- Port Sonoma Marina: Planted Year 1 to Year 4
- Napa River: Planted Year 2 to Year 4
- Stankweather Cove: Planted Year 2 to Year 4
- Seminary Cove: Planted Year 2 to Year 4
- Tennessee Valley: Planted Year 4
- Golden Gate Fields: Planted Year 1 to Year 4
- Coyote Creek: Planted Year 2 to Year 4
- Aviso Slough: Planted Year 2 to Year 3
- Permanent Creek: Planted Year 2 to Year 4

ISP Restoration Program
Spartina foliosa Collection Sites

Map produced: 01/06/2015
Imagery: Bing Maps
APPENDIX 4:

Response to Hybrid *Spartina* in *S. foliosa* Bed #43
APPENDIX 4: RESPONSE TO HYBRID SPARTINA IN S. FOLIOSA BED #43

SAN FRANCISCO ESTUARY INVASIVE SPARTINA PROJECT
1830 Embarcadero • Suite 100 • Oakland • California 94606 • (510) 536-4782

Preserving native wetlands

Internal Memorandum

Date: October 22, 2014
ISP Memo # 14-11
Ref Memo # #NA

To: Marilyn Latta

From: Jeanne Hammond, Restoration Program Manager
Peggy Olofson, Director

Subject: Response to Hybrid Spartina in Spartina foliosa Propagation Bed #43

Project biologist Whitney Thornton and Restoration Program Manager Jeanne Hammond visited The Watershed Nursery on September 4, 2014 to visually assess the Spartina foliosa propagation beds pursuant to protocol (Olofson Environmental, Inc. 2012), in preparation for the 2014-15 planting season. In one bed of forty (bed #43), an unusual morphology was identified as suspected hybrid Spartina. This morphology was present in two clumps, representing approximately 50 stems and covering a circular area measuring less than 0.5 meters in diameter. One of these clumps had reddish stems as shown in Figure 1. A DNA sample was taken from the center of the clump that exhibited reddish stems and an additional DNA sample was taken from a nearby plant that was visually identified as S. foliosa. These samples were sent to UCLA genomics lab for priority genetic analysis.

Because this propagation bed is part of a larger propagation effort for native cordgrass restoration, it was determined that the suspect plant(s) would be removed immediately, prior to receipt of genetic results. As the plant(s) exhibited a phenotype typically associated with hybrid Spartina (i.e., red stems) these plants would not be suitable for outplanting, even if results from genetic testing were to confirm they were S. foliosa. Whitney Thornton visited the nursery again on September 10, 2014 to identify and help remove the suspect plant(s). The plant(s) were easily relocated and dug from the bed. The two clumps were growing closely together so both were completely pulled out (Figure 2). Additional DNA samples were taken from bed #43: one sample from the primary suspect clump and one from an adjacent clump that seemed to be connected via rhizome but did not have red stems, as well as two additional samples taken from close to the location of the removed plants.

Bed #43 was populated with plants collected on April 3, 2014 from the collection area on Alviso Slough shown on Figure 3. Plants that were collected from Alviso Slough on April 3, 2014 are currently growing in propagation beds 30, 31, 40, 41, 43 and 44.

DNA Lab Results – Confirmed Hybrid Spartina

A total of six (6) DNA samples were taken from bed #43. In addition, three (3) DNA samples were taken from other propagation beds of plants that were visually identified as S. foliosa. Seven of these nine DNA samples were confirmed as S. foliosa. Of the three DNA samples that
were taken of suspect plants, two were genetically confirmed as hybrid *Spartina*. The two samples confirmed to be hybrid *Spartina* were taken from the same clump that exhibited red stems – one sample during each visit – to verify that the plant that was removed was the same plant sampled during both visits. The phenotype (i.e., red stems) and genotype for the two confirmed hybrid DNA samples were the same. The DNA sample that was taken from the adjacent clump that seemed to be connected via rhizome but did not have red stems was confirmed to be *S. foliosa*. (Note: this plant was also removed from the bed as described above).

**Information on Alviso Slough *S. foliosa* Collection Area**

The *S. foliosa* collection area at Alviso Slough is a 1.0 meter-wide band of *S. foliosa* along the edge of the slough in the upstream reach of Alviso Slough. The collection area is brackish, as indicated by the co-occurrence of *S. foliosa* and sedge species such as *Bolboschoenus maritimus*. Prior to the 2012 collection, the collection area was 1000 meters away from known hybrid *Spartina* downstream. DNA sampling was conducted prior to collection per protocol (eight DNA samples) and all samples were confirmed as *S. foliosa*. Collection went forward and an additional six DNA samples were taken during the actual collection (leaves taken from some of the 800 harvested plugs) all of which were confirmed as *S. foliosa*. All planting that occurred in 2012 and again in 2013 from this collection have been monitored and confirmed visually as *S. foliosa*. In addition, 22 samples that were taken from the Alviso Slough beds during two different sampling periods in 2012 were confirmed by genetic testing as *S. foliosa*. At the time of collection in 2014, 2013 mapping showed the closest mapped hybrid *Spartina* was 600+ meters away from collection area. The ID confidence of the closest suspected hybrid locations were low and the decision was made to go ahead with collection. Additional DNA samples were taken during collection to verify the collection was *S. foliosa* (600 harvested plugs, 10 DNA samples). Nine of 10 DNA samples were confirmed as *S. foliosa*. Genetic testing of the 10th sample failed, and insufficient data was available to verify species identification (i.e., data was available for only 3 of 15 markers but those three markers had alleles present in *S. foliosa*). Failures of this type happen periodically with all genetic analysis, and since 90% of the analyses were successful and conclusively *S. foliosa*, this was not considered to be alarming.

**Information on Seed Bank and Seed Viability**

An important factor to take into consideration is the potential for any of the existing Alviso Slough propagation beds (beds 30, 31, 40, 41, 43, and 44) to potentially harbor hybrid *Spartina* seed that may produce additional hybrid *Spartina* plants. For this we made a conservative assumption that if the one hybrid plant discovered may have come from seed present in the Alviso Slough collected material, then there may be additional seeds present in the material as well.

Studies in multiple estuaries have found that the seed bank for *Spartina alterniflora* (as well as *S. maritima* and *S. anglica*) is not persistent after one year (examples for *S. alterniflora* are Callaway and Josselyn 1992, Daehler 2000, Xiao 2009). Most of these studies were conducted on mudflats. Seed viability for *S. alterniflora* was also estimated at eight months (Sayce and Mumford 1990). Both *S. alterniflora* and *S. foliosa* require a moist chilling period (approximately six weeks) prior to germination (Seneca 1974a and b, Crispin 1976, Biber and
Caldwell 2008). Given ideal temperatures and storage, Crispin (1976) also found that *S. foliosa* had much higher germination (70%) in fresh water than in saline water (30% germination at 2% salinity). One study found that using the methods described above for pre-germination (i.e., cold storage period), fresh water flushing (the trigger to end seed dormancy) resulted in rapid germination of hybrid *Spartina*, typically within the first month, and that there was no germination after two months (C. Davis – D. Ayres lab - grey literature – no date). Any seeds present in the propagation beds at the nursery are exposed to periodic fresh water flushing which may mimic the trigger to end seed dormancy.

Based on the studies cited, we concluded that the risk of additional hybrid *S. alterniflora* plants being produced from seed in the Alviso Slough propagation beds is low. Plant collection for these beds occurred in April 2014, and any seeds potentially present in the soil at that time would have been produced the previous growing season – in 2013. An estimate of seed age for seeds produced in late 2013 (using a conservative estimate that seeds could have been produced through November) would be a minimum of 13 months in January 2015, beyond the maximum estimated age of viability from the literature.

**Conclusion and Agreed Actions**

On October 21, 2014, Project Manager Marilyn Latta, Director Peggy Olofson, Restoration Program Manager Jeanne Hammond, and nursery owner Diana Benner, met at the Coastal Conservancy to review the available information. It was agreed that, because of rigorous donor site selection and harvesting protocols, there was little likelihood that hybrid *Spartina* seedlings had been directly harvested from the Alviso Slough location and propagated in the nursery beds, and that the available data on seed bank viability indicated the Alviso Slough beds presented a low risk of containing additional viable hybrid *Spartina* seed. Nevertheless, we concluded it was important to avoid any risk of outplanting hybrid *Spartina* in the San Francisco Bay, and agreed on the following actions:

1. Expert ISP biologists will survey the Alviso Slough collection area for additional hybrid *Spartina* (planned for October 21, 2014). Additional DNA samples will be taken if any plants with suspicious morphologies are identified. [Note: survey was completed on 10/21/14 by Whitney Thornton, based on observation and two DNA samples, not additional hybrid was found.]

2. ISP will discontinue use of Alviso Slough as a *S. foliosa* collection area.

3. In addition, ISP will discontinue use of two other South Bay collection sites, Permanente Creek and Coyote Creek. No collection from either of these sites occurred in 2014.

4. The Watershed Nursery will immediately destroy all plants in the six Alviso Slough propagation beds (beds 30, 31, 40, 41, 43, 44), and dispose of plants and soil material in a manner that ensures that recontamination will not occur. Based on an estimate provided by The Watershed Nursery in September 2014, the loss of these beds translates to approximately 2,900 plugs (or 8,700 stems) that will not be available for outplanting this season.
5. Expert ISP biologists (i.e., Whitney Thornton and/or Jeanne Hammond) will continue to visually assess the remaining 34 propagation beds periodically to check for any unusual or suspicious plant morphologies and take DNA samples as needed.

6. The Watershed Nursery staff will continue to visually assess the propagation beds and conduct periodic inflorescence clipping as needed. Nursery staff will notify ISP if any suspicious plants are identified.

**Chronology of Events**


September 4, 2014 – J. Hammond sent email notifying D. Benner and L. Bennett of survey findings including suspicious plant in bed #43 and DNA samples taken.

September 9, 2014 – J. Hammond sent email to M. Latta, and D. Benner notifying that, prior to genetic testing results, ISP would like to go ahead and remove suspected plant from nursery bed and coordinating that effort.

September 10, 2014 – W. Thornton and L. Bennett conducted plant removal from propagation bed #43 and additional DNA samples were taken.

October 16, 2014 – B. Ort informed the Revegetation Program of the DNA results (confirmed hybrid *Spartina*).

October 20, 2014 – Staff prepared the draft memorandum “Summary of and Response to Confirmed Hybrid Spartina in *S. foliosa* Propagation Bed #43”, and P. Olofson forwarded via email to M. Latta, requesting brief discussion during scheduled check-in meeting on 10/21/14.

**Figures 4 to 6** show additional information about mapped *Spartina* locations and DNA results for the Alviso Slough area. Figures 4 and 5 show 2013 mapped (field identified) *Spartina* locations and DNA results (prior to the 2014 collection), respectively, and Figure 6 shows 2014 data acquired after the propagation bed collection in April 2014.

**Literature Cited**


Davis, C.W. XXXX. Seedling germination and salinity tolerance in cordgrass: *Spartina foliosa* and *Spartina alterniflora* x *foliosa* Hybrids. Unpublished manuscript from D. Ayres lab.
APPENDIX 4: RESPONSE TO HYBRID SPARTINA IN S. FOLIOSA BED #43


Figure 1. Suspected Hybrid *Spartina* in Bed #43

Figure 2. Photo of Suspect Plant Removed from Bed #43
Figure 3. Map of Alviso Slough *Spartina foliosa* Collection Area(s) and 2010-13 Mapped Hybrid *Spartina* Locations
Figure 4. Map of Alviso Slough showing 2013 *Spartina* Mapped Locations
Figure 5. Map of Alviso Slough showing 2010-2013 DNA Results
Figure 6. Map of Alviso Slough showing 2014 Mapped Spartina Locations and DNA Results