San Francisco Estuary Invasive *Spartina* Project Restoration Program

Year 13 (2023-2024) Installation Report and Year 12 (2023) Initial Survivorship Monitoring Results

Prepared for:

California State Coastal Conservancy
San Francisco Estuary Invasive *Spartina* Project
1515 Clay Street
Oakland, California 94612

Prepared by:

Olofson Environmental, Inc.
1001 42nd Street, Suite 230
Oakland, California 94608

January 16, 2025

ACKNOWLEDGEMENTS

This report was prepared by Jeanne Hammond, the Invasive *Spartina* Project Restoration Program Manager, and incorporates the hard work done by other OEI biologists including Dorothy Aldridge, Melanie Anderson, Cat Brett, Riley Burke, Ava Currie, Lindsay Domecus, Simon Gunner, Jennifer McBroom, Tripp McCandlish, Brian Ort, Dylan Pastor, Tobias Rohmer, Isabella Sanchez-Mendoza, Dany Stephens and Emily Zierdt Smith; as well as contributions from Ingrid Hogle and Drew Kerr. We would also like to thank our partners and contractors including the California Invasive Plant Council, The Watershed Nursery, RECON Environmental, and SOLitude Lake Management.

This program would not be possible without the participation of our partner/landowners including U.S. Fish and Wildlife Service Don Edwards and San Pablo Bay National Wildlife Refuges, California Department of Fish and Wildlife, East Bay Regional Park District, City of San Leandro, Hayward Area Recreation and Park District, City of Alameda, City of South San Francisco, County of San Mateo Watershed Protection Services, and the Alameda Flood Control and Water Conservation District.

This report was prepared for the California State Coastal Conservancy with support and funding from the following contributors:

California Coastal Conservancy
San Francisco Bay Restoration Authority

CONTENTS

FIGURES

TABLES

PHOTOS

INTRODUCTION

The California Coastal Conservancy initiated the Invasive *Spartina* Project (ISP) Restoration 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 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 rail[1]). The plan focused on habitat enhancements at strategic locations near where recent removal of non-native cordgrass (hybrid *Spartina alterniflora* x *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*. That initial five-year plan continues to guide the program, and we completed a thirteenth year of habitat enhancements in winter 2022-23.

A main objective of the ISP Restoration Program is to install native plant species that enhance foraging, roosting, and nesting cover as well as high tide refuge cover for the California Ridgway's rail (Olofson Environmental, 2012) and other wildlife species. To date, OEI and partners have installed close to 600,000 native tidal marsh and marsh-upland transition zone plants at over 40 sites around SF Bay.

This document reports on plant installation activities completed in Year 13 (the winter of 2023-24) and 2023 monitoring results primarily for Year 12 (2022-23) plantings. Other habitat enhancements implemented by the program, including construction of high tide refuge islands, are reported separately.

OVERVIEW OF YEAR 13 (WINTER 2023-2024) PLANT INSTALLATION

During Year 13 (2023-24), over 16,000 native tidal marsh and marsh-upland transition zone plants were planted at 13 ISP sub-areas (**Table 1, Table 2).** The native species planted in Year 13 included marsh gumplant (*Grindelia stricta*), Pacific cordgrass (*Spartina foliosa*), and six marsh-upland transition zone species. As in previous years, marsh gumplant and Pacific cordgrass were planted because they grow taller than other native salt marsh plants, provide more vertical structure for cover, and are critically important vegetative components of native marshes that have populations of California Ridgway's rail. Pacific cordgrass was planted in low elevation areas along marsh channels at two sub-areas, Cogswell A and Whale's Tail South (**Table 1**). Marsh gumplant was planted at mid- to high-marsh elevations along marsh plain channels at six sub-areas (**Table 1**). Marsh-upland transition zone species were planted at six sub-areas to enhance high tide refuge habitat.

For the second consecutive year, extended wet weather resulted in cancellations of groundtruthing and planting days. Due to inaccessible wet levees for most of the winter, both groundtruthing and planting days were cancelled multiple times at Ideal Marsh South, resulting in reallocation of Pacific cordgrass plants to another site, Cogswell A. Because of this potential for wet levees during the winter, we planned for early winter (late November) groundtruthing and planting days for the UTZ planting area at Cargill Mitigation Marsh and that site was successfully planted this year. All activities were re-scheduled, and all planting was completed successfully despite the wet weather.

[1] The Fifty-fifth Supplement to the Ornithologists' Union Checklist 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).

Table 1. Year 13 (2023-24) ISP Sub-Areas and Planting Numbers

Site Name/ISP Subarea Code	Pacific Cordgrass			Marshplain Marsh Gumplant			Marsh-Upland Transition Zone (UTZ)							TOTAL PLANTS***
	Plugs*	Sods**	Total Pacific cordgrass***	D16s	D40s	Total Marsh Gumplant	Ambrosia psilostachya (D16)	Baccharis glutinosa (D16)	Baccharis pilularis (D16)	Euthamia occidentalis (D16)	Elymus triticoides (SC)	Artemisia californica (D16)	Total UTZ	
Damon Marsh (17d.4)				200	200	400								400
Bunker Marsh (20g)							100	60	40	80	40	40	360	360
Citation Marsh Central (20d.2b)							300	300	100	200	400		1,300	1,300
Citation Marsh South (20d.1)				300	300	600								600
East Marsh (20e)				200	200	400								400
Cogswell A (20m)	900		4,500				200	260	40	120	460		1,080	5,580
Cogswell Marsh B South (20n.2)				200	200	400								400
Cogswell Marsh B Main (20n.3)							200	200	40	100	400		940	940
Cogswell C (20o)							300	200		100	400		1,000	1,000
Cargill (13f)							200	200			400		800	800
Whales Tail South (13e)		91	3,050											3,050
Ideal Marsh South (21b)	0		0											0
Bair B2 North West (02c.1a)				540	540	1,080								1,080
Bair B2 North East (02c.1b)				60	60	120								120
ISP 2023-24 Plant Totals	900	91	7,550	1,300	1,300	2,600	1,200	1,160	180	520	2,060	0	5,120	16,030

* 1 plug contains on average 5 stems, ** 1 sod is approximately equivalent to ~6.7 plugs, *** Pacific cordgrass is reported as stems in totals

Table 2. Year 13 (2023-24) Plant Installation Schedule

Date(s) of Plant Installation	Region	Site	Contractor	Access
11/27-11/28/2023	Union City	Cargill Mitigation Marsh (13f)	RECON	Truck/foot
11/29-11/30/2023	Hayward	Bunker Marsh (20g), East Marsh (20e)	RECON	Truck/foot
12/4-12/5/2023	San Mateo	Bair B2 North West (02c.1a), Bair B2 North East (02c.1b)	SOLitude	Airboat
12/4-12/5/2023	Hayward	Cogswell A (20m)	RECON	Truck/foot
12/12-12/14/2023	Hayward	Cogswell C (20o)	RECON	Truck/foot
12/13-12/15/2023	Hayward	Citation Marsh Central (20d.2b), Citation Marsh South (20d.1)	SOLitude	Truck/foot
12/21/2023	Hayward	Cogswell B (20n)	RECON	Truck/foot
1/4/2024	Hayward	Cogswell A (20m)	RECON	Truck/foot
1/16/2024	Union City	Whale's Tail South (13e)	SOLitude	Airboat
1/17-1/18/2024	Hayward	Cogswell B (20n)	RECON	Truck/foot
1/30/2024	San Leandro Bay	Damon Marsh (17d.4)	RECON	Truck/foot
2/28/2024	Hayward	Cogswell A (20m) – plant reallocation from Ideal Marsh South	SOLitude	Truck/foot

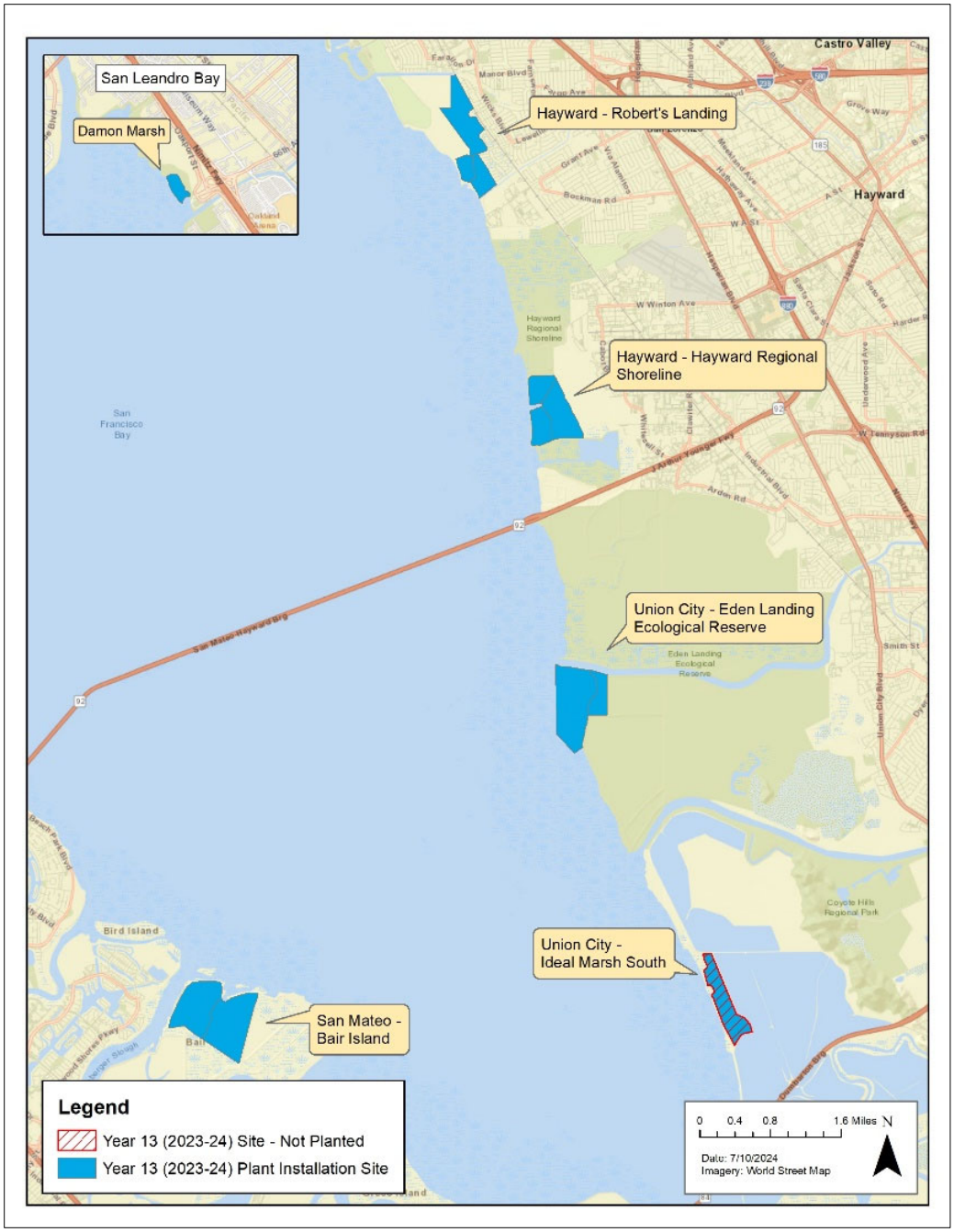

Figure 1. Year 13 (2023-24) Plant Installation Sites

Plant Propagation

As shown on **Table 1** above, marsh gumplant, Pacific cordgrass and marsh-upland transition zones species including marsh baccharis (*Baccharis glutinosa*), coyote brush (*Baccharis pilularis*), creeping wild rye (*Elymus triticoides*), western goldenrod (*Euthamia occidentalis*) western ragweed (*Ambrosia psilostachya*), and California sagebrush (*Artemisia californica*) were outplanted in Year 13. These plants, as in past years, were propagated at The Watershed Nursery, a commercial native plant nursery located in Point Richmond, California.

Marsh Gumplant

Marsh gumplant were propagated in two pot sizes, D16 (Deepot 16 that contains 16 cubic inches of soil) and D40 (Deepot 40 with 40 cubic inches). **Photo 1** shows an example of the D16 and D40 pot sizes. **Photo 2** shows marsh gumplant grown in D40 pots and contained in a tray that holds 20 plants. Pots are typically contained in plant trays for growing and transporting to planting sites. Plants grown for Year 13 outplanting were germinated from seed collected along Old Alameda Creek and Newark Slough in Alameda County. No plants were salt-hardened. Plants were trimmed at the nursery, as needed, to focus growth to the roots and to reduce possible transplant stress.

Photo 1. Example of a D16 (left) and D40 size (right) pot

Photo 2. Example of marsh gumplant grown in D40 pots contained in planting trays that are used for growing and transport to planting sites

Pacific Cordgrass

Pacific cordgrass was propagated in five nursery beds according to program protocols (Thornton 2012). Propagation beds for Year 13 outplanting were started with plant material held over from the Year 12 propagation effort. Salt-hardening of the Pacific cordgrass beds prior to outplanting was discontinued for Year 13. Each propagation bed contained plant material from one source population: one bed from Golden Gate Fields in Alameda County, one bed from Starkweather Cove in Marin County, one bed from the Napa River near American Canyon in Solano County and two beds from Port Sonoma Marina near the mouth of the Petaluma River in Sonoma County. The Watershed Nursery also maintained two additional propagation beds: one bed from Tennessee Valley in Marin County and one bed from the Napa River in Napa County. **Figure 2** shows the general location of each source population where plant material in current nursery propagation beds was originally collected. The different colors for each source population shown on the map are used each year by the nursery and in the field to track each source from harvesting to outplanting. **Photo 3** shows several of the Pacific cordgrass beds at The Watershed Nursery.

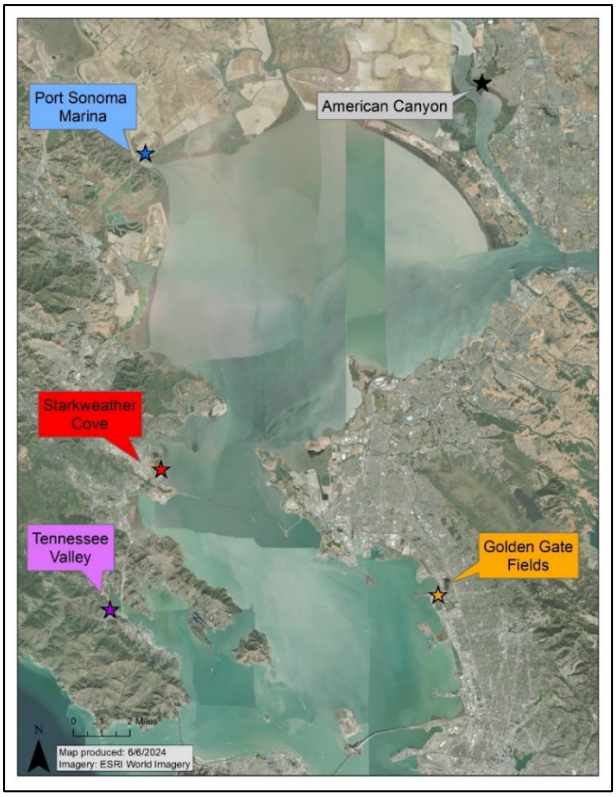

Figure 2. Source locations - Pacific cordgrass plant collection for amplification in nursery beds

Photo 3. Pacific cordgrass beds at The Watershed Nursery, November 2023

Cordgrass plant material for outplanting was harvested from the propagation beds in two ways: plugs and sods. Plugs contained the minimum amount of plant material and soil determined by nursery staff to be a viable planting unit which typically included ~5 stems and associated rhizome. Plugs were harvested from deeper beds and the roots/soil part of the plug typically measured ~6-8 inches long. Sods were larger chunks of plant material harvested from shallow beds, each sod was either a square (ap-proxi-mately 1ft by 1ft in size) or a rectangle (approximately 6-8" wide by 18-24" long). These larger-sized planting units contain more developed and intact rhizomes and more soil which may result in lower transplant stress. Sods were tested at locations where plant establishment from plugs has been low.

During outplanting, source populations were tracked at each site to help determine if source would influ-ence initial survivorship. Pacific cordgrass plant material is transported from the nursery to outplanting sites in bus tubs as shown in **Photo 4**.

Photo 4. Examples of bus tubs used to transport Pacific cordgrass. In this photo, sods are being transported to Whale's Tail South.

Planting Designs

The program focuses on high density planting designs to meet our goal of rapid enhancement. The Year 13 planting design for marsh gumplant repeats the same high-density design used in previous years. Two planting designs for Pacific cordgrass were used in Year 13, plots of plugs planted in linear rows as in previous years and plots planted with sods as described below. Planting designs for marsh-upland transition zone species developed in Year 11 were again used in Year 13.

Marsh Gumplant

Marsh gumplant was planted at six subareas including Bair B2 North West (02c.1a), Bair B2 North East (02c.1b), Citation Marsh South (20d.1), Cogswell Marsh B South (20n.2), Damon Marsh (17d.4), and East Marsh (20e), using the same design as in Years 3 to 12 (**Figure 3**). Marsh gumplant were planted in plots approximately 4.5 meters long with 20 plants in two rows, each plant spaced 0.5 meters apart. **Photo 5** shows a close-up of gumplant planted within a plot and **Photo 6** shows a marsh gumplant plot after installation along a marsh plain channel at Citation Marsh. For sites accessed using boats, Bair B2 North West (02c.1a), Bair B2 North East (02c.1b), an airboat was used to maximize the tide window the crew could be on site for planting.

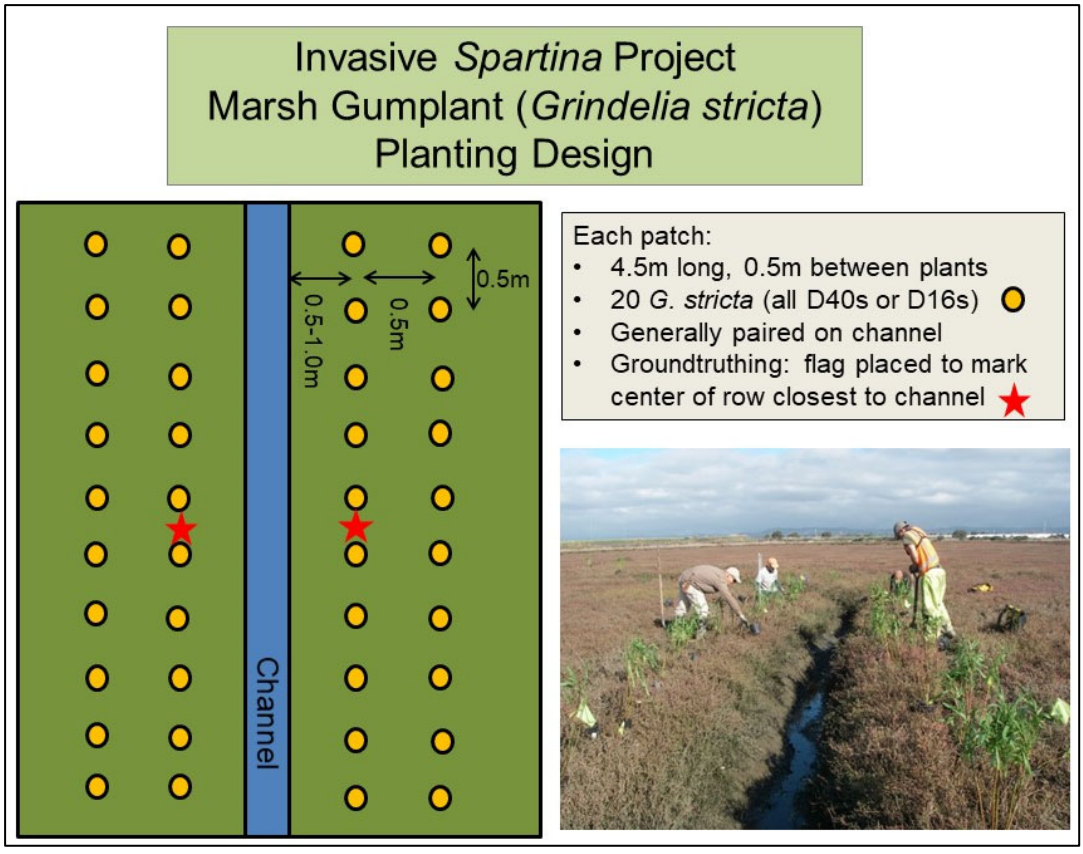

Figure 3. Year 13 (2023-24) marsh gumplant planting design

Photo 5. Close-up view of marsh gumplant after planting at Citation Marsh

Photo 6. Planted marsh gumplant plot at Citation Marsh

Pacific Cordgrass

Pacific cordgrass planting occurred at two of the three sub-areas originally proposed in the 23-24 planting plan. Extended wet weather restricted access to Ideal Marsh South through the end of February, resulting in reallocation of plants to one of the other two sub-areas, Cogswell A. Planting designs at those two sites included plugs (Cogswell A) and sods (Whale's Tail South).

Cogswell A – Hayward Regional Shoreline. In Year 13, the "paired rows" planting design was used to plant 900 plugs at Cogswell A. The basic planting unit was a plot that included five plugs. The five plugs were planted in a square shape with a plug at each corner and one plug in the center as shown in **Figure 4**. The distance between plugs on the corners of each plot was 0.25m. Multiple plots were then planted together in two linear rows (**Figure 5**) located along a channel, with one of the rows directly adjacent to the vegetated marsh edge, typically perennial pickleweed (*Salicornia pacifica*). The planted channel at Cogswell A runs along the northern edge of the site but is not directly connected hydrologically (**Figure 6** and **Photo 7**). Sources planted at Cogswell A included Golden Gate, American Canyon, and Starkweather Cove.

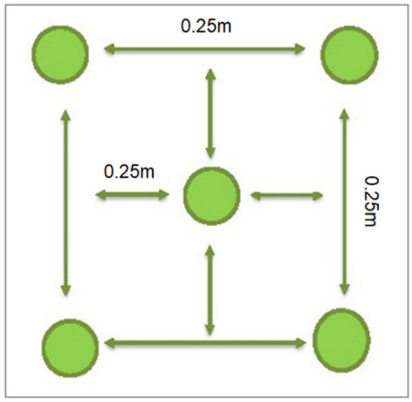

Figure 4. Schematic of basic Pacific cordgrass planting plot

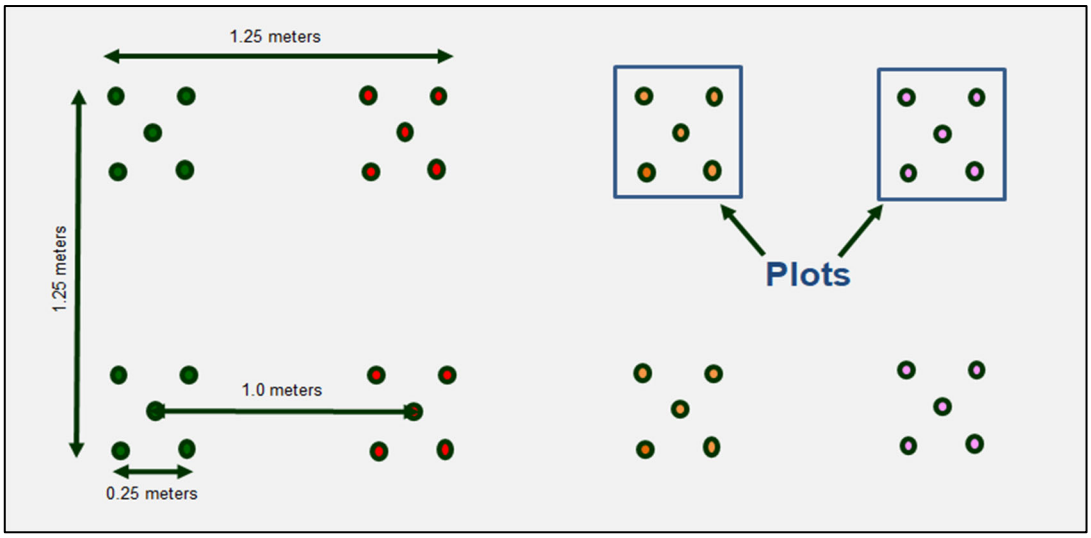

Figure 5. Year 13 (2023-24) Pacific cordgrass planting design – "paired rows"

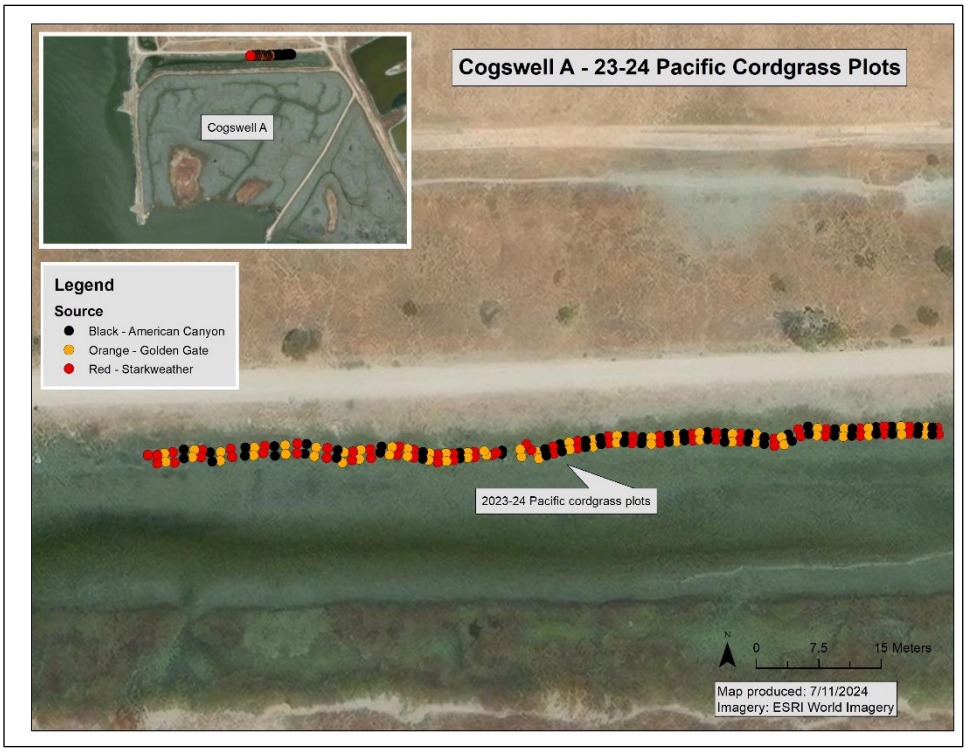

Figure 6. Pacific cordgrass paired rows planting design at Cogswell A

Photo 7. Pacific cordgrass plugs planted at Cogswell A

Whale's Tail South - Eden Landing Ecological Reserve. Low survivorship of native cordgrass plugs planted along narrow marsh channel banks led to a very small-scale test of sods (n=3) in Year 11 and a larger-scale sods planting effort (n=90) in Year 13. Sods are larger-sized planting units that have more developed and intact rhizomes as well as more soil. Larger planting units could have lower transplant stress which might result in higher rates of plant establishment. **Photo** 4 shows some of the sods installed at Whale's Tail South during transport. Note that each nursery bin contained two sods. The bin in the foreground of **Photo 4** is oriented so that you can see the rectangular shape of the two sods. The 90 sods installed at Whale's Tail South measured approximately 6-8 inches by 18-24 inches and were 5" deep. These sods were called "sod ribbons" and were planted perpendicular to channel bank edges so that the upper edge was planted in perennial pickleweed and the lower edge in bay mud as shown in **Figure 7**. Planting across the suitable elevational range present on channel edges mimics the environment that natural Pacific cordgrass clones grow in with culms at lower elevations submerged while higher elevation culms have access to sunlight and air. Sods were anchored as part of installation using three bamboo stakes. The upper end of each sod was staked with one bamboo and the lower elevation end was staked with two bamboos in an "X". An example of an installed sod ribbon is shown in **Photo 8**. Sods were sourced from Port Sonoma Marina propagation beds.

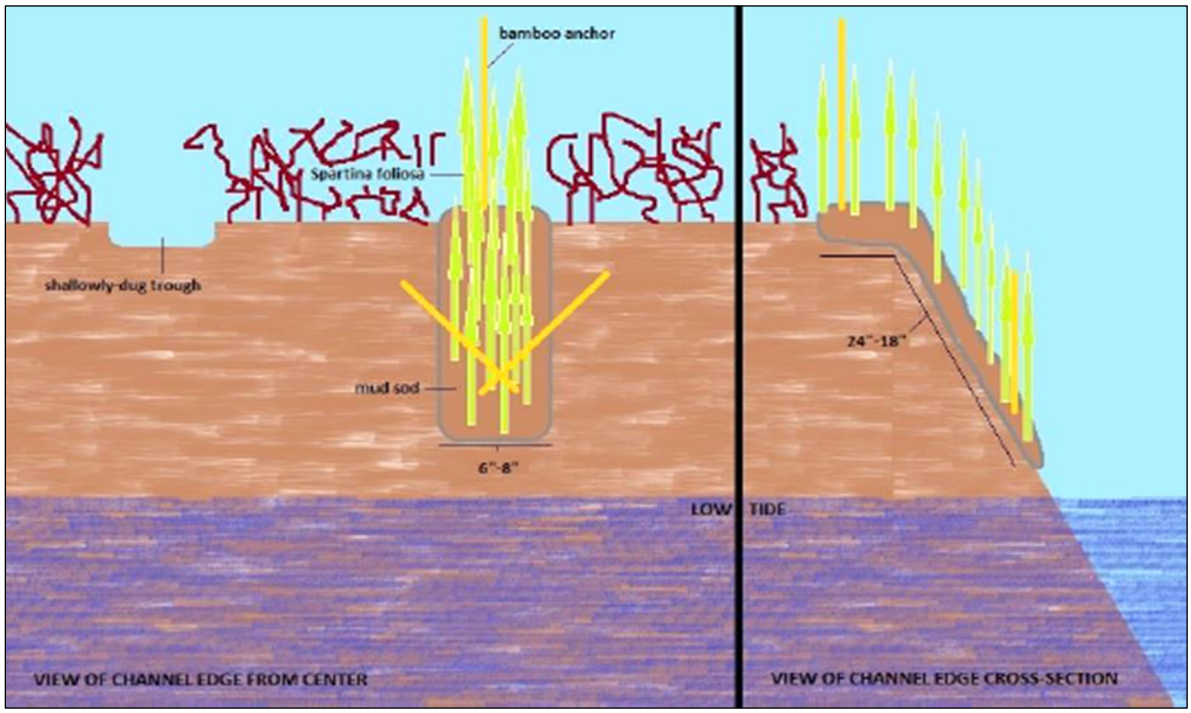

Figure 7. Pacific cordgrass sod ribbons planting design

Photo 8. Example of installed Pacific cordgrass sod ribbon

Marsh-Upland Transition Zone

Marsh-upland transition zone species were planted in Year 13 to enhance high tide refuge habitat at six restoration marshes: Cargill Mitigation Marsh, Cogswell A, Cogswell B, Cogswell C, Bunker Marsh, and Citation Marsh. The designs were intended to rapidly enhance habitat by planting dense single species plots of rhizomatous perennials that would grow together quickly to provide habitat cover. Planting designs were repeated at all sites and are shown below in **Figure 8**. Six native salt tolerant perennial species were selected for planting. Four of the six species were also rhizomatous perennials with the ability to persist and spread into new areas via rhizomes in years when rainfall is not suitable for seed germination and establishment of new plants. When established, rhizomatous perennials can form dense patches which provide year-round habitat cover. Rhizomatous perennial species including western ragweed (*Ambrosia psilostachya*), western goldenrod (*Euthamia occidentalis*) and marsh baccharis (*Baccharis glutinosa*) were planted in dense plots that contained 20 plants in a 5 by 4 grid (example shown in **Photo 9**).

One rhizomatous perennial grass species, creeping wild rye (*Elymus triticoides*), was planted in linear plots of 20 plants (two rows of 10 plants, example shown in **Photo 10**). Two non-rhizomatous species, coyote brush (*Baccharis pilularis*) and California sagebrush (*Artemisia californica*), were selected based on stature, hardiness, and salt tolerance. Both species were planted in small groupings of four plants because of the large crown size of plants at maturity as shown in **Figure 8** below.

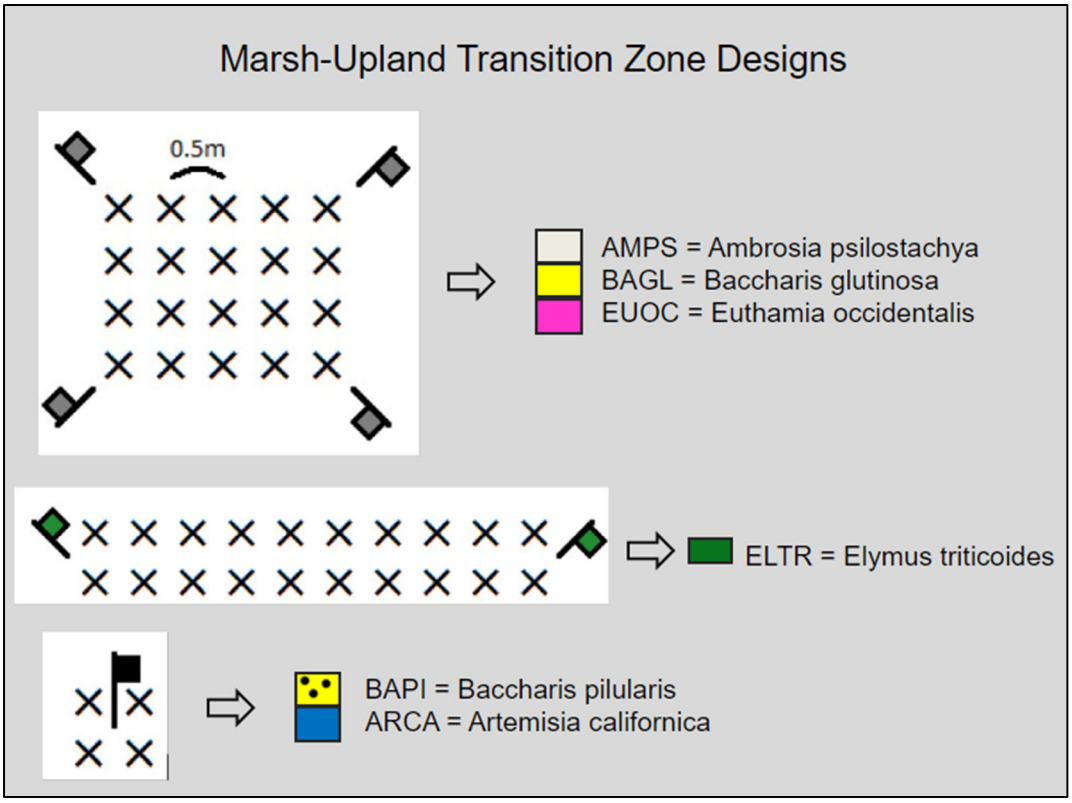

Figure 8. Marsh-upland transition zone planting designs

Photo 9. Example 5 x 4 grid plot being planted with 20 *Baccharis glutinosa* plants at Cargill Mitigation Marsh

Photo 10. Example linear *Elymus triticoides* plot containing two rows of 10 plants after plant installation at Cogswell B

Year 13 Installation Maps and Photo Points by Site

The installation maps included below were used by ISP staff during fieldwork to complete the planted planting activities at each site. Photo point locations that were established for Year 13 plantings are included for some sites.

Citation Marsh-Robert's Landing, City of San Leandro

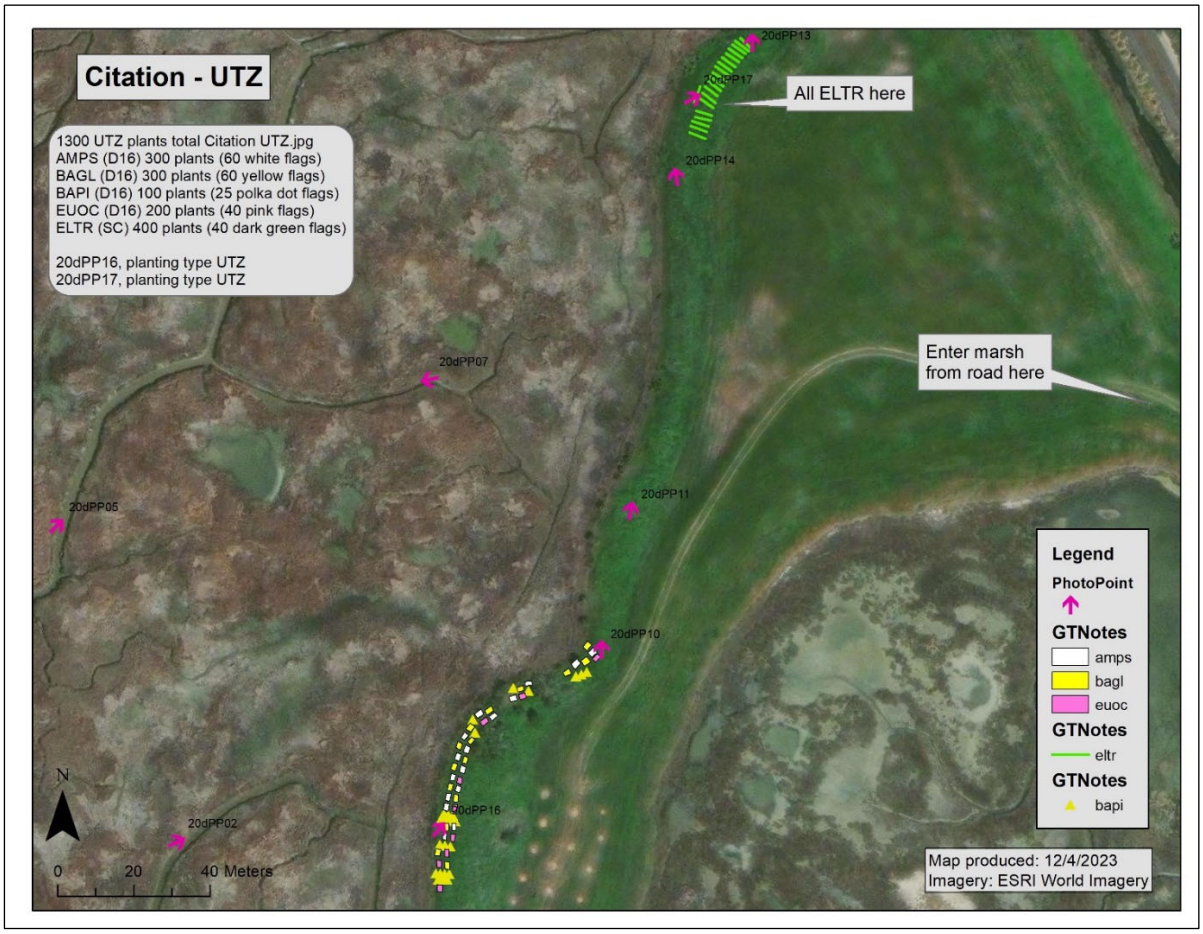

Figure 9. Citation Marsh Central and South - marsh-upland transition zone installation map

Photo 11. Photo Point 20dPP16 shows marsh-upland transition zone plots after planting at Citation Marsh South

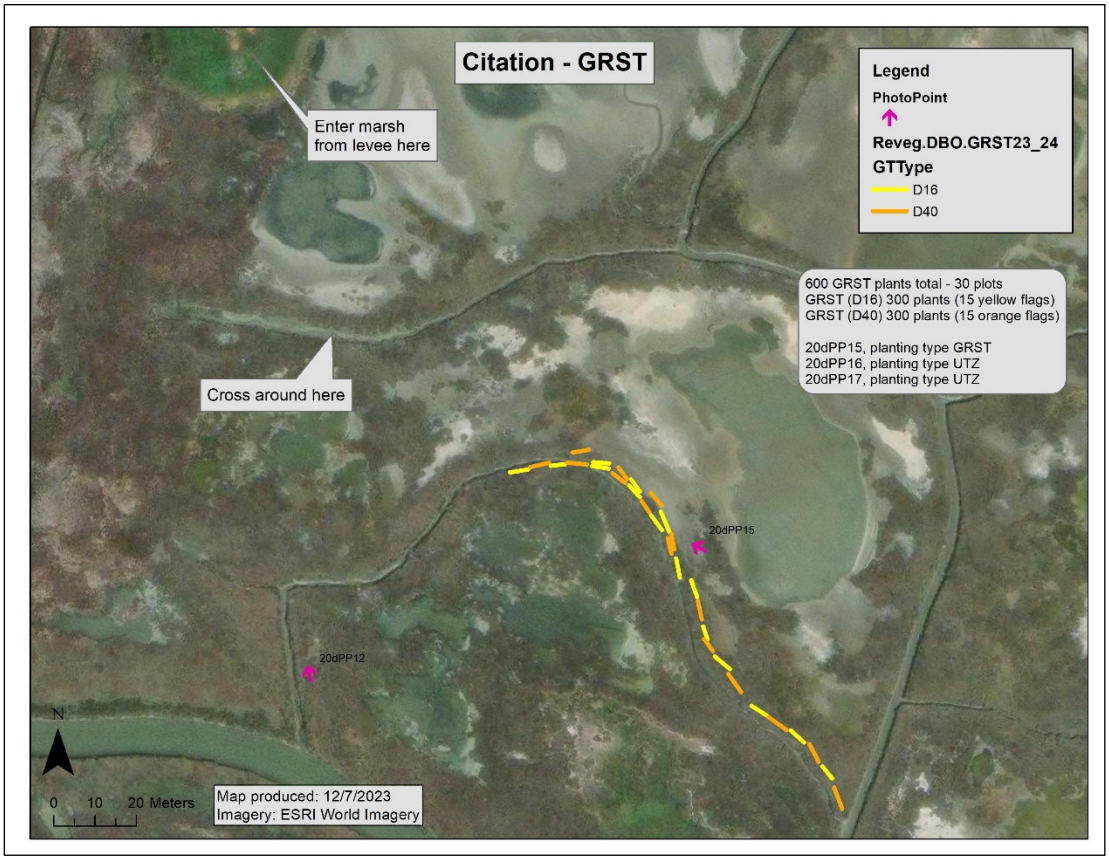

Figure 10. Citation Marsh South plant installation map for marsh gumplant

Photo 12. Photo Point 20dPP15 shows marsh gumplant plots after planting at Citation Marsh South

Bunker Marsh-Robert's Landing, City of San Leandro

The planting plan for Bunker Marsh included 480 plants to be installed near previous plantings. During installation, the RECON crew discovered the substrate was mostly rubble fill material and that it was extremely difficult to create planting holes. Some of the plants were reallocated to Cogswell A.

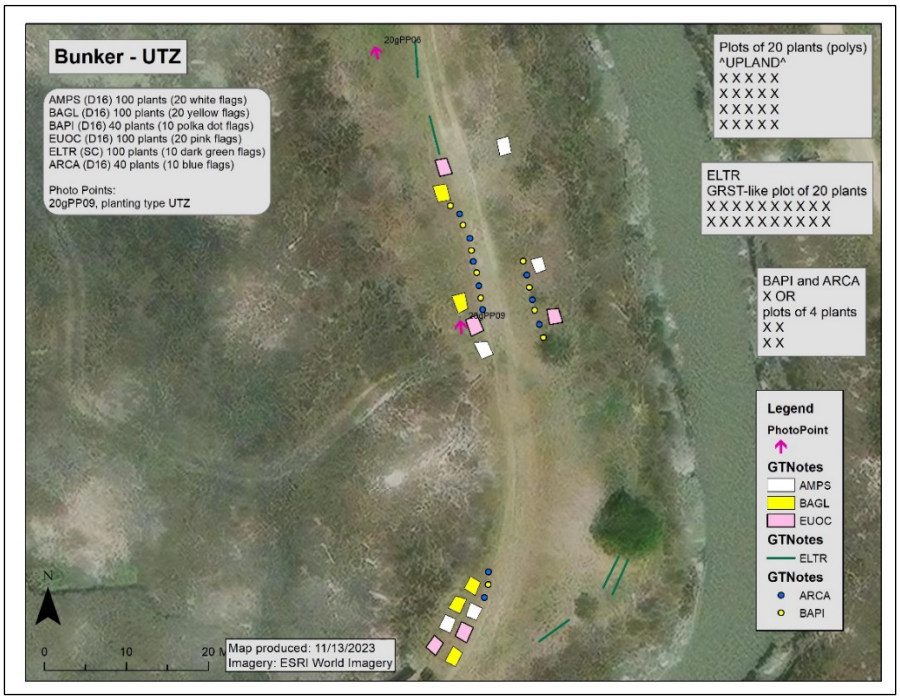

Figure 11. Plant installation map for marsh-upland transition zone at Bunker Marsh

Photo 13. Photo Point 20gPP08 shows 23-24 marsh-upland transition zone plots after planting at Bunker Marsh

East Marsh-Robert's Landing, City of San Leandro

Figure 12. Marsh gumplant installation map at East Marsh

Cogswell A, Hayward Regional Shoreline

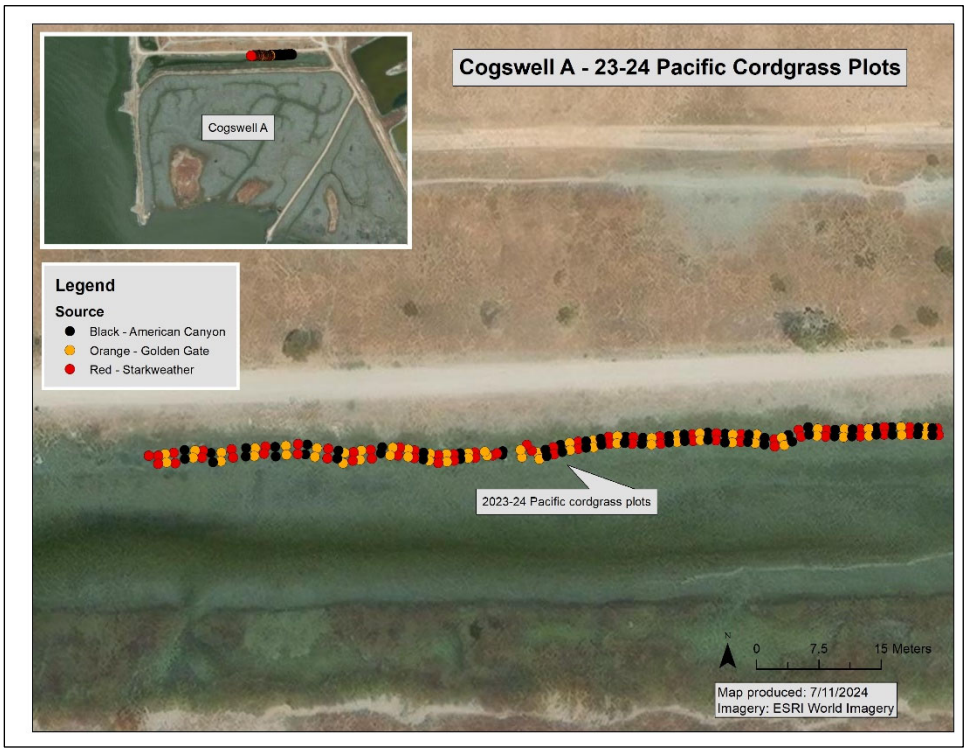

Figure 13. Pacific cordgrass plots installed at Cogswell A in 2023-24

Photo 14. Photo point 20mPP32 showing Pacific cordgrass plots prior to planting at Cogswell A

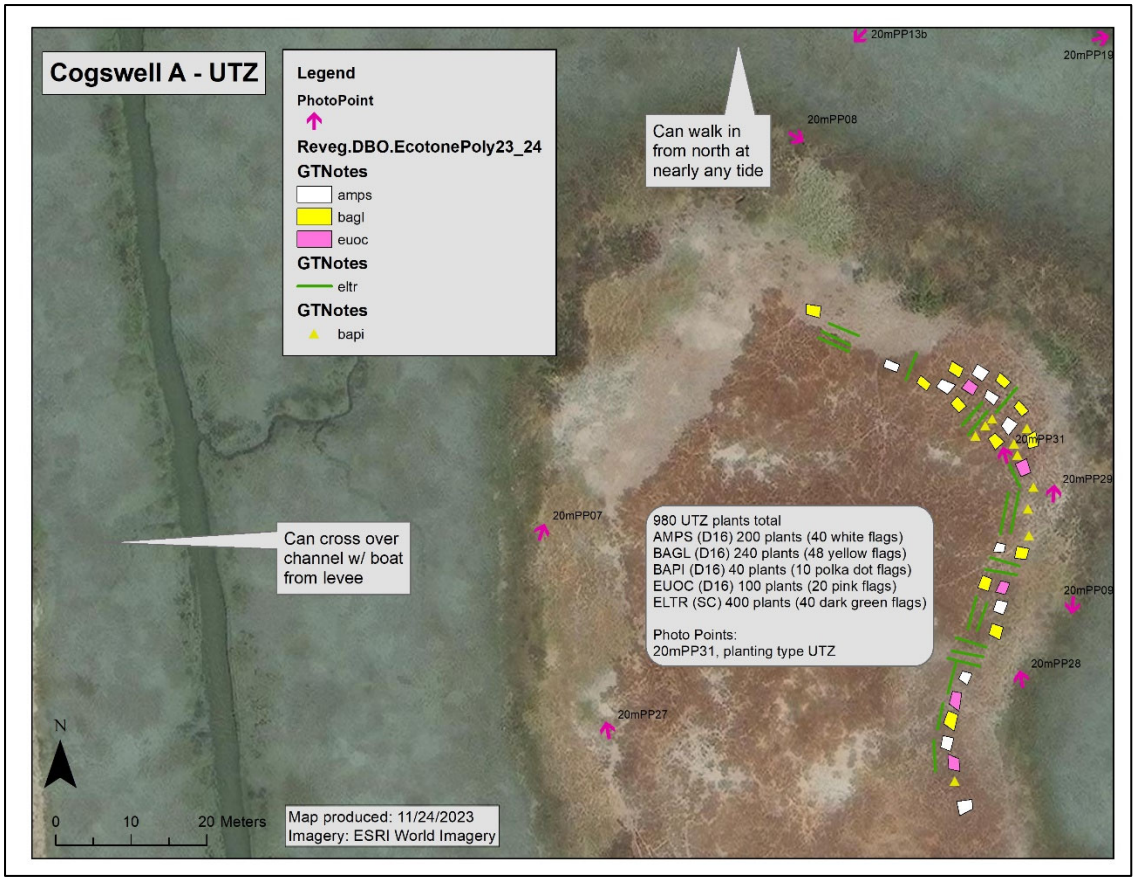

Figure 14. Marsh-upland transition zone installation map for Cogswell A

Photo 15. Photo point 20mPP29 shows marsh-upland transition zone plots after planting at Cogswell A

Cogswell B, Hayward Regional Shoreline

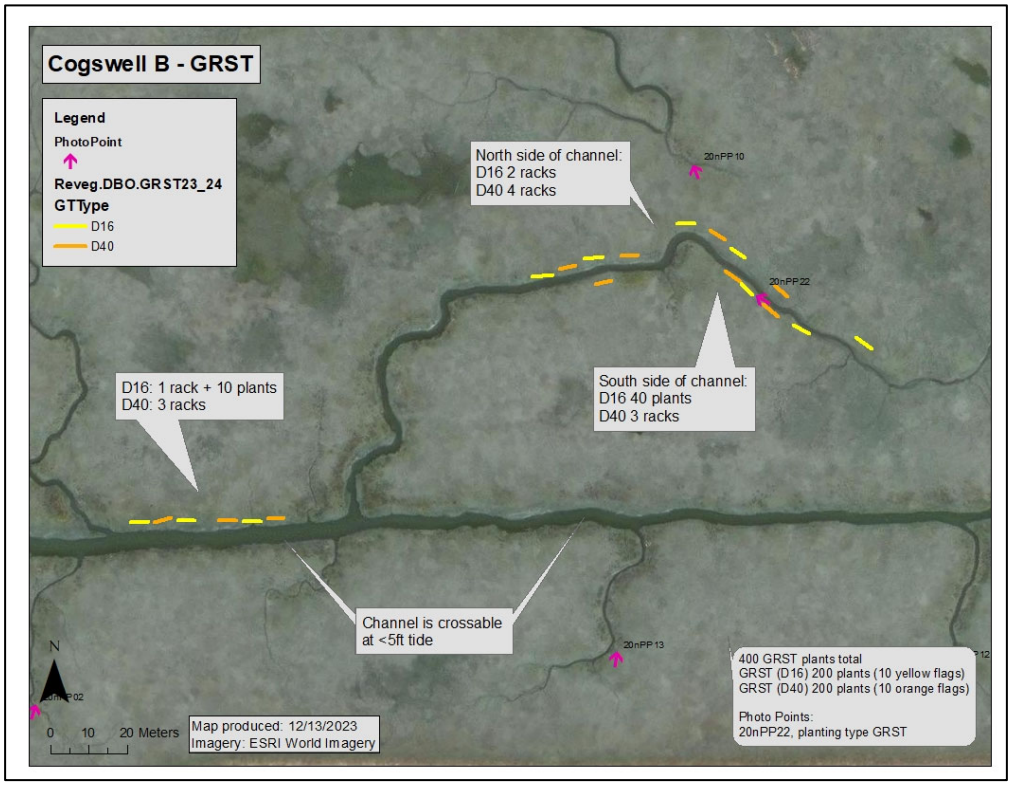

Figure 15. Marsh gumplant installation map for Cogswell Marsh B South

Photo 16. Photo point 20nPP22 shows marsh gumplant plots after installation at Cogswell Marsh B South

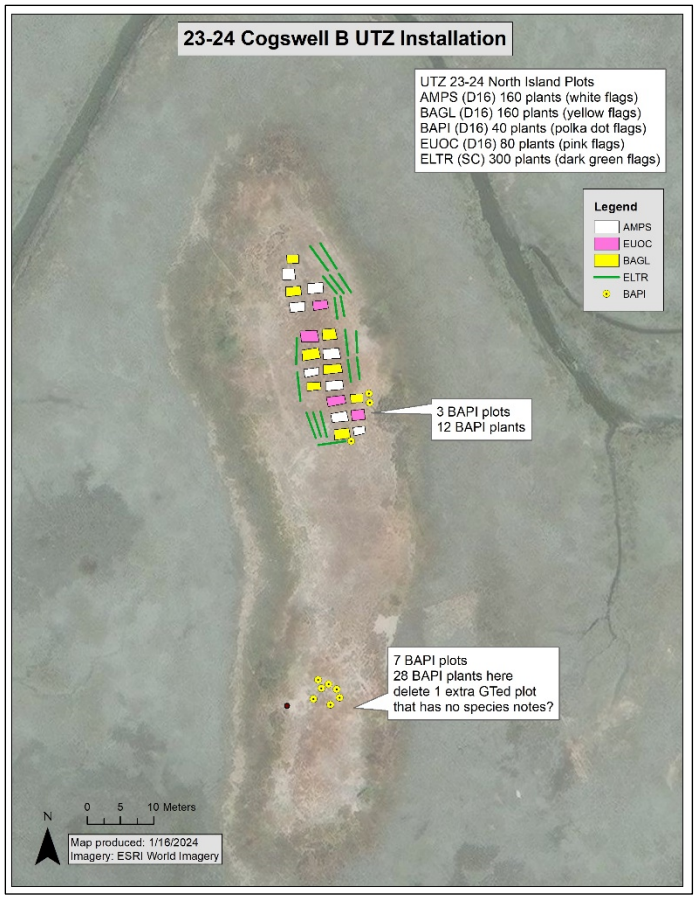

Figure 16. Marsh-upland transition zone installation map for Cogswell Marsh B Main

Photo 17. Photo Point 20nPP21 shows marsh-upland transition zone plots after installation at Cogswell Marsh B Main

Cogswell C, Hayward Regional Shoreline

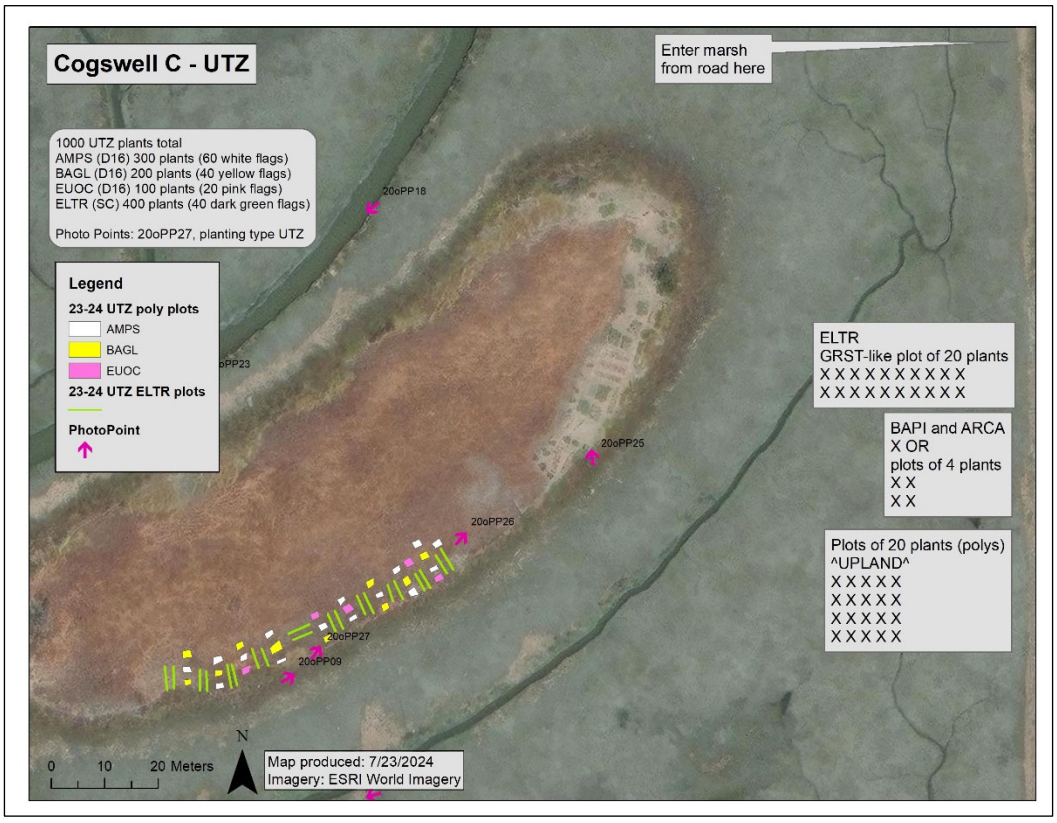

Figure 17. Marsh-upland plant installation map for Cogswell C

Photo 18. Photo Point 20oPP27 showing plots after plant installation at Cogswell C

Ideal Marsh South, Don Edwards San Francisco Bay NWR

Plant installation at Ideal Marsh South was cancelled in 2023-24 due to inaccessible levees. The map below shows the planned but not implemented planting plan.

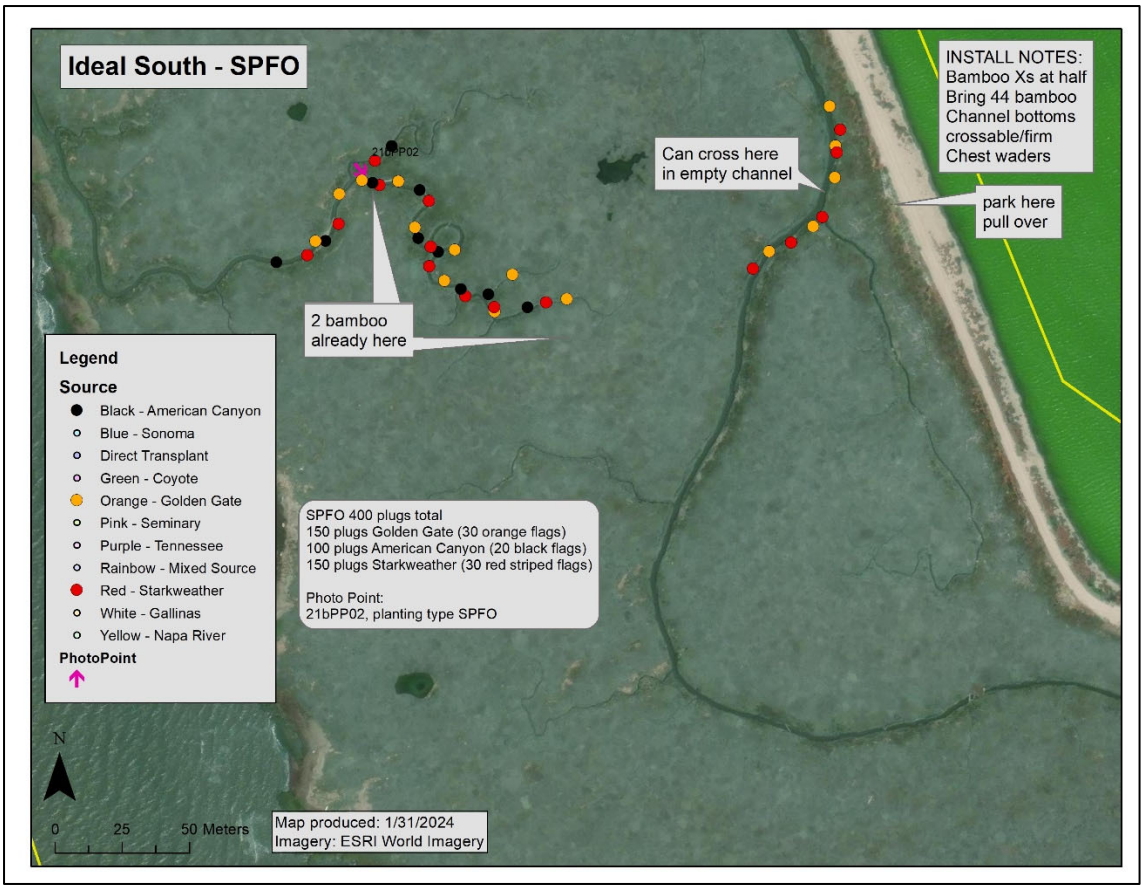

Figure 18. Planned but not implemented Pacific cordgrass plugs installation map for Ideal Marsh South

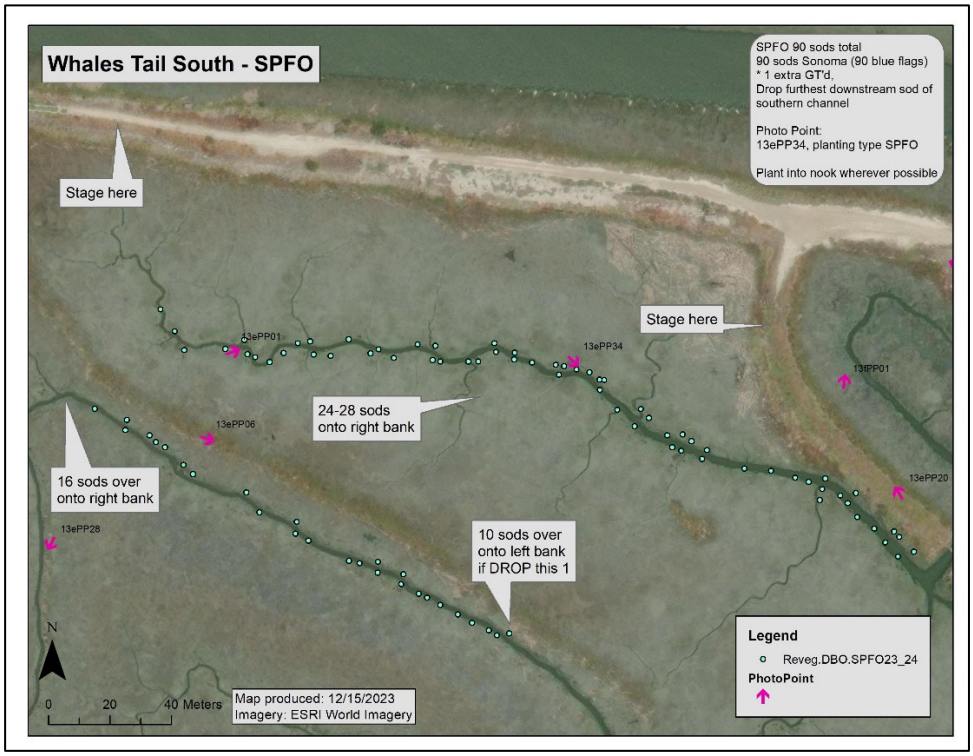

Figure 19. Pacific cordgrass sod installation map for Whale's Tail South

Photo 19. Photo point 13ePP34 shows locations along a channel planned for Pacific cordgrass sods

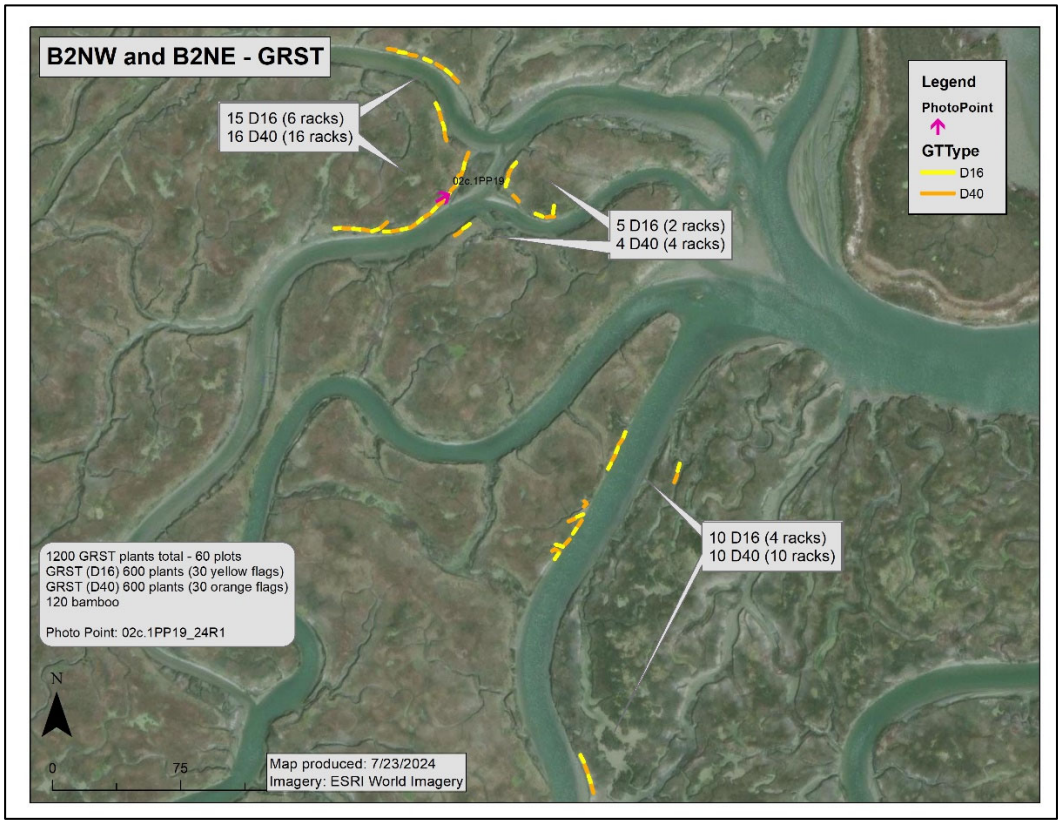

Figure 20. Marsh gumplant plant installation map for B2NE and B2NW

Photo 20. Photo Point 02c.1PP19 taken after marsh gumplant installation at B2NW

MONITORING RESULTS

Initial Survivorship Monitoring for Year 12

This section reports on the initial survivorship monitoring that was conducted in the fall of 2023 for Year 12 (2022-23) plantings at all sites. The initial survivorship monitoring for Year 13 (2023-24) plantings will occur in the fall of 2024 and monitoring results will be included in next year's report.

Plantings installed in the winter of Year 12 (2022-23) were monitored after the first growing season to determine initial survivorship. Initial survivorship monitoring data were collected on individual plants, plant plugs, or sods that were outplanted at sites.

Marsh Gumplant

Data collection for initial survivorship of marsh gumplant plantings consisted of counting the total number of surviving individuals present in each planted plot. Each plot was installed with 20 plants in two rows of 10 plants that were all one size of pot, either D16s or D40s.

Marsh gumplant was planted at five sub-areas in Year 12. Initial plant survivorship after one growing season was 48.8% overall (**Table 3**), higher than in Years 10 or 11 (14.6% and 38%, respectively), likely due to increased precipitation during the winter. Looking at survivorship by row, the inner row, or row closer to channel edge, did about 10% better overall than the outer row. Inner row gumplant are closer to the channel, where substrate drains more quickly, and marsh gumplant are known to grow better in well-drained areas.

Table 3. Initial Survivorship Results for Monitoring in 2023 of Year 12 (2022-23) Marsh Gumplant Plots

Site Name	Total # Plots Planted and Monitored	% Survivorship of Plants in Inner Row (10 total plants)	% Survivorship of Plants in Outer Row (10 total plants)	Mean # of Plants Surviving in Plots (out of 20 total plants)	% Plant Survivorship (Plots)	Total # Plots with at least one plant surviving	% Plots with Survivorship (at least one plant survived)
Bair Island – B2 North South of Boardwalk	9	75.6%	73.3%	14.89	74.4%	9	100.0%
Bair Island – B2 North West	39	48.5%	43.6%	9.21	46.0%	38	97.4%
Bair Island – B2 North East	62	56.9%	45.6%	10.25	51.3%	61	98.4%
Robert's Landing - Citation Marsh South	20	64.0%	44.5%	10.85	54.3%	18	90.0%
Robert's Landing - East Marsh	20	33.5%	25.5%	5.90	29.5%	14	70.0%
Total	**150**	**53.7%**	**43.9%**	**9.76**	**48.8%**	**140**	**93.3%**

Figure 21 shows the results of an analysis of pot size effects on survivorship of marsh gumplant. Both D16 and D40 pot sizes have been planted at sites for five years, typically alternating plots of each pot size along channel edges to compare survivorship. An analysis of relative survivorship comparing plots with either D16 or D40 pots, from 1-4 years after planting, found no significant difference in survivorship.

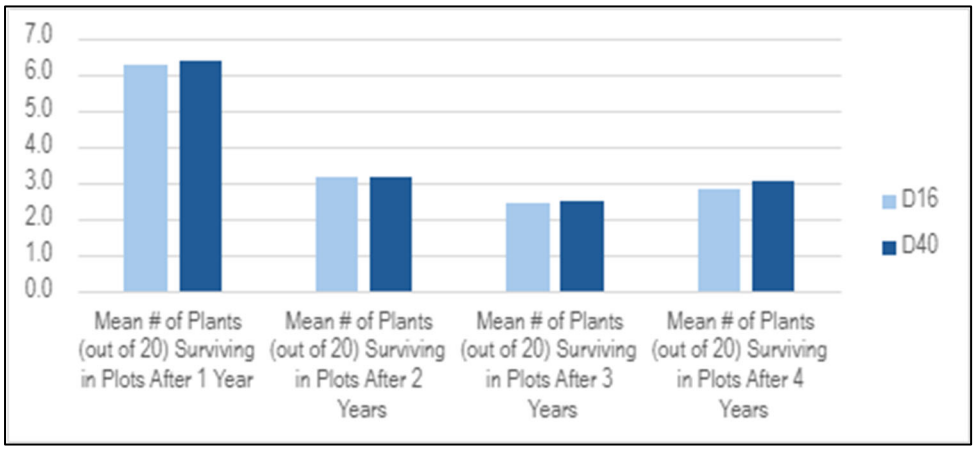

Figure 21. Relative survivorship of marsh gumplant comparing D16 versus D40 pot size from one to four years after planting

Pacific Cordgrass

Data collection for initial survivorship of Pacific cordgrass involved either counting the number of live plugs (plugs with green stems) in each planted plot or the number of surviving sods at a site. The metrics recorded for plug plots included the number of surviving plugs in a plot (out of either 5 or 10 plugs total), the number of surviving plots (where at least one plug survived per plot), the maximum stem height, and number of inflorescences.

Pacific cordgrass was planted at four sub-areas in the East Bay in Year 12: Cogswell A at Hayward Regional Shoreline (planted as plugs); Whale's Tail North (sods) and Pond E9 (plugs) in Eden Landing Ecological Reserve; and Ideal Marsh South (plugs and sods) in the Don Edwards San Francisco Bay NWR. Initial survivorship data from fall 2023 is shown in **Table 4**.

Table 4. 2023 Initial Survivorship Monitoring Results for Year 12 (2022-23) Pacific Cordgrass Plots

Site Name	Type of Plot	# Plots Planted	# Plots Monitored in 2023	Mean Survivorship of Plugs per Plot	% Surviving Plugs	% Plots with Survivorship (at least one plug survived)
Hayward Regional Shoreline – Cogswell A	5 plugs	100	39	3.51	70.3%	97.4%
Eden Landing - Pond E9	5 plugs	182	182	4.06	81.2%	99.5%
Eden Landing - Whale's Tail North	1 sod	60	60	n/a	n/a	96.7%
Don Edwards SFB NWR – Ideal Marsh South	10 plugs	82	82	n/a	n/a	37.8%
Don Edwards SFB NWR – Ideal Marsh South	1 sod	30	30	n/a	n/a	100.0%

Overall Year 12 initial survivorship of 5 plug plots at Cogswell A and Pond E9 was 79.3% compared to 28% for Year 11 plots. Higher survivorship was likely due to the sites selected for planting in Year 12 and different site-specific conditions compared with sites selected in Year 11. In particular, Year 11 site Pond E8A was historically used as a salt evaporator pond and had very low plug survivorship.

Efforts to plant Pacific cordgrass on marsh plain channel edges with limited areas for horizontal planting have been largely unsuccessful. Two planting methods were used in Year 12 to encourage plant establishment in optimal elevations at Ideal Marsh South and Whale's Tail North. One method was planting larger, more linear plots with ten plugs in two rows. These plots were installed along narrow marsh channel edges at Ideal Marsh South. Monitoring was only conducted at the plot-level due to time limitations and survivorship was low, only 37.8% of plots had at least one plug that survived. However, Pacific cordgrass is rhizomatous, which means that each surviving plug, once established, can spread laterally to provide cover over a much larger area. Future monitoring will determine whether plant establishment and spread is occurring at this site.

The "sods" planting method was used at a larger scale in Year 12 at both Whale's Tail North and Ideal Marsh South to continue testing plant installation along marsh plain channel edges. Sods were used because they include larger chunks of belowground plant material that have potential for greater survivorship. For sods, Year 1 survivorship was determined by continued presence of the sod and not whether there were any associated green stems. This decision was made due to the likelihood that rhizome material in the sod may remain dormant underground for at least one year. Monitoring in 2023 found that "survivorship" of sods (meaning continued presence of sod material but not necessarily green stems) was high for both sites. Second-year monitoring in 2024 will use the presence of green stems to determine whether each Year 12 sod "survived" or not.

Table 5 below shows the results from an analysis of initial survivorship of Pacific cordgrass plugs by source population from the last five years of monitoring data (2019 to 2023). Monitoring data included in these summary results is for 5-plug plots across sites from the first fall after planting. Note that not all source populations were planted in all five of the years included in this analysis. Sources included in all five years of monitoring data included American Canyon, Golden Gate Fields, Napa River, Port Sonoma Marina, and Starkweather Cove.

Table 5. Analysis of initial Pacific cordgrass survivorship by source (plugs) from 2019 to 2023

SOURCE	Total # Plots Planted	# Plots Monitored After 1 Year	Mean # of Plugs (out of 5) Surviving in Plots After 1 Year	% Survivor-ship (Plugs) After 1 Year	% Plugs Survived IF at Least One Survived Per Plot After One Year
American Canyon, Solano County	337	292	3.56	71.2%	77.5%
Coyote Creek, Santa Clara County	73	72	2.60	51.9%	75.0%
Golden Gate Fields, Ala-meda County	381	310	2.99	59.9%	81.3%
Napa River, Napa County	403	351	3.02	60.5%	77.6%
Seminary Cove, Marin County	125	125	3.83	76.6%	83.0%
Port Sonoma Marina, Sonoma County	576	535	3.26	65.2%	79.2%
Starkweather Cove, Marin County	519	450	3.60	72.0%	79.1%
Tennessee Valley, Marin County	316	228	4.09	81.8%	82.7%

As shown in **Table 5**, initial survivorship of plugs is fairly high for all sources, ranging from 51.9% to 81.8%. Furthermore, for 5-plug plots with at least one surviving plug, the range is both narrower and skews higher from 75.0% to 83.0%. This estimate of survival mitigates for the chance plots of certain sources were more often planted in entirely unhabitable micro-conditions. Note that several of these sources are no longer available for planting as part of our program, including the lowest performing source, Coyote Creek, and the highest performing site, Tennessee Valley. Sources were discontinued for several reasons, including a reduction in the overall number of nursery propagation beds (each bed contains a single source population) from 45 beds in Year 5 (2015-16) to 5 beds in 2023-24, and, for several sources, low amplification of plant material in the propagation beds after several years in the nursery. These summary results also do not indicate whether survivorship of each source varies by site after outplanting, but this is not an issue for our program as we will continue to plant all sources across sites to maximize genetic diversity.

Marsh-Upland Transition Zone

Marsh-upland transition zone species were planted to enhance year-round refuge habitat at treated sites. Eight hardy, salt tolerant perennial species were installed in transition zones to provide native high tide refuge habitat at six sub-areas: coyote brush (*Baccharis pilularis*), creeping wild rye (*Elymus triticoides*), marsh baccharis (*Baccharis glutinosa*), western ragweed (*Ambrosia psilostachya*), western goldenrod (*Eu-thamia occidentalis*), alkali heath (*Frankenia salina*), saltgrass (*Distichlis spicata*), and California sagebrush (*Artemisia californica*). Monitoring results are shown below. Overall initial survivorship for coyote brush and California sagebrush was high at 86.6% and 78.5%, respectively (**Table 6** and **Table 7**).

Table 6. 2023 Initial Survivorship Monitoring Results for Year 12 (2022-23)
Coyote Brush (*Baccharis pilularis*) Plots (4 plants per plot)

Site Name	Total # Plots Planted	# Plots Monitored in 2023	Mean # of Plants Surviving in Plots (out of 4 total plants)	% Survivor-ship	Total # Plots with at least one plant sur-viving	% Plots with Survivorship (at least one plant survived)
Bunker Marsh	19	19	3.58	89.5%	17	89.5%
Cargill Mitigation Marsh	10	8	3.75	93.8%	8	80.0%
Citation Marsh (Upper and Central)	40	40	3.75	93.8%	40	100.0%
Cogswell A	10	10	3.30	82.5%	9	90.0%
Cogswell B (Main and Bayfront)	10	10	4.00	100.0%	10	100.0%
Cogswell C	10	10	2.20	55.0%	9	90.0%
Total	**99**	**97**	**3.54**	**86.6%**	**93**	**93.9%**

Table 7. 2023 Initial Survivorship Monitoring Results for Year 12 (2022-23)
California Sagebrush (*Artemisia californica*) Plots (4 plants per plot)

Site Name	Total # Plots Planted	# Plots Monitored in 2023	Mean # of Plants Surviving in Plots (out of 4 total plants)	% Survi-vorship	Total # Plots with at least one plant sur-viving	% Plots with Sur-vivorship (at least one plant survived)
Bunker Marsh	15	15	3.40	85.0%	14	93.3%
Citation (Upper and Central)	25	25	3.16	79.0%	24	96.0%
Cargill Mitigation Marsh	10	10	2.70	67.5%	10	100.0%
Total	**50**	**50**	**3.14**	**78.5%**	**48**	**96.0%**

For creeping wild rye, overall survivorship was high at 80.5%, with lower survivorship at Citation Marsh (35.6%,**Table 7)**. Lower survivorship at Citation Marsh was likely the result of competition for resources with annual weeds, as weeding was not completed in some plots until later in the growing season. Weeding tasks at Citation were not completed for several reasons, including an active song sparrow nest in one area, and staff needed for higher priority tasks.

Table 8. 2023 Initial Survivorship Monitoring Results for Year 12 (2022-23)

Creeping Wild Rye (*Elymus triticoides*) Plots (20 grass plugs per plot)

Site Name	Total # Plots Planted	# Plots Monitored in 2023	Mean # of Plants Surviving in Plots (out of 20 total plants)	% Survivorship	Total # Plots with at least one plant surviving	% Plots with Survivorship (at least one plant survived)
Bunker Marsh	14	14	15.79	78.9%	14	100.0%
Cargill Mitigation Marsh	26	26	19.20	96.0%	26	100.0%
Citation Marsh (Upper and Central)	23	23	7.13	35.6%	22	95.7%
Cogswell A	26	26	18.16	90.8%	26	100.0%
Cogswell B (Main and Bayfront)	11	11	19.82	99.1%	11	100.0%
Cogswell C	10	10	19.10	95.5%	10	100.0%
Total	**110**	**110**	**16.05**	**80.5%**	**109**	**99.1%**

Overall initial survivorship for all five species planted in 4x5 grids was high (over 80%), with one species, alkali heath, slightly lower at 73.5% (**Table 9**). Survivorship for each species combining all sites was high. Saltgrass had the lowest survivorship at 57.3%, likely due to annual weed species that quickly overgrew planted plots before weeding reduced competition. Frequent watering and weeding contributed to the high survivorship for most species at most sites. Watering was conducted a maximum of two times per month at most sites. Our watering efforts were initiated during the planting effort, when we watered plants immediately after planting (if needed), and then continued as needed through the end of June. As all five species are rhizomatous, we expect that if even just one plant survived and became established in a plot, that plant may spread laterally by rhizome. The "% Plots with Survivorship (at least one plant survived)" column in Table 9 indicates that for all species except saltgrass, plants survived in more than 90% of plots.

Table 9. 2023 Initial Survivorship Monitoring Results for Year 12 (2022-23) Rhizomatous Perennial Marsh-Upland Transition Zone Species Planted in 4x5 Grids (20 plants per plot)

Species	Total # Plots Planted	# Plots Monitored in 2022	Mean # of Plants Surviving in Plots (out of 20 total plants)	% Survivorship	Total # Plots with at least one plant surviving	% Plots with Survivorship (at least one plant survived)
Marsh baccharis (*Baccharis glutinosa*)	50	50	19.10	95.5%	50	100.0%
Western ragweed (*Ambrosia psilostachya*)	50	50	17.42	86.6%	48	96.0%
Western goldenrod (*Euthamia occidentalis*)	50	50	18.78	93.9%	50	100.0%
Alkali heath (*Frankenia salina*)	15	15	17.73	88.7%	14	93.3%
Saltgrass (*Distichlis spicata*)	20	20	11.45	57.3%	14	70.0%

Photo Point Monitoring

Photo points are set up prior to plant installation and initial follow-up photos are taken immediately after planting is complete. A subset of the photo point photos taken immediately after planting for Year 13 sites are included above (section called Year 13 Installation Maps and Photo Points by Site). Follow-up photo points taken in 2023 that are included here represent a variety of planting years.

Photo 21. Photo Point 20gPP01 shows Year 2 (2012-13) marsh gumplant planted areas at Bunker Marsh, Robert's Landing. Photo taken August 2023.

Photo 22. Photo Point 20dPP14 shows Year 12 (2022-23) UTZ plantings during their first growing season at Citation Marsh, Robert's Landing. Photo was taken in August 2023.

Photo 23. Photo Point 13fPP07 shows Pacific cordgrass expansion from Year 4 (2014-15) planted areas at Cargill Mitigation Marsh. Photo taken August 2023.

Photo 24. Photo Point 20mPP16 shows Year 2 (2012-13) marsh gumplant at Cogswell A, Hayward Regional Shoreline. Photo taken August 2023.

Photo 25. Photo Point 20mPP29 shows Year 12 (2022-23) UTZ plantings during their first growing season at Cogswell A, Hayward Regional Shoreline. Photo taken August 2023.

Photo 26. Photo Point 20nPP14 shows Year 5 (2015-16) marsh gumplant at Cogswell B, Hayward Regional Shoreline. Photo taken August 2023.

Photo 27. Photo Point 20nPP20 shows Year 12 (2022-23) UTZ plantings at Cogswell B, Hayward Regional Shoreline. Photo taken August 2023.

Photo 28. Photo Point 20oPP20 shows Year 5 (2015-16) marsh gumplant at Cogswell C, Hayward Regional Shoreline. Photo taken August 2023.

Photo 29. Photo Point 20oPP26 shows Year 12 (2022-23) UTZ plantings at Cogswell C, Hayward Regional Shoreline. Photo taken August 2023.

Photo 30. Photo Point 05bPP01 shows Year 6 (2016-17) marsh gumplant planted at Dumbarton Marsh, Don Edwards SFB NWR. Photo taken August 2023.

Photo 31. Photo Point 17aPP05 shows Year 8 (2018-19) Pacific cordgrass planted at Elsie Roemer, City of Alameda that is now submerged under sand from nearby Crown Beach. Photo taken October 2023.

Photo 32. Photo Point 18gPP06 shows Year 9 (2019-20) Pacific cordgrass planted at San Bruno Marsh, City of South San Francisco. Photo taken September 2023.

Photo 33. Photo Point 02c.1bPP01 shows Year 12 (2022-23) marsh gumplant planted at Bair Island – B2NE, Don Edwards SFB NWR during first growing season. Photo taken September 2023.

REFERENCES

Chesser, R.T., R.C. Banks, C. Cicero, J. L. Dunn, A.W. Kratter, I.J. Lovette, A.G. Navarro-Siguenza, P.C. Rasmussen, J.V. Rensen, Jr., J.D. Rising, D.G. Stotz, and K. Winker. 2014. Fifty-Fifth Supplement to the American Ornithologists' Union Checklist of North American Birds. The Auk Vol. 131, No. 4 pp. CSi-CSxv. http://www.bioone.org/doi/abs/10.1642/AUK-14-124.1

Thornton, W., 2012. Protocol for Selection, Propagation, and Monitoring of *Spartina foliosa* Donor Populations for Revegetation Projects in the San Francisco Estuary. Prepared by Olofson Environmental, Inc. for the State Coastal Conservancy, May 18, 2012. 14 pages + Apps.

Olofson Environmental, Inc. January 2012. San Francisco Estuary Invasive *Spartina* Project California Clapper Rail Habitat Enhancement, Restoration, and Monitoring Plan. Report prepared for the California State Coastal Conservancy San Francisco Invasive *Spartina* Project, 1330 Broadway, 13th Floor, Oakland, CA 94612. January 2, 2012. http://www.spartina.org/project_documents/revegetation_program/ISP%20CLRA%20Habitat%20Enhancement%20Plan_Fin_01072012%28all%29.pdf

U.S. Fish and Wildlife Service. September 2011. Formal Consultation for the Proposed San Francisco Estuary Invasive *Spartina* Project: *Spartina* Control Program and Restoration for 2011 on 95 sites; Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties, California. #8 1420-201 1-F-0686-3. September 23, 2011.

Zaremba, K., J. Hammond, J.T. McBroom, W. Thornton, S. Chen, D. Kerr, and E. Grijalva. August 2011. Draft San Francisco Estuary Invasive *Spartina* Project Revegetation and Monitoring Plan. Prepared by Olofson Environmental, Inc. for California State Coastal Conservancy, Oakland, CA 94612. August 26, 2011.

Personal Communications

Josh Hull, Andy Raabe, Ben Solvesky, September 15, 2011. Telephone conference call with Peggy Olofson, Katy Zaremba, Jeanne Hammond (Olofson Environmental, Inc., Invasive *Spartina* Project); and Amy Hutzel, Coastal Conservancy. Providing FWS comments on the Draft Invasive *Spartina* Project Revegetation and Monitoring Plan dated August 26, 2011.