

BEST PRACTICES FOR TIDAL MARSH RESTORATION AND  
ENHANCEMENT IN THE SAN FRANCISCO ESTUARY

*This page intentionally left blank*

## Appendix K Best Practices for Tidal Marsh Restoration and Enhancement in the San Francisco Estuary

---

This document was prepared by the San Francisco Invasive *Spartina* Project<sup>1</sup> to help inform and advise individuals and organizations engaged in tidal marsh restoration or other practices that could spread non-native *Spartina* cordgrass. Drafts of this document were distributed to representative groups and individuals for comment in the summer and fall of 2007. This document incorporates comments received from representatives of the Don Edwards San Francisco Bay National Wildlife Refuge, San Francisco Bay Regional Water Quality Control Board, California Department of Fish and Game, Santa Clara Valley Water District, U.S. Army Corps of Engineers, the South Bay Salt Pond Restoration Project, and Marin Audubon. One of the primary changes from previous versions was the removal of a recommended 2-mile minimum buffer between restoration projects and viable non-native *Spartina*, in lieu of more general statement to not open a tidal restoration “too near” non-native *Spartina*. It should be noted that, based on findings of the ISPs “drift card study” described in item 6, “too near” could be a greater or lesser distance than two miles, and this should be considered carefully for each project. Another significant change was the addition of item 9, which describes the conditions under which a party might proceed with a project that does not follow the recommended practices. The key to this sort of variation is that it should be done only with awareness and buy-in by potentially affected parties, including the Coastal Conservancy.

The Best Practices were reviewed by partners of the South Bay Salt Pond Restoration Project at a special meeting on October 23, 2007, and they were subsequently included in sections of the Project’s EIS/EIR. It is our hope that all proponents of restoration projects will consider and follow these guidelines, and that, where appropriate, regulatory agencies, including San Francisco Bay Regional Water Quality Control Board, U.S. Army Corps of Engineers, and the San Francisco Bay Conservation and Development Commission, will incorporate them as conditions into permits for restoration and mitigation projects.

### 1. Do not plant non-native *Spartina* at any time

Tidal wetland projects should not plant or otherwise introduce any non-native *Spartina*, including *S. alterniflora*, *S. densiflora*, *S. anglica*, *S. patens*, and *S. maritima*, or any hybrid of these species.

**Justification:** All species of *Spartina* have proven to be invasive and damaging to the native ecosystem when introduced outside of their native ranges.

### 2. Verify genetics of native *Spartina* plantings

For the next several years, presumed native *Spartina foliosa* seed or seedlings that are to be planted as part of a restoration or enhancement project should be genetically analyzed to confirm absence of *S. alterniflora* or *S. densiflora* genetic markers<sup>2</sup>. Any plant or seed lots found to have *S. alterniflora* or *S. densiflora* genetic markers should not be planted, and should be destroyed.

**Justification:** Non-native *Spartina* hybrids can be extremely difficult to identify based on plant morphology (even by highly trained experts), but they may still carry invasive genetic

---

<sup>1</sup> A regional project sponsored by the State Coastal Conservancy in partnership with US Fish and Wildlife Service.

<sup>2</sup> Analysis should be done by a qualified university or commercial laboratory in accordance with the procedures developed by the ISP. The ISP will be happy to provide laboratory references and/or arrange for samples to be processed through the ISP at cost.

characteristics that could be passed on in seed and pollen. Even plants or seed from seemingly native *S. foliosa* stands in the South Bay have been found to contain non-native *Spartina* genes. It is reasonable to suspect that nurseries might mistakenly sell non-native or hybrid plants, thinking them native. Native genetics should not be assumed based on morphology or locality.

### 3. Do not plant native *Spartina* where it may become pollinated by hybrid *Spartina*

There should be no planting of native *Spartina foliosa* too near stands of *S. alterniflora* x *foliosa* hybrids, which could pollinate *S. foliosa* flowers and produce hybrid seed. The *Spartina* Project is currently recommending 100 meters as the minimum distance between planted *S. foliosa* and pollen-producing *S. alterniflora* x *foliosa*. The restoration project sponsor should also be aware that it can be very challenging, even for experts, to distinguish between native and non-native *Spartina* seedlings, and visually discerning hybrid seedlings from a field of newly planted native seedlings may be impossible. Therefore, it is strongly recommended that native *Spartina* not be planted until there is no or extremely low risk of hybrid invasion.

**Justification:** Native *Spartina* is readily fertilized by the large volume of pollen produced by *S. alterniflora* x *foliosa* hybrids, thus producing hybrid seed and adding to the spread of the invasive population. Researchers at University of California, Davis, (Davis et. al 2004a & 2004b) have determined that the volume of wind-blown pollen from a *S. alterniflora* meadow in Willapa Bay, Washington, decreased by an average of 85% across a 100-meter-wide channel on the downwind side of the meadow. The researchers also concluded that incidence of successful pollination decreased in isolated plants and sparse meadows, where the overall volume of pollen available to the plant flower was reduced.

### 4. Monitor and remove

Tidal marsh restoration and mitigation projects should be rigorously monitored at least annually for the presence of non-native or hybrid *Spartina*. In addition to field identification, representative samples of any found *Spartina* should be genetically analyzed to verify absence of *S. alterniflora* or *S. densiflora* genetic markers. Any found non-native or hybrid *Spartina* plants should be removed or killed before their first season of flowering and seed set, which typically occurs during the second year.

**Justification:** Any *Spartina* growing in newly restored sites within several miles of live *S. alterniflora* or *S. alterniflora* x *foliosa* has a high likelihood of being hybrid (hybrids are usually the first to establish because they can take root in deeper tidal zones). *S. densiflora* x *foliosa* hybrid has just recently been identified, and caution is warranted since it is not clear how it may manifest in new restoration projects. Non-native *Spartina* plants should be removed before seed set because once seed is produced, the plants are capable of spreading offsite extremely rapidly, and control becomes difficult and costly (ref. Cooley Landing Restoration Project).

### 5. “Success” = “No non-native *Spartina*”

One of the criteria for “success” of any mitigation or restoration project must be that there is no non-native or hybrid *Spartina* found, that is, 0.00% cover of non-native or hybrid *Spartina*. Any *Spartina* found growing in a young restoration site should be genetically analyzed to verify absence of *S. alterniflora* or *S. densiflora* genetic markers. Any found non-native or hybrid *Spartina* plants should be removed or killed before their first season of flowering and seed set. A

regulatory agency should not sign off on the permit of a mitigation/restoration project unless and until it is clear of all non-native *Spartina*.

**Justification:** The ISP has become aware that one or more mitigation project proponents effectively claimed success at the time of the agencies' five-year review, because only a few stands of hybrid *Spartina* (e.g., <10% cover) were reported to exist on site. However, within the next two years, these sites became dominated by hybrid *Spartina*, a condition that could have been easily predicted (and was predicted by the ISP) based on existing knowledge of the species. Because of the exponential rate of spread, it takes only one stand of hybrid *Spartina* to spell disaster for the preservation of wetland resources associated with a project (ref. MLK Restoration Marsh, Cogswell Marsh, Cargill Mitigation Marsh, LaRiviere Marsh).

**6. Do not open a new marsh (i.e., make the tidal connection) too near *Spartina alterniflora* or *S. alterniflora* hybrids**

Tidal wetland restoration or mitigation projects should not initiate connection with tidal flows (full or damped) at locations where *S. alterniflora* or *S. alterniflora* x *foliosa* seed or propagules are likely to get into the site. Other parts of the project, such as building trails and preparing the marsh surface, can proceed while work is done to eradicate the non-native *Spartina* patches. The project sponsor should consider participating with *Spartina* eradication in the area to expedite the process.

**Justification A:** *Spartina* seeds float on the water surface and are readily transported, sometimes great distances, depending on tide, current, and winds. Limited historical information is available on the specific movement of surface particles from one location to another within the Bay, however, the ISP conducted a study over several years to help illuminate this better. For the study, 2,100 brightly painted balsa wood cards were released from 14 locations during six events over several seasons. The cards contained instructions on how to report the location of found cards to the ISP. By winter 2009, approximately 25% of the released cards had been reported by about 350 individuals, and reports continue to come in. Based on these results, we have learned that cards (as surrogate for *Spartina* seed) released in the Central and South Bay tend to drift mostly from north to south, and from west bay to east bay, with some cards traveling up to 20 miles. In the east bay, cards appear to remain close to the release points, washing back up on the shore in nearby marshes. Cards released from the Alameda Flood Control Channel and Cogswell Marsh often drift south and end up on the north edge of the Don Edwards National Wildlife Refuge. In the northwestern Central Bay, cards released from Corte Madera Creek float to points throughout the eastern and western Central Bay, as well as out the Golden Gate to the outer shoreline south and north of the Gate, including Muir Beach, Stinson Beach, Limantour Beach, Drake's Estero, Ocean Beach, and Pomponio State Beach (see attached maps).

These results demonstrate clearly that seed and plant fragments from an existing infestation may readily be carried to other locations, near and far. Some drift patterns are more predictable, and some vary significantly between seasons. A restoration project must consider its location in respect to existing seed and fragment sources, and with consideration of potential patterns of dispersal on the tides, to determine its risk of invasion by non-native *Spartina*. ISP staff are available to assist project proponents with analyzing their sites to determine potential seed sources and estimate risk of invasion based on site specific information.

**Justification B:** Newly restored tidal marsh provides an ideal nursery for *S. alterniflora* and hybrids, which establish easily and spread rapidly in the shallow intertidal zone. Repeated efforts

to “design around” hybrid *Spartina* invasion by such methods as relocating the tidal connection, creating very low intertidal habitat, or construction steep banks to minimize suitable marsh transition zones, have proven futile (e.g., North Marsh, Cargill Mitigation Marsh, Eden Landing, *et al.*). If hybrid seed, rhizomes, or fragments are present, they will be the first plant to establish in a new site, spreading rapidly to mudflats, channels, and other restoration projects, and adding substantially to the cost and timeline of bay wide eradication.

## 7. Clean equipment

Take care to not introduce non-native *Spartina* seed or propagules into a new restoration project on contaminated excavators, dredges, or other equipment. Require that all equipment be cleaned prior to entry in an intertidal area if it has been in contact with non-native *Spartina* plants, seeds, or roots. Conversely, any equipment used in a non-native *Spartina* infested area should be carefully cleaned before movement off of the site. Note: These practices must be incorporated into the contract specifications, or the contractor will not be obligated to implement them.

**Justification:** Movement of invasive plants via equipment, clothing, etc. is a common problem in weed management. Introduction of hybrid *Spartina* seed or propagules on construction equipment or boats is suspected as the most likely source of infestation in at least two sites (Petaluma Marsh and Steven’s Creek Marsh).

## 8. Avoid potentially contaminated dredged material

Make sure that top layer dredged materials brought to a restoration site (e.g., from a marina), do not contain non-native *Spartina* seed or fragments. If you are dredging a site with suspected non-native *Spartina*, be sure to dispose of the dredged material such that it will not be able to spread vegetative propagules or seed or take root. Safe disposal locations would include areas well outside of the tidal marsh, or buried within the deeper levels of a tidal marsh fill.

**Justification:** Any dredged material containing seed, plant fragments, or roots will readily take root and start new *Spartina* growth if left in an area where there is periodic tidal inundation.

## 9. Variations to these Practices

Variations to these practices may be appropriate based on site-specific conditions and scientific analysis. Proposed variations should be developed with assistance from the San Francisco Estuary Invasive *Spartina* Project, who can help evaluate conditions and develop alternatives in a timely way.

The project sponsors should also discuss proposed variations with nearby marsh owners/managers, who could be affected by the potential infestation of the project, as well as with the State Coastal Conservancy, who is currently bearing the bulk of the expense and responsibility for bay wide eradication of invasive *Spartina* in support of State and Federal long term ecosystem restoration goals. Variations that might increase risk of spreading invasive *Spartina* should be implemented only with agreement from affected neighbors and the Coastal Conservancy.

All projects should include active site monitoring and rapid response to remove any non-native *Spartina* for up to 10 years, depending on the specific conditions and threat of infestation. Responsibility and funding for monitoring and response should be identified and dedicated in advance.

**Justification:** While the best practices listed in 1-8 above are not restrictive enough to guarantee no spread of non-native *Spartina*, they do substantially reduce the risk. Even so, the conditions may be overly conservative in some situations, such as in areas where there has been effective ongoing treatment and seed-producing plants are extremely rare or no longer present. The decision to move forward with a project like this should be considered carefully, with full understanding of the potential consequences by all who may be affected.

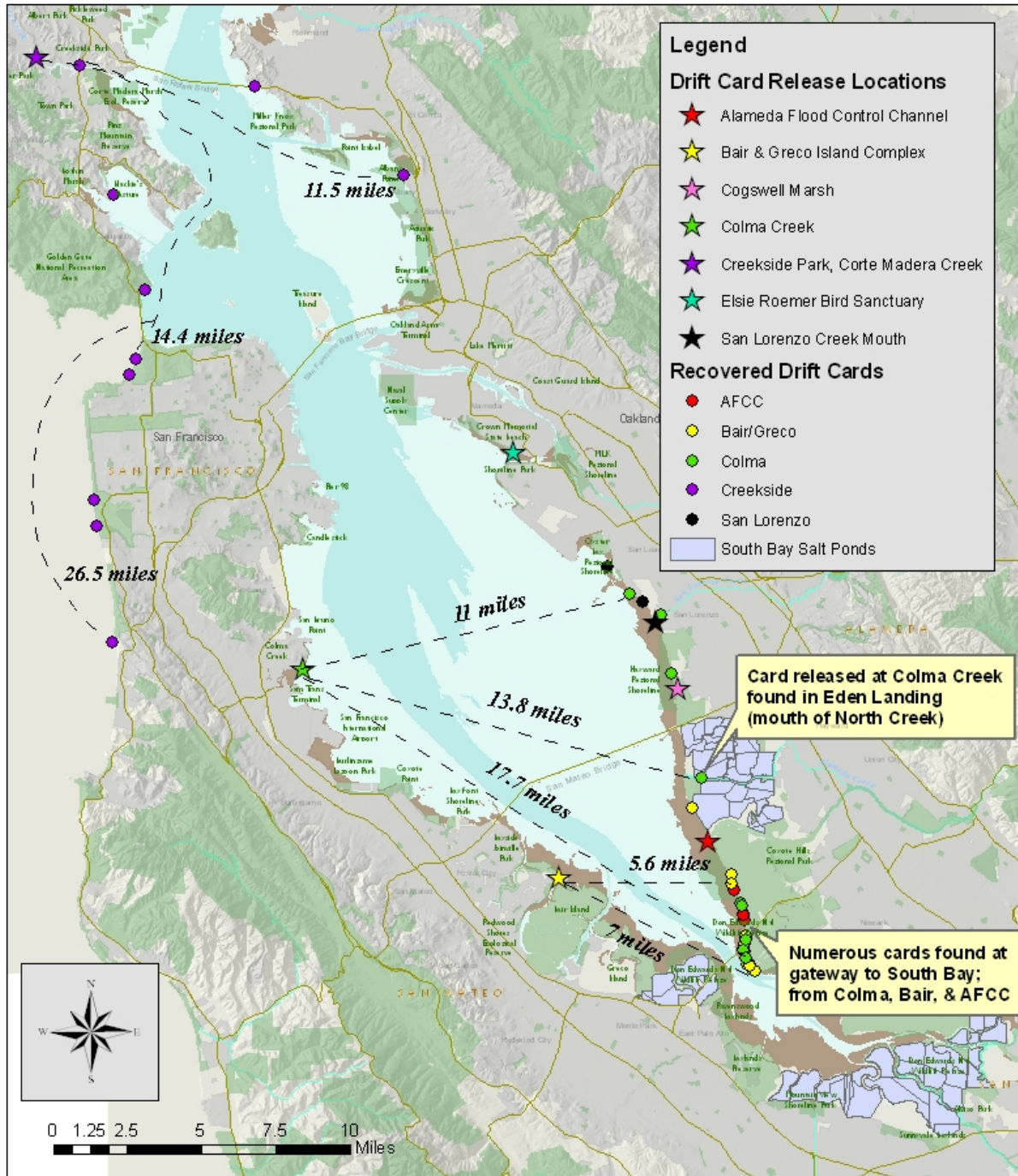
## References

- Davis, H.G., C.M. Taylor, J.G. Lambrinos, and D.R. Strong. 2004a. Pollen limitation causes an Allee effect in a wind-pollinated invasive grass (*Spartina alterniflora*). *Proceedings of the National Academy of Sciences USA* 101:13804-13807.
- Davis, H.G., C.M. Taylor, J.G. Lambrinos, and D.R. Strong. 2004b. Pollen limitation in a wind-pollinated invasive grass, *Spartina alterniflora*. *Proceedings of the Third International Conference on Invasive Spartina*.

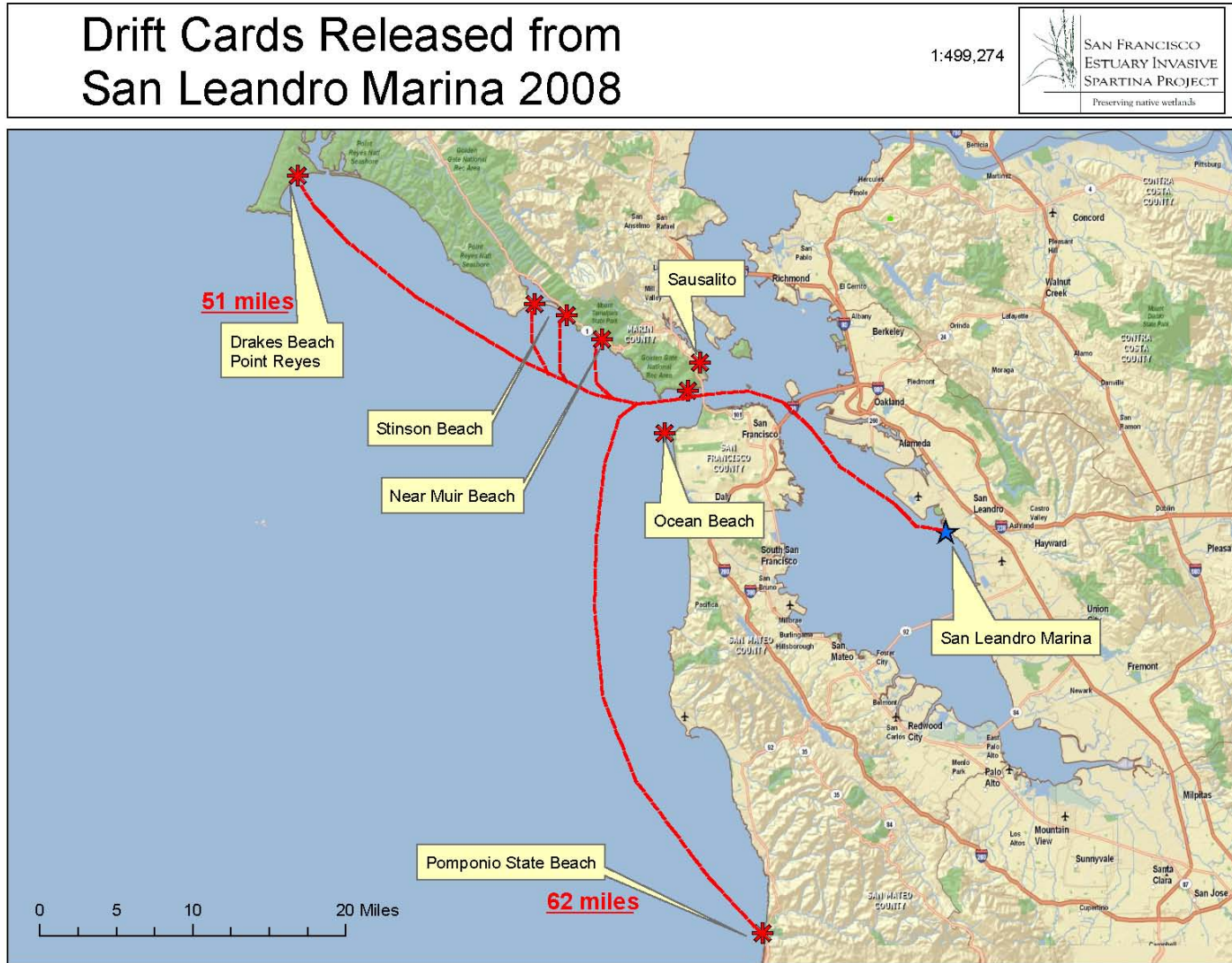


# Selected Preliminary Drift Card Reporting Results March - October 2007

1:267,168







*This page intentionally left blank*