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

DRAFT

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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.** Native *Spartina foliosa* seed or seedlings that are to be planted as part of an restoration or enhancement project should be genetically analyzed to confirm absence of *S. alterniflora* or *S. densiflora* genetic markers[1]. 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 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, and 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*, 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

[1] Analysis should be done by University of California, Davis, Don Strong Laboratory (contact *Spartina* Project for sampling and shipping assistance), or a qualified commercial laboratory in accordance with the procedures developed by the Strong Lab.

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 volumes 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 pollenization decreased in isolated plants and sparse meadows, where the overall volume of pollen available to the plant flower was reduced. While the volume of pollen produced by pure vs. hybrid *Spartina* is not comparable (hybrid *Spartina* produces much more pollen), the general phenomenon of reduction in volume over distance probably is.

4. **Monitor and remove.** Tidal marsh restoration and mitigation projects should be monitored 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.

   Justification: Any *Spartina* growing in newly restored sites within several miles of live *S. alterniflora* or *S. alterniflora* x *S. 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 *S. 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 spread rapidly, and control becomes difficult and costly (ref. Cooley Landing Restoration Project).

5. **Project Success = No non-native *Spartina***. One of the criteria for "success" of any 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. **Don't open a new marsh (i.e., make the tidal connection) too near *Spartina alterniflora* and 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 *S. 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 assisting with *Spartina* eradication 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 information is available on the specific movement of surface particles from one location to another within the Bay, however, the ISP is conducting a study to help illuminate this better. Our best understanding so far is that surface particles (small wooden cards) released in the central and south bay tended to drift mostly from north to south, and from west bay to east bay, with some particles traveling up to 20 miles. In the east bay, particles appear to remain close to the release points, washing back up on the shore in nearby marshes. In the northwestern central bay, particles released from Corte Madera Creek floated out the Golden Gate to the outer shoreline south of the Gate (see attached map). Data is not yet available for the far south bay. The ISP is available to assist projects with determining potential seed sources, and with estimating 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 tidal 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. **Be careful with 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.

   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 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 your sight (e.g., from a marina), do not contain non-native *Spartina* seed or fragments. If you are dredging a site with non-native *Spartina*, be sure to dispose of the dredged material such that it will not be able to spread seed or take root. Safe locations would include out of the tidal marsh area, 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 the above best practices may be appropriate based on site-specific conditions and scientific analysis. Proposed variations should be developed with assistance or review 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.

Justification: While the best practices listed in 1-7 above are not restrictive enough to guarantee no spread of non-native *Spartina*, they do provide a relatively high level of certainty. 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 & 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 & D.R. Strong. 2004b. Pollen limitation in a wind-pollinated invasive grass, *Spartina* alterniflora. Proceedings of the Third International Conference on Invasive *Spartina*.