South San Francisco Bay Weed Management Plan 1st Edition

Prepared by

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OVERVIEW

On the Don Edwards San Francisco Bay National Wildlife Refuge (hereafter, Refuge), similar to other natural lands, weeds reduce and degrade wildlife habitat and impede successful habitat restoration. In specific instances, weeds alter hydrology and ecosystem function and act as source populations that infest not only Refuge lands but adjacent properties. In addition, weeds alter landscapes, block views, and increase trail and fire break maintenance needs. On the Refuge, invasive weeds infest habitat types ranging from sub-tidal mudflats to uplands, and are of greatest concern in habitats where they may potentially harm threatened and endangered species, migratory bird species and their habitats. Habitats of concern include tidal marshes, marsh/upland transition zones, and vernal pool grasslands, as well as other habitat types. While this plan encompasses Refuge lands, the plan is easily adaptable for use by adjacent South Bay landowners such as California Department of Fish and Wildlife (CDFW) at Eden Landing Ecological Reserve and the privately managed lands of Cargill Salt, Inc.

This South San Francisco Bay Weed Management Plan (hereafter WMP) is a structured outline for controlling the most invasive and problematic non-native weeds within the Project Area as part of an overall weed management and re-vegetation program. The WMP uses an adaptive management approach to prioritize, implement and evaluate weed treatment and re-vegetation actions and to modify management priorities and strategies as necessary over time. As part of the WMP, we identify goals for a weed management program and set objectives and priorities for the control or eradication of target weed species, according to their impacts on native species and communities, particularly impacts on threatened and endangered species. The WMP also prioritizes specific projects or circumstances within the Project Area that necessitate weed management and recommends control actions to be implemented in these various situations. Monitoring is a critical component of the WMP adaptive management process and the WMP works in conjunction with the draft Weed Inventory and Monitoring Plan prepared for the Don Edwards San Francisco Bay National Wildlife Refuge (draft Weed I&M Plan, Marriott and Tertes 2013). The draft Weed I&M Plan provides a guide for detecting and mapping the distribution and abundance of established and new infestations, for recording the success of weed control in treatment areas, and for tracking growth of known infestations over time.

INTRODUCTION

The Weed Management Plan has been developed for the prevention, detection, and control of priority invasive weed species affecting the Don Edwards San Francisco Bay National Wildlife Refuge trust resources and adjacent lands. It also provides guidelines for the re-vegetation of native plant species in weed treated areas as an essential component of weed management. This plan complies with, and is developed under, the authority of the National Invasive Species Management Plan (Executive Order 13112), and addresses priorities and recommendations for weed control and native plant restoration outlined in state and regional plans, including; the California Noxious & Invasive Weed Action Plan (CDFA 2005), Baylands Ecosystem Habitat Goals (Goals Project 1999), Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (USFWS 1999), and the Recovery Plan for the Western Snowy Plover, Pacific Coast Population (USFWS 2007). This plan also fulfills the requirement for the U.S. Army Corps of Engineers O&M Section 404 Permit Special Condition 9 (Permit #2008-00103S) for the South Bay Salt Pond Restoration Project EIR (EDAW et al. 2007). The ultimate purpose of this WMP is to provide the basis for a weed management program that will aid in the fulfillment of the mission, purposes and goals of the US Fish and Wildlife Service, Don Edwards San Francisco Bay National Wildlife Refuge and other local land managers, including California Department of Fish and Wildlife.

A weed is commonly defined as any plant that grows where it is not wanted. Weeds can be classified as native or non-native, invasive or non-invasive, and noxious or not noxious. A non-native weed is one that originated outside of a defined geographic area. For the purposes of this plan, we consider a non-native weed to be any plant that did not occur within the South San Francisco Bay (South Bay) pre-European settlement. Some relatively "benign" weeds may not pose a threat to the habitat they colonize, and may be replaced easily by native successional species. However, some weeds flourish where they establish and spread quickly and pervasively, crowding out native vegetation, altering habitat diversity and function and often creating a monoculture. These weeds are considered "invasive" and may also be considered "noxious" according to location and designation. Legally, a noxious weed is defined as any plant designated by a Federal, State or county government or agricultural authorities as injurious to public health, agriculture, recreation, wildlife or property.

In broad terms, invasive species are organisms that have been introduced deliberately or unintentionally into an environment in which they did not evolve, are capable of establishing self-sustaining populations in disturbed or "untransformed ecosystems" (MacDonald et al. 1989 in Keefer et al. 2010), have no natural enemies to limit their reproduction and spread, and are likely to cause harm to human health or the environment (Keefer et al. 2010). Successful invasive species tend to have broad ecological requirements and tolerances, effective reproductive and dispersal mechanisms (Rejmanek and Richardson 1996 in Keefer et al. 2010), competitive ability superior to that of natives in the original or modified system, and the capability of altering the site by significantly changing resource ability and/or disturbance regimes (Baker 1965 in Keefer et al. 2010).

Within the National Wildlife Refuge System, invasive species are, collectively, the single greatest threat to native plants, fish, and wildlife with the potential to degrade entire ecosystems

(USFWS 2004). Invasive species impact nearly half of the species currently listed as threatened or endangered under the U.S. Endangered Species Act (National Invasive Species Council 2008). Invasive plants, specifically, are reported as the number one threat to wildlife habitat within the National Wildlife Refuge System and management of invasive plants is the number one area of increased spending in the Wildlife Refuge System (US Government Accountability Office, 2008). According to Fiscal Year 2011 data, more than 2.4 million acres of the Refuge System are impacted by invasive plants (USFWS 2013).

BACKGROUND

Site Description and History

The Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) was established in 1974 with the purposes of preserving and enhancing highly significant wildlife habitat, protecting migratory waterfowl and other wildlife, including species known to be threatened with extinction, and for providing an opportunity for wildlife-oriented recreation and nature study. The Refuge serves the mission of the National Wildlife Refuge System, which is "working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people". It comprises approximately 40,000 acres of mudflat, managed ponds, tidal ponds, tidal marsh, marsh/upland transition zone and uplands in the South San Francisco Bay (South Bay, Figure 1), and is one of seven wildlife refuges in the San Francisco Bay National Wildlife Refuge Complex.

The Refuge is part of the San Francisco Bay Estuary (Estuary); an extremely productive, diverse ecosystem. More than 250 species of birds, 120 species of fish, 81 species of mammals, 30 species of reptiles, and 14 species of amphibians regularly occur in the San Francisco Estuary (Siegel and Bachand 2002). The Estuary supports populations of species that are of regional, hemispheric, and global importance and was designated as a Ramsar Site in 2013. A number of endemic, endangered, threatened, and rare wildlife species or subspecies reside within the San Francisco Bay Area, and within the Refuge (Table 1).

Since the 1800s, over 90% of the Estuary's original wetlands have been degraded or lost, and it has been more heavily invaded by nonnative species than any other aquatic ecosystem in North America (Cohen and Carlton 1998). The South Bay supports some of the most important habitat remaining in the Estuary, in spite of the highly urbanized surrounding areas and the dramatic alteration of the Bay itself for shipping, salt production, and urban development (Goals Project 1999). South Bay habitats include open waters and sub-tidal habitats to the upper reaches of tidal action, tidal and non-tidal wetlands, former and current salt evaporation ponds adjacent to the Bay, and the upland areas immediately adjacent to these features. Many of these habitats have been dramatically modified by anthropogenic activities including dredging, diking, filling, agriculture, salt production and flood protection.

Figure 1 South San Francisco Bay includes lands south of the San Mateo Bridge. Habitat types are noted within the Refuge Approved Acquisition Boundary.



Threats to the environments and native species of South Bay include habitat loss, urban development, increasing predator populations, and invasive species.

The South Bay Salt Pond Restoration Project (SBSPRP) is a multiagency effort to restore and enhance approximately 13,000 acres of wetland habitats throughout the South Bay. Lands included in the SBSPRP are Eden Landing Ecological Reserve managed by California Department of Fish and Wildlife (CDFW), Ravenswood Pond Complex located in the West Bay, and the Alviso Pond Complex located in the southernmost portion of the South Bay, managed by the Refuge (Figure 2). This WMP covers lands included in the SBSPRP, as well as additional Refuge Lands.

Weed Management Areas

For planning, monitoring and management purposes we have broken the South San Francisco Bay into 5 distinct weed management areas: Newark, Mowry, Alviso,West Bay and Eden Figure 2: Weed management areas present in the South Bay. Newark, Mowry, Alviso, and West Bay include lands owned and/or managed by the Refuge.



Landing (Figure 2). While Eden Landing weed management area, owned and managed by CDFW, is not included specifically in this WMP, the WMP is applicable to this area. These areas correspond to the same management areas in the Refuge Comprehensive Conservation Plan (USFWS 2012).

Newark Weed Management Area: The Newark Weed Management Area (WMA) includes all of the Cargill operated Newark pond complex, and is bordered by the Alameda Flood Control Channel to the north, and Dumbarton Narrows (northern boundary of Audubon Marsh) to the south. It also includes the Munster Unit to the east of the Eden Landing Ecological Reserve and a stretch of shoreline adjacent to San Lorenzo. This area consists primarily of 4,000 acres of

active salt evaporation ponds, owned by USFWS but managed for salt production by Cargill, Inc. The Newark WMA contains a narrow strip of fringing marsh, including the 130-acre Ideal Marsh, which was restored from former salt ponds by a natural levee breach around 1930. The Newark WMA also includes wide mudflats that flank its bayside portion of the ponds and more extensive marsh around Newark Slough. Significant uplands in this area include the Refuge headquarters hill and an extensive levee system around salt evaporation ponds.

Restoration Activities:

Several restoration efforts have established muted tidal systems from the former diked areas. These areas include the 110-acre Mayhew's Landing, 140-acre LaRiviere Marsh, and 10-acre Entry Triangle Marsh; restorations were completed in 1994, 1997, and 2001, respectively.

The Tidal Marsh Transition Zone Restoration Research Project team conducted a five acre restoration project of the marsh-upland transitional habitat associated with LaRiviere Marsh in 2011 and 2012.

Mowry Weed Management Area:

The Mowry WMA runs along the north shoreline of South Bay from Dumbarton Narrows (northern boundary of Audubon Marsh) to the Southern/Union Pacific railroad. This unit also includes the Warm Springs Seasonal Wetland sub-unit.

The Mowry WMA is dominated by approximately 6,000 acres of commercial salt ponds and associated levees constructed circa 1920. The Mowry WMA includes remnant pre-historical (10,000 to 6,000 years ago) fringing marsh and extensive mudflat. Dumbarton Marsh and Audubon Marsh are located adjacent to the mouth of Newark Slough. Marshes also fringe Mowry Slough and the northern shore of Coyote Creek including the relatively large Calaveras Point Marsh. Creeks in the area include Mowry, Albrae, and Mud Sloughs, as well as Plummer Creek and Barge Canal.

The Mowry WMA includes a vernal pool grassland area in South Fremont known as the Warm Springs Seasonal Wetland sub-unit. These 700 acres include both natural and restored vernal pools, with historic and current cow grazing.

<u>Restoration Activities:</u> Restoration activities in this WMA have focused on vernal pool habitat. As mitigation for a large commercial development, 444 acres of disturbed vernal pool habitat were restored between 1998-2003 on lands adjacent to the original Warm Springs Unit. This area, known then as the Pacific Commons Preserve, was managed cooperatively with the Refuge. Catellus Inc., the developer, and WRA Inc., their environmental consulting firm, continued to manage and monitor the site until all permit requirements were met. The Pacific Commons Preserve was donated to the Refuge in 2008 and became part of the Warm Springs Unit of Don Edwards San Francisco Bay NWR. In 2012, the Refuge took over management of this area. Continued weed management and native vegetation restoration is needed throughout Warm Springs. Parts of the former Pacific Commons Preserve lands are particularly weedy and will require ongoing efforts.

In 2012, the Refuge conducted a restoration study on upland habitat to determine the most effective soil treatment method for native seeding. Data from this study are currently being analyzed and results will be applied to other weedy portions of Warm Springs as funding permits.

Alviso Weed Management Area: The Alviso WMA consists of former salt evaporation ponds currently managed for wildlife. It is bordered to the north by the San Francisco Bay and Coyote Creek, and by Charleston Slough in the west. This area includes the Alviso Pond Complex, the biggest tract of managed ponds operated by the Refuge (7600 acres). Creeks in the area include Coyote Creek, Artesian Slough, Alviso Slough, Guadalupe Slough, Stevens Creek, Permanente Creek, Mud Slough and Charleston Slough. The mudflats and fringing marsh along all of the creeks are also included in this area.

Significant uplands in this area include the Environmental Education Center built on an old landfill site and an extensive levee system around salt evaporation ponds.

<u>Restoration Activities:</u> Several former diked wetlands have been restored, including Coyote Creek Lagoon and Warm Springs Mouse Pasture. Warm Springs Mouse Pasture is managed as a diked seasonal wetland to maintain habitat for the salt marsh harvest mouse. Coyote Creek Lagoon was breached in 1986 to Coyote Creek and Mud Slough. Since tidal action was introduced, the site has rapidly filled with sediment. Marsh became established around the perimeter of the lagoon, and is gradually expanding toward the center of the site, which is currently mudflat.

Multiple restoration projects are occurring and have occurred within this Management Area, as part of the SBSPRP (SBSPRP 2012). The Island Ponds (ponds A19/A20/A21) were fully breached in 2006 to restore the ponds to tidal marsh, as part of the Initial Stewardship Plan of the SBSPRP (Life Science Inc. 2003). In 2012 pond A17 was restored to tidal action and A16 was enhanced with installation of water control structures and construction of bird nesting islands. Pond A6 was breached to tidal action in December 2010. Pond A8 was opened to muted tidal action in 2011, although it still functions as a pond. The remaining ponds in this WMA continue to have bay waters circulated through them per the Initial Stewardship Plan of the SBSPRP.

The 390-acre New Chicago Marsh was restored to muted tidal marsh in 1994. In 2013, a new upgraded pump system and improved water control structure were added between pond A16 and New Chicago Marsh to enhance the existing water management and habitat quality through moderation of summer salinity levels and winter flooding depth and duration.

Starting in 2007, the Tidal Marsh Transition Zone Restoration Research Project team began a six acre restoration project of the marsh-upland transitional habitats associated with New Chicago Marsh around the Environmental Education Center (EEC). Weed management has been ongoing at the EEC for over a decade. In 2011, work began on 11 acres of transition zones around pond A6; and in 2012 work began on restoring 12 acres of transitional plant communities at Moffett Field.

West Bay Weed Management Area: This area contains some of the most extensive tidal marsh remaining in the South Bay, including Bair Island, Greco Island and the Faber-Laumeister tracts. This area is located along the west shoreline of South Bay from Redwood City to the Faber Tract in East Palo Alto and includes the marshes mentioned above, as well as managed ponds. The two managed pond systems include the Ravenswood Pond Complex, former salt evaporation ponds with an extensive levee system managed by the USFWS and the Redwood City Saltworks, active salt evaporation ponds under Cargill Salt ownership and management. Creeks in this area include Flood Slough, Westpoint Slough, Redwood Creek, Steinberger Slough, Smith Slough, Corkscrew Slough, Deepwater Slough, and Belmont Slough.

The Refuge's West Bay (aka Ravenswood) ponds are operated as seasonal ponds with rainfall providing most of the water and tidal waters added as needed to meet management objectives for waterfowl and shorebird management.

<u>Restoration Activities:</u> Outer Bair, Middle Bair and Inner Bair Islands of the overall Bair Island complex are currently undergoing restoration. Outer Bair Island was fully breached to tidal action in 2009, and is being passively restored to tidal marsh. Middle Bair was breached in 2012 and Inner Bair will be filled using beneficial reuse of upland dredge spoil and then breached by 2014. Restoration actions at pond SF2 were completed in 2010, as part of phase 1 of the SBSPRP. They included the creation of 30 bird nesting islands, internal levees and inclusion of a water control structure that will enable shallow water management within this pond. Ponds within the Ravenswood Pond Complex are slated for future restoration to managed ponds and tidal marsh in phase 2 of the SBSPRP.

WEED MANAGEMENT PROGRAM

Weed Management Program Goals

The ultimate purpose of this WMP is to provide the basis for a weed management program that will aid in the fulfillment of the missions and purposes of the Service and the Refuge. To meet this purpose, the specific goals of the weed management program are as follow:

- 1. Increase the health and functionality of wildlife habitats in South Bay through the control and/or eradication of high priority invasive weed infestations, and through the active revegetation of weed treated areas with native plants.
- 2. Manage and maintain important habitat for wildlife and plants by preventing the establishment, or controlling infestations, of weeds in high priority projects or case scenarios.
- 3. Prevent future invasions of weeds that do not currently occur in the South Bay, and prevent future infestations of specific weeds into areas that are currently devoid of these species, by implementing an Early Detection Rapid Response system.
- 4. Coordinate with neighbors, partners and internal Refuge staff to share information, brainstorm about control efforts and coordinate weed management within the South Bay.

Inventory and Monitoring

Inventory and monitoring are critical components of the weed management program because it is through these processes that we obtain the information used to direct and adapt the management program to actual on the ground conditions. Inventories provide weed distribution and abundance information, while monitoring allows us to track known infestations through time, detect new species for rapid response, and to evaluate the success of control methods used. Mapping, inventory and subsequent monitoring will show landscape-scale change in overall weed distribution and/or total infested acres over time. The Refuge will use the draft Weed I&M Plan in conjunction with the WMP to gather information and manage invasive weeds within the South Bay (Marriott and Tertes 2013).

Outreach and Coordination

In order to reach our goals, we must work in cooperation with our neighboring land owners and partners in the community. The California Invasive Plant Council (Cal-IPC) is an important partner to the Refuge. Cal-IPC's mission is to protect California's land and waters from ecologically-damaging invasive plants through science, education, and policy. The activities they run are varied: assessing impacts of invasive plants, maintaining comprehensive inventory, supporting restoration workers by providing trainings and reference materials, supporting research (enhancing dialogue between researchers and land managers) by hosting a national symposium, promoting public education and outreach events, advocating for policy initiatives, reducing invasive plant introductions through horticulture, support development of biological

control agents, and coordinating statewide weed mapping. This symbiotic relationship is especially noted with Cal-IPC's support of restoration, support of research, and our weed mapping coordination.

The San Francisco Estuary Invasive Spartina Project (ISP), established by the California State Coastal Conservancy in 2000, is a coordinated regional effort among local, state, and federal organizations dedicated to preserving California's extraordinary coastal biological resources through the elimination of the introduced species of *Spartina*. The ISP is comprised of a number of components including outreach, research, permitting, mapping, monitoring, and the allocation of funds for efforts to eliminate populations of non-indigenous *Spartina*. The USFWS is one of several organizations that provides funding, coordination and permitting for this project.

California Weed Management Areas are local stakeholder groups (from private landowners to non-profit groups to government agencies) working on weed projects, typically organized by the county. Official Weed Management Area partners sign a Memorandum of Understanding (MOU) indicating their commitment to working on invasive plant problems to the extent resources allow. With these MOUs and plans with clearly defined goals and objectives, funding can be granted for local weed eradication projects.

Priority Weed Species and Projects

Due to limited resources available for weed control, we set priorities to control the most invasive infestations with the greatest potential to endanger our trust resources. We used a process developed by The Nature Conservancy (TNC 2001) to assign priority to weed species that are the fastest growing, most disruptive, and affect the most highly valued habitats. We also considered the difficulty of control, giving higher priority to infestations we think we are most likely to control with available technology and resources (TNC 2001). Additionally we prioritized projects to prevent new infestations, new species from establishing, and for the protection of trust resources.

Prioritization of Weed Species for Management

We prioritized invasive species for control and eradication through a series of steps. First we developed a list of the most invasive weeds known within the Refuge. We compared this to priority rankings of invasive weeds from state, regional and local weed informational sources, including Cal-IPC, California Department of Food and Agriculture, Regional Water Quality Control Board, Weed Management Area lists, California Native Plant Society East Bay List, Baylands Ecosystem Goals Project (Goals Project 1999), Draft Recovery Plan for Tidal Marsh Ecosystems (USFWS 2009), and Baye (2008). We selected the most invasive species from these lists and cross referenced them to obtain a list of high ranking weeds common to most or all reference lists. We cross referenced this general list with our initial South Bay list to obtain a final list of highly invasive weeds that occurred both on the general list and on the original South Bay list. We arbitrarily restricted the final list to the top 25 species (Table 2), for feasibility of mapping. Weeds that ranked highly on the general list, but which were not known to occur or occurred only in isolated patches within the Refuge, were put on an Early Detection Weed Species Watch List (Table 3).

Throughout 2010 and 2012, we conducted an initial inventory of the Refuge wherein we mapped the 25 species on the final list. We then analyzed our data to determine which species were most highly problematic and those which we needed to prioritize for management. We ranked these species in order of management priority using three categories adapted from The Nature Conservancy (2001), and one additional category developed for this WMP. Refuge biologists independently scored each weed in all categories and their scores were averaged to obtain ranking order, as displayed in Table 2. These categories were:

- 1. The current extent of the species
- 2. The current or potential invasiveness of the species
- 3. The impact to threatened or endangered (T&E) or migratory bird species and their habitats
- 4. The feasibility of control of the species

Following is a description of how we assigned priority for each category (and the corresponding score for each).

- 1. Current extent of the species:
 - a. Species present as new populations, or as outliers of larger infestations outside Refuge boundaries (3)
 - b. Species present in large infestations that continue to expand (2)
 - c. Species present in large infestations that are not expanding (1)
- 2. Invasiveness of the Species:
 - a. Species that alter ecosystem processes such as fire frequency, sedimentation, nutrient cycling, or other ecosystem processes. These are species that "change the rules of the game", often altering conditions so radically that few native plants and animals can persist (3)
 - b. Species that outcompete natives and dominate in disturbed or undisturbed native communities but which do not qualify as category "a" (2)
 - c. Species that do not outcompete dominant natives but:
 - 1. prevent or depress recruitment or regeneration of native species (for example, New Zealand Spinach (*Tetragonia tetragonioides*) in ecotone may depress recruitment of native Alkali heath (*Frankenia salina*); OR
 - 2. reduce or eliminate resources (e.g., food, cover, nesting sites) used by native animals; OR
 - 3. promote populations of invasive non-native animals by providing them with resources otherwise unavailable in the area (1)

3. Impact to Threatened and Endangered or Migratory Species and their Habitat:

a. Species invades all habitat types necessary for the survival of T&E or migratory bird species (3)

- b. Species invades only a portion of the habitat types necessary for the survival of T&E or migratory bird species (2)
- c. Species does not invade habitat used by T&E or migratory bird species, but affect other native species (1)
- 4. Feasibility of Control of the Species:
 - a. Species likely to be controlled or eliminated with available technology and resources and area will be recolonized by native species (passive restoration) with little further input (3)
 - b. Species difficult to control, but can be managed. Active restoration will be necessary. (2)
 - c. Species difficult to control with available technology and resources and/or whose control will likely result in substantial damage to other, desirable species (1).

We weighted the last category, "Feasibility of Control of the Species" by one half (as compared to the other categories) because we determined that difficulty of controlling all infestations of a specific species on the Refuge should not necessarily deter the control of smaller priority populations of the same species. Therefore difficulty of control was not a relatively strong management consideration under all circumstances.

We made some changes to the prioritized list based on working knowledge of the species within the Refuge. For instance, we considered *Dittrichia graveolens* as one of the highest priority species, even though it ranked eighth according to our system, because of this species' unprecedented rate of expansion throughout the area, its superior ability to spread via travel corridors, and because of the Refuge's participation in the coalition of County Weed Management Areas and Bay Area partners currently working to control the spread of this invasive weed. We rated *Atriplex semibaccata* lowest priority, though it ranked higher, due to its fairly ubiquitous growth on levees, and its seemingly benign nature in the habitat it colonizes (Table 4).

Additional High Priority Projects

Some circumstances and projects will require the need for immediate weed control, even if the weed in question does not fall under the high priority classification.

Those situations include:

 Early Detection and Rapid Response (EDRR): when a weed on the Bay Area Early Detection Network's list, Cal-IPC's watch list or our Early Detection Weed Species Watch List (Table 3), is first detected we will attempt to eradicate the weed. Implementing weed management strategies early while infestations are manageable reduces the economic, cultural, and environmental impact these populations can have on the ecosystem and economy.

- 2. Dirt movement: when dirt is moved by heavy equipment within a project where only an isolated site will be affected (including islands), we will attempt to control the growth of initial weeds germinating from the new or relocated sediment (fill), and in certain cases, seed the area with native plants.
- 3. Wildlife Habitat Management: some weeds that are not listed as high priority in this WMP may become a priority in situations where they inhibit nesting or roosting of trust species. For example *Mesembryanthymum nodiflorum* is not a top priority weed, but at pond SF2 it inhibits nesting for western snowy plovers when it covers the pond bottom. In this situation, managing *M. nodiflorum* may be considered a priority for weed management at that site.
- 4. Habitat Maintenance: certain areas will require weed management for access, fire control and aesthetics. As of 2013, the Refuge maintenance department coordinates these activities with the Refuge manager and biologists and conducts these activities on the Refuge. Weed control that has been ongoing for multiple years include: Headquarters Hill, Tidelands Trail, Marshalnds Road, Grand Ave, EEC restoration site, selected Alviso levees, Mayhew's Landing (firebreak), Munster tract (firebreak), and the Warm Springs Trail.
- **5.** Restoration: To prevent weeds from invading newly restored areas, weed control and prevention must be implemented before, during and after restoration. One example includes protecting inboard levees from outboard weeds (especially *Lepidium* and *Salsola*) after breaching. Another example includes prevention of "new" weeds in areas where marsh is developing (for example, at the Island Ponds and Bair Island).

Methods of Treatment

This WMP utilizes an integrated long term treatment approach, combining mechanical, cultural, thermal and chemical treatment methods to control and eradicate weed infestations within the Project Area. We recognize that preventative control is the most essential component of weed management, and will make significant effort to employ this method. However, to control already established weeds, we will consider all weed control methods currently available, and chose the best techniques based upon effectiveness, cost, and minimal ecological disruption (especially with respect to native species and communities and particularly to our trust resources). Although this WMP provides an outline for specific management methods to be used with specific species, appropriate control methods will still be considered and determined on a case by case basis. All significant actions will be approved by a Refuge Biologist or Weed Management Specialist before management action is taken. We will take action only when careful consideration indicates that leaving the weed unchecked will result in more damage than controlling it with available methods. Controlling weeds on disturbed sites can be futile without vegetative restoration, as often weed control itself causes disturbance, and weeds will readily reinvade treated areas. Therefore, we include re-vegetation as a critical component of weed management.

Special Herbicide Safety & Environmental Considerations

There are a few invasive weeds that will necessitate access to and herbicide application in, sensitive habitat, such as tidal marsh and vernal pool habitat. Conservation measures and Best Management Practices to reduce disturbance to, and adverse effects of herbicides and additional control techniques on estuarine and vernal pool wildlife, plants and associated habitat elements (e.g., native vegetation, water, and invertebrates) are outlined in Appendix 1 and Appendix 2. Training material will include the "Walking in the Marsh" protocol which addresses potential disturbance effects to marsh species, including California clapper rails and salt marsh harvest mice (Appendix 3).

TARGETED WEED CONTROL AND RE-VEGETATION PLANS

The following section includes priority weed species present within the Refuge, including a brief description of each weed, the current distribution of the weed within the WMA, previous treatments, treatment objectives for control, general methods known to control the weed, and treatment recommendations. Additionally, specific populations or infestations are prioritized due to their perceived threat in certain habitats or situations. Only the highest and high priority species identified are addressed in this section (Table 4).

Note: The invasive plant species of greatest concern in the Estuary, and in the South Bay is *Spartina alterniflora x Spartina foliosa* hybrid. However a targeted weed control plan for the *Spartina alterniflora x Spartina foliosa* hybrid is currently well established to eradicate non-native *Spartina* in the estuary (San Francisco Estuary Invasive Spartina Project 2003). The San Francisco Estuary Invasive Spartina Project (ISP) is a coordinated regional effort among local, state and federal organizations dedicated to preserving California's coastal biological resources through the elimination of introduced species of *Spartina*. Refuge staff work closely with the ISP to control Spartina within the Project Area. At such time the ISP or a similar effort ceases to lead the invasive Spartina control effort, invasive Spartina monitoring and management will be added to this WMP and would become the Refuge responsibility within the Project Area.

The following treatment recommendations are based on the initial weed inventory conducted between 2010 and 2012, which covered approximately half of the Refuge.

Pepperweed (Lepidium latifolium) – Highest Priority

Ecology

Lepidium latifolium is a highly invasive perennial in the family Brassicaceae. A native to Asia and southeastern Europe, *L. latifolium* was introduced to the U.S. in the 1930's and has spread rapidly throughout the western United States, particularly in California and Nevada (DiTomaso and Healy 2007). *Lepidium latifolium* is a true invasive, in that it invades intact native ecosystems, and can form complete monocultures, displacing native vegetation and wildlife (DiTomaso and Healy 2007), and disrupting ecosystem function. The Cal-IPC classifies the statewide impact of *L. latifolium* as high¹ (2011) and California Department of Food and Agriculture lists it as a B Rated² noxious weed (CDFA 2013).

Lepidium latifolium infests freshwater, brackish, saline, and alkaline environments, across a wide range of habitats including riparian areas, wetlands, marshes, meadows, floodplains and various upland habitats (Young et al. 1995, Bossard et al. 2000, Renz & Blank 2004, Howald 2000, in Hogle et al. 2007). *Lepidium latifolium* is most aggressive in wetland areas (Eiswerth et al. 2005, Renz & Blank 2004), where it may form concentrated monocultures. These monocultures and the dense thatch they produce can inhibit emergence of annual plants by blocking the penetration of light to the soil surface (Renz 2000 in Hogle et al. 2007). These monocultures may provide abundant habitat for some species in the spring and summer, but *L. latifolium* defoliates, leaving skeleton structures with little or no habitat value in the winter. High tide refugia, which are a limiting resource for California clapper rails and salt marsh harvest mice during winter high tides, may be rendered useless if invaded by *L. latifolium* (Hogle et al. 2007).

Lepidium latifolium spreads via small and copious seeds, or by vegetative propagation (Trumbo 1994). Seeds and roots may be dispersed long distances by water. This invasive spreads rapidly along roadways and levees due both to high disturbance rates at these sites as well as the source of human and wildlife vectors present (Hogle et. al. 2007). *Lepidium latifolium* also spreads vegetatively and forms a large and vigorous creeping root system that fragments easily, with fragments as small as 2.5 cm giving rise to new individuals (Wotring et al. 1997 in Hogle et al. 2007). *Lepidium latifolium* tends to spread out from existing populations (as opposed to spreading via long distance dispersal mechanisms).

Salinity is a significant determinant of abundance (Spenst 2006), however, plants are more closely tied to foliar nitrogen and flooding surrogates (mean soil particle size, and elevation) (Spenst 2006). *Lepidium latifolium* invasion success in estuarine environments is generally

¹ **High Rated** - These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.

² **B Rated** -a pest of known economic or environmental detriment and, if present in California, it is of limited distribution

associated with lower aqueous salinity levels, higher elevations, sandier soils, and less frequent inundation (May 1995, Grossinger et al. 1998 in Hogle et al. 2007).

Lepidium latifolium will necessitate access to and herbicide application in mid to low marsh habitat. It will also necessitate access to sensitive high marsh and marsh/upland transition zone. In addition, *L. Latifolium* also occurs in sensitive vernal pool habitat in the Warm Springs unit of the Refuge. Conservation measures to reduce disturbance to, and adverse effects of herbicides on, estuarine and vernal pool wildlife, plants and associated habitat elements (e.g., native vegetation, water, and invertebrates) are presented in Appendix 2.

Distribution/Extent of the Problem

The abundance of *L. latifolium* in the San Francisco Bay area has increased exponentially since its initial invasion (Grossinger et al. 1998, May 1995, Trumbo 1994, in Hogle et al. 2007). *Lepidium latifolium* is now well established in Bay area marshes (May 1995), and population increases in tidal wetlands in the estuary have made control and eradication efforts a priority for resource managers (Spenst 2006). Populations are found growing throughout the salinity gradient in the estuary, from freshwater to saline tidal marshes.

Lepidium latifolium infests slough channels, upper marsh, marsh-upland transition zone and uplands throughout the entire Refuge. As of 2011, *L. latifolium* is especially abundant in the Alviso WMA, where it is ubiquitous along the tidal side of levees, particularly east of Guadalupe Slough. Some of most dense concentrations of the invasive are in the Artesian Slough channel adjacent to pond A17. Other sprawling infestations include the channel west of ponds A22 and A23, parts of Warm Springs, and in Mud Slough on the border of the Mowry WMA. Large populations exist in the Audubon, Dumbarton and Mowry marshes of the Newark WMA, as well as along Newark Slough and in Mayhew's Landing. In the West Bay WMA, *L. latifolium* predominantly occurs along the levees of the Faber-Laumeister tract, the bayside levee of pond SF2 and along Ravenswood Slough. Small spot populations less than 2 m² exist throughout the entire Refuge.

Previous Treatments within Project Area

In the past, Refuge personnel have treated *L. latifolium* by hand pulling or spraying aquatic approved herbicides such as Habitat® and AquaMaster® on small spot populations in upper marsh and transition zone habitat, and spraying Garlon® 4 and Milestone® VM Plus herbicide on small spot populations in uplands. Of these four herbicides, Milestone® VM Plus proved to be ineffective. In 2013, pepperweed was treated with Telar® XP (Chlorsulfuron) herbicide at Warm Springs and initial results look promising.

Treatment Objectives

The following treatment objectives are listed in order of priority and feasibility, and should be met in listed order, as additional resources become available.

- 1. Eradicate outlier "spot" populations that are less than 2 m in diameter and which are not within 100m of a large infestation.
- 2. Control *L. latifolium* on restored acreage of Warm Springs, where infestations have the potential to spread to adjacent un-infested vernal pool grasslands.

- 3. Control L. latifolium on the inner levees, transition zones and marshes of restoration sites.
- 4. Contain *L. latifolium* at the boundaries (or "leading edge") of medium-sized (~25m radius) infestations that are easily accessed, and all infestations that are on roadsides.
- 5. Contain *L. latifolium* at the boundaries of large (over 25m), isolated populations (those other than the Alviso WMA infestation).
- 6. Contain *L. latifolium* at the boundaries of the Alviso WMA infestation.
- 7. Work with neighbors to control their infestations on adjacent lands.

Treatment Options and Control Methods

Physical methods will not be used to control *L. latifolium* due to the ineffectiveness of this type of treatment on the weed, and the disturbance to habitat that any physical method of control produces (Hogle et al. 2007). *Lepidium latifolium* quickly regenerates from pieces of rootstock left in the soil. Roots are easily fragmented, tolerate desiccation (Renz 2000), and can regenerate from fragments as short as 2.5 cm (Wotring et al. 1997), perhaps even smaller (J. DiTomaso, pers. comm.). Manual and mechanical methods are unsuccessful at getting all deep underground root growth, which may reach depths of 3 meters or more (Blank & Young 2002). Multiple studies have shown that burning, mowing, disking, or tilling alone are ineffective at controlling *L. latifolium* (Hogle et al. 2007). All of these methods led to increased or unchanged densities after one year (Renz 2002, Howald 2000, Young et al. 1998), and would be too disruptive to sensitive marsh habitat where most of our infestations occur. Pepperweed dies back when sprayed with high salinity water (ex. 40-50ppt), although the high number of applications required to be effective (20 applications), make this method prohibitive.

Chemical treatment is the most effective control method for *L. latifolium* and involves the least disturbance to sensitive marsh habitat. In tidally influenced areas, seeds may not play a large role in recruitment. Because the main mode of reproduction in the South Bay is most likely by root expansion, an herbicide which reaches and kills the roots is the most effectual way to kill the plant (Wilson et al. 2004). We therefore will use a systemic herbicide that is registered for aquatic use. Currently this includes Roundup Custom® (glyphosate) and imazapyr-based aquatic herbicide such as Polaris® and Habitat®. The most effective herbicides for *Lepidium* control may be chlorsulfuron, metsulfuron methyl, and imazapyr (Cox 1997 in Bossard et al. 2000), however glyphosate has also been demonstrated effective (Bossard et al. 2000). A solution of imazapyr (as Habitat®), and a solution with a mixture of imazapyr and glyphosate (as AquaMaster®) have both been used to effectively reduce infestations of *Lepidium* in the San Pablo Bay (G. Block, pers. comm.). Bell (2011), found imazapyr to be the most effective control treatment of *L. latifolium*. However, in both of the above cases, one years' herbicide treatment was not enough to kill *Lepidium*, and follow-up treatments were required to insure long term control.

In marsh habitat, we will use a 1 to 2% solution of imazapyr-based aquatic herbicide. Where practicable, application will be timed to coincide with ebbing tides to protect non-target vegetation, and to provide at least 1 hour dry time for applications. For treatments in the transition zone areas, (above mean higher-high tide but within 25m of mean higher-high tide), we will use a 1 to 2% solution of glyphosate-based aquatic herbicide. In upland habitat at least

8m from the high tide line, or other bodies of water, we will use herbicides such as chlorsulfuron, or glyphosate based products.

Herbicide applications will take place when *L. latifolium* is actively growing and has reached the late bud-to-flower stage of growth, typically occurring April to June. This promotes translocation and also allows for easy detection and identification of target plants (Hogle et al. 2007). An alternative method of controlling pepperweed uses the application of high salinity water (40-50ppt) (David Thomson pers. comm.). However to be effective, it requires 20 applications which is very time consuming and unfeasible.

Treatments for Specific Objectives

<u>Objective 1.</u> Eradicate outlier "spot" populations that are less than 2m in diameter and which are not within 100m of a large infestation. (Outer Bair Island, pond R1, North Shoreline Trail, Faber-Laumeister marsh, and LaRiviere marsh).

We will treat spot populations using a backpack sprayer, and will access the treatment location by walking to the site via the shortest route possible (using trail and levees when possible). The applicator will use a flat fan nozzle tip on a standard backpack wand, and will spray stems, foliage and flowers with an upward motion starting at the level of the highest touching neighboring plant, and moving upward to the *L. latifolium* crown. Applicators will spray each stem to wet, but not to drip. There will be little to no disturbance with this treatment type, as applicators will have been trained to "Walk in the Marsh" and will take the shortest path feasible to the site. Only one to two applicators will be accessing any given spot populations. The application method ensures that marsh species will likely not be affected by the herbicide, as minimal vegetation other than the target plants will be sprayed.

Active re-vegetation of spot treated sites will likely not be needed. If the spots treated are in the lower to upper marsh, native species (predominantly pickleweed (*Sarcocornia pacifica*) are likely present in the understory of the *L. latifolium*, and will expand into the treated area once the *L. latifolium* is eradicated. If the spot treatments are in the transition zone or upland, it is likely that native species, or other (less invasive) weeds, that are present in the area will grow in behind the treated target plants. Spot treatments will not disturb enough area enough to merit active revegetation.

<u>Objective 2</u>. Control L. latifolium on restored acreage of Warm Springs, where infestations have the potential to spread to adjacent un-infested vernal pool grasslands.

Objective 2 concerns the control of *L. latifolium* from the newly acquired mitigation lands (added in 2012) that are now part of the Warm Springs sub-unit. The original Warm Springs sub-unit is almost free of *L. latifolium*. However, the adjacent lands, due to their history of ground disturbance, have some large upland populations of *Lepidium*. Continued control of *Lepidium* at Warm Springs will prevent its spread into un-infested acreage and will ultimately increase native plant abundance. *Lepidium* has been treated here in the past with Milestone® VM Plus which proved ineffective at killing the roots. Telar® XP is currently the best known herbicide for control of *Lepidium* in upland areas (I. Loredo pers. comm.).

The applicator, either Refuge staff or the cooperative rancher, will treat *Lepidium* using a truck or ATV mounted sprayer when *Lepidium* plants are in the late budding to blooming stage. This is typically late April to June. At this point most vernal pools are dry and most vernal pool vegetation has gone to seed. Applicators will not spray in pools that are still holding water or which still have native vernal pool vegetation in bloom. These areas will have a 8m no-spray buffer. Wick applicators may be used to treat these areas.

Re-vegetation of treated sites may be needed. Alkali heath, as well as some native and nonnative grass species, have been seen to reestablish after treatment of weeds at Warm Springs. However, as resources allow, preparing the ground and seeding with an upland seed mix would be desirable to increase the abundance of vernal pool natives.

<u>Objective 3.</u> Control L. latifolium on the internal levees (and transition zones and marshes as they develop) of restoration sites. (Bair Island and ponds SF2, A19-A21, A5-A8, A16-A17, E8A/E9/E8X and E12-E13)

Tidal marsh restoration sites provide opportunities for spread of *L. latifolium*, especially along site perimeters where tidal deposition takes place and soils contain higher proportions of sand. For example, all tidal restoration sites of San Pablo Bay have been colonized by *L. latifolium* (Hogle et al. 2007).

The interiors of newly breached restoration ponds are "clean habitat" as they have been inundated with water and therefore weed free. By eradicating or preventing the establishment *L. latifolium* on the internal levees, and associated marsh/upland transition zones of these ponds we can assist in the prevention of spread into the marshes as they develop. As phase two of the South Bay Salt Pond Restoration Project commences, this may pertain to more restoration sites.

We will access sites directly, driving roads and levees on an ATV or in a truck, or by accessing levees by boat. The applicator will park their vehicle and then walk to the site, using a backpack sprayer, an ATV mounted spray tank with hose and wand, or a truck (or boat) mounted spray rig with hose and spray gun to treat populations on the levee or transition zone. Spraying method will be similar to Objective 1 above. There will be no disturbance to sensitive habitat or sensitive wildlife with this treatment type, as applicators and all equipment involved will remain on the levee.

If infestations are less than 2m in diameter, no re-vegetation is needed. If the infestations treated are larger than 2m in diameter, re-vegetation should occur, and the applicator should coordinate with the Refuge biologist to plan for restoration efforts at that restoration site.

<u>Objective 4</u>. Contain L. latifolium at the boundaries (or "leading edge") of medium-sized infestations that are easily accessed, and all infestations that are on roadsides. (Newark Slough marsh and levees between pond N1 and Marshlands Road (in the vicinity of Crescent Pond), the Warm Springs trail, and pond SF2)

The patches described in Objective 4 are relatively small infestations within the Refuge, and easily accessible. We will treat these infestations at their boundaries, so that they do not spread in area. The applicator will access and spray with the same technique as mentioned in Objective 1 treatment.

Re-vegetation of this type of treatment is not necessary, as the understory (though possibly stunted by the *L. latifolium* infestation) will remain, and natives surrounding the infestation should help to fill in the treated area.

<u>Objectives 5.</u> Contain L. latifolium at the boundaries of large isolated populations (those other than the Alviso WMA infestation .

As of year 2011 large isolated infestations occur at Mayhew's Landing, Ravenswood Slough, Audubon, Dumbarton and Mowry marshes.

The applicator will access and spray with the same technique as mentioned in Objective 1 treatment.

Objective 6. Contain L. latifolium at the boundaries of the Alviso WMA infestation.

Control area within and adjacent to upland restoration area at the EEC using 1.5-2% AquaMaster®. The applicator will access and spray with the same technique as mentioned in Objective 1 treatment.

<u>Objective7.</u> Work with neighbors to control their infestations.

The ultimate control of *L. latifolium*, which will require substantial additional funding and coordinated efforts with adjacent property owners, will be to control all infestations within the project area

Satisfying objectives 5-7 will involve multiple personnel entering the marsh with potentially heavy equipment such as ARGO amphibious off-road vehicles, bearing spray tanks with hose and wands. Crews may also use boats to access parts of infestations that are close to sloughs and bay edges. In this case, crew members may dismount from the boat, and walk into the marsh with a hose and spray wand.

All infestations that are treated should be mapped after treatment, monitored two months after treatment, and monitored again the following April/May. It is probable that eradication will require multiple years of treatment. Once treatment has been started, it is **highly** recommended that the same infestations be treated each year until the infestation is eradicated. Infestations that are controlled just at their leading edge will require annual maintenance treatment in perpetuity. The control of *L. latifolium* in general, will require a continuous annual effort. Potential sources of seeds and root fragments will continue to enter the marshes, marsh/upland transition zones and uplands of the Refuge via off-site sources dispersing along creeks and sloughs, tidal waters, travel, and from adjacent properties. Until the neighboring populations are eradicated, the Refuge will continue to be re-infested.

Where large infestations have been treated, re-vegetation will be necessary. The intertidal areas will most likely re-vegetate themselves, but the upper marsh, transition zone and uplands should be seeded or planted after *L. latifolium* infestations have been treated at least 3 years in a row.

Algerian sea lavender (Limonium ramosissimum) – Highest Priority

Ecology

Limonium ramosissimum, Algerian sea lavender, is a perennial in the family Plumbaginaceae. A salt-tolerant forb of Mediterranean origin, the plant displays invasive characteristics including broad salinity tolerance, prolific seed production and the ability to compete with native plants (Page et al. 2007). *L. ramosissimum* grows in basal rosettes, which appear like "pom-poms", with leaf blades that are obovate in shape with a tapered base. The plant flowers in June with lavender to pink petals and appears very similar to the native species *L. californicum*.

Limonium ramosissimum grows in coastal salt marshes, especially in highly disturbed marsh edges. In San Francisco Bay, *L. ramosissimum* has been found in the high marsh and upland transition zone where it forms near-monocultures and competes directly with native salt marsh species (Archbald and Boyer 2010). At the upper-end of this elevational range, *L. ramosissimum* grows taller, more robustly and produces more seed, competing directly with perennial pickleweed, and altering high tide wildlife refugia (G. Archbald, unpublished). *Limonium ramossisimum* spreads by seeds, and mature plants annually produce tens of thousands of seeds per square meter. Seeds float viably for weeks in bay water, later able to germinate in fresh or saline conditions (Archbald 2009). Algerian sea lavender has been identified as an EDRR species. It has a Limited³ Cal-IPC rating and was added to the Cal-IPC watchlist in 2011 (Cal-IPC 2013).

Distribution/Extent of the Problem

Two forms of Algerian sea lavender, *L. ramosissimum* and *L. ramosissimum ssp provincial*, have been discovered in San Francisco Bay salt marshes since 2007 (Archbald 2011). Seven patches of *L. ramosissimum* have been detected within the Refuge, and three additional patches have been detected immediately adjacent to Refuge boundaries in the South Bay. South Bay populations include those at Ideal Marsh, LaRiviere and outboard of pond N9 in the Newark WMA, Greco Island, ponds SF2 and R1 in the West Bay WMA, and Coyote Creek Lagoon in the Mowry WMA and A6 in Alviso WMA. Populations just outside Refuge boundaries are located at Plummer Creek by the Mowry WMA and Whale's Tale Marsh North and Mount Eden Creek Muted Marsh in the Eden Landing WMA.

Previous Treatments within Project Area

This weed was initially treated in 2010 by handpulling at Greco Island (1 plant) and pond R1 (less than 5m diameter patch). In 2012 and 2013, plants were hand-pulled at Ideal Marsh, Coyote Creek Lagoon and ponds R1 (increased to 3 patches over 5m) and N9. Additional patches were hand-pulled at LaRiviere Marsh, Faber-Laumeister, pond A6, pond SF2, Mount

³ Limited Rating- These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

Eden Creek Muted Marsh and the upland restoration area at the EEC. These additional infestations were incidentally created by a native seed supplier's mistaken collection at Plummer Creek Mitigation Area and provided in a restoration seed mix that called for California sea lavender, *Limonium californicum*.

Treatment Objectives

The following treatment objectives are listed in order of priority and feasibility. Objectives 1 through 4 should be met in listed order, as additional resources become available.

- 1. Eradicate populations where treatment has already been initiated.
- 2. Work with CDFW to eradicate populations on Eden Landing Ecological Reserve.
- 3. Work with adjacent property owners to eradicate populations just outside Refuge boundaries.

Treatment Options and Control Methods

Plants are very easily hand pulled, and should be pulled and bagged, prior to seeding in June-July. Scraping has proved to be useful in areas of dense rosettes. Herbicide spraying treatment with imazapyr-based herbicide may be an alternative in areas with large populations occurring in high marsh, if this method proves to be less invasive and faster than hand pulling.

Treatments for Specific Objectives

The Refuge is currently working with Cal-IPC as part of a Bay-wide effort to eradicate *L. ramossisimum* from the Bay Area. Due to the multiple partner effort to eradicate this weed, the relatively recent detection of this invasive species (before it has had a chance to spread), and the fact that our populations are so small, few and isolated, this weed is a high priority for management. The eradication of this invasive, and potentially destructive, weed epitomizes the ideal of EDRR.

<u>Objective 1</u> Eradicate populations where treatment has already been initiated (Greco Island, Ideal marsh, ponds SF2, A6, R1 and N9, LaRiviere Marsh, and Coyote Creek Lagoon).

These populations occur in high marsh habitat and along levees, and personnel will have to walk through the marsh to access them. Prior to any treatment, a qualified biologist will confirm that walking through the marsh to the infestation will not compromise the 213m buffer restriction on nesting California clapper rail.

Personnel will walk the shortest route possible through upper marsh to access these populations, and will use roads or trails if possible. Personnel will hand pull any remaining plants before they begin to seed in June and July, and will bag the plants and haul out of the marsh to dispose of. There will not be significant disturbance with this treatment, as treatment areas are small. Personnel will minimize disturbance by following the "Walk through the Marsh protocol" and will only pull *L. ramossisimum* plants, trying to minimize disturbance to the soil, while still capturing the root mass of all plants.

Re-vegetation of treated areas may mitigate any disturbance caused. Re-vegetation may need to occur if populations are greater than $2m^2$, and if surrounding vegetation is not likely to re-colonize the disturbed area. The necessity of re-vegetation will be assessed on a case by case

basis. Re-vegetation, through seeding or planting with high marsh and marsh/upland transition zone natives, may start the first fall after treatment, but will likely need to be repeated in subsequent years until the *L. ramosissimum* seed bank is depleted.

<u>Objective 2</u> Work with CDFW to eradicate populations within Eden Landing WMA (Whale's Tail Marsh and Mount Eden Creek Muted Marsh)

As of 2013 two populations are known to occur within Reserve boundaries. The Whale's Tail Marsh population occurs within high marsh, and has been present for at least 3 years. The population found along the ecotone of Mount Eden Creek Muted Marsh was introduced during a recent restoration project. All treatment and re-vegetation methods and considerations are the same as in Objective 1 for this species.

<u>Objective 3</u> Work with adjacent property owners to eradicate populations just outside Refuge boundaries (Plummer Creek mitigation area).

As of 2013, there is one population at Plummer Creek mitigation area. We recommend working with Wildlands, Inc. to eradicate the population at Plummer Creek. All treatment and revegetation methods and considerations are the same as in Objective 1 for this species.

Yellow Starthistle (Centaurea solstitialis) – Highest Priority

Ecology

Yellow starthistle (*Centaurea solstitialis*) is one of the most widespread invasive broadleaf weeds on rangeland and natural areas in the US, and is California's most widespread weed. It is a member of the Asteraceae, has yellow flowers and produces plumed seeds. It is a taprooted, winter annual/biennial that forms monocultures, and displaces native vegetation. A single plant can produce more than 100,000 seeds. In California, seeds can stay viable for two to four years. Seedlings emerge after the first rains, in November and December, bolt between April and June and begin to produce flower heads in June and continue through September (DiTomaso et al. 2006). The Cal-IPC classifies the statewide impact of yellow starthistle as high and the California Department of Food and Agriculture lists it as a C Rated⁴ noxious weed (CDFA 2013).

Distribution/Extent of the Problem

Yellow starthistle occurs in disturbed uplands, primarily along roadsides and levees within the project area. In the Newark WMA, large infestations occur along Marshlands Road; spot populations are also found in Mayhew's Landing. In the Mowry WMA, spot populations have been found at Warm Springs and along the Warm Springs Trail. In the West Bay WMA, patches are located along the western and eastern corners of pond SF2 (parallel to bicycle trail), the main Faber-Laumeister levee (northwest bound), and spot populations are present on Inner Bair Island. In the Alviso WMA, populations are found along the Moffet Bay Trail at the south end of pond AB2. Spot populations occur along Grand Boulevard at the EEC, and the southwestern corner of AB1.

Previous Treatments within Project Area

Treatments of yellow starthistle on the Refuge have primarily consisted of mowing the population along Marshlands Road. However, mowing has only occurred once or twice in a season and therefore has allowed for late season seed set. In 2010, herbicide treatment was combined with mowing to great effect at the Marshlands Road location. Habitat® (which is not recommended for use above high tide line/waterline in this plan) was used, due to proximity of the population to water. Starthistle has also been treated effectively at Warm Springs using Milestone® VM Plus and Garlon® 4.

Treatment Objectives

The following treatment objectives are listed in order of priority and feasibility, and should be met in listed order, as additional resources become available.

- 1. Control populations near large expanses of upland habitat that could potentially be infested and where treatment has already been initiated.
- 2. Control spot populations.
- 3. Control yellow starthistle in restoration sites.

⁴ **C-Rated** - A pest of known economic or environmental detriment and, if present in California, it is usually widespread.

- 4. Control populations on roadsides, heavily trafficked areas, trails, construction areas, and parking lots.
- 5. Prevent the spread of yellow starthistle_out from major travel corridors within the Refuge.

Control Methods

Yellow starthistle is most effectively controlled by herbicide, mowing or a combination of mowing and herbicide treatment. Hand pulling this annual is an effective method to rid that year's population, but yellow star thistle is so spiny that hand-pulling is not the preferred method of control. Grazing by goats, sheep or cattle is also a very effective control method. "Intensive grazing in late May and June using large numbers of animals for short duration can reduce plant height, canopy size, and seed production" (DiTomaso et al. 2007).

Herbicide treatment of yellow starthistle is most effective at the rosette stage, though it can be treated successfully at bolt growth stage. However, there is a greater risk of viable seed production at later application timings. Transline® and Milestone® are both effective herbicides on yellow starthistle. Results of field trials conducted by the University of California-Davis indicate that the ideal time to apply Milestone® to control yellow starthistle in the Central Valley of California is within a three-month period from December through February (DiTomaso et al. 2005), although in the Bay Area this date may be later (I. Loredo pers. comm.). Milestone® at 3 to 5 fl oz/A (fluid ounces per acre) and Transline® at 8 to 10 fl oz/A can be applied from early rosette to bolt growth stage when soil moisture is present and plants are actively growing. The higher application rate should be applied at the bolt growth stages such as bolt to early bud, compared to Milestone®.

Roundup® and AquaMaster® (glyphosate) are non-selective, post-emergent herbicides that effectively control starthistle. Glyphosate is most effective at controlling yellow starthistle in the bolting, spiny, and early flowering stages. It is best to wait to spray after the completed life cycles of native annuals and before the yellow starthistle produces seed. Glyphosate is non-selective and therefore applicators must be diligent around desirable plants; a 1-2% solution to spot treat small patches is effective.

Another herbicide option is Habitat[®] (imazapyr). Imazapyr is a non-selective, pre and post emergent herbicide. Habitat[®] works best as a pre-emergent for YST, but can also be used as a post-emergent in the seedling or rosette stage, though not as effectively.

Once yellow starthistle begins to produce flower heads it may still be treated by mowing. Mowing is best when conducted at a stage where 2 to 5 percent of the seed heads are flowering, although a second or perhaps third mowing may be necessary. Herbicide may be used in combination with mowing, if applied as soon as plants start to bolt after being mowed. Flower heads may also be manually cut and bagged, however this is a very labor intensive effort.

Successful control strategies require dramatic reduction or, preferably, elimination of new seed production, multiple years of management, and follow-up treatment or restoration to prevent rapid reestablishment.

Treatments for Specific Objectives

<u>Objective 1</u> Control populations near large expanses of upland habitat that could potentially be infested and where treatment has already been initiated (Marshlands Road)

There is one population of YST that occurs as a linear strip along Marshland Road for Objective 1. This population is less than 1 km away from Headquarters Hill and Maintenance Parking Lot, which are potential recruitment sites for founder colonies and are connected to the patch through dispersal corridors (road and trail). This population may have been dispersed from roadside patches by vehicles via Highway 84; new introductions are possible. Immediately after detection in summer of 2010, this colony was treated with herbicide in its late stage (flowering).

Due to difficulty of detecting seedlings and rosettes, follow-up treatment should be conducted from bolting through budding stages when the plants are visible. If spray-trained personnel with adequate plant taxonomical skills are available, herbicide treatment during the rosette stage should be implemented on small patches on areas with less than 50% cover to minimize disturbance of native vegetation. Early stage treatment may be applied using chemical and manual methods. For small patches with rosettes, a backpack sprayer will suffice. Hand tools may be used to pull rosettes and seedlings; plant debris may be left onsite if they do not contain flower buds. For this location on Marshlands Road, mowing is not recommended because a large portion of the plants are on the soft wetland transition zone. If late stage treatment is necessary, a vehicle-mounted spray rig (50 gal tank) may be used to apply herbicide, using the roadside as the staging area.

Objective 2 Control spot populations (Grand Blvd, AB1, Mayhews Landing and Inner Bair)

Due to its high fecundity, long dispersal distances, and long-term seed viability (2-4 years), founder populations have rapid expansion rates. Existing spot populations along Grand Boulevard at the EEC, the southwestern corner of AB1, Mayhew's Landing, Warm Springs, and Inner Bair are easily accessed through roads and trails. Herbicide treatment via backpack spraying is best applied during early stages, while a weed whacker or herbicide can be effective during late stages. These spot populations are small in size and may also be treated using hand tools. If time and resources are available, a combined approach using chemical treatment in the rosette stage, and mechanical control in the bolting/flowering stage, may be applied to these spot populations to prevent spread. Additionally, treatment to spot populations may be applied with minimal impact to surrounding habitat.

<u>Objective 3</u> Control in restoration sites (Faber-Laumeister, pond SF2 and uplands at EEC)

Existing populations in these sites should be controlled immediately and regularly. In these two restoration sites, the levee habitats are critical components of marshland transition zones; these zones also provide nesting and foraging sites and corridors for several wildlife species. Population increases of yellow starthistle in these localities will result in additional trail maintenance and potential decrease in usage by wildlife. In addition, yellow starthistle patches present in public trails may reduce their aesthetic value and could decrease recreational usage.

Controlling these populations will prevent existing patches to increase in size, and it will also prevent establishment of new seed banks.

Because the restoration project in the middle levee of Faber-Laumeister involves several organizations, such as Save The Bay, coordination with project managers and field personnel is required before implementing treatment. The most effective treatment period is backpack spraying during winter or spring when the plants are in the rosette stage; in this period, work schedules should be based on dryer periods when the trails are navigable. If treatment should be done after the bolting stage (spring to summer), a vehicle-mounted spray rig (50 gal tank) may be used to apply herbicide. A weed whacker may also be used. Upland restoration of Faber Laumeister by Save The Bay began in 2010.

The newly constructed islands in pond SF2 will have high soil salinity that will prevent establishment of most plants for a number of years. As the soils leach out with rain water, monitoring on these islands should be conducted, as yellow starthistle may deter birds from using the site.

Yellow starthistle has a patchy presence in the upland restoration areas of the EEC. These patches should be controlled prior to setting seed, by hand pulling or herbicide application.

<u>Objective 4</u> Control populations on roadsides, heavily trafficked areas, trails, construction areas, and parking lots (Faber-Laumeister, ponds SF2 and AB2)

Medium-sized patches (~25 m radius) are found in trail systems and roadsides of Faber-Laumeister, pond SF2, and along the Moffet Bay Trail at the south end of pond AB2 (West Bay Area WMA).

Yellow starthistle is found on the perimeter of pond SF2 adjacent to Highway 84. These patches may be controlled in the early stage via herbicide treatment (backpack), or late treatment using a weed whacker or other manual tools. A portion of this locality is owned by the California Department of Transportation (Caltrans); for future efforts, communication and collaboration with this agency should be considered. As of 2011, CalTrans removed a large patch of yellow starthistle, and mulched the site to prevent aggressive re-growth of weeds.

Several patches that are greater than 25 m in radius have established in Moffet Bay Trail at the south end of pond AB2. The areas inhabited by yellow starthistle in this site are upland levee habitats. This section is regularly mowed by levee maintenance personnel during mid-summer, when the plants are in their late flowering stage. An effort should be made to implement mowing during the budding/early flowering stage with a follow-up mowing during the late stage. Light herbicide application may also be combined in addition to manual treatment. These areas are highly disturbed, and usually have bare ground; therefore, the treatment methods proposed in this objective inflicts very little impact to biological resources. Even though these patches are situated on disturbed areas, presence of native habitat and wildlife in adjacent areas should be noted during surveys.

<u>Objective 5</u> Prevent the spread of priority weeds out from major travel corridors within the Refuge.

All populations of yellow starthistle are found near major travel corridors, such as roads and trails. A 100 m buffer around known populations should be inspected for new patches annually. Dispersal from wind, vehicles and other human traffic, however, may transport seeds to farther locations. The section of Newark Slough Trail parallel to this patch should also be monitored for potential new infestations.

Re-vegetation

Active re-vegetation is recommended following yellow starthistle control in appropriate areas. Successful re-vegetation requires choosing desirable plant species that are well-adapted to the site because plants that grow well and quickly are the best competitors to help prevent starthistle from re-establishing.

<u>Stinkwort (Dittrichia graveolens) – High Priority</u>

Ecology

Dittrichia graveolens, or stinkwort, is an invasive annual in the Asteraceae family. It is native to Africa, Asia and Europe, and since its first documentation in the US in 1984, it has rapidly expanded its range, becoming one of the fastest spreading weeds in California (J. DiTomaso, pers. comm.). It forms dense monocultures that outcompete native plants, and reduces cover and habitat for wildlife when stinkwort dies back in winter and spring. Cal-IPC classifies the statewide impact of *D. graveolens* as moderate⁵, but has also recognized it as a "red alert" species, which includes new invasive plants and range expansions, in 2004, 2009 and 2010 (www.cal-ipc.org).

An erect herb that resembles a small pine tree during early growth period, *D. graveolens* grows up to 1m tall and produces many branches, originating at its base, with alternate leaves covered with fine hairs (DiTomaso et al. 2013). Terpenes produced by the plant exude an extremely aromatic, camphor-like smell. *Dittrichia graveolens* is known to emerge as a small rosette in May-June, however, recent information suggests that it might germinate with the first rains in fall and winter (J. DiTomaso, pers. comm.). Stinkwork grows most rapidly in late summer through fall when most plants have already seeded and died back. *Dittrichia graveolens* plants, even as small as two centimeters, produce flowers beginning in September and flower through December.

Dittrichia graveolens produces copious amounts of sticky seed (estimated 15,000 seeds per plant), which are well adapted to spread and disperse via multiple modes, including; wind, water, soil movement and any object they touch (i.e. humans, animals, vehicles, machinery, etc.). Seeds have a parachute of fine hairs that are well developed for wind dispersal, and can be windborne over 200m. Seeds remain viable in soil for three or more years.

Dittrichia graveolens primarily infests upland habitat, but grows in upland/marsh transition habitat in San Francisco Bay (M. Marriott, pers. obs.). It inhabits disturbed areas and/or areas where there is little vegetative competition. It can become dominant in pastures because animals will not eat it. It can out-compete other plants and plant communities where harsh soil conditions limit the growth of other plants; including serpentine soils, alkaline soils, and soils with heavy metals, and is known to bioaccumulate mercury, zinc, and nickel (Brownsey et al. 2013).

The Refuge is currently working along with County Weed Management Areas to control *D*. *graveolens* which has been increasingly recognized recently by California land management

⁵ **Moderate** - These species have substantial and apparent-but generally not severe-ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.

agencies to be a serious threat. This weed is a high priority for control because of this its unprecedented rate of expansion throughout the South Bay, its superior ability to spread via travel corridors, and its capacity to dominate wildlands, including sensitive marsh/upland transition zones.

Distribution/Extent of the problem

Dittrichia graveolens infests uplands, levees and upland/marsh transition zones throughout the project area. Especially concentrated along travel corridors and where soil has been moved or disturbed, *D. graveolens* is abundant along roadsides and in heavily trafficked areas on the Refuge. Populations are concentrated at Inner Bair Island, Marshlands Road and Headquarters area (including LaRiviere, Harrier's Spur trail, Tidelands Trail, parking lot and adjacent areas), Mayhew's Landing, the north and south sides of pond SF2, Warm Springs Trail, the entrance road to the EEC (Grand Avenue), the southern portion of pond A12 and along the Moffet/Bay and Steven's Creek East trails in Alviso. Small spot populations less than 2m² exist sporadically throughout the entire Refuge.

Previous Treatments within Project Area

Within the Refuge, *D. graveolens* has primarily been treated along the entrance to Marshlands Road, Headquarters hill (including Harrier's Spur Trail), Headquarters maintenance area, the levees of LaRiviere, Mayhew's Landing, along Grand Avenue at the EEC, within the restoration area at the EEC, along Warm Springs Trail, and within the Warm Springs unit of the Refuge. Treatments have included hand pulling and bagging, and spraying spot populations along roadsides and trails with Habitat®, Glyphosate and Milestone® VM Plus.

Treatment Objectives

The following treatment objectives are listed in order of priority and feasibility, and should be met in listed order, as additional resources become available.

- 1. Control infestations along major roads.
- 2. Control infestations in heavy equipment and vehicle parking locations (to prevent spread to Refuge and other locations).
- 3. Control populations on trails, and other travel corridors.
- 4. Control spot populations.
- 5. Control large infestations, which function as source populations.

Treatment Options and Control Methods

Herbicide and/or hand pulling are the most effective methods of control (DiTomaso et al. 2013). Infestations must be treated at least twice within one growing season, because *D. graveolens* produces multiple cohorts, and one treatment of a population, even with a pre-emergent, is often not sufficient to control the weed. The weed is most effectively treated early in its growth stages, and should therefore be treated soon after it emerges, but before it produces flower heads (May/June), and then again when subsequent cohorts begin to emerge (August/September). Once flower heads develop, *D. graveolens* routes its resources into producing seeds, if stressed. The plant will go to seed under most control regimes, including herbicide application and hand pulling. Therefore it is most effective to treat *D. graveolens* before it forms flower heads. Once

flowering, the only way we have found to control this plant is by hand pulling and disposing of it in a sealed bag (DiTomaso et al. 2013).

Mowing, weed whacking, grazing and/or burning are not effective control methods, as the plant resprouts readily when cut, grazed or burned. We have found Habitat® (imazapyr), and Milestone® VM Plus (aminopyralid with Garlon®) to be most effective, early in season. Apply at labeled rates when plants are small and prior to flowering. Herbicide uptake is most effective while plants are actively growing and before biomass of vegetation has built up. Most of the plant must be covered with herbicide to be effective. No herbicide works once flower heads form (flower heads don't even need to be open), as the plant responds to the stress by seeding.

Terpenes within stinkwort may cause allergic contact dermatitis in humans and may cause headaches, blistering and itchiness; therefore handlers are advised to wear gloves (Brownsey et al. 2013).

All *Dittrichia* populations require multiple treatments per year, as *Dittrichia* germinates continuously April-September, and perhaps longer (M. Marriott, pers. obs.) in the Bay Area. Therefore, even areas treated with pre-emergent herbicides should be treated multiple times per year. *Dittrichia* should be also be treated at least 3 years in a row before re-vegetation efforts commence to deplete the seedbank.

Treatments for Specific Objectives

<u>Objective 1</u> Control infestations along major roads. (Marshlands Rd, Grand Ave, Thornton Ave, Hwy 84)

Roadsides will not be re-vegetated due to continual disturbance and will require annual maintenance.

Objective 2 Control spot populations.

Small spot populations less than $2m^2$ exist sporadically throughout the entire Refuge. Areas of known patches include the restoration area at the EEC and the Warm Springs unit.

Objective 3 Control infestations in heavy equipment and vehicle parking locations.

To prevent cars and heavy equipment from dispersing seeds to other areas of the Refuge, the following areas should be maintained annually: maintenance yard and parking lots at Refuge Headquarters (Newark WMA) and the parking lot at EEC (Alviso WMA).

<u>Objective</u> 4 Control populations on trails, and other travel corridors.

Control areas along levees of LaRiviere Marsh, Harrier Spur trail, Mayhews Landing, and Tidelands Trail (Newark WMA) Warm Springs Trail (Mowry WMA), the southern portion of A12, the Moffet/Bay and Steven's Creek East trails, (Alviso WMA) and the north and south sides of pond SF2 (West Bay WMA).
Objective 5 Control large infestations, which function as source populations.

At Inner Bair Island, consider the possibility of flooding the *Dittrichia* infested area. This would require that a small notch or weir structure be constructed in a levee that would allow water to enter at high tide. *Dittrichia* is not known to grow in water, and continuous inundation with saline water would likely kill *Dittrichia*.

Re-vegetation

Large areas where populations are treated in upland and transition zone habitats should be actively re-vegetated to prevent reestablishment of *Dittrichia*. However *Dittrichia* is extremely aggressive, and dominates other vegetation in disturbed sites, such as treatment sites. So, we recommend depleting the seedbank by treating *Dittrichia* at least three years in a row before revegetation.

Special Environmental Considerations for Dittrichia graveolens treatment.

Dittrichia graveolens is known to grow in vernal pool habitat in the Warm Springs unit of the Refuge. However, *Dittrichia* is a late germinating plant and typically the earliest control efforts occur in June and continue through September. At this point, vernal pool plants have flowered and seeded out (generally in May to early June). Treatment of *Dittrichia* therefore can be done without affecting native vernal pool vegetation.

Purple Starthistle (Centaurea calcitrapa) – High Priority

Ecology

Purple Starthistle (*Centaurea calcitrapa*) is an herbaceous invasive that acts as a winter annual, biennial or perennial depending on climate and conditions. A member of the Asteraceae, it is native to the Mediterranean region. Purple starthistle forms flower heads surrounded by long, sharp-pointed spines, and reproduces only by seed, that often falls just below the plant or is carried by animals. The longevity of seeds is approximately 3 years (DiTomaso et al. 2013). Cal-IPC lists purple starthistle as moderate, while the California Department of Food and Agriculture classifies the invasive as a B Rated Noxious Weed (CDFA 2013).

Distribution/Extent of the Problem

Purple starthistle is regarded as a major problem in the San Francisco Bay Area (Roche and Roche 1990 in Bossard et al. 2000). On the Refuge, it is currently found along Marshlands Road, the maintenance lot at Headquarters, and a small patch is present in the Dumbarton-Audubon area in the Newark WMA; it is also present at Warm Springs in the Mowry WMA. Due to the small size of each of these patches, these isolated populations should be easy to eradicate.

Previous treatments within Project Area

Purple starthistle (on Marshlands Road) was treated with 2% glyphosate in 2009 and again in 2010. At Warm Springs unit, starthistle has been treated with Garlon® 4Ultra and Milestone® VM Plus, as well as hand-pulled and bagged.

Treatment Objectives

The following treatment objectives are listed in order of priority and feasibility, and should be met in listed order, as additional resources become available.

- 1. Eradicate populations that have previously been treated from the project area.
- 2. Eradicate any populations found within the project.

Treatment Options and Recommended Management Methods

The same control methods that apply to yellow starthistle also apply to purple starthistle (see section above). Transline® is effective on purple starthistle, but has little or no effect on grasses (Bossard et al. 2000). Late winter or spring application is optimal, when the seedlings and rosettes are most sensitive. Glyphosate is also effective. Mowing, grazing, biological controls and burning are not effective control methods for purple starthistle (DiTomaso et al. 2013).

Treatments for Specific Objectives

<u>Objective 1</u> Eradicate populations that have previously been treated from the project area (Marshlands Road and Warm Springs).

Because control has already started at the Marshlands Road location, it is strongly recommended that it continue until all plants and seeds in the seed bank are eliminated. There are two patches near Marshlands Road, which are located near the entrance to maintenance parking lot, and the

intern house. These patches are small ($<2 \text{ m}^2$), easily accessible and very close to weed control equipment and supplies, thereby allowing control and monitoring to be expedient. The roadside where patches are found is highly disturbed, and usually contain other non-native species associated with purple star thistle; therefore, the treatment methods proposed in this objective inflicts no impact to biological resources due to the lack of native habitat in these areas.

Control should continue at the Warm Springs unit using a combination of hand-pulling and herbicide treatment.

<u>Objective 2</u> Eradicate any populations and outliers found within the project (R1, Greco Island and Dumbarton-Audubon Marsh).

Three additional small populations ($<2 \text{ m}^2$) occur, on the Refuge. The R1 population was only a few square meters, and the Greco Island population consisted of only one plant. In 2011, a patch near the northeast "tail" of Dumbarton-Audubon marshes was reported. Due to the small size of these patches, they are best treated with herbicide (e.g. 2% glyphosate) using backpack sprayers. All patches in these localities are situated in upland parcels outside sensitive habitat; therefore, no impact will be generated.

Re-vegetation

There are no specific re-vegetation treatments identified for purple starthistle.

Alkali Russian thistle (Salsola soda) – High Priority

Ecology

Alkali Russian thistle (*Salsola soda*) is a summer annual in the family Chenopodiaceae. The weed is native to south Europe, but was introduced to San Francisco Bay in 1968 (Thomas, 1975 in Tamasi 1998), and has subsequently become widespread in the San Francisco Bay. It is closely related to Russian thistle (*S. tragus*), which is commonly known as tumble weed. However, unlike tumble weed, *S. soda* is a halophyte (though not obligate) and occurs in wetlands including vernal pools, swamps, brackish marshes and mudflats (DiTomaso and Healy, 2007). It may form dense stands, especially in disturbed areas or places where dredge soil is placed.

Alkali Russian thistle is thought to produce both by seeds and vegetatively. Floating fruits act to distribute its seeds on tidal currents. Seeds disperse via water, humans, animals and vehicles or machinery. Seeds remain viable in soil for three or more years (Cal-IPC Assessment Form 2011). *S. soda* has quickly spreading vegetative structures (rhizomes, roots, etc.) that may root at nodes, and fragment easily, possibly becoming established elsewhere.

Salsola soda generally inhabits disturbed habitats and has become dominant or co-dominant in disturbed soils, levees, spilled or discharged dredge slurries, and areas where there is artificially reduced tidal action (Cal-IPC – Plant Assessment Form 2011). It also inhabits high tide drift line, marsh plains, and levees, and is locally abundant on tidal creek edges in South Bay. However, of greatest concern, *S. soda* is also becoming widespread in undisturbed brackish marsh vegetation in parts of the South Bay where it has been found in undisturbed, mixed stands of *Distichlis spicata* and *Salicornia virginica* (Baye 1998). Its establishment in previously unvegetated areas has been documented, (Baye, in Tamasi, 1998), and it may replace the native pickleweed and therefore transforming the landscape (Olson, 1995, pers. comm. – in Tamasi 1998), although this needs to be studied further.

Alkali Russian thistle has high potential to invade restoration areas where it easily colonizes disturbed soil and salt pans at marsh edges (Baye 1998). It has made initial invasions in recently restored tidal marshes, such as the Sonoma Land Trust Petaluma Marsh Restoration Project (Baye 1998). Cal-IPC classifies the statewide impact of *S. soda* as moderate, but has also recognized it as a "red alert" species in 2009.

Distribution/Extent of the Problem

Currently *S. soda* is widely present throughout the geographical extremes of the Bay, from Tubbs Island in San Pablo Bay to the A15/A16 levee in South Bay, and has been reported in several locations in Suisun Bay (Tamasi 1998). In Dumbarton Marsh and Newark Slough (one of the largest salt marsh areas in the south bay) *S. soda* is now invading not only the typical high tide drift-lines and disturbed levees, but on the tidal creek bank edges (often with *Atriplex triangularis* and *Grindelia stricta*) and on extensive areas of outer Dumbarton Marsh in undisturbed, dense mixed stands of saltgrass (*Distichlis spicata*) and pickleweed (Baye 1998).

As of the 2011, it is most abundant at Mayhew's Landing, in the transition zone between Newark Slough and Tidelands Trail in the Newark WMA, in parts of Warm Springs in the Mowry WMA, and at Outer Bair Island in the West Bay WMA. It occurs sporadically along Marshlands Road, the Pavillion area at headquarters, and North Shoreline Trail in the Newark WMA. It also occurs on the levee slopes of ponds R1 and SF2, Faber-Laumeister and at Greco Island in the West Bay WMA and at ponds A6 and A16 in the Alviso WMA. It is widespread in the brackish marshes of the Alviso Unit, along Coyote Creek, South Coyote Slough, Artesian Slough, Alviso Slough, and Guadalupe Slough.

Previous treatments within Project Area

We have hand-pulled *S. soda* at Mayhew's Landing and Warm Springs, and sprayed a small population adjacent to LaRiviere along Thornton Avenue with Habitat® in 2009. The treatment with Habitat® was successful, and we have not seen regrowth at that location as of 2011.

Treatment Objectives

The following treatment objectives are listed in order of priority and feasibility, and should be met in listed order, as additional resources become available.

- 1. Control populations that have previously been treated from the project area.
- 2. Control populations on roadsides, heavily trafficked areas, trails, construction areas, and parking lots.
- 3. Control restoration sites.
- 4. Control spot populations.

Treatment Options and Recommended Management Methods

Hand-pulling is optimal for this shallow rooted weed. Plant debris should be bagged and removed from site as *Salsola* may resprout. On a positive note, it has a short-lived seedbank (less than 2 years). *Salsola* readily resprouts when cut, grazed or burned and fragments can easily become established.

Treatments for Specific Objectives

<u>Objective 1</u> Control populations that have previously been treated from the project area.

Currently this is limited to Mayhew's Landing, LaRiviere, and Warm Springs. Staff and volunteers should continue hand-pulling and bagging plants.

<u>Objective 2</u> Control populations on roadsides, heavily trafficked areas, trails, construction areas, and parking lots.

Treatment areas should include Marshlands Road, transition zone between Newark Slough and Tidelands Trail and the Pavillion.

Objective 3 Control restoration sites.

Treatment areas should include Outer Bair Island and levees of pond SF2.

Objective 4 Control spot populations

Treatment areas include the levee slopes of R1, Faber-Laumeister, A6 and A16, and Greco Island.

Re-vegetation

Treated areas may be planted with appropriate native wetland or riparian plants found within the area. Native California sea lavender, pickleweed, alkali heath, saltgrass, gum plant (*Grindelia robusta*), salt marsh baccharis (*Baccharis douglasii*) and other wetland plants may be planted in treatment sites.

Special Environmental Considerations for Salsola soda treatment.

Treatment of *S. soda* may require that personnel enter the upper marsh and upper marsh transition zone. Conservation measures to reduce disturbance to, and adverse effects of herbicides on, estuarine and vernal pool wildlife, plants and associated habitat elements will be the same as those for *L. latifolium* (Hogel et al. 2007). However, to further minimize disturbance to nesting California clapper rail, we will reserve treatment until late summer after *S. soda* starts flowering, and only at low tide (Appendix 3).

Treatment of *S. soda* may require that personnel enter vernal pool sites. To minimize disturbance to sensitive vernal pool species, personnel will avoid entering vernal pools and will establish an 8m no-spray buffer around blooming vernal pool native plants. *Salsola* populations at Warm Springs are concentrated in a few upland areas and do not occur within pools.

<u>Pampas grass (Cortaderia selloana) and Jubata grass (Cortaderia</u> <u>jubata) – High Priority</u>

Ecology

Pampas grass, *Cortaderia selloana*, and Jubata grass, *Cortaderia jubata*, are perennial grasses of the family Poaceae. Pampas and jubata grasses are so similar in appearance that they are very difficult to distinguish from one another. For that reason, jubata grass is often referred to as pampas grass. Both grasses are native to South America and grow in damp soils. Initial growth after germination is slow, but rapidly increases once the seedling becomes established. Seedling survival is low in shaded areas or in competition with grasses or sedges. Once established though, these invasive grasses quickly colonize bare ground and out-compete the natives by means of crowding. Roots of a single plant can occupy a soil volume of about 1km² and they produce later roots that can spread to 4m in diameter and 3.5m in depth. These *Cortaderia* species are capable of living up to fifteen years. These plants like undisturbed coastal shrubland and marshes, inland riparian areas, and other interior sites where sufficient moisture is available.

The two species may differ in their reproductive methods. According to the University of California- Davis Weed Research and Information Center (WRIC), jubata grass reproduces via apomixis, asexual reproduction with seeds, while pampas grass reproduces sexually. The Cal-IPC, however, states that both species reproduce asexually via apomixes. The nature of *C. jubata*'s reproduction is an important factor in its weediness. With only female flowers produced, an individual inflorescence produces 100,000 seeds that can be dispersed by the wind up to 20 miles. Jubata grass flowers from late July to September, often in its first year of growth. Pampas grass reproduces sexually, with flowers usually occurring from late August through September and no flowers produced until two to three years post-germination. When both male and female plants are present and pollination occurs, each individual pampas grass of these grasses is their range. Unlike jubata grass, pampas grass can tolerate winter frost, warmer summer temperatures, more intense sunlight, and moderate drought. This wider range tolerance has allowed pampas grass to be more successful inland, while jubata grass is more restricted to the coast.

Cortaderia selloana was introduced to California in the mid-1800s as an ornamental and for erosion control and is still a commonly grown ornamental throughout California. It was also used to provide supplementary dryland forage material. It was able to escape cultivation in many coastal areas, presumably by fragmentation of the parent plant or by seed. Although pampas grass is dioecious, most populations in California are female because of ornamental selection for their showier plumes. Therefore very few seed is actually produced, limiting their ability to spread. Pampas grass has spread along sandy, moist ditch banks. Disturbed sites with bare and sandy soil, ample moisture, and light are most favorable for seedling establishment. Both species have become considered noxious weeds in some areas of California, especially along the coast (DiTomaso and Healy 2007). The Cal-IPC classifies the statewide impact of *C. selloana* as high and the California Department of Food and Agriculture lists it as a B Rated noxious weed (CDFA 2013).

Distribution/Extent of the Problem

Pampas grass stands currently exist in Mayhew's Landing in Newark WMA and New Chicago Marsh in Alviso WMA, both managed marshes. There is also one plant along headquarters hill. A few plants also exist along the A16/A17 levee in Alviso WMA. There is also a large stand located on Middle Bair Island.

Previous Treatments within Project Area

A small stand of C. selloana, in New Chicago Marsh in Alviso, was sprayed in 2009.

Treatment Objectives

The following treatment objectives are listed in order of priority and feasibility, and should be met in listed order, as additional resources become available.

- 1. Control populations that have previously been treated from the project area.
- 2. Control spot populations.

Treatment Options and Control Methods

Distinguishing between the two species is not important in terms of control techniques. Pulling or hand-grubbing seedlings is found to be highly effective, but for larger plants a Pulaski, mattock, or a long-bladed shovel are the safest and most effective tools for removing established clumps. To prevent re-sprouting, it is important to remove the entire crown and top section of the roots (re-growth is unlikely from the lower roots). Turn the removed plants upside down to expose the roots to the air or remove from the area so the roots cannot re-establish themselves under moist soil conditions. If flowering or seeding plants are cut, plant debris should be put in garbage bags and disposed of or incinerated off site. Mechanically removed clumps killed with a soil residual root-absorbed compound can be left to decompose at the site, and therefore may shade out potential seedling establishment of other Cortaderia. In disturbed sites, mulching and over-seeding with desired native vegetation will help suppress any new seedling growth. Control of pampas and jubata grasses can be achieved by spot treatment with a post-emergence application of glyphosate at about 2% solution or 8 quarts per 100 gallons. The addition of nonionic or silicone-based surfactant may enhance foliar penetration of the herbicide. Herbicide spray should wet the plant, but not to the point of herbicide runoff. Fall applications result in better control compared to summer applications because photosynthetic assimilates are translocating downward at a faster rate late in the season (Costello in Bossard et al. 2000); but it may also be necessary to apply herbicide prior to maturation of viable seed in the late summer. For large clumps, the top foliage can be removed by cutting or burning and the regrowth treated with a systematic post-emergence herbicide. Grazing success has not been reported in the US, however, cattle has been shown to provide effective control in New Zealand (Gosling et al. 2000). According to the University of California-Davis WRIC, burning or grazing alone does not provide long-term control and no biological control efforts have been investigated.

Treatments for Specific Objectives

Objective 1 Control populations that have previously been treated from the project area

This includes New Chicago Marsh.

<u>Objective 2</u> Control spot populations

Including plants at Mayhew's Landing, Headquarters Hill, pond A16/A17 levee and Bair Island.

Re-vegetation

Treatment sites may be re-vegetated with a native plant mix that is similar to the local community. If known native seed banks occur within the site, it may be left to grow. The site, however, needs to be monitored for re-sprouts of *Cortaderia*.

<u>Giant reed (Arundo donax) and Common reed (Phragmites australis)</u> – <u>High Priority</u>

Ecology

Arundo donax, commonly known as giant reed, is a perennial grass from the family Poaceae. Additional common names include bamboo reed, elephant grass, giant cane, reed grass, donax reed, Spanish reed and wild cane. Several synonymous scientific names for *Arundo donax* are as follows: *Arundo latifolia*, *Arundo sativa*, *Cynodon donax*, *Donax arundinaceus*, *Scolochloa arundinaceae*, *Scolochloa donax*, and *Arundo glauca*. Giant reed is native to the Mediterranean region and southern and east Asia. It is a mostly glabrous plant with semi-woody, inflexible stems that are about 1-4 cm thick. These stems are bamboo-like, tough and hollow with long internodes, and can grow up to just over 8 meters tall. The leaves are alternate, two-ranked in a single plane, and up to 1m long. A plume-like inflorescence is produced at the tips of the stems, however viable seed has not been observed in North America.

Arundo donax reproduces vegetatively from rhizomes and stem fragments, which are dispersed by mud, water, and human activities. The dense network of rhizomes can develop new shoots when buried under 1-3 meters of silt. Rhizomes allow this plant to develop dense, clonal stands, especially with their rapid growth in the warm season. Giant reed occurs in a wide range of soil types, but it grows best in well-drained, moist soils. It out-competes natives by monopolizing soil moisture and shading. These dense stands displace native vegetation, diminish wildlife habitat, and increase flooding and siltation in natural areas. Some salinity and extended periods of drought are tolerated, however, *A. donax* does not survive in areas with prolonged or regular periods of freezing. It can typically be found growing on sites with a low slope, including riparian areas, wetlands, ditches, sand dunes, and disturbed sites.

Phragmites australis australis, otherwise known as common reed, is also a perennial grass in the Poaceae family. Not to be confused with the subspecies that is native to North America, *Phragmites australis americanus*, the common reed is originally from Eurasia. Some of its other synonymous scientific names include *P. communis, Arundo phragmites, P. altissimus, P. berlandieri, P. dioicus, P. maximus, P. vulgaris,* and *P. phragmites.* This grass can grow up to 3m tall, with elongate leaves that are 2-4 cm at their widest. Their flowers form bushy panicles in late July and August that are usually purple or golden in color; these inflorescences appear "fluffy" as the seeds mature.

Similarly to *A. donax, P. australis australis* typically resides in wetlands, riparian areas, shorelines, roadsides, and disturbed sites. Common reed, with its deep-rooted network of rhizomes, often grows in monotypic stands, out-competing native plants for light and space. Also akin to giant reed, non-native *Phragmites* can increase fire potential and alter both marsh hydrology and wildlife habitat. However, unlike *Arundo donax*, common reed has the capability for seed reproduction, yet primarily uses vegetative reproduction.

Distribution/Extent of the Problem

Giant reed was introduced to and planted in California from the late 1700's to early 1800's for erosion control in flood channels, roofing material, and windbreaks. More recently it has

become problematic in riparian corridors throughout many areas of the state. Today *A. donax* is distributed throughout California (up to 500 m in elevation): along the North Coast, southern North Coast Ranges, Central-western region, Southwestern region, deserts, central Sierra Nevada foothills and the Central Valley. The Cal-IPC classifies the statewide impact of giant reed as high and the California Department of Food and Agriculture lists it as a B Rated noxious weed (CDFA 2013).

Specific to the Refuge, both Alviso WMA and Newark WMA have giant reed stands. There are several stands along the Guadalupe River in the Alviso WMA. The stand located just north of the Gold Street bridge is Refuge owned and stands along pond A8 and adjacent to the old landfill at the junction of Gold Street and Highway 237 are owned and/or managed by the Santa Clara Valley Water District. The Newark WMA has 2 stands, one in Mayhew's Landing and one by the pavilion at headquarters.

Previous Treatments within Project Area

There has been no treatment.

Treatment Objectives

There are currently no treatment objectives for this weed. Objectives will be developed as time permits.

Treatment Options and Control Methods

Manually removing small populations of *A. donax* can prevent the development of large, problematic infestations. Prescribed burning removes stems, but does not kill the rhizomes. Mechanical removal may fragment rhizomes and stems, which may develop into new plants if not removed from the site. Cutting the stems of mature plants and treating the stumps (cut-stumps, cut-daub) with systemic herbicide is effective from March to October. A foliar spray application of a 1.5% glyphosate- based herbicide mixed at 1.5% is a successful control method.

As with giant reed, it is best to control a population of *P. australis australis* soon after establishment. This results in an increased chance of success because rhizome networks won't be as extensive. The optimal method of control is an herbicide treatment followed by the burning of the biomass. Burning the dead stems and litter may help encourage germination of native plants in the following growing season. However, do not burn plants in the spring or summer before flowering because this may stimulate growth of the invasive. Although not ideal, mechanical pulling of these exotic weeds is possible; this is unlikely to kill the plant but may slow the spread. Small fragments of root or rhizome may break off and be left in the soil in the process of pulling, allowing for potential re-establishment.

Re-vegetation

Treatment sites may be re-vegetated with a native plant mix that is similar to the local community. If known native seed banks occur within the site, it may be left to grow. The site, however, needs to be regularly monitored for re-sprouts.

<u>Italian thistle (Carduus pycnocephalus) and Slenderflowered thistle</u> (Carduus tenuiflorus) – High Priority

Ecology

Italian thistle (*Carduus pycnocephalus*) and slenderflower thistle (*Carduus tenuiflorus*), are winter annuals in the family Asteracea. These species have very similar ecologies and are known to hybridize (though seldomly) (DiTomaso and Healy 2007). Native to the Mediterranean, southern Europe, and North Africa, *C. pycnocephalus* was reported in 1912 in California, and since then has spread along the California coast, among other areas. Slenderflower thistle is native to central Europe. The Cal-IPC classifies the statewide impact of *C. pycnocephalus* as moderate and *C. tenuiflorus* as limited and the California Department of Food and Agriculture lists both species as a C Rated noxious weeds (CDFA 2013).

Both thistles have purplish-pink flowers that are clustered in groups; Italian thistle has groups of two to five flowers while slenderflower thistle has groups of five to 20 flowers. Italian thistle stems have wings that are generally 5 mm wide, and usually do not extend all the way to flower heads, whereas slenderflower thistle stems have wings that may be 10 mm wide, and usually extend to flower heads. Slenderflower thistle looks like a robust Italian thistle. Both have branched slender taproots.

Germination of both generally occurs after the first rains in November and December, and bolting occurs between March and May. Rosettes and early growth can be so dense that they blanket the soil, inhibiting germination of all other plants. Italian thistle inhabits disturbed areas where the soil is composed of sand or clay. Thistles can become dominant in disturbed open sites, roadsides, pastures, annual grasslands, and waste areas, but generally do not compete well with health established grasses or other vegetation (DiTomaso and Healy 2007). These thistles reproduce by seeds only, which can remain dormant in the soil for up to ten years. Plants can produce up to 20,000 seeds, spread primarily by wind, and may be transported by humans, animals, soil movement and vehicles or machinery.

Distribution/Extent of the Problem

Both thistles are abundant within the Refuge. It infests uplands, transition zones and in a few instances even upper marsh in all locations mapped during the 2010 inventory. It is most abundant on the sloping sides of levees, and on the northeast side of Headquarters hill. At Warm Springs, where populations have been treated for years, Italian thistle has declined by approximately 75% (I. Loredo pers. comm.).

Previous treatments within Project Area

Generally, thistles have been opportunistically spot treated with Habitat® or Glyphosate on the Refuge, and no consistent treatment has taken place. However, on the Warm Springs unit, Italian thistle patches are sprayed consistently and annually with Garlon® 4 or Milestone® VM Plus. Environmental education and Volunteer groups have treated the same patches of these thistles around Headquarters over the past few years by cutting off flower heads.

Treatment Objectives

1. Control the populations at Warm Springs that have been consistently treated for several years. Continue to spot-treat as needed.

Treatment Options and Recommended Management Methods

Hand pulling can be effective well before seed is set, as long as the root is severed at least 10cm below ground level so the plant does not re-grow. Downed debris can be piled and tarped on-site to kill any remaining viable seeds and later used as mulch. Once thistles have bolted and formed flower heads, an effective technique involves cutting stems and flowers off and bagging them. As these thistles are annual, this may be enough to halt reproduction for the plants involved. Mowing is not recommended because plants can produce a significant amount of seed even if thistles are consistently mowed to 8cm. Weed whacking is an option, if plants are consistently chopped to ground level. However, once flower heads have formed, this is not a recommended technique, unless all severed flower heads are collected (which is highly unlikley). Grazing is not an optimal control method, as most animals avoid grazing on these thistles due to their spines.

A long-term, annual herbicide treatment regime is optimal for control of large patches. Transline® is effective at controlling thistles, and can be used on early-flowering or advanced stage plants, causing seed to abort or be sterile (Sindel 1991 in Bossard 2000). Glyphosate as Roundup® is also effective, and may be a good alternative when spraying thistle that is within 8m of the mean high water mark. We have also had good success with Garlon® 4 and Milestone® VM Plus in the upland habitats of Warm Springs.

Re-vegetation

Treatment sites may be re-vegetated with a native plant mix that is similar to the local community; if known native seed banks occur within the site, it may be left to re-vegetative passively. The site, however, needs to be monitored for thistle re-sprouts.

French broom (Genista monspessulana) – High Priority

Ecology

French broom, *Genista monspessulana*, is common on coastal plains, mountain slopes, and in disturbed places such as river banks, road cuts, and forest clear cuts, but it can colonize grassland and open canopy forest. Native to the Mediterranean, Cal-IPC classifies the statewide impact of French broom as high. French broom is thought to have been introduced to the Bay Area in the mid-1800's as an ornamental and continues to be sold in the nursery trade. As of 2010, French broom occupies approximately 100,000 acres in California. Broom grows in varied soil moisture conditions, but prefers siliceous soils and alkaline soils with pH 8. Broom has a life span typically of ten to fifteen years, with seeds germinating December to July and remaining viable for at least five years and possibly much longer. A medium-sized shrub can produce over 8,000 seeds a year. The seed bank may persist 30+ years, so control without extreme measures will have minimal success (DiTomaso et al. 2013).

Current Distribution within the WMP

French broom currently exists at the Headquarters Hill in Newark.

Previous treatments within Project Area

In recent years this plant has been removed from the Refuge by California Conservation Corps crews and large volunteer groups as part of the fire management plan. Plants have been removed by hand-pulling, hand tools such as weed wrenches and loppers and herbicide application to cut stems/stumps.

Treatment Objectives

The following treatment objectives are listed in order of priority but not necessarily feasibility.

1. Control populations that have previously been treated from the project area.

Treatment Options and Recommended Management Methods

There are several treatment options when controlling French broom. Mechanical methods can be very effective and economical when using large groups of volunteers. Hand-pulling and weed wrenches are effective for broom removal in small infestations because they remove the entire stem and roots, eliminating resprouting. Cutting shrubs at or below ground level in late July or August, after it has gone to seed can reduce resprouts but does not address seed production. Tarps should be placed on the ground and all downed broom placed on top for easy removal from the area to avoid spreading mature seed to uninfested areas. A solution of 3 percent glyphosate sprayed on foliage until wet has been used to treat mature French broom shrubs. Triclopyr (as in Garlon® 4 Ultra) in a 25% herbicide/75% oil solution is effective for low-volume basal bark application. Cut stump treatment may also be used with 50% Garlon® 4 Ultra, 25-50% Glyphosate, or 20% Imazapyr. Herbicide applications should be made during periods of active growth after flower formation and seed set but before seed dehisces (Bossard et al. 2000). Standing dead shrubs will need to be removed to prevent fire hazard.

Sites should be monitored at least once a year, when flowers are blooming but prior to setting seed, for five to ten years during treatment and every two years thereafter. Seedlings need to be

pulled annually for at least five years, in areas where mature shrubs have been treated, to prevent the same scenario from re-developing.

Treatments for Specific Objectives

<u>Objective 1</u> Control populations that have previously been treated from the project area.

French Broom on Headquarters Hill is treated annually. Both mechanical and chemical control methods should continue until mature plants, seedlings and extensive seed bank are exhausted. Broom removal will continue to be a high priority weed area for large volunteer groups.

Re-vegetation

Broom requires a long-term commitment to control and aggressive re-vegetation using fast growing natives (i.e. toyon, coyote brush, California sage).

Poison Hemlock (Conium maculatum) – High Priority

Ecology

Conium maculatum, poison hemlock, is a biennial dicot herb in the family Apiaceae. Poison hemlock originated from Europe, North Africa, and Asia, and has been introduced to North America. It contains highly toxic alkaloids that were used by the ancient Greeks for capital punishment (e.g., Socrates). Ingestion has resulted in human deaths; it is rarely eaten by livestock.

Poison hemlock may grow up to 3m in erect branched leaves. The compound umbel inflorescence has 10-20 small white to yellowish flowers, each with 5 petals. Flowers develop from April to July, usually one year after germination. Poison hemlock reproduces by seeds and not vegetatively. Taproots are long, thick, and fleshy. *Conium maculatum* is often branched into several arms with abundant lateral roots.

Seeds of poison hemlock are primarily dispersed by falling under their stands. Plants that are near streams, however, can disperse seed by water. Additionally, seeds can attach to mud, animal fur, human clothing, shoes, and machinery. Seeds are fully developed by mid-June to mid-July, and 90 percent dehisce from September through December; the remaining seeds are dispersed until late February. Although deposited seeds can be dormant up to three years, poison hemlock seeds can germinate immediately after deposition, and can grow on a wide range of temperature and soil types. Germination occurs throughout the year except April, May, and July; germination period peaks on late winter and early spring. Due to seed dormancy, long duration of dispersal, and capacity to germinate in varying conditions, poison hemlock can spread vigorously throughout the year while establishing seed banks.

Poison hemlock is widely distributed throughout North America and common throughout California and occurs in elevations below 1000 m. The Cal-IPC classifies the statewide impact of poison hemlock as moderate.

Distribution/Extent of the Problem

Poison hemlock is common on levees in the Alviso WMA, including ponds A1, A8, A16 and A17. It can also be found in Mayhews Landing and along Marshlands Road.

Previous treatments within Project Area

Opportunistic treatments have occurred but on a very limited scale. Over the past 15 years hemlock has been treated over approximately 10 acres of the EEC. Treatments have mostly consisted of mechanical methods, although some thermal (green flaming or wilting) and some chemical (salinization) has also occurred (D. Thomson pers. comm.).

Treatment Objectives

There are currently no treatment objectives for this weed. Objectives will be developed as time permits.

Treatment Options and Control Methods

Hand removal is recommended for small infestations. When pulling the plants, dig down and remove the entire taproot (DiTomaso et al. 2013). Pulled plants must be removed from site, as the roots are allelopathic, and will inhibit natives from growing back. Follow up treatment with herbicide on the new growth is recommended to prevent re-flowering. Glyphosate based herbicides such as Roundup® should be used before bolting at a rate of 1.5%. Triclopyr based herbicides such as Garlon 4® Ultra should be used in the seedling to rosette stage and is most effective on smaller plants (DiTomaso et al. 2013).

Fennel (Foeniculum vulgare) – High Priority

Ecology

Fennel is an erect perennial herb that grows 1-3m tall. It has feathery leaves that sheath the stems where they meet. The stem and leaves produce an anise (black licorice) scent. Small yellow flowers clustered in large, rounded, umbrella-like groups bloom from April through July.

Fennel will reproduce from both root crown and seed. Germination can occur almost any time of the year. Vegetative growth begins in mid-winter and peaks in July to August. Flowering stems die during late fall and early winter, although some remain alive and begin to produce new leaves with the onset of rains. Seed production is prolific and can begin as early as May and continue through early November, generally seed production peaks in August and September. Seeds may persist in soil for several years without germinating. Seeds are dispersed by water and on vehicles and clothing. Birds and rodents eat the seeds and may disperse them as well. Fennel produces an allelopathic substance that inhibits growth of other plants close by.

Fennel likes mesic locations with a Mediterranean clime from sea level to 610m that have soils that are more acidic, with a pH ranging from 4.8 to 8.3. Preferred soil type appears to be well drained, sandy soils, but can also thrive in sites with high clay content. Fennel colonizes disturbed areas, especially weedy sites adjacent to fresh or brackish water, and pastures, abandoned lots, and roadsides. It is common in open habitats such as grasslands, coastal scrub, savannas, and the bank of creeks, estuaries, and bays and tolerates drought and frost.

Fennel is a member of the Apiaceae family native to southern Europe and the Mediterranean region and has occurred in California for at least 120 years. Cal-IPC classifies the statewide impact of *Foeniculum vulgare* as high and the California Department of Food and Agriculture lists it as a C Rated noxious weed (CDFA 2013).

Distribution/Extent of the Problem

Fennel is ubiquitous along levees and in other uplands in all areas of the Refuge.

Previous treatments within Project Area

In recent years this plant has been removed by California Conservation Corps crews and large volunteer groups as part of the fire management plan. Plants have been removed by hand-pulling, hand tools such as loppers and foliar herbicide application. Areas treated include Headquarters Hill, Marshlands Road, the levee in LaRiviere, EEC restoration site, and Mayhew's Landing.

Treatment Objectives

1. Work with volunteers, staff and partners to control fennel.

Treatment Options and Recommended Management Methods

Digging out individual plants by hand is preferred to plowing or bulldozing because it minimizes soil disturbance, but it is labor-intensive. Slashing just before flowering may kill the plants or repeat slashing of regrowth may be needed. Slashing the stems at flowering will prevent seet set

(DiTomaso et al. 2013). Cutting, mowing, and chopping temporarily reduce the height of fennel plants within a stand, but they are ineffective as methods of removal and minimally impact the spread of fennel stands. Prescribed burning done in the fall (November-December) followed by herbicide sprays the following two springs can reduce fennel cover 95 to 100 percent. Grazing is ineffective on older and/or dense stands, but it can be effective where stands are small.

Glyphosate sprayed in spring prior to flowering at the manufacturers recommended rate has been found to reduce fennel cover 75 to 80 percent. Triclopyr can be used in early spring (February-March) at rates of 6 lbs/100 gallons water to achieve a kill rate round 95 to 100 percent. Late summer treatments were found to be less effective than spring.

Plant debris may be left on the removal site if the patch has not yet flowered or seeded. If flowering or seeding plants are cut, plant debris should be put in garbage bags and disposed of or incinerated off site.

Treatments for Specific Objectives

<u>Objective 1</u> Work with volunteers, staff and partners to control fennel (Headquarters Hill, Marshlands Road and Mayhews Landing).

Control fennel when it is actively growing and flowering, generally between May and November. Digging out individual plants by hand is preferred, but is labor intensive. Cutting and chopping are optional, although they only temporarily reduce the height of fennel plants within a stand. In subsequent years, fennel that has been chopped tends to grow shorter and is easier to control.

Re-vegetation

Native herbaceous species will shortly become dominant in an area where fennel is removed, but the areas will quickly become dominated by non-native grasses. Fennel removal should be considered only a first step in a larger restoration process that will require other actions to favor recolonization by native species.

PLANT COMMUNITY RESTORATION PROGRAM

The goal of this plan is to increase the health and functionality of wildlife habitats in South Bay. To this end, we will focus on the communities we want in place of the weeds we control. As an essential component of the weed management program, we will actively re-vegetate treated areas that we do not expect to be naturally re-colonized by natives, as resources allow. Plant communities are depauperate in terrestrial habitats surrounding the estuary, so recruitment in disturbed sites is usually dominated by regionally abundant non-native species. Seeding and planting into treated areas with native plants is an important step in preventing the re-infestation of weeds.

We will prioritize regionally-appropriate native species based on their aggressiveness (competitive abilities with weeds) that develop robust communities to occupy sites and resist invasions by non-natives. We plan to place more weight on broadleaf plants (forbs) in areas outside the coastal fog-belt due to inadequate rainfall for native grass dominance, but will continue including both guilds as diversity has shown itself to improve results (Thomson & Kakouros 2013).

In upper marsh and transition zone to terrestrial habitats, we will conduct re-vegetation projects between October (or as soon as rains commence) through January 31st, so as to avoid activity during Clapper Rail nesting season. In the uplands, we may continue with re-vegetation until March. We will enter the marsh to seed or plant only during low tides to limit stress on marsh species. We will use a combination of direct seeding and planting techniques. Restoration will be used within the context of the larger weed management program and control of invasives will continue.

Direct Seeding

The majority of the direct seeding will occur in late October, or when winter rains begin. The seed mix we will use for seeding upper marsh and upland transition was developed by David Thomson, and includes forty-five native species (Table 5), to be used based on availability (Table 5, Thomson & Kakouros 2013). This seed mix is appropriate for all upper marsh and transitional habitat in South Bay, and will be augmented with upland species to seed uplands (Table 6). At Warm Springs, an upland seed mix of ten native grasses and forbs was developed in 2012 and consists of a subset of the plants identified in Table 5 and 6. Aggressive natives will readily colonize highly disturbed sites and establish a "nurse crop" of early successional species. Sites that have been densely infested by weeds for years may no longer have a native seed bank and require more complete plant community restoration. Aggressive natives can outcompete weeds that would otherwise establish in treated areas. After a few seasons, these natives also create a new seed bank that will continue to serve as weed competitors during future disturbances.

Direct seeding efficacy rises with the degree of seedbed preparation. Therefore, where possible, 5cm of compost will be spread in seeding areas to prepare the sites with poor soils for seeding. Tilling or soil ripping to a minimum depth of 0.5m, should also be performed when compaction has occurred to less than 80% density. Soils should also be left rough, as the texture creates micro-habitats that help keep seed and water more evenly distributed, and the shading of

seedlings may improve their establishment. The seed mix will be broadcast by hand at the rate appropriate to the site and covered with 2,000 pounds of rice straw per acre as possible. Biodegradable, jute-fiber straw blankets can be used in high wind areas and on steep slopes to help hold the materials in place (D. Thomson, unpublished).

Amending with compost by topdressing is feasible over large acreages; it also makes a good seedbed, and if several centimeters are applied it can inhibit the germination of forb seeds via burial. Mulching with straw should also improve moisture retention, act like a grass thatch layer to reduce forb recruitment from the seed bank by shading, and could eventually contribute to improved soil structure. The addition of straw mulching may help impede seed browse by passerines. Soil treatments and mulching will not occur in the upper marsh, but may occur in the transitions and upland.

Seed collecting, storage and Plant propagation

Seeds on the suggested palate will be purchased or collected in the field. Optimally, seeds will be collected as close as possible to treatment sites, but if adequate stock is not available locally, then collections can be imported from outside the local area. Imports should come from sites with similar conditions or landscape position (i.e. close to the estuary, on similar topography, etc.). Seed can be locally collected or purchased (such as from Pacific Coast Seed in Livermore, California).

Seed needs to be kept in a cool (room temperature or cooler) dry facility. Although seeds in the suggested seed palate are viable for multiple years, seeds should be used as close to the collection date as possible for maximum effectiveness. Seeds and cuttings will be propagated in the Refuge nursery for planting.

Planting

Planting season will be timed to coincide with winter rains (late October-January 31st), but not to conflict with California clapper rail nesting season. Each plant should be mulched with straw or wood chips. If rain does not fall within one week after planting, plants should be watered once a week until regular rain returns. Following planting, plants should be watered at least once a month, from April to September, twice if necessary.

WEED DATABASE

The weed database serves as a centralized weed management project digital "logbook" for the Refuge. All weed management projects conducted on the Refuge should be entered into the database. All staff and volunteers working on weed management projects are asked to enter their data into the database or give their data to the weed management specialist or Refuge biologist for data input.

The database serves as a centralized location where any weed worker can access information about projects that have occurred in the past, or that are currently ongoing. This helps with coordination of efforts. If a volunteer group is available for a project, the coordinating staff member can look to see what was done at the same time the previous year, and put volunteers on the same project, for maximum efficiency at depleting the seed bank in that project area. If weeds spread by seed, it is not efficient to manage an area one year and then not return to it.

We ask that all personnel who directly work with, or coordinate, weed projects, enter data concerning the project into the Refuge weed database. This will include reporting location of the project, which may be done by drawing on maps or describing in words, to then be entered into GIS.

The weed database will assist with coordination between Refuge departments (i.e. Biology, Warm Springs/Pacific Commons Biology, Maintenance, Environmental Education, Public Use, Volunteer coordinator/volunteers, Refuge Nursery manager, EEC Restoration project staff) and on the ground weed efforts. The weed database will also assist coordination with partners such as Save the Bay, California Department of Fish and Wildlife, YCC crews, and CCC crews.

VOLUNTEER WEED MANAGEMENT PROJECTS

As with almost all weed management projects, once a control project is started on a particular infestation, management should be continued annually until the seed bank is exhausted (see "Priority Species" accounts for seed bank longevity for each species). Before a project is started, the person heading the project must commit to returning annually to treat that project area for the at least the number of years that the treatment species' seeds are viable. Volunteer coordinators and biologists should ensure that volunteers will be available in future years to continue projects they have started. Optimally, the person heading the project will be able to monitor the project area for at least 3 years after project completion to make sure there is no weed re-growth. Otherwise, the work done has only served to decrease the seed bank for one year, and will not serve to eradicate the population.

Projects need to be continued on an annual basis over many years to accomplish eradication. Check with the weed database for location and timing of weed control projects from the previous year(s).

SECTION for VOLUNTEER PROJECTS

- 1. One time group
- 2. Returning volunteers
- 3. Large groups (corporate groups, eagle scouts)

As of 2013, the following projects would be optimal for volunteers.

- 1) French broom (high priority weed) on Headquarters hillside (20+ year commitment).
- 2) Italian thistle (high priority weed) all over the north side of Headquarters Hill (3+ year commitment per patch).

- 3) Italian thistle (high priority weed) by Pavillion and on ridge above Harrier Spur.
- 4) Oxalis (EDRR) patches by vending machine outside of Headquarters building, in patches around Headquarters Hill, on the trail behind the T24 building. Bermuda buttercup is difficult to control. Prevent the plant from escaping constrained planters and accessing wildlands. Aggressive and repeated methods are required for eradication. Can start pulling this when it sprouts, but is easiest to see when it starts flowering, around February.
- 5) Fennel (high priority weed) on Headquarters Hill, Marshlands Road, Harrier Spur, Quarry Trail, and Mayhew's Landing (ongoing).
- 6) *Salsola soda* (high priority weed) in Mayhew's Landing, along trail by Pavillion and levees near EEC.
- 7) Fountain grass (EDRR) by Headquarters outlook (across from vending machine), Headquarters parking lot and along fenceline of Mayhew's Landing. Fountain grass is difficult to eradicate. Small clumps may be uprooted with a shovel, or a pick, or they may be cut back so as to prevent seeding. These methods may need to be repeated several times per year, and continued annually until the seed bank is exhausted, which may take up to seven years (Tunison et al. 1994).
- 8) Vetch (not ranked) on the hillside up to the Headquarters Building Delivery entrance and on hillside along Harrier Spur trail.
- 9) Algerian Sea Lavender (highest priority weed) in Coyote Creek Lagoon.

Some control projects will be ongoing because eradication of the seed sources are unlikely. In these cases, the best that can be done is regular maintenance control, which does not need to be done annually. If a volunteer coordinator is not sure that volunteers will be available to control a certain population every year, the following projects would be ideal;

- Acacia (medium priority weed) and eucalyptus (medium priority weed) seedlings and young trees around Headquarters Hill, and along Marshlands Road. Small seedlings may be pulled by hand, and young trees may be extracted using a weed wrench or cut with a hand saw. If the tree stump remains, herbicide treatment by a certified applicator should be applied using the cut stump method. Ideally stumps should be treated within 5 minutes of being cut to prevent resprouting. However if immediate application is not practical, stumps should be recut and treated in the fall prior to winter rains.
- 2) *Dittrichia* (high priority weed) along Marshlands Road, on the hillside up to the Headquarters building delivery entrance, Harrier Spur Trail and Tidelands Loop Trail (verify with biologist to make sure plants have not been treated with herbicide).
- 3) *Dittrichia* (high priority weed) in maintenance area and around trailers (verify with biologist to make sure plants have not been treated with herbicide).

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Bay Area Early Detection Network http://www.cal-ipc.org/WMAs/BAEDN/

California Department of Food and Agriculture- Integrated Pest Control http://www.cdfa.ca.gov/plant/ipc/

California Invasive Plant Council http://www.cal-ipc.org/

Don Edwards San Francisco Bay National Wildlife Refuge http://www.fws.gov/refuge/don_edwards_san_francisco_bay/

East Bay Chapter California Native Plant Society http://ebcnps.org/

National Invasive Species Council http://www.invasivespecies.gov/

San Francisco Bay Regional Water Quality Control Board http://www.waterboards.ca.gov/rwqcb2/

San Francisco Estuary Institute http://www.sfei.org/

San Francisco Estuary Invasive Spartina Project http://www.spartina.org/

South Bay Salt Pond Restoration Project http://www.southbayrestoration.org/

U.C. IPM Online- Statewide Integrated Pest Management Program http://www.ipm.ucdavis.edu

U.S. Fish and Wildlife Service Invasive Species http://www.fws.gov/invasives/

Invertebrates		
Vernal Pool Tadpole Shrimp	(Lepidurus packardi)	FE
Amphibians		
California Tiger Salamander	(Ambystoma californiense)	FT, CSSC
Mammals Solt March Harrist Manag	(Deithnodouterung n. novivertig)	DE CE CD
Salt Marsh Harvest Mouse		FE, SE, SP
Salt Marsh Wandering Shrew	(Sorex vagrans naticoetes)	CSSC
Dinda		
American Peregrine Falcon	(Falco peregrinus gratum)	SD
California Clapper Rail	(Rallus longirostris obsoletus)	FE SE SP
California Black Rail	(Laterallus iamaicensis coturniculus)	ST. SP
California Least Tern	(Sterna antillarum browni)	FE. SE. SP
Western Snowy Plover	(Charadrius alexandrinus nivosus)	FT, CSSC
Black Skimmer	(Rynchops niger)	CSSC (nesting)
Alameda Song Sparrow	(Melospiza melodia pusillula)	CSSC
Bryant's Savannah Sparrow	(Passerculus sandwichensis alaudinus)	CSSC
Loggerhead Shrike	(Lanius ludovicianus)	CSSC (nesting)
Northern Harrier	(Circus cyaneus)	CSSC (nesting)
San Francisco Common Yellowthroat	(Geothlypis trichas sinuosa)	CSSC
Western Burrowing Owl	(Athene cunicularia hypugea)	CSSC
Contra Costa goldfields	(Lasthenia conjugens)	FE
Golden Eagle	(Aquila chrysaetos)	SP
White-tailed Kite	(Elanus caeruleus)	SP
Vaux's Swift	(Chaetura vauxi)	CSSC (nesting)
Tricolored Blackbird	(Agelaius tricolor)	CSSC (nesting)
Short-eared Owl	(Asio flammeus)	CSSC (nesting)
Common Loon	(Gavia immer)	CSSC (nesting)
California Yellow Warbler	(Dendroica petechia brewsteri)	CSSC (nesting)
Barrow's Goldeneye	(Bucephala islandica)	CSSC (nesting)
American White Pelican	(Pelecanus erythrorhnchos)	CSSC (nesting)
Bank Swallow	(Riparia riparia)	ST
Bald Eagle	(Haliaeetus leucocephalus)	SE, SP
Plants		
Contra Costa Goldfields	(Lasthenia conjugens)	FE, CNPS 1B.1
Alkali Milk-vetch	(Astragalus tener var. tener)	CNPS 1B.2
Brittlescale	(Atriplex depressa)	CNPS 1B 2

Table 1 Special Status Species within Project Area

San Joaquin Spearscale	(Atriplex joaquiniana)	CNPS 1B.2
Congdon's Tarplant	(Centromadia parryi ssp. congdonii)	CNPS 1B.2
Point Reyes Bird's-beak	(Cordylanthus maritimus ssp. palustris)	CNPS 1B.2
Hoover's Button-celery	(Eryngium aristulatum var. Hooveri)	CNPS 1B.1
Hall's Bush-mallow	(Malacothamnus hallii)	CNPS 1B.2
Prostrate Navarretia	(Navarretia prostrata)	CNPS 1B.1
Saline Clover	(Trifolium depauperatum var. hydrophilum)	CNPS 1B.2

Federal and State Status:	CNPS Status:
FE =Federally-listed Endangered	1A - Presumed extinct in California FE – Federally Endangered
FT =Federally-listed Threatened	1B - Plants rare, threatened, or endangered in California and elsewhere $SR-State$ Rare
SE =State-listed Endangered	3 - Plants about which information is needed-a review list $\ensuremath{\text{SE}}-\ensuremath{\text{State}}$ Endangered
ST =State-listed Threatened SP =State Fully Protected Species	4 - Plants of limited distribution-a watch list .1 - seriously endangered in California
CSSC = California Species of Special Concern	.2 - fairly endangered in California

Table 2. Prioritized List of Weed Species

COMMON NAME	SCIENTIFIC NAME	CURRENT EXTENT of weed infestation	INVASIVENESS (current or potential)	IMPACT to T&E SPECIES (current of potential)	FEASIBILITY OF CONTROL (i.e. ease of detection, accessibility, control effort, cost, etc.) (multiplied by 0.5)	SSFB WMP Rank (priority)
Perennial pepperweed	Lepidium latifolium	2	3	3	0.5	8.5
Algerian Sea Lavendar	Limonium ramossissiumum	3	2	2	1.5	8.5
Yellow Starthistle	Centaurea solstitalis	3	3	1	1	8
Purple Starthistle	Centauria calcitrapa	3	2	1	1.5	7.5
Alkali Russian thistle	Salsola soda	2	2	3	0.5	7.5
Pampas grass/Jubata grass	Cortaderia sellanoa and Cortaderia jubata	3	2	1	1	7
Common reed/Giant reed	Phragmites australis and Arrundo donax	3	2	1	1	7
Stinkwort	Dittrichia graveolens	2	2	2	0.5	6.5
Italian thistle/Slenderflowered thistle	Carduus pycnocephalus and Carduus tenuiflorus	2	2	2	0.5	6.5
French broom	Genista monspessulana	2	3	1	0.5	6.5
Poison Hemlock	Conium maculatum	2	3	1	0.5	6.5
Fennel	Foeniculum vulgare	2	2	2	0.5	6.5
Himalayan blackberry	Rubus discolor/Rubus armeniacus	2	2	1	1	6
New Zealand spinach	Tetragonia tetragonioides	2	1	2	0.5	5.5
Iceplant	Carpobrotus edulis and Carpobrotus chilensis x edulis hybrid	2	1	2	0.5	5.5
Black mustard and other mustard species	Brassica nigra	2	1	2	0.5	5.5
Slenderleaf Iceplant	Mesembryanthemum nodiflorum	2	1	2	0.5	5.5
Wild radish	Raphanus sativus	2	2	1	0.5	5.5
Australian saltbush	Atriplex semibaccata	2	1	2	0.5	5.5
Blessed milk thistle	Silybum marianum	2	2	1	0.5	5.5
Olive	Olea europaea	2	1	1	1.5	5.5
Bull thislte	Cirsium vulgare	2	1	1	1	5
Myoporum	Myoporum laetum	2	1	1	1	5
Malta starthistle	Centaurea melitensis	2	1	1	0.5	4.5
Acacia and other Acacia species	Acacia melanoxylon	2	1	1	0.5	4.5
Tasmanian blue gum	Eucalyptus globulus	2	1	1	0.5	4.5

Table 3 Early Detection Weed Species Watch List

Common Name	Scientific Name
Australian bentgrass	(Agrostis avenacea)
Tree of heaven	(Ailanthus altissima)
White top (a.k.a. hoary cress)	(<i>Cardaria draba</i>) ¹
Wooly distaff thistle	(Carthamus lanatus)
Spotted knapweed	(Centaurea maculosa) ²
Silverleaf cotoneaster	(Cotoneaster pannosus)
Bermuda grass	(Cynodon dactylon) ¹
Cape/German/English ivy	(Delairea odorata and Hedera helix) ¹
Brazilian waterweed	(Egeria densa)
Erect veldtgrass	(Ehrharta erecta)
Edible fig	(Ficus carica) ¹
Water iris	(Iris pseudacorus)
Purple loosestrife	(Lythrum salicaria) ²
Pennyroyal	(Mentha pulegium)
Bermuda-buttercup	(Oxalis pes-caprae) ¹
Crimson fountain grass	(Pennecetum setaceum) ¹
Harding grass	(Phalaris aquatica) ¹
Smilo grass	(Piptatherum mileaceum) ¹
Salt marsh grass	(Pucinellia maritime) ¹
Giant Salvinia	(Salvinia molesia)
Chinese tallow tree	(Sapium sebiferum) ²
Scarlet wisteria tree (a.k.a. Red sesbania)	(Sesbania punicea) ²
Medusa head	(Taeniatherum caput-medusae) ¹
Tamarisk (a.k.a. Salt cedar)	(Tamarix chinensis and Tamarix ramosissima)
Gorse	(Ulex europaeus)
Periwinkle	(Vinca major) ¹

¹known to occur on Refuge, but isolated (will control) – keep eye out for other populations ² BAEDN's 2010 Early Detection & Rapid Response Target Species List

Table 4. Priority Weed Species for Management

<u>Highest Priority</u>	
Perennial pepperweed	(Lepidium latifolium)
Algerian sea lavender	(Limonium ramosissimum)
Yellow starthistle	(Centaurea solstitialis)
High Priority (Ranked from Highest to Lowest)	
Stinkwort	(Dittrichia graveolens)
Purple starthistle	(Centaurea calcitrapa)
Alkali Russian thistle (a.k.a. Glasswort, Opposite leaf Russian Thistle)	(Salsola soda)
Pampas grass/Jubata grass	(Cortaderia sellanoa and C. jubata)
Common reed/Giant reed	(Phragmites australis and Arrundo
	donax)
Italian thistle/Slenderflowered thistle	(Carduus pycnocephalus and C.
	tenuiflorus)
French broom	(Genista monspessulana)
Poison Hemlock	(Conium maculatum)
Fennel	(Foeniculum vulgare)
Medium Priority (Ranked from Highest to Lowest)	
Himalayan blackberry	(Rubus discolor/R. armeniacus)
New Zealand spinach	(Tetragonia tetragonioides)
Iceplant (a.k.a. Yellow sea fig or Hottentot fig)	(Carpobrotus edulis and C.chilensis x
	edulis hybrid)
Black mustard	(Brassica nigra)
Wild radish	(Raphanus sativus)
Blessed milk thistle	(Silybum marianum)
Olive	(Olea europaea)
Bull thistle	(Cirsium vulgare)
Myoporum (a.k.a. Ngaio tree)	(Myoporum laetum)
Australian saltbush	(Atriplex semibaccata)
Slenderleaf Iceplant	(Mesembryanthemum nodiflorum)
Malta starthistle (a.k.a. tocolote)	(Centaurea melitensis)
Wattle	(Acacia melanoxylon and other A. spp.)
Tasmanian blue gum	(Eucalyptus globulus)

Table 5. Direct Seeding Species

Common Name	Species	Common Name	Species
common yarrow	Achillea millefolium	hayfield tarweed	Hemizonia congesta
Diego bent grass	Agrostis pallens	telegraph weed	Heterotheca grandiflora
western ragweed	Ambrosia psilostachya	alkali barley	Hordeum depressum
fiddleneck	Amsinckia menziesii	poverty weed	Iva axillaris
Parish's pickleweed	Anthrocnenum subterminalis	CA goldfields	Lasthenia californica
California sagebrush	Artemisia californica	yellow-rayed goldfields	Lasthenia glabrata
mugwort	Artemisia douglasiana	forked pepperweed	Lepidium oxycarpum
saltbush	Atriplex californica	California sealavender	Limonium californicum
brittlescale	Atriplex depressa	Spanish clover	Lotus purshianus
seaside brome	Bromus maritimus	arroyo lupine	Lupinus succulentus
red maids	Calandrinia ciliata	coast tarweed	Madia sativa
common spikeweed	Centromadia pungens	common mousetail	Myosurus minimus
Coulter's horseweed	Conyza coulteri	purple needlegrass	Nasella pulchra
alkali weed	Cressa truxillensis	common phacelia	Phacelia californica
saltgrass	Distichlis spicata	fern-leaf phacelia	Phacelia distans
creeping wildrye	Elymus triticoides	alkali plantain	Plantago maritima
annual willow herb	Epilobium brachycarpum	silverweed	Potentilla anserina ssp pacifica
golden yarrow	Eriophyllum confertiflorum	CA buttercup	Ranunculus californicus
California poppy	Escholschzia californica	golden dock	Rumex maritimus
Western goldenrod	Euthamia occidentalis	perennial pickleweed	Sarcocornia pacifica
alkali heath	Frankenia salina	salt marsh sand spurry	Spergularia marina
sea milk wort	Glaux maritima	inkweed	Suaeda moquinii
marsh gumplant	Grindelia stricta	Pacific aster	Symphyotrichum chilensis
		annual fescue	Vulpia microstachys

Table 6. Container Plantings

Species	Common Name	Species	Common Name
Abronia sp.	verbenas	Ceanothus cuneatus	buck brush
Achilliea millefolium	yarrow	Chlorogalum pomeridianum	soaproot
Adenostoma fasciculatum	chamise	Clarkia sp.	farewell to spring
Agrostis pallens	Diego bent grass	Croton setigerus	dove weed
Allium dichlamydeum	onion	Danthonia californica	CA oatgrass
Anaphalis margaritacea	pearly everlasting	Dendromecon rigida	bush poppy
Aquilegia sp.	columbine	Deschampsia cespitosa	tufted hairgrass
Arabis blepharophylla	rock cress	Dichelostemma capitatum	blue dicks
Arctostaphylos sp.	Manzanita	Diplacus aurantiacus	sticky monkey flower
Artemisia californica	CA sage	Distichlis spicata	saltgrass
Artemisia douglasiana	mugwort	Downingia pulchella	flat-faced downingia
Arthrocnemum	Parish's pickleweed	Dudleya sp.	succulents
Asclepias fascicularis	narrowleaf milkweed	Elymus condensatus	giant wildrye
Astragalus tener	alkali milk vetch	Elymus glauca	blue wildrye
Atriplex californica	saltbush	Elymus triticoides	creeping wildrye
Atriplex depressa	brittlescale	Erigeron glaucus	seaside daisy
Baccharis douglasii	salt marsh baccharis	Eriodictyon californicum	yerba santa
Brodiaea terrestris	dwarf brodiaea	Eriogonum nudum	naked stem buckwheat
Calamagrostis nutkaensis	Pacific reedgrass	Eriophyllum confertiflorum	golden yarrow
Calochortus sp.	mariposa lily	Eriophyllum lanatum	wooly sunflower
Camissonia ovata	suncups	Eriophyllum	Lizard Tail
Cardamine californica	milkmaids	Festuca idahoensis	Idaho fescue
Castilleja densiflora	Johnny-nip	Festuca rubra	red fescue
Frankenia salina	alkali heath	Mimulus aurantiacus	sticky monkey flower
Garrya elliptica	coast silktassel	Monardella villosa	coyote mint
Gaultheria shallon	salal	Nassella pulchra	purple needlegrass
Grindelia stricta	marsh gumplant	Navarrettia cotulifolia	broad leaved navarrettia
Helianthus bolanderi	Bolander's sunflower	Phacelia sp.	various
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Heliotropium currasavicum	seaside heliotrope	Polystichum munitum	western swordfern
Hemizonia congesta	tarweed	Prunella vulgaris	self-heal
Heteromleles arbutifolia	Christmas berry	Prunus ilicifolia	holly-leaf cherry
Heterotheca grandiflora	telegraph weed	Pteridium aquilinum	western brackenfern
Heterotheca sessiliflora	golden aster	Quercus durata	scrub oak
Iris douglasiana	iris	Quercus lobata	white oak
Iva axillaris	poverty weed	Ranunculus californicus	buttercups
Kekiella sp.	penstemon	Rhamnus crocea	redberry
L. chamissonis	beach lupine	Rosa californica	California Wild Rose
L. formosus	summer lupine	Rubus ursinus	Pacific blackberry
Lasthenia glabrata	yellow-rayed goldfields	S. spathulata	
Layia chrysanthemoides	smooth tidytips	S. bipinnatifida	purple sanicle
Lepechinia sp.	pitcher sage	Salvia apiana	White Sage
Leymus condensatus	giant wildrye	Salvia mellifera	Black Sage
Leymus triticoides	creeping wildrye	Salvia spathacea	crimson sage
Leymus x multiflorus	many-flowered wildrye	Sanicula arctopoides	footsteps-of-spring
Limnanthes douglasii	common meadowfoam	Sarcocornia pacifica	perennial pickleweed
Limonium californica	CA sea lavender	Scrophularia californica	CA bee plant
Lomatium spp.	lomatium	Sidalcea malviflora	checker bloom
Lotus scoparius	deerweed	Sisyrinchium bellum	blue-eye-grass
Lupinus albifrons	silver lupine	Solidago californica	goldenrod
Malvella leprosa	alkali mallow	Spergularia marina	salt marsh sand spurry
Streptanthus glandulosus	Common Jewelflower	Viola pedunculata	golden violet
Symphoritrichum chilensis	Pacific aster	Wyethia angustifolia	mules ears
Tauschia hartwegii	Hartweg Tauschia	Yucca sp.	уисса
Trichostema lanatum	woolly blue curls	Zigadenus fremontii	Fremont's Camas
Trifolium fucatum	bull clover		
Trifolium wormskioldii	cow clover		
Triteleia laxa	Ithuriel's spear		

Appendix 1 Best Management Practices for Weed Spread Prevention

Sanitization and education are important to reduce and prevent the spread of invasive weed species. The following recommendations are made for all projects in all areas within the WMP. For more detailed information, refer to Preventing the Spread of Invasive Plants: Best Management Practices for Land Managers (Cal-IPC, 2012).

Programmatic Planning

• Adopt official policy to prevent invasive plant introduction and spread. Include invasive plant risk evaluation as a component of initial project planning. Integrate invasive plant prevention BMPs into design, construction, vegetation management and maintenance planning activities. Coordinate invasive plant prevention efforts with adjacent property owners and local agencies. Develop monitoring plans for BMP implementation and effectiveness.

Activity Planning

• Provide prevention training to staff, contractors and volunteers prior to starting work. Conduct a site assessment for invasive plant infestations before carrying out field activities. Schedule activities to minimize potential for introduction and spread of invasive plants. Integrate cleaning BMPs into planning for land management activities. Prepare worksite to limit the introduction and spread of invasive plants. Monitor the site for invasive plants after land management activities.

Project Material BMPs

• Use a weed-free source for project materials. Prevent invasive plant contamination of project materials when stockpiling and during transport.

Travel BMPs

• Plan travel to reduce the risk of invasive plant spread. Integrate cleaning activities into travel planning.

Tool, Equipment and Vehicle Cleaning BMPs

• Designate cleaning areas for tools, equipment, and vehicles. Inspect tools, equipment, and vehicles before entering and leaving the worksite. Clean soils and plant materials from tools, equipment, and vehicles before entering and leaving the worksite. Clean pack, grazing and support animals.

Clothing, Boots and Gear Cleaning BMPs

• Wear clothing, boots and gear that do not retain soil and plant material. Designate cleaning areas for clothing, boots and gear. Clean clothing, footwear and gear before leaving the worksite.

Waste Disposal BMPs

• Designate waste disposal areas for invasive plant materials. Render invasive plant material nonviable when keeping it on-site. When disposing of invasive plant material offsite, contain it during transport.

Soil Disturbance BMPs

• Minimize soil disturbance. Implement erosion control practices. Manage existing topsoil and duff material to reduce contamination by invasive plants.

Vegetation Management BMPs

• Schedule vegetation management activities to maximize the effectiveness of control efforts and minimize introduction and spread of invasive plants. Manage vegetation with methods favorable to desirable vegetation. Retain existing desirable vegetation and canopy.

Re-vegetation and Landscaping BMPs

• Develop re-vegetation and landscaping plans that optimize resistance to invasive plant establishment. Acquire plant materials locally. Verify that species used are not invasive. Re-vegetate and/or mulch disturbed soils as soon as possible to reduce likelihood of invasive plant establishment.

Appendix 2 Conservation Measures- Herbicide Safety & Environmental Considerations

Conservation measures to reduce adverse effects of herbicides on estuarine and vernal pool wildlife, plants and associated habitat elements (e.g., native vegetation, water, invertebrates) are presented below (Hogle et al. 2007). Herbicides used on the Refuge will go through a rigorous review process and will have completed necessary environmental documentation and procedures (e.g., pesticide use proposal). All herbicides approved by the Service through the Pesticide Use Proposal (PUP) process would be applied at label rates and all label recommendations would be followed (e.g., measures to preclude herbicide application on windy days).

Marsh Access: treatment, monitoring, re-vegetation

1) Vehicle and foot access pathways to target weed through tidal marsh will be minimized and use of existing roads and trails for control work will be maximized. Shortest possible access paths through the marsh to treatment patches will be identified prior to marsh access. Control methods to be used in each area will be selected to minimize potential impacts to marsh habitat and listed species from control operations.

2) If breeding CA clapper rails are determined to be present in a marsh, marsh access using aquatic-tracked vehicles (ARGOS) will not be allowed in contiguous marsh areas within 700-ft (213-m) of an identified clapper rail calling center (also referred to as the "700-ft Buffer Area") to avoid nest destruction, nest abandonment, and harassment of breeding rails. If the intervening distance across a major slough channel or across a substantial physical barrier between the rail calling center and the proposed access area is greater than 200-ft (61-m), then access may proceed within the breeding season.

3) Aquatic-tracked vehicles (ARGOS) will not travel within 50-ft (15-m) of slough channels to avoid crushing high vegetation, such as gumplant, that grows along channels.

4) Boats will be used to access marsh areas (where feasible) to treat large areas of target weed (ex. Pepperweed) along slough edges (e.g., use of intelli-sprayer with 300-ft hoseline) to further reduce the necessity of walking long distances through the marsh.

5) Crews will be instructed to walk carefully through the marsh, avoiding high pickleweed cover (e.g., >1-ft) and wrack where salt marsh harvest mice are likely to nest or find cover.

6) All personnel entering the marsh will be trained to identify and avoid direct and indirect disturbance to endangered species and associated habitats. Training material will include taped recordings of rail calls and the "Walking in the Marsh" protocol which addresses potential disturbance effects to rails and SMHM (Appendix 3).

7) Before spray operations commence each year, a qualified clapper rail biologist familiar with the project area will familiarize the spray crew with the area and ensure that all crew members know the location of each "700-ft Buffer Area" for protection of nesting clapper rails. Crews will be instructed to avoid these areas unless accompanied by a qualified clapper rail biologist.

8) During the clapper rail breeding season, before crews are allowed to enter a clapper rail "700-ft Buffer Area" to conduct control work, the Refuge Biologist, or designee, will work with other qualified clapper rail biologists and the spray crew to develop a strategy for control that will minimize the amount of time the crew spends in each "700-ft Buffer Area" while conducting control. This planning session will include use of detailed maps showing target weed locations within each "700 Buffer Area".

9) During the clapper rail breeding season, a qualified clapper rail biologist such as a Refuge Biologist, will accompany spray crews into "700-ft Buffer Areas" and will supervise and guide control operations within these areas.

10) Crews will limit time within a clapper rail (CLRA) nesting area (call center + 700-ft buffer) to 30 minutes or less to minimize disturbance to adult rails and to avoid potential nest destruction or nest abandonment.

11) If clapper rail nests are encountered during control work, observers will immediately leave the vicinity of the nest and report findings to the refuge biologist.

12) If clapper rail adults are encountered during control work, observers will move away from the birds if they are giving alarm calls or otherwise appear agitated.

Herbicide Application/Treatments

13) Herbicides will be applied by a certified applicator and in accordance with application guidelines and the manufacturer label.

14) Herbicide applications would be timed to coincide with ebbing tides to protect non-target vegetation, to allow a minimum of 6 hours dry time for glyphosate/imazapyr mixture applications, and at least 1 hour dry time for imazapyr applications.

15) Herbicides will be applied directly to target weeds and at low or receding tide to minimize the potential application of herbicide directly on the water surface.

16) The Refuge will train all certified applicators to correctly identify target weeds and distinguish this species from native species in the action area.

17) Certified applicators will be provided with GPS units and detailed maps showing specific locations where treatments will occur.

18) Field-based mixing and filling operations shall be confined to areas appropriately leveed/bermed or otherwise protected to minimize spread or dispersion of spilled herbicide or surfactants into surface waters.

19) Most target weed patches within marshes will be accessed for treatment only one time per year and will be accessed for mapping/post –treatment assessment monitoring only one time per year.

20) Few plants within vernal pools will be treated with herbicides. If *Lepidium latifolium* needs to be treated in a vernal pool that still contains native plants that have not gone to seed, it will only be treated using methods of direct contact. This includes wick application or "glove in glove" method (herbicide soaked cotton gloves worn over rubber or nitrile gloves, and stroked over the target weed leaf surfaces), so as to avoid the possibility of drift or non-target contact.

Re-vegetation

21) Plantings will be focused in areas where the target weed removal has occurred. Seeds will be collected from native populations within 15 miles of the Refuge, when possible.

22) Re-vegetation activities along the marsh-upland transition zone will be supervised by the Refuge biologist or Refuge representative to assure that access into the marsh is prohibited. Supervision will include on-site presence during restoration activities.

23) Re-vegetation activities will occur during low tides (<4.5-ft NGVD).

24) Re-vegetation activities will occur during October and November, outside of the clapper rail nesting season.

25) When digging holes for planting, impacts to existing native vegetation should be minimized.

Monitoring

26) Monitoring of patches within clapper rail buffer areas (700-ft from call center) will be avoided during the CA clapper rail nesting season.

27) Persons conducting post-treatment monitoring will be trained to identify and avoid direct and indirect disturbance to endangered species. Training material will include taped recordings of rail calls and the "Walking in the Marsh" protocol.

28) If clapper rail or salt marsh harvest mouse nests or adults are encountered during monitoring, observers will immediately leave the vicinity and report findings to the Refuge biologist.

Walking In the Marsh:

Methods to Increase Safety and Reduce Impacts to Wildlife/Plants

I. Safety

- A. *Before heading out into the marsh check the tides*: tides can affect your ability to move through the marsh. Be aware of how long you plan to be in the marsh, what channels you may have to cross, and how the tides will change while you are in the field.
- B. Plan your route through the marsh: use existing aerial imagery and maps to identify channels and sloughs that may impede access. When available, use high points such as boardwalks or levees to scope out a route. Scoping a route can be especially important in scenarios where visibility across the marsh is low (e.g., South Bay, Suisun). It may be necessary to flag stations and/or access corridors through the marsh prior to surveys. If more than one person is accessing the marsh, travel together along major access routes to avoid the development of multiple paths. At the end of the sampling period, persons furthest out should walk out first, meeting up with others along the major access route...this minimizes the potential of people getting lost and ensures that anyone who is injured will be found in a timely manner (before everyone else has left the marsh). The goal should be to plan a safe route into and out of the marsh while minimizing travel and pathways.
- C. *Channels and sloughs*: Avoid jumping channels in locations where you cannot see through vegetation on the opposite bank. Thick vegetation (e.g., pickleweed, gumplant) can obscure the edge of the bank. Considerations before jumping: depth of water/channel, steepness of the channel edges, tide levels. If you are not confident that you can make the jump and the edges have high dense vegetation that you cannot see through.....DO NOT JUMP.
- D. *Getting stuck in the mud*: If you are sinking into mud, try to keep moving to avoid getting stuck further. If a leg gets stuck, try to twist your leg to break the suction while leaning your weight on your other leg or knee. Use whatever material you have available (e.g., clipboard, backpack) for leverage (e.g., lean on those items).

E. *Other*: Besides general items such as water and food, it's a good idea to bring a flashlight and a phone (+GPS) in cases of an emergency. Let someone know what marsh area you will be in and when you plan to complete work for the day. Designate an end time and final meeting place when more than one person is out in the marsh at the same time.

II. Avoiding Impacts to Wildlife and Plants

- A. Movement through the Marsh. While walking through the marsh, keep noise to a minimum. Avoid using multiple pathways through the marsh. Use trails if they exist. Plan and map your route to minimize environmental impacts and decrease running into hazards/barriers such as large channels. When looking for a suitable place to jump a channel, do not walk along the edge of the channel/slough because these areas provide nesting habitat for many species including the endangered CA clapper rail. To find an alternate jump site, walk parallel to the channel at a distance where vegetation is lower in height and where visibility of the ground surface is greater. At all times, observe the environment you are walking through to avoid disturbance. Choose channel jump sites where vegetation is lower or you can clearly discern what you are jumping onto. In general, avoid walking adjacent and parallel to channels/sloughs.
- B. Avoiding nests and nest substrates. Tidal marsh species have nests that are well concealed and therefore easy to disturb when walking through the marsh. To avoid stepping on a nest, do not walk through thick vegetation or areas where you cannot see through to the ground. Avoid walking on vegetation whenever possible since plants serve as nesting substrate for many species in the marsh. In general, be aware of the area you are walking through. See Tables 1 for nest characteristics of common tidal marsh birds.
- C. *Bird Behavior*. If a bird vocalizes or flushes within close range of where you are standing or walking (e.g., < 10-m), it is possible that a nest or young are nearby. When these circumstances arise, stop whatever you are doing and leave the immediate area (be sure to watch where and what you are walking on). Choose an alternate route through the marsh, identify the new route and location of the sighting/occurrence on a map, and record coordinates of the location if possible. Be sure to pass this information on to others that may use the same route or are</p>

conducting surveys in the same area. Be very observant of where you walk as you leave the area. There exists the possibility that you could step on a nest or young, both of which can be concealed by vegetation and are cryptic. When alarmed, individuals may freeze in place (especially juveniles).

- D. *Tidal lagoons/ponds*. Avoid walking along tidal lagoons and ponds in marsh interiors that support foraging, roosting, or nesting shorebirds and waterfowl. Be observant of the distance at which birds flush or become alarmed.
- E. *Tides*. Avoid conducting surveys during high tides as much as possible. These are periods when many wildlife species are at greatest risk (e.g., predation). If your surveys require a high tide, be aware of the increased risk you may cause for wildlife and take all precautions to reduce that risk (e.g., avoiding areas where sensitive species are known to occur).

Nest characteristics	Clapper Rails	Black Rail	Song Sparrow	Common Yellowthroat	Marsh Wren
Size and shape (approximate)	Platform, 21- cm (8.3")	Small cup or bowl w/ canopy, 10- cm (4-5")	Small cup Approx 4 inches (10cm)	Small cup Approx 3 to 4 inches (10cm)	Spherical Football shape
Concealment	High concealment	High concealment	High concealment	High concealment	Fairly obvious
Height	Ground or slight rise	Below 30 cm	Below 30 cm	Commonly below 30 cm	Above 30 cm
Nest substrate					
Salicornia (pickleweed)	X*	X*	X*	Х	Х
<i>Grindelia</i> (gumplant)	X*	Х	X*	X*	Х
Distichlis spicata (saltgrass)	Х				
Scirpus maritimus		X*	X*	X*	X*
Scirpus americanus		X*	X*	X*	X*
Scirpus acutus/californicus		Х	Х	Х	X*
Scirpus robustus	Х				
Spartina foliosa	Х	Х	Х	Х	X*
<i>Typha</i> (cattails)		Х	X*	X*	X*
Wrack	Х				
Breeding season	March-July	April-July	March to June	March to July	

Table 1. Nest characteristics and breeding season of common tidal marsh birds.

*common nest substrate

Sources: PRBO (IRWM training document, 2004), Goals Project (2000), The Birds of North America (No.'s 340, 448, 704).

Like birds, the endangered salt marsh harvest mouse (SMHM) also constructs a nest. The nest is commonly a ball of vegetation that is on the ground or up in pickleweed (Fisler 1965). The reproductive season for SMHM peaks during summer and fall (Fisler 1965, Bias 1993).