San Francisco Estuary Invasive *Spartina* Project

2013 ISP Monitoring and Treatment Report

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Cover Photos: (clockwise from top left)

Top Left: An example of the type of GIS tools used by the ISP to map and treat invasive Spartina. Yellow dotted lines show the path followed by the biologist while overseeing treatment crews, with different colored points indicating treated and not yet treated hybrid Spartina. With this kind of information, ISP managers are able to keep track of what has been done and direct treatment personnel to plants that have been missed.

Right: A treatment crew from the San Mateo County Mosquito and Vector Control District push a flat-bottomed jon boat across the soft mud, transporting equipment and herbicide mixture to treat a remote hybrid Spartina alterniflora clone at Ravenswood Open Space Reserve in Menlo Park. Left untreated, these mudflat clones can expand at a rate of greater than three meters per year, and produce copious seed capable of floating long distances on the tide to establish new populations. (D. Kerr)

Bottom Left: Some native Spartina foliosa found along a tidal channel while kayaking Wildcat Marsh in Richmond.

Middle Left: A freshly treated clone of hybrid Spartina alterniflora that established in the South Bay Salt Pond Project’s Pond A6 (aka Knapp Tract) four years after the site was restored to tidal action.

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California Coastal Conservancy
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# TABLE OF CONTENTS

1. INTRODUCTION AND SUMMARY OF PROGRESS THROUGH 2012 ........................................... 1

2. TREATMENT AND MONITORING COMPLETED IN 2013 .................................................... 3

   2.1. Bay-wide Inventory ............................................................................................................ 3

   2.2. Regional Inventory and Treatment Activities ................................................................. 13

      2.2.1. Region 1: Marin ....................................................................................................... 13

      2.2.2. Region 2: San Francisco Peninsula ......................................................................... 19

      2.2.3. Region 3: San Mateo .............................................................................................. 23

      2.2.4. Region 4: Dumbarton South .................................................................................. 29

      2.2.5. Region 5: Union City ............................................................................................. 33

      2.2.6. Region 6: Hayward .................................................................................................. 37

      2.2.7. Region 7: San Leandro Bay .................................................................................... 41

      2.2.8. Region 8: Bay Bridge North .................................................................................. 45

      2.2.9. Region 9: Suisun ..................................................................................................... 49

      2.2.10. Region 10: Vallejo ................................................................................................ 53

      2.2.11. Region 11: Petaluma ............................................................................................ 57

      2.2.12. Region 12: Outer Coast ....................................................................................... 61

3. SPECIAL TOPICS .................................................................................................................. 65

   3.1. South Bay Salt Pond Restoration Project ....................................................................... 65

   3.2. Restricted Treatment Sites ............................................................................................ 69

   3.3. New Infestations and Sub-areas Added in 2013 ............................................................ 73

4. CONSIDERATIONS FOR 2014 ............................................................................................. 75

5. REFERENCES ......................................................................................................................... 77

Appendix 1. Target Species Descriptions

Appendix 2. ISP Program Areas
TABLE OF FIGURES

Figure 1. ISP Reporting Regions and 2013 survey efforts throughout San Francisco Bay Estuary .......... 5
Figure 2. 2013 Spartina alterniflora x foliosa hybrid presence throughout San Francisco Bay Estuary by ISP Reporting Region and sub-area................................................................. 7
Figure 3. 2013 Spartina densiflora presence throughout San Francisco Bay Estuary by ISP Reporting Region and sub-area ................................................................. 8
Figure 4. 2013 Spartina densiflora x foliosa hybrid, S. anglica, and S. patens presence throughout San Francisco Bay Estuary by ISP Reporting Region and sub-area ................................................................. 9
Figure 5. Bay-wide trend of invasive Spartina from 2005-2013 by net cover and treatment cover ........ 10
Figure 6. Bay-wide trends of invasive Spartina infestation from 2001-2013 by Reporting Region ........ 11
Figure 7. Bay-wide trend of invasive Spartina by treatment authorization since 2010, the most recent year the ISP was allowed to treat all detected invasive Spartina .................................................. 11
Figure 8. Distribution of invasive Spartina in 2013 across the 32 sub-areas of Reporting Region 1: Marin. .................................................................................................................. 14
Figure 9. Distribution of invasive Spartina in 2013 within the Corte Madera Creek Watershed of ISP's Region 1. .................................................................................................................. 15
Figure 10. Distribution of invasive Spartina in 2013 across the 35 sub-areas of Reporting Region 2: San Francisco Peninsula .................................................................................................. 20
Figure 11. Distribution of invasive Spartina in 2013 across the 26 sub-areas of Reporting Region 3: San Mateo .................................................................................................................. 25
Figure 12. Distribution of invasive Spartina in 2013 across the 25 sub-areas of Reporting Region 4: Dumbarton South ............................................................................................................... 30
Figure 13. Hybrid S. alterniflora clones off shore of Ideal Marsh North (21a) expanded rapidly between 2012 and 2013 and were treated by backpack in July ...................................................................... 33
Figure 14. Distribution of invasive Spartina in 2013 across the 21 sub-areas of Reporting Region 5: Union City .................................................................................................................. 34
Figure 15. Distribution of invasive Spartina in 2013 across the 27 sub-areas of Reporting Region 6: Hayward ..................................................................................................................... 38
Figure 16. Illustration of the importance of herbicide dry time, with efficacy near 100% at the upper elevation while efficacy was near 0% at the lower end ................................................................. 40
Figure 17. Distribution of invasive Spartina in 2013 across the 19 sub-areas of Reporting Region 7: San Leandro Bay ............................................................................................................. 43
Figure 18. Distribution of invasive *Spartina* in 2013 across the 12 sub-areas of Reporting Region 8: Bay Bridge North.

Figure 19. Distribution of invasive *Spartina* in 2013 across the single sub-area and adjacent shoreline of Reporting Region 9: Suisun.

Figure 20. Distribution of invasive *Spartina* in 2013 across the 4 sub-areas of Reporting Region 10: Vallejo.

Figure 21. Distribution of invasive *Spartina* in 2013 across the four sub-areas of Reporting Region 11: Petaluma.

Figure 22. Distribution of invasive *Spartina* in 2013 across the five sub-areas of Reporting Region 1: Outer Coast.

Figure 23. ISP biologists remove sediment-covered tarp first laid down in 2010 over a hybrid *S. alterniflora* clone at Drakes Head.

Figure 24. Map of the South Bay Salt Ponds and neighboring recent restoration projects in South San Francisco Bay. Sites are differentiated based on whether they have been restored to tidal action and if so, whether they have been infested with hybrid *S. alterniflora* or not as of 2013. Sites are labeled with the year in which they were restored to tidal action.

Figure 25. In September 2013, a mature hybrid *S. alterniflora* clone was found in the northwestern breach of Knapp Tract (Pond A6), which was opened to tidal action in 2010.

Figure 26. Distribution map of the 11 ISP sub-areas in which treatment of hybrid *S. alterniflora* has been restricted since 2011.

Figure 27. Bay-wide trend of invasive *Spartina* net area, by treatment authorization since 2010.
TABLE OF TABLES

Table 1. 2013 Bay-wide summary of invasive *Spartina* area by species .................................................. 6
Table 2. 2013 Bay-wide summary of invasive *Spartina* area by ISP Reporting Region. .............................. 6
Table 3. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 1: Marin. ........ 16
Table 4. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 2: San Francisco Peninsula ........................................................................................................................................... 21
Table 5. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 3: San Mateo .. 26
Table 6. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 4: Dumbarton South ............................................................................................................................................ 31
Table 7. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 5: Union City ... 35
Table 8. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 5: Hayward ...... 39
Table 9. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 7: San Leandro Bay ............................................................................................................................................... 44
Table 10. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 8: Bay Bridge North ............................................................................................................................................... 48
Table 11. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 9: Suisun ......... 51
Table 12. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 10: Vallejo ..... 55
Table 13. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 11: Petaluma .. 59
Table 14. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 12: Outer Coast. ............................................................................................................................................... 63
Table 15. Hybrid *S. alterniflora* quantities and trends from 2009-2013 at the 11 ISP sub-areas where treatment has been restricted since 2011 ........................................................................................................ 71
1. INTRODUCTION AND SUMMARY OF PROGRESS THROUGH 2012

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

In the last several decades, four non-native cordgrasses, including Spartina alterniflora (Atlantic smooth cordgrass), S. densiflora (Chilean cordgrass), S. anglica (English cordgrass), and S. patens (salt meadow cordgrass), were introduced to the Estuary. Each of these species is known to be invasive outside of its native range, and each has demonstrated varying degrees of invasiveness since establishing in the Estuary. Spartina species are closely related, and both S. alterniflora and S. densiflora subsequently hybridized with native S. foliosa (Daehler and Strong 1996; Ayres, Strong et al. 2003; Ayres, Grotkopp et al. 2008). Offspring of S. alterniflora x foliosa hybrids backcrossed with the parent species and with one another, producing an extremely robust and fertile “hybrid swarm,” which has invaded habitat throughout the Estuary, threatening the ecological integrity of the existing tidal wetlands and mudflats as well as the potential for future restoration efforts (Daehler and Strong 1996; Goals Project 1999; Ayres, Strong et al. 2003; State Coastal Conservancy 2003; Ayres, Zaremba et al. 2004; Ayres, Grotkopp et al. 2008). For further detail on each species of Spartina found in the Estuary, see Appendix 1.

Non-native Spartina has been determined to pose many serious threats to the Estuary, as was described in the ISP’s Programmatic Environmental Impact Statement/Environmental Impact Report (PEIS/EIR) adopted by the Conservancy in 2003 (State Coastal Conservancy 2003). Impacts of non-native Spartina include the destruction or degradation of endangered species habitat, loss of flood control capacity, creation of mosquito-breeding areas, corruption of salt marsh restoration efforts, and the possible eventual extinction of native Spartina foliosa. The purpose of the ISP is to implement a regional program to eradicate non-native Spartina species from the Estuary. This goal is accomplished through a highly-coordinated non-native Spartina inventory mapping and treatment effort that is planned and supervised by ISP biologists.

Mapping and treatment is conducted throughout the growing season each year (normally May through November) over the 50,000 acres of potential Spartina habitat. Beginning in 2008, inventory efforts have been conducted primarily on the ground on foot or using various boats, or by helicopter for select large and isolated sites. During inventory, biologists identify Spartina to species and map non-native plants as either a point, line or polygon using various handheld U.S. Global Positioning System (GPS) receivers running ArcPad (ESRI, Redlands, CA) geographic information systems (GIS) mapping software. Staff inventory sites prior to treatment to allow thorough and focused mapping as well as DNA sampling if appropriate. Having the target plant locations confirmed and mapped in advance also reduces the amount of ground that treatment crews must cover, enhancing worker safety and reducing the disturbance to the marsh. Biologists spatially demarcate each feature by assigning radii to points, widths to
Defining “Area”

The ISP uses the terms “net area” and “treatment area” to define the extent of non-native Spartina. Net area refers to the size of the infestation if the space between stems were subtracted from the overall footprint of the plant or clump of plants. Net area is the metric typically used in botanical surveys.

Treatment area describes the area that will be directly affected by treatment. Treatment area is a separate measurement used for planning, and it is generally 2 to 3 times greater than the net area of a given instance of invasive Spartina.

Unless otherwise noted in the text, all references to area in this report are net area.

lines, and the specifically mapped shapes of polygons, and assign a cover class to each feature to record density of live Spartina within that feature’s delineated boundary (see inset: Defining “Area”). During treatment, ISP biologists guide agency personnel or contracted herbicidal applicators to each previously-mapped Spartina feature and update that feature in ArcPad to record that day’s treatment activity (e.g. “treated,” “not treated,” “sub-optimally treated” etc.). This method of treatment survey has been implemented by ISP since 2010, and it has greatly improved the ability of field staff to accomplish thorough treatment of sites in the limited amount of time available with the treatment crew(s) for a given day. For further detail on the methods employed by ISP in its Treatment, Monitoring, and all other Programs, please see Appendix 2.

The ISP has made tremendous progress controlling non-native Spartina throughout the San Francisco Estuary and in the neighboring coastal areas of Point Reyes National Seashore and Bolinas Lagoon. In 2012, the ISP mapped a total of 38 net acres of non-native Spartina, a greater than 95% estuary-wide reduction since the peak of the invasion at 805 acres in 2005. In 2012, treatment restrictions that were set in place in 2011 for 26 sub-areas were lifted at fifteen sub-areas across the Estuary. This allowed for successful treatment of the 18.6 acres of Spartina in the sub-areas where treatment was authorized, while 19.6 acres of hybrid S. alterniflora was mapped in the 11 sites that maintain restrictions. These 11 sub-areas contained over half of the remaining non-native Spartina in the Bay in 2012 and maintain their treatment restrictions for the 2013 season. For further information on the invasion histories and treatment activities around the Bay, see the 2012 ISP Monitoring and Treatment Report (Rohmer, Kerr et al. 2014).
2. TREATMENT AND MONITORING COMPLETED IN 2013

The ISP’s activities and progress are described in this section, first from a bay-wide perspective, and then in more detail for each of the following 12 “Reporting Regions”:

<table>
<thead>
<tr>
<th>ISP Reporting Regions</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region 1. Marin</td>
<td>Region 7. San Leandro Bay</td>
</tr>
<tr>
<td>Region 2. San Francisco Peninsula</td>
<td>Region 8. Bay Bridge North</td>
</tr>
<tr>
<td>Region 4. Dumbarton South</td>
<td>Region 10. Suisun</td>
</tr>
<tr>
<td>Region 5. Union City</td>
<td>Region 11. Petaluma</td>
</tr>
<tr>
<td>Region 6. Hayward</td>
<td>Region 12. Outer Coast</td>
</tr>
</tbody>
</table>

The ISP developed the Reporting Regions based on regions initially defined by USFWS for assessment of California Ridgway’s rail (*Rallus obsoletus obsoletus*)\(^1\) populations. The reporting region boundaries also take into consideration natural and political landscape features, similarity in land management issues, geographic proximity and ecological connectedness of the treatment sub-areas, and general impact of non-native *Spartina* invasion on the region. Using these reporting regions allows the ISP to cohesively present treatment and monitoring data in a manner more suitable for correlation with California Ridgway’s rail (hereafter “Ridgway’s rail”) data.

2.1. BAY-WIDE INVENTORY

In 2013, the ISP prioritized inventory and treatment of sites to where there is known infestation and to areas at higher risk of new invasion. Prior to the beginning of the season, ISP biologists reviewed historical bay-wide inventory data, and determined the relative invasion pressure or impact risks according to the following set of criteria: historic presence of non-native *Spartina*, proximity to seed source from nearby infestations, and habitat suitability for colonization by non-native *Spartina*. Sub-areas were then divided into categories: sites for full inventory, sites for partial inventory, sites to be coarsely inventoried, and sites to not be monitored in 2013. Sites selected for full inventory have historic infestation or a high risk of colonization due to inviting habitat conditions and nearby seed source. Marshes selected for partial inventory are characterized by remote infestations in very large sub-areas; the historically colonized areas were thoroughly surveyed, though the remainder of the site was not. The 11 sites where treatment was restricted in 2013 were mapped less rigorously with more cursory methods than is standard for ISP, with the rationale being that detailed locations of plants would neither inform current year treatment nor inventory for the following year. For more detail on the mapping methods and data at the sites with coarser inventory, see Section 3.2 in this report. Sites where inventory was not conducted in 2013 have no recent infestation history and are under little threat of new infestation due to either sub-optimal quality of habitat for *Spartina* colonization or geographic isolation from extant infestations.

\(^1\) Previously named the California clapper rail (*Rallus longirostris obsoletus*).
This prioritization of sub-areas for inventory resulted in approximately 30,000 acres being thoroughly inventoried in 2013, which comprises ~60% of the total amount of potential *Spartina* habitat available, all of which was inventoried in 2012. **Figure 1** shows the location of the ISP Reporting Regions and sub-areas with status of inventory completion by sub-area for 2013. Where treatment was authorized in 2012 and 2013, the ISP reduced net cover by 34% between 2012 and 2013, which reflects a greater than 98% decline since peak infestation (**Table 1**). However, Bay-wide a total of 38.4 acres of non-native cordgrass was mapped (**Tables 1 & 2**), which represents a slight increase of 0.05% from the 38.2 acres documented in 2012 and a decline of 95.2% of the peak infestation of 805 acres in 2005. Four regions contain the vast majority of remaining non-native *Spartina* in the Estuary (in decreasing order of cordgrass cover): San Leandro Bay (13.13 acres), Hayward (11.63 acres), San Mateo (10.39 acres), and Dumbarton South (2.48 acres). The amount in these four regions accounts for 98% of all remaining invasive cordgrass in the Estuary. Each of the three most infested regions have some level of treatment restriction placed on them, and the 26 acres of hybrid *S. alterniflora* found in sub-areas with treatment restrictions accounts for almost 70% of the 2013 bay-wide total, which is 16.3% of the bay total at peak in 2005 (**Table 1, Figure 2**).

With many sub-areas approaching eradication, and considering the challenges of complete detection and treatment on any given day, the ISP instituted a second round of inventory and treatment in 2013. Most sites chosen for this Round 2 are linear stretches along bayfront or banks of flood control channels that were initially surveyed and treated early in the season, since they do not provide habitat for Ridgway’s rails. Some hybrid *S. alterniflora* plants may not have emerged at this point; since these sites have received intensive treatment for years, any remaining rhizomes have been weakened and are down to their last reserves. At this point in the year there is also a lot of grazing by herbivores (mainly geese), which can “mow” the above-ground biomass and cause biologists to miss a point that is still alive below-ground. Individual small plants may also be missed during the first round of inventory due to the tall pickleweed (*Sarcocornia pacifica*) and other native vegetation present, or due to the amount of effort needed to successfully cover the enormous size of some sites. All Round 2 inventories were conducted by ISP biologists in mid-November after all other sites in the Estuary had been surveyed and treated once, and managers could assess whether the time and resources were available to proceed. Round 2 treatments were conducted at 25 sites by a handful of participants over a four-day span in late November.

**Figures 2-4** show the Reporting Regions and provide graphic summaries of the distribution of each non-native *Spartina* species within each Reporting Region and each sub-area. **Figure 2** shows that the greatest presence of hybrid *S. alterniflora* is congregated around the Central and South Bay, but persisting at low levels in all other regions. Region 1 is the source of the *S. densiflora* infestation and where that species remains at its highest (**Figure 3**). **Figure 4** shows that *S. densiflora x foliosa* hybrid is no longer found in Region 2 and is exclusively in Region 1.
Figure 1. ISP Reporting Regions and 2013 survey efforts throughout San Francisco Bay Estuary.
### Table 1. 2013 Bay-wide summary of invasive Spartina area by species.

<table>
<thead>
<tr>
<th>Spartina species</th>
<th>Net Cover 2013</th>
<th>Net Cover 2012</th>
<th>Change Since 2012</th>
<th>% Change Since 2012</th>
<th>Peak Year</th>
<th>Peak Amount</th>
<th>Change Since Peak</th>
<th>% Change Since Peak</th>
<th>% Remaining since Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S. alterniflora x foliosa</strong> Sub-areas with 2013 Treatment Authorization</td>
<td>12.26 ac.</td>
<td>18.54 ac.</td>
<td>-6.28 ac.</td>
<td>-34%</td>
<td>2005</td>
<td>636.1 ac.</td>
<td>-623.84 ac.</td>
<td>-98.1%</td>
<td>1.9%</td>
</tr>
<tr>
<td><strong>S. alterniflora x foliosa</strong> Sub-areas with 2013 Treatment Restrictions</td>
<td>26.08 ac.</td>
<td>19.61 ac.</td>
<td>+6.47 ac.</td>
<td>+33%</td>
<td>2005</td>
<td>162.73 ac.</td>
<td>-136.22 ac.</td>
<td>-83.7%</td>
<td>16.3%</td>
</tr>
<tr>
<td><strong>S. alterniflora x foliosa TOTAL</strong></td>
<td>38.34 ac.</td>
<td>38.15 ac.</td>
<td>+0.19 ac.</td>
<td>+0.50%</td>
<td>2005</td>
<td>798.35 ac.</td>
<td>-760.01 ac.</td>
<td>95.2%</td>
<td>4.8%</td>
</tr>
<tr>
<td><strong>S. densiflora</strong></td>
<td>46.87 m²</td>
<td>105.12 m²</td>
<td>-58.25 m²</td>
<td>-55%</td>
<td>2005</td>
<td>4.17 ac.</td>
<td>-4.16 ac.</td>
<td>-99.7%</td>
<td>0.3%</td>
</tr>
<tr>
<td><strong>S. densiflora x foliosa</strong></td>
<td>16.19 m²</td>
<td>8.81 m²</td>
<td>+7.38 m²</td>
<td>84%</td>
<td>2005</td>
<td>347.82 m²</td>
<td>-331.63 m²</td>
<td>95.3%</td>
<td>4.7%</td>
</tr>
<tr>
<td><strong>S. anglica</strong></td>
<td>3.99 m²</td>
<td>1.86 m²</td>
<td>+2.13 m²</td>
<td>115%</td>
<td>2006</td>
<td>382.66 m²</td>
<td>-378.67 m²</td>
<td>99.0%</td>
<td>1.0%</td>
</tr>
<tr>
<td><strong>S. patens</strong></td>
<td>0.023 ac.</td>
<td>0.01 ac.</td>
<td>+0.013 ac.</td>
<td>125%</td>
<td>2005</td>
<td>0.65 ac.</td>
<td>-0.627 ac</td>
<td>96.5%</td>
<td>3.5%</td>
</tr>
</tbody>
</table>

### Table 2. 2013 Bay-wide summary of invasive Spartina area by ISP Reporting Region.

<table>
<thead>
<tr>
<th>Region #</th>
<th>Region Name</th>
<th># Sub-Areas</th>
<th>Potential Invasive Spartina (ac.)</th>
<th>Proportion of Region Authorized for Treatment (by acreage)</th>
<th>Net Cover 2013 (ac.)</th>
<th>Change Since 2012 (ac.)</th>
<th>% Change Since 2012</th>
<th>Peak Year</th>
<th>Peak Amount (ac.)</th>
<th>Change Since Peak (ac.)</th>
<th>% Decline Since Peak</th>
<th>% Remaining since Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Marin</td>
<td>32</td>
<td>2,988</td>
<td>All</td>
<td>0.05</td>
<td>-0.13</td>
<td>-71.71%</td>
<td>2005</td>
<td>6.10</td>
<td>6.05</td>
<td>-99.13%</td>
<td>0.87%</td>
</tr>
<tr>
<td>2</td>
<td>SF Peninsula</td>
<td>35</td>
<td>910</td>
<td>All</td>
<td>0.28</td>
<td>-0.86</td>
<td>-75.47%</td>
<td>2004</td>
<td>125.47</td>
<td>-125.20</td>
<td>-99.78%</td>
<td>0.22%</td>
</tr>
<tr>
<td>3</td>
<td>San Mateo*</td>
<td>26</td>
<td>4,926</td>
<td>97%</td>
<td>10.39</td>
<td>2.35</td>
<td>29.13%</td>
<td>2004</td>
<td>134.79</td>
<td>-124.40</td>
<td>-92.29%</td>
<td>7.71%</td>
</tr>
<tr>
<td>4</td>
<td>Dumbarton South</td>
<td>25</td>
<td>7,527</td>
<td>All</td>
<td>2.48</td>
<td>-2.57</td>
<td>-50.90%</td>
<td>2008</td>
<td>39.55</td>
<td>-37.06</td>
<td>-93.72%</td>
<td>6.28%</td>
</tr>
<tr>
<td>5</td>
<td>Union City</td>
<td>21</td>
<td>3,139</td>
<td>All</td>
<td>0.18</td>
<td>-0.25</td>
<td>-58.20%</td>
<td>2004</td>
<td>233.07</td>
<td>-232.89</td>
<td>-99.92%</td>
<td>0.08%</td>
</tr>
<tr>
<td>6</td>
<td>Hayward*</td>
<td>27</td>
<td>1,421</td>
<td>72%</td>
<td>11.63</td>
<td>4.06</td>
<td>53.60%</td>
<td>2005</td>
<td>225.91</td>
<td>-214.28</td>
<td>-94.85%</td>
<td>5.15%</td>
</tr>
<tr>
<td>7</td>
<td>San Leandro Bay*</td>
<td>19</td>
<td>412</td>
<td>64%</td>
<td>13.13</td>
<td>-1.92</td>
<td>-12.74%</td>
<td>2006</td>
<td>84.60</td>
<td>-71.47</td>
<td>-84.48%</td>
<td>15.52%</td>
</tr>
<tr>
<td>8</td>
<td>Bay Bridge North</td>
<td>12</td>
<td>1,703</td>
<td>All</td>
<td>0.14</td>
<td>-0.52</td>
<td>-78.42%</td>
<td>2009</td>
<td>6.49</td>
<td>-6.35</td>
<td>-97.80%</td>
<td>2.20%</td>
</tr>
<tr>
<td>9</td>
<td>Suisun</td>
<td>1</td>
<td>217</td>
<td>All</td>
<td>0.02</td>
<td>0.01</td>
<td>58.94%</td>
<td>2005</td>
<td>0.65</td>
<td>0.62</td>
<td>-96.41%</td>
<td>3.59%</td>
</tr>
<tr>
<td>10</td>
<td>Vallejo</td>
<td>4</td>
<td>19,884</td>
<td>All</td>
<td>0.06</td>
<td>0.04</td>
<td>156.77%</td>
<td>2009</td>
<td>0.32</td>
<td>0.26</td>
<td>-81.32%</td>
<td>18.68%</td>
</tr>
<tr>
<td>11</td>
<td>Petaluma</td>
<td>4</td>
<td>5,709</td>
<td>All</td>
<td>39.7 m²</td>
<td>-12.03 m²</td>
<td>-23.25%</td>
<td>2007</td>
<td>0.15</td>
<td>0.14</td>
<td>-93.59%</td>
<td>6.41%</td>
</tr>
<tr>
<td>12</td>
<td>Outer Coast</td>
<td>5</td>
<td>2,928</td>
<td>All</td>
<td>0.004</td>
<td>-0.015</td>
<td>-78.56%</td>
<td>2007</td>
<td>0.05</td>
<td>0.04</td>
<td>-91.51%</td>
<td>8.49%</td>
</tr>
<tr>
<td>ALL</td>
<td>SFB Estuary</td>
<td>211</td>
<td>51,764</td>
<td>98.66%</td>
<td>38.4</td>
<td>0.18</td>
<td>0.47%</td>
<td>2005</td>
<td>805.00</td>
<td>766.52</td>
<td>-95.23%</td>
<td>4.77%</td>
</tr>
</tbody>
</table>

* This region has treatment restrictions in at least one sub-area. The amount of the region that is authorized for full treatment is calculated by area in column 5.
Figure 2. 2013 *Spartina alterniflora x foliosa* hybrid presence throughout San Francisco Bay Estuary by ISP Reporting Region and sub-area.
Figure 3. *Spartina densiflora* presence throughout San Francisco Bay Estuary by ISP Reporting Region and sub-area.
Figure 4. 2013 Spartina densiflora x foliosa hybrid, S. anglica, and S. patens presence throughout San Francisco Bay Estuary by ISP Reporting Region and sub-area.
There were 12 sub-areas with prior invasion history in which no non-native *Spartina* was found in 2013: Murphy’s Creek (04i) and China Camp (23o) in Region 1; Hunter’s Point Naval Reserve (12d) and Fisherman’s Park (19m) in Region 2; Coyote Creek-Alameda County (05f, Region 5); Triangle Marsh (20w, Region 6); two sub-areas in Region 10, White Slough/Napa River (26a) and Sonoma Baylands (26d); Grey’s Field (24b, Region 11); and three sub-areas in Region 12, Limantour Estero (25b), Drakes Estero (25c), and Bolinas Lagoon, South (25e).

Re-infestation by hybrid *S. alterniflora* in 2013 occurred in minor amounts in three sub-areas where none was detected in 2012: in Region 5, Old Alameda Creek Upstream of 20 Tide Gates (13g) had 0.1 m² and Eden Landing-Pond 10 (13i) had 0.6 m², and Hayward Shoreline Outliers (20p, Region 6) had 2 m².

**Figures 5-7** show bay-wide and Regional trends of invasive *Spartina* over the years. Since the peak infestation of 805 acres in 2005, cover had dropped annually down to 38 acres in 2012, when the downward trend leveled out and no change was detected between 2012 and 2013 (**Figure 5**). As **Figure 7** shows, the decreasing trend continued within the sites where treatment was authorized, though was offset by an equal increase in *Spartina* in those 11 sites where full treatment has not been authorized since 2010. These trends are expected to continue until treatment is reauthorized, as is discussed further in greater detail in Section 3.2 of this report.

![Graph: Baywide Invasive Spartina Acreage by Year Since Peak](image)

*Figure 5. Bay-wide trend of invasive Spartina from 2005-2013 by net cover and treatment cover.*

* Treatment acre measurements began in 2008
**2007 data were artificially low due to constraints of aerial photo interpretation that year.*

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Invasive *Spartina* Project  
2013 ISP Monitoring and Treatment Report
Figure 6. Bay-wide trends of invasive *Spartina* infestation from 2001-2013 by Reporting Region.

Figure 7. Bay-wide trend of invasive *Spartina* by treatment authorization since 2010, the most recent year the ISP was allowed to treat all detected invasive *Spartina*.
2.2. REGIONAL INVENTORY AND TREATMENT ACTIVITIES

2.2.1. REGION 1: MARIN

The Marin Region is composed of 32 sub-areas in Marin County stretching from the Golden Gate Bridge to the mouth of the Petaluma River. It includes several large, contiguous tracts of marsh, most notably those in the Novato Creek, Corte Madera Creek and Las Gallinas Creek Watersheds. Relative to the Central and South Bays, the Marin Region has never had a very sizeable infestation in terms of acreage, but there were many small infestations scattered throughout the marshes and creek banks. However, the region has the most diverse infestation, with four non-native Spartina species present (S. alterniflora x foliosa hybrids, S. densiflora, S. densiflora x foliosa hybrids, and S. anglica), the majority occurring in the Corte Madera Creek Watershed. Creekside Park (04g) along upper Corte Madera Creek is the original introduction site for both S. densiflora and S. anglica to the Estuary, and the ISP has been able to contain S. anglica to this original introduction site, while S. densiflora had already been discovered in five other regions prior to the initiation of ISP treatment.

The ISP thoroughly inventoried 29 of this region’s 32 sub-areas on foot when accessible, and by kayak or Whaler for the upstream portions of watersheds and the jagged shorelines that are less traversable by foot. The three sub-areas that were not fully surveyed (Sausalito [23k], Bothin Marsh [23j], and Novato [23m]) are time-consuming to cover in their entirety, and are currently under low pressure for new infestation. Each of these marshes has small, isolated areas of historic and persisting infestation (combined less than 15 net m² in 2012), the areas around which were all thoroughly monitored on foot in 2013. A combined total of 1.0 net m² of hybrid S. alterniflora was found in these three sub-areas in 2013. A total of 0.05 net acre of non-native cordgrass of four species was found throughout the Marin Region in 2013, which reflects a 0.13-acre decline (72%) from 2012 inventory and a reduction of 6.05 acres (>99%) since peak infestation in 2005 (Figures 8 & 9, Table 3).

A total of 148 m² (0.037 acre) of hybrid S. alterniflora was inventoried in Region 1, more than half of which was found in the neighboring sub-areas Corte Madera Creek Mouth-North Bank (04j.1) and Lower Corte Madera Creek (Bon Air Rd to HWY 101) (04i). Twelve sub-areas of the Marin Region contained no hybrid S. alterniflora in 2013. Hybrid S. alterniflora was always just a minor component of the Corte Madera Creek non-native Spartina infestation, but managing it here poses special challenges. There is a great deal of native cordgrass throughout the lower watershed, and nascent hybrid infestations have gone undetected until they reached a detectible critical mass, or could otherwise be distinguished by distinct morphological characteristics. In addition, there are many residential properties along these tidelands, each with its own specific shoreline configuration where new infestations could gain a foothold (some with both a front and back yard composed of salt marsh habitat). The ISP and the Friends of Corte Madera Creek Watershed have worked to adapt inventory methods to address these areas, including shifting from kayak/boat surveys to contacting each landowner and surveying long stretches of private properties on the ground.

In 2013, ISP found several substantial clones of hybrid S. alterniflora along stretches of lower Corte Madera Creek from the Bon Air Bridge to Hwy 101. These stands were at least two years old but
Figure 8. Distribution of invasive *Spartina* in 2013 across the 32 sub-areas of Reporting Region 1: Marin.
had eluded detection because they had not previously matured to the extent that their hybrid morphological features were evident. In this area of the Estuary, mature hybrid is normally very tall (at least 50% taller than adjacent S. foliosa), with wide leaves, and often with red coloration well up along the thick stems. Treatment in 2013 consisted of herbicide applications on individual clones or scattered plants using a backpack sprayer.

As Region 1 is where S. densiflora was first introduced, this species remains most prevalent here, with 45 m², 96% of the Estuary’s persisting population. It has continued to decline in almost every sub-area, although in 2013, 17.5 m² of new S. densiflora (40% of region’s total cover) was found and promptly dug behind residential fences along College of Marin Ecological Study Area (04b). This area contains dense cover of brackish marsh species that were impacted heavily by the current drought, which enabled detection of the hidden S. densiflora. The remaining S. densiflora infestation continues to be managed primarily with manual removal at all sites. Spartina densiflora behaves like a discretely-rooted bunchgrass in the San Francisco Estuary, not spreading asexually by rhizomes, so when plants are small or coverage is sparse, each individual plant is dug with a trowel or shovel, taking care to capture as much of the root as possible. Manual methods are typically more effective than herbicide on these small plants, probably due to the in-rolled nature of the leaves that possess a very thick cuticle with little surface area, which may inhibit sufficient uptake of herbicide.
Table 3. Summary of 2013 invasive Spartina area by sub-area within Reporting Region 1: Marin.

<table>
<thead>
<tr>
<th>Reporting Region</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net Spartina Coverage By Species</th>
<th>All Invasive Spartina Cover</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>net area</td>
<td>percent</td>
<td>peak year</td>
</tr>
<tr>
<td>Split Sub-Area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REGION 1: MARIN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>03a: Blackie’s Creek (above bridge)</td>
<td>5/16; 9/25; 1/15/14</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>0</td>
<td>0.2 m²</td>
</tr>
<tr>
<td>03b: Blackie’s Creek Mouth</td>
<td>5/16; 9/25; 1/15/14</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>0</td>
<td>0.03 m²</td>
</tr>
<tr>
<td>04a: Corte Madera Ecological Reserve</td>
<td>5/31; 10/1; 1/10/14</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>0</td>
<td>0.05 m²</td>
</tr>
<tr>
<td>04b: College of Marin Ecological Study Area</td>
<td>5/17; 1/20/14</td>
<td>Dug</td>
<td>0</td>
<td>0</td>
<td>17.5 m²</td>
</tr>
<tr>
<td>04c: Piper Park East</td>
<td>5/22; 1/6/14</td>
<td>Dug</td>
<td>0</td>
<td>0</td>
<td>0.4 m²</td>
</tr>
<tr>
<td>04d: Piper Park West</td>
<td>5/22; 1/6/14</td>
<td>Dug</td>
<td>0</td>
<td>0</td>
<td>0.06 m²</td>
</tr>
<tr>
<td>04e: Larkspur Ferry Landing Area</td>
<td>5/17; 10/13</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>0</td>
<td>0.7 m²</td>
</tr>
<tr>
<td>04f: Riviera Circle</td>
<td>7/18-7/19; 8/30; 11/15</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>0</td>
<td>0.11 m²</td>
</tr>
<tr>
<td>04g: Creekside Park</td>
<td>6/26; 11/25-11/27</td>
<td>Dug, Backpack</td>
<td>3 m²</td>
<td>0.001 m²</td>
<td>8 m²</td>
</tr>
<tr>
<td>04h: Upper Corte Madera Creek (Above Bon Air Rd)</td>
<td>5/17; 7/19; 8/30; 9/30; 1/10/14</td>
<td>Dug, Backpack</td>
<td>13 m²</td>
<td>2 m²</td>
<td>3 m²</td>
</tr>
<tr>
<td>04i: Lower Corte Madera Creek (Bon Air Rd to HWY 101)</td>
<td>5/17; 8/30; 9/30; 1/16/14</td>
<td>Dug, Backpack</td>
<td>0.23 m²</td>
<td>24 m²</td>
<td>5 m²</td>
</tr>
<tr>
<td>04j: 1: Corte Madera Creek Mouth - North Bank</td>
<td>6/26; 10/13; 10/14; 11/25</td>
<td>Dug, Backpack</td>
<td>0.04 m²</td>
<td>54 m²</td>
<td>1 m²</td>
</tr>
<tr>
<td>04k: 2: Corte Madera Creek Mouth - South Bank</td>
<td>8/30; 9/30; 11/15</td>
<td>Dug, Backpack</td>
<td>0.08 m²</td>
<td>3 m²</td>
<td>0.3 m²</td>
</tr>
<tr>
<td>04l: Boardwalk No. 1 (Arkites)</td>
<td>5/22; 1/20/14</td>
<td>Dug</td>
<td>0.002 m²</td>
<td>0</td>
<td>2 m²</td>
</tr>
<tr>
<td>04m: Murphy Creek</td>
<td>To Invasive Spartina</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>09: Tiscornia Marsh / Pickleweed Park</td>
<td>5/15; 9/25; 1/8/14</td>
<td>Dug, Backpack</td>
<td>0.04 m²</td>
<td>0.02 m²</td>
<td>0.1 m²</td>
</tr>
<tr>
<td>23a: Brickyard Cove</td>
<td>5/16; 9/30</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>0</td>
<td>10 m²</td>
</tr>
<tr>
<td>23b: Beach Drive</td>
<td>9/25</td>
<td>Backpack</td>
<td>0</td>
<td>6 m²</td>
<td>0</td>
</tr>
<tr>
<td>23c: Loch Lomond Marina</td>
<td>9/25</td>
<td>Backpack</td>
<td>0</td>
<td>0.7 m²</td>
<td>0.002 m²</td>
</tr>
<tr>
<td>23d: 1: San Rafael Canal Mouth East</td>
<td>5/16</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>5 m²</td>
<td>0</td>
</tr>
<tr>
<td>23d: 2: San Rafael Canal Mouth West</td>
<td>9/25</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>0</td>
<td>2 m²</td>
</tr>
<tr>
<td>23e: Muzzi and Maratsa Marsh</td>
<td>5/31; 10/1; 10/13; 1/10/14</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>20 m²</td>
<td>0.2 m²</td>
</tr>
<tr>
<td>23f: Paradise Cai</td>
<td>7/18</td>
<td>Dug</td>
<td>0</td>
<td>0</td>
<td>0.2 m²</td>
</tr>
<tr>
<td>23g: Greenwood Cove</td>
<td>5/21; 1/15/14</td>
<td>Dug</td>
<td>0.06 m²</td>
<td>0</td>
<td>0.4 m²</td>
</tr>
<tr>
<td>23h: Strawberry Point</td>
<td>5/21; 3/31/14</td>
<td>Dug</td>
<td>0</td>
<td>0</td>
<td>0.3 m²</td>
</tr>
<tr>
<td>23i: Strawberry Cove</td>
<td>9/25</td>
<td>Backpack</td>
<td>0</td>
<td>7 m²</td>
<td>0</td>
</tr>
<tr>
<td>23j: Bothin Marsh</td>
<td>9/25</td>
<td>Backpack</td>
<td>0</td>
<td>0.8 m²</td>
<td>0</td>
</tr>
<tr>
<td>23k: Sausalito</td>
<td>9/25</td>
<td>Backpack</td>
<td>0</td>
<td>0.1 m²</td>
<td>0</td>
</tr>
<tr>
<td>23l: Starkeweather Park</td>
<td>5/15; 8/14</td>
<td>Dug</td>
<td>0</td>
<td>0</td>
<td>0.002 m²</td>
</tr>
<tr>
<td>23m: Novato</td>
<td>7/18</td>
<td>Backpack</td>
<td>0</td>
<td>0.1 m²</td>
<td>0</td>
</tr>
<tr>
<td>23n: Triangle Marsh and shoreline</td>
<td>S. densiflora; 10/15; S. alterniflora hybrid</td>
<td>Dug, n/a</td>
<td>0</td>
<td>0.2 m²</td>
<td>0.06 m²</td>
</tr>
<tr>
<td>23o: China Camp</td>
<td>No Invasive Spartina 2012 or 2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>REGION 1 TOTAL</td>
<td></td>
<td></td>
<td>4 m²</td>
<td>16 m²</td>
<td>148 m²</td>
</tr>
</tbody>
</table>
There are no large, mature *S. densiflora* plants remaining in the Estuary, so the ISP is essentially working to exhaust its seed bank, which is viable for approximately 3-5 years. To efficiently accomplish this, ISP conducts two rounds of inventory and removal each year, one in May/June and the other in January, which allows for the greatest possible detection of the target plants; in May/June, the *S. densiflora* will often have a flower stalk sticking up above the surrounding vegetation, and in January, the pickleweed is either red or fully senescent, which allows the dark green *S. densiflora* to visually stand out.

At two locations where *S. densiflora* is growing in a marsh with a Ridgway’s rail population, Creekside Park (4g) and Corte Madera Creek Mouth-North Bank (4j.1), imazapyr herbicide was applied in mid-June to halt the development of the plants and prevent dispersal of seed. This was followed by several days of manual removal later in the season (after September 1), when crews could access the sites without potentially disrupting nesting Ridgway’s rails. The treatment effort was substantially reduced at both of these sites in 2013, with only three days of manual removal required to remove all of the *S. densiflora* plants remaining at these two sites.

Likewise, *S. densiflora x foliosa* hybrid persists in reduced amounts in Region 1 and as of 2013, nowhere else in the Estuary. A total area of 16.2 m² was mapped across nine marshes, which is an 84% increase over 2012 inventory. This increase was driven almost entirely by proliferation of new patches in Upper Corte Madera Creek (Above Bon Air Rd) (04h) where an increase of 11 m² (600%) occurred between 2012 and 2013. The increase in *S. densiflora* hybrid from 2012 to 2013 is very similar to the situation with hybrid *S. alterniflora* described above, where plants may escape detection until they mature. *Spartina densiflora* hybrid can also take multiple years to show the morphological features that distinguish it from an adjacent or surrounding stand of native *S. foliosa*. By the time a plant is detected, it can already be a substantial clone, and since the entire Estuary-wide infestation of this species is so small, the addition of one new clone can represent a significant percentage increase. Fortunately imazapyr has been more consistently effective on this hybrid than on pure *S. densiflora*, probably because the hybrid is more similar to its *S. foliosa* parent, with wider leaves that are neither in-rolled nor possess a thick cuticle.

Completing the Marin Region’s suite of non-native *Spartina* species is *S. anglica*, which has only ever been found at one sub-area, Creekside Park (04g), where 4 m² persisted in 2013. Despite the increase between 2012 and 2013, remaining *S. anglica* at Creekside Park is at 0.01% of its 2006 peak of 383 m². After successfully reducing the *S. anglica* infestation down to just 2 m² by 2012, several patches were discovered during treatment in 2013, hidden as a sub-strata beneath a thick fringe of *S. foliosa* along a slough bank. *Spartina anglica* is often not in flower by treatment time since the scheduling for this site is largely dictated by its primary invader, *S. densiflora*, with the goal of the herbicide application being to stop seed production in that species until digging can be implemented in the autumn. When *S. anglica* is not bearing its conspicuous flowers and is growing under dense *S. foliosa*, it can be very hard to distinguish. This likely explains the increase in this species from 2012 to 2013, and these lessons will be applied to the eradication of *S. anglica* moving forward.

There were two sub-areas in Region 1 that had previously been infested with non-native cordgrass where no non-native was found in 2013: Murphy’s Creek (04l), which has a history of *S. densiflora* infestation since 2007, and China Camp (23o) where a hybrid *S. alterniflora* clone was found and treated in 2011.
Ridgway’s rail surveys conducted by the ISP and Point Blue Conservation Science at 30 sites resulted in reduced detections in 2013 from those in the prior three years (McBroom 2013), though this data is believed to be a superficial result of poor survey conditions and does not reflect an actual population decline in the region. Ridgway’s rail populations in the Marin Region are supported by abundant large native marshes of high quality habitat, and are not expected to be impacted by the remaining 219 m² of non-native Spartina or in this region. As a result, the ISP has not targeted Region 1 for habitat enhancement with the exception of Creekside Park, where the previously rampant infestation by multiple Spartina species displaced many native marsh plants. ISP provided 600 Grindelia stricta plants to Friends of Corte Madera Creek Watershed for installation at Creekside Park in 2012-2013 to supplement nesting substrate and high tide refuge cover for resident California Ridgway’s rails. Due to generally abundant native cordgrass and low threat from hybrid S. alterniflora in the region, the ISP collected S. foliosa from two nearby Marin County marshes, Starkweather Park (23l) and Strawberry Cove (23i), for propagation and future outplanting by the Restoration Program.
2.2.2. REGION 2: SAN FRANCISCO PENINSULA

The 35 sub-areas of the San Francisco Peninsula Region extend from the Golden Gate Bridge to the San Mateo Bridge and by 2012, treatment by ISP partners had predominantly returned the sites to the mud-flat and riprap-lined shoreline habitats that they were prior to infestation by hybrid *S. alterniflora*. The three most prominent extant marsh habitats in the region are found at the confluence of Colma Creek and San Bruno Creek (site 18) in South San Francisco, the shoreline of SFO (19h), and at the mouth of Seal Slough (19p) in San Mateo. Only one sub-area (12h) was not thoroughly inventoried in 2013 and consists of Treasure, Yerba Buena and Angel Islands, all of which are under minimal threat of infestation due to the low habitat quality of their shorelines. The remaining 34 sub-areas were surveyed completely on foot and resulted in 0.28 acre of non-native cordgrass. This amount is 0.86 acre less (a 75% reduction) than what was found in this region in 2012 and represents a total of 0.22% of the footprint (125.47 acres) at the peak in 2004 (Table 2).

Hybrid *S. alterniflora* has been tremendously reduced across most sites in this region with 29 of 35 sub-areas containing less than 10 net m² of cover. The majority (87%) of the remaining hybrid *S. alterniflora* in this region is located in four sub-areas (in order of decreasing amount): Sanchez Marsh (19k), Seal Slough Mouth-Central Marsh (19p.1), Seal Slough Mouth-Peripheral Marshes (19p.2), and SFO (19h) (Table 4, Figure 10). In November 2013, ISP staff conducted a second round of inventory to detect and treat all new sprouts and regrowth that may have appeared since the original rounds of inventory and treatment in June, July and August. A total of 100 new plants were mapped totaling 4.6 net m² of cover. ISP partners treated all of these features that otherwise would have enjoyed a full growing season prior to 2014 inventory and treatment.

*S. densiflora* has persisted at very low levels in Region 2 at two neighboring sub-areas, Sanchez Marsh (19k) and Burlingame Lagoon (19l), since its discovery here in 2004. In 2013 only 0.19 m² was mapped at these two sites combined, which is a greater than 40% decline since 2012 and a greater than 99.9% decline since its peak here in 2007. These *S. densiflora* were removed manually and these areas continue to receive the twice-annual survey that ISP implements for this species (described in detail in Section 2.1) as the seed bank is exhausted. Similarly, *S. densiflora* hybrid has also been present in Region 2, and also only at these same two sub-areas since 2006. 2013 marks the first year in which *S. densiflora* hybrid has been found neither at these sites, nor any other sub-area in the San Francisco Peninsula Region.

ISP partner and Conservancy grant recipient San Mateo County Mosquito and Vector Control District (SMCMVCD) treats the vast majority of the hybrid *S. alterniflora* sites in the San Francisco Peninsula Region. Most sites in this region were treated with herbicide by backpack sprayer, and 24 of the 33 sub-areas (73%) with any hybrid *S. alterniflora* detected in 2013 had less than 2 m² remaining. Airboat applications were still essential at several sites because target plants were growing too far out onto the extensive mudflats to allow access by foot. The airboat was employed at several sub-areas within the Colma Creek/San Bruno Complex, at San Francisco International Airport and the neighboring sub-areas to the south, and also at the two largest remaining infestations in the region: Sanchez Marsh and Seal Slough. The airboat is also used to deploy personnel with backpacks throughout the sites to increase safety and reduce worker fatigue.
Figure 10. Distribution of invasive *Spartina* in 2013 across the 35 sub-areas of Reporting Region 2: San Francisco Peninsula.
### Table 4. Summary of 2013 invasive Spartina area by sub-area within Reporting Region 2: San Francisco Peninsula.

<table>
<thead>
<tr>
<th>Reporting Region</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net Spartina Coverage By Species</th>
<th>All Invasive Spartina Cover</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Species</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>controla</td>
<td>peters</td>
<td>foliosa</td>
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<tr>
<td><strong>Region 2: San Francisco Peninsula</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12a: Pier 34</td>
<td>7/30</td>
<td>Backpack</td>
<td>0</td>
<td>0.02 m²</td>
<td>0</td>
</tr>
<tr>
<td>12b: Pier 98 / Heron’s Head</td>
<td>9/12, 11/22</td>
<td>Backpack</td>
<td>0</td>
<td>43 m²</td>
<td>0</td>
</tr>
<tr>
<td>12c: India Basin</td>
<td>7/30</td>
<td>Backpack</td>
<td>0</td>
<td>0.03 m²</td>
<td>0</td>
</tr>
<tr>
<td>12d: Hunters Point Naval Reserve</td>
<td></td>
<td>No Invasive Spartina 2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12e: Yosemite Channel</td>
<td>10/16</td>
<td>Backpack</td>
<td>0</td>
<td>2 m²</td>
<td>0</td>
</tr>
<tr>
<td>12f: Candlestick Cove</td>
<td>7/29, 11/26</td>
<td>Backpack</td>
<td>0</td>
<td>0.1 m²</td>
<td>0</td>
</tr>
<tr>
<td>12g: Crissy Field</td>
<td>9/19</td>
<td>Backpack</td>
<td>0</td>
<td>0.07 m²</td>
<td>0</td>
</tr>
<tr>
<td>12h: Yerba Buena Island</td>
<td>10/15</td>
<td>Backpack</td>
<td>0</td>
<td>0.003 m²</td>
<td>0</td>
</tr>
<tr>
<td>12i: Mission Creek</td>
<td>7/30</td>
<td>Backpack</td>
<td>0</td>
<td>0.003 m²</td>
<td>0</td>
</tr>
<tr>
<td>18a: Colma Creek</td>
<td>7/10, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>2 m²</td>
<td>0</td>
</tr>
<tr>
<td>18b: Navigable Slough</td>
<td>7/10, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>3 m²</td>
<td>0</td>
</tr>
<tr>
<td>18c: Old Shipyard</td>
<td>7/10, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>0.3 m²</td>
<td>0</td>
</tr>
<tr>
<td>18d: Inner Harbor</td>
<td>7/10, 8/9, 11/26 (R2)</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>0.1 m²</td>
<td>0</td>
</tr>
<tr>
<td>18e: Sam Trans Peninsula</td>
<td>7/10, 8/9, 11/26 (R2)</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>0.7 m²</td>
<td>0</td>
</tr>
<tr>
<td>18f: Confluence Marsh</td>
<td>7/10, 8/9</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>0.2 m²</td>
<td>0</td>
</tr>
<tr>
<td>18g: San Bruno Marsh</td>
<td>7/11, 8/11, 11/26 (R2)</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>7 m²</td>
<td>0</td>
</tr>
<tr>
<td>18h: San Bruno Creek</td>
<td>7/10, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>72 m²</td>
<td>0</td>
</tr>
<tr>
<td>19a: Brisbane Lagoon</td>
<td>7/9, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>0.4 m²</td>
<td>0</td>
</tr>
<tr>
<td>19b: Sierra Point</td>
<td>7/9, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>0.8 m²</td>
<td>0</td>
</tr>
<tr>
<td>19c: Oyster Cove</td>
<td>7/9, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>2 m²</td>
<td>0</td>
</tr>
<tr>
<td>19d: Oyster Point Marina</td>
<td>7/9, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>0.08 m²</td>
<td>0</td>
</tr>
<tr>
<td>19e: Oyster Point Park</td>
<td>7/9, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>0.4 m²</td>
<td>0</td>
</tr>
<tr>
<td>19f: Point San Bruno</td>
<td>7/9</td>
<td>Backpack</td>
<td>0</td>
<td>0.8 m²</td>
<td>0</td>
</tr>
<tr>
<td>19g: Seaplane Harbor</td>
<td>9/12</td>
<td>Backpack</td>
<td>0</td>
<td>0.2 m²</td>
<td>0</td>
</tr>
<tr>
<td>19h: SFO</td>
<td>9/10, 9/12</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>141 m²</td>
<td>0</td>
</tr>
<tr>
<td>19i: Mills Creek Mouth</td>
<td>7/11, 8/9</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>2 m²</td>
<td>0</td>
</tr>
<tr>
<td>19j: Easton Creek Mouth</td>
<td>7/11, 8/9</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>0.6 m²</td>
<td>0</td>
</tr>
<tr>
<td>19k: Sanchez Marsh</td>
<td>5/20, 9/9, 9/12; 1/22/14</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>454 m²</td>
<td>0.2 m²</td>
</tr>
<tr>
<td>19l: Burlingame Lagoon</td>
<td>5/20, 9/9, 9/12; 1/22/14</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>9 m²</td>
<td>0.03 m²</td>
</tr>
<tr>
<td>19m: Fisherman’s Park</td>
<td>No Invasive Spartina 2012 or 2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19n: Coyote Point Marina / Marsh</td>
<td>7/26, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>1 m²</td>
<td>0</td>
</tr>
<tr>
<td>19o: San Mateo Creek / Ryder Park</td>
<td>7/11, 11/26 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>2 m²</td>
<td>0</td>
</tr>
<tr>
<td>19p: 1: Seal Slough Mouth - Central Marsh</td>
<td>10/10</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>227 m²</td>
<td>0</td>
</tr>
<tr>
<td>19p: 2: Seal Slough Mouth - Peripheral Marshes</td>
<td>7/26, 10/10; 11/26 (R2)</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>159 m²</td>
<td>0</td>
</tr>
<tr>
<td>19r: Anza Lagoon</td>
<td>7/11</td>
<td>Backpack</td>
<td>0</td>
<td>0.1 m²</td>
<td>0</td>
</tr>
<tr>
<td><strong>Region 2 Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
New treatment methods were utilized at two sites in 2013 based on feedback from ISP biologists regarding efficacy and efficiency. Both Pier 98/Heron’s Head (12b) and Crissy Field (12g) transitioned from manual removal to imazapyr application; when digging hybrid *S. alterniflora*, the rhizomes often break, which stimulates vegetative growth. In the marsh environment it can also be virtually impossible to remove every bit of rhizome from the substrate, especially once the infestation has expanded beyond a small, discrete patch. In both marshes, digging had been attempted for multiple seasons. At Heron’s Head, the infestation was still continuing to expand, and had reached a level where manual removal was infeasible. Although the Crissy Field clone was initially small, it expanded in response to inadequate early digging efforts. Eventually the clone was reduced by very intensive digging by the National Park Service, but it was unlikely that this method would result in local eradication. Both infestations were treated with imazapyr in 2013, Crissy Field for the first time.

Round 2 inventory and treatment (as described in the introduction to Section 2 of this report) was conducted at 15 sites approaching eradication in Region 2 in 2013. This included seven of the eight sub-areas in the Colma Creek/San Bruno complex (Site 18) that once contained 55 acres of hybrid *S. alterniflora* at the peak of the infestation, as well as eight sub-areas in the West Bay Complex (Site 19).

The ISP surveyed 33 sites in the San Francisco Peninsula Region for California Ridgway’s rails in 2013, and one additional site was surveyed by Avocet Research Associates. Detections were the same as 2012 (three birds), though both of these years are lower than prior years, when hybrid *S. alterniflora* dominated multiple shorelines and provided a large amount of non-native habitat for Ridgway’s rails at the Colma Creek/San Bruno complex in South San Francisco. With the removal of invasive hybrid monocultures from this area, the mudflats are now restored to their original extent, and the region is once again limited in the amount of area at suitable elevation for native tidal marsh vegetation to establish. With no significant opportunity to enhance habitat that could support California Ridgway’s rail in this region, the ISP’s revegetation efforts here have been limited and experimental. A pilot project to introduce *S. foliosa* along Colma Creek (18a) and in San Bruno Marsh (18g) was begun by W. Thornton (San Francisco State University’s Romberg Tiburon Center) in 2011 and continued through 2013.
2.2.3. REGION 3: SAN MATEO

The San Mateo Region consists of 26 sub-areas that line the western South Bay between the San Mateo and Dumbarton Bridges. Control of hybrid *S. alterniflora* in this region is especially important to protect some large historic tracts of native marsh (Greco Island [02f, 02h]), extensive tracts of restored marsh (Bair Island [02c, 02d]), and remaining large commercial salt ponds that are slated for restoration to tidal activity. This region has been heavily impacted by the hybrid *S. alterniflora* invasion, which quickly colonized the shoreline, marshes, and newly-breached areas undergoing restoration from agriculture or salt production back to fully-tidal marsh. Only one sub-area in this region was not thoroughly inventoried in 2013: a new restoration marsh, Central Bair (02o), that was only breached in early 2013. The remaining 25 sub-areas were extensively surveyed on foot or by various boats (airboat, kayak, Whaler, or Achilles inflatable boat). In prior years the expanses of Bair Island were frequently inventoried by helicopter, which is a coarser method of mapping. In 2013 the entire site was mapped on the ground, which yielded a much finer scale and better quality inventory of the marsh. B2 North Quadrant East (02c.1b) is not authorized for full treatment and so was more coarsely mapped, since finer scale locations of plants were not needed for ground-based treatment.

In 2013 a total of 10.69 acres of non-native *Spartina* was mapped, all but 0.5 m² of which was hybrid *S. alterniflora* (Table 5, Figure 11). This represents a 29% increase over 2012 inventory, which was driven by an almost 4-acre increase in the only four sites in this region containing >1 acre of infestation (in decreasing order): B2 North Quadrant East (02c.1b), B2 North Quadrant South (02c.2), Ravenswood Slough and Mouth (02i), Upper Belmont Slough and Redwood Shores (02a.2). These four sub-areas contain 74% of the region’s total, and 20% of the remaining non-native cordgrass in the Estuary. The increase in hybrid cover at these sites may be attributed to a variety of factors, including treatment restrictions in 2011 and reduced treatment efficacy in 2012 due to senescence of the plants at two sub-areas prior to treatment. The late issuance of ISP’s Biological Opinion in 2012 resulted in the treatment season ostensibly beginning in September, which did not allow enough time for treatment of all infestations during the active *Spartina* growing season. Viable seed was produced in quantity, and mature plants were allowed to expand instead of being controlled and reduced by effective treatment. In addition, the 2012 treatment season was the first year of full implementation of the SMCMVCD airboat. Although it allowed for the first year of treatment of all sub-areas in the Region, the task of transitioning some of the large infestations from helicopter to ground-based treatment was beyond the capacity of the team in the time available.

In contrast, Greco Island North (02f) and Greco Island South (02h), which together held 1.06 acres in 2012 and 23.8 acres of invasive *Spartina* in 2005, were reduced to a combined total of 0.34 acre in 2013. This dramatic decline allowed ISP biologists to inventory the entire island in three days, down from seven in 2012.

One unfortunate event in 2013 was the discovery of *S. densiflora* plants in two sub-areas where it had never been found before, West Point Slough NW (02e) and Redwood Creek (02k). *Spartina densiflora* had previously only been found in one site in Region 3, the muted Maple Street Channel (19s), where large mature plants had seemingly been planted. These two new occurrences are in sub-areas adjacent
to Maple Street Channel, and ISP is concerned that some level of hydrologic connectivity may have allowed spread of more propagules to the area. These plants were manually removed, and these areas will be added to the twice-annual survey that ISP implements for this species (described in detail in Section 2.1).

In 2013, 20 sub-areas (77% of the total sub-areas) in the San Mateo Region were treated by airboat. The airboat crews frequently deployed backpack applicators onto the marsh plain to treat scattered plants beyond reach of the 300 feet of airboat hose. With the SMCMVCD airboat in good working order all season and two airboats available from the private contractor Aquatic Environments Inc., every portion of the challenging sites throughout Region 3 was treated during the active growing season for the first time in the history of the project. In 2012, with the late start due to permitting delays, two sites [Belmont Slough (2a) and Ravenswood Slough (2i)] experienced a high percentage of senescence by the time of treatment. ISP subsequently moved these sites up in the rotation in 2013 to get them back on an eradication trajectory, and also added treatment by truck and hose from the levee to both allow the airboat more time to treat mudflats and other inaccessible areas, and to reduce the burden on backpack applicators and increase efficiency.

Although airboat access is invaluable for hybrid *S. alterniflora* treatment on mudflats in this region, there are significant challenges and limitations, as ISP has learned through direct experience. Two young restoration marshes in Region 3 (Pond B3 [2m] and Ravenswood Open Space [2i.1]) are among the most challenging to access in the Estuary. Pond B3 on Bair Island was breached in 2008, when there were still large adjacent populations of uncontrolled hybrid *S. alterniflora*. This 412-acre site was quickly invaded, but also colonized by *S. foliosa*, adding to the challenge of balancing native restoration with invasive management. The site apparently had a significant degree of engineering, evident by the rocky fill present in some channels (which the airboat gets hung up on) and the steep channels with 90 degree banks that require near bank-full water to come down off the marsh plain with the airboat. These factors allow only a short window of treatment on a receding tide of sufficient height, which, in the summer months, can push start times into the afternoon when it is often too windy to conduct treatment.

The other young restoration marsh, Ravenswood Open Space, also has a similar gravelly substrate that requires some water to traverse, which inhibits the detection and treatment of short plants and seedlings. In addition, morning high tides through the summer never reach the > 7 foot level needed to inundate the substrate and make it passable. The infestation at this site exploded over the course of a single year from 9 m² in 2012 to 393 m² as a sufficient number of propagules had established where treatment access was most difficult. In 2013, SMCMVCD learned about the composition of the substrate the hard way and promptly got the airboat stuck. It took three separate trips out to this remote site to accomplish thorough treatment and put this infestation back on the downward trajectory.
Figure 11. Distribution of invasive Spartina in 2013 across the 26 sub-areas of Reporting Region 3: San Mateo.
Table 5. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 3: San Mateo.

<table>
<thead>
<tr>
<th>Split Sub-Area</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net <em>Spartina</em> Coverage By Species</th>
<th>All Invasive <em>Spartina</em> Cover</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REGION 3: SAN MATEO</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>02a: 1a: Belmont Slough Mouth</td>
<td>8/12-8/13; 9/11; 10/9/10</td>
<td>Truck, Backpack, Airboat</td>
<td>0 0.3 acres 0 0.3 acres 1.2 acres 2004</td>
<td>94% 32% increase (328 m²)</td>
<td>Since Peak</td>
</tr>
<tr>
<td>02a: 1b: Belmont Slough Mouth South</td>
<td>8/12-8/13; 9/11; 10/9</td>
<td>Truck, Backpack, Airboat</td>
<td>0 342 m² 0 342 m² 0.5 acres 2004</td>
<td>97% 71%</td>
<td></td>
</tr>
<tr>
<td>02a: 2: Upper Belmont Slough and Redwood Shores</td>
<td>8/13-8/14; 9/11; 9/13/10</td>
<td>Backpack, Airboat</td>
<td>0 1.2 acres 0 1.2 acres 3.8 acres 2004</td>
<td>91% 131% increase (0.7 acres)</td>
<td></td>
</tr>
<tr>
<td>02a: 3: Bird Island</td>
<td>9/11/10</td>
<td>Backpack, Airboat</td>
<td>0 176 m² 0 176 m² 592 m² 2006</td>
<td>96% 65%</td>
<td></td>
</tr>
<tr>
<td>02a: 4: Redwood Shores Mitigation Bank</td>
<td>10/9</td>
<td>Backpack</td>
<td>0 4 m² 0 6 m² 31 m² 2001</td>
<td>90% 11%</td>
<td></td>
</tr>
<tr>
<td>02b: 1: Corkscrew Slough</td>
<td>10/9/10; 11/27</td>
<td>Backpack, Airboat</td>
<td>0 536 m² 0 537 m² 0.8 acres 2004</td>
<td>90% 53%</td>
<td></td>
</tr>
<tr>
<td>02b: 2: Steinberger Slough South, Redwood Creek</td>
<td>8/14-8/15; 8/27; 9/26; 10/8-10/9</td>
<td>Backpack, Airboat</td>
<td>0 0.9 acres 0 0.9 acres 4.2 acres 2005</td>
<td>92% 65% increase (0.4 acres)</td>
<td></td>
</tr>
<tr>
<td>02c: 1b: B North Quadrant East</td>
<td>8/23: Aerial Seed Suppression Only</td>
<td></td>
<td>0 2.7 acres 0 2.7 acres 11.8 acres 2005</td>
<td>88% 80% increase (1.2 acres)</td>
<td></td>
</tr>
<tr>
<td>02c: 2: B2 North Quadrant South</td>
<td>8/13/8/23; 10/8-10/9</td>
<td>Backpack, Airboat</td>
<td>0 2 acres 0 2 acres 8.1 acres 2001</td>
<td>82% 101% increase (1 acre)</td>
<td></td>
</tr>
<tr>
<td>02d: 1a: B2 South Quadrant West</td>
<td>8/12</td>
<td>Backpack, Airboat</td>
<td>0 662 m² 0 662 m² 1.3 acres 2004</td>
<td>&gt;99% 77%</td>
<td></td>
</tr>
<tr>
<td>02d: 1b: B2 South Quadrant East</td>
<td>8/14</td>
<td>Backpack, Airboat</td>
<td>0 10 m² 0 10 m² 268 m² 2004</td>
<td>&gt;99% 91%</td>
<td></td>
</tr>
<tr>
<td>02d: 2: B2 South Quadrant (2)</td>
<td>8/14</td>
<td>Backpack, Airboat</td>
<td>0 113 m² 0 113 m² 0.3 acres 2006</td>
<td>96% 66%</td>
<td></td>
</tr>
<tr>
<td>02d: 3: B2 South Quadrant (3)</td>
<td>10/23</td>
<td>Backpack</td>
<td>0 140 m² 0 140 m² 417 m² 2001</td>
<td>99% 164% increase (87 m²)</td>
<td></td>
</tr>
<tr>
<td>02e: West Point Slough NW</td>
<td>8/9</td>
<td>Airboat</td>
<td>0 158 m² 0.02 m² 158 m² 952 m² 2005</td>
<td>93% 74%</td>
<td></td>
</tr>
<tr>
<td>02f: Greco Island North</td>
<td>9/25-9/26</td>
<td>Backpack, Airboat</td>
<td>0 0.3 acres 0 0.3 acres 2.5 acres 2008</td>
<td>97% 61%</td>
<td></td>
</tr>
<tr>
<td>02g: West Point Slough SW and East</td>
<td>10/10</td>
<td>Backpack</td>
<td>0 73 m² 0 73 m² 707 m² 2005</td>
<td>&gt;99% 33%</td>
<td></td>
</tr>
</tbody>
</table>
Region 3 contains the only site that received aerial treatment in 2013, the eastern portion of Bair Island’s B2 North Quadrant (2c.1b), which is one of the 11 sites with restricted treatment in ISP’s 2012 Biological Opinion. Seed suppression, which involves the application of a dilute solution of imazapyr mixture (normally one third of the rate applied during standard applications), was conducted by helicopter at this site. The goal of seed suppression is to arrest the development of the *Spartina*, stopping seed production and dispersal and vegetative expansion of the clones, while not killing the plants outright. This can preserve the tall vegetative structure in the marsh, which may be used by Ridgway’s rail for nesting, foraging, and high tide refuge habitat. The restricted treatment sites, and a 3-year study of the seed suppression method undertaken by ISP in 2013, are discussed in more detail in Section 3.2 of this report.

The San Mateo Region continues to support a significant population of California Ridgway’s rails, and the ISP conducts surveys for them at 17 sites on an annual basis. 2013 data show a continued positive trend in rail numbers over the last four years (McBroom 2013), despite the removal of 20 net acres of invasive *Spartina* from this region over the same time period. The presence of abundant *S. foliosa* and persisting hybrid *S. alterniflora* in this region leave the ISP Restoration Program few opportunities for planting native cordgrass. However, four high tide refuge islands were constructed and planted in 2013 - two along Belmont Slough (2a.1-2), one on Bird Island (2a.3), and one at Bair Island (B2 North Quadrant [2c]). In addition, approximately 6,000 plants were installed at Greco Island North (02f) and B2 North Quadrant. Most of these consisted of *G. stricta* (sometimes with *Distichlis spicata*) plantings on the marshplain, but a suite of *G. stricta*, *Elymus triticoides*, *Baccharis douglasii* and *Artemisia californica* were also installed in the upland transition zone of B2 North Quadrant in 2013. Until the infestation of hybrid *S. alterniflora* in this region can be reduced to a minimal level, the ISP cannot safely install *S. foliosa* and will continue to explore other options for enhancing habitat for the San Mateo Ridgway’s rail population.
2.2.4. REGION 4: DUMBARTON SOUTH

Region 4 is comprised of all tidal wetlands south of the Dumbarton Bridge. This includes freshly breached restoration sites, salt evaporator ponds that are slated for restoration to tidal marsh, large expanses of marsh protected and managed by the USFWS as part of San Francisco Bay Don Edwards National Wildlife Refuge (DENWR), and the marsh fringes that provide connectivity between them. As one of the focal areas for restoration by the South Bay Salt Pond Restoration Project (SBSP), control of invasive Spartina in this area is key to the SBSP achieving its long term goals. The Dumbarton South Region is the second largest in the estuary and ISP has used helicopters in the past to survey large portions of it. In 2013, for the first time in project history, 24 of the region’s 25 sub-areas were thoroughly inventoried “on the ground,” either on foot or by kayak. A portion of Coyote Creek to Artesian Slough (15a.5) was not surveyed – the less saline upper reaches, where there is no history of invasion and the threat of new infestation is minor. The freshly breached Pond A17 (sub-area 15a.7 added this year) was not yet appropriate for survey, since it supported no vegetation at time of inventory in 2013.

Hybrid S. alterniflora is the only species of non-native cordgrass that has been found in Region 4, and in 2013 ISP biologists mapped a total of 2.48 net acres (Table 6, Figure 12). This is a 50% reduction from 2012, but still amounts to 6.5% of the Estuary total, placing this region as the fourth most infested, behind San Leandro Bay, Hayward, and San Mateo regions. No one marsh in this region contains more than one net acre of infestation, and the most infested three sub-areas – Cooley Landing West (16.2), Calaveras Marsh (05a.2), and Alviso Slough (05a.4) – hold about a half-acre each. Eighteen sub-areas in this region showed declines in hybrid S. alterniflora cover between 2012 and 2013, and changes at the six sub-areas that experienced increases were of minor amounts, never exceeding 50 m².

One site in this region, Knapp Tract (15a.6), was breached as a SBSP restoration in late 2010, and was added to the ISP inventory in 2012. In 2013, the first occurrence of hybrid S. alterniflora (0.006 net m² of cover) was discovered within its bounds. The colonization by invasive Spartina was expected, as some of the breaches broke the levee separating Knapp Tract from Alviso Slough (15a.4), and the site is located directly across Coyote Creek from Calaveras Marsh (05a.2), the second largest remaining population of hybrid S. alterniflora in Region 4. In 2012 a similar colonization event was discovered at the Island Ponds (05i), which are also located across Coyote Creek from Knapp Tract and adjacent to Calaveras Marsh. These events of infestation in new restoration sites further highlight the need for coordination between SBSP and ISP (discussed further in Section 3.1). With annual monitoring and treatment, however, this colonization trend can be turned around, as witnessed in Coyote Creek-Alameda County (05f). Historic presence of hybrid peaked at this sub-area in 2008 with 0.04 acre and has not been detected for its third year in a row.

The remote nature of the marshes in Region 4, as well as their size and complexity, requires that ISP partners access many of the sites by airboat. The enormous size of Calaveras Marsh (5a.2), stretching up to 900 meters in depth from the shoreline to the upland, warrants the use of a Marshmaster amphibious tracked vehicle to treat remaining stands colonizing the marsh plain and channels and to assist the applicators with refilling backpacks so they don’t have to walk back and forth to the airboat along the
Figure 12. Distribution of invasive *Spartina* in 2013 across the 25 sub-areas of Reporting Region 4: Dumbarton South.
Table 6. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 4: Dumbarton South.

<table>
<thead>
<tr>
<th>REPORTING REGION</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net <em>Spartina</em> Coverage By Species</th>
<th>All Invasive <em>Spartina</em> Cover</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>anglica</td>
<td>alterniflora</td>
<td>foliosa</td>
</tr>
<tr>
<td>Split Sub-Area</td>
<td></td>
<td></td>
<td>Coverage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REGION 4: DUMBARTON SOUTH</td>
<td></td>
<td></td>
<td>Coverage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>02: Ravenswood Open Space Preserve (5 of Hwy 92)</td>
<td>10/11</td>
<td>Backpack</td>
<td>0</td>
<td>12 m²</td>
<td>0</td>
</tr>
<tr>
<td>02n: SF2</td>
<td>10/11</td>
<td>Backpack</td>
<td>0</td>
<td>1 m²</td>
<td>0</td>
</tr>
<tr>
<td>05a: Dumbarton/Audubon</td>
<td>9/9; 9/11; 9/27; 10/11; 10/22 Backpack, Airboat</td>
<td>0</td>
<td>499 m²</td>
<td>0</td>
<td>510 m²</td>
</tr>
<tr>
<td>05c: Newark Slough West</td>
<td>8/28</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>19 m²</td>
<td>0</td>
</tr>
<tr>
<td>05d: Llafiviere Marsh</td>
<td>9/27</td>
<td>Backpack</td>
<td>0</td>
<td>93 m²</td>
<td>0</td>
</tr>
<tr>
<td>05e: Mayhew's Landing</td>
<td>10/11</td>
<td>Backpack</td>
<td>0</td>
<td>64 m²</td>
<td>0</td>
</tr>
<tr>
<td>05f: Coyote Creek - Alameda County</td>
<td>No invasive <em>Spartina</em> detected 2011-2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>05g: Cargill Pond (W Hotel)</td>
<td>10/11</td>
<td>Backpack</td>
<td>0</td>
<td>7 m²</td>
<td>0</td>
</tr>
<tr>
<td>05h: Plummer Creek Mitigation Marsh</td>
<td>10/11</td>
<td>Backpack</td>
<td>0</td>
<td>20 m²</td>
<td>0</td>
</tr>
<tr>
<td>05i: Island Ponds</td>
<td>8/29</td>
<td>Airboat</td>
<td>0</td>
<td>44 m²</td>
<td>0</td>
</tr>
<tr>
<td>08: Palo Alto Baylands</td>
<td>9/16; 9/26; 10/16</td>
<td>Backpack</td>
<td>0</td>
<td>598 m²</td>
<td>0</td>
</tr>
<tr>
<td>15a: Charleston Slough to Mountainview Slough</td>
<td>9/9; 9/12</td>
<td>Truck, Backpack</td>
<td>0</td>
<td>42 m²</td>
<td>0</td>
</tr>
<tr>
<td>15a: Stevens Ck to Guadalupe Slough</td>
<td>9/10</td>
<td>Truck, Backpack</td>
<td>0</td>
<td>33 m²</td>
<td>0</td>
</tr>
<tr>
<td>15a: Guadalupe Slough</td>
<td>9/10</td>
<td>Truck, Backpack</td>
<td>0</td>
<td>98 m²</td>
<td>0</td>
</tr>
<tr>
<td>15a: Alviso Slough</td>
<td>9/11; 9/16; 10/15; 10/15</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>0.5 acres</td>
<td>0</td>
</tr>
<tr>
<td>15a: Coyote Creek to Artesian Slough</td>
<td>8/29; 9/16; 10/15</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>41 m²</td>
<td>0</td>
</tr>
<tr>
<td>15a: Pond A17</td>
<td>New Subarea - No Invasive <em>Spartina</em> 2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15b: Faber / Laumeister Marsh</td>
<td>9/24</td>
<td>Backpack</td>
<td>0</td>
<td>84 m²</td>
<td>0</td>
</tr>
<tr>
<td>15c: Shoreline Regional Park</td>
<td>9/23</td>
<td>Backpack</td>
<td>0</td>
<td>206 m²</td>
<td>0</td>
</tr>
<tr>
<td>16: Cooley Landing Central</td>
<td>11/25-11/26</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>967 m²</td>
<td>0</td>
</tr>
<tr>
<td>16: Cooley Landing West</td>
<td>9/26; 11/25</td>
<td>Truck, Backpack</td>
<td>0</td>
<td>0.6 acres</td>
<td>0</td>
</tr>
<tr>
<td><strong>REGION 4 TOTAL</strong></td>
<td></td>
<td></td>
<td>0</td>
<td>2.5 acres</td>
<td>0</td>
</tr>
</tbody>
</table>
shoreline. This is the only permitted use of amphibious vehicles in ISP’s current BO. Some of the small infestations along large sloughs in the far South Bay are accessed from the adjacent levees for treatment by Santa Clara Valley Water District (SCVWD).

The Dumbarton South Region contains arguably the most challenging site to treat in the entire Estuary, Cooley Landing (16). This site is the quintessential example of how the difficulty of access increases as a young restored pond reaches an intermediate level of maturation. Several years ago, ISP partners were able to approach the eastern mudflat portion of the site by airboat, rising up out of one of the major channels and onto the mid-elevation marsh plain that was still largely unvegetated. Perennial pickleweed is now widely established at this elevation, and the airboat can no longer access these areas due to the friction caused by the above-ground biomass. However, hauling hose out from the airboat on some of these unconsolidated sediments is extremely difficult, and portions of the infestation are beyond reach of the 300-foot length of hose, requiring a time-consuming search for multiple access points to get full coverage. Treatment is further complicated by the wide variety of hybrid and native cordgrass forms present at the site, which makes accurate identification of treatment targets time-consuming and challenging.

The marshes of Palo Alto Baylands (08) continue to pose challenges to full detection and thorough treatment of the hybrid *S. alterniflora* at the site. There are many acres of *S. foliosa* throughout the 218-acre complex, and the wide varieties of tidal habitat, influenced heavily by nearby wastewater discharge, can illicit different forms and phenologies in the cordgrass. Consequently, both the hybrids and *S. foliosa* plants take many forms. Many hybrid *S. alterniflora* clones do not show definitive characteristics until late in the growing season (even into late September/early October), while some of the more widespread invaders senesce early and can thwart thorough treatment. In 2013, 598 m\(^2\) was detected and treated in the Palo Alto Baylands, a 46% reduction from the 1,102 m\(^2\) found in 2012. However some hard-to-access clones on the islands along Embarcadero Road began senescence ahead of treatment, which may have reduced treatment efficacy. Genetic results for this site, which would have assisted hybrid identification, were not received until after the 2013 treatment season, resulting in lost opportunity to expand treatment to additional plants identified through genetics.

Aside from the challenging cases described above, the progress towards eradication throughout the core marshes of DENWR has been inspiring. The infestations at the main sites in this complex (Mowry [5a.1], Dumbarton/Audubon [5b], Newark Slough [5c], and La Riviere [5d]) required treatment of only 1,140 m\(^2\) of hybrid *S. alterniflora* within its 1,896 acres of tidal habitat, representing a 98.7% decline from the 22.69 acres of hybrid *S. alterniflora* present at the peak of the infestation.

The number of California Ridgway’s rails in this region continue to increase, despite the ISP’s success in reducing the presence of hybrid *S. alterniflora*. Through the combined efforts of the ISP, DENWR, and Point Blue Conservation Science, 30 sites were surveyed for Ridgway’s rails in the Dumbarton South Region in 2013. This region includes some of the highest quality Ridgway’s rail habitat in the Estuary, and survey results revealed detection increases over the last two years (McBroom 2013; PBCS 2014). Marshes in this region generally have abundant *S. foliosa* and are not a high priority for ISP revegetation efforts. However, the ISP and partners constructed one high tide refuge island at Cooley Landing (16.2) in 2013. No other habitat enhancements were installed in 2013.
2.2.5. REGION 5: UNION CITY

Lining the East Bay from the San Mateo Bridge to the Dumbarton Bridge, this region was the original introduction site for *S. alterniflora* to San Francisco Bay at Pond 3 (01f) in the early 1970s. These plantings later hybridized with native *S. foliosa* and eventually resulted in the bay-wide spread of their highly invasive generations of offspring. The 21 sub-areas of Region 5 have experienced the most dramatic turn in invasive *Spartina* presence witnessed in the Estuary. Once harboring 233 acres of hybrid *S. alterniflora*, all but one site in this region were extensively monitored on foot in 2013, and 0.18 net acre of hybrid (0.08% of the peak amount) was mapped (Table 7, Figure 14). Eden Landing-Ponds E8A, E9, and E8X (13m), which was breached in 2011, was partially kayaked for inventory. Only a portion of this sub-area was of appropriate elevation for potential *Spartina* establishment, and no *Spartina* of any species was found to be colonizing in 2013.

Continued declines were observed at 11 sub-areas, while slight increases (less than 15 m² each) were observed at eight sub-areas. One site of historic infestation (Ideal Marsh North [21a]) experienced a more substantial increase in hybrid cover of more than 300 m² (0.07 acre) (Figure 13). The largest patches of hybrid *S. alterniflora* at this site in 2013 were on the mudflat, while most of the plants found on the narrow plain above the marsh scarp were tiny. Many small clones had been grazed and were thus not visible during the first round of treatment. These were subsequently identified and treated in the autumn. Reasons for the expansion described above are unknown, though considering that the majority of the infestation was at a very low tidal elevation on the mudflats, insufficient dry time for the herbicide is suspected.

Re-infestation was documented in two sites where no hybrid *S. alterniflora* was detected in 2012: Upstream of 20 Tide Gates (13g) and Eden Landing-Pond 10 (13i), totaling a combined 0.7 m². In each of these sites, the new plants were located near controlled tidal flow gates, which may have provided temporary connectivity with an outside seed source.

Monitoring in this region is becoming increasingly challenging, as mature hybrid *S. alterniflora* becomes rarer and new recruits of uncertain ancestry become more common. This is exacerbated by the restoration efforts of both SBSP and ISP: as SBSP breaches more ponds, they become ripe for colonization by...
Figure 14. Distribution of invasive *Spartina* in 2013 across the 21 sub-areas of Reporting Region 5: Union City.
Table 7. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 5: Union City.

<table>
<thead>
<tr>
<th>REPORTING REGION</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net <em>Spartina</em> Coverage By Species</th>
<th>All Invasive <em>Spartina</em> Cover</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>anglica</td>
<td>patens</td>
<td>densiflora</td>
</tr>
<tr>
<td>Split Sub-Area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REGION 5: UNION CITY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01a: Channel Mouth</td>
<td>7/9-7/10; 11/27, 11/29 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>0</td>
<td>2 m²</td>
</tr>
<tr>
<td>01b: Lower Channel</td>
<td>7/9-7/10; 11/27, 11/29 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>60 m²</td>
<td>0</td>
</tr>
<tr>
<td>01c: Upper Channel</td>
<td>7/9-7/10; 11/27, 11/29 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>18 m²</td>
<td>0</td>
</tr>
<tr>
<td>01d: Upper Channel - Union City Blvd to I-880</td>
<td>7/9-7/10; 11/27 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>35 m²</td>
<td>0</td>
</tr>
<tr>
<td>01e: Strip Marsh No. of Channel Mouth</td>
<td>7/9; 11/27 (R2)</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>1 m²</td>
<td>0</td>
</tr>
<tr>
<td>13a: Old Alameda Creek North Bank</td>
<td>9/11-9/12</td>
<td>Backpack</td>
<td>0</td>
<td>0.2 m²</td>
<td>0</td>
</tr>
<tr>
<td>13b: Old Alameda Creek Island</td>
<td>9/11-9/12</td>
<td>Backpack</td>
<td>0</td>
<td>34 m²</td>
<td>0</td>
</tr>
<tr>
<td>13c: Old Alameda Creek South Bank</td>
<td>8/13</td>
<td>Backpack</td>
<td>0</td>
<td>3 m²</td>
<td>0</td>
</tr>
<tr>
<td>13d: Whale’s Tail North Fluke</td>
<td>9/11-9/12</td>
<td>Backpack</td>
<td>0</td>
<td>4 m²</td>
<td>0</td>
</tr>
<tr>
<td>13e: Whale’s Tail South Fluke</td>
<td>8/13</td>
<td>Backpack</td>
<td>0</td>
<td>2 m²</td>
<td>0</td>
</tr>
<tr>
<td>13f: Cargill Mitigation Marsh</td>
<td>8/13</td>
<td>Backpack</td>
<td>0</td>
<td>18 m²</td>
<td>0</td>
</tr>
<tr>
<td>13g: Upstream of 20 Tide Gates</td>
<td>9/12</td>
<td>Backpack</td>
<td>0</td>
<td>0.1 m²</td>
<td>0</td>
</tr>
<tr>
<td>13i: Eden Landing - Mt Eden Creek</td>
<td>8/14</td>
<td>Backpack</td>
<td>0</td>
<td>0.02 m²</td>
<td>0</td>
</tr>
<tr>
<td>13j: Eden Landing - Mt Eden Creek Marsh</td>
<td>9/11-9/12</td>
<td>Backpack</td>
<td>0</td>
<td>0.6 m²</td>
<td>0</td>
</tr>
<tr>
<td>13k: Eden Landing Reserve South - North Creek Marsh</td>
<td>8/14</td>
<td>Backpack</td>
<td>0</td>
<td>4 m²</td>
<td>0</td>
</tr>
<tr>
<td>13l: Eden Landing Reserve North - Mt Eden Creek Marsh</td>
<td>8/14</td>
<td>Backpack</td>
<td>0</td>
<td>6 m²</td>
<td>0</td>
</tr>
<tr>
<td>13m: Eden Landing - Ponds E8A, E9, and EBX</td>
<td>No Invasive <em>Spartina</em> 2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>21a: Ideal Marsh North</td>
<td>7/26; 11/29 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>346 m²</td>
<td>0</td>
</tr>
<tr>
<td>21b: Ideal Marsh South</td>
<td>8/27; 10/22</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>176 m²</td>
<td>0</td>
</tr>
<tr>
<td>REGION 5 TOTAL</td>
<td>0</td>
<td></td>
<td>713 m²</td>
<td>0</td>
<td>715 m²</td>
</tr>
</tbody>
</table>
whatever *Spartina* propagules are available, and ISP is actively reintroducing *S. foliosa* that had been extirpated by the hybrid invasion in this Region. Until recently, this Region’s propagule base has been predominantly of hybrid origin, but now that native propagules are becoming more prominent, young plants cannot be assumed to be non-native (further discussion included in Section 3.1). This is exactly the desired effect: proliferation of native marshes, but it comes at the cost of increasing monitoring time and difficulty in identifying immature plants. This predicament has the potential to intensify as more salt ponds are restored to tidal action. However, if the threat from neighboring infestation can be further attenuated, we can allow these young marshes to develop with native vegetation.

Herbicide treatment methodology has changed dramatically within this region over the years, transitioning first from broadcast helicopter applications on hundreds of acres of meadow, to large-scale spot treatments by amphibious tracked vehicles as sites came under control, to target spot application from trucks, and finally to carefully focused application by backpack sprayer. In 2013, treatment was conducted solely by backpack, and only relatively minor applications were necessary at all sites throughout this region. With the reduction in cover, the time burden continues to drop, with now only a handful of days required to thoroughly cover every corner of all sites.

The Alameda Flood Control Channel, original introduction site of *S. alterniflora*, contained only 118 m² of hybrid *S. alterniflora* in 2013, a 99.9% reduction from the 141 acres found there at the peak of the infestation. This level of success and progress towards eradication has allowed for active native *S. foliosa* re-vegetation by ISP, which is beginning to thrive and expand into a thick band along the channel. Of the 20 sub-areas in the region that had hybrid *S. alterniflora* detected in 2013, 12 (60%) have less than 6 m², and only two sites (Ideal Marsh North & South [21a, 21b]) have greater than 100 m² each.

Many of the sites in Region 5 were selected by ISP as appropriate for the first year of Round 2 inventory and treatment as described in the introduction to Section 2. Round 2 inventory and treatment was conducted at seven sites approaching eradication in 2013. This includes all six sub-areas in the Alameda Flood Control Channel complex (Site 1), as well as the adjacent Ideal Marsh North.

Invasive *Spartina* and its treatment have little to no effect on California Ridgway’s rail populations in Region 5, as only 0.08% of the peak infestation remains. The ISP and DENWR annually survey 20 sites in the Union City Region for Ridgway’s rails, and 2013 results were consistent with past years’ results, indicating a stable trend for rail populations in the region (McBroom 2013). However, with its multiple young restoration marshes and large areas that were heavily impacted by the initial hybrid *S. alterniflora* infestation, Ridgway’s rail habitat in this region could be greatly improved, both to attract Ridgway’s rails where they currently do not occur, and to increase numbers in marshes where they are present. Since most native cordgrass was assimilated by the hybrid invasion and subsequently treated and removed from many marshes in this region, there is ample opportunity for *S. foliosa* reintroduction in many marshes. In 2013 alone, the ISP Restoration Program installed approximately 40,000 *S. foliosa* plants throughout nine sub-areas in the Alameda Flood Control (1a, 1b, 1c, 1f) and Eden Landing Ecological Reserve (13d, 13e, 13f, 13), and 13k) complexes. Native cordgrass reintroduction has proven especially successful at Alameda Flood Control Channel and North Creek Marsh (13k). An additional 8,000 *G. stricta* plantings, often paired with *D. spicata* plantings, were installed in these sub-areas as well. The upland transition zones of Whale’s Tail-South Fluke (13e) and North Creek Marsh were also planted with *G. stricta, E. triticoides, B. douglasii* and *A. californica*.
2.2.6. REGION 6: HAYWARD

The Hayward Region extends from the San Mateo Bridge to Oakland Airport on the east side of the San Francisco Bay. It is heavily urbanized and consists of 27 sub-areas clustered around three relatively young but large restoration marsh complexes, the oldest of which (Cogswell Marsh [20m-o]) was restored in 1980. All sites in this region were mapped on foot and a total of 11.63 acres of non-native cordgrass, all hybrid S. alterniflora, was mapped, reflecting a 53.6% increase (4 acres) since 2012 (Figure 15, Table 8). This is the largest increase of non-native Spartina cover of any region in the Bay for 2013. Treatment was not permitted in six sub-areas of Region 6: Cogswell B (20n), Cogswell C (20o), Citation Marsh North (20d.2), North Marsh (20f), Bunker Marsh (20g), and San Lorenzo Creek Mouth North (20h.1) (See section 3.2 for further discussion). These sites were inventoried more coarsely in order to concentrate inventory efforts on sites where treatment would be implemented in 2013. These six marshes, however, hold 11.3 acres of hybrid S. alterniflora, which comprises 97% of the region’s total invasive cordgrass inventory and 29% of the entire San Francisco Bay inventory. At its peak in 2005, this region contained 226 acres of hybrid S. alterniflora, the second highest amount of any ISP Region in the Bay, behind only Union City (Region 5). Region 6 currently maintains that same position, but now with only San Leandro Bay (Region 7) containing more, as is discussed in Section 2.2.7.

In Hayward Region sub-areas where treatment has been authorized since 2011, only 0.35 acre of invasive Spartina remains, which is 0.14% of the Region’s 2005 footprint. One sub-area in particular, Triangle Marsh (20w), experienced its second year in a row in which no hybrid S. alterniflora was detected.

With such a small footprint of infestation remaining in the sub-areas that were permitted for treatment, most of the infestations only required spot imazapyr application by backpack sprayer. East Bay Regional Parks District (EBRPD) also used an airboat to treat two sites within their jurisdiction, Oro Loma West (07b) and Oyster Bay Regional Shoreline (20a), where access to infestations out on soft mudflats was required. Three sites within Region 6 received Round 2 inventory and treatment: Dog Bone Marsh (20c), Bockmann Channel (20i), and Estudillo Creek (20u). These sites contained a combined 10.3 m² of hybrid S. alterniflora, mapped over the two rounds of inventory.

An especially disappointing reduction in hybrid cover from 2012 treatment was experienced at Metropolitan Golf Links (20b), where the infestation in a tidal channel that extends into the golf course was reduced by only 1%. Although the 2012 treatment occurred fairly late in the growing season (October), this poor efficacy appears to be a good example of the importance of sufficient dry time for the imazapyr herbicide (Figure 16). ISP records indicate that the treated plants were likely inundated by greater than a 5 ft. tide before they had sufficient dry time.
Figure 15. Distribution of invasive *Spartina* in 2013 across the 27 sub-areas of Reporting Region 6: Hayward.

Representation of *Spartina* reflects distribution and does not equate to actual footprint. More detailed data and finer scale maps are available from ISP upon request.
### Table 8. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 6: Hayward.

<table>
<thead>
<tr>
<th>Reporting Region</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net <em>Spartina</em> Coverage By Species</th>
<th>All Invasive <em>Spartina</em> Cover</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>anglica</td>
<td>patens</td>
<td>foliosa</td>
</tr>
<tr>
<td><strong>REGION 6: HAYWARD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>07a: Oro Loma Marsh - East</td>
<td>9/24; 10/10</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>68 m²</td>
<td>0</td>
</tr>
<tr>
<td>07b: Oro Loma Marsh - West</td>
<td>9/24; 9/26</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>556 m²</td>
<td>0</td>
</tr>
<tr>
<td>20a: Oyster Bay Regional Shoreline</td>
<td>7/16; 7/24</td>
<td>Backpack</td>
<td>0</td>
<td>27 m²</td>
<td>0</td>
</tr>
<tr>
<td>20b: Oakland Metropolitan Golf Links</td>
<td>7/12</td>
<td>Backpack</td>
<td>0</td>
<td>401 m²</td>
<td>0</td>
</tr>
<tr>
<td>20c: Dog Bone Marsh</td>
<td>8/9; 11/23 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>8 m²</td>
<td>0</td>
</tr>
<tr>
<td>20d.1: Citation Marsh South</td>
<td>9/10</td>
<td>Backpack</td>
<td>0</td>
<td>3 m²</td>
<td>0</td>
</tr>
<tr>
<td>20d.2: Citation Marsh North</td>
<td>No Treatment Authorized since 2010</td>
<td>0</td>
<td>3 acres</td>
<td>0</td>
<td>3 acres</td>
</tr>
<tr>
<td>20e: East Marsh</td>
<td>8/9</td>
<td>Backpack</td>
<td>0</td>
<td>1 m²</td>
<td>0</td>
</tr>
<tr>
<td>20f: North Marsh</td>
<td>No Treatment Authorized since 2010</td>
<td>0</td>
<td>1.7 acres</td>
<td>0</td>
<td>1.7 acres</td>
</tr>
<tr>
<td>20g: Bunker Marsh</td>
<td>No Treatment Authorized since 2010</td>
<td>0</td>
<td>0.8 acres</td>
<td>0</td>
<td>0.8 acres</td>
</tr>
<tr>
<td>20h.1: San Lorenzo Creek and Mouth North</td>
<td>No Treatment Authorized since 2010</td>
<td>0</td>
<td>45 m²</td>
<td>0</td>
<td>45 m²</td>
</tr>
<tr>
<td>20h.2: San Lorenzo Creek and Mouth South</td>
<td>8/9; 9/10</td>
<td>Backpack</td>
<td>0</td>
<td>30 m²</td>
<td>0</td>
</tr>
<tr>
<td>20i: Bockmann Channel</td>
<td>7/15; 11/23 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>0.09 m²</td>
<td>0</td>
</tr>
<tr>
<td>20j: Sulphur Creek</td>
<td>7/15</td>
<td>Backpack</td>
<td>0</td>
<td>0.2 m²</td>
<td>0</td>
</tr>
<tr>
<td>20k: Hayward Landing</td>
<td>7/15</td>
<td>Backpack</td>
<td>0</td>
<td>0.007 m²</td>
<td>0</td>
</tr>
<tr>
<td>20l: Johnson’s Landing</td>
<td>7/15</td>
<td>Backpack</td>
<td>0</td>
<td>0.3 m²</td>
<td>0</td>
</tr>
<tr>
<td>20m: Cogswell Marsh, Quadrant A</td>
<td>9/10</td>
<td>Backpack</td>
<td>0</td>
<td>11 m²</td>
<td>0</td>
</tr>
<tr>
<td>20n: Cogswell Marsh, Quadrant B</td>
<td>No Treatment Authorized since 2010</td>
<td>0</td>
<td>5.2 acres</td>
<td>0</td>
<td>5.2 acres</td>
</tr>
<tr>
<td>20o: Cogswell Marsh, Quadrant C</td>
<td>No Treatment Authorized since 2010</td>
<td>0</td>
<td>0.6 acres</td>
<td>0</td>
<td>0.6 acres</td>
</tr>
<tr>
<td>20p: Hayward Shoreline Outliers</td>
<td>7/15</td>
<td>Backpack</td>
<td>0</td>
<td>2 m²</td>
<td>0</td>
</tr>
<tr>
<td>20q: San Leandro Shoreline Outliers</td>
<td>8/9</td>
<td>Backpack</td>
<td>0</td>
<td>77 m²</td>
<td>0</td>
</tr>
<tr>
<td>20r: Oakland Airport Shoreline and Channels</td>
<td>7/25</td>
<td>Backpack</td>
<td>0</td>
<td>196 m²</td>
<td>0</td>
</tr>
<tr>
<td>20s: H.A.R.D. Marsh</td>
<td>7/17</td>
<td>Backpack</td>
<td>0</td>
<td>5 m²</td>
<td>0</td>
</tr>
<tr>
<td>20t: San Leandro Marina</td>
<td>7/12</td>
<td>Backpack</td>
<td>0</td>
<td>0.02 m²</td>
<td>0</td>
</tr>
<tr>
<td>20u: Estudillo Creek Channel</td>
<td>7/12; 11/23 (R2)</td>
<td>Backpack</td>
<td>0</td>
<td>2 m²</td>
<td>0</td>
</tr>
<tr>
<td>20v: Hayward Landing Canal</td>
<td>8/2</td>
<td>Backpack</td>
<td>0</td>
<td>16 m²</td>
<td>0</td>
</tr>
<tr>
<td>20w: Triangle Marsh</td>
<td>No invasive <em>Spartina</em> 2012 or 2013</td>
<td>0</td>
<td>11.6 acres</td>
<td>0</td>
<td>11.6 acres</td>
</tr>
</tbody>
</table>

Invasive *Spartina* Project
In 2013 the ISP surveyed 25 California Ridgway’s rail sites in the Hayward Region. Interestingly, there continued to be decreases in rail detections at multiple sites where treatment has not been permitted since 2011, notably at Robert’s Landing (20d, 20f, 20g) and Cogswell C (20o), despite the rapid increases in hybrid *S. alterniflora* cover observed in each site. These decreases have shifted the regional trend for Ridgway’s rails from being stable for four years to now being on the decline (McBroom 2013), while hybrid *S. alterniflora* cover increased by over 50% in the last year. The large amount of remaining invasive *Spartina* here precludes the introduction of *S. foliosa* as a habitat enhancement for Ridgway’s rails, though most of the region’s marshes are relatively young and do have much *G. stricta* establishment. The ISP Revegetation Program installed approximately 20,000 *G. stricta* plants (sometimes paired with *D. spicata*) in 2013 across nine sub-areas in the Cogswell, Oro Loma, and Robert’s Landing marsh complexes. The upland transition zone of Cogswell A was also planted with *G. stricta, E. triticoides, B. douglasii* and *A. californica*. *Spartina foliosa* was experimentally planted along the Cogswell A shoreline, but this planting was soon invaded by hybrid *S. alterniflora* and so was treated and killed.
2.2.7. REGION 7: SAN LEANDRO BAY

The San Leandro Bay Region is an exceptionally urbanized portion of the East Bay that extends north from the Oakland Airport to the Bay Bridge. Its 19 sub-areas consist of long thin tidal areas along rip-rap shorelines and open mudflats, punctuated by fragmented areas of extant marsh habitat. All sub-areas of Region 7 (Figure 17, Table 9) were monitored on foot in 2013, with the exceptions of Oakland Inner Harbor (17f), Crab Cove, and some inland channels by Elsie Roemer (both are small portions of 17a), which were surveyed on foot and also by boat. As in 2012, this region has four sub-areas that maintain treatment restrictions: Arrowhead Marsh-East (17c.2), MLK New Marsh (17h), Fan Marsh (17j), and MLK Regional Shoreline-Damon Marsh (17d.4) (see section 3.2 for further discussion). As such, these sites were coarsely mapped in order to prioritize inventory at sites where treatment would be effective in 2013.

Hybrid *S. alterniflora* was the only non-native cordgrass species found in Region 7, with a net cover of 13 acres, a 13% decline from 2012. This decline is driven solely by the treatment of 1.96 acres of invasive cordgrass that had expanded in Arrowhead West (17c.1), where increases had been seen in 2012 as a result of temporary treatment restriction in 2011. Ninety five percent of hybrid *S. alterniflora* found in Region 7 is located in the four sub-areas where treatment has not been authorized since 2010, This area represents 33% of the total amount of invasive *Spartina* remaining in San Francisco Bay. The San Leandro Bay Region contains no sub-areas where invasive *Spartina* cannot be found.

As in Region 2 (San Francisco Peninsula), ISP conducted a secondary round of inventory along the shoreline fringing San Leandro Bay in 2013. This was conducted from October 28-November 1 to detect new growth and regrowth that otherwise would escape attention and be allowed to flourish for a growing season prior to inventory in 2014. A total of 50 new plants were mapped, amounting to 1.5 net m$^2$ of cover. However, due to resource constraints and the close proximity too many acres of uncontrolled *Spartina* in the restricted sites, a second round of treatment to eliminate these Round 2 inventory detections was not mobilized in autumn 2013.

Most of the sub-areas in Region 7 were treated by backpack sprayer in 2013, but an airboat was required at several sub-areas because of the occurrence of plants out on soft mudflats. The airboat was also used to transport applicators to Arrowhead Marsh West, as well as to provide the greater volume of herbicide needed to complete treatment at this site. ISP used a Whaler to treat Oakland Inner Harbor (17f), to allow the crew to approach from the water due to the many fences and other obstacles that complicate ground-access to every dock, vacant lot, and industrial shoreline throughout this sub-area.

The efficacy from 2012 applications at two very complex sub-areas illustrate the importance of the ISP’s treatment survey protocol, where applicators are accompanied by staff biologists to navigate back to the previously-inventoried *Spartina*. The infestation at Oakland Inner Harbor was reduced by 87% from 113 m$^2$ to 15 m$^2$, and the Coliseum Channels (17i) reduced by a similar 86% from 199 m$^2$ to 28 m$^2$. These two sub-areas cover 193 acres of potential habitat with countless nooks and crannies that could harbor a hybrid *S. alterniflora* plant. It is unlikely that any herbicide applicator could have achieved this high level of target acquisition without the oversight and guidance of GPS data-equipped biologists in the field.
In 2013, the ISP surveyed 13 Ridgway’s sub-areas in the San Leandro Bay Region for California Ridgway’s rail. Data show a slight increase of six birds over 2012, though the population in this region remains on a negative four-year trend (McBroom 2013). Treatment restrictions at numerous sites in this region currently leave few opportunities for California Ridgway’s rail habitat enhancement, due to risk of hybrid *S. alterniflora* encroaching on and overwhelming new plantings in the absence of control efforts. Plantings of *S. foliosa* in these areas would also likely be pollinated by the hybrids, which would cause the native plants to produce hybrid seeds and spread the infestation. Two marshes were appropriate for installation of *G. stricta* in 2013, and 675 plants were installed within MLK New Marsh (17h) and Damon Marsh (17d.4). Save The Bay, in collaboration with the ISP, installed more than 2,400 plants over the past two seasons (2011-2012 and 2012-2013) in Arrowhead Marsh West (17c.1) where treatment was permitted and where hybrids are largely controlled. One high tide refuge island was also constructed and planted at MLK New Marsh.
Figure 17. Distribution of invasive *Spartina* in 2013 across the 19 sub-areas of Reporting Region 7: San Leandro Bay.
Table 9. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 7: San Leandro Bay.

<table>
<thead>
<tr>
<th>REPORTING REGION</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net <em>Spartina</em> Coverage By Species</th>
<th>All Invasive <em>Spartina</em> Cover</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>anglica</td>
<td>patens</td>
<td>densiflora</td>
</tr>
<tr>
<td>Split Sub-Area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REGION 7: SAN LEANDRO BAY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17a: Alameda Island South (Ellie Roemer Bird Sanctuary, Crown Memorial State Beach, Crab Cove)</td>
<td>8/22; 9/24</td>
<td>Backpack</td>
<td>0</td>
<td>233 m²</td>
<td>0</td>
</tr>
<tr>
<td>17b: Bay Farm Island</td>
<td>9/24</td>
<td>Backpack</td>
<td>0</td>
<td>3 m²</td>
<td>0</td>
</tr>
<tr>
<td>17c: Arrowhead Marsh West</td>
<td>9/10-9/11; 10/14</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>0.5 acres</td>
<td>0</td>
</tr>
<tr>
<td>17d: MLK Regional Shoreline - Fan Marsh Shoreline</td>
<td>No Treatment Authorized since 2010</td>
<td>7/16</td>
<td>Airboat</td>
<td>0</td>
<td>53 m²</td>
</tr>
<tr>
<td>17e: San Leandro Creek North</td>
<td>7/16</td>
<td>Backpack</td>
<td>0</td>
<td>8 m²</td>
<td>0</td>
</tr>
<tr>
<td>17f: East Creek - MLK Shoreline</td>
<td>7/16</td>
<td>Backpack</td>
<td>0</td>
<td>39 m²</td>
<td>0</td>
</tr>
<tr>
<td>17g: MLK Regional Shoreline - Damon Marsh</td>
<td>No Treatment Authorized since 2010</td>
<td>0</td>
<td>0.3 acres</td>
<td>0</td>
<td>0.3 acres</td>
</tr>
<tr>
<td>17h: Airport Channel</td>
<td>7/16</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>1 m²</td>
<td>0</td>
</tr>
<tr>
<td>17i: Coliseum Channels</td>
<td>7/11; 8/2</td>
<td>Backpack</td>
<td>0</td>
<td>3 m²</td>
<td>0</td>
</tr>
<tr>
<td>17j: Airport Channel</td>
<td>7/16</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>3 m²</td>
<td>0</td>
</tr>
<tr>
<td>17k: Doolittle Pond</td>
<td>7/16</td>
<td>Backpack</td>
<td>0</td>
<td>1 m²</td>
<td>0</td>
</tr>
<tr>
<td>17l: Alameda Island (Aeolian Yacht Club and East Shore)</td>
<td>8/22; 9/25</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>13.1 acres</td>
<td>0</td>
</tr>
</tbody>
</table>

REGION 7 TOTAL | 0 | 13.1 acres | 0 | 13.1 acres | 41.5 acres | 2006 | 84% | 13% |
2.2.8. REGION 8: BAY BRIDGE NORTH

The Bay Bridge North Region includes all East Bay shoreline marshes north of the Bay Bridge and southwest of the Carquinez Strait. This region is typified by riprap shorelines and fragmented marshes with little or no room for expansion due to urban development. The exceptions are intact historic Whittell Marsh (10a) and Giant Marsh (10c), and the large and partially-brackish Wildcat Marsh (22a) and San Pablo Marsh (22b). ISP surveyed the 12 sub-areas in Region 8 on foot in 2013, except for the shorelines and ponds adjacent to Wildcat Marsh, which were surveyed by kayak. A total of 0.14 acre of hybrid S. alterniflora was found, which marks a 78% reduction since 2012 and a 98% decline since this region’s peak in 2009 (Figure 18, Table 10). Five instances of S. densiflora were found, three in Whittell Marsh and two in nearby Southern Marsh (10b), with a combined cover of 0.05 net m², an 88% decline since 2012. Both of these sub-areas historically had S. densiflora infestation, though none was found in Southern Marsh in 2012. Only 0.003% remains of the 17.5 m² peak amount of S. densiflora that was found in this region in 2004.

Due to the limited potential habitat along stretches of this region’s hardscape shoreline, portions of the region, such as stretches of Richmond/Albany Shoreline/Pinole (22f), were not surveyed in 2013, so that ISP efforts could be focused in areas of potentially higher risk and impact (See Figure 1). Shorelines proximal to historic infestations were revisited on foot, but areas that lacked recent detection of infestation were not thoroughly inventoried.

Nine of the 12 sub-areas (75%) in Region 8 contained less than 29 m² of hybrid S. alterniflora each, with a total of just 94 m², which allowed backpack applications to be the predominant method of treatment in 2013. Even at sites that require an airboat for thorough access to the entire site (San Pablo and Wildcat marshes), backpack applicators deployed onto the marsh plain covered the majority of the ground. Both of these marshes had some larger mudflat clones that were treated using the power sprayer on the airboat, to assure full coverage on the tall plants, and minimize applicators needing to walk out in the soft mud with backpacks.

While only a modest amount, the 417 m² of hybrid S. alterniflora found in San Pablo Marsh in 2013 constitutes 72% of the entire Region 8 infestation. However, this site has experienced a greater than 98% reduction since the peak infestation (4.17 acres), even though the eastern portion (22b.1) was one of the 26 sites not permitted for treatment in 2011. The eastern portion contained only 116 m² in 2013, and although acres of hybrid cordgrass were removed from the mudflat and channel mouths over the years, the site still contains acres of intact S. foliosa fringe. The existing native cordgrass provides habitat suitable for Ridgway’s rails and a source of native seeds to help re-populate portions of the marsh that were previously dominated by the hybrid S. alterniflora infestation.

Over the past several years, many hybrid S. alterniflora clones along the banks of San Pablo Creek in the western portion of the site (22b.2) matured and were finally discernable amongst their native cordgrass relatives and in the brackish vegetation that is more prevalent upstream. Timing of treatment has been moved from mid-July, which is relatively early in the season, to early September, so that hybrids can be more thoroughly detected and effectively treated.
Twelve Ridgway’s rail sites in this region were surveyed for California Ridgway’s rail in 2013, 10 by the ISP and two by Point Blue Conservation Science. Since 2008, treatment has consistently reduced hybrid S. alterniflora cover in this region, while California Ridgway’s rail surveys over the same time period indicate a positive four-year trend (McBroom 2013). Ample well-developed rail habitat exists at the region’s two largest marshes, Wildcat Marsh (22a) and San Pablo Marsh (22b), and these sites support the bulk of the region’s rail population (PBCS 2014). There is little need for enhancement at these two marshes, and there is little opportunity for planting at other marshes in the Region; the ISP did not implement any revegetation projects in this region in 2013.
Figure 18. Distribution of invasive Spartina in 2013 across the 12 sub-areas of Reporting Region 8: Bay Bridge North.
<table>
<thead>
<tr>
<th>Split Sub-Area</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net Spartina Coverage By Species</th>
<th>Net Area</th>
<th>Peak</th>
<th>Year</th>
<th>Net Area Decline</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REGION 8: BAY BRIDGE NORTH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06a: Emeryville Crescent East</td>
<td>8/27</td>
<td>Backpack</td>
<td>0</td>
<td>27 m²</td>
<td>0</td>
<td>27 m²</td>
<td>117 m²</td>
<td>2004 &gt;99%</td>
</tr>
<tr>
<td>06b: Emeryville Crescent West</td>
<td>8/13</td>
<td>Backpack</td>
<td>0</td>
<td>3 m²</td>
<td>0</td>
<td>3 m²</td>
<td>18 m²</td>
<td>2004 &gt;99%</td>
</tr>
<tr>
<td>10a: Whittel Marsh</td>
<td>5/16; 1/9/14</td>
<td>Dug</td>
<td>0</td>
<td>0.3 m²</td>
<td>0.04 m²</td>
<td>0.4 m²</td>
<td>4 m²</td>
<td>2005 &gt;99%</td>
</tr>
<tr>
<td>10b: Southern Marsh</td>
<td>5/16; 9/13; 1/9/14</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>7 m²</td>
<td>0.02 m²</td>
<td>7 m²</td>
<td>35 m²</td>
<td>2010 98%</td>
</tr>
<tr>
<td>10c: Giant Marsh</td>
<td>9/13</td>
<td>Backpack</td>
<td>0</td>
<td>14 m²</td>
<td>0</td>
<td>14 m²</td>
<td>76 m²</td>
<td>2010 96%</td>
</tr>
<tr>
<td>22a: Wildcat Marsh</td>
<td>9/12</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>29 m²</td>
<td>0</td>
<td>29 m²</td>
<td>176 m²</td>
<td>2010 98%</td>
</tr>
<tr>
<td>22b: 1: San Pablo Marsh East</td>
<td>9/10</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>117 m²</td>
<td>0</td>
<td>117 m²</td>
<td>853 m²</td>
<td>2009 &gt;99%</td>
</tr>
<tr>
<td>22b: 2: San Pablo Marsh West</td>
<td>9/10; 9/12</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>300 m²</td>
<td>0</td>
<td>300 m²</td>
<td>0.4 acres</td>
<td>2009 93%</td>
</tr>
<tr>
<td>22c: Breuner Marsh (Rheem Creek)</td>
<td>9/13</td>
<td>Backpack</td>
<td>0</td>
<td>66 m²</td>
<td>0</td>
<td>67 m²</td>
<td>735 m²</td>
<td>2009 97%</td>
</tr>
<tr>
<td>22d: Stege Marsh</td>
<td>9/18</td>
<td>Backpack</td>
<td>0</td>
<td>6 m²</td>
<td>0</td>
<td>6 m²</td>
<td>57 m²</td>
<td>2009 97%</td>
</tr>
<tr>
<td>22e: Hoffman Marsh</td>
<td>9/18</td>
<td>Backpack</td>
<td>0</td>
<td>0.02 m²</td>
<td>0</td>
<td>0.02 m²</td>
<td>0.3 m²</td>
<td>2004 &gt;99%</td>
</tr>
<tr>
<td>22f: Richmond / Albany / Pinole Shoreline</td>
<td>8/27; 10/16; 10/31</td>
<td>Backpack</td>
<td>0</td>
<td>8 m²</td>
<td>0</td>
<td>8 m²</td>
<td>56 m²</td>
<td>2005 &gt;99%</td>
</tr>
<tr>
<td><strong>REGION 8 TOTAL</strong></td>
<td>8/27; 10/16; 10/31</td>
<td>Backpack</td>
<td>0</td>
<td>577 m²</td>
<td>0.05 m²</td>
<td>578 m²</td>
<td>0.9 acres</td>
<td>2009 98%</td>
</tr>
</tbody>
</table>
2.2.9. REGION 9: SUISUN

The Suisun Region is bounded on the west by the Carquinez Strait and extends east approximately to Antioch, where the salinity transitions to freshwater wetlands within the San Joaquin-Sacramento Delta. ISP’s Suisun Region consists of a single sub-area, Southampton Marsh (11), which was surveyed thoroughly on foot in 2013. Southampton Marsh, a part of the Benicia State Recreation Area, is the only location in the Estuary where Spartina patens has been documented, and it has persisted there since the early 1960s. In 2013, ISP staff mapped a total of 94 m² of non-native cordgrass in this marsh, 91 m² of which was S. patens and 3 m² of which was hybrid S. alterniflora (Figure 19, Table 11). As a result of treatment, hybrid S. alterniflora showed a 65% reduction from 2012 cover, while the S. patens experienced a 79% expansion in the absence of 2012 treatment (covered in greater detail below). The long rocky shoreline that lines the Carquinez Strait was not surveyed in 2013 so that resources could be focused on portions of the bay with more invasion pressure that would benefit more from inventory and treatment.

ISP treated a distant outlier population of hybrid S. alterniflora remaining at Southampton Marsh in 2013 after Ridgway’s rail breeding season ended on September 1. This work was prioritized by State Parks in recognition of the threat posed by hybrid S. alterniflora to Suisun Bay, and potentially the Delta, as sea level rise pushes the tidal prism further into the now-freshwater system. However, treatment of S. patens remained on hold as the ISP worked with State Parks and USDA-ARS researcher Brenda Grewell to develop a treatment plan that will remove the invasive cordgrass while reducing to acceptable levels impacts on three special status species. The main issue is reducing impacts to the hemi-parasitic plant Chloropyron molle ssp. molle (soft bird’s beak), some of which is growing within stands of S. patens. There has not been any treatment of S. patens at the site since a Ridgway’s rail was detected in 2011 during pre-breeding season surveys, and State Parks instituted exclusion zones where no management could occur from February 1 through October 1. There are also California black rail (Laterallus jamaicensis coturniculus) exclusion areas throughout the marsh to protect one of the larger populations of this bird in the Estuary. The team is working with ornithologist Jules Evens (Avocet Research Associates) to finalize a plan that will allow treatment of the majority of the S. patens in April 2014, pending results from Ridgway’s rail surveys. The plan would allow follow-up treatment in winter 2014 in the most vulnerable black rail areas, most likely by tarping and manual removal, since the S. patens will be senescent.

The Suisun Region, with its extensive brackish and freshwater marshes, has a very low density of California Ridgway’s rails, which generally prefer more saline conditions. Avocet Research and Associates surveyed Southampton Marsh in 2013 and did not detect any California Ridgway’s rails at the site (J. Evens, pers. comm.). Though tracts of native cordgrass extend along its shorelines, the hydrology of this region and the resulting marshes do not support a significant California Ridgway’s rail population, and no habitat enhancement efforts have been undertaken here by the ISP to date.
Figure 19. Distribution of invasive *Spartina* in 2013 across the single sub-area and adjacent shoreline of Reporting Region 9: Suisun.
Table 11. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 9: Suisun.

<table>
<thead>
<tr>
<th>Split Sub-Area</th>
<th>REGION 9: SUISUN</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net <em>Spartina</em> Coverage By Species</th>
<th>All Invasive <em>Spartina</em> Coverage</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>REGION 9 TOTAL</td>
<td>9/6</td>
<td>Dug, Backpack</td>
<td>91 m², 3 m², 0 m², 94 m², 390 m²</td>
<td>2005, 96%</td>
<td>59% increase (35 m²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2.10. REGION 10: VALLEJO

The Vallejo Region covers the northern portion of San Pablo Bay, bounded by the mouth of the Petaluma River to the west, the City of Vallejo to the east, and extending eight miles inland to the north. Due to the region’s large size, ISP employed several methods to complete inventory at its four sub-areas in 2013. Portions of the shoreline at San Pablo Bay NWR and Mare Island (26b), Sonoma Creek (26c), and Sonoma Baylands (26d) were inventoried by airboat. Mare Island was also inventoried on foot for both *S. densiflora* and hybrid *S. alterniflora* using all-terrain vehicles provided by USFWS San Pablo Bay National Wildlife Refuge. The expansive White Slough/Napa River sub-area (26a) is under very low invasion pressure by non-native *Spartina*, and so was not surveyed in 2013 except for the 128 acres that comprise White Slough Marsh, where there had historically been cordgrass of questionable ancestry.

The total amount of non-native *Spartina* mapped in this region was 0.06 acre, 0.11 m² of which was four instances of *S. densiflora* found along the Mare Island shoreline that were manually removed and dispersed offsite (Table 12, Figure 20). The remainder of invasive cordgrass in this region was all hybrid *S. alterniflora*: 46 m² along Sonoma Creek and 0.05 acre along the shoreline of Mare Island. The Mare Island inventory reflects an 889% increase over 2012 levels, the most rapid 2013 proportional expansion of hybrid *S. alterniflora* witnessed in the Bay, though it amounts only to a 0.04-acre increase. Despite this increase, the 2013 footprint is less than 19% of the amount that was found and treated in this site at peak in 2009 (0.32 acre). This expansion is most likely due to nascent plants that spread further northwest along the shoreline from the 2009 infestation. Until 2013, these plants did not display characteristics that readily identified them as hybrid, though after several years of maturation, they began growing more robustly and displaying the deep red sheaths that are often seen in hybrid *S. alterniflora* in San Pablo Bay.

An opposite trend was observed at Sonoma Baylands, where no non-native *Spartina* has been found since 2010, when a 21 m² clone was detected, treated, and eliminated in a single application. Similarly, no non-native *Spartina* has been found in White Slough/Napa River (26a) for four years.

The Sonoma Creek infestation was treated by backpack relatively early in the year (August 7) because this population of hybrid *S. alterniflora* is known to senesce ahead of much of the rest of the Estuary. The infestation continues to remain on an eradication trajectory, with the main problem area being a large polygon of short-form hybrid (less than six inches tall) that is persisting in a matrix of *Distichlis spicata*. It does not appear to be thriving, but was beginning to senesce even by the early treatment date, which may have reduced treatment efficacy.

The size of the hybrid *S. alterniflora* infestation that was finally detected at Mare Island after years of maturation required substantial treatment in 2013. Because of the remote location of the hybrid population and the miles of undeveloped shoreline that comprise the sub-area, an airboat was used to provide access for treatment. Mare Island is a relatively unique site in the Estuary, in that it is actually accreting sediment and prograding marsh onto the mudflat, due to the dynamics of sediment transport and deposition in this area of San Pablo Bay. As a result, the native and invasive cordgrass colonizing the
Figure 20. Distribution of invasive Spartina in 2013 across the 4 sub-areas of Reporting Region 10: Vallejo.

Representation of Spartina reflects distribution and does not equate to actual footprint. More detailed data and finer scale maps are available from ISP upon request.
### Table 12. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 10: Vallejo.

<table>
<thead>
<tr>
<th>REPORTING REGION</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net <em>Spartina</em> Coverage By Species</th>
<th>All Invasive <em>Spartina</em> Cover</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>anglica  patens  densiflora alteriflora foliosa densiflora</td>
<td>Net Area</td>
<td>Peak Year</td>
</tr>
<tr>
<td>Split Sub-Area</td>
<td></td>
<td></td>
<td></td>
<td>Treatment Area</td>
<td></td>
</tr>
<tr>
<td>REGION 10: VALLEJO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26a: White Slough / Napa River</td>
<td>No invasive <em>Spartina</em> detected 2011-2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>26b: San Pablo Bay NWR and Mare Island</td>
<td>6/19; 9/13</td>
<td>Dug, Backpack</td>
<td>0</td>
<td>193 m²</td>
<td>0.2 m²</td>
</tr>
<tr>
<td>26c: Sonoma Creek</td>
<td>8/7</td>
<td>Backpack</td>
<td>0</td>
<td>46 m²</td>
<td>0</td>
</tr>
<tr>
<td>26d: Sonoma Baylands</td>
<td>No invasive <em>Spartina</em> detected 2011-2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>REGION 10 TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
leading edge of the fringe are highly variable in morphology, making it difficult for ISP biologists to discern between them in the field. In 2013, significant buffers into the surrounding matrix of *S. foliosa* were treated around the hybrid plants in an effort to suppress this expansion and get the site back on an eradication trajectory.

The strong freshwater influence and the very young status of many of the restoration sites in the Vallejo Region currently results in few resident California Ridgway’s rail, though there is considerable future potential Ridgway’s rail habitat. In 2013, ISP, Point Blue Conservation Science, and staff of San Pablo Bay NWR surveyed eight sites and detected low numbers of California Ridgway’s rails consistent with prior years. With hybrid *Spartina* only colonizing two remote areas within this vast region, native cordgrass has very successfully established at recent restoration sites like Tolay Creek and Sonoma Baylands (26d). No ISP revegetation efforts have been directed to this region due to observed natural recruitment of native plants.
2.2.11. REGION 11: PETALUMA

The Petaluma Region consists of the wetlands lining the tidal portions of the Petaluma River and its tributaries in Marin and Sonoma Counties, from downtown Petaluma to the river’s mouth in northwestern San Pablo Bay. The historic infestation of this region by hybrid *S. alterniflora*, which peaked in 2007 at 0.15 acre, has been fairly localized to the upper reaches of the Petaluma River and was very possibly brought about by propagules dispersed here via uncleaned dredge equipment. The northernmost of the region’s four sub-areas, Upper Petaluma River-Upstream of Grey’s Field (24a) and Grey’s Field (24b) were thoroughly inventoried by boat, airboat and on foot. The northern half of neighboring Petaluma Marsh (24c) to the south was surveyed by airboat as well, though the lower half was not inventoried due to a lack of historic infestation and reduced invasion pressure. Further south, Lower Petaluma River-Downstream of San Antonio Creek (24d) was not inventoried in 2013, as no instance of non-native *Spartina* has ever been detected in this sub-area despite thorough monitoring in previous years.

Inventory of this region in 2013 yielded 40 m² of hybrid *S. alterniflora* and no other non-native cordgrass species (Figure 21, Table 13). This represents a 23% reduction over 2012 presence in this region. Late treatment in 2012 due to permitting delays is believed to have caused reduced efficacy and allowed hybrid seed production and dispersal in this area. Remaining invasive *Spartina* presence in this region is at 6% of its peak value in 2007.

Most of the infestation along the Petaluma River was treated from an airboat in 2013 to allow the crew to efficiently cover the great distance between the few instances of hybrid *S. alterniflora*, which were spread along the shoreline. Treatment was conducted on a receding tide to maximize dry time of the herbicide. Treatment was conducted about a month earlier than in 2012, and it is anticipated that this will result in better efficacy, less seed production and dispersal, and a greater reduction in the infestation.

The Petaluma Region’s high-quality rail habitat was largely surveyed by Point Blue Conservation Science, who reported a continued decline in this region’s California Ridgway’s rail population (PBCS 2014). The cause of continued decline is unknown, but invasive *Spartina* and its treatment are not indicated as factors. Since the occurrence and control of hybrid *Spartina* has been very limited in this region and there is abundant *S. foliosa*, no ISP revegetation projects were implemented in 2013.
Figure 21. Distribution of invasive *Spartina* in 2013 across the four sub-areas of Reporting Region 11: Petaluma

Representation of *Spartina* reflects distribution and does not equate to actual footprint. More detailed data and finer scale maps are available from ISP upon request.
Table 13. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 11: Petaluma.

<table>
<thead>
<tr>
<th>REPORTING REGION</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net <em>Spartina</em> Coverage By Species</th>
<th>All Invasive <em>Spartina</em> Cover</th>
<th>Net Area Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Split Sub-Area</td>
<td></td>
<td></td>
<td>anglica</td>
<td>patens</td>
<td>densiflora</td>
</tr>
<tr>
<td>REGION 11: PETALUMA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24a: Upper Petaluma River - Upstream of Grey’s Field</td>
<td>9/3; 10/8; 10/22</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>37 m²</td>
<td>0</td>
</tr>
<tr>
<td>24b: Grey’s Field</td>
<td>No invasive <em>Spartina</em> detected 2011-2013</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>24c: Petaluma Marsh</td>
<td>10/8</td>
<td>Backpack, Airboat</td>
<td>0</td>
<td>2 m²</td>
<td>0</td>
</tr>
<tr>
<td>REGION 11 TOTAL</td>
<td></td>
<td></td>
<td>0</td>
<td>40 m²</td>
<td>0</td>
</tr>
</tbody>
</table>
2.2.12. REGION 12: OUTER COAST

The Outer Coast Region includes the geographically-isolated watersheds on the western border of Marin County. This region is composed of remote coastal estuaries and bays, several of which have been colonized by a couple instances of hybrid S. *alterniflora*. These historic colonies and their surroundings in Estero de Limantour (25b), Drakes Estero (25c) and Bolinas Lagoon (25d & 25e) were monitored in 2013, though further reaches across the region were not thoroughly inventoried. The remote, low-invasion-pressure areas were not surveyed in order to prioritize inventory and treatment efforts at higher risk sites in the San Francisco Estuary. While Tomales Bay (25a) has never been colonized by hybrid *S. alterniflora*, two marshes in the sub-area, Tom’s Point and Hog Island Oyster Company, were invaded by *S. densiflora* and peaked at a net coverage of 5 m² in 2010 (Figure 22, Table 14).

Inventory in 2013 revealed 20 instances of *S. densiflora* within Tomales Bay: 15 plants at Tom’s Point and five plants at Hog Island Oyster Company totaling a combined cover of 0.73 net m². This is an increase from 2012 amounts (0.01 m²), which was most likely realized due to environmental conditions between the two years. Dry winter conditions during 2012 and 2013 resulted in desiccation of pickleweed, which left it low-growing and discolored, while the *S. densiflora* thrived in the diminished vegetative competition. The small but bright green *S. densiflora* recruits were more easily detected and are most likely the result of the remaining local seedbank, estimated by ISP experience to have a 3-5 year viability. Trends have been declining at these sites over the last two years, and hopefully these plants represent the last persisting seedbank sprouts in the substrate.

ISP has made monumental strides in reducing hybrid *S. alterniflora* presence in this region. Although the National Park Service utilizes herbicide for vegetation management within Point Reyes National Seashore, it was not authorized for *Spartina* work. Thus, eradication efforts on hybrid *S. alterniflora* clones in Drakes Estero and Estero de Limantour have been conducted solely by tarping (Figure 23). For the second year in a row, no invasive *Spartina* was detected at Limantour Estero and the neighboring slough at Drake’s Head. Drakes Estero experienced its first year of “zero detect” in 2013 after successful tarping that began in 2006 and continued through the subsequent years, with additional covering of small satellite populations as they sprung up.

In Bolinas Lagoon, the remaining hybrid *S. alterniflora* is relegated to the northern area (25d), as the southern area (25e) reached its second year of zero detection in 2013. The most problematic part of the remaining infestation consists of two large clones on the mudflat that were discovered in 2011 and have since coalesced into one large polygon. This stand was mowed to the base in both 2012 and 2013 to stop seed dispersal, while Marin County Parks & Open Space District conducted several public workshops and a CEQA review of the application of imazapyr to manage the problem. The clones are located on unconsolidated mudflat sediment that would not hold tarp staked to the surface. Digging that large a stand of hybrid *S. alterniflora* is not an option, so imazapyr application is the only feasible treatment method to eliminate the infestation. A neighboring infestation on a small pocket of pickleweed marsh to the south.
Figure 22. Distribution of invasive Spartina in 2013 across the five sub-areas of Reporting Region 1: Outer Coast.
Table 14. Summary of 2013 invasive *Spartina* area by sub-area within Reporting Region 12: Outer Coast.

<table>
<thead>
<tr>
<th>REPORTING REGION</th>
<th>2013 Treatment Dates</th>
<th>2013 Treatment Method</th>
<th>Net <em>Spartina</em> Coverage By Species</th>
<th>Net Area</th>
<th>Treatment Year</th>
<th>Peak Year</th>
<th>Since Peak</th>
<th>Since 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Split Sub-Area</td>
<td></td>
<td></td>
<td><strong>anglica</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REGION 12: OUTER COAST</td>
<td></td>
<td></td>
<td><strong>patens</strong></td>
<td>0</td>
<td>0</td>
<td>0.7 m²</td>
<td>0.7 m²</td>
<td>2 m²</td>
</tr>
<tr>
<td>25a: Tom's Point, Tomales</td>
<td>5/30; 1/14/14; 1/28/14</td>
<td>Dug</td>
<td><strong>transgrows</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2010</td>
</tr>
<tr>
<td>25b: Limantour Estero</td>
<td>No Invasive <em>Spartina</em> 2012 or 2013</td>
<td></td>
<td><strong>alttifolia</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2002</td>
</tr>
<tr>
<td>25c: Drakes Estero</td>
<td>No Invasive <em>Spartina</em> 2013</td>
<td></td>
<td><strong>densiflora</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2002</td>
</tr>
<tr>
<td>25d: Bolinas Lagoon, North</td>
<td>9/25</td>
<td>Mowed</td>
<td><strong>anglica</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2010</td>
</tr>
<tr>
<td>25e: Bolinas Lagoon, South</td>
<td>No Invasive <em>Spartina</em> 2012 or 2013</td>
<td></td>
<td><strong>patens</strong></td>
<td>0</td>
<td>0</td>
<td>16 m²</td>
<td>0</td>
<td>86 m²</td>
</tr>
<tr>
<td>REGION 12 TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>16 m²</td>
<td>0.7 m²</td>
<td>17 m²</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;99%</td>
<td>79%</td>
</tr>
</tbody>
</table>
was effectively tarped and no live plants were detected in that area in 2013. An additional clone of hybrid *S. alterniflora* was confirmed through genetic testing just north of the mudflat stand, and it is hoped that Marin County Parks & Open Space District will complete its planning and permitting phase and initiate herbicide treatment of all populations in 2014.

The present range of the California Ridgway’s rail is limited to the tidal marshes of the San Francisco Estuary, with the exception of occasional observations along the Outer Coast. In October of 2012, the ISP detected a California Ridgway’s rail in Tomales Bay during a *Spartina* survey, but no Ridgway’s rail surveys have been conducted in the Outer Coast Region. As such, no ISP revegetation projects have been implemented here to date.
3. SPECIAL TOPICS

3.1. SOUTH BAY SALT POND RESTORATION PROJECT

The South Bay Salt Pond Restoration Project (SBSP), managed by the Conservancy, is the largest tidal marsh restoration effort on the West Coast, with the goal of restoring native wetland ecosystem functioning to 15,100 acres of commercial salt ponds acquired from Cargill in 2003. This ambitious project has a timeline of approximately 50 years to restore the decommissioned salt ponds to salt marsh and a variety of other tidal habitats. In addition, within the SBSP area of San Francisco Bay south of the San Mateo Bridge, there are several thousand additional acres adjacent to, and sometimes contiguous with, the SBSP sites that are in the process of tidal restoration from salt ponds and other land uses, such as agriculture. As these systems mature, they promise to provide much-needed support to a variety of species that have been seriously impacted by the loss of 85-90% of the historic wetlands around the Estuary since the turn of the 20th Century.

However, when these sites are first breached, and for several years hence until the plant community begins to mature, they are the most vulnerable of any habitat in the Estuary to invasion and rapid domination by hybrid S. alterniflora. While the initial elevation of the restoration sites varies greatly due to subsidence or the import of fill, they all lack vegetation initially, although some may have sparse remnants of pickleweed on mounds or around the perimeter. With the absence of competition and biotic resistance, hybrid S. alterniflora can freely colonize and quickly expand vegetatively through the soft mud. Once hybrid S. alterniflora is well established, it can significantly alter the hydrology and further development of the plant community, pushing the site off of a native tidal marsh development trajectory.

To protect these projects, the ISP places a high priority on monitoring them at least annually, and rapidly following up with treatment if necessary. However, the burden of adding large tracts to the acreage ISP already inventories each year is significant. Typically, these new marshes are remote and very challenging to access at the proper tide for a thorough assessment of invasive Spartina presence or for treatment when necessary. As of 2013, the SBSP and other nearby restoration sites are represented by 14 ISP sub-areas distributed across three Regions: Redwood Shores Mitigation Bank (02a4), Ravenswood Open Space Preserve (N of Hwy 84) (02j.1), Pond B3 (02m), and Central Bair (02o) in Region 3; SF2 (02n), Island Ponds (05i), Knapp Tract (15a.6), and Pond A17 (15a.7—new in 2013) in Region 4; and North Creek (13h), Pond E10 (13i), Mt. Eden Creek (13j), North Creek Marsh (13k), Mt. Eden Creek Marsh (13l), and Ponds E8A, E9, and E8X (13m) as components of Eden Landing Ecological Reserve in Region 5. Figure 24 shows the sub-areas within SBSP complexes and other neighboring restoration marshes, including the status of restoration and the infestation of ten of these sub-areas by hybrid S. alterniflora, the only species of non-native cordgrass to appear in these sites to date.
Prior to 2013, ISP detected infestations in all three SBSP complexes, but infestations were minor in both the Alviso Complex (only in Pond A21 of the Island Ponds) and the Ravenswood Complex (only at SF2 just south of the Dumbarton Bridge). However, the Eden Landing (Baumberg) Complex includes numerous ponds that had been quickly and heavily infested by hybrid *S. alterniflora* soon after breaching, as a result of propagules produced by the large hybrid populations present along the bayshore at the time. Outside of SBSP efforts, recent tidal restoration has occurred in the Belmont Slough/Bair/Greco area where Redwood Shores Mitigation Bank (breached 2010) and Pond 3 (breached 2008) also became quickly colonized by hybrid.

In 2013, 986 net m$^2$ (0.24 net acre) of hybrid *S. alterniflora* was found across these recent restoration sites, up 174% from 361 net m$^2$ in 2012. This increase was driven by two significant hybrid expansions in Region 3, one at Ravenswood Open Space Preserve (N of Hwy 84) and one at Pond B3, and a moderate expansion in Region 4, at the western-most Island Pond (A21). Infestation at Ravenswood Open Space  Preserve increased drastically between 2012 and 2013 from 9 m$^2$ to 393 m$^2$, while Pond B3 almost doubled from 287 m$^2$ to 531 m$^2$ in the same timeframe. Pond A21 also increased, though only from 5 m$^2$ to 44 m$^2$. All other recent restoration sites experienced an aggregate 68% reduction in infestation from 59 m$^2$ to 19 m$^2$ due to annual monitoring and treatment by ISP.
No hybrid *S. alterniflora* was found in two sub-areas, Eden Landing-Ponds E8A, E9, and E8X (13m) and Central Bair (O20). Both sub-areas are very recently breached — late 2012 and early 2011 respectively — and no *Spartina* of any origin has yet been detected. The marsh elevation at these two sub-areas is still shifting post-breach and was not yet appropriate for colonization by cordgrass in 2013. ISP will continue to vigilantly monitor these locations on an annual basis to control infestation by invasive *Spartina* and promote establishment by *S. foliosa*. Fortunately, the invasion pressure for these two new sub-areas is now very low, since the immediately surrounding marshes of the Eden Landing complex contained just 662 m² of hybrid *S. alterniflora* in 2013, and active treatment is conducted each summer before any remaining plants can disperse viable seed.

Hybrid *S. alterniflora* was found for the first time in Knapp Tract (aka Pond A6, ISP sub-area 15a.6) in the Alviso Complex, which was breached in 2010. Only one plant was detected, a seedling totaling 0.005 net m².

Colonization by hybrid *S. alterniflora* at this sub-area was not unexpected considering the site’s fresh mudflat condition, its location directly across Coyote Creek from Calaveras Marsh (5a.2), which contained 0.53 acre of hybrid cordgrass in 2013 and 0.73 acre in 2012, and the substantial hybrid infestation just outside the site’s eastern breaches at the mouth of Alviso Slough. There was also a large clone of hybrid *S. alterniflora* detected and treated in 2013 within the northern breach off Guadalupe Slough (see Figure 25). Pond A17 in the Alviso Complex was breached in 2012, but no hybrid *S. alterniflora* was detected within its boundaries in 2013.

Considering the frequent and rapid colonization of freshly breached sites by hybrid *S. alterniflora*, ISP conducted a genetic survey of new *Spartina* recruits at 11 sub-areas to better understand invasion potential (Thornton et al. 2013). A combination of mudflat and young restoration sites were selected in Central and Southern San Francisco Bay. Twenty colonizing seedlings were randomly selected from each
location, and plant tissue samples were collected and genetically analyzed to determine if the new recruits were of native or non-native origin. The results showed that proximity to mature stands of *Spartina* drive which species is most likely to colonize these habitats that currently do not support competing vegetation. Sampled sites that were most proximal to predominantly native cordgrass stands were colonized mostly by *S. foliosa*, while sites with substantial amounts of hybrid *S. alterniflora* nearby were predominantly colonized by invasive cordgrass. This highlights both the benefit of introducing *S. foliosa* to areas where it currently occurs in low amounts, and the need to further control the extant hybrid *S. alterniflora* seed sources surrounding young and easily invaded sites. Efforts are currently underway by the ISP’s Revegetation Program to introduce *S. foliosa* and to reduce the amount of invasion potential at restored SBSP marshes, but these efforts will need to increase as more salt ponds are breached as a part of this widespread restoration project.
3.2. RESTRICTED TREATMENT SITES

The 2012 USFWS Biological Opinion (BO; USFWS Memorandum, Aug 21, 2012) authorized full treatment at all but 11 sub-areas. At one of these sub-areas, B2 North Quadrant East (02c.1b) in the San Mateo Region (Region 3), aerial application of herbicide for suppression of hybrid S. alterniflora seed production was the only treatment permitted. Seed suppression entails the application of a dilute solution of herbicide to stop production and dispersal of seed and expansion of vegetation, but the solution is too weak to cause plant mortality. This method is employed to maintain the above-ground biomass of the hybrid S. alterniflora in areas where other vegetative structure is insufficient to provide Ridgway’s rails with nesting substrate and cover from predators. In 2013, ISP initiated a 3-year study within B2 North Quadrant-East to determine an optimal herbicide concentration that would arrest the development of the hybrid S. alterniflora plants while maintaining tall, dense cover for Ridgway’s rails.

The 2012 BO (and the subsequent 2013 amendment) prohibited treatment at the remaining ten sub-areas: Citation Marsh (20d), North Marsh (20f), Bunker Marsh (20g), San Lorenzo Creek Marsh North (20h.1), Cogswell Quadrant B (20n), and Cogswell Quadrant C (20o) in the Hayward Region (Region 6); and Arrowhead Marsh East (17c.2), MLK Regional Shoreline-Damon Marsh (17d.4), MLK New Marsh (17h), and Fan Marsh (17l) in San Leandro Bay (Region 7). These treatment restrictions were intended to limit adverse impacts on Ridgway’s rails. Distribution of these sites is shown in Figure 26.

In order to focus inventory efforts in other marshes that would inform treatment for 2013, these 11 sites were surveyed on a coarser level to ascertain the general distribution and abundance of non-native cordgrass without the level of detail required to relocate individual plants for treatment purposes. This involved mapping large polygons of infested areas and assigning broad cover classes, since the areas were not thoroughly monitored to map each specific instance of Spartina. To test the comparability of these cursory methods with our standard mapping methods, we performed standard inventory within a subsection of two marshes and compared the results of both methods via GIS analysis. We found that surveyors tended to under-estimate percent cover within the large polygons mapped during cursory mapping efforts, resulting in significantly lower Spartina cover calculations than those yielded by our standard mapping methods. To adjust for these errors, we calibrated all large polygon features mapped using these cursory methods by using broader groupings of percent cover classifications, which more accurately reflect the decreased precision when mapping in this coarse fashion.

The results show an aggregate increase in Spartina cover over 2012 of six acres, which is a 30% annual increase. The 26 acres of hybrid S. alterniflora in the restricted treatment zones account for 69% of the total remaining invasive Spartina footprint in the Bay (Tables 1 and 15, Figure 27).

By the 2013 monitoring season, the sub-areas with no treatment allowance had been untreated for three full growing seasons, and the Spartina footprint had expanded beyond 2011 levels for every site except for Arrowhead Marsh East (17c.2) and San Lorenzo Creek Mouth North (20h.1). Arrowhead
Figure 26. Distribution map of the 11 ISP sub-areas in which treatment of hybrid *S. alterniflora* has been restricted since 2011.
Marsh East has long had a high density of hybrid *S. alterniflora* and has never received full treatment; its last aerial treatment for seed suppression occurred in 2010, and hybrid *Spartina* area and cover have remained consistent since then because the site is essentially at “carrying capacity,” with hybrid *S. alterniflora* fully established in all areas where it can grow. The reduction of 0.48 acre of *Spartina* between 2012 and 2013 at this site is the result of a slight boundary shift that corrected a similar boundary expansion in 2012 due to misinterpretation of maps during 2012 treatment on the ground. The decrease of 30 m$^2$ at San Lorenzo Creek Mouth North was the result of accidental treatment by backpack of hybrid, also due to a misinterpretation of maps and site boundaries in areas that were not affecting Ridgway’s rail habitat. Despite its small size (20 acres), Arrowhead Marsh East continues to be the site containing the most hybrid *S. alterniflora* in the Estuary, with 7.15 acres. Cogswell B, which had been reduced to 0.58 acre prior to treatment restrictions (down from 10.1 acres in 2005), is now the second most invaded sub-area, with 5.23 net acres of hybrid distributed throughout 102 acres of marsh.

In the absence of treatment at the eight other “no treatment” sub-areas, the remaining hybrid *S. alterniflora* began to rebound quickly from the previous years of control work by ISP partners. In addition to dispersing seed capable of re-infesting cleared areas within the marshes and establishing new infestations elsewhere in the Estuary, the uncontrolled hybrid *S. alterniflora* can quickly expand vegetatively within each site. The underground root structures (rhizomes) radiate out from the clone, expanding its diameter and allowing it to encroach back onto mudflats, tidal channels and the marsh plain.
Invasive Spartina Project 72 2013 ISP Monitoring and Treatment Report

Figure 27. Bay-wide trend of invasive Spartina net area, by treatment authorization since 2010. An annual decline in bay-wide infestation has been observed since 2006 when treatment began, but was halted for the first time in 2013 when hybrid S. alterniflora in sites where treatment is restricted increased to 26 acres, 70% of the bay-wide total.

The very rapid annual expansion of hybrid S. alterniflora at many of the untreated sites provides a sobering reminder of the remarkable vigor of this invasive ecosystem engineer. The loss of mudflat from the conversion to monotypic hybrid S. alterniflora marsh destroys intertidal foraging habitat for shorebirds (Stralberg, Toniolo et al. 2004). It also shifts the benthic invertebrate group from surface feeders available to birds and other consumers to belowground feeders that are inaccessible (Neira, Grosholz et al. 2006). The domination of tidal marsh and mudflat alike by hybrid S. alterniflora results in a loss of biodiversity, in marsh plants and the wildlife they support, as well as a reduction in benthic invertebrate biomass (the foundation for the estuarine food web in mudflats) by greater than 70% (Brusati 2004; Levin, Neira et al. 2006).

Disruption of habitat can have ripple effects throughout the system; loss of perennial pickleweed directly impacts species that depend on this plant, such as the endangered salt marsh harvest mouse (Reithrodontomys raviventris), for which pickleweed is both the primary food source and preferred habitat. Other special status species that are vulnerable to these same changes in the composition of the tidal marsh plant community include California black rail (Laterallus jamiacensis coturniculus), three subspecies of song sparrow (Melospiza melodia pusillula, M.m. maxillaris and M.m. samuelis) and saltmarsh common yellowthroat (Geothlypis trichas sinuosa), all of which are year-round tidal marsh residents. Established stands of hybrid S. alterniflora are also capable of altering the hydrology within marshes, as the dense vegetation accretes sediment over time and clogs channels used as foraging corridors for
Ridgway’s rails and other animals. These and many other detrimental environmental effects of invasive *Spartina* are covered in detail in the ISP’s Programmatic Environmental Impact Report/Statement (State Coastal Conservancy, 2003).

The potential effects of the suspended treatment at 11 sub-areas in the interest of California Ridgway’s rails are varied and substantial. At a minimum, the suspension will result in 10 or more additional years of region-wide monitoring and treatment at a cost of many millions of dollars, to keep these propagule sources in check and eventually achieve regional eradication.

**3.3. NEW INFESTATIONS AND SUB-AREAS ADDED IN 2013**

There were no ‘new’ invasive *Spartina* infestations discovered in 2013. ISP defines a ‘new’ infestation as a freshly discovered instance of invasive *Spartina* greater than one kilometer from any historic location. In 2012, a single new infestation was found in Region 4 that consisted of 1.9 m² of hybrid *S. alterniflora* that was all sprayed by backpack. In 2013 this infestation continued, but had been reduced to 0.3 m², all of which was also sprayed.

One new sub-area, Pond A17 (15a.7), was added in Region 4: Dumbarton South as a freshly breached former salt pond. As of the 2013 monitoring season, it has not yet been colonized by *Spartina* of any sort (see previous discussions in sections 2.2.4 and 3.1).
4. CONSIDERATIONS FOR 2014

The goal of the ISP is to eradicate non-native Spartina from the Estuary in order to restore and preserve native tidal marsh. Over the past nine years (2005-2013), the ISP and its partners have made great progress towards this goal, having reduced the cover of the invasion by 95% since its peak of 805 net acres in 2005, and many sites are approaching eradication. In 2013 there were less than 40 net acres of non-native Spartina Estuary-wide, and in 12 previously-invaded sub-areas, no invasive Spartina could be found (see Section 2.1). However, this year the ISP documented for the first time a shift in the eradication trajectory of hybrid S. alterniflora, which increased a modest 0.2% bay-wide following the 22% (10 acre) reduction between 2011 and 2012.

The reverse in population trend is driven by the increasing amount of hybrid S. alterniflora in the eleven sites now in their third year of treatment restrictions (discussed in section 3.2). These sites contained greater than 26 acres of hybrid S. alterniflora in 2013, which is now increasing in density within the sub-area boundaries, and acting as a seed source to re-infest neighboring shorelines of the San Leandro Bay and Hayward Regions. The opportunity to re-examine treatment permissions at these sites is dependent on California Ridgway’s rail numbers increasing by 80 rails above the 2010 level for three consecutive years. The first year of such an increase in rail numbers has not yet been achieved (McBroom 2014), and although efforts of the ISP’s revegetation program have been highly successful in establishing new S. foliosa and G. stricta cover in the marshes, it is currently unknown whether Ridgway’s rail populations may respond positively to this new habitat, or may otherwise expand at existing or restored tidal marshes within the target areas. With this high level of uncertainty regarding the rails, it is impossible to say when comprehensive eradication efforts may again be underway, and thus the timeframe for achieving eradication of invasive Spartina is completely unknown.

In addition to the uncertain timeframe for resuming treatment, ISP faces other challenges in accomplishing the goal of eradication. As invasive Spartina cover is successfully reduced around most of the Estuary, finding and removing the last few plants dispersed throughout this large area is inherently difficult. The task is further complicated by (1) challenges identifying some forms of hybrid S. alterniflora in their early growth stages, when they can appear similar to S. foliosa, and (2) the increasingly large area requiring monitoring, as former salt ponds are restored to tidal action. Both of these complications were encountered more acutely in 2013 than prior seasons, which led ISP staff to modify monitoring and treatment methods for the current and future seasons.

Hybrid S. alterniflora identification -- Differentiation between S. foliosa and hybrid S. alterniflora is especially challenging in immature (< three year-old) plants and/or if hybrid plants are the result of repeated backcrossing with S. foliosa, in which case they more closely resemble their native ancestors. Some expansions observed in 2013 (e.g. San Pablo Bay NWR-Mare Island [26b], Sanchez Marsh [19k], and portions of Calaveras Marsh [05a.2]) are the result of these cryptic plants escaping detection and treatment in prior years, only to mature and become detectable in 2013. To avoid similar increases in the future and to better inventory marshes with these more perplexing plant forms, more targeted DNA sampling will occur early in 2014, when it will be most helpful for informing inventory and treatment. ISP has very rarely received genetic results prior to inventory, and this new monitoring approach at a limited number
of appropriate sites is expected to be very useful in identifying and treating these morphologically con-
fusing plants before they have the opportunity to proliferate.

Increasing survey area – While the ISP coordinates this regional eradication program, partners are pro-
ceeding with large scale restoration projects that increase the area of potential habitat available for the
invasive *Spartina* to spread. This was discussed further in Section 3.1. The new marshes are critical for
achieving the community’s long-term native marsh restoration goals, and so every effort must be made
to protect the marshes from infestation by hybrid *S. alterniflora*. However, because they are typically
remote and expansive, these new marshes are also among the most difficult in the Estuary to access,
monitor, and treat. Due to a finite budget and limited suitable treatment times during the season, in
2013 the ISP prioritized sites for inventory based in large part on likelihood of infestation. Thus, most of
the invaded and high risk sites were surveyed, but approximately 40% of potential *Spartina* habitat, in-
cluding some of the marshes that were recently restored to tidal action, was not. As recently-breached
restoration marshes accrete sediment and achieve elevations suitable for colonization by invasive
*Spartina*, more and more effort will be required to make sure these sites are monitored and treated.
Several young restoration sites (Pond B3 [02m, Region 3] and the Island Ponds [05i, Region 4]) had
reached this point and were minimally surveyed in 2013. But the sites are now rapidly vegetating, and
the ISP expects they will require much more time and effort in 2014 for more thorough monitoring. Sim-
ilarly, large and more recently-breached sites like Central Bair (02o, Region 3), Knapp Tract (05a.6j, Re-

gion 4), Pond A17 (15a.7, Region 4), and Eden Landing-Ponds E8A, E9x, and E8X (13m, Region 5) are al-
ready likely to require thorough survey (and treatment if hybrid *S. alterniflora* is found) for the first time
in the coming 2014 season. Several of these new sub-areas were visited in 2013 to begin developing effi-
cient access strategies for both monitoring and treatment.

Moving Forward—The ISP will continue monitoring and treatment of the 12 net acres of non-native
*Spartina* remaining in the unrestricted sites to achieve local eradication as quickly and efficiently as pos-
sible. This will include diligent monitoring and treatment at sites proximal to those with treatment re-
strictions, where abundant, uncontrolled hybrid *S. alterniflora* is still producing and exporting viable
seeds and propagules into the treatment sites. Any lapse in vigilance at these vulnerable sites will likely
result in their being rapidly populated and dominated by the invasive *Spartina*. Similarly, as more
marshes develop after restoration to tidal action.

The ISP will continue to work with its partners at the newly restored sites to adapt and implement moni-
toring and treatment strategies that will allow these sites to establish suitable native habitat. The ISP
will also continue implementation of its Restoration Program, with extensive planting of native marsh
plants at strategic locations to rapidly establish and enhance habitat for California Ridgway’s rails. These
locations include marshes where the threat of infestation by *S. alterniflora* has been successfully re-
duced to acceptable levels, as well as in recently restored marshes. ISP’s revegetation work to date looks
promising, but it is not certain whether this effort will promote increase of Ridgway’s rail populations in
the near term. The ISP, Conservancy, and DENWR will continue to work with staff and management at
USFWS to further clarify conservation and regulatory objectives and timelines, and develop a viable
strategy for achieving California Ridgway’s rail conservation objectives and eradication of invasive
*Spartina* from the Estuary.
5. REFERENCES


APPENDIX 1:

Target Plant Species Descriptions
There are one native and four non-native species of cordgrass in the San Francisco Estuary. The native species, Pacific cordgrass (*Spartina foliosa*), is avoided during treatment and is conserved by controlling the invasive species that can displace or genetically assimilate it. Key aspects of the cordgrass species found in the Estuary are contrasted below. All species and hybrids are perennial, salt-tolerant grasses that spread both sexually and asexually. The roles these species play in their native habitats give ecologists an indication of their potential to alter the salt marsh ecosystem of San Francisco Bay.

**NATIVE: PACIFIC CORDGRASS (**SPARTINA FOLIOSA**)**

California’s only native cordgrass, *S. foliosa*, grows in a narrow range of the tidal spectrum due to its relatively short stature and intolerance for drought. *Spartina foliosa* is a vital component of the salt marsh plant community, occurring at the lowest intertidal elevation of any native macrophyte. This lower tidal marsh zone occurs at the upper elevation of the mudflat and along channel banks and benches. Native cordgrass is also found scattered throughout the next zone in the elevational gradient, the middle tidal marsh zone, or pickleweed (*Salicornia virginica*) marsh plain. *Spartina foliosa’s* slender leafy shoots seldom exceed five feet in height including seed heads, with most shoots ranging from approximately one to three feet tall. Cordgrass height correlates with its tolerance of submersion, and as such *S. foliosa* can occupy only a limited range in the lower and middle tidal marsh zones (Cain and Harvey 1983). Its leaves and stems wither in fall and are shed in winter, as the clones die back to the mud substrate.

*Spartina foliosa* is particularly valued as habitat for the endangered California clapper rail (*Rallus longirostris obsoletus*), which spends most of its time foraging for food within, or close to, the protective canopy of cordgrass. California clapper rails can move within *S. foliosa* stands, and they spend most of their time under cover of the cordgrass foliar canopy, usually selecting prey items such as benthic and aquatic invertebrates inhabiting the cordgrass stands and their edges. The benthic invertebrate community found in the substrate at the base of *S. foliosa* is also an important food source to a variety of other consumers including both resident and migratory shorebirds.

While it was widely recognized that hybrid *S. alterniflora* (discussed in the next section) could potentially threaten the existence of native *S. foliosa*, control of the hybrids began sufficiently early that *S. foliosa* still anchors thousands of acres of tidal marsh throughout the Estuary. Most of the North Bay was relatively unimpacted by hybrid *S. alterniflora*, and more than 99% of the cordgrass in the remnant marshes throughout the Estuary is still intact *S. foliosa*. However, *S. foliosa* was assimilated into the hybrid swarm, and even locally extirpated, in some of the largest infestations around South San Francisco Bay, including the Alameda Flood Control Channel (Site 1) and Eden Landing (Site 13). These sites are the focus of an extensive reintroduction effort by the Conservancy that began in 2010, to establish stands of *S. foliosa* that will begin to disperse seeds throughout these sites, leveraging the investment in direct planting.
ATLANTIC SMOOTH CORDGRASS (SPARTINA ALTERNIFLORA) AND ITS HYBRIDS

Atlantic smooth cordgrass is unique among the world’s cordgrass species in terms of its growth potential and ecological breadth. *Spartina alterniflora* is genetically very similar to *S. foliosa*, but the two species have significant differences. In size, growth rate, pollen and seed production, culm (stem) density and ecological tolerances, *S. alterniflora* is more robust than *S. foliosa* (Smart and Barko 1978; Boyer, Callaway et al. 2000). The San Francisco Estuary population of *S. alterniflora* was introduced from seed collected in Maryland in the early-1970s to aid in a dredge spoils stabilization and marsh restoration experiment (Faber 2000). Genetic similarity to *S. foliosa* allowed multiple hybridization and eventual backcrossing events that produced the “hybrid swarm” that has posed the most widespread and intrusive threat to the Estuary (Daehler and Strong 1997). Pollen production, higher fertility, greater tolerance for both inundation and drought, and increased timeframe for flowering make these hybrids a prominent threat to native cordgrass through outcompetition, pollen swamping, and hybrid assimilation (Rhymers and Simberloff 1996; Ayres, Garcia-Rossi et al. 1999; Anttila, King et al. 2000; Levin, Neira et al. 2006).

Hybrid *S. alterniflora* was well established and widely distributed in the Central and South Bay at the start of the ISP Control Program, but it was detected early and controlled by ISP in the North Bay. Although a small population established on the shoreline of Southampton Marsh (Site 11) in Benicia State Recreation Area, hybrid *S. alterniflora* has not yet been detected further into Suisun Bay, despite intensive surveys. Over the years, outlier populations have been detected on the Petaluma River (Site 24), Sonoma Creek (26c), and Mare Island (26b), and single clones were found at both China Camp State Park (23o) and Sonoma Baylands (26d). Pioneering hybrid *S. alterniflora* populations have also been detected and managed at Drakes Estero, Limantour Estero, and Bolinas Lagoon on the Point Reyes peninsula (Site 25). The abundance of hybrid *S. alterniflora* remains greatest in San Leandro Bay (Oakland), Robert’s Landing in San Leandro, and outer Bair Island Ecological Reserve (Redwood City), but has been reduced by 95% bay-wide, down to 38 net acres\(^1\) since its peak of 805 net acres in 2005.

When stands of *S. foliosa* are displaced by hybrid *S. alterniflora*, not only does the biomass of the benthic invertebrates decline by more than 70%, the benthic community also shifts from surface feeders to belowground feeders that are inaccessible to foraging birds (Levin et. al. 2006).

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\(^1\) The ISP uses the terms “net area” and “treatment area” to define the extent of non-native *Spartina*. Net area refers to the size of the infestation if the space between stems were subtracted from the overall footprint of the plant or clump of plants. Net area is the metric typically used in botanical surveys. Treatment area describes the area that will be directly affected by treatment. Treatment area is a separate measurement used for planning, and it is general 2 to 3 times greater than the net area of given instance of invasive *Spartina*.
CHILEAN CORDGRASS (SPARTINA DENSIFLORA) AND ITS HYBRID WITH PACIFIC CORDGRASS (S. FOLIOSA)

Chilean cordgrass (also called dense-flowered cordgrass) is a distinctive cordgrass species native to South America that grows as a bunchgrass in the middle marsh plain, eventually forming tussocks and meadows (Spicher and Josselyn 1985; Kittelson and Boyd 1997). *Spartina densiflora* was introduced to California in Humboldt Bay by dry ship ballast containing propagules from South American ports that traded lumber (Spicher and Josselyn 1985). Thought for most of the 20th century to be a form of Pacific cordgrass, *S. densiflora* was deliberately transplanted to a salt marsh restoration project at Creekside Park (4g) along Corte Madera Creek in Marin County in the 1970s. Within the salt marshes fringing Corte Madera Creek, it became a locally-dominant component of the middle and high salt marsh vegetation, displacing even robust pickleweed.

While the bulk of the *S. densiflora* invasion has been contained within Marin around the Corte Madera Creek watershed, other populations have been detected and largely eliminated in Redwood City (19s), Point Pinole Regional Shoreline (Site 10), Burlingame (19k & 19l), Tom’s Point (25a) in Tomales Bay, and the shoreline of San Pablo Bay National Wildlife Refuge (26b). Most of the novel population establishments appear to have been the result of active planting by anonymous parties. When established in close proximity to *S. foliosa*, *S. densiflora* has produced infertile hybrids with the native cordgrass that spread solely via vegetative growth (Ayres, Zaremba et al. 2008).

By 2013, the population of *S. densiflora* had been reduced to 47 m² Estuary-wide, and only 16 m² of the hybrid between *S. foliosa* and *S. densiflora* remained; both are reductions of more than 95% since the peak years for each. These successful reductions have been achieved through dedicated implementation of an adaptive Integrated Vegetation Management (IVM) strategy that includes multiple treatment methods. Because of the unique biology of this form of *Spartina*, any single-tool approach would have been ineffective. The efficacy of herbicide treatment (using imazapyr) varies widely between large plants and small plants, as well as between pioneering individuals and established stands. The seed bank viability of *S. densiflora* is estimated at 3 to 5 years (as compared to 1 to 1.5 years for *S. alterniflora*), which increases the time required for full eradication, even after an infestation is effectively reduced to just a few individuals. With these additional challenges, it is fortunate that *S. densiflora* appears to be somewhat limited in its ability to disperse around the San Francisco Bay ecosystem, and that the infestation has never approached the scale of hybrid *S. alterniflora*, which both consistently responds well to imazapyr treatment and has shorter seed viability.

ENGLISH CORDGRASS (SPARTINA ANGLICA)

English cordgrass is an aggressive invader of mudflats and salt marshes in Britain, New Zealand, Australia, and the Pacific Northwest, and thrives in cool temperate climates. It originated in Britain as a fertile hybrid derived from introduced Atlantic smooth cordgrass and common cordgrass (*S. maritima*). It was introduced to the San Francisco Estuary at Creekside Park (4g) along Corte Madera Creek in Marin
San Francisco Invasive *Spartina* Project

APPENDIX 1

County, along with Chilean cordgrass (*S. densiflora*), in 1976. Unlike Atlantic smooth cordgrass and Chilean cordgrass, this species failed to disperse from its point of introduction to expand the infestation beyond Creekside Park. It may be at or near its southern climatic limit on the Pacific Coast in the Estuary.

*Spartina anglica* is nearly eradicated from San Francisco Bay, and it is not known to occur in any other location in California. The ISP mapped just 4 m² of *S. anglica* in 2013. There are several factors that contributed to this infestation lingering longer than might be expected given its relatively small size and presence at only a single ISP site. *Spartina anglica* flowers and sets seed in early summer, slightly later than *S. densiflora* but far ahead of hybrid *S. alterniflora*. This phenology did not allow for treatment ahead of seed dispersal prior to 2008, when ISP was first permitted to enter the sites before California clapper rail breeding season ends on September 1. In addition, there were several other years where either delayed permits (2011 and 2012 Biological Opinions) or political concerns (delays with Marin County finalizing its revised IPM Policy in 2009) caused the implementing ISP partner, Friends of Corte Madera Creek Watershed, to miss the optimal treatment window for that year. Finally, the remaining *S. anglica* at Creekside Park is often found growing as a short understory to the native *S. foliosa* that lines the main channel, which limited the full detection of the target plants, and the desire to preserve as much of the native cordgrass as possible further complicated the matter.

**SALT-MEADOW CORDGRASS (SPARTINA PATENS)**

In its native range on the Atlantic coast, salt-meadow cordgrass is naturally restricted to the well-drained high salt marsh and relatively moist sandy depressions at or above tidal influence. However, in the San Francisco Estuary, it has thrived along channel banks and on the pickleweed plain. *Spartina patens* arrived in the Estuary by the early 1960s in Southampton Marsh (Site 11; Benicia State Recreation Area), as evidenced by a sample present in the California Academy of Science’s collection from circa 1962. At the initiation of treatment by ISP and the California Department of Parks and Recreation (State Parks), 0.65 net acre of salt-meadow cordgrass was present in large, discrete patches at Southampton Marsh. In 2013, the net cover was only 0.023 acre, though this is more than double the 2012 footprint; treatment has been stalled because of complications related to the presence of three special status species.

*Spartina patens* has spread into an area of Southampton Marsh that supports a population of an endangered annual hemi-parasitic plant, soft bird’s-beak (*Chloropyron molle* ssp. *molle*, formerly *Cordylanthus mollis* ssp. *mollis*). The treatment approach initially approved and used in this area of the marsh was to treat the *S. patens* stands with herbicide in the late fall, after the soft bird’s beak had produced seed and senesced, so that the treatment would not negatively affect the soft bird’s beak population. However, *S. patens* itself flowers in
May at that location, and by the time herbicide was applied in October, the $S. \text{ patens}$ plants had also already produced seed and begun senescing. When a plant senesces it is no longer able to uptake and translocate the herbicide, processes that are necessary to kill the plant. It soon was clear that no additional headway was being made toward eradication of $S. \text{ patens}$.

In 2011, the ISP worked with rare plant researcher Brenda Grewell (USDA-ARS) and State Parks to develop a new eradication plan to address the shortcomings of the earlier plan. The new plan would permit limited, temporary impacts to $C. \text{ molle ssp. molle e}$ so that the $S. \text{ patens}$ could be treated effectively, and may include collecting and banking seed from the hemi-parasite to sow once $S. \text{ patens}$ has been eradicated and native host plants reestablished.

However, implementation of the new plan has now been postponed because of the reappearance of California clapper rail in Southampton Marsh in 2011, after years of absence at the site. In an effort to nurture the potential new clapper rail population, State Parks set up extensive marsh exclusion zones, including areas of $S. \text{ patens}$ populations, and again restricted entry for treatment until after October 1. The 2012 and 2013 breeding season surveys did not detect any California clapper rail at the site, but the exclusion zones were still in effect, making it impossible to begin implementing the new strategy.

REFERENCES


APPENDIX 1


APPENDIX 2:

ISP Program Areas
Invasive *Spartina* Project Programs

The ISP is comprised of three broad programs—treatment, monitoring, and restoration, which coordinate closely to achieve the ISP goals. Monitoring is comprised of several programs including *Spartina* inventory monitoring, treatment monitoring, California clapper rail monitoring, and water quality monitoring. Important tools within the monitoring programs are genetic sampling and analysis of *Spartina*, and photo point monitoring. The many programs work together to assure and document an effective regional treatment effort, while protecting water quality, wildlife, and the ecosystem structure. The status of each of the program areas is provided below.

**TREATMENT PROGRAM**

The Treatment Program coordinates a multitude of contractors, agencies, landowners, and staff to plan and conduct annual treatment of the various non-native *Spartina* species found throughout the Estuary. Pilot efforts to test herbicide methods and coordination mechanisms began in 2004, when the total known footprint of non-native *Spartina* was at that time 758 acres. In 2005, the ISP partners began coordinated, Estuary-wide treatment. Treatment initially focused on large infestations and areas where partners were most ready to begin work, and expanded to include the total of sites in 2006 and 2007. Aerial broadcast treatment by helicopter at several of the large hybrid *Spartina* monocultures of the central and south bay soon effectively reversed the spread of hybrid *Spartina* and established control over the infestations. Once continuous meadows of hybrid *Spartina* at sites like Alameda Flood Control Channel (Site 1), Eden Landing Ecological Reserve (Site 13) in Union City, and Seal Slough (19p) in San Mateo, were reduced to a patchy distribution of plants across each site, the herbicide methods were shifted away from broadcast spray to use of amphibious tracked vehicles on the mudflats and marsh plain, and hauling hose from trucks staged on surrounding levees to accessible marshes. Smaller infestations were treated by applicators with backpack sprayers walking through the marsh, as well as by manual removal of isolated seedlings. *Spartina densiflora*, a species that grows in a bunchgrass form and doesn’t spread significantly by rhizome, was effectively controlled by a strategic combination of herbicide application and digging (see Chilean Cordgrass description in Appendix 1 of the 2013 ISP Monitoring and Treatment Report).

After several years of regionally coordinated control work, the character of the infestations had changed. Very large meadows of non-native *Spartina* were rare, replaced by sparse infestations spread over larger areas that were more difficult to locate and access. New outlier populations were being discovered in more remote areas of the Estuary. By 2008, the ISP began to experiment with utilizing airboats on the open mud to allow treatment during low tide, thus maximizing herbicide dry time. The airboats were also used to deploy personnel with backpacks onto the marsh plain of islands and other sites.
that were inaccessible by land. By 2009, this approach was employed for treatment throughout Don Edwards San Francisco Bay National Wildlife Refuge (DENWR), and by 2012 there were as many as four airboats on a given day working on hybrid Spartina treatment around the Estuary. While the use of airboats in this way is essential for accessing difficult areas at this stage, the vast majority of herbicide treatment is conducted by trained personnel walking through the marsh with backpack herbicide sprayers.

Similarly, there have been shifts in methodology for S. densiflora treatment. By 2012, all sites were using manual removal as the primary technique, with only two sites still requiring an early season application of herbicide to stop seed production until digging could be implemented after California clapper rail breeding season. Mowing was also an important technique used early on in combination with other treatment methods at sites with meadows of S. densiflora, but the reductions achieved through the successful implementation of the adaptive IPM strategies allowed Friends of Corte Madera Creek to discontinue mowing in 2012. Control methods used in 2013 are listed by subarea in each of the Reporting Region tables in the accompanying report.

MONITORING PROGRAM

Inventory Monitoring

The ISP began Estuary-wide inventory monitoring of invasive Spartina in 2000, with annual monitoring of all known infestation sites beginning in 2004. The original geographic scope of inventory monitoring was limited to the bayward side of most major highways (Hogle 2008). Since 2006, all potential invasive Spartina habitat identified within the San Francisco Estuary and tidal tributaries, Bolinas Lagoon, Point Reyes National Seashore, and Tomales Bay has been surveyed by ISP biologists or its partners. This includes annual surveys over 50,000 acres of tidal marsh and mudflat throughout the Estuary and Outer Coast areas. The inventory area is shown in Section 2.1 of the 2013 Monitoring and Treatment Report). While the area inventoried covers some large remnant marshes as well as many fringe marshes, it also includes miles of flood control channels and many small fragmented marshes, channels and drainage ditches in a matrix of highly urbanized land use.

Inventory monitoring is conducted for two purposes: to track change in the extent and net cover of the infestation over time for analyzing and reporting, and to locate and map patches of invasive Spartina to inform management and coordination of Treatment Program operations. The ISP typically completes inventory of sites prior to treatment (generally from May through October) to allow for the most efficient use of time and personnel during limited treatment windows. Minimizing time in the marsh during treatment also serves to minimize potential disturbance to marsh plants and animals. Data is collected using global positioning system (GPS) and managed using a Geographic Information System (GIS).

Since 2008, all monitoring has been conducted on the ground or by helicopter for select large and remote sites where large patches of infestation persist. Ground mapping is done mostly on foot, but also by kayak and motorized boats when surveying islands, extensive shorelines, and lengthy waterways. 2012 was the last year that ISP conducted monitoring by helicopter due to its inherent decrease in precision as compared to ground mapping. As of 2013, all sites previously monitored by helicopter have been reduced to a lower status of infestation level and warrant more detailed ground mapping.

A history of the evolution of the ISP Monitoring Program between 2000 and 2012 (Zaremba and Hogle, in progress) will soon be available on the ISP website (http://www.spartina.org/project.htm).
Genetic Sampling and Analysis

Genetic analysis is a necessary tool for all of the ISP programs. *Spartina* leaf samples are collected and genetically analyzed to distinguish plants with native vs. non-native ancestry. Staff collect leaf samples from *S. foliosa* and hybrid *S. alterniflora* to verify identification of select plants, guide treatment practices, and keep an eye on new or changing plant morphologies. A genetic sampling plan is developed internally each season to address questions posed by the Treatment and Restoration programs and assure efficient use of limited laboratory resources. Samples are shipped to a commercial laboratory for extraction, and then sent to the UCLA Human Genomics Laboratory, where they are analyzed using Simple Sequence Repeats (SSRs; aka “microsatellites”) and scored. The laboratory used fifteen SSR loci during the 2013 monitoring season. The ISP analyzes the data from UCLA using the software package Structure (Pritchard Lab, Stanford University) to determine, for every sampled plant, the likelihood of it being descended from *S. alterniflora* ancestry. The ISP incorporates these results into the program’s GIS layers for further analysis and for reference in the field during future treatment and inventory events. Over 3,000 plants have been collected and analyzed in this manner since 2010, allowing the identification and treatment of many otherwise morphologically indistinct hybrid *S. alterniflora* plants throughout the Estuary.

More information regarding the genetic sampling program is available in the Monitoring Program Quality Assurance Document (http://www.spartina.org/project_documents/QAD_2009_Update_All.pdf) and the ISP *Spartina* Monitoring Program Approach report referenced above.

Photo Point Monitoring

Another tool used by the Treatment and Monitoring Programs is photo point monitoring. The ISP established and has maintained 136 permanent locations within 57 sub-areas from which staff take consistent photos twice annually to qualitatively monitor marsh changes between seasons and years. Photo points are used to inform the extent of the next treatment effort and to visually document the changes in vegetation occurring at the sites. Visible changes often include rapid disappearance of large areas of non-native *Spartina* within one to three seasons of treatment, passive (and frequently rapid) establishment of native vegetation, and expansion or “rebounding” of hybrid *Spartina* populations when treatment is missed or restricted for one or more seasons.

The intra- and inter-annual visual comparisons of marsh composition are useful to the ISP for monitoring treatment efficacy and for presenting local trends to outside parties. These photos are especially useful to illustrate different marsh trajectories when comparing sites with continuous full treatment with those where treatment was absent or incomplete, as has happened since 2011 in 11 sub-areas a result of permit restrictions. An example of photo point data is provided on the next page. Also, all ISP Photo Point photos are available on the web, through Google Maps and Picasa Web Albums, at http://maps.google.com/maps/ms?ie=UTF8&hl=en&msa=0&msid=212795091225976478689.00049ce382daadf691d97&t=h&z=10.

Treatment Monitoring

The ISP began monitoring all treatment events in 2009. Treatment monitoring involves pairing ISP personnel with the agency or private contractor treatment crews to accomplish the following important objectives: (1) assure protection of California clapper rails and other sensitive species during treatment activities; (2) enhance conservation of native *S. foliosa* that may be present by delimiting it in no-treatment areas for the crew; (3) substantially improve the ability for crews to locate and target plants for treatment by leading them to less obvious plants requiring treatment; and (4) document completed...
treatment in real time at the patch level. As previously mapped *Spartina* locations are revisited, ISP staff update the map features using GPS data loggers to reflect the day’s treatment action (e.g. “treated,” “not treated,” “sub-optimally treated” etc.). This data is uploaded daily to the ISP’s ArcGIS geodatabase for use in the field the next day. Accompanying treatment crews also allows ISP staff to identify, mapping, and concurrently record treatment of patches of invasive *Spartina* that had not been detected during initial inventory monitoring. Treatment monitoring is perhaps the most important of the ISP’s new programmatic initiatives, allowing ISP partners to gain ground on the remaining substantial infestations in the West Bay, and greatly accelerating the rate at which eradication may be achieved at all sites.

Since the timing of inventory and treatment overlap from mid-July through November, the ISP hires additional staff (interns) to conduct treatment monitoring at suitable sites – that is, at sites where native *Spartina* is not present, where hybrid *Spartina* has been recently mapped by more experienced staff, or where native and hybrid morphologies are sufficiently distinct to allow the interns to make consistently correct determinations. More experienced biologists are thus reserved to inventory and monitor treatment at more complex sites. The ISP employed three interns for the 2013 monitoring season to conduct treatment surveys and assist with inventory.

**California Clapper Rail Monitoring**

Implementation of *Spartina* control measures requires annual breeding season surveys of the endangered California clapper rail (*Rallus longirostris obsoletus*) in marshes affected by the invasion and management of non-native *Spartina*. Annual breeding-season surveys provide a standardized measure of

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*An example of photo point monitoring data showing habitat transition over several years.*
clapper rail presence and distribution in marshes throughout the Estuary. This information guides the ISP in the planning, permitting, and implementation of treatment strategies and helps to minimize the impacts of *Spartina* control on rail populations. Results from California clapper rail surveys help determine the time of year in which ISP monitoring staff and treatment contractors will enter a site so as to not disturb birds present during their breeding season, and are used by USFWS and others for making decisions regarding the ISP program.

In 2013, the ISP conducted California clapper rail surveys at 147 *Spartina*-invaded sites between January 15 and April 15. A range of 336 to 468 (average 402) California clapper rails were detected at 49 of the 147 sites surveyed. Detailed survey results from 2013 can be found in the 2013 ISP Clapper Rail Monitoring Report (McBroom 2013).

**Water Quality Monitoring**

The application of herbicide for *Spartina* control is covered under the Statewide General National Pollutant Discharge Elimination System (NPDES) Permit for Application of Aquatic Pesticides for Aquatic Weed Control in Waters of the United States (General Permit No. CAG990005; [www.swrcb.ca.gov/water_issues/programs/npdes/docs/aquatic/permit.pdf](http://www.swrcb.ca.gov/water_issues/programs/npdes/docs/aquatic/permit.pdf)). To obtain coverage under this permit, each grantee or other ISP partner that will be applying herbicide must submit a Notice of Intent (NOI) to comply with the terms of the General Permit and an annual fee to the Regional Water Quality Control Board (RWQCB). The permit requires preparation of an Aquatic Pesticide Application Plan (APAP) that includes a Water Quality Monitoring Plan (WQMP), which must be updated annually as needed. The ISP arranged with the State Water Resources Control Board and the San Francisco Bay RWQCB to allow the ISP to prepare and implement a programmatic APAP and WQMP on behalf of the ISP partners who submitted NOIs. The ISP prepared a programmatic APAP in 2006 and updates it annually. The APAP is available on the ISP website at [http://www.spartina.org/documents/2013_Invasive_Spartina_Project_APAP.pdf](http://www.spartina.org/documents/2013_Invasive_Spartina_Project_APAP.pdf).

The General Permit requires that at least 10% of treated sites be monitored for impacts to water quality. In 2013, 143 ISP sites were treated with herbicide; hence 14 sites were monitored. The permit requires that three sampling events be conducted for each site: one pre-treatment background sampling, one treatment event sampling, and one post-treatment sampling. Details regarding sampling and analysis methods are provided in the 2013 Aquatic Pesticide Application Plan (Kerr 2013), and the monitoring results are provided in the 2013 Water Quality Monitoring Report (Kerr 2013).

As with many substances, there are no State or Federal numeric water quality objectives or limits established for imazapyr herbicide; therefore, concentrations are compared to tested toxicity and effects levels found in the literature. In 2013, concentrations of imazapyr herbicide measured immediately following treatment events were two to four orders of magnitude below those reported in the literature as a concern to humans or the animals that inhabit the tidal marsh ecosystem. Imazapyr is not persistent in the aquatic environment because it is rapidly degraded by sunlight; thus, as expected, the one-week post-treatment samples with any residual herbicide detected showed a mean reduction of 91.4% of the treatment event levels.

The ISP commissioned a focused review of imazapyr herbicide in 2005, prior to adopting it into the Treatment Program. The review, *The use of Imazapyr Herbicide to Control Invasive Cordgrass (Spartina spp.) in the San Francisco Estuary: Water Quality, Biological Resources, and Human Health and Safety* (Leson & Associates 2005), is on the ISP website at [www.spartina.org/project_documents](http://www.spartina.org/project_documents). The Conservancy’s findings under CEQA may be found at [www.spartina.org/2005Addendum.htm](http://www.spartina.org/2005Addendum.htm).
RESTORATION PROGRAM

The Restoration Program was initiated in 2011 to rapidly establish habitat features to benefit California clapper rails in areas where recent removal of non-native *Spartina* has caused decreases in clapper rail habitat. The plan for the program is contained in the California Clapper Rail Habitat Enhancement, Restoration and Monitoring Plan (Olofson Environmental, Inc. 2012). As part of the plan, the Conservancy and other regional ISP partners are employing several habitat enhancement methods including construction of high tide refuge islands, deployment of artificial floating nesting islands, and extensive revegetation, focusing on native tidal marsh plant species that provide foraging, breeding, and high tide refuge cover.

In its first three years (fall 2011 through early 2014) the Restoration Program deployed 125 artificial “floating nesting islands” in conjunction with USGS (Casazza, Takekawa et al. 2012), constructed six earthen high tide refuge islands (Busnardo and Archbald 2013), and installed with partners more than 215,000 plants across 30 sites to develop and provide habitat for California clapper rails. The Restoration Program relies on data from the monitoring, treatment, and clapper rail programs to identify suitable areas for revegetation; specifically, these are areas in proximity to California clapper rail populations with suitable elevation and other features, and sufficiently free from hybrid *S. alterniflora* infestation to safely allow establishment of native plants. This last condition is particularly critical for planting of native *S. foliosa*, as plantings too near hybrid *S. alterniflora* would be at risk of being pollinated by the hybrid, resulting in production and spread of more hybrid seeds. Details of the Restoration Program and activities can be found on the ISP website at www.spartina.org/project.htm.

REFERENCES


