Marin Audubon Society's Bahia Wetland Restoration Project
2009 – 2014
Funded by the US EPA's San Francisco Bay Water Quality Improvement Fund

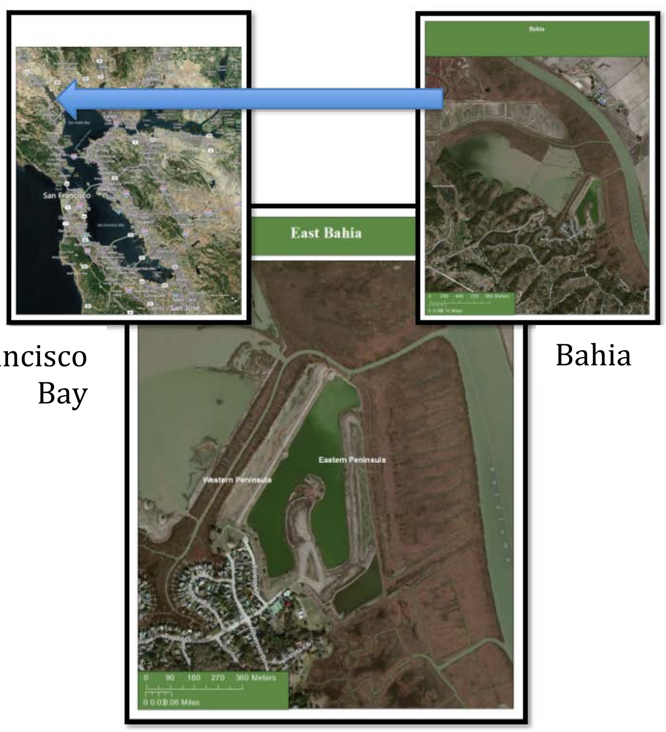
Contents

I. Site Summary

The entire 632-acre Bahia site is comprised of three distinct areas: West Bahia, Central Bahia and East Bahia (figure 1). In 2003 MAS purchased the Bahia property to save this ecologically valuable area from development. The Bayland and upland areas of Central and Western Bahia were turned over to the Marin County Open Space District and the California Department of Fish and Wildlife. MAS retained the 60-acre East Bahia property and a smaller parcel to the west and is actively managing the restoration of these areas. The land at East Bahia surrounds a privately owned lagoon and restoring the entire parcel to wetland is not possible. MAS worked with the hydrology firm PWA and Plant Ecologist Peter Baye to develop a restoration plan that will gradually transform this man-made area into a landscape made of expanded tidal marsh (merging with existing marshlands) that transitions through the gradually sloping ecotone to low uplands of native perennial sod-forming grasses, scattered native oaks and seasonal wetlands.

The Bahia Restoration and Revegetation Project site is located on the East Bahia parcel along the Eastern and Western Peninsulas where the levees have been reconstructed to provide the gently sloping ecotones rising from the tidal marsh to the upland areas (see attachment C for East Bahia Revegetation Plan pg 46).

Figure 1. Overview of Site Location



San Francisco Bay

Bahia

East Bahia

Figure 2. Map of East Bahia

II. Summary of Project Goals and Results

During the 4 years of this contract (March 1, 2009 - January 31, 2013), the Marin Audubon Society (MAS) Bahia Restoration and Revegetation Project has completed the tasks described in the contract Scope of Work. These tasks included enhancing the tidal marsh ecotone habitat along two levees comprised approximately of 10.5 acres on the Eastern and Western Peninsulas adjacent to 14.5 acres of newly restored tidal marsh at Eastern Bahia. Ecological improvements were made through removal of invasive plant species and revegetation of native plants in habitat for sensitive species. Ecological enhancement in habitat included improvements in native coverage consistent with the recovery plan for the salt marsh harvest mouse and the California Ridgway's rail indicating "upper portions of marshes must be restored to provide refugia for both species" [1] and the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* which indicates ecotone marsh-to-terrestrial ecotones should be expanded or restored.[2]

The Bahia Restoration and Revegetation Project has enhanced native tidal marsh habitat by propagating approximately 11,000 native *Elymus triticoides* (formerly *Leymus t.*) rhizomes in the on-site nursery beds from plants collected on site (Central Bahia) and through the out-planting and mulching of over 6,000 *E. triticoides* rhizomes from these plants, as well as by the planting and mulching of more than 600 native colonial flowering perennial and shrub plants and trees propagated with local seed source by the Watershed Nursery (TWN) and removing several species of highly invasive weeds from along 10.5 acres of the two levees in the project area (42 cumulative acres over the four year project period). Native plant coverage increased and will continue to increase as these newly established plants colonize the project area. The restoration activities were accomplished with the help of over 500 community volunteers and contacted workers that served over 1,500 hours.

Please refer to the table in section V for detailed planting and propagation numbers including species.

III. Description of Project Components (tasks)

To complete the project, MAS provided (1) project management, (2) development of monitoring protocols (3) the propagation and planting of native plants, and removal of non native invasive plants, (4) the monitoring and recording of vegetation metrics, (5) the evaluation of planting success, and (6) Dry Season Adaptive Management.

[1] U.S Fish and Wildlife Service. 1984. Salt Marsh Harvest Mouse and California Clapper Rail Recovery Plan. Portland Oregon.. pg. 47.

[2] U.S. Fish and Wildlife Service. 2009. Draft recovery Plan for Tidal Marsh Ecosystems of Northern and Central California. Sacramento, California. pgs 197 and 213.

As part of the project management task, MAS prepared quarterly reports, financial statements and oversaw personnel responsible for the Project. The quarterly reports discussed project activities conducted during the quarter, progress towards milestones, environmental outcomes, problems encountered and their resolution, and activities planned for the succeeding quarter.

To develop measurements of success, a Quality Assurance Project Plan (QAPP) that was developed by the San Francisco Estuary Institute, Save the Bay and the Marin Audubon Society (see further discussion below).

To complete the native plant propagation and planting and invasive plant removal task, MAS coordinated community-based volunteer restoration projects and hired contracted professional restoration crews (Conservation Corps North Bay, Cagwin & Dorwood, The Watershed Nursery, Shelterbelt Builders) to manually remove invasive species, build and maintain on site nursery beds for growing native, sod-forming grasses, *Elymus triticoides* and sedges, *Carex barbarae*. Volunteers and contractors also collected *E. triticoides* from an on-site source to propagate in these beds (with the guidance of Plant Ecologist, Peter Baye), prepared rhizomes of these propagated grasses for planting and out-planted rhizomes following invasive removal. Other native plants were propagated by the TWN and out planted by contractors and community volunteers. Volunteers and contracted workers also worked to eliminate priority invasive species from the project area during the summer and fall months.

To evaluate plant establishment, MAS Board Members conducted monitoring using protocols from the approved QAPP and assessed data collected under these protocols (see further discussion below).

After the propagation and outplanting was complete, MAS had funds left in contract and worked with SFEP and the EPA to modify the contract to expand the scope of work. This new task (6) included the planting of nine separate thickets on the Eastern Peninsula that were composed of an array of native species and the use of DriWater to ensure their survival. A more detailed description of this task and the monitoring results from this work can be found in Attachment D (pg 72).

IV. QAPP Development

The QAPP for the Bahia Restoration and Revegetation Project was developed in coordination with the San Francisco Estuary Institute and Save the Bay. The draft monitoring protocol that was developed through the QAPP process is intended to be used as a standardized protocol for data collection to track restoration outcomes and to meet the need for standardized data on the responses of the ecotone plant community to onsite vegetation management (Attachments B).

For this project, MAS monitoring data was used to assess the change in percent cover of native vs. invasive species in the project area at Eastern Bahia prior to restoration activities and following non-native plant removal and the out planting of over 6,600 native plants in the ecotone.

The vegetation monitoring was performed by two MAS Board Members; Jude Stalker, a Wetland Biologist and Lowell Sykes who is familiar with the protocol methods and with the flora of the site.
A summary of the monitoring results is described below.

V. Summary of Expected Outputs and Outcomes and Accomplished Deliverables

The primary outputs expected for this project included the following:

a. Baseline ecological assessment data for restoration site;
b. 2,040 native plants/rhizomes to be planted in habitat at restoration site;
c. 1,200 native plants/ rhizomes to be planted in nursery beds: and
d. 25-acres of invasive plants removed from restoration site.

From March 1, 2009 - January 31, 2013, MAS monitored plants to provide baseline and annual ecological assessment data. Over 1,000 native *Elymus triticoides* and 200 native *Carex barbarae* plants were planted in the MAS nursery beds which produced over 12,000 viable rhizomes and plants. Over 6,000 of these propagated native sedge plants and grass rhizomes were outplanted and mulched at the restoration site along with over 600 native flowering perennials, shrubs and oaks, far exceeding the 2,040 plants expected. The remaining propagated plants and rhizomes were left in the nursery beds for future use. MAS also removed several species of invasive plants annually from the entire 10.5 acres of tidal marsh-ecotone and upland habitat in the project area, cumulatively totaling 42 acres. These numbers and plant species are provided in table 1 below. This work was accomplished with the help of over 500 volunteers and contracted workers for a total of approximately 1,500 project hours (1,200 and 300 hours respectively).

The primary outcomes expected for this project included the following:

1. Increased acreage of wetland in transition/upland zone; and
2. Improved wetland condition.

The work detailed in this report improved wetland habitat conditions and increased the acreage of transition zone habitat by enhancing the upland area adjacent to the tidal marsh with the planting of native plant species and the reduction of the existing seed source of invasive plant species, meeting expected outcomes.

Table 1: This table lists the plant species propagated, the number of plants that were yielded from that process, the list of all native species planted on site and the number of individuals. On the far right, the list of invasive species removed is provided. These species were removed over a two year period.

Native Plants and Rhizomes Propagated (in on-site beds)	Yeild from Propagation (12,000 total)	Native Species Planted	Number of Individuals Planted (>6,747 total)	Invasive Species Removed (from 42 acres in 2 years)
Elymus triticoides	~ 11,000	*Elymus triticoides*	> 6,000	*Raphanus sativus*
Carex *barbarae*	~ 1,000	*Carex barbarae*	~ 100	*Dittrichia graveolens*
		Baccharis pilularis	53	*Foeniculum vulgare*
		Baccharis douglasii	139	*Lotus corniculatus*
		Euthamia occidentalis	170	*Agrostis avenacea*
		Rosa californica	33	*Xanthium strumarium*
		Ambrosia psilostachya	20	*Centaurea solstitialis*
		Carex pragracilis	40	*Phalaris aquatica*
		Aster chilensis	40	*Carpobroyus chilensis*
		Scrophularia californica	20	*Lepidium latifolium*
		Sambucus Mexicana	35	
		Quercus agrifolia	>30	
		Hordeum brachyantherum	67	

VI. Methodology and Execution

Within the four-year contract period, MAS enlisted, mobilized and trained volunteers and contracted workers to propagate native *E. triticoides* plants in on-site nursery beds, revegetate and enhance 10.5-acres of the Upland Transition Zone (UTZ) adjacent to 14.5 acres of newly restored tidal salt marsh habitat, which is connected to the vast and established tidal marsh along the Petaluma River. The adjacent tidal marshes have established populations of the federally endangered Ridgway's rail; the state threatened black rail as well as many other aquatic and terrestrial species. This newly created tidal marsh habitat and upland refugia will benefit these species greatly. Restoration activities included:

- Harvesting local source of *Elymus triticoides* and *Carex barbarae* (from Central Bahia and another local MAS site).

- Building, planting and maintaining on-site nursery beds for *Elymus triticoides* and *Carex barbarae*.

- Planting and mulching of native plants in the project area.

  Native plants planted included: ***Elymus triticoides*** (creeping wild rye grass), ***Carex barbarae*** *(Santa Barbara sedge),* ***Baccharis pilularis*** (coyote brush)*,* ***Baccharis douglasii*** (marsh baccharis)*,* ***Euthamia occidentalis*** (Western goldenrod)*,* ***Rosa californica*** (California rose)*,* ***Ambrosia psilostachya*** (Cuman ragweed)*,* ***Carex pragracilis*** (California field sedge)*,* ***Aster chilensis*** (California aster)*,* ***Scrophularia californica*** (California bee plant), ***Sambucus mexicana*** (blue elderberry) and ***Quercus agrifolia*** (coast live oak).

- Maintaining plantings in the project area (caging, mulching, etc., when needed).

- Consultations with experts on best practices for conducting native planting and invasive plant removal.

- Reducing infestations of invasive plants through strategic manual removal as recommended by Peter Baye in Vegetation Management Plan for East Bahia.

  Invasive plant species that were prioritized and removed included: ***Raphanus sativus*** (wild radish), **Dittrichia graveolens** (stinkwort),***Foeniculum vulgare*** (fennel), ***Lotus corniculatus*** (birds-foot trefoil), ***Agrostis avenacea*** (Australian bentgrass), **Xanthium strumarium** (cocklebur), **Centaurea solstitialis** (yellow star thistle) ***Phalaris aquatica*** (harding grass), ***Carpobroyus chilensis*** (iceplant)*,* and ***Lepidium latifolium*** (perennial pepperweed).

- Monitored and evaluated restoration success using the UTZ monitoring protocol developed by SFEI, STB & MAS: *Data Collection Protocol: Plant Community Structure of Intertidal-upland Ecotone* (Attachment B)*.*

- Educated community volunteers about the history of Bahia, values of wetlands and importance of wetland restoration.

VII. Summary of Monitoring Data

Native and Invasive Plant coverage was measured prior to restoration activities and following invasive removal and planting activities using our approved QAPP methods. The below table summarizes data collected pre and post restoration activities conducted under this project:

Eastern Peninsula:

Stratum	Percent cover native *2010*	Percent cover Lolium multiflorum *2010*	Total percent cover non-native *2010*	Percent Cover native *2012*	Percent cover Lolium multiflorum *2012*	Total percent cover non-native *2012*	Percent Change in native cover	Percent Change in non-native cover
Intertidal	0	0	4	15	16	32	15	28
Low	0	19	36	19	13	51	19	15
Middle	0.07	84	98	4	38	95	4	-3
High	0	75	79	1	30	70	1	-9
Intertidal	0	3	3	18	0	0.6	18	-3
Low	0.2	38	64	1.4	18	98	1.2	34
Middle	0	78	92	0	14	100	0	8
High	Not monitored 2010			0	35	100	No 2010 Data	

Western Peninsula:

Stratum	Percent cover native *2010*	Percent cover Lolium multiflorum *2010*	Total percent cover non-native *2010*	Percent Cover native *2012*	Percent cover Lolium multiflorum *2012*	Total percent cover non-native *2012*	Percent Change in native cover	Percent Change in non-native cover
Intertidal	0.4	2	3	6	8	17	5	2
Low	0	8	16	6	7	94	6	78
Middle	0	3	14	2	69	96	2	82
High	0	7	13	4	72	84	4	71
Intertidal	0	0.6	3	0	15	43	0	40
Low	0	48	50	0	86	98	0	48
Middle	0	86	88	4	82	94	4	6
High	0	100	100	0	85	100	0	0
Intertidal	0	0.4	4	0	49	77	0	73
Low	0	5	5	2	99	99	2	94
Middle	0	76	76	0.2	84	88	0.2	18
High	0	100	100	2	92	99	2	-1
Intertidal	0	0.25	4	2	2	41	2	37
Low	0	16	20	0	100	100	0	80
Middle	0	36	43	0	83	85	0	62
High	0	100	100	0	100	100	0	0

VIII. Evaluation

a. Outcome accomplishments vs. expected results

MAS was able to accomplish identified outputs through the described tasks:

MAS worked with SFEI to field-test the UTZ protocol, found ways to streamline the data collection methods, collaborated with SFEI on the final drafts of the protocol and successfully conducted the baseline and annual ecological assessment data collection using this protocol.

With the help of volunteers and contracted crews, MAS planted over 6,600 plants and rhizomes in the project area, well exceeding the goal of 2,040 plants/rhizomes. The survivorship of many of these plants (particularly along the Eastern Peninsula) was lower than expected due to the poor soil quality and the severe drought. In December 2012, 295 additional native colonial flowering perennial and shrub plants were planted in the project area. The 110 that were planted in the higher elevations of the Eastern Peninsula were planted by the professionals at TWN who provided extra measures such as including the addition of a light soil amendment, sheet- and straw-mulching and the installation of three ‘DRiWater’ gel packs per plant. These plants will be monitored and maintained regularly to increase their chances of survival. Despite this lower than expected survival rate, the perennial and shrub plants that have survived have improved the overall condition of the wetland-upland ecotone habitat by providing upland refugia and adding a greater diversity of native plant species and these ‘pioneers’ will serve a very valuable role as the seed sources for the recruitment of native plants in the future. The surviving *E. triticoides* is still in relatively small-scattered patches. The expectation is that these patches, along with additional plantings will spread by vegetative growth over time, increasing the area of coverage by this native sod-forming grass and providing upland refugia for the animals that depend on it for their survival.

Over the project period, MAS constructed and maintained six on-site nursery beds and propagated enough plants to provide approximately 11,000 plantable *E. triticoides* rhizome segments. Approximately 6,000 rhizomes were harvested from these beds and planted along the UTZ in the project area. These numbers also exceeded the expected outputs outlined in the scope of the project.

The construction and productivity of the MAS nursery beds has provided MAS with an excellent way to harvest, propagate and out-plant the thousands of rhizomes of *E. triticoides* and hundreds of *C. barbarae* sedges on site and has greatly reduced the cost of acquiring these plants for the project.

Within the 25-acres of (newly restored) tidal marsh and marsh-upland ecotone of the project area, the invasive plant removal was conducted along the ecotone and upland portions of the Eastern and Western Peninsulas. Fortunately, very few invasive species can tolerate the saline waters of the tidal marsh and except for a small recruitment of invasive *Lepidium latifolium* (perennial pepperweed), which was promptly treated by a professional crew (Shelterbelt Builders), only native marsh plants have established in the marsh (via the seedbank in the Bay waters).

As a newly constructed area, the marsh-upland ecotone is continually being colonized and dominated by non-native plant species. Despite the fact that MAS prioritized the most invasive species and removed these plants annually from the entire 10-acres of ecotone and upland habitat within the project area, the amount of cover of non-native plants increased through the project period due to the colonization of new, unvegetated soil and the lack of establishment and competition by native plants. Although these and other invasive species will persist at East Bahia until the native plants have become better established, MAS has observed a decrease in presence of the invasive species that were removed early to prevent the deposition of a significant seed bank. By prioritizing and removing the highly invasive plant species each year before they set seed, larger infestations of these species has been prevented.

The most dominant non-native plant species present in the ecotone of the project area is *Lolium multiflorum* (creeping wild rye grass). This species was intentionally hydro-seeded onto the area immediately following construction as recommended by Plant Ecologist Peter Baye, to develop a rapid cover of a selected “cover crop” species and to minimize the availability of disturbed, open soil that is susceptible to re-invasion by noxious weeds. The gradual development of permanent, dominant native vegetation will eventually replace the *L. multiflorum* as the dominant species’ to inhibit weed invasion and growth. Although this species is not native, its dominance, as reflected in the monitoring data, is actually desired over the presence of other invasive non-native species.

b. Lessons learned and project implications

Using the UTZ protocol to conduct the monitoring proved to be a very time consuming method for gaining data on percent cover of plant species within the project area.
In an effort to reduce the time required to collect the data, the sample size for monitoring the vegetation was made smaller. Although this did reduce the time needed to conduct the surveys, it also made the possibility for capturing the actual plantings in the monitoring smaller. Although over time, as the plantings continue to colonize, their survivorship and dominance may be reflected in data from this protocol, data collection, entry and interpretation is still far too time consuming (over 150 hours through the project period) for MAS’s capabilities. MAS will likely use a simpler method of monitoring in the future to determine species dominance over time at the project site.

MAS has experienced varying degrees of native plant survivorship throughout its restoration sites and understands the importance of soil and maintenance conditions to the survivorship of these plants. Many of the colonial flowering perennial & shrub plants planted on the higher areas in 2010-2012 did not survive and were replanted in the winter of 2012 using a professional contractor and crew with more extensive methods for ensuring the survival of these plants through the dry season.
Hopefully, this will ensure a better survivorship rate for these plants

Domination of the project area by invasive species is expected until the native plant species have established and spread out in cover. This will undoubtedly take more time than the duration of the project period and MAS will continue to combat these invasives and plant more natives until the native plants have established and can eventually dominate the plant community in the upland habitat.

Lessons learned from the project include:

- It is crucial to choose a monitoring protocol that will assess the needs of the project at hand and not utilize a large portion of the resources needed for the project itself.

- Assessing the planting conditions is key to deciding on the appropriate techniques for both planting and maintaining native plants. While native plants may have a high survivorship rate in some places, it cannot be assumed that this is the case everywhere. Soil conditions should be assessed prior to planting and appropriate planting and maintenance techniques (particularly watering or the use of gel packs, and also soil augmentation particularly to address cracks in bay mud) should be employed to ensure the best chance for survival.

- Prioritizing invasive plants to be removed can eliminate the chances of domination by the most invasive plants.

- Removing each invasive plant species as early as possible once they have become present at a site and seasonally before they develop or set seed, will prevent a rapid increase and potentially unmanageable infestation of these species. Mulching will also help reduce invasive plant infestations.

- Planting natives in high densities and early on in the project will allow for a quicker establishment of natives, giving them a better competitive advantage over the invasive plants.

c. Partnerships

Environmental Protection Agency (EPA):
The EPA funded this project through the San Francisco Bay Water Quality Improvement Fund. SFEP applied, in partnership with MAS, for these funds and was awarded after review.

San Francisco Estuary Partnership (SFEP):
SFEP worked with MAS to acquire grant funding for this project and were the grant mangers for the Bahia March Restoration. MAS also partnered with SFEP in the creation of the video podcast 'Marsh Magic'.
This podcast is instrumental in helping to raise awareness of the efforts of MAS at Bahia and to educate the public on the importance of wetlands and the value of wetland restoration and preservation.

The Center for Volunteer and Nonprofit Leadership (CVNL):
CVNL is a local organization that promotes community engagement and provides volunteer recruitment and has listed the Habitat Stewardship Program at Bahia as one of its 'FLEX' volunteer programs since 2009.
They have generously recruited many community volunteers and provided staff and volunteer 'project leaders' to assist with volunteer and project management.

California Department of Fish and Wildlife (CDFW):
MAS has a strong longstanding and ongoing partnership with the CDFG related to acquisition and management of many of the bayland properties that MAS has acquired and restored throughout the years. After Bahia was successfully saved from development and acquired by MAS, the 400-acre Central Bahia parcel to CDFG and continues to manage the restoration activities there. The source of *Elymus triticoides* used for propagation in the nursery beds and outplanted for this project was harvested from Central Bahia with the permission of CDFG.

Conservation Corps North Bay (CCNB):
CCNB provides several crews of students participating in 'Project ReGeneration' each summer to help MAS accomplish the many tasks required to manage the Bahia property.

San Francisco Estuary Institute (SFEI):
MAS assisted SFEI and Save the Bay in the creation of the standardized vegetation monitoring protocol used for this project by field testing the draft protocols and providing input regarding the methods and procedures.

d. Future work

MAS will continue to restore and enhance the area in this project as well as the entire area of East Bahia for many years into the future. The plan for this site includes additional native revegetation of the high marsh, marsh-upland ecotone, seasonal ponds and upland area as well as the continual removal of priority invasive plant species. The goal is to establish a dominance of native plants throughout the site and to eventually eliminate a majority of the invasive species. Vegetation monitoring will continue as the species composition of the site evolves to assess the succession of the plant species and to better inform future management decisions.

VIII. Conclusions

MAS has successfully acquired and restored several wetland properties in Marin County throughout its history. Because MAS is an all-volunteer organization, it relies heavily on the support and collaboration of many individuals, agencies and organizations to successfully accomplish this work.

The collaborative partnerships, community support and funding for this project have given the restoration and revegetation project at East Bahia a strong and successful start to the long term vision of creating a native bayland-upland landscape while engaging the local community in the stewardship activities of the project.

MAS accomplished the tasks of planting more than 6,600 native plants and rhizomes in tidal marsh transition zone and upland habitats; planted more than 1,200 native rhizomes in nursery beds, and removed Invasive plant species from more than 10.5-acres at Bahia.

The lessons learned will be useful in informing future management of this and other properties and will be shared with other individuals and organizations working to accomplish similar goals.

Attachment A

Photos of restoration site and activities at Bahia

Bahia Nursery Beds

MAS Volunteers and WSN crew planting new nursery beds-March 2009

***Elymus triticoides* and *Carex barbarae* in nursery beds-June 2011**

Elymus triticoides **rhizome and new shoots**

Western Peninsula

Western Peninsula prior to planting-February 2010

MAS volunteers planting *Elymus triticoides* on W. Peninsula January 2010

Flags marking *Elymus triticoides* planting areas – W. Peninsula 2010

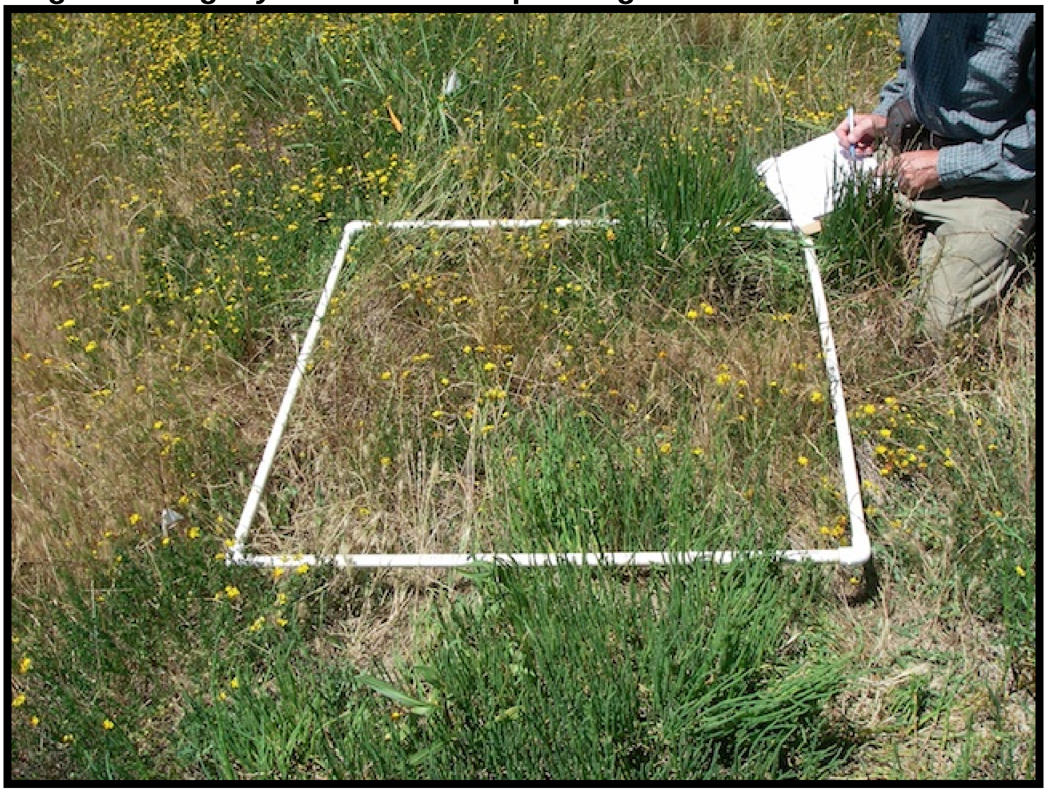
Elymus triticoides **(green) on W. Peninsula-June 2012**
(*Lolium multiflorum*-brown)

Baccharis douglasii **on W. Peninsula-June 2012**

Eastern Peninsula

Eastern Peninsula prior to planting-January 2010

Flags marking *Elymus triticoides* planting areas – E. Peninsula 2010



***Elymus triticoides* in monitoring quadrat on E. Peninsula - May 2012**

Native flowering perennial and shrub plantings on E. Peninsula 2013

MAS volunteers planting *Elymus triticoides* on E. Peninsula - February 2010

Attachment B

Data Collection Protocol
Plant Community Structure of Intertidal--Upland Ecotone

Data Collection Protocol
Plant Community Structure of Intertidal--Upland Ecotone

San Francisco Estuary
Wetlands Regional Monitoring Program

Joshua N. Collins, Ph.D.
San Francisco Estuary Institute

Darcie Goodman-Collins, Ph.D.
Save the Bay

Jude Stalker
Marin Audubon Society

Version 19
May 28, 2010

Introduction

This protocol is designed for assessing the ambient condition of vegetation and the effectiveness of vegetation management in the ecotone between intertidal areas and uplands.

The intertidal-upland ecotone of San Francisco Bay functions as a refuge for intertidal wildlife (Goals Project 1999, Baye 2008), including the endangered Ridgway's rail and salt marsh harvest mouse (USFWS 2010). It tends to be especially rich in plant species (Goals Project 2000, Baye 2008), although non-native species are often abundant (Fetscher et al, 2009).

This ecotone has been severely impacted by the conversion of tidal wetlands into agricultural lands and commercial salt ponds, and by the filling of marshes for residential and industrial development (Collins and Grossinger 2004). Bayshore development has encroached into or through the ecotone in many areas. Hundreds of miles of levees have been constructed atop the ecotone to protect adjacent land development from extreme high tides. Railroads, pipelines, and transmission corridors commonly trace the ecotone along the bayshore and have disrupted the ecotone to varying degrees. Much of the existing ecotone is now confined to the bayward facing slopes of earthen levees and road grades. The few relatively intact remnants of the historical ecotone have been subject to decades of farming or ranching.

The ecological functions of this ecotone have been gaining recognition within the regional community of natural resource scientists and managers. This is evident by the increasing number of efforts to restore and protect the ecotone. However, there are scant data about the success of different restoration efforts. Carefully collected data about the success of different plant species at different positions within the zone under different management regimes is needed to inform restoration design. This information can be developed through dedicated research and from restoration projects that use standard methods of data collection to track restoration outcomes. This protocol is intended to meet the need for standardized data about the responses of the ecotone plant community to onsite vegetation management. This protocol can also be used in broader surveys of the ambient condition of the ecotone. Standardized use of this protocol will allow comparisons between local management actions and ambient conditions.

In this protocol, plant community structure is assessed in terms of the abundance of each plant species and bare ground observed during the assessment (i.e., the percent of a specified area of land surface within the ecotone that is covered by each species or bare ground). Information about the abundance of native and non-native species, planted species and other species is automatically developed by the database. These data are particularly useful for characterizing the distribution of common species that make up the bulk of the biomass in the ecotone and less valuable for identifying rare species. These data can also help assess the value of the ecotone as wildlife habitat. If these data are collected at sites before and after they are restored, the data can be used to asses the effects of the restoration efforts.

Many kinds of additional data might be collected along with the data on absolute percent cover of plant species. For example, measures of plant vigor (i.e., plant height, leaf size, amount of flowering or seed-set, etc), plant patch size, and soil fertility provide additional information about plant community structure and site potential that are sometimes more sensitive to management actions than percent cover. At this time, this protocol is restricted to the measure of percent cover to minimize monitoring costs.

With the advent of Global Positioning Systems (GPS) and web-based Geographic Information Systems (GIS), data collection in the field can be integrated with data management and visualization. This protocol is designed to encourage collaborative efforts to learn from restoration projects by standardized applications of conventional scientific methodologies and new Information Technology (IT) to compare projects to each other and over time. This protocol compliments the one for monitoring tidal marsh vegetation (Vasey et al., 2002).

Definition of the Tidal Marsh Ecotone

In concept, the intertidal-upland ecotone is a zone of decreasing tidal influence extending landward from tidal marshland or tidal flat up to or slightly beyond the maximum landward effect of tidal waters on plant community structure. The overall breadth of the zone decreases as its steepness increases. Steep shores have very narrow ecotones. Long alluvial valleys sloping gently to the intertidal zone can have very broad ecotones (Collins and Grossinger 2004). Due to the shape of the tidal curve (i.e., the pattern traced by plotting the rise and fall of the tides over time), plus friction caused by vegetation through which the tidal waters flow, the frequency and duration of tidal inundation decreases exponentially with distance landward through the ecotone. Near the upper limit of the ecotone (i.e., near the top of the tidal curve), large percent changes in the frequency and duration of tidal inundation correspond to slight changes in elevation. That is, the top of the ecotone might be inundated once every few years and slightly higher places are never effectively inundated. The vegetation of the lower limit of the ecotone tends to resemble the adjacent tidal marsh plain. With distance landward, the vegetation shifts to species indicative of the upper limits of regular tidal action, and then to mixtures of these species and upland species. The upper limit of the ecotone is indicated by only traces of vegetation affected by the tidal waters. The width of the ecotone can be increased by wave run-up, boat wakes, and extreme high tides during storms, and the deposition of salts picked-up from the intertidal zone and carried landward by onshore winds.

For the purposes of this protocol, the following practical definitions apply.

- The upland ecotone is defined as the area extending bayward from the backshore onto the adjoining marsh plain or tidal flat for a distance of 2.0m, and extending landward from the backshore to whichever of the following two elevation contours is lower: (A) the top of any earthen levee, road grade, or other artificial topographic feature that can support vegetation or (B) an elevation contour 2.0m higher than the nearby marsh plain, or, if there is no marsh plain nearby, 2.5m above the maximum height of adjacent tidal flat.
- The backshore is defined as the approximate landward extent of daily tidal processes that influence the topography of the ecotone and the distribution and abundance of plant species indicative of the local tidal marsh plain. This is usually a topographic contour slightly higher than the local Mean Higher High Water (MHHW) datum.
- A marsh plain is defined as a flat area at least 100m^2 having essentially uniform slope that is subject to regular tidal inundation and that supports at least 5% cover of vegetation, 75% of which consists of plants restricted to tidal marshes. Tidal flats meet all these criteria except that they lack 5% cover of vegetation. The indicative species of the tidal marsh plain vary with salinity regime. To identify these plant species for any tidal marsh, the interior reaches of the marsh plain equidistant from any tidal marsh channels or pannes must be examined. Typical marsh plain flora for saline and brackish regimes include, but are not limited to, *Salicornia virginica* (pickleweed), *Jaumea carnosa* (fleshy jaumea), *Distichlis spicata* (salt grass), *Juncus balticus* (Baltic rush), *and Triglochin maritimum* (seaside arrowgrass).

  In the case of tidal marsh restoration sites that do not yet support 5% cover of tidal marsh vegetation, the backshore is defined as the landward extent of the non-vegetated tidal flat. Most restoration sites have at least a narrow band of marsh vegetation that can be used to delineate the backshore based on the field indicators provided below (see discussion of Sample Strata in section on Sample Design).

There are not a lot of data to validate the prescribed upper limit of the ecotone (i.e., see the first bulleted definition in the list of definitions immediately above). A summary of known elevations and ages of tidal marsh plains around San Francisco Bay suggests that they gain elevation as they age, and that the elevations of mature plains range from about Mean High Water (MHW) (marshes between 100 and 200 years old) to about 0.2m above MHHW (marshes much older than 200 years), and that most marsh plains around San Francisco Bay are less than 200 years old (Goals Project 1999). It might therefore be assumed that most marsh plains have an average elevation between MHW and MHHW. Based on the readily available tidal height data from gauges around the Bay that meet federal standards for accuracy and precision (http://ports-infohub.nos.noaa.gov/hq/bench_mark.shtml?region=ca), extreme high water events (the highest observed water levels) range in elevation from about 0.4m to 1.2m above local MHW, and from about 0.2m to 0.9m above local MHHW, depending in part on tidal range. Higher values are for areas with greater tidal range. Assuming that the *minimum* upper limit of the ecotone is equal to the *maximum* observed water level, and that the marsh plain is about halfway between MHW and MHHW, and assuming a moderate tidal range, then the upper limit of the ecotone probably has a minimum height of about 1.0m above the marsh plain. The National Ocean Survey (NOS) found the average upper limit of salt-tolerant vegetation to be 0.8m above the marsh plain at Point Pinole in San Pablo Bay (NOS 1975). At Palo Alto, Hinde (1954) observed pickleweed (*Salicornia virginica*) at about 1.2m above the average marsh plain. NOS (1975) observed alkali heath (*Frankenia salina)* slightly more than 1.3m above the marsh plain. Based on these data, it seems reasonable to assume that the maximum upper limit of the ecotone, as directly affected by the tides, is probably not more than 1.5 m above the height of the nearby marsh plain, and is certainly not more than 2.0m above the marsh plain. The 2.0m value used in this protocol is further justified by assuming that some minimum amount of upland area higher than the tidally-influenced vegetation is an upward extension of the ecotone, just as the margin of the marsh or tidal flat is a downward extension of the ecotone. With regard to tidal flats, it can be assumed that the lower limit of tidal marsh vegetation (i.e., the upper limit of tidal flats) corresponds to local Mean Tide Level (MTL) (Atwater and Hedel 1976), and that the average difference in elevation between marsh plains (i.e., the elevation midway between MHW and MHHW) and MTL around the Bay is about 0.5m (based on the tidal gauge records). Therefore, the upper limit of the ecotone is probably about 2.5m above the maximum height of the nearby tidal flat (i.e., the marsh plain is 0.5m above the flat, and the top of the ecotone is not more than 2.0m above the marsh plain).

However, tidal marsh vegetation has been observed at elevations greater than 2.0m above the adjacent marsh plain. In uplands sloping gently upward from tidal marsh and subject to strong onshore winds, the lead author has found *Frankenia salina* and salt grass (*Distichlis spicata*) mixed with upland grasses at elevations more than 3m higher than the adjacent baylands. In a recent description of the tidal-marsh-upland ecotone of San Francisco Bay (Baye 2008), field photographs clearly show the ecotone, as defined by distinctive vegetation, extending more than 2m above the marsh plain at China Camp (San Pablo Bay), and elsewhere. Ecotone restoration projects commonly consider the entire bayward faces of shoreline levees as areas of potential ecotone, and these faces commonly extend more than 2m above nearby tidal marshland. Coyote brush (*Baccharis pilularis*) is considered a tidal marsh plant species (Baye 2007), in part because it occupies natural levees along tidal marsh sloughs. It is commonly regarded as a species well-suited for the upland reaches of the ecotone, although it also occurs at much higher elevations. Given these observations, the upper elevation limit of the ecotone as prescribed for this protocol is conservative. It should be revisited as new field data for delineating the ecotone are developed. The upper limit would ideally be defined using local tidal height data collected near the backshore. Such data are very rare at this time.

Personnel

Anyone who can identify wetland vascular plant species and who understands this written protocol should be able to conduct this sampling, if provided with appropriate orientation and supervision.

All field personnel must adhere to practices that ensure their safety and the well being of plants and other wildlife inhabiting the ecotone and adjacent habitats. All personnel must know and adhere to the policies and laws that govern access to, and activities within, the ecotone. For example, access can require written permission to cross private lands, and activities within the ecotone might be constrained by policies protecting threatened or endangered wildlife. Contact local land owners and the Endangered Species Office of the U.S. Fish and Wildlife Service for more information about restrictions and requirements for accessing the intertidal-upland ecotone.

Primary Monitoring Questions

The protocol is designed to answer the following questions.

- What is the plant species richness of the ecotone?
- Which plant species dominate the ecotone?
- How do plant species richness and dominance vary across the ecotone?
- Does plant species richness or dominance vary with restoration design or practice?
- Do the effects of restoration design or practice vary across the ecotone?

When used as directed as part of a monitoring program, this protocol can provide basic information about the status of the plant community of the ecotone in relation to restoration and management practices. If applied consistently over time and from one site to another, it can be used to compare sites, compare restoration and management practices, and to track basic temporal changes in plant community structure. However, it provides little information about such factors as plant vigor, the distribution and abundance of rare plant species, or the wildlife support functions of ecotone vegetation. This protocol could be used to assess such factors if the relevant data were added to this protocol.

This protocol is designed to elucidate spatial and temporal changes in plant community structure of the ecotone, based on standardized monitoring. The monitoring data can be used to develop hypotheses about the causes and consequences of the observed patterns, but are unlikely to be suitable for testing the hypotheses. Understanding cause-and-effect relationships requires specially designed experimentation. This protocol might be used in hypothesis testing, depending on the experimental design.

Monitoring Design

Overview

A stratified-random sampling approach is used to characterize the plant community of the ecotone with regard to the abundance of plant species within 2-4 elevation strata. Additional data on the status of plant species as native or alien, and on site-specific factors such as restoration design, restoration practice, management activities, and salinity regime are derived from the sampling data plus basic information about site characteristics and history.

Assumptions

The underlying assumptions of this monitoring design are listed below.

- Percent cover of plant species varies with elevation across the intertidal-upland ecotone.
- Percent cover of plant species is sensitive to restoration project design and practices, including removal and/or planting of vegetation, fertilization, irrigation, mowing, and herbicide application.
- The relationship between the percent cover of plant species and restoration design and practice varies with elevation across the intertidal-upland ecotone.

Sample Universe

The sample universe (aka sample frame) depends on the purpose of the assessment. For example, when the protocol is applied to an ambient survey, the sample universe consists of all areas of the ecotone within the geographic scope of the survey. When the protocol is used to assess individual restoration projects, the sample universe includes the entire ecotone within the project area that is subject to on-the-ground restoration or management actions. The sample universe of a project can grow as the actions expand across the project area.

Sample Site

A sample site is a continuous portion of ecotone at least 50m long, but not longer than 500m, and having essentially the same width and overall plant community appearance. The following criteria should be used to decide on the end points of a sample site.

- A site *should be* between 50m and 500m long. These are guidelines and not rules.
- The plant community must have the same *overall appearance* throughout. Some variability in plant community structure along a site is expected.

- A site must not incorporate major differences in restoration design or management activities (e.g., differences in irrigation, species removed or planted, etc.), or elapsed time since the management activities were initiated (i.e., all parts of a given site should represent the same stage of plant community development or succession). The complete history of a site is seldom known. But, major differences in historical treatments or impacts should not be incorporated into a site. This is an important criterion for elucidating differences in plant community structure between different practices and different times. If sites include areas subject to different activities, or that represent different periods since the activities were begun, then the differences in plant community between practices and periods cannot usually be discerned.
- Each upland sample stratum within a site (see section title "sample strata" immediately below) must be at least 1m wide to accommodate the standard 1.0m^2 sampling frame. There is no maximum width for any upland stratum, *but except for the special situation of a very broad ecotone* (see paragraph 3 of Step 4 in section titles "Sample Strata" below), there can be no more than 3 upland strata for any site. Some ecotones are so narrow that they consist of only 2 strata, the intertidal stratum and one upland stratum.

Sample Strata

Each sample site shall be separated into elevation strata. The purpose of these strata is to account for the assumed effect of tidal elevation (i.e., frequency and duration of tidal inundation or wetting), on plant community structure. Without such stratification, the sample data tend to be too variable to detect differences in plant community over time or between sites. The following procedure shall be used to stratify a site.

1. For each sample site as defined above, identify and mark the approximate location of the backshore. The backshore is an elevation contour; the entire backshore of a site has the same elevation. In concept, the backshore is the landward extent of daily tidal processes that directly affect the topography of a site and the distribution and abundance of marsh plain plant species within the site. Boat wakes, extreme high tides associated with winter storms, and the landward distribution of salt deposited by onshore winds are disregarded in backshore identification. The backshore has a variety of field indicators that should be used together to identify the likely position of the backshore (Figure 1). These indicators include the following.
    - In general, the backshore is slightly higher than the adjacent marsh plain (or tidal flat if there is no adjacent marsh plain).
    - The shoreline often has a wave-cut bench or other break in slope created by tidal action. The top of the bench is usually slightly lower than the backshore.
    - The landward extent to which plants indicative of the marsh plain comprise at least 75% absolute cover tends to indicate the backshore in mature ecotones.
    - Native shrubs such as gum plant (*Grindelia stricta*) and coyote brush (*Baccharis pilularis*) sometimes inhabit the backshore. The bases of the trunks of the

lowermost individuals of these species are sometimes a good indicator of the backshore.

- In the absence of shrubbery, fencing or other obstructions to the landward distribution of wrack (i.e., floating trash, wood and plant debris, and other detritus carried by the tides), the average height of the wrack line tends to be slightly higher than the backshore. Where shrubbery or other obstructions prevent wrack from freely moving landward to the limits of the tides, the wrack tends to settle on the marsh plain and is therefore somewhat lower than the backshore.
- Independent delineations of the backshore by different workers at a site should not differ from each other by more than 25cm *in height,* relative to the adjacent marsh plain or tidal flat.

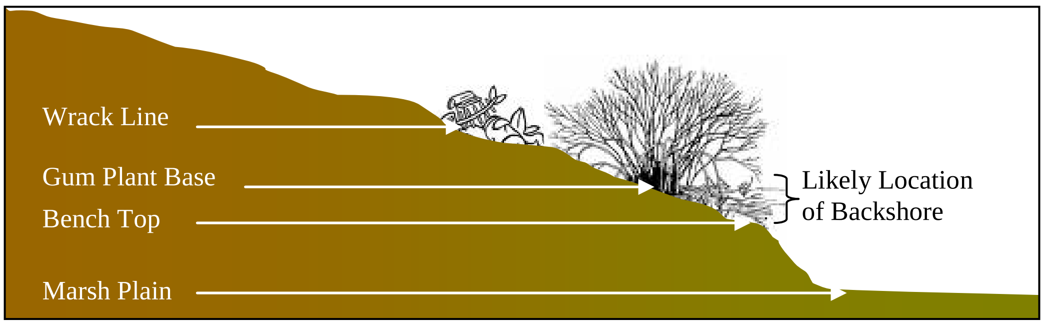


Figure 1: Conceptual diagram of the likely position of the backshore in relation to various field indicators.

2. Determine the minimum width of the portion of the transition zone that extends landward from the backshore. Inspect the entire site and locate areas where the width seems minimal. Measure width at these locations by holding a tape in the air parallel to the ground surface between the backshore and the landward limit (i.e., upper edge) of the ecotone. Use more appropriate of the two following alternative definitions of the ecotone to estimate its upper limit.

   The upland ecotone extends landward to whichever of the following two elevation contours is lower: (A) the top of any earthen levee, road grade, or other artificial topographic feature that can support vegetation or (B) an elevation contour 2.0m higher than the nearby marsh plain, or, if there is no marsh plain nearby, 2.5m above the maximum height of adjacent tidal flat.

3. The lower-most stratum of a site always consists of an area of the intertidal marsh or tidal flat 2.0m wide that adjoins and parallels the backshore (Figure 2).

4. This step determines the number of upland strata and their standard width for any site. Most sites will have 3 upland strata of equal width. Divide the minimum ecotone width from step 2 above by 3. If the resulting quotient is between 3 and 10, the upland portion of the ecotone will have 3 strata, each as wide as the quotient. For example, if the upland portion of the ecotone is 3m wide, it will have three

upland strata each 1m wide. If the upland portion is 12m wide, each of the three upland strata will be 4m wide.

If the quotient is less than 3 but greater than 2, divide the overall minimum width of the upland portion of the ecotone by 2, and the upland portion will have two strata, each as wide as the quotient. For example, if the minimum width of the upland portion is 2.75m wide, then it is only wide enough for 2 strata, each of which will be about 1.3m wide (i.e., 2.75/2 = 1.375, rounded to 1.3). If the width is less than 2m, then the upland portion of the ecotone comprises a single stratum.

Very broad ecotones (i.e., sites where the minimum width of the upland portion of the ecotone is greater than 30m) require special treatment. In the few examples examined thus far, the broadest area of the upland portion of the ecotone corresponds to the lowermost upland stratum. The resulting variability in community structure across this one stratum can increase the variance of the sample data and reduce the ability of the data to discern differences between this stratum and neighboring strata. The solution is to further stratify the stratum. If the upland strata are each more than 10 m wide, based on Step 2 above for determining stratum width, subdivide the lowermost upland stratum into two substrata of equal width (Figure 3).

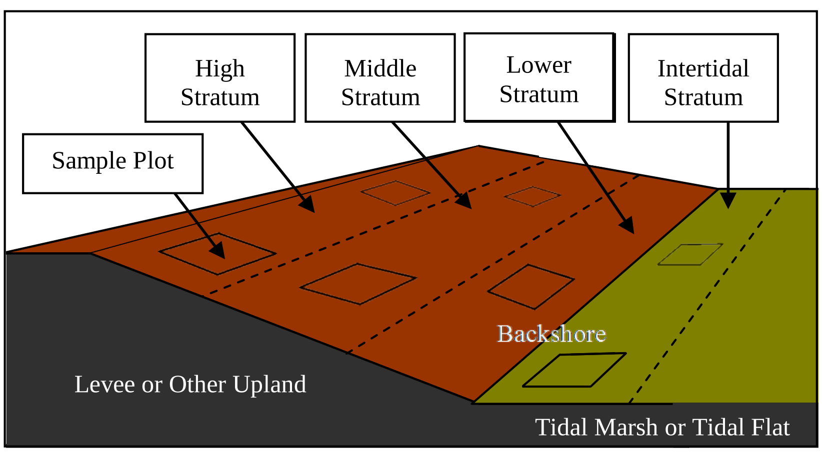


Figure 2: Conceptual diagram of tidal marsh-upland ecotone sample strata, showing some sample plots (black rectangles) in each stratum for a site wide enough for three upland strata.

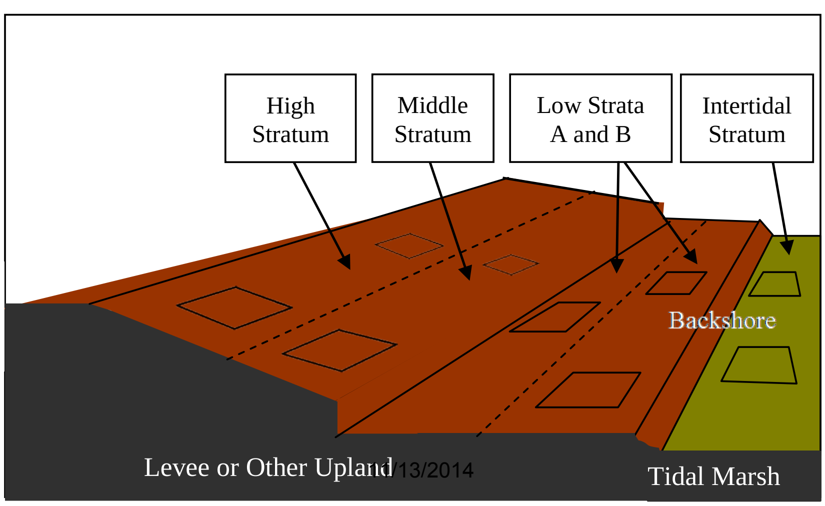


Figure 3: Conceptual diagram of an ecotone with an especially

Most sites are not completely uniform in their width. The upland portion of a site might be wide enough for three strata in almost all places and two strata elsewhere. As explained in the section below on data collection, the number of strata can vary within a site, so long as the dominant number is based on the minimum width of the upland portion of the ecotone, as instructed in this step.

Sample Plots

Sample plots are square areas $1m^2$ in size (100 cm to a side) that are randomly selected within each of the sample strata.

Sample Size and Sample Plot Selection

Sample size is the number of plots per stratum at one site. Sample size can differ between strata at a site, and between sites. The following process for determining sample size is designed to assure that the sample for any given stratum adequately represents the abundance (absolute percent cover) of each common plant species occurring in the ecotone.

Candidate sample plots are randomly selected for each stratum at each site according to either of the two following procedures. This is referred to as the sample draw. One alternative procedure uses high-resolution aerial imagery in a Geographic Information System (GIS). However, use of GIS requires access to it plus GIS expertise that are not essential for this protocol. The field alternative can be used when a GIS is not available.

GIS Alternative

1. In a GIS, draw the boundaries of the sample strata on recent-vintage, 1-m pixel resolution or higher resolution digital aerial imagery (i.e., recent NAIP imagery or suitable site-specific imagery).
2. Using the GIS, create a line down the center of each stratum, and measure the length of these centerlines.
3. Using the GIS, divide the centerline of each stratum into a continuous series of non-overlapping, 1-m long segments. For example, if the stratum centerline is 100m long, it will have 100 1-m long segments.

4. For each centerline, assign a unique alpha-numeric code to each 1-m long segment.
5. For each centerline, determine how many 1-m long segments in aggregate equal 10% of the total length of the centerline. For example, if the centerline is 100m long, then 10 1-m long segments comprise 10% of the centerline length. This is the sample draw size.
6. For each stratum, randomly select the number of 1-m segments equal to the sample draw size. The randomly selected cells equal the sample draw.
7. The middle of each selected 1-m long segment of the sample draw will correspond to the center of a sample plot. Mark the latitude and longitude of the middle of each selected 1-m long segment on the map of each stratum to produce a map of the sample plots.
8. The sample plots can be located in the field by inputting their unique latitude and longitude coordinates as way-points into a Geographic Positioning System (GPS) with 1m horizontal accuracy, or by using the sample plot map from Step 7 immediately above.

Field Alternative

1. Stretch one or more 100-m long measuring tapes graduated in centimeters along the backshore of the site. A 250-m long site will have 2 and one half 100-m long tapes stretched out end–to-end. A 500-m long site will have 5 (five) 100-m long tapes stretched end-to-end. Make sure the tapes follow a single elevation contour, plus or minus about 10cm in elevation. Leave the measuring tapes in place until all the strata are sampled. It is helpful to stake the backshore at regular intervals and to attach the tapes to the stakes above the vegetation. A survey level can be used to stake the backshore.
2. Determine the sample draw size based on the length of the backshore in meters (i.e., the length of the site). If the entire backshore is 100-m long (i.e., if the site is 100m long), each stratum will have a total number of 100-1 = 99 possible plots (the 100-m distance is excluded). The sample draw size equals 1/10 (one tenth) of the site length. If the backshore is 100m long, then the sample draw size is 10. If the backshore is 500m long, the sample draw size is 50.
3. Randomly select the plots for the sample draw. One method is to separately number equal-size slips of paper from 1 to the number equal to the length of the stratum in meters minus 1 meter (i.e., if the stratum is 100m long then separately number 99 pieces of paper from 1 to 99); mix the pieces of paper thoroughly in a hat or other suitable container; withdraw the number of slips equal to the sample draw size (as determined in Step 2 immediately above). Each selected slip of paper identifies the location of one sample plot in the sample draw for one stratum, in terms of its distance in meters along the backshore.

   Withdraw the slips of paper one at a time, and record their numbers in the order in which they are withdrawn.

4. Repeat steps 1-4 for each stratum of each site. It is essential that a separate sample (i.e., a separate set of sample plots) be drawn for each stratum. Note that all the strata will have the same length, and will therefore also have the same number of sample plots (i.e., Steps 1 and 2 only need to be done once per site), but the locations of the plots that are actually used will not necessarily be the same for any two strata because the plot locations are randomly selected separately for each stratum.

   Note: for any given site, the sample strata will stay the same from one sample period to another, but each sample period will require a new sample draw for each stratum.

Finalizing the Sample

Finalizing the sample means deciding how many plots from the sample draw have to be collected within each sample stratum to adequately represent its plant species richness and the abundance of the common plant species. It is not likely that the entire sample draw will have to be used to meet these objectives. The sample is finalized separately

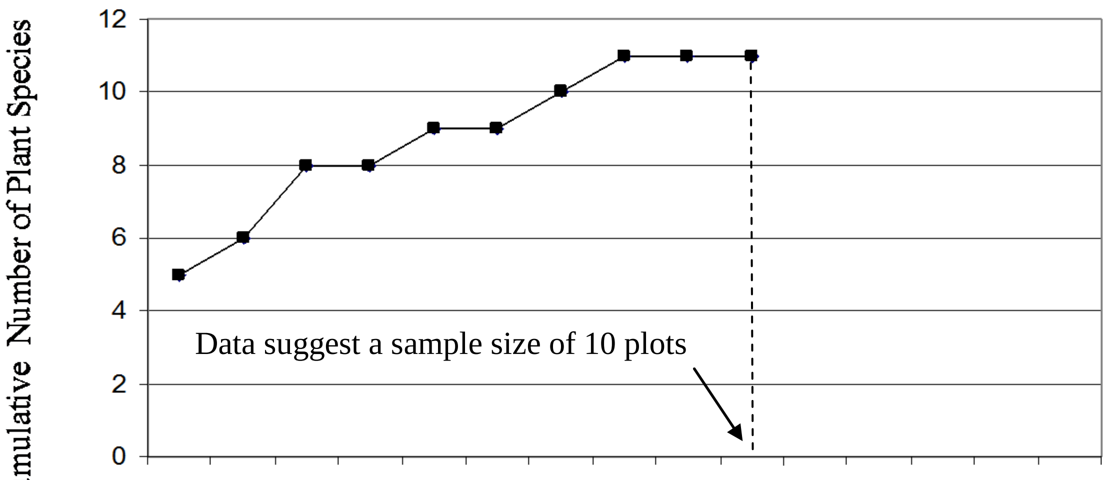


Figure 4: Example species-area curve for one stratum showing an asymptote at eight sample plots, indicating that for this stratum only 8 plots are needed.

for each stratum.

The sample is finalized as data are being collected. Finalizing the sample is part of data collection. The process of finalizing the sample is explained separately here, but is actually integral to data collection, which is outlined in the next section of this protocol.

1. The sample plots for each stratum are visited in the order in which they were selected into the sample draw. The first plot randomly selected is visited first, regardless of where it is along the stratum. The plot selected second is visited second, and so on.
2. The last kind of data collected at each plot is the total number of "new" species occurring at the plot. "New" species are species that have not been observed in

previous plots within that stratum. All the species occurring in the first plot are counted as "new."

3. As data collection proceeds from one plot to the next within a stratum, a graph is constructed showing the cumulative number of "new" species observed (Figure 4).
4. Sampling stops for a stratum when the number of "new" species does not change for three consecutive plots (Figure 4). This means that each stratum will have a minimum sample size of 3 plots.
5. The data on abundance (i.e., absolute percent cover) for all the plots within a finalized sample are used to identify the dominant plant species, using the following method adopted from the US Army Corps of Engineers (USACE 2008). This step will be conducted after the data have been collected.
    A. For each species, add together the plot-specific values for absolute percent cover. There should be one value for each species in the sample for each stratum.
    B. For each stratum, add together the species-specific values from step 5A above.
    C. For each species, divide its value from step 5A by the value from step 5B. Each species will thus have a single percent cover value for the stratum as a whole.
    D. List the species in descending order of their percent cover, using the values for each species calculated in step 5C above.
    E. Starting at the top of the list from step 5D above, and proceeding consecutively down the list, select the species that, when their values for percent cover are added together, the sum exceeds 50%. These are considered dominant species. If the first species has a cover value ≥ 50%, it is a dominant species. All species of equal cover value that contribute to meeting this requirement must be selected.
    F. Identify any other species that by themselves have an overall percent cover for the stratum as a whole of at least 20%. These are also considered dominant species.
6. The percent cover data for the species identified as dominant in step 5D and 5E above are used in a power analysis to determine whether the sample size determined based on the species-area curves is adequate to be either 80% or 95% certain of estimated differences in percent cover between any two strata for any observed plant species.

Data Collection

Data collection entails field-based measurements of the selected parameters of plant community structure for all the sample plots during one sample period. For each site, the following sampling steps shall be conducted in the following order.

1. Begin data collection at the first plot selected into the sample draw for the intertidal stratum. Locate the distance along the tape measure that corresponds to this first plot.
2. At this location along the tape, extend a second tape 1.0 m perpendicular to the backshore onto the marsh plain.
3. A square plot frame having an area of $1m^2$ (100 cm per side) is carefully lowered onto the marsh plain, such that the 1.0m mark of the tape is at the center of the frame, without undo disturbance to the plant cover within the plot or around it. Do not disturb the adjoining upland stratum. Each intertidal stratum plot should cover the distance across the marsh plain from 0.5m to 1.5m away from the backshore.
4. Collect the following data for the first sample plot.
    a. Visually estimate the absolute percent cover of bare ground and each plant species in the plot. Bare ground can be represented by either or both of two kinds, fine textured or coarse textured (see datasheet). Since plant species can vertically overlap, their values for absolute percent cover can sum to more that 100% for each plot.
    b. Each species observed is classified as (1) native or non-native according to the Jepson Manual (Hickman, 1993); (2) planted or not planted based on site-specific list of planted species; and (3) removed or not removed based on a site-specific list of species that were removed. Planted individuals are not assessed separately from naturally recruited individuals. The net effect of recruitment can be assessed as the difference between the first and subsequent samples.
    c. The visual estimates of absolute percent cover greater than 3% are rounded to the nearest 5%. Values ≤ 3% are rounded to the nearest 1%.

        All field personnel who are collecting data to compare strata within or among sites must be calibrated to each other. This means that each person independently estimates absolute percent cover for each species in the same calibration plot; that the participating personnel compare their estimates; that they confer with each other regarding any differences greater than 5 percentage points for any species having an absolute percent cover value > 3%; and that they repeat the process on additional calibration plots until no two estimates for the same species in a plot differ by more than 5 percentage points.
    d. All data must be recorded on the standard datasheet for this protocol (see attached datasheet).
5. Complete steps 1-5 of the section above titled "*Finalizing the Sample*".
6. Complete all the sampling in the intertidal stratum before proceeding to an upland stratum. Complete the sampling in one upland stratum before proceeding to another.

7. To sample an upland stratum, go to the distance along the tape at the backshore that corresponds to the first plot selected into the sample draw for that stratum. Extend a second tape uphill and perpendicular to the backshore to the middle of the upland stratum being sampled. Carefully center the sample frame on the end of the second tape, such that the downhill edge of the frame is parallel to the backshore (Figure 5). Collect data from the plots according to Steps 4 and 5 immediately above.

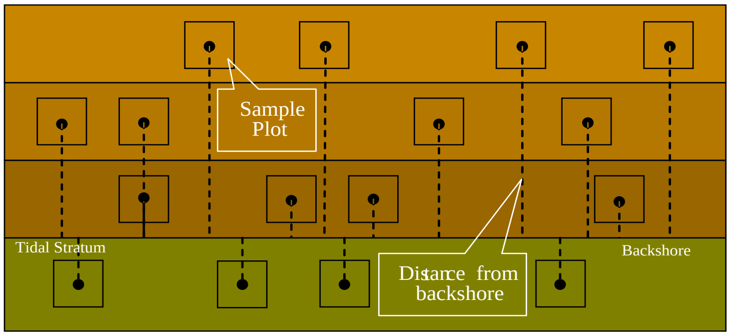


Figure 5: Schematic diagram of arrangement of sample plots within each stratum at randomly selected distances along the backshore. The distances are randomly

Sample Timeframe and Sample Period

The sample timeframe is the time of day and time of year when the field data should be collected. All data should be collected after most of the perennial vegetation has added its annual biomass and before annual vegetation has senesced. The data for the intertidal stratum should be collected at a time of day when the stratum is not inundated with water.

The sample period is the portion of the timeframe when data are actually collected. All data for all strata and sites should be collected during the shortest period possible to maximize their comparability.

For the purpose of assessing the effects of management activities, baseline data should be collected before the activities ensue and annually thereafter. The length of the monitoring effort (i.e., the number of years of monitoring) will vary from project to project.

Basic Field Equipment

- ✓ 100m transect tape to lay along the backshore
- ✓ Survey level for sighting the backshore
- ✓ 25m transect tape for locating sample plot centers perpendicular to the backshore
- ✓ 1m^2 plot frame divided into 100 equal-size cells (10cm to a side)
- ✓ GPS unit
- ✓ Camera
- ✓ PVC markers and hammer
- ✓ Plant press for collecting reference specimens

- ✓ Data sheets

Data Analysis and Interpretation

The species-area curves used to determine the final sample size will be developed in the field, as the data are being collected. A datasheet for this purpose is attached. Whether a species is native or alien will be determined automatically by the database. The database will also automatically identify the dominant species for each stratum of each site, and for each site as a whole, using the modified version the USACE 50/20 rule.

The power analyses needed to assess the adequacy of the final sample size for determining the differences in species abundance between strata or between sites, given the sample size determined from species-area curves, will be conducted after the data are collected.

Since ecotone width can vary among sites, the number of strata might also vary among sites. Also, since the number of plots needed to assess species richness can vary among strata, the number of plots might vary among strata as well as among sites. These differences in sample design do not influence the comparison of one stratum to another within a site, one stratum or site to itself over time, or the comparison of sites that have the same number of strata. But, they do limit comparisons between sites having different numbers of strata, as explained below.

Consider the situation illustrated by Figure 6. Site A and Site B are adjacent to each other and therefore subject to the same tidal regime. The intertidal strata of the two sites are comparable because they represent the same marsh plain. However, since the upland strata are delimited by equally subdividing the upland portion of the ecotone at each site, it is possible for two adjacent sites of different width to have different numbers of upland strata. In this example, Site A is wide enough for three upland strata (labeled 1-3), whereas Site B is only wide enough for two uplands strata (labeled 1 and 2). Because of the difference in slope between the two sites, all of stratum A2 is lower in elevation than stratum B2. This means that Stratum A2 is inundated more frequently than stratum B2. The plant communities of these two strata are therefore likely to be different. In general, sites with different numbers of upland strata should be compared based on their intertidal strata, and based on the overall condition for all upland strata combined, and not on the basis of individual upland strata. This limitation could be eliminated by delimiting the upland strata based on the frequency of tidal inundation, but the required tidal data do not exist for most sites.

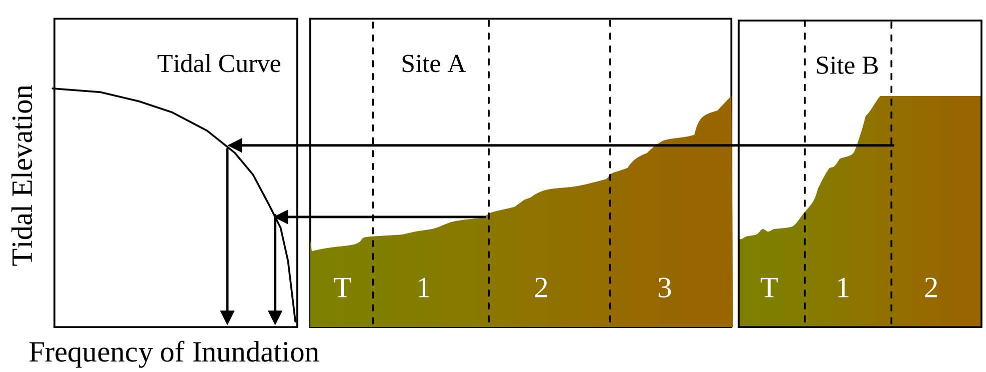


Figure 6: Schematic diagram of two hypothetical adjacent sites A and B having different numbers of upland strata that represent different inundation regimes. For example, stratum A2 is lower than stratum B2, and is therefore inundated more frequently.

The data generated by this protocol are categorical. That is, they describe conditions within discrete portions of the ecotone, called sample strata. Based on this protocol, each stratum will have a population of data points with a mean and variance that can be used to statistically test for differences between strata at a site, between different time periods for the same stratum at a site, and between comparable strata of different sites. The appropriate statistical tests for these comparisons will be analyses of variance. Relationships between two or more parameters measured at the same plots can be explored using regression analyses (Figure 6).

Each stratum and site will be analyzed in terms of species richness, the frequency of occurrence and absolute percent cover of each dominant plant species and bare ground, and absolute percent cover of non-native dominant species. The results can be used to assess how the distribution and abundance of plant species indicative of the tidal marsh plain vary among sites, and how the plant community varies with distance above adjoining marshland or tidal flat. The degree to which these patterns correlate to site-specific factors, including ecotone width, salinity regime, restoration design, and management practices, can also be assessed. Such assessments can help determine which plant species are best suited for each elevation stratum within and among sites, and to determine which restoration and management practices are more effective.

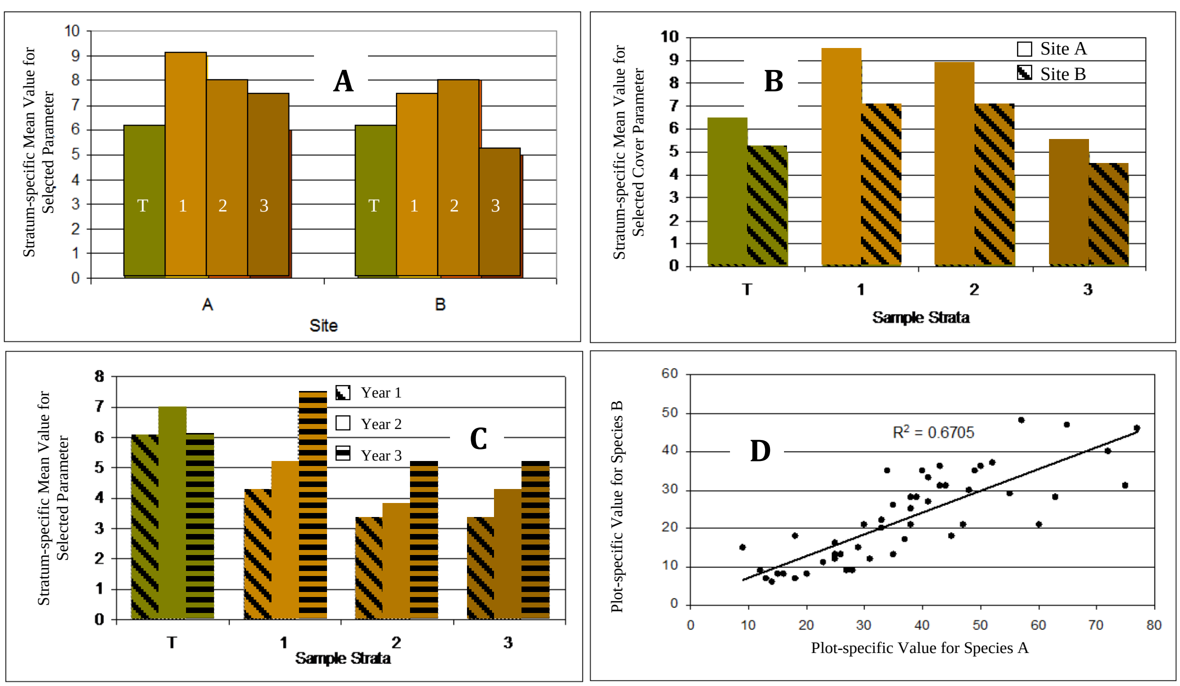


Figure 7: Example plots of hypothetical results showing (A) comparison of two parameters at one site; (B) comparison of two sites based on one cover parameter; (C) changes over time for one parameter at one site; and (D) correlation between two dominant plant species at one or

References Cited

Atwater, B.F. and C.W. Hedel. 1976. Distribution of seed plants with respect to tide levels and water salinity in the natural tidal marshes of the northern San Francisco Bay Estuary, California. Open File Report 76-389. U.S. Geological Survey, Menlo Park, CA.

Baye, P.R. 2007. Selected tidal marsh plant species of the San Francisco Estuary a field guide. Prepared for the San Francisco Estuary Invasive Spartina Project, California Coastal Conservancy, Oakland CA.

Baye, P.R. 2008. Vegetation management in terrestrial edges of tidal marshes, western San Francisco Estuary, California. Prepared for Marin Audubon Society, Mill Valley, CA.

Collins, JN and RM Grossinger. 2004. Synthesis of scientific knowledge concerning estuarine landscapes and related habitats of the South Bay Ecosystem. Technical report of the South Bay Salt Pond Restoration Project. San Francisco Estuary Institute, Oakland CA.

Daubenmire, RF. 1959. A canopy-cover method of vegetational analysis. Northwest Science 33:43–46.

Goals Project. 1999 Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, CA.

Goals Project. 2000. Baylands ecosystem species and community profiles: life histories and environmental requirements of key plants, fish, and wildlife. P.R. Olofson (ed). San Francisco Bay Regional Water Quality Control Board, Oakland CA.

Hickman, JC (Ed.). 1993. The Jepson manual, higher plants of California. University of California Press, Berkeley, CA.

Fetscher, AE, M. Sutula, J. Callaway, VT Parker, M Vasey, JN Collins, and W Nelson. 2009. Regional patterns in vegetation communities of California salt marsh: insights from a probabilistic survey. Southern California Coastal Water Research Project, Costa Mesa, CA

Hinde, H.P. 1954. The vertical distribution of salt marsh phanerogams in relation to tide levels. Ecological Monographs 24(2):209-225.

Josselyn, M. 1983. The ecology of the San Francisco Bay tidal marshes: a community profile. US Fish and Wildlife Service, Division of Biological Services, Washington D.C.

NOS. 1975. The relationship between the upper limit of coastal marshes and tidal datums. National Oceanic and Atmospheric Administration, Rockville, MD.

USACE. 2008. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region (Version 2.0). U.S. Army Corps of Engineers Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

USFWS. 2010. Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (January 2010). Region 8, U.S. Fish and Wildlife Service, Sacramento, Ca.

USFWS. 1987. Diked baylands wildlife study. Division of Ecological Services, US Fish and Wildlife Service, Sacramento CA.

Vasey, M, J Callaway, VT Parker. 2002. Data collection protocol: tidal wetland vegetation, Wetland Regional Monitoring Program, San Francisco Estuary Institute, Oakland CA.

Intertidal – Upland Ecotone Plant Community Monitoring Data Sheet

Page ___ of ___

Project Name: ______________________________

Sample Site Name: _____ ______________________________

Sample Site Code: ______________________________

Date: ______________________________

Start Time: _______________ **End Time:** _______________

Begin UTM: ______________________________

End UTM: ______________________________

Begin UTM: ______________________________

End UTM: ______________________________

Field Staff: ______________________________

____

____

____

____

Stratum	Sample Plot	Species Code	Absolute Percent Cover	Comments

Biotic Cover Code:
Plants: first three letters of genus and first letter of species (e.g. SALV for *Salicornia virginica*).

Sessile animals (shellfish etc): SA

Abiotic Cover Code:
Fine Bare Ground (FBG): diameter of most particles ≤ 2mm

Coarse Bare Ground (CBG): diameter of most particles > 2mm

Strata Codes:
From low to high elevation: Tidal (T), Upland A (UA), Upland B (UB), Upland C (UC); there are normally three upland strata (UA-UC)

Sample Plot Code:
3 letter acronym of site name, first letter of Strata code, and plot number (e.g. MLKT1, MKLT4, MLKUA3, MLKUA1, MLKUC3, etc)

Intertidal – Upland Ecotone Plant Community Species Area Curve

Project Name: ______________________________ ______________________________ ____

Sample Site Name:
Sample Site Code: ___________________-

Sample Date: ______________________________

Stratum Code: ___________________

Cumulative Number of New Plant Species

30																														
29																														
28																														
27																														
26																														
25																														
24																														
23																														
22																														
21																														
20																														
19																														
18																														
17																														
16																														
15																														
14																														
13																														
12																														
11																														
10																														
9																														
8																														
7																														
6																														
5																														
4																														
3																														
2																														
1																														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**

Consecutive Sample Plots Starting with the First Selected into the Samp

Attachment C

Bahia Wetland Restoration Project East
Bahia Revegetation Plan

Peter R. Baye, Ph.D.
Botanist, Coastal Plant Ecologist
33660 Annapolis Road
Annapolis, California 95412

(415) 310-5109 baye@earthlink.net

BAHIA WETLAND RESTORATION PROJECT
EAST BAHIA REVEGETATION PLAN

Example and model of major vegetation types – MAS Petaluma Marsh Expansion Project, Novato

Prepared by

Peter R. Baye, Ph.D.

Prepared for:

Marin Audubon Society
(Barbara Salzman, Project Manager)
P.O. Box 99
Mill Valley, CA 94942

March 2007

1.0. Introduction

1.1 Background. This revegetation plan was prepared in coordination with the February 2007 revised engineering plans prepared by Philip Williams and Associates, LLC (PWA), for the East Bahia component of Marin Audubon Society's Bahia Wetland Restoration Project, Novato, Marin County, California. This revegetation plan applies to the PWA engineering plan drawings and cross-sections dated February 19 and 21, 2007.

The basic goal of the project is to modify the existing artificial upland fill "peninsulas" (remaining from a discontinued former residential development project), and reconstruct tidal salt marsh, native terrestrial grassland (including seasonal wetlands and some native oaks), and transitional habitats between them. Tidal marsh habitat restoration, including critical sub-habitats characteristic of mature habitats, is the highest priority component of the restoration plan because it supports the recovery of endangered species and other special-status species.

1.2 Project purpose and habitat objectives. One of the principal purposes for the wetland habitat reconstruction is to expand and improve long-term habitat for the existing special-status marsh-dependent wildlife in the surrounding Lower Petaluma Marsh – particularly the California clapper rail, California black rail, San Pablo song sparrow, and salt marsh harvest mouse. Critical marsh habitat elements for these species include:

(a) **tidal channels** within a middle/high **tidal marsh plain**, bordered by tall native perennial marsh vegetation;

(b) **proximity to high tide vegetation cover** for wildlife in adjacent "upland transition zones" during spring tides and storm surges;

(c) **protection against excessive disturbance** by predators, or other intrusions that may discourage breeding or reduce breeding success.

1.3 Existing vegetation. The existing peninsulas are generally derelict, weedy meadows, dominated by non-native annual and perennial grasses, and coarse broadleaf nuisance weeds including Italian and bull thistles, curly dock, cocklebur, and wild radish. Some vigorous native oak saplings have established on the peninsulas, indicating the suitability of the soil for their growth. Pampas (jubata) grass and fennel are abundant at the western peninsula. Examples of existing and recent vegetation conditions are shown in Appendix 1.

1.4. Overview of habitat restoration. The eastern and western peninsulas will be gradually transformed to a landscape of expanded tidal marsh (merging with existing marshlands), and low uplands with dense, continuous cover of native perennial sod-forming grasses that remain green at least through early summer. The central peninsula and adjacent baylands southwest of them will be sites of deposition for some excavated peninsula sediment, and will be reclaimed as valley grassland with seasonal wetlands and scattered oaks.

1.4.1. Tidal marsh. The majority of the western and eastern peninsulas will be excavated to develop tidal marsh on a gentle gradient between upper intertidal elevations and several feet above the highest tides. Tidal channels will be excavated within the western peninsula's new tidal marsh strip, connecting with the existing fringing tidal marsh along the Homeowners

Association Channel. This will expand the existing tidal marshes adjacent to the site, and enhance them by providing a gentle gradient with high tide cover and transition zone (ecotone) with native terrestrial vegetation. Alkali-bulrush and pickleweed are expected to visually dominate this vegetation most years. During droughts, pickleweed and some cordgrass would dominate, and alkali-bulrush would temporarily decline; alkali-bulrush would rebound in non-drought years. The upper edge of the marsh would support a distinct vegetation including saltgrass, gumplant, alkali-heath, creeping wildrye, and some uncommon low-growing colonial flowering perennials and shrubs (marsh baccharis, western goldenrod, coyote-brush, bee-plant, California rose). Examples of typical tidal marsh plants are shown in Appendix 2.

1.4.2. Perennial valley grassland. The dominant native terrestrial vegetation proposed for nearly all areas above the highest tides on all peninsulas is a perennial sod-forming grass, creeping wildrye. This species tends to form uniform and dense stands with wheat-like seedheads (not harsh or bristly) on clay soils, and is well-adapted to the drained bay mud (clay-silt) substrates present. It has successfully established on similar bayland soils and settings in the lower Petaluma River vicinity. This perennial grass establishes primarily by vegetative growth (creeping stems below ground), and is expected to require at least five years to develop extensive cover. Continuous creeping wildrye cover is expected within ten years. A few widely spaced, slow-growing valley oaks will be included in the central peninsula "hill" fill. Examples of typical plant species in this vegetation from the project site vicinity (Petaluma River baylands) are shown in Appendix 3.

1.4.3. Seasonal wetlands. Within the flat grassland areas, and at the edge of the western peninsula's tidal marsh, some undrained depressions will be constructed to support shallow (approximately 1.5 feet deep or less) swales and pools flooded during winter months. These would be vegetated with native perennial spikerushes (grass-like, soft-stem, slender creeping plants with shoots that disintegrate in summer) and meadow barley, as well as creeping wildrye. The seasonal wetlands above high tide lines would be desiccated in summer. The seasonal wetlands bordering the tidal marsh may be re-flooded during extreme high summer tides in June and July, and would instead include salt-tolerant vegetation such as saltgrass, jaumea, and pickleweed. Examples of typical plant species in this vegetation from the project site vicinity (Petaluma River baylands) are shown in Appendix 4.

2.0 Habitat and Vegetation Goals

Primary project goals for revegetation of the excavated and graded peninsulas include:

2.1 Stabilization - Stabilize bare graded substrates, restricting surface erosion caused by runoff (including rill and gully erosion) or shoreline erosion (waves during storms) in the short-term and long-term. Vegetation cover should also suppress wind erosion and dust.

2.2. Resistance to weed invasion – Develop rapid cover of selected "cover crop" species to minimize the availability of disturbed, open soil that is susceptible to re-invasion by noxious weeds with seed sources already present at the site. Cover crop species will include fast-growing naturalized non-native species that are not noxious weeds. Gradually develop permanent, dominant native vegetation that will strongly inhibit weed invasion and growth.

2.3 Wetland-dependent wildlife habitat: Provide tidal marsh and marsh edge wildlife habitat for priority wetland-dependent species with special conservation status: suitable for nesting and flood refuge habitat of California clapper rails; foraging/roosting habitat of wading birds and dabbling ducks; and nesting, foraging and flood refuge habitat for the salt marsh harvest mouse.

2.4 Native local vegetation and species diversity: to emulate to the greatest extent feasible the heterogeneous vegetation structure and native plant species diversity of tidal marsh and valley grassland/savannah (Baye *et al.* 2000, Holstein 2000).

Auxiliary goals for revegetation (desirable, subordinate goals for compatibility with adjacent land uses) include:

- **Esthetics**: Improve visual esthetic quality of the peninsulas by replacing coarse weedy vegetation (mostly annuals, dead and brown in summer) with extensive perennial swards of native sod-forming grasses, picturesque widely spaced oaks, and flowering native shrubs.

- **Recreational compatibility**: Establish native perennial sod-forming grasses tolerant of moderate trampling associated with responsible public access. Inhibit and reduce annual grasses with barbed "foxtail" seedheads, and weedy, bristly thistles, cockleburs, etc. that attach to fur and fabric. Eliminate pampas (jubata) grass with harsh, saw-edge leaves.

3.0 Description of Revegetation Units

The revegetation units are described in detail below in terms of the expected conditions at the East Bahia peninsula project site resulting from the combined effects of spontaneous (natural) establishment of vegetation and artificial planting.

3.1. Tidal marsh: Locations of tidal marsh restoration sites within East Bahia are along the outer portions of the east and west peninsulas, contiguous with existing tidal brackish marsh of Homeowners Association Channel and California Department of Fish and Game's "Toy Marsh" (PWA 2007). Most native tidal marsh plants are expected to establish rapidly and dominate the excavated peninsula areas with native vegetation. Predominantly native vegetation is expected to completely cover and stabilize excavated intertidal areas (other than channel beds and banks) within approximately three to five years. This estimate is based primarily on long-term observations of marsh formation on the graded upper intertidal edges of Carl's Marsh (the nearest tidal restoration project with full tidal range, located north of the east shore of the Petaluma River Bridge) during the first five years of its formation (1994-1999). Only limited, localized planting of selected salt marsh species is recommended to ensure early establishment of seed parent plants, and to compensate for observed low rates of recruitment of infrequent, desirable native species or slow-growing species (Section 4).

Relatively mature marsh vegetation patterns are expected to establish within approximately 15 to 20 years, based on comparison of older marshes that have established in the vicinity within the last 30 years. The tidal marsh vegetation, however, should begin to differentiate into visually distinct middle marsh, high marsh, intermediate high marsh and terrestrial grassland zones, and local salt pan vegetation in less than ten years. These zones are described below.

3.1.1. Intertidal middle marsh zone: intertidal, regularly submerged marsh near MHW. Variable **dominant vegetation** will vary over years according to salinity/rainfall cycle: *saline phases* (high summer soil salinity associated with low-rainfall spring months) would be **pickleweed**-dominant. The *brackish phase* of the middle marsh zone would prevail in years of substantial late spring rains, when **alkali-bulrush** would be dominant, or co-dominant with pickleweed. Long-term succession will be towards increased pickleweed dominance as the marsh plain accretes (builds up in variable elevations approaching Mean Higher High Water). Early in succession (approximately the first two years after excavation), brass-buttons, spearscale, and other low-growing annual salt marsh plants may be temporarily abundant before they are displaced by perennial pickleweed and alkali-bulrush. *Distribution*: gradient between existing tidal marshes and excavated portions of west and east peninsula.

3.1.2. High marsh zone: emergent marsh at/above MHHW flooded by bay waters only during spring tides and storm surges. **Dominant vegetation**: heterogeneous patches of **pickleweed** (tall form), **saltgrass, jaumea, gumplant, alkali-heath**; ephemeral or minor component of spurrey, brass-buttons; minor persistent component of sea-lavender and other native salt marsh forbs. Early in succession (approximately the first two years after excavation), brass-buttons, spearscale, and other low-growing annual salt marsh plants may be temporarily abundant before they are displaced by perennial pickleweed, saltgrass, and gumplant. *Distribution*: two subzones: edges of excavated tidal channels (top of bank), and high tide shoreline below highest drift-lines (local storm surge elevation) and local Mean Higher High Water.

3.1.3. High marsh pan: Local undrained depression (basin), intermediate with seasonal wetlands, but intermittently flooded by spring tides, storm tides, as well as winter/spring rainfall. Vegetation would be variable over years. It would fluctuate annually because of variation in flooding duration, seasonal salinity, seasonal timing of bed emergence. Natural barrens (bare flats with dried sun-bleached algal mats, salt evaporite films, or highly stunted vegetation) are likely to occur over portions of the pan bed some years. Vegetation within the pan is likely to be naturally stunted compared with robust, well-drained tidal marsh vegetation. Expected plant species composition (combined result of spontaneous colonization and planting) either within pans or around its margins would include **saltgrass, pickleweed, alkali-heath, brass-buttons, rabbit's-foot grass, alkali-bulrush,** and possibly **iris-leaf rush** and **smooth goldfields**. Fresh-brackish vegetation may develop in successive years of late and abundant rainfall.

3.1.4. High marsh-terrestrial ecotone: Transition between (and including portions of) upper edge of high tidal marsh (uppermost drift-lines) and terrestrial vegetation (above highest tides, or supratidal) embankment fill. Vegetation structure would be patchy and heterogeneous, including grassland, colonial forbs, and scrub. Expected prevalent plant species would include **saltgrass, alkali-heath, creeping wildrye, meadow sedge, spikeweed, marsh baccharis, western goldenrod, western ragweed,** and some **California rose, coyote brush, blue elderberry**. A transitional/temporary cover crop of nonnative but widespread **perennial or Italian ryegrass** would be established over the supratidal portions of the embankment, and may extend into this zone. Perennial ryegrass would persist in mature plantings, but not as a dominant plant.

3.2. Nontidal seasonal wetland swales: Locations of seasonal wetland swales (graded shallow depressions) will be within Central peninsula grasslands, forming narrow, small swales or basins with compacted, impermeable clay-silt beds. Swales would be flooded by rainfall and local runoff in winter and spring months for variable periods of time (weeks or months) each rainy season. They would be embedded within valley grassland (3.3). Dominant vegetation would vary between drought and above-normal rainfall cycles, and would include **spikerush, meadow sedge, iris-leaf rush and brown-headed rush, Semaphore grass, meadow barley, creeping wildrye.** Colonies of **rayless goldfields, popcornflower, smooth goldfields** may be established as options for diversification. Non-native weedy wetland plants such as cocklebur, Harding grass, brass-buttons, and rabbit's-foot grass (and other nonnative wetland weeds) would likely regenerate to some extent after grading, but their abundance should be limited and reduced by competition with creeping, colonial perennial native vegetation over an approximate 10 year period.

3.3 Valley grassland and oak savannah: Locations are central peninsula fill and Albatross/west peninsula fill areas. **Dominant vegetation** would be **creeping wildrye**. A small number of valley **oaks** (on flats) and **coast live oaks** (mostly on levee slopes) would be established as discrete, widely spaced specimen trees. **Common manzanita** may be planted on well-drained terrestrial fill substrates if they are exposed at the fill surface. Immediately after grading, the fill would be stabilized by a temporary/transitional cover crop composed of non-native **perennial and Italian ryegrass** (for short-term, immediate suppressive competition with invasive non-native plant seedlings), which would be replaced by dominant creeping wildrye over a period of approximately 10 years.

3.4. Transitional cover crop: ryegrass. Perennial and Italian ryegrass, closely related widespread, naturalized non-native species used in lawn and pasture seed mixes, is proposed for use as a temporary, transitional cover crop to stabilize soils and competitively inhibit growth of noxious weeds during the first growing season (fall rains through spring) and in subsequent years while the desired native grassland vegetation gradually establishes dominance. Perennial ryegrass (and related Italian ryegrass, a highly similar semi-annual form) is widely established on the existing peninsulas, and also occurs in derelict bayland meadows all around the project site vicinity. Perennial ryegrass self-sows and regenerates vegetatively. It would be established initially by hydroseeding (hydraulic spray of a slurry composed of seeds and cellulose (wood pulp) fiber mulch, with colorant added to guide spray coverage. Gradually, taller native perennial creeping wildrye would dominate the perennial ryegrass. Hydroseed mulch also acts as a temporary soil binder and weak stabilizer while ryegrass roots establish and stabilize soils.

4. Revegetation Process and Activities

This section describes procedures for revegetation, and the process expected for establishment of the vegetation in the different habitats constructed. Specifications for planting and management are described.

4.1. Tidal marsh

4.1.1. Intertidal marsh. Dominant pioneer intertidal marsh vegetation (pickleweed, alkali-bulrush, saltgrass) is expected to establish spontaneously on barren, graded bay mud substrate exposed on excavated portions of the western and eastern peninsulas. No major planting is expected to be needed for rapid colonization of the middle and high marsh zones. Even in drought years (high salinity) pickleweed is likely to establish extensively over the marsh plain. In periods of two or more consecutive wet years (brackish marsh, abundant late spring rains), alkali-bulrush is likely produce abundant viable seeds and experience suitable seedling establishment conditions. Because the shoreline here is sheltered (well-buffered by extensive areas of dense, tall marsh vegetation) and has a low-gradient shoreline, there is insignificant erosion potential prior to vegetation establishment, and thus no need for early stabilization by extensive planting.

If compacted terrestrial fill or old roadbed material along the peninsula is exposed at the final graded surface, it must be either ripped (deep tillage) or lined with at least a 0.5 ft cover of bay mud. If compacted terrestrial (stony) substrate is left as the revegetation surface, it would most likely constrict development (depth) of tidal marsh plant root systems and result in stunted, short, sparse high marsh vegetation. Small patches of stunted high marsh vegetation may be acceptable (they are associated with high species diversity, particularly of uncommon species), but extensive or well-distributed patches of tall high marsh vegetation are needed as wildlife cover (flood refuge).

During the first two years after grading intertidal surfaces, a temporary high frequency or abundance of brass-buttons and spearscale may be expected. Brass-buttons is likely to decline abruptly as pickleweed becomes dominant and establishes mostly closed cover, probably by the end of the third growing season after grading.

Gumplant is relatively scarce in the existing adjacent tidal marshes, and seed sources for spontaneous colonization of the excavated marsh is likely to be very limited relative to seed sources of potential invasive wetland weed species such as perennial pepperweed. Because gumplant along tidal channel banks is a critical sub-habitat for many special-status marsh wildlife species, planting low densities of gumplant along channel bank crests is recommended to establish adequate local seed sources for establishment of its high abundance early in marsh succession. Establishment of gumplant is likely to be limited after vegetation cover is closed by pickleweed or saltgrass, so early establishment (when vegetation gaps favorable for gumplant seedling and juvenile growth are common) is desirable.

Planting: **Gumplant** seedlings/juveniles should be planted at low frequencies (irregular intervals averaging approximately 6 feet) along both banks of excavated tidal channels, at least at the upper ends of the channels. Planting should as early as possible (the first November-February period after construction). These founder plants (seed parents) should provide ample local seed dispersal for subsequent colonization of gaps between them. No planting of pickleweed or saltgrass or jaumea in intertidal areas is justified, because the difference between planted and unplanted areas probably would be insignificant by the third year after grading. Transplants should be propagated in the growing season prior to construction.

Each of the West Peninsula tidal channels along the Homeowners Association Channel (three excavated, bifurcated channels connected with the Homeowners Channel Marsh; PWA 2007) should have between 200 to 300 linear feet of both channel banks planted with **gumplant** from their upper ends the trunk of the main channel. Planting should consist of individual transplants spaced at variable, irregular intervals averaging 6 feet apart. Gumplant transplants should be located at the highest elevation within a 6 ft wide zone (side-cast zone) of the excavated channel. The single-thread channel at the terminus of the western peninsula should have most of its length planted at the upper end. The total estimated number of gumplant transplants (1-season cultivated seedlings) for the west peninsula is approximately 500 plants. Local populations around the site should provide seeds for propagation.

The East Peninsula contains three relatively linear, somewhat sinuous channels approximately 500 feet in length each (PWA 2007). The adjacent marsh supports relatively sparse populations of **gumplant**, so both banks of each constructed channel should also be planted with gumplant at a irregular, variable average of 6 ft intervals (total 500 gumplant transplants).

4.1.2. High marsh and lower terrestrial ecotone (MHHW peninsula shorelines up to highest drift-lines). Two types of plantings are proposed for this zone: one for supplemental diversification of native vegetation, and one (contingent on severity of wetland weed invasion) to manage weed invasions with competition.

The high tidal marsh zone of the lower Petaluma River is **vulnerable to invasion by numerous nonnative plants**, including stinkwort, Australian bentgrass, and perennial pepperweed. A contingent **pre-emptive planting strategy** may be justified to establish native vegetation cover rapidly before weeds have an opportunity to dominate this zone during early stages of revegetation, when open, bare substrate is most vulnerable to weed invasion. Without early and ample competition from native perennial plants of this tidal marsh zone, these wetland weeds would be difficult or infeasible to control in subsequent years by selective removal. It is not generally feasible to predict year-to-year variations in the relative abundance of tidal marsh weeds and native plants. The relative frequency of native dominants (saltgrass, pickleweed, gumplant) and noxious weeds of the high marsh zone (perennial pepperweed, Australian bentgrass, Mediterranean saltwort, stinkwort) should be carefully assessed in the first growing season. If the frequency of noxious wetland weeds is biologically significant, this should trigger a contingent supplemental planting of saltgrass (a spreading, colonial grass that suppresses weed seedling establishment) in the high marsh zone (up to the highest drift-lines) during the dormant transplant season (November-February) after the new marsh's first growing season. **Saltgrass** plantings would consist of plugs or clonal divisions (rooted or partially rooted clumps of shoots), spaced at irregular intervals 3 to 6 feet apart, in the high marsh zone. Otherwise, native plantings in the high marsh zone would be limited to very low density plantings of relatively uncommon native species.

The natural establishment of desirable, uncommon native plant species in the high marsh ecotone will be limited by low rates of seed dispersal from scarce populations in the region's tidal marshes. Establishment of founder (seed parent) populations of uncommon native perennial species, planted at low frequency along the shoreline, is recommended. These species include **western goldenrod, marsh baccharis, meadow sedge, bee-plant** (tidal marsh ecotypes), **western ragweed,** and **common aster** or **Suisun aster** (historically native to Petaluma and Sonoma Valley). All but bee-plant are strongly colonial, spreading vegetatively by rhizomes (underground stems). These perennials should be planted along the high tide shoreline (within to slightly below the highest drift-line zone) of the east and west peninsulas as clonal divisions propagated from either wild stock, or nursery-grown stock from local wild populations. All transplanting should occur during the dormant season during periods of frequent rainfall (November-February). Transplants should be propagated in the growing season prior to construction. Source populations for propagated planting stock should be obtained from the vicinity of the lower Petaluma River if they exist there; if not, they should be obtained from the nearest population. These perennial species should be planted at *irregular, haphazard* intervals with *approximate average* density of one transplant unit of all species (each *randomly* selected) per average 15 foot interval of peninsula high tide shoreline. A total of approximately 270 high marsh ecotone perennial transplants (all species; approximately 45 transplants of each species, depending on whether both or one aster species are used) would be required for the cumulative 4000 lineal feet (estimated) of suitable high tide shoreline along the east and west peninsulas.

Gumplant need not be planted along the peninsula high tide shorelines if the adjacent constructed tidal channel banks are planted with it. Seed sources from the adjacent channel bank plantings should be sufficient to supply local seeds dispersing to the high tide shoreline.

The native annual **spikeweed** should be introduced to the high tide line (upper drift-line zone) by direct seeding in fall (before rains moisten soil). Spikeweed seed will need to be propagated in the growing season prior to fall seeding. Seed sources should be obtained from northern San Pablo Bay baylands. Seedheads should be raked into 3 foot wide scraped patches (roughly circular areas scarified with a hoe) located within a zone up to six feet centered around the highest observed drift-lines. The number of scrapes/colonies and sowing density would probably be limited by availability of propagated seed. A reasonable goal for first-year seeding would be an average of one scrape/colony per 50 feet of high tide shorelines (haphazard intervals, average), with a total of 80 scrapes for the cumulative estimated 4000 feet of suitable shoreline along the west and east peninsulas. A minimum of 200 seedheads should be seeded into each scraped patch.

In the long-term, **creeping wildrye** is expected to spread vegetatively into the high marsh ecotone downslope from adjacent terrestrial grassland plantings (4.3). It is not necessary or cost-effective to separately plant creeping wildrye at or below the highest drift-lines (extreme high tide line).

4.1.3. Terrestrial grassland of East and West Peninsulas above the highest drift-lines. The new terrestrial embankment above the highest tide line would be highly **vulnerable to invasion by numerous nonnative plants** typical of freshly capped levees in northern San Pablo Bay, including broadleaf weeds (**wild radish, yellow star-thistle, bull thistle, Italian thistle, stinkwort** and **perennial pepperweed**), noxious grass weeds (**Australian bentgrass, Harding grass, jubata or pampas grass, wild oats, ripgut brome)**. A **pre-emptive planting strategy** is therefore justified to stabilize the terrestrial substrate and minimize the duration and area of open, bare soil. The recommended strategy is a combination of a short-term cover crop for fast competitive suppression of weed seedlings, and a long-term competitive perennial dominant cover for the matrix of the terrestrial grassland.

A practical temporary/transitional **cover crop** of nonnative **perennial wildrye** (commercial hydroseed application) is proposed to compete with levee weed seedlings and suppress their colonization. Wildrye is already a characteristic, long-naturalized dominant species of seasonal wetlands and swales in the Petaluma Marsh baylands. It would be gradually dominated or replaced by planted native perennial and shrub species (see below). Weed management is the primary short-term goal of revegetation during the initial (2-4) years after construction.

The long-term vegetation proposed for the embankment is a matrix of native **creeping wildrye** with patchy, irregular colonies of native shrubs, clonal perennial forbs and grasslike plants. Planting would be necessary for these species that would otherwise establish very slowly or erratically because of scarce local native seed sources, and excessive weed seed sources and competition.

East and West peninsula areas above the highest tide-lines (drift-lines) should be hydroseeded (hydraulic spray of slurried cellulose fibers and seed) with commercial grades of mixed **perennial and Italian ryegrass** prior to winter rains and after completion of grading. The hydroseed mix should lack fertilizer because bay mud has ample nutrient levels for ryegrasses, and fertilizer addition would provide a competitive advantage to most weeds. Ryegrass would germinate with fall rains and provide rapid cover to stabilize graded soils and compete with weeds.

During the winter dormant planting season, the entire constructed peninsula surface above high tide lines should be planted with divisions of native **creeping wildrye**, except in seasonal wetland depressions. All transplanting should occur during the dormant season during periods of frequent rainfall (November-February). Transplants should be propagated in the growing season prior to construction. Each transplant consists of a cluster of rooted shoots (tillers) and attached short rhizome segment, divided in winter while leaf growth and area are minimal. Creeping wildrye should either be propagated directly by division of wild stock, or nursery-grown stock from local wild bayland populations. Creeping wildrye should be planted at irregular, haphazard intervals (not uniform planting rows or grids) averaging at least 6 feet. Very small doses of urea-based slow-release fertilizer may be placed below each transplant (not applied to the soil surface) at the time of planting. A total of 9,170 creeping wildrye transplants are estimated for the western peninsula grassland on the embankment and slope above tidal marsh 2,500 transplants are estimated for the eastern peninsula embankment.

If significant patches of broadleaf weeds establish within grassland plantings during the first five years of establishment, they should be mown before they set seed. The timing of mowing to prevent seed set varies with the weed species (typical examples: stinkwort = October mowing; star-thistle, bull thistle, Italian thistle = early June mowing; fennel = July mowing, etc.). Depending on size and distribution of weed patches, mowing may be done with manual or tractor-drawn mowers. Mowing must avoid shrub plantings and the zone below the highest drift-lines.

The terrestrial grasslands of the peninsula embankments should include scattered **scrub thickets** along the gentle outer slope and the crest of the embankment. Scrub thicket patches should be planted with the following species: **California rose, coyote brush, blue elderberry,** and (less frequently) **coast live oak.** Coyote brush is expected to establish spontaneously, and its planting is optional. A total of 5 to 10 coast live oak saplings may be planted (or retained within pre-existing conditions) on the embankment. Other coastal scrub species present in the vicinity on fractured bedrock-derived soils (such as **bush monkeyflower**) are not expected to thrive on bay mud soils of embankments, and are not recommended for planting except as field trials. The total number and location of scrub patches can be varied according to needs for deterring inappropriate levels of access to the tidal marsh edge. Scrub thickets may be clustered near access points and the crest of the peninsula embankment. Scrub thicket plantings may be installed in phases, with planting concentrated in years of above-average rainfall to promote high survivorship of woody transplants. Transplants should be sheltered by loose dead brush to reduce exposure to wind, browsing animals (hares, deer) and sun. Approximately 10 patches of scrub on the east and west peninsulas, each consisting of a random species assortment of species transplanted 6 feet apart, 6 shrub transplants per patch, are suggested as a minimum initial planting effort. Precise transplant locations should be determined in the field and fitted to minor variations in topography (slight depressions that maximize infiltration of rainfall and soil moisture).

4.2. Nontidal seasonal wetland depressions of the Central Peninsula. Within the Central peninsula, six depressions and swales with compacted clay soils will be constructed within the gently sloping Central peninsula top (PWA 2007). These depressions will range between approximately 50 to 100 feet long and 40 to 80 feet wide (PWA 2007). The total area of seasonal wetlands is estimated at approximately 0.6 acre, but the actual area may be less, depending on flooding patterns and soil permeability after construction. The depressions will form seasonally wet meadow (wet grassland or seasonal marsh) within the terrestrial grassland matrix. These depressions should not be hydroseeded, if possible.

The lowest portions of the depressions (beds) should be planted with dormant perennials (spikerush, rush, meadow sedge, meadow barley) in the first dormant season (November-February) after construction, but the gentle side slopes should not be planted the first year because the upper flooding boundaries of the seasonal wetlands will not be detectible (or accurately predictable) until several years after construction, after several variable winter rainfall periods. Semaphore-grass, in contrast, will be planted as seeding/juvenile plants during the late winter (wet season flooded phase). The wetland planting zone above the beds in any case is likely to be variable among years. The planting of these depressions, therefore, is proposed to be phased over at least two years. The plantings of perennial seasonal wetland plants (particularly clonal, creeping species) are expected to gradually spread upslope to the natural upper wetland boundary, and the **creeping wildrye** from the matrix of terrestrial grassland is expected to spread downslope into the depressions.

Spikerush, iris-leaf rush, brown-head rush, meadow sedge, Semaphore grass, and **meadow barley** are proposed as the principal initial plantings for seasonal wetland depressions. Their relative abundance is not predictable over time, but it is likely that only some of these perennial species will dominate the seasonal wetlands in the long-term. Spikerush should be planted at a 2:1 ratio with all other species. Experimental small-scale reintroductions of native vernal pool/seasonal wetland plants occurring between the Petaluma River and Sears Point (**rayless goldfields, popcornflower, smooth goldfields, flowering quillwort**) are recommended as options for future revegetation.

The matrix planting density for the beds of seasonal wetlands should be a nearest-neighbor distance of 3 to 6 feet, depending on availability of stock. A relatively high density (3 ft spacing) would be desirable. All transplanting should occur during the dormant season during periods of frequent rainfall (November-February). The maximum total number of transplants required for the cumulative 0.6 acre area of seasonal wetlands would be approximately 2,900. About two thirds of this amount (2,000 transplants) should be propagated and phased for planting the first fall after construction, and the remainder may be added, if needed in the second year. This lot would comprise 1,000 spikerush divisions and 250 each of colonial native rushes (brown-headed rush and iris-leaf rush), meadow sedge, Semaphore-grass, and meadow barley.

Seasonal wetlands may require mowing in mid-summer if they become re-infested with noxious seasonal wetland weeds currently present at the site (Harding grass, cocklebur) or new invasions (Australian bentgrass, stinkwort). Most other non-native seasonal wetland weeds (e.g., brass-buttons, ryegrass, rabbit's-foot grass, etc.) may be tolerated. Localized late-season mowing (October) would be required if seasonal wetland edges become infested with stinkwort.

4.3. Terrestrial grassland and oak savannah: Central Peninsula and southern Western Peninsula. The filled areas above tidal elevations at the Central Peninsula and the southwest extension of the Western Peninsula (at the end of Bolero and Albatross streets) will be revegetated with hydroseed mix of **ryegrasses** and sprigging with **creeping wildrye**, as on the above-tide portions of the western and eastern peninsula embankments. These areas will require an estimated 14,200 transplants of creeping wildrye at average 6 ft spacing.

A small number of slow-growing **valley oaks** will be established with very wide, irregular spacing (100 – 200 feet apart) on the Central Peninsula. Because of the large mature size and naturally wide spacing of these oaks, and uncertain survivorship of transplants, about 10 valley oaks should be planted at haphazard locations between seasonal wetland depressions on the Central Peninsula, and a total of 3 or 4 should be set as a final population size, whether achieved by deliberate thinning or by mortality by year 5 after planting. Existing coast live oaks at this location may be retained if feasible for construction. A small number (not to exceed a final post-mortality/post-thinning number of 10 widely spaced trees) of **coast live oaks** and **California bay** saplings are proposed for planting at haphazard locations (precise locations to be determined on site after construction) in these areas. The number of planted saplings may exceed the desired final number of trees, to anticipate natural mortality. A 2:1 ratio of planted:final sapling density is recommended.

Toyon and **common manzanita** may naturally disperse by seed in this grassland, as they have done in portions of the peninsulas. They are not proposed for initial planting. Supplemental transplanting of propagated local stock of these species may be treated as a contingency measure in future years if they do not recruit spontaneously after more than five years.

4.5. Planting schedule. Planting should generally occur in the fall after construction. All direct seeding (spikeweed, ryegrass) should be done in fall before the first predicted "germinating rains" (rainfall sufficient to saturate the upper soil profile; more than 0.5 inch rainfall), usually late October. All perennial and woody transplanting should be done during early winter dormancy, during periods of frequent rains, prevailing cloud cover, low temperatures, and after the soil profile is thoroughly wetted to a depth of at least two feet. This transplanting window is expected between mid-December and early February most years. Transplanting should be avoided during periods of soil saturation following heavy or frequent rainfall (due to risk of wet clay compaction). Planting times may be adapted to variable weather. If transplanting is delayed, and excessive foliage growth occurs on transplants (excessive demand for moisture during establishment of divisions), the transplanting season may be extended slightly during wet weather by (a) pruning back shoot and leaf growth to approximate early winter conditions, and (b) cutting, mowing, or removing weeds and annual grasses within 1-2 feet of the transplant.

4.6. Provenance of native species: Priorities for collection of all propagation materials of native species should be either **local** (on site, adjacent), within the **Petaluma Marsh**, or in **San Pablo Bay west of Tolay Creek**. Species that currently occur naturally within this area should not be obtained from outside this area. Only tidal marsh or tidal marsh edge/ecotone populations should be sampled as genetic sources for propagation.

5.0 Revegetation schedule and implementation.

The expected schedule for revegetation actions and results is outlined below by growing season (moist soil period: fall rains to early/mid-summer desiccation when active growth stops in most plants).

5.1 2007-2008 Growing season

- 2007 propagation for 2008 planting. Cultivated (irrigated, fertilized) stock of perennial and woody native plants (local creeping wildrye, spikerush, meadow sedge, marsh baccharis, western goldenrod, western ragweed, California rose, blue elderberry, etc.) will be propagated and grown at an off-site outdoor nursery. Seed of spikeweed will be collected in fall 2008 for propagation in 2009. Seed sources for valley oak will be identified and obtained if possible for propagation.

- Post-grading hydroseeding (October to November 2007). Bare graded soils above high tide line on all peninsulas will be hydroseeded with perennial ryegrass as a transitional cover crop.

Ryegrass would germinate with soil-wetting fall rains, and establish extensive green cover during winter and early spring.

- Winter 2008 planting of creeping wildrye. Depending on availability of suitable local wildrye transplant stock in 2007, the first phase of creeping wildrye would be transplanted between November 2007 and February 2008 on terrestrial grasslands of all peninsulas. Transplants will root during moist winter months and gradually leaf out in late winter through spring, after roots establish. Cultivated (irrigated, fertilized) stock of local creeping wildrye will be propagated and grown at an off-site outdoor nursery.

- Winter 2008 planting of high marsh perennials and shrubs. Widely spaced colonies of native shrubs, perennials available from 2007 propagation will be transplanted along the high tide line and adjacent uplands along peninsulas. Gumplant will be planted along bank edges of constructed tidal channels.

- Winter 2008 planting of seasonal wetlands. Spikerush, rush, sedge transplants should be planted out in exposed beds (bottom) of the six seasonal wetland basins of the Central Peninsula. Semaphore grass will be planted mid-winter during flooding phase of seasonal wetlands.

- Spring 2008 vegetation establishment. Pickleweed spontaneously establishes frequently in the intertidal zone along excavated peninsulas. Transient tidal wetland "weeds" such as brass-buttons also establish. If spring rains are ample and tidal channel salinity remains low in April-May, alkali-bulrush seedlings will establish frequently. Other tidal marsh plant seedlings establish, mostly along the high tide shoreline. Creeping wildrye develops green, tufted shoots, in upland grasslands, but little lateral spread (few and short creeping shoots first year). Broadleaf weeds and annual grasses establish at variable density. Mowing of weeds should occur to minimize seed production in late spring/early summer, depending on species and seasonal timing.

- Late spring 2008 grassland weed inspection. Grasslands should be inspected for late-stage bolting or early flowering of yellow star-thistle to determine the location and extent of mowing to prevent seed production and infestation.

- Early summer 2008 - weed inspections and adaptive management. High tide lines of peninsulas will be inspected for size and number of noxious weed colonies, to determine if supplemental planting of saltgrass is needed for late fall. Seasonal wetlands and grasslands will be inspected for infestation of noxious weeds to determine the location and extent of mowing to prevent seed set. Inspection

- Summer 2008. Pickleweed (and alkali-bulrush, if salinity remains low in early summer) seedlings grow rapidly in the upper intertidal zone, establishing sparse cover. Gumplant transplants establish juvenile (non-flowering) plants along top edges of tidal creek banks. Transplanted perennials and shrubs spread slightly. Ryegrass dries to straw and produces seeds. Weeds begin to produce seeds in terrestrial grassland. Mowing of weeds should occur to minimize seed production in late spring/early summer, depending on species and seasonal timing.

- Fall 2008 – stinkwort inspection. High tide lines of peninsulas and upper edges of seasonal wetlands will be re-inspected to detect early flowering stages of stinkwort in mid-late October. All stinkwort colonies must be mown or manually removed prior to seed set.

- Fall 2008 spikeweed sowing. Native spikeweed patches are scraped and direct-seeded along high tide lines of peninsulas.

5.2 2008- 2009 Growing season

- Fall 2008. Perennial ryegrass regenerates from seed and vegetative plants after soils are moistened by rainfall.
- Fall 2008. Supplemental planting of seasonal wetlands and shrub species.

6. Monitoring. No formal monitoring plan has been included within the limited scope of this revegetation plan. A minimum of practical monitoring is necessary for purposes of management, particularly seasonally timed weed inspections, weed control at early stages of invasion, and post-transplant assessment of growth and survivorship. Essential adaptive management actions guided by monitoring include weed control (abatement of seed production, removal of perennial populations), replanting of unacceptably high local or general levels of transplant mortality), and increased protection of selected individual plantings against herbivory, moisture stress, vandalism, or trampling.

Annual fixed-perspective photomonitoring each peninsula, from multiple perspectives and viewing stations, is recommended for low-cost, long-term (over 10 years) qualitative comprehensive assessment of revegetation at East Bahia, regardless of whether quantitative sampling is conducted. Consistent, repeated photography from known locations and orientations provides valuable interpretive information about patterns and rates of vegetation change, and long-term trends.

7. Summary of planting quantities.

species	propagule type	vegetation unit(s)	West Peninsula	East Peninsula	Central Peninsula	total
Aster, common	vegetative division/plug	high marsh	12	12	0	24
Aster, Suisun	vegetative division/plug	high marsh	12	12	0	24
Baccharis (coyote-brush)	sapling	peninsula embankment grassland	20 (optional)	20 (optional)	0	30 (optional)
Baccharis, Marsh	vegetative division (bare-root dormant shoot)	high marsh	25	25	0	50
Barley, meadow	juvenile seedling-grown	seasonal wetland	25	25	250	300
Bay, California	sapling	Central peninsula grassland	0	0	5	5
Bee-plant	juvenile seedling-grown	high marsh	25	25	0	50
Elderberry, blue	sapling (bare-root dormant)	peninsula embankment grassland	20	20	0	30
Gumplant	juvenile seedling-grown	high marsh at channel bank	500	500	0	1000
Oak, coast live	sapling	Central peninsula grassland	5	5	10	20
Oak, valley	sapling (bare-root dormant)	Central peninsula grassland	0	0	10	10
Rushes (brown-headed, iris-leaf)	vegetative division/plug	seasonal wetland	0	0	250	250
Ryegrasses (perennial, Italian)	hydroseed	grassland (all peninsulas)	[bulk hydroseed by acreage]	[bulk hydroseed by acreage]	[bulk hydroseed by acreage]	[contractor estimate]
Rose, California	vegetative division sucker (bare-root)	peninsula embankment grassland	20	20	0	40
Sedge, meadow	vegetative division/plug	seasonal wetland, high marsh	25	25	250	300
Semaphore grass	juvenile seedling		0	0	250	250
Spikeweed	seed (seedhead)	high marsh	8,800	7,200	0	16,000
Spikerush	vegetative division/plug	seasonal wetland	0	0	1000	100
Western goldenrod	vegetative division/plug	high marsh	25	25	0	50
Western ragweed	vegetative division/plug	high marsh	25	25	0	50
Wildrye Creeping	vegetative division/plug	grassland (all peninsulas	12,500	2,500	10,800	25,800

REFERENCES

Baye, P.R., P.M. Faber and B. Grewell. 2000. Tidal marsh plants of the San Francisco Estuary. In: Olofson, P.R., ed. 2000. Baylands Ecosystem Species and Community Profiles: life histories and environmental requirements of key plants, fish, and wildlife. Goals Project (Baylands Ecosystem Habitat Goals), pp. 9-32. San Francisco Bay Regional Water Quality Control Board, Oakland, California.

Holstein, Glen. 2000. Plant communities ecotonal to the baylands. in: Olofson, P.R., ed. 2000. Baylands Ecosystem Species and Community Profiles: life histories and environmental requirements of key plants, fish, and wildlife. Goals Project (Baylands Ecosystem Habitat Goals), San Francisco Bay Regional Water Quality Control Board, Oakland, California.

PWA (Philip Williams and Associates) 2007. Revised engineering plans and cross-sections for East Bahia, Bahia Wetlands Restoration Project, Novato California, dated February 5, 2007. Prepared for Marin Audubon Society, Mill Valley, California.

Appendix 1. Recent vegetation and habitat conditions at East Bahia.

Figure 1-1. Central Bahia, winter 2007, seasonal wetland and weedy grassland.

Figure 1-2. East Bahia central peninsula, levee. Winter 2007.

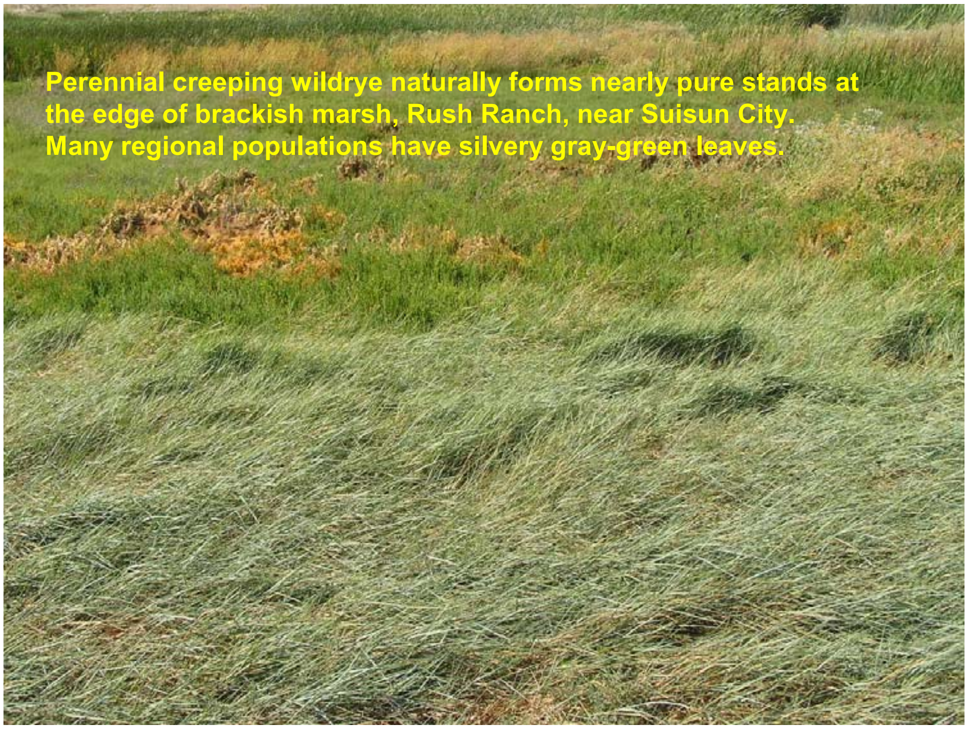
Figure 1-3. East Bahia Western peninsula adjacent to tidal marsh of HOA channel.

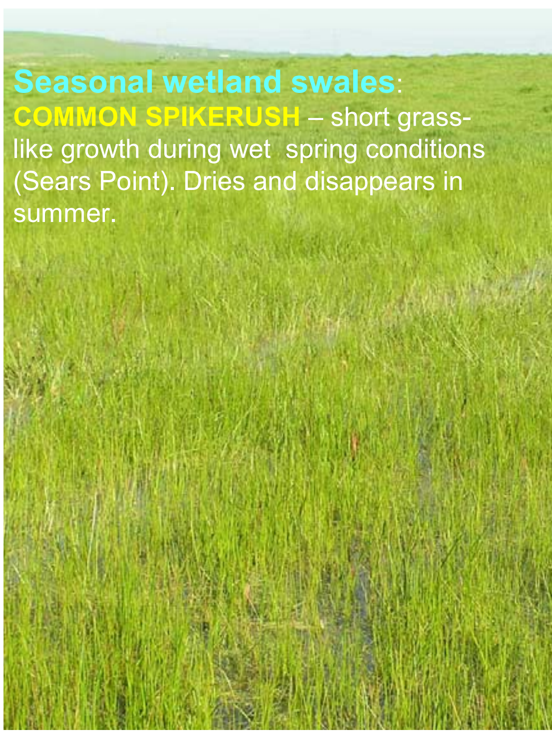
Figure 1-4. Existing seasonal wetland swale in East Bahia eastern peninsula. Winter 2007.

Figure 1-5. Existing seasonal wetland swale southwest of Central Peninsula. Winter 2007.

Figure 1-6. Weed-dominated grassland, western peninsula upland. Fall 2006.

Appendix 2. Visual guide to selected plants and vegetation described in text.


Perennial creeping wildrye naturally forms nearly pure stands at
the edge of brackish marsh, Rush Ranch, near Suisun City.
Many regional populations have silvery gray-green leaves.


Seasonal wetland swales:
COMMON SPIKERUSH – short grass-like growth during wet spring conditions (Sears Point). Dries and disappears in summer.

Perennial pickleweed


Common and Suisun aster


Marsh baccharis

Peter R. Baye Ph.D.
Coastal Plant Ecologist
baye@earthlink.net
(415) 310-5109

western goldenrod (

Gumplant

Gumplant, pickleweed, creeping wildrye

Peter R. Baye Ph.D.
Coastal Plant Ecologist
baye@earthlink.net
(415) 310-5109

APPENDIX 3
Common and Botanical Names Used in Text

Alkali-bulrush *Bolboschoenus maritimus* (syn. *Scirpus maritimus*)
Australian bentgrass *Agrostis avenacea*
Bee-plant (tidal marsh ecotype) *Scrophularia californica*
Brown-headed rush *Juncus phaeocephalus* var. *paniculatus*
Blue elderberry *Sambucus mexicana*
Bull thistle *Cirsium vulgare*
Bush monkeyflower *Mimulus aurantiacus*
California bay *Umbellularia californica*
California rose *Rosa californica*
Coast live oak *Quercus agrifolia*
Common aster *Symphiotrichum chilense* (syn. *Aster chilensis*)
Common manzanita *Arctostaphylos manzanita*
Cordgrass *Spartina foliosa*
Coyote brush *Baccharis pilularis*
Creeping wildrye *Leymus triticoides*
Flowering quillwort *Lilaea scilloides*
Gumplant *Grindelia hirsutula,* San Francisco Bay ecotype [syn. *Grindelia stricta* var. *angustifolia*]
Iris-leaf rush *Juncus xiphioides*
Italian ryegrass *Lolium multiflorum*
Italian thistle *Carduus pycnocephalus*
Jaumea *Jaumea carnosa*
Jubata grass *Cortaderia jubata*
Marsh baccharis *Baccharis douglasii*
Meadow barley *Hordeum brachyantherum*
Meadow sedge *Carex praegracilis*
Pampas grass *Cortaderia sellowana*
Perennial pepperweed *Lepidium latifolium*
Perennial ryegrass *Lolium perenne*
Pickleweed *Sarcocornia pacifica* (syn. *Salicornia virginica*)
Popcornflower *Plagiobothrys bracteata*
Rabbit's-foot grass *Polypogon monspeliensis*
Rayless goldfields *Lasthenia glaberrima*
Ripgut brome (grass) *Bromus diandrus*
Rabbit's-foot grass *Polypogon monspeliensis*
Saltgrass *Distichlis spicata*
Semaphore grass *Pleuropogon californicus*
Spikeweed *Centromadia pungens* ssp. *maritima*
Spikerush *Eleocharis macrostachya*
Stinkwort *Dittrichia graveolens*
Toyon *Heteromeles arbutifolia*
Valley oak *Quercus lobata*
Western goldenrod *Euthamia occidentalis*
Western ragweed *Ambrosia psilostachya*
Wild oats (grass) *Avena fatua*
Yellow star-thistle *Centaurea solstitialis*

Attachment D

Bahia East-West Peninsula Thicket Monitoring Year 1 Annual Monitoring Report May 2014

Prepared by:

The Watershed Nursery
601 A Canal Blvd.
Richmond, Ca. 94804
(510)234-2222 ph
(510) 234-2242 fx
diana@thewatershednursery.com
www.thewatershednursery.com

Project Description:

In 2012 The Watershed Nursery (TWN) contracted with the Marin Audubon Society (MAS) for the installation of native plants on their Novato, California Bahia property along the 'Eastern peninsula'. Previous plantings conducted along the two peninsulas on the property had minimal success. The 2012 TWN contract provided extra measures in planting and maintenance with the goal of developing a protocol that could be successful in getting establishment along both these peninsulas. In 2013 TWN contracted with MAS for on-going maintenance and monitoring of the Bahia Eastern peninsula plantings. This report represents the first of two years of monitoring conducted to assess success of plant establishment along the eastern peninsula.

Project Background:

The planting design used for the upper elevations of these peninsulas was based on the description by Peter Baye (Coastal Ecologist) of 'thickets' in which the design entails planting species in patches or groups spaced along the levee rather than individual plants separated out along the levee (Table 1). For example a planting of 3 to 5 herbaceous perennial species (such as *Aster chilensis* & *Scrophularia californica*) planted on 1' to 3' centers planted with 2 to 4 shrub species (*Baccharis pilularis* & *Sambucus mexicana*) planted on 3' to 5' centers. The intention of this design is to create pockets of high tide refugia and habitat more quickly than spaced plantings. A total of 110 individual plants of 4 native species, 2 herbaceous perennial and 2 shrub species, were installed in the thickets. Table 1 includes planting species details for each thicket.

Table 1: Initial thicket plantings installed on Bahia eastern peninsula fall 2012

Thicket #	*Aster chilensis*	*Baccharis pilularis*	*Sambucus mexicana*	*Scrophularia californica*
1	5	4	2	2
2	5	4	2	2
3	5	4	2	2
4	5	3	3	2
5	4	3	2	3
6	4	3	2	3
7	4	3	2	3
8	4	3	2	2
9	4	4	2	1

The soils on the eastern peninsula are bay mud and have exhibited extensive cracking around previous plantings exposing roots to desiccation. Because of the soil conditions TWN proposed to excavate holes ~2x width and depth of the plant and mix the site soil with an intermediate grade of soil amendment. TWN did not use pure compost or very loamy soils due to the risk of developing a root system which grows only in the excavated planting hole and does not successfully establish in project soils. A soil with some clay components and slightly more sand and organic matter than site soils was used. TWN also installed 3 Driwater tubes per plant and placed cardboard and straw mulch around each planting to retain soil moisture.

The original installation contract included budget for one summer with 3 replacements of the Driwater gelpacks. In 2013 an additional maintenance and monitoring contract extended Driwater installation for an additional summer (2014) of 3 replacement cycles. Driwater gelpack replacement is scheduled generally for mid-March, mid-June, and mid-August of each year but is adjusted based on length of rainy season. (*An additional Driwater installation was conducted in January 2014 due to low rainfall). In addition to the second year of Driwater installation the contract included two years of monitoring to be conducted in May of 2014 and 2015. This report is the summary of the first round of monitoring.

Monitoring methods:

The monitoring included assessment of survival, vigor and height for each plant installed within each thicket. Vigor is assessed on a scale of 0-3 with 0= dead/missing, 1=stressed, 2=stable, and 3=actively growing (with new leaf, flower or fruit production). The monitoring results were used to info maintenance activities in the May 2014 scheduled Driwater replacement.

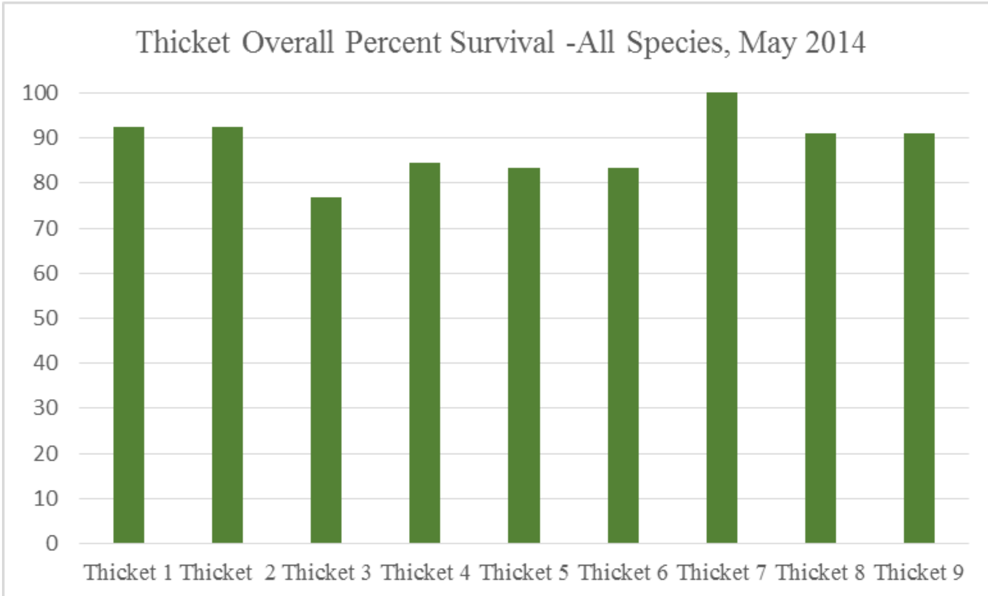
Monitoring results:

The location of each thicket recorded during monitoring is shown in Table 2.

Table 2: GPS and descriptor for each thicket.

Thicket #	GPS	Acc (m)	Description
1	38° 07'30.5", 122° 31'04.2"	4.2	184' past fence on south end of peninsula
2	38° 07'32.2", 122° 31'04.2"	4.6	160' past thicket #1
3	38° 07'33.5", 122° 31'04.4"	4.5	115' past thicket # 2
4	38° 07'35.1", 122° 31'04.4"	5.8	170' past thicket #3
5	38° 07'36.7", 122° 31'04.5"	4.8	170' past thicket #4
6	38° 07'38.8", 122° 31'04.8"	4.8	197' past thicket#5
7	38° 07'41.3 ", 122° 31'05.0"	3.5	260' past thicket #6
8	38° 07'43.7", 122° 31' 05.4"	2.4	240' past thicket #7
9	38° 07'45.0", 122° 31'05.6"	n/k	135' past thicket # 8

The average percent survival for all thickets was 88%, ranging from 77% at the lowest to 100% survival, standard deviation 6.8% (Figure 1).
Figure 1: Percent survival all species for thicket plantings May 2014



Specific species percent survival ranged from 75% for *Sambucus mexicana* to 100% for *Aster chilensis* (Figure 2). Average vigor by species ranged from a stressed rating of 1.5 to actively growing rating of 2.9 (Figure 3). Height of planted material ranged from ~30 to ~65 cm (Figure 4).

Figure 2: Average percent survival by species for all thicket plants

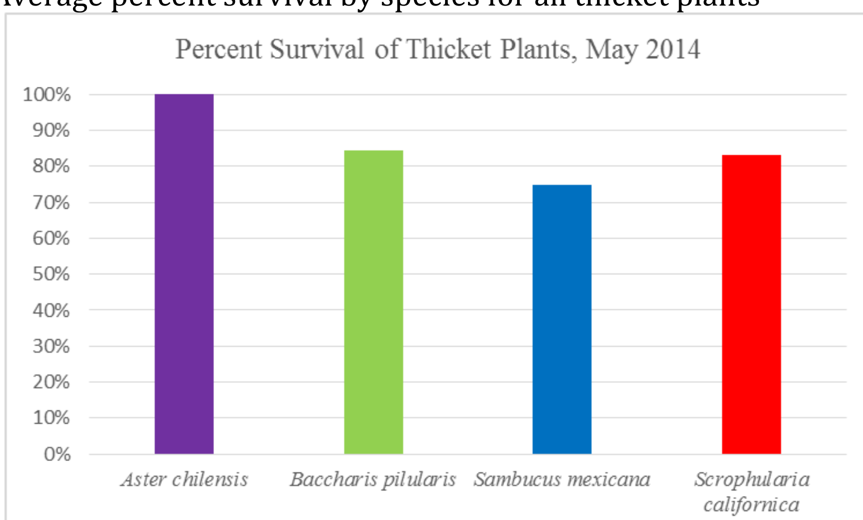


Figure 3: Average vigor by species for all thicket plants

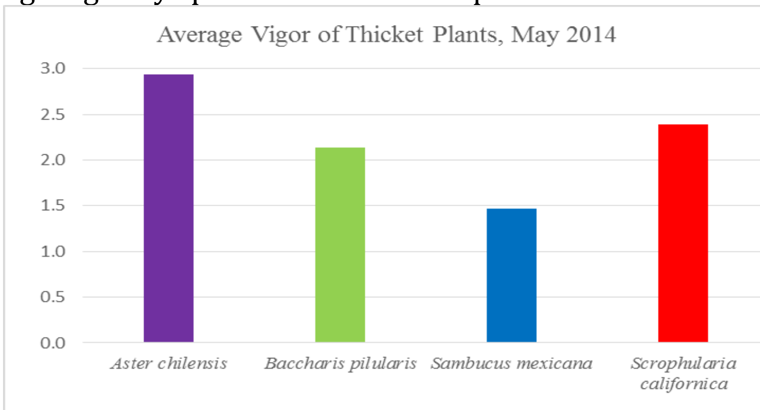
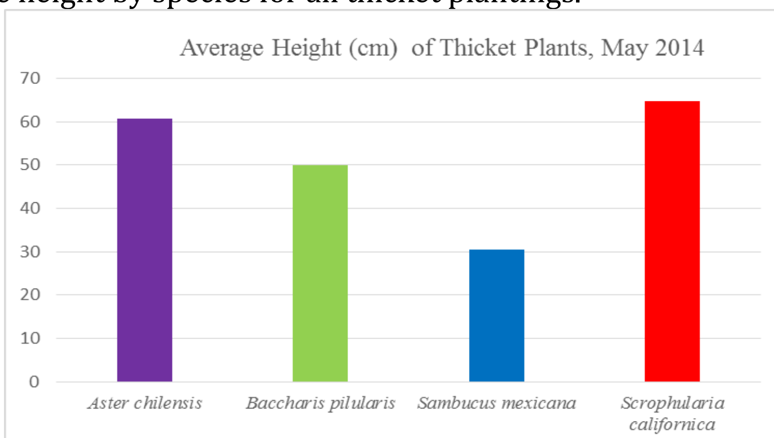


Figure 4: Average height by species for all thicket plantings.



Discussion:

Overall the thicket plantings are establishing better than with previous planting approaches. All vigor and height averages include missing or dead plants so the average for the remaining established plants is higher (Table 3).

Table 3: Vigor and Height comparison with or without zero values

Species	**Average Vigor including dead**	**Average Vigor without dead**	**Average Height(cm) including dead**	**Average Height (cm) without dead**
Aster chilensis	2.9	2.9	60.8	60.8
Baccharis pilularis	2.1	2.5	50.0	59.3
Sambucus mexicana	1.5	2.0	30.5	40.7
Scrophularia californica	2.4	2.9	64.7	77.7

The most successful species on site is the *Aster chilensis*. This species is growing vigorously, has 100% survival, was beginning to bud and flower during this monitoring event and many plants had evidence of having flowered and set seed last year. There are places where this species is spreading rhizomatously as well. Although the survival of the *Baccharis pilularis* is not as high as the aster for the most part the plants that have established look robust and are reaching a size to begin to provide some cover. The *Scophularia californica* had individuals with low vigor in some thickets and other thickets with very robust individuals but even many of the smaller plants were beginning to flower and the flowers were being visited by bees. The *Sambucus mexicana* is the species with the lowest vigor and survival. At the time of this monitoring many of the plants looked as though they were already entering summer water stress dormancy despite presence of Driwater.

For the spring 2014 Driwater placement TWN was requested by MAS to reduce the Driwater tubes from 3 to 2 tubes per plant for those plants seeming to be well established. For the plants where Driwater tubes were removed soil was added to fill in resulting hole. In the May 2014 Driwater replacement ~1 tsp of a slow release fertilizer was added at the bottom of a single Driwater tube for individual plants which appeared to be struggling to establish. In July 2013 and May 2014 TWN also added soil to cracks and placed supplemental mulch. Both the July 2013 and one of the May 2014 maintenance days were additional days budgeted by MAS for project. Table 4 provides a summary of maintenance activities performed in regards to removal of Driwater tubes and addition of fertilizer. All plants were remulched. In areas where there was mortality of a planting all Driwater tubes were left for the potential of replacement plantings to be installed fall 2014.

Table 4: Bahia thickets May 2014 maintenance notes

Thicket #	**Species**	**MaintenanceNotes**
1	*Baccharis pilularis*	reduce to 2 Driwater
	Baccharis pilularis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Baccharis pilularis	reduce to 2 Driwater
	Scrophularia californica	leave tubes
	Scrophularia californica	keep 3, add slo-release

2	*Baccharis pilularis*	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
	Baccharis pilularis	reduce to 2 Driwater
	Scrophularia californica	keep 3, add slo-release
	Sambucus mexicana	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
3	*Baccharis pilularis*	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Scrophularia californica	keep 3, add slo-release
	Scrophularia californica	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
	Sambucus mexicana	leave tubes
4	*Sambucus mexicana*	keep 3, add slo-release
	Aster chilensis	reduce to 2 Driwater
	Scrophularia californica	keep 3, add slo-release
	Scrophularia californica	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Baccharis pilularis	leave tubes
	Sambucus mexicana	leave tubes

5	*Sambucus mexicana*	leave tubes
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
	Scrophularia californica	keep 3, add slo-release
	Scrophularia californica	leave tubes
	Baccharis pilularis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
6	*Scrophularia californica*	keep 3, remulch
	Scrophularia californica	keep 3, remulch
	Scrophularia californica	keep 3, remulch
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Baccharis pilularis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Baccharis pilularis	leave tubes
	Sambucus mexicana	leave tubes
7	*Baccharis pilularis*	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
	Scrophularia californica	keep 3, add slo-release
	Scrophularia californica	keep 3, add slo-release
	Scrophularia californica	keep 3, add slo-release
	Baccharis pilularis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release

8	*Baccharis pilularis*	reduce to 2 Driwater
	Scophularia californica	keep 3, add slo-release
	Scophularia californica	keep 3, add slo-release
	Sambucus mexicana	leave tubes
	Baccharis pilularis	keep 3, remulch
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Baccharis pilularis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
9	*Baccharis pilularis*	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Sambucus mexicana	keep 3, add slo-release
	Aster chilensis	reduce to 2 Driwater
	Aster chilensis	reduce to 2 Driwater
	Baccharis pilularis	reduce to 2 Driwater
	Sambucus mexicana	keep 2 (add 1 if possible), add slo-release
	Baccharis pilularis	keep 3
	Scrophularia californica	leave tubes
	Baccharis pilularis	reduce to 2 Driwater

The Marin Audubon Society has also conducted additional maintenance activities in the thickets, specifically addition of supplemental water with a motorized wheelbarrow apparatus. TWN is not aware of other MAS activities that may have been conducted on the site.

Photo 1: Thicket #1, looking north along peninsula

Photo 2: Thicket 9

Photo 3: Elderberry (*Sambucus mexicana*)

Photo 4: Coyote bush (*Baccharis pilularis*)

Photo 5: Pacific aster (*Aster chilensis*/new name *Symphyotrichum chilense)*