Techniques for Ecological Restoration of *Spartina foliosa* following local eradication of invasive *Spartina alterniflora* hybrids

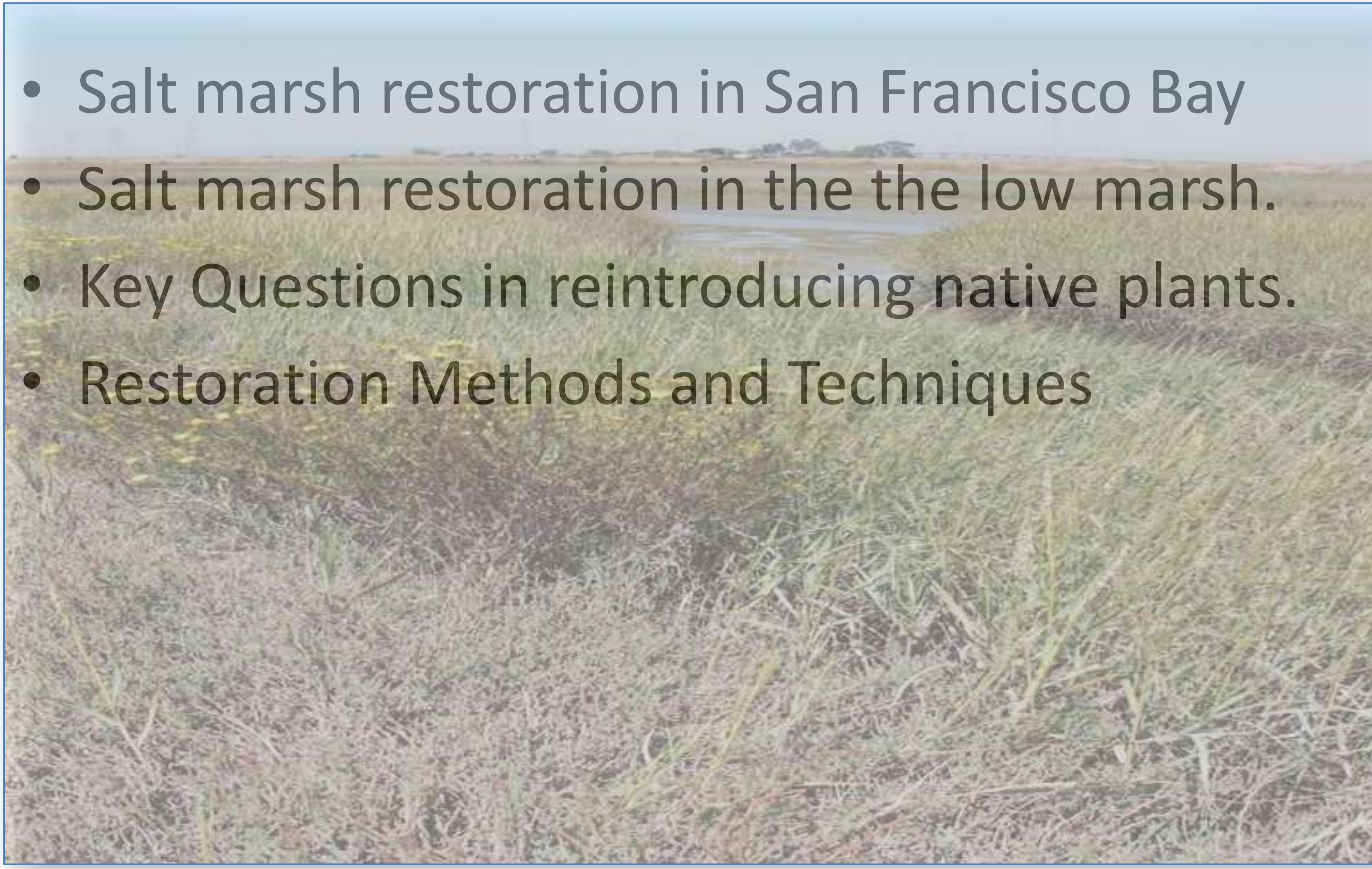
Whitney Thornton[1,2] and Katharyn Boyer[1]
[1]San Francisco State University[1] and Coastal Conservancy's Invasive Spartina Project[2]

San Francisco Estuary Invasive Spartina Project
Preserving native wetlands

OEI Olofson Environmental, Inc.

Coastal Conservancy

Talk Outline



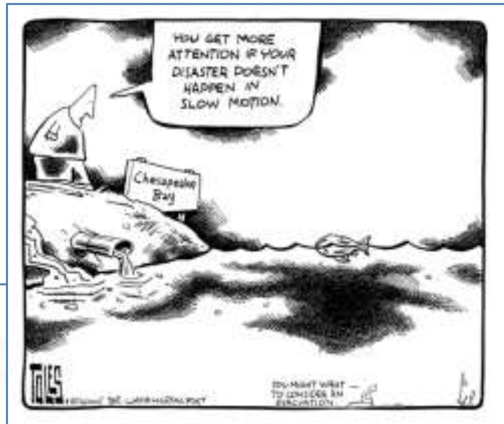
- Salt marsh restoration in San Francisco Bay
- Salt marsh restoration in the the low marsh.
- Key Questions in reintroducing native plants.
- Restoration Methods and Techniques

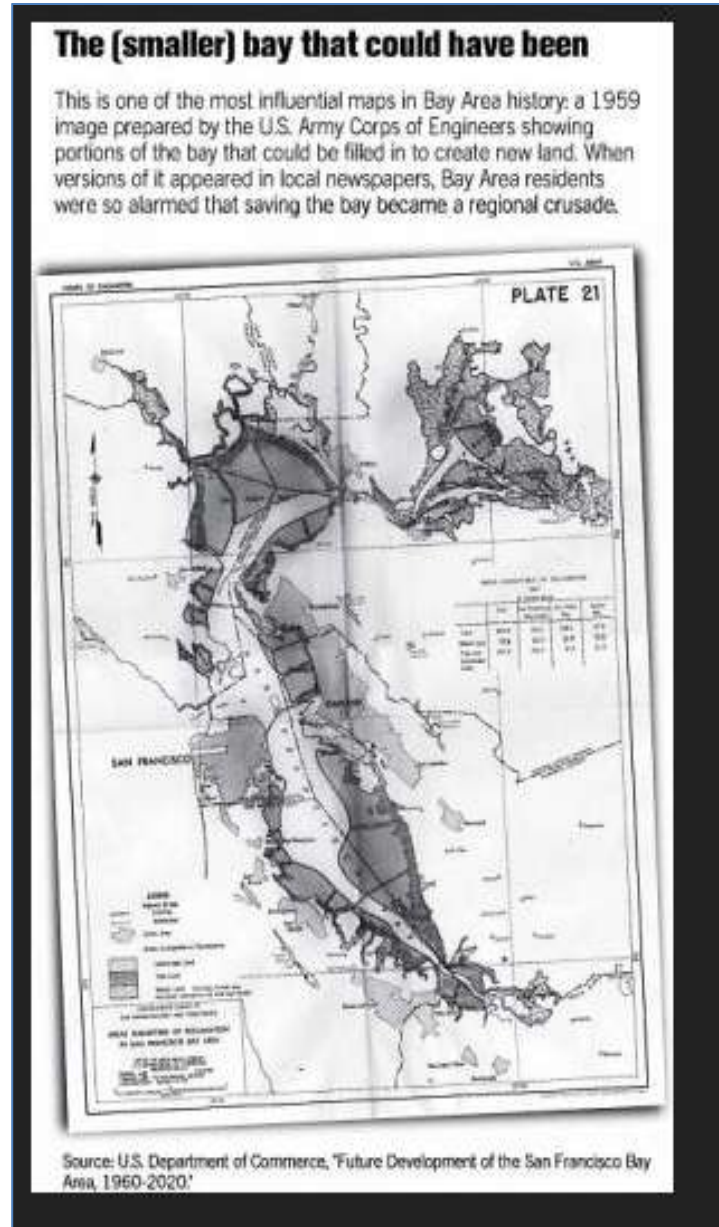
Wetland loss in the San Francisco Estuary

Circa 1770-1820 | Circa 1997

The Bay Institute

1959: USACE
1965: McAteers Petris





The (smaller) bay that could have been

This is one of the most influential maps in Bay Area history: a 1959 image prepared by the U.S. Army Corps of Engineers showing portions of the bay that could be filled in to create new land. When versions of it appeared in local newspapers, Bay Area residents were so alarmed that saving the bay became a regional crusade.

Source: U.S. Department of Commerce, "Future Development of the San Francisco Bay Area, 1960-2020."

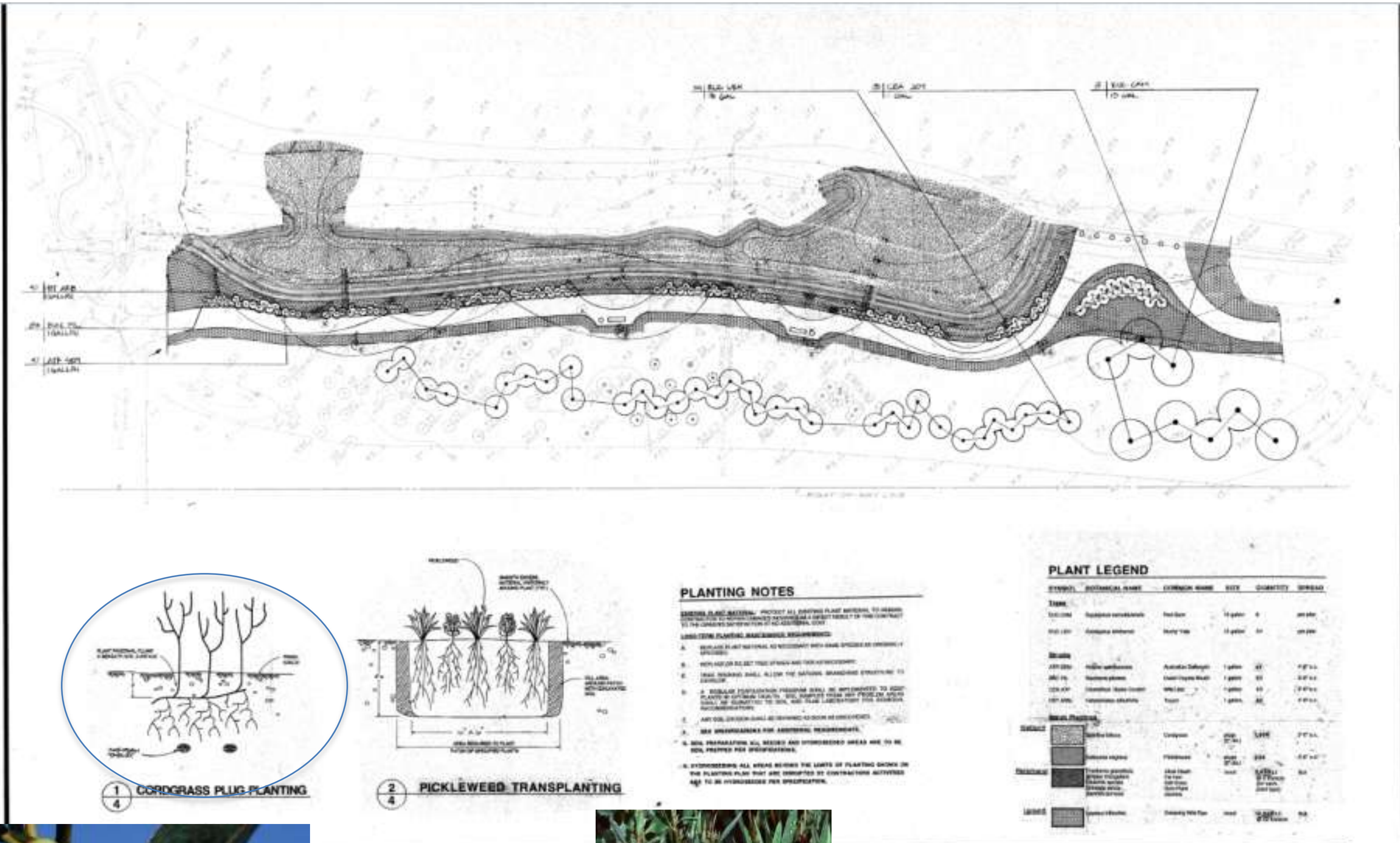
King 2005

Scale and Scope of Coastal Salt Marsh Restoration

Williams and Orr 2002

Changes in approaches to Tidal Marsh Restoration

- Time scale
- Connectivity
- Approach to establishing vegetation


PLANTING NOTES
PLANT LEGEND
1
4
CORDGRASS PLUG PLANTING
2
4
PICKLEWEED TRANSPLANTING

Pacific Cordgrass

Spartina foliosa Trin.

- Clonal Grass

Pacific Cordgrass

Spartina foliosa Trin.

- Clonal Grass
- Endemic

FIGURE 5-1 Map of the coastline of California and Baja California with locations of 19 bay-estuarine systems.

Pacific Cordgrass

Spartina foliosa Trin.

- Clonal Grass
- Endemic

FIGURE 5-1 Map of the coastline of California and Baja California with locations of 19 bay-estuarine systems.

Pacific Cordgrass

Spartina foliosa Trin.

- Clonal Grass
- Endemic

FIGURE 5-1 Map of the coastline of California and Baja California with locations of 19 bay-estuarine systems.

Pacific Cordgrass

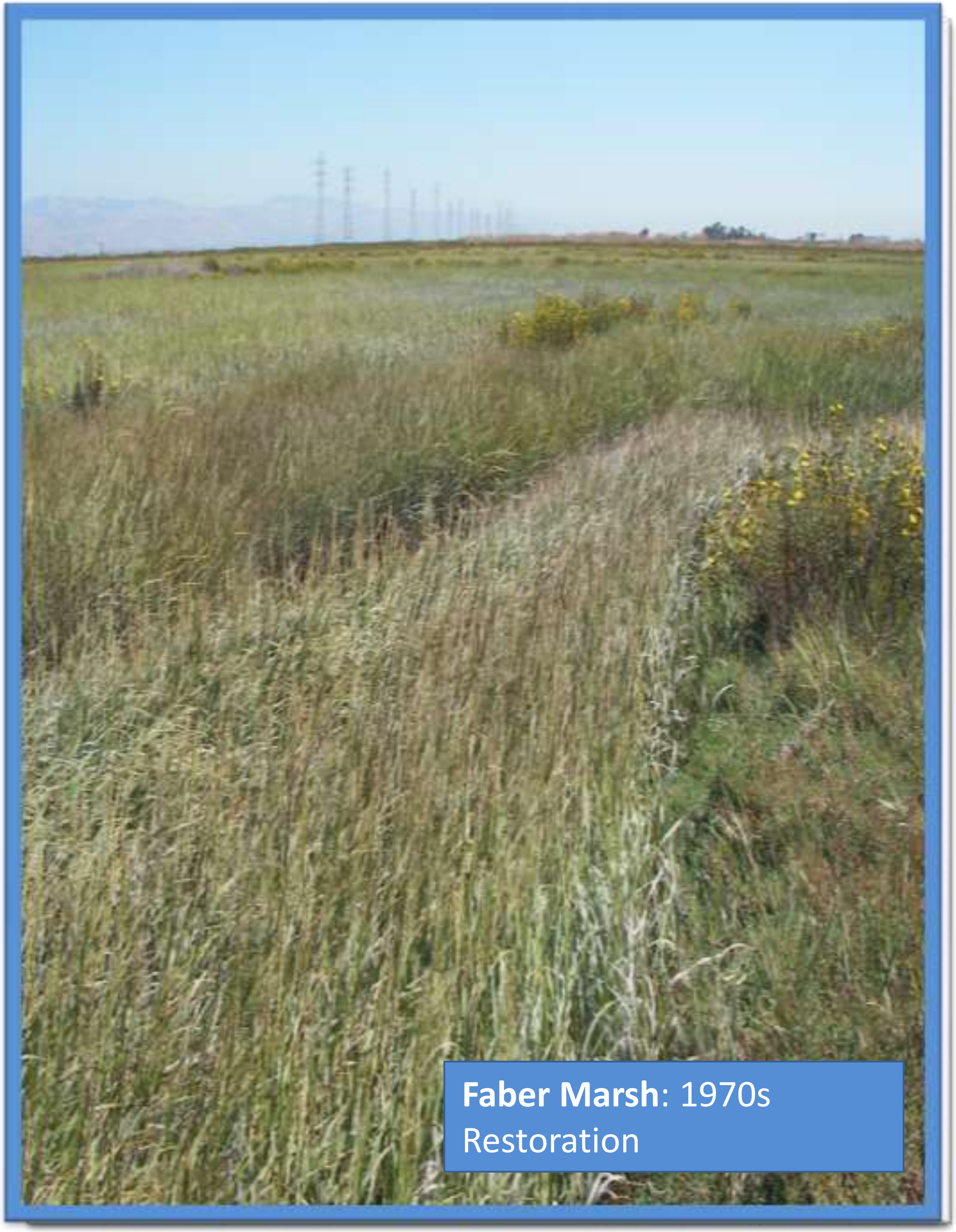
Spartina foliosa Trin.

- Clonal Grass
- Endemic
- Early Colonizer

Pacific Cordgrass

Spartina foliosa Trin.

- Clonal Grass
- Endemic
- Early Colonizer



Pacific Cordgrass

Spartina foliosa Trin.

- Clonal Grass
- Endemic
- Early Colonizer
- Structure of the low marsh zone

Pacific Cordgrass

Spartina foliosa Trin.

- Clonal Grass
- Endemic
- Early Colonizer
- Structure of the low marsh zone

Spartina alterniflora

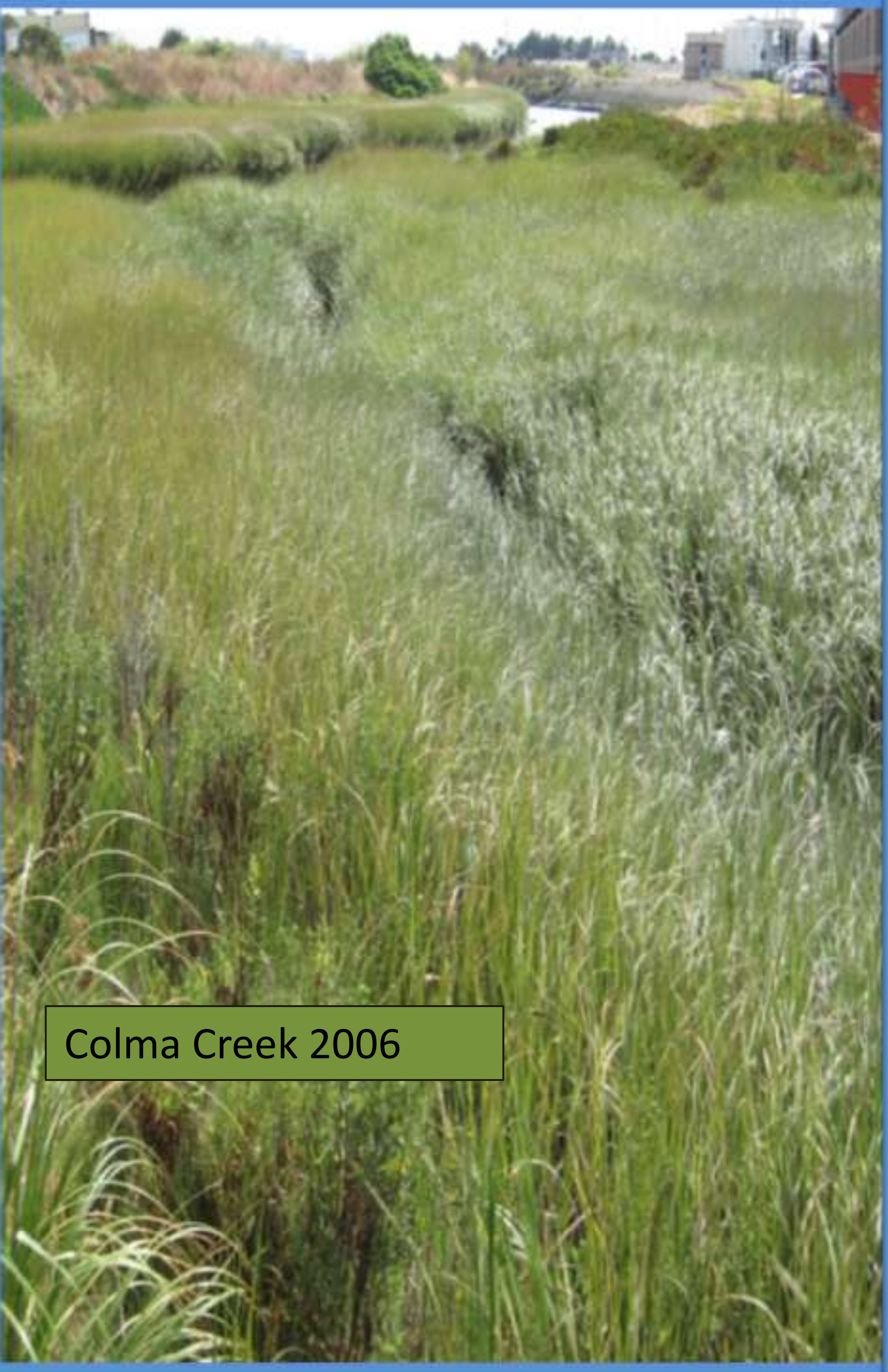
One of 3 non-native congeners of *S. foliosa* introduced 1970s

Intentionally planted for the purpose of shoreline stabilization.

Purposely moved at least once from initial planting site to mitigation sites

Hybridized with *S. foliosa*, and extirpated it from portions of the central south bay.


Spartina alterniflora

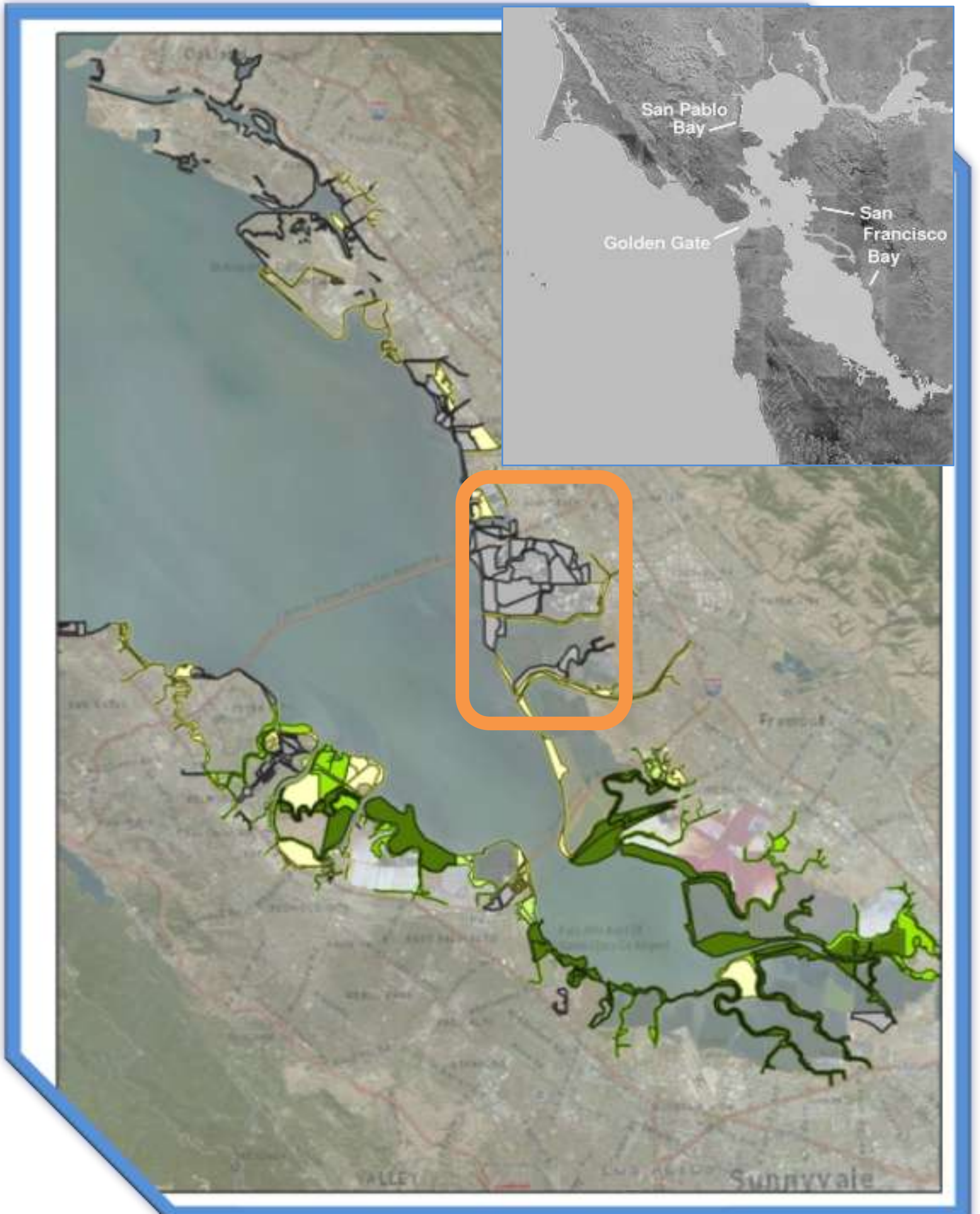

Colma Creek 2006


Colma Creek 2012

California Clapper Rail

Restoration Targeted

- Central San Francisco Bay.
- Areas with active hybrid control.
- Areas with limited invasion pressure.



Journal of Coastal Research	SI	27	203-211	Royal Palm Beach, Florida	2001

Salt Marsh Restoration Experience in San Francisco Bay

Philip Williams and Phyllis Faber

In 1983, Margaret Race completed a critical review of these projects showing how more than 90% of *Spartina* plantings had died out and suggesting tidal restoration projects were failures because they did not meet their stated goals (RACE, 1983). Although *Spartina* did subse-

Failure

Restoration Mistakes

Spartina densiflora, collected from Humboldt Bay was planted. At that time, *S. densiflora* was mistakenly considered to be the native *S. foliosa*. In the Pond 3 restoration, the exotic *Spartina alterniflora* was imported from Maryland as an experiment to compare planting by broadcasting seed or by planting plugs. (Both of these exotics are now invading adjacent marshes displacing both the native *S. foliosa* and other wetland species.)

By the early 1980s, it was recognized that plantings were unnecessary because of the large seed source in San Francisco Bay that established naturally over time.

Unnecessary

Goals of Planting Efforts

- Establish self-sustaining populations of native cordgrass.
- Test cordgrass planting techniques in a methodical way.
- Provide replication in cordgrass designs.

4 Research Questions

- What sources should we plant of native cordgrass?
- How should we protect native cordgrass?
- How should these sources be planted?
- Where should we plant them?

It is hard to find a good parent….

1. Free of hybrid
2. Robust populations of native cordgrass
3. Not California Clapper Rail nesting habitat

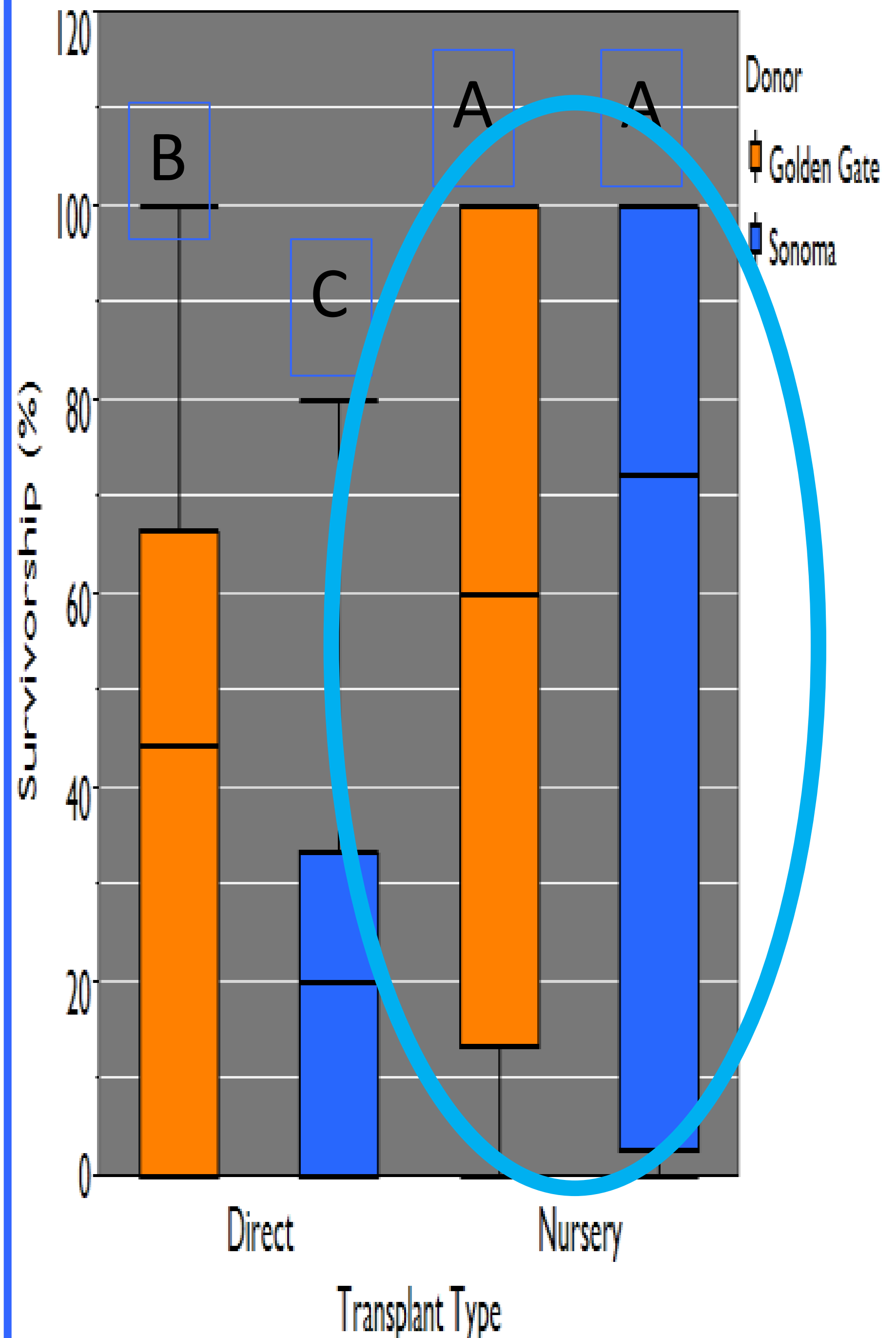
What sources should we plant of native cordgrass?

http://newell.myweb.uga.edu

What sources should we plant of native cordgrass?

http://newell.myweb.uga.edu

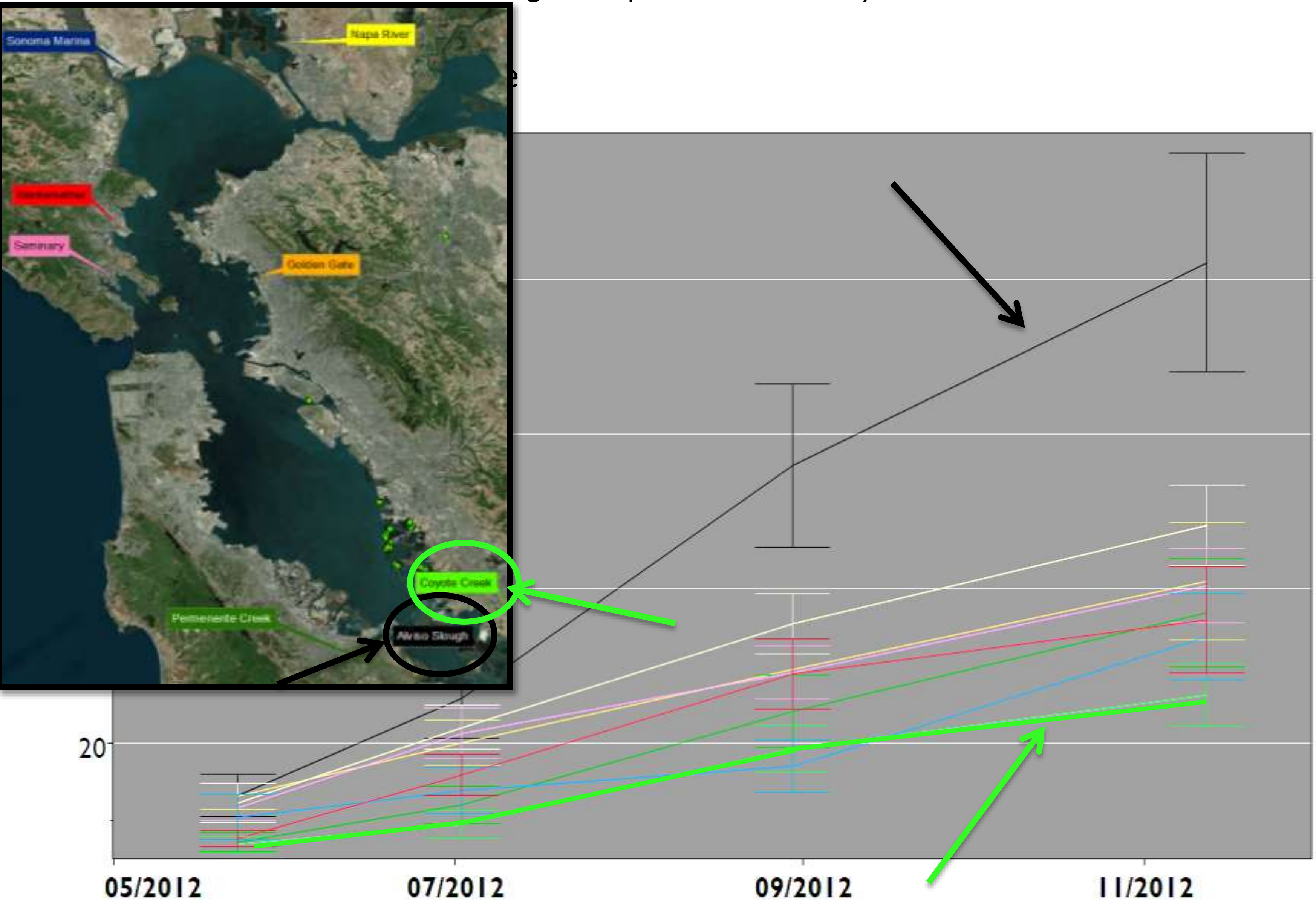
What sources should we plant of native cordgrass?



Each error bar is created as 95% confidence interval from the mean

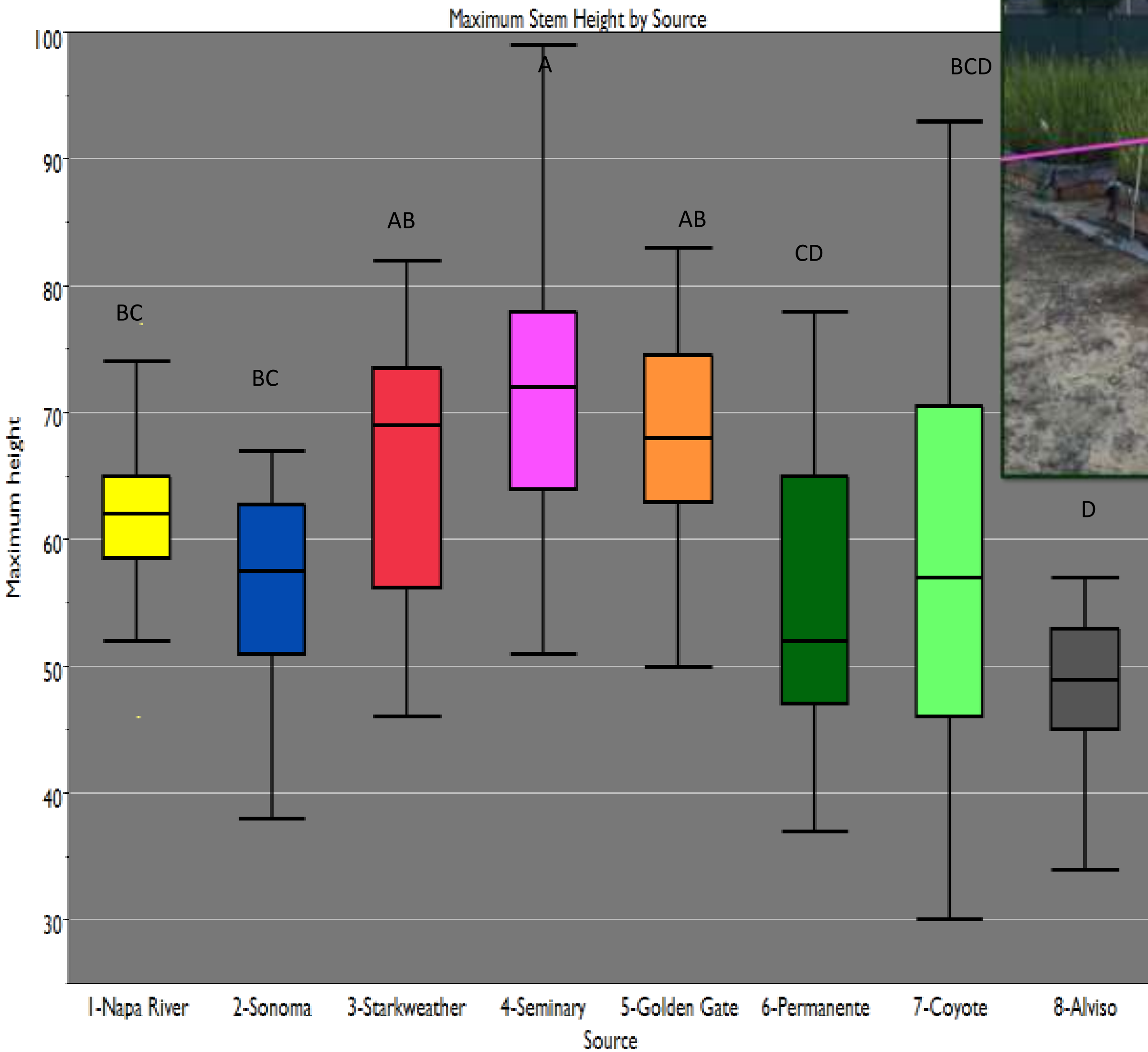
What sources should we plant of native cordgrass?

Results: Does donor source influence growth patterns in nursery conditions?



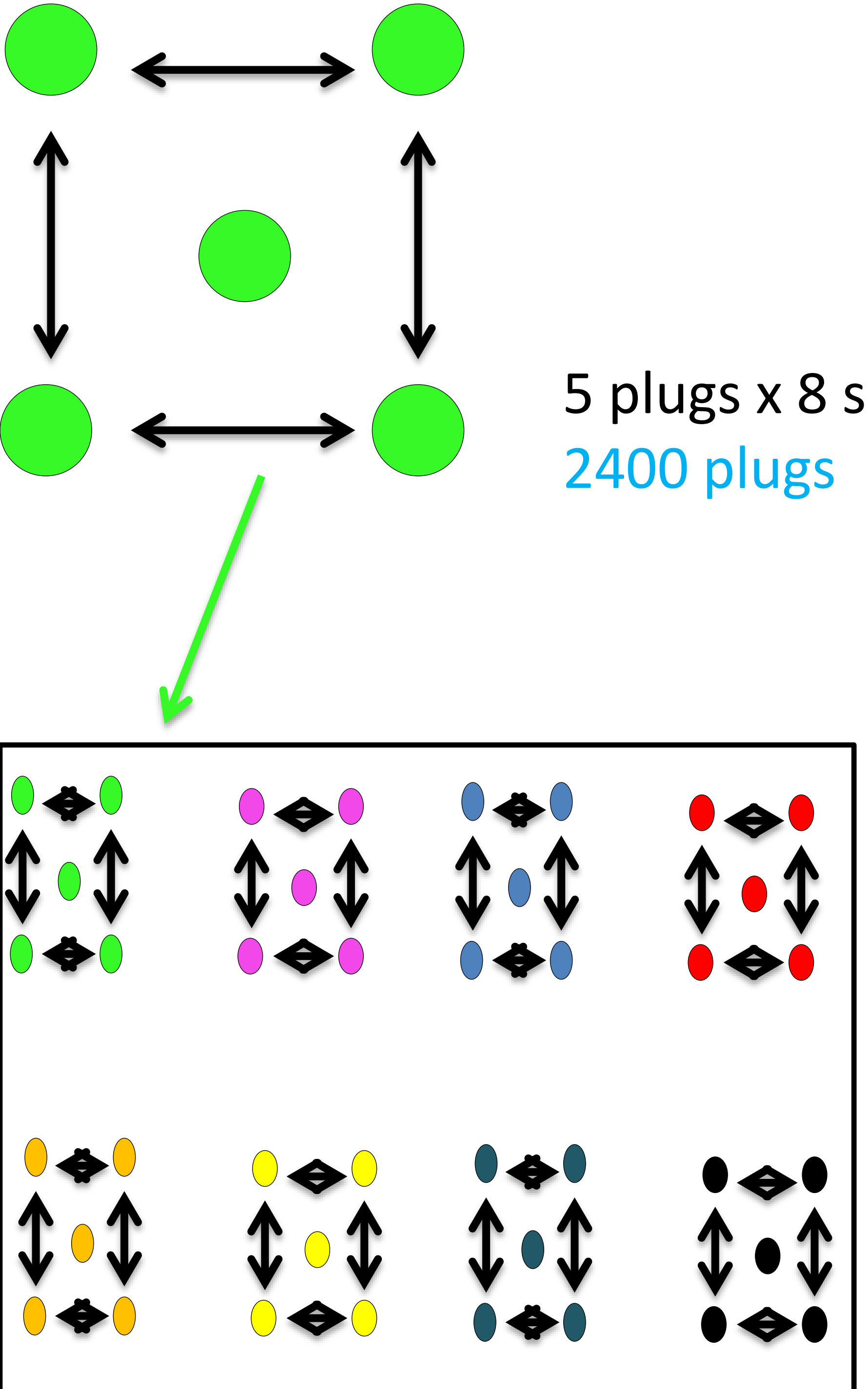
Each error bar is constructed using a 95% confidence interval of the mean.

Maximum stem height by source in November 2012



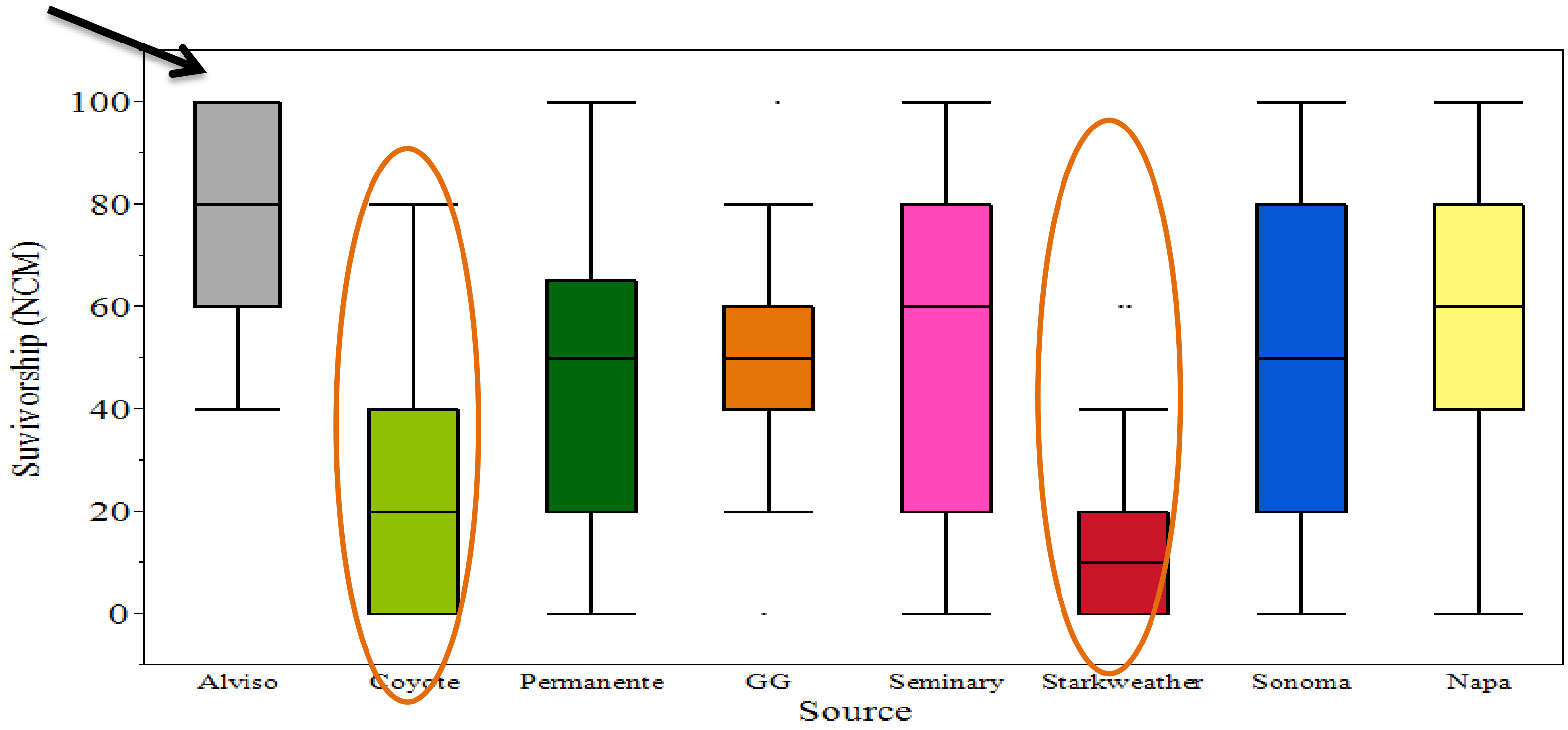
Each error bar is constructed using a 95% confidence interval of the mean.

Field Planting



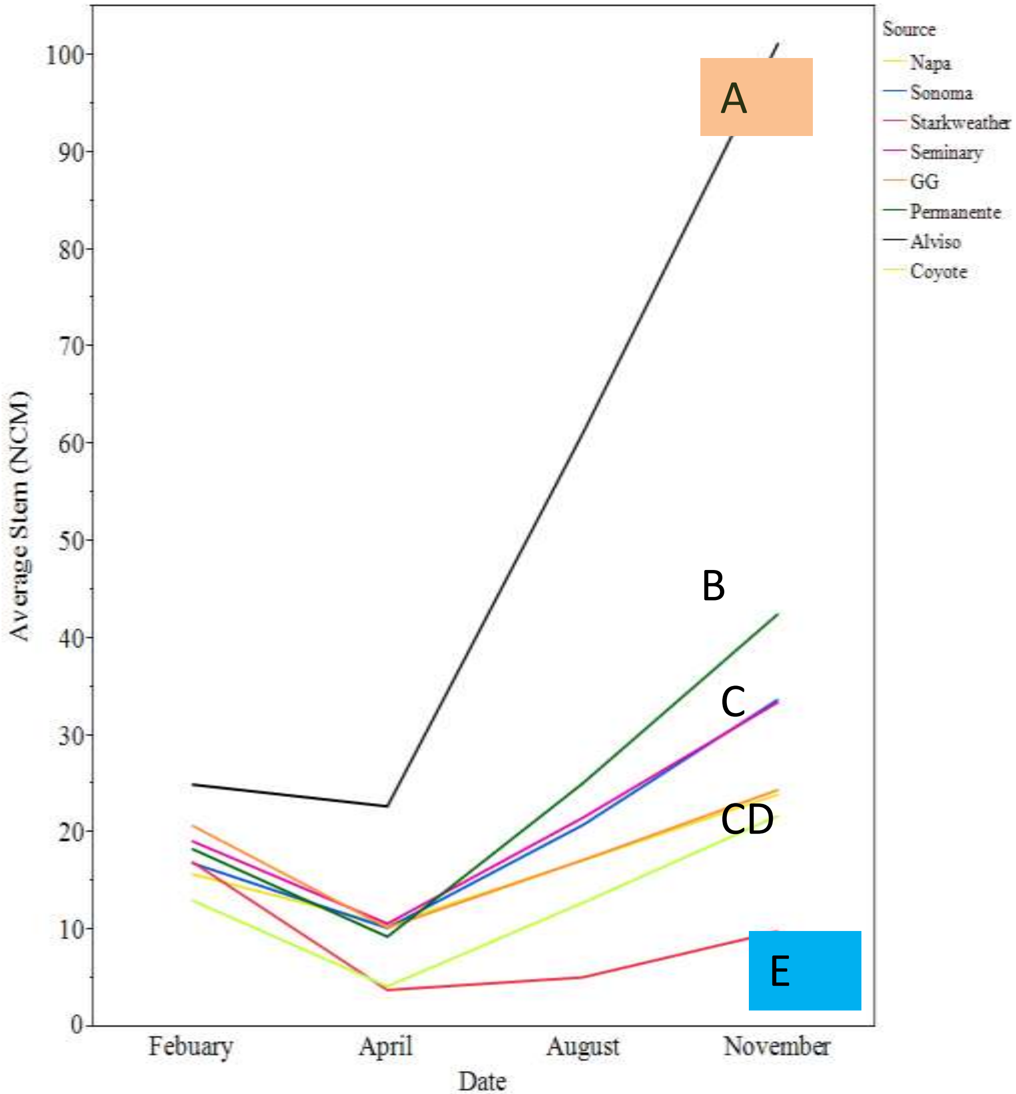
5 plugs x 8 sources x 30 replicates x 2 sites= 2400 plugs

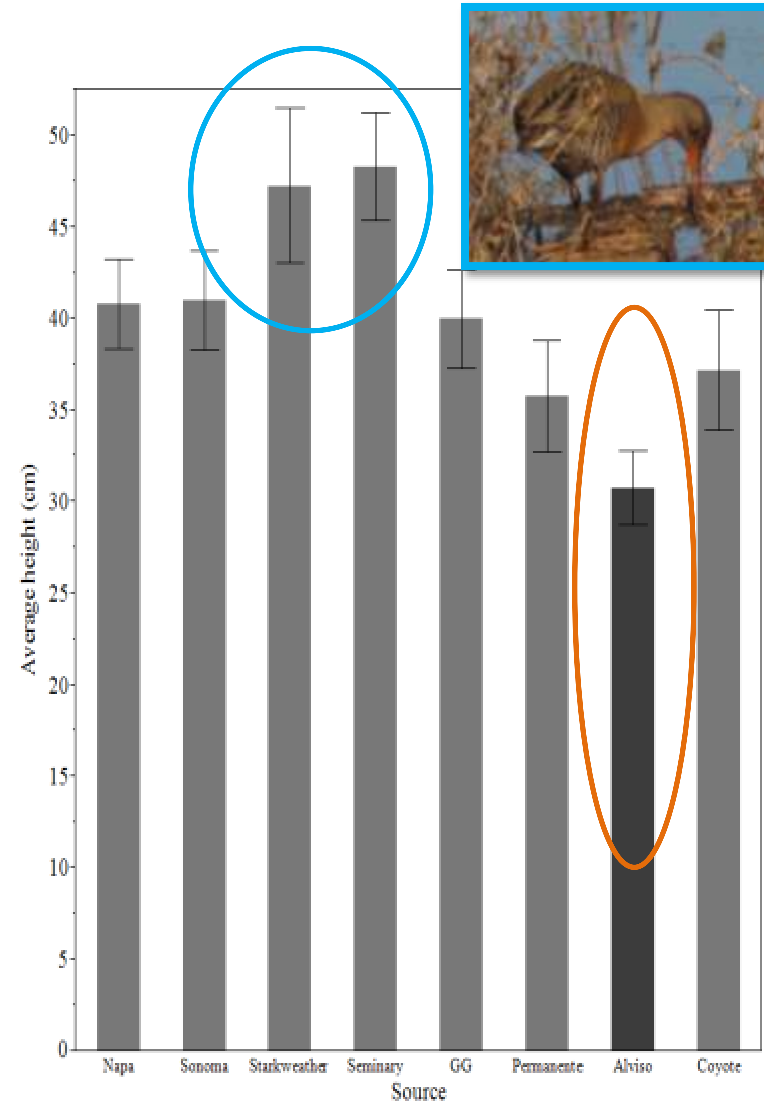
The effect of source on survivorship North Creek Marsh (2012 planting)



Each error bar is created as 95% confidence interval from the mean, What sources should we plant of native cordgrass?

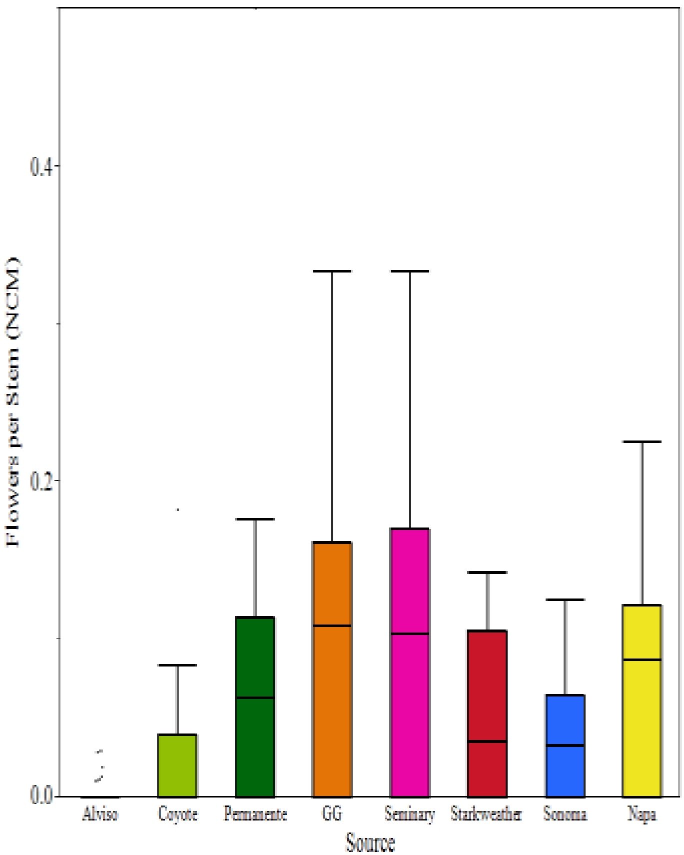
The effect of source on growth rate and height North Creek Marsh (2012 planting)

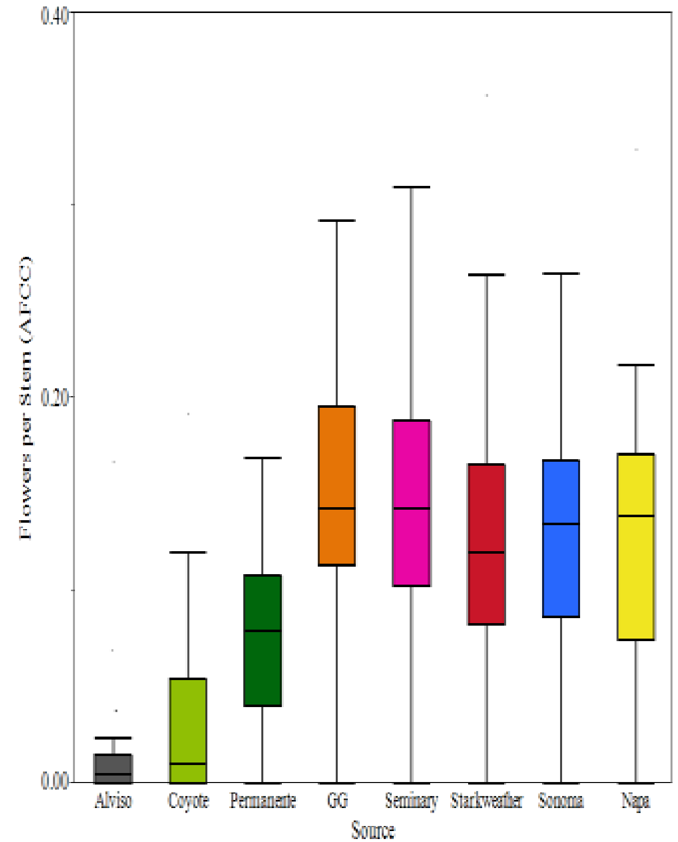




What sources should we plant of native cordgrass?

The effect of source on flowering rates North Creek Marsh and AFCC (2012 planting)





Each error bar is created as 95% confidence interval from the mean

4 Research Questions

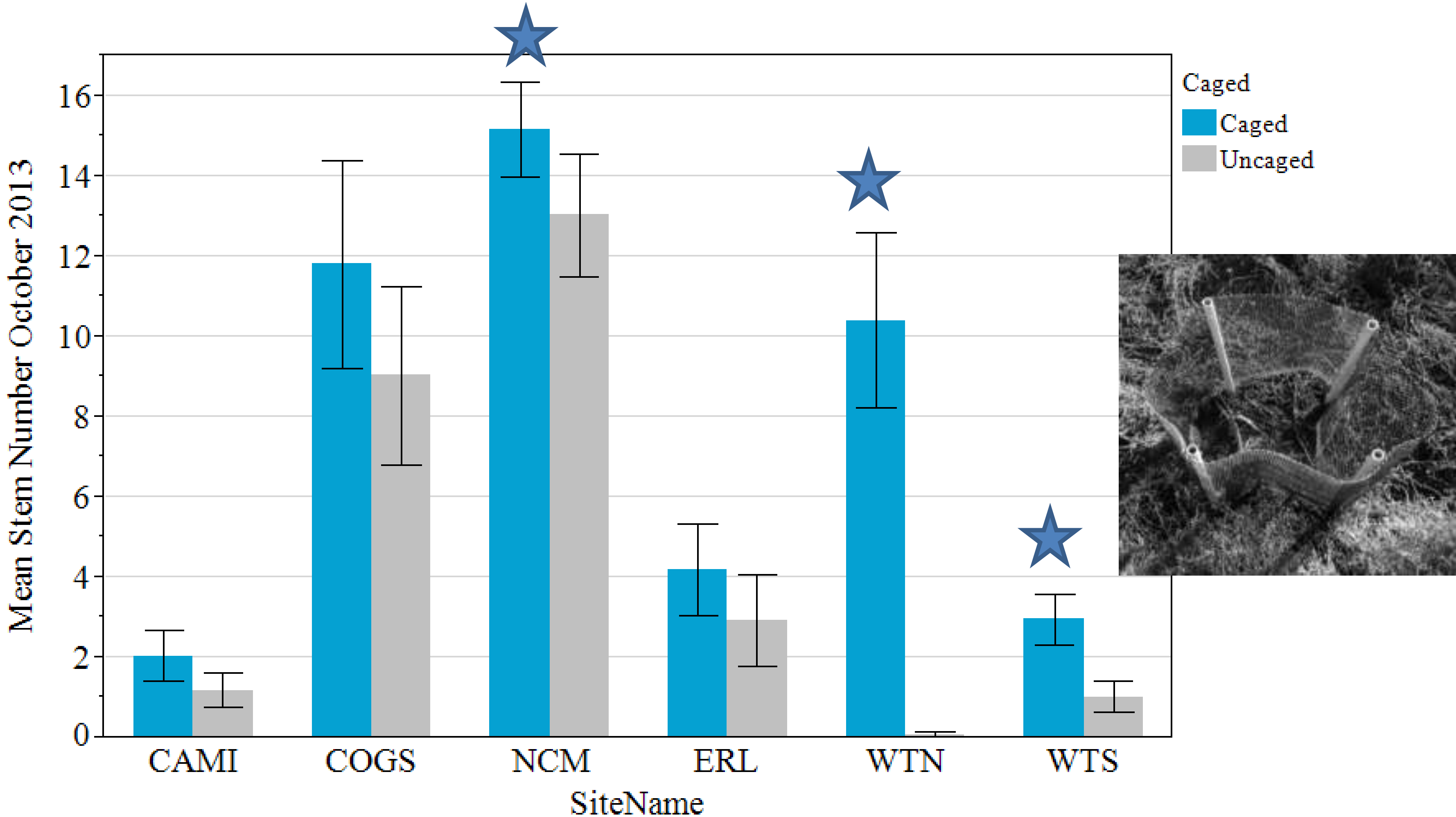
- What sources should we plant of native cordgrass?
- How should we protect native cordgrass?
- How should these sources be planted?
- Where should we plant them?

How should we protect native cordgrass?

2010: A learning experience.

How should we protect native cordgrass?

The effect of rope and plastic mesh caging all sites: 2012 planting



Each error bar is created as 95% confidence interval from the mean

The effect of rope caging
North Creek Marsh (2011 planting)

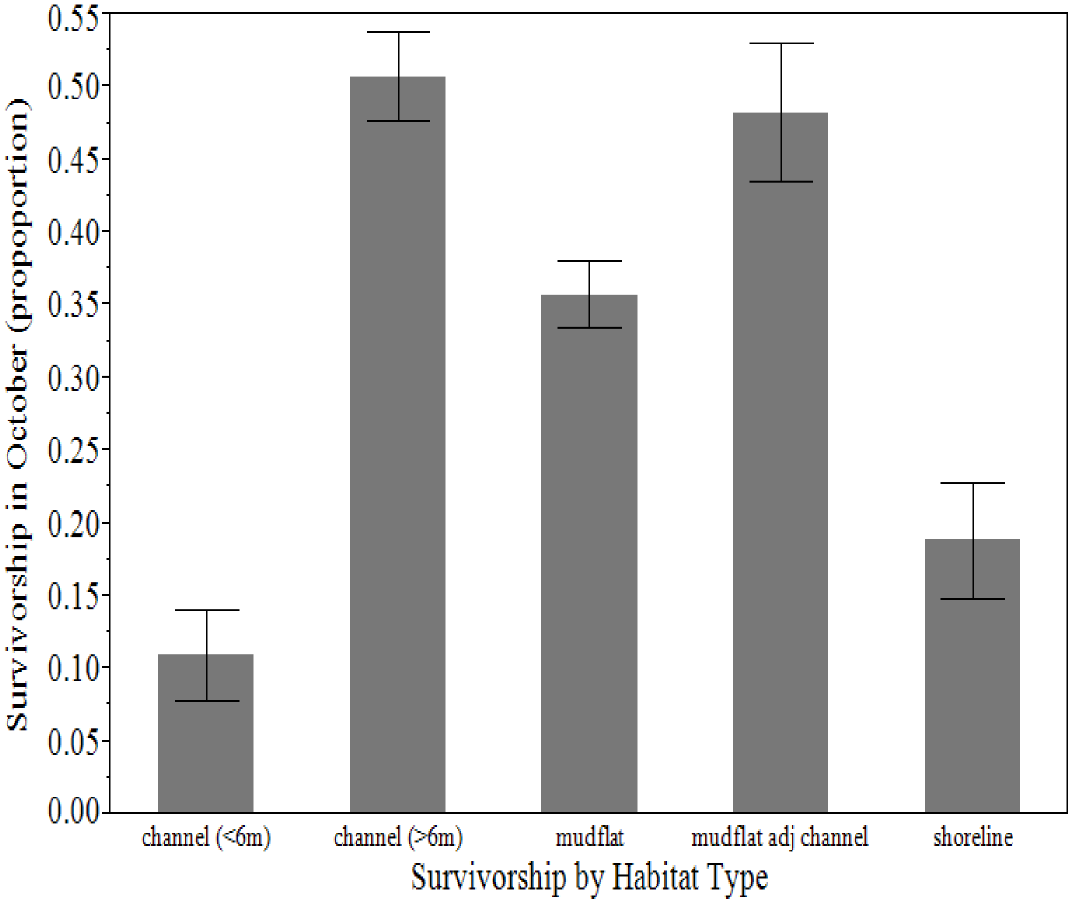
Each error bar is created as 95% confidence interval from the mean

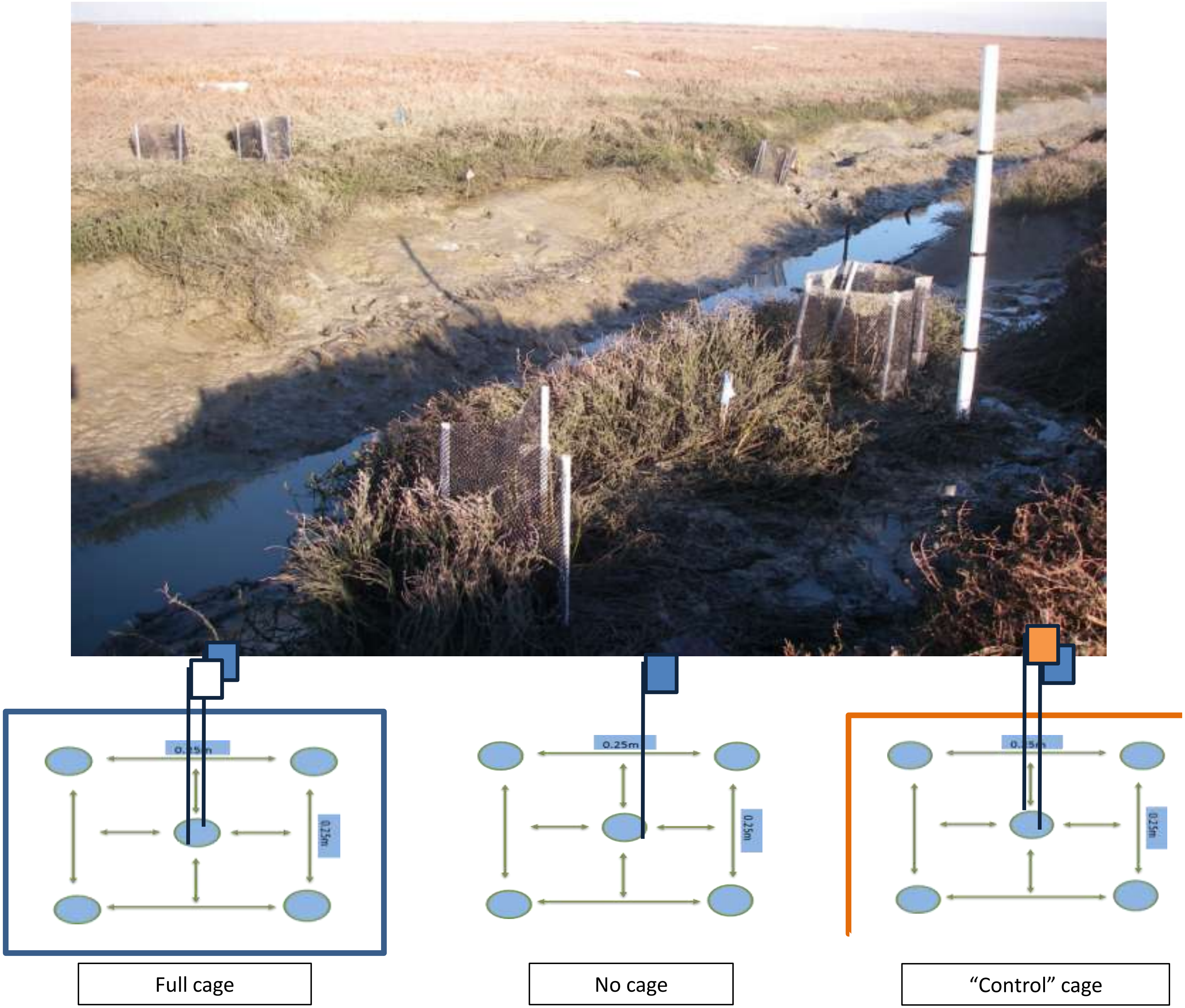
4 adaptive management questions

- What sources should we plant of native cordgrass?
- How should we protect native cordgrass?
- **How should these sources be planted?**
- **Where should we plant them?**

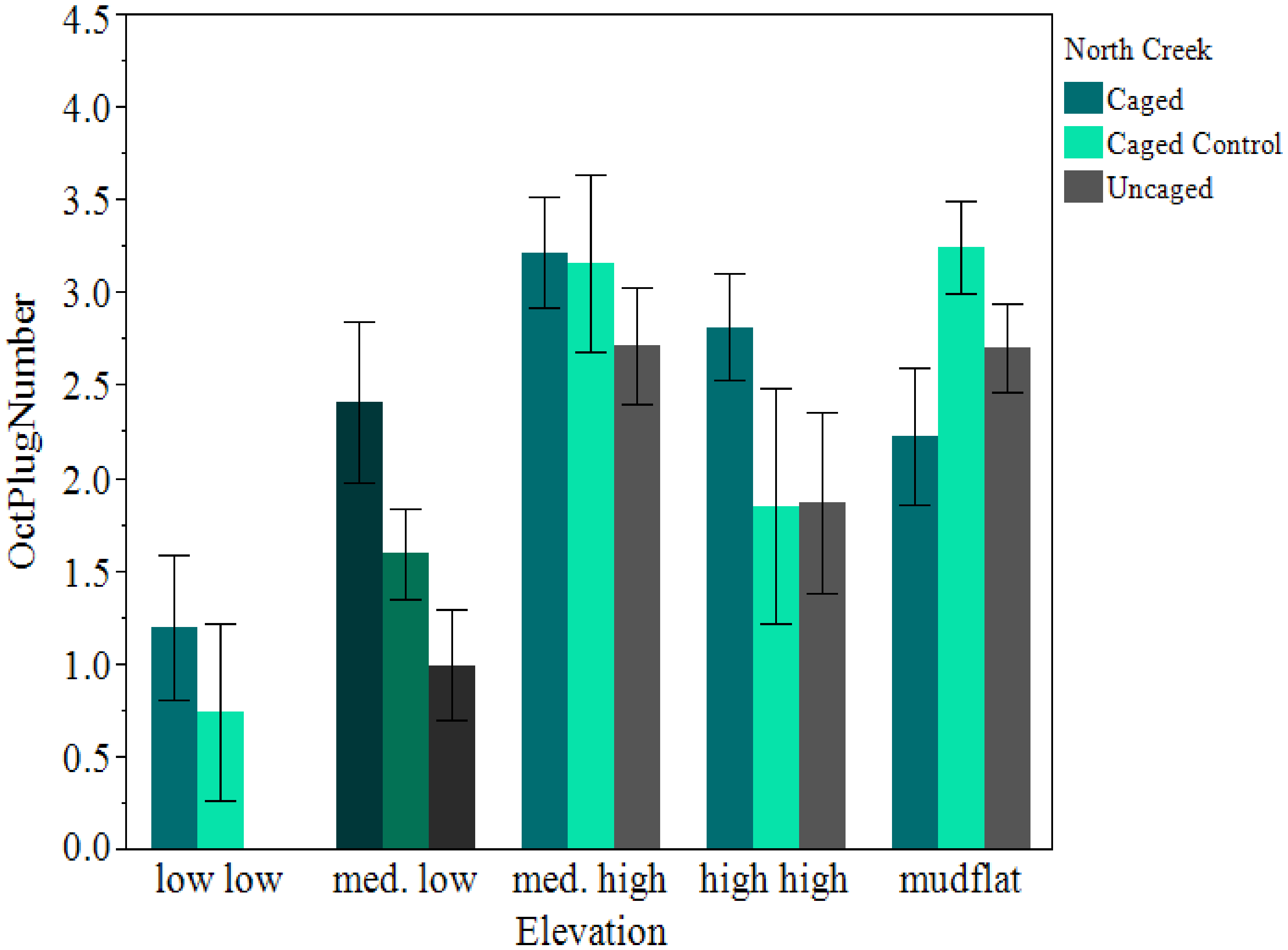
How and where do we plant?

The effect of habitat type on survivorship
(All 2012-2013 plantings)




0.25m
0.25m
Full cage
No cage
“Control” cage

How and where do we plant?



Each error bar is created as 95% confidence interval from the mean

Conclusions

- "Restoration plantings" have been a vector for invasive species in the past.
- *Spartina foliosa* can be established, but restoration designs should be catered to site needs.
- There is a need for peer-reviewed literature on restoration methods in tidal salt marsh in the San Francisco Bay.

So many people to thank!

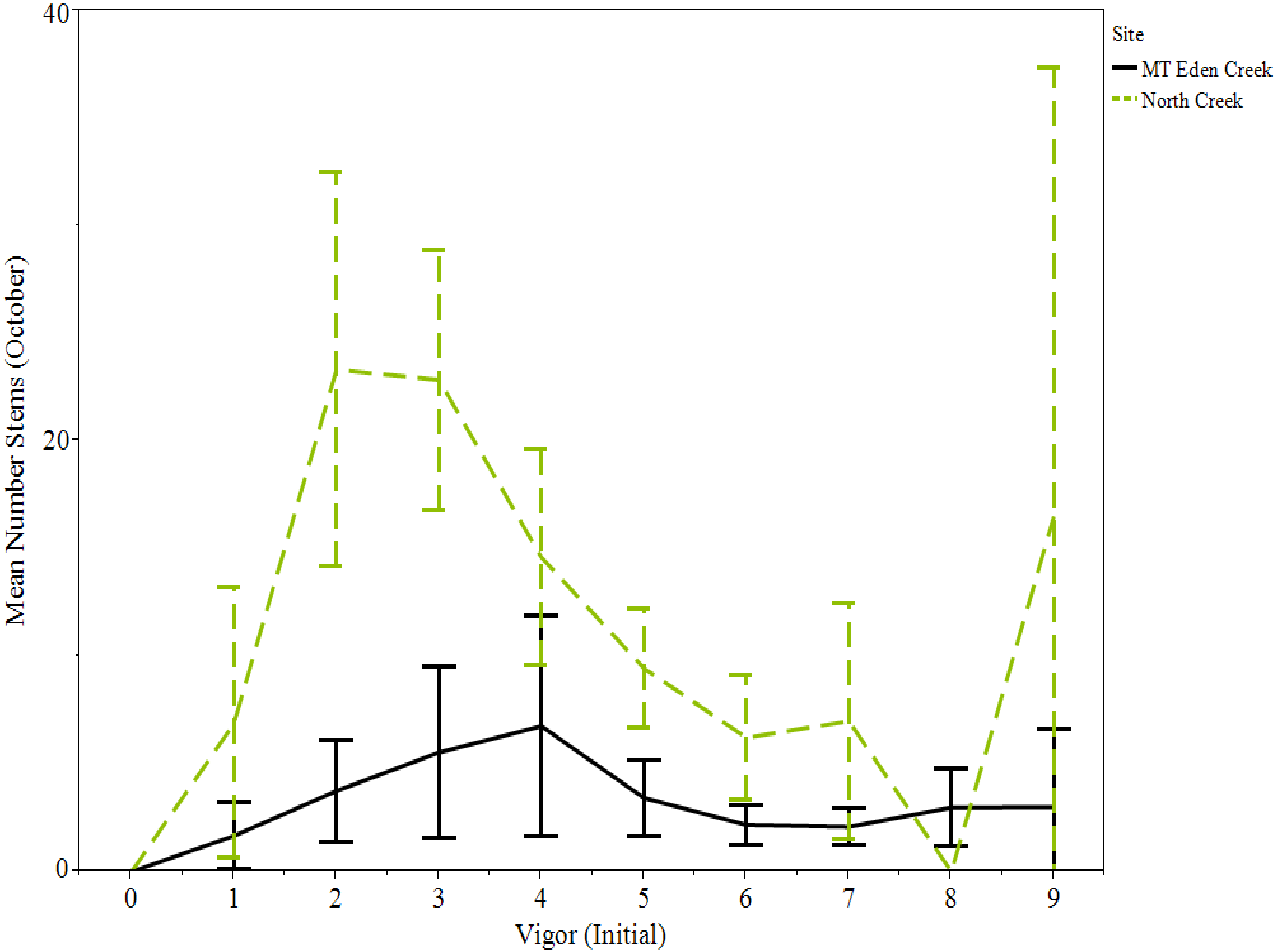
- Boyer Lab at San Francisco State University
- Olofson Environmental/ ISP Staff
- The Watershed Nursery
- The Grosholz Lab and Laura Feinstein
- The plethora of people that I have borrowed equipment from, grilled incessantly, hounded, and annoyed. (USGS WERC, John Callaway, Tom Parker, Mike Vasey, Peter Baye, Laura Feinstein, UCLA Human Genomics Lab)

Coastal Conservancy

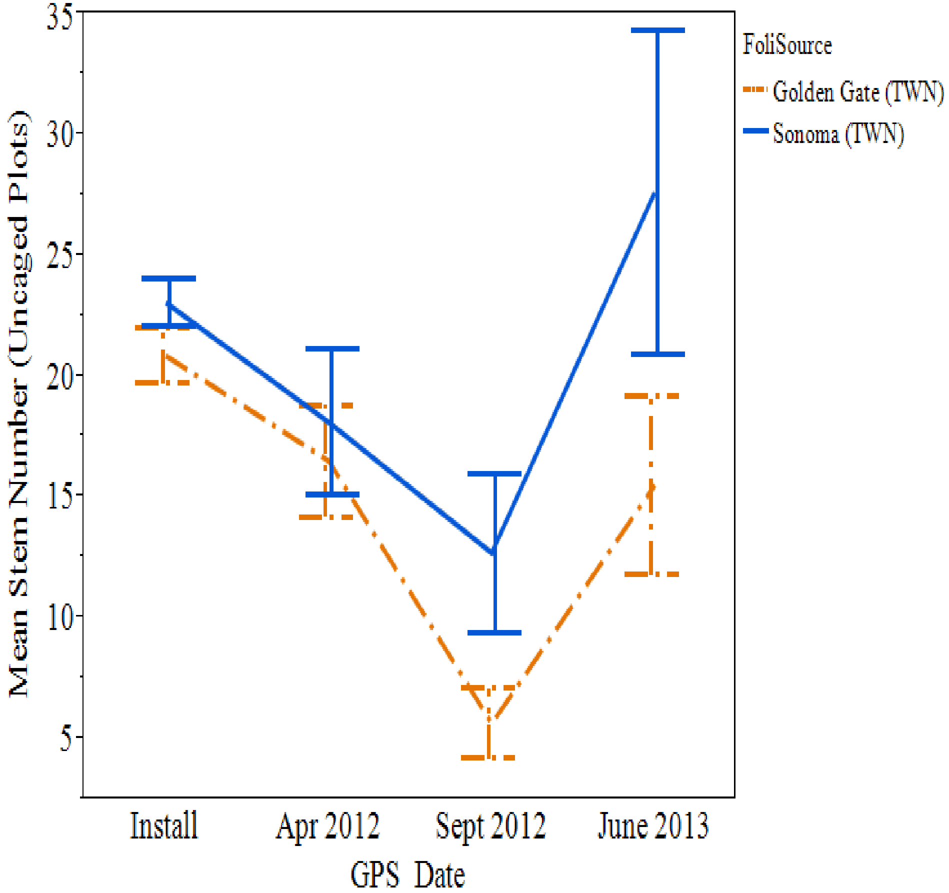
San Francisco Estuary Invasive Spartina Project
Preserving native wetlands

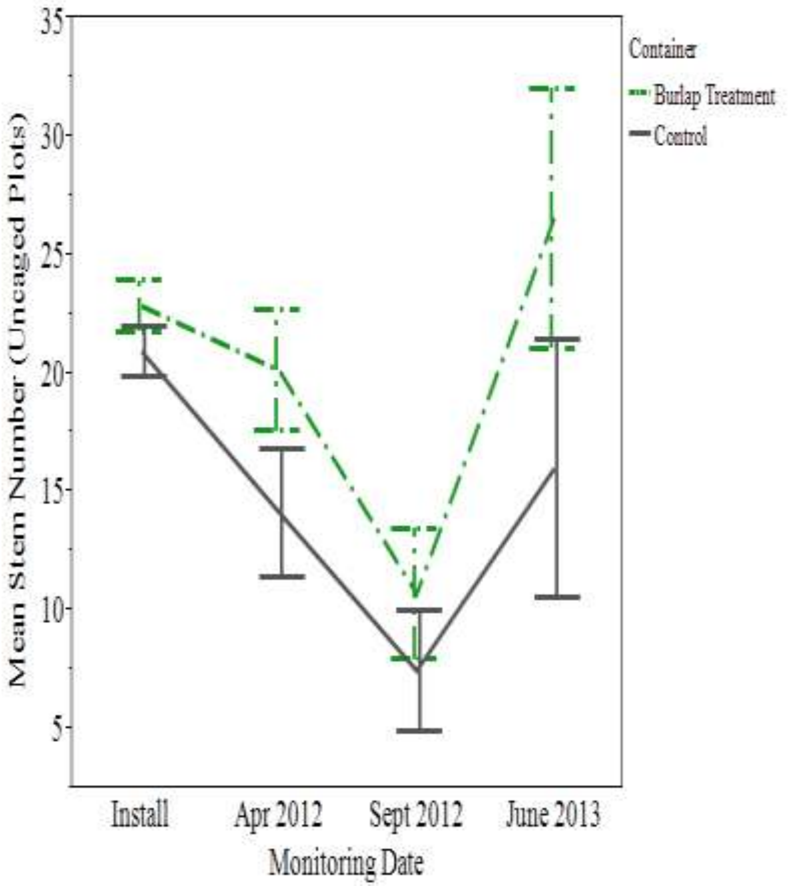
Romberg Tiburon Center for Environmental Studies

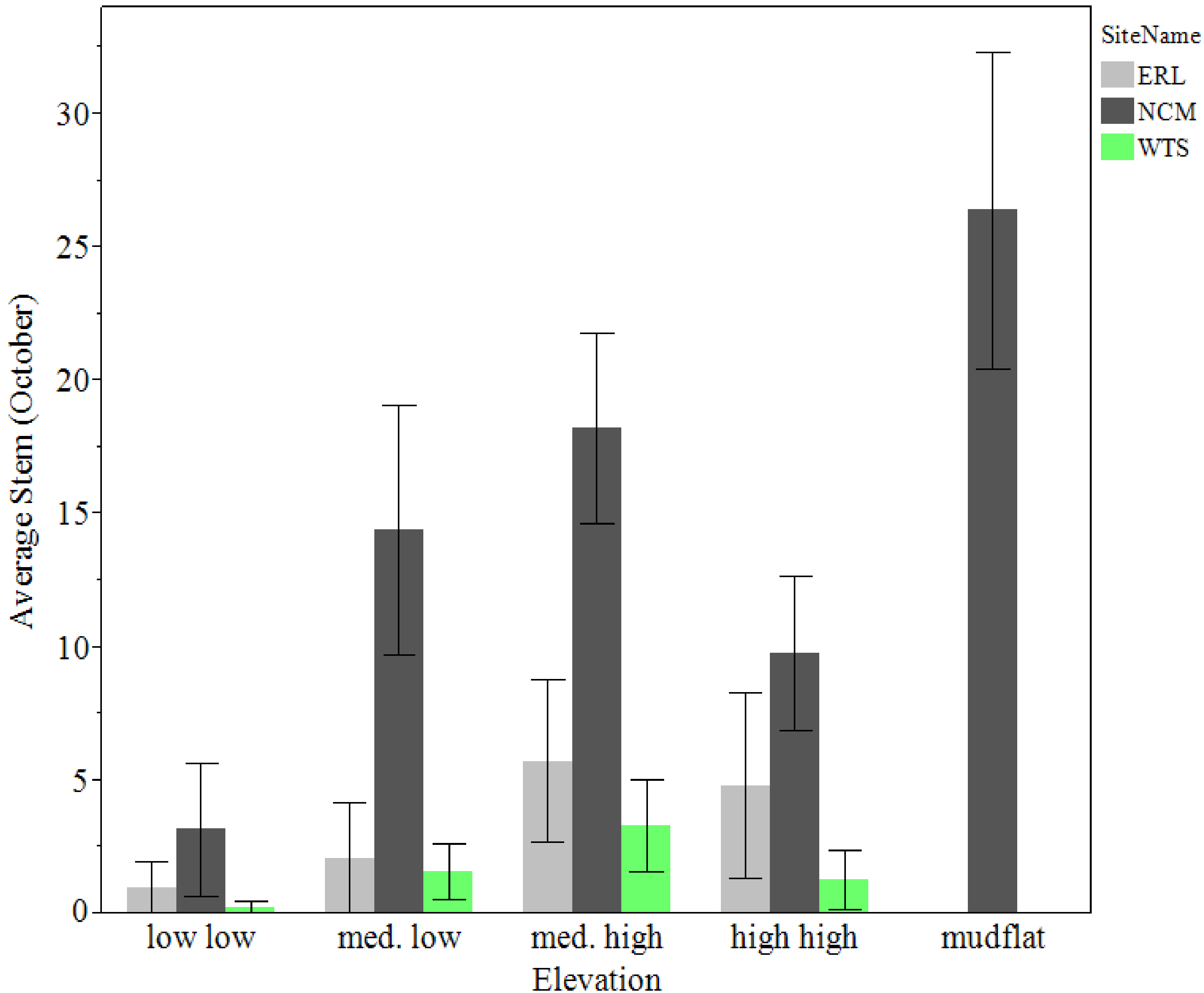
OEI
Olofson Environmental, Inc.

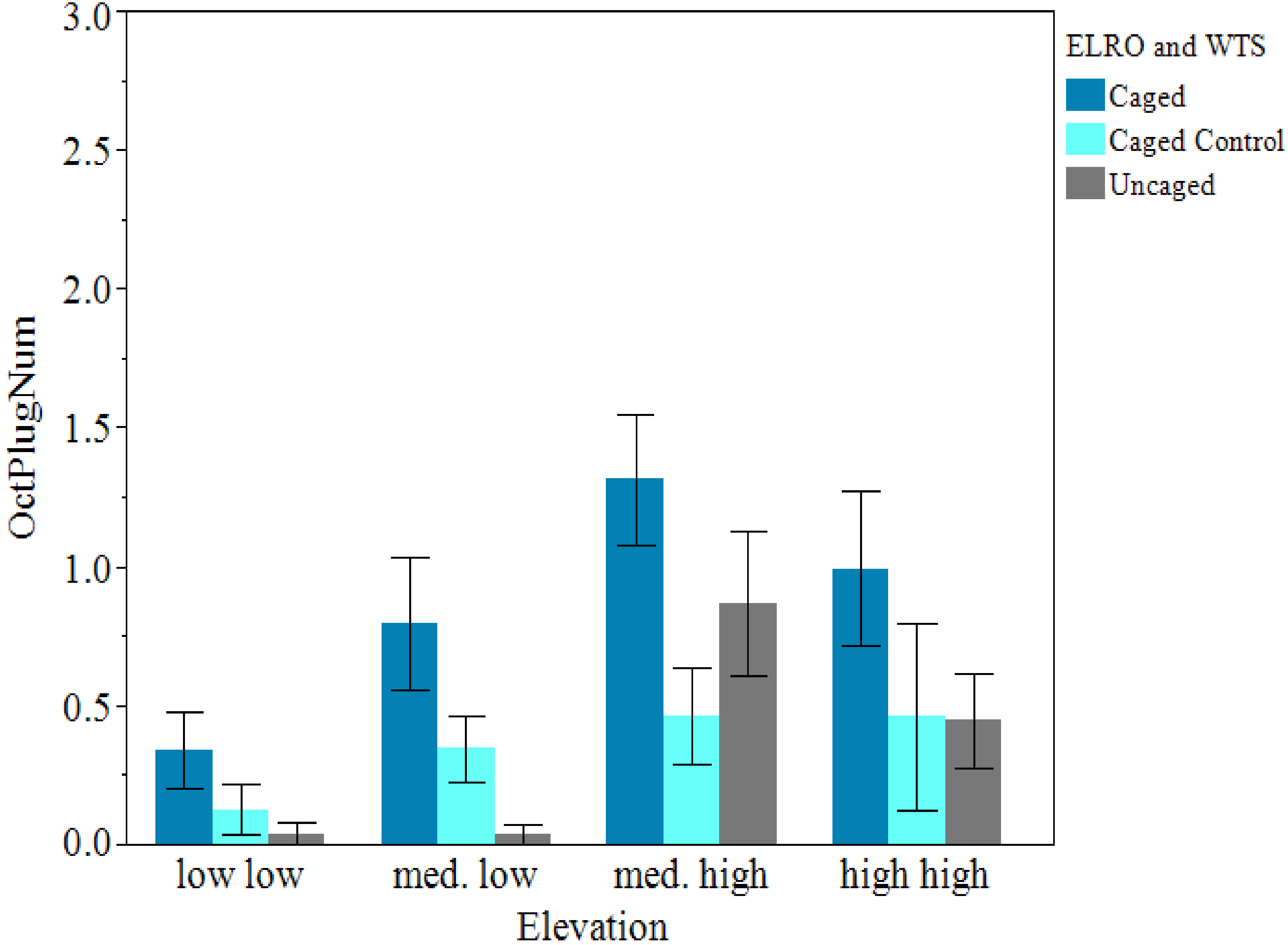

Site
MT Eden Creek
North Creek
Mean Number Stems (October)
Vigor (Initial)
40
20
0
0
1
2
3
4
5
6
7
8
9

Uncaged (Source and Burlap)

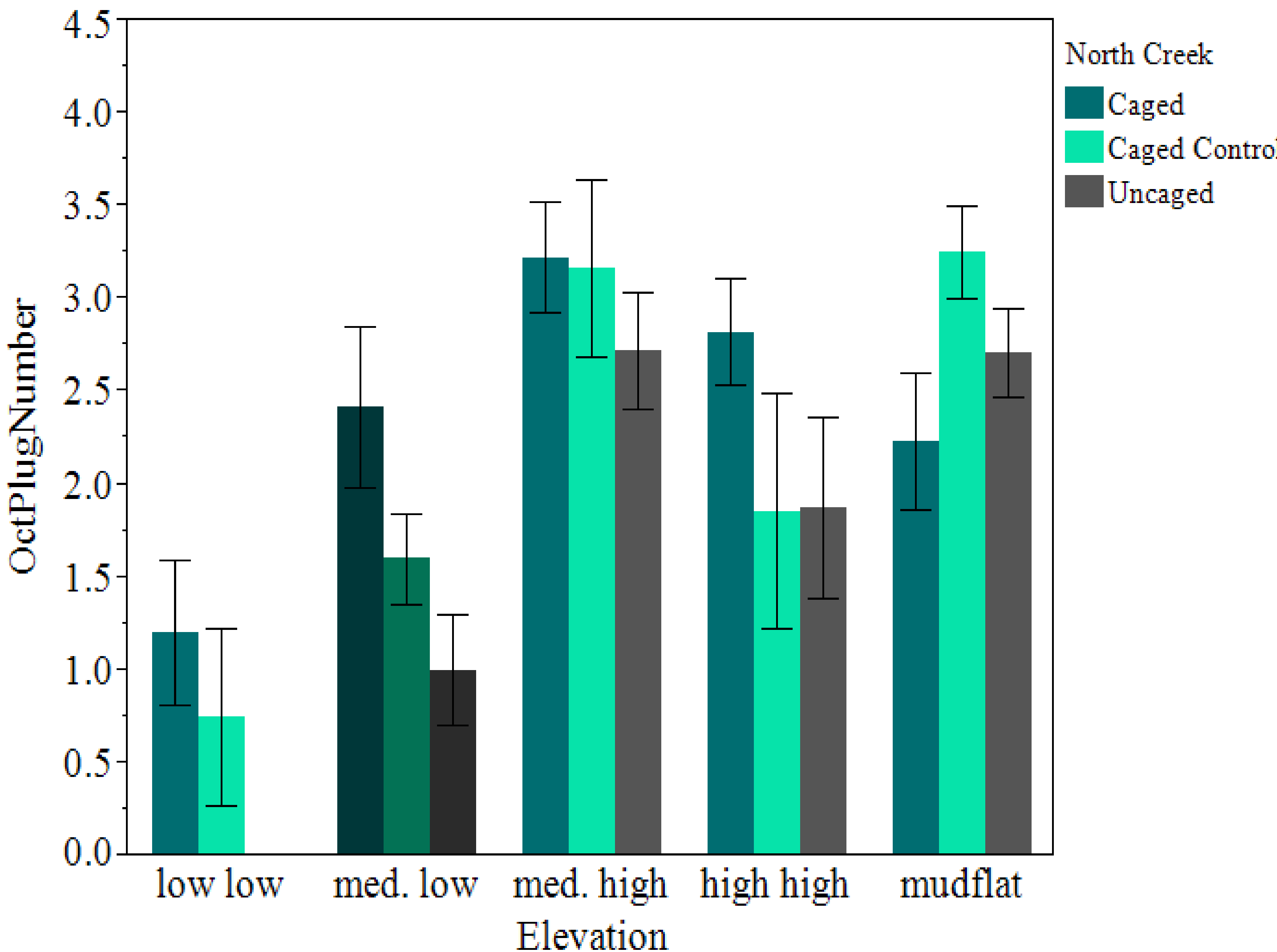




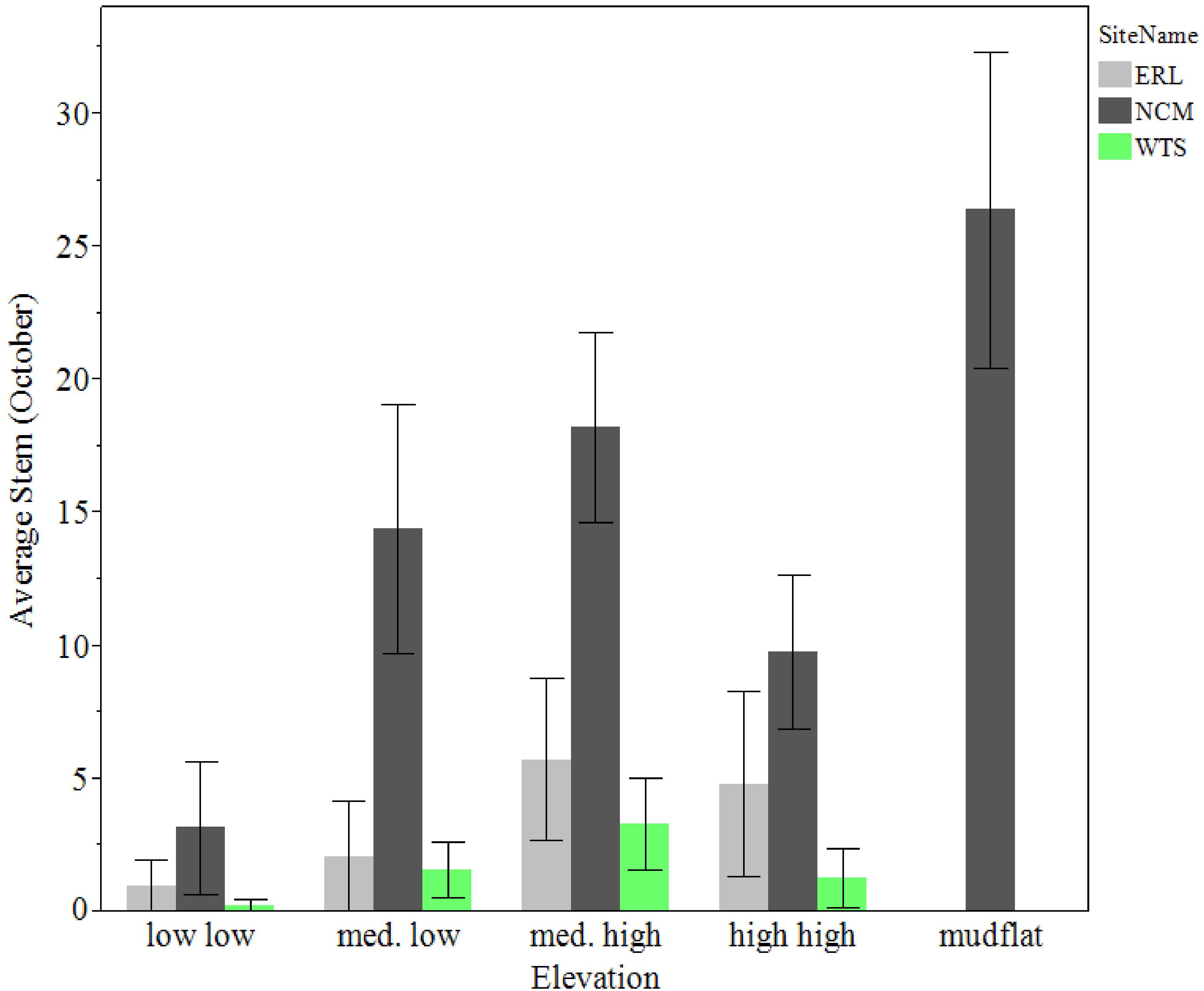

SiteName
ERL
NCM
WTS
Average Stem (October)
0
5
10
15
20
25
30
low low
med. low
med. high
high high
mudflat
Elevation



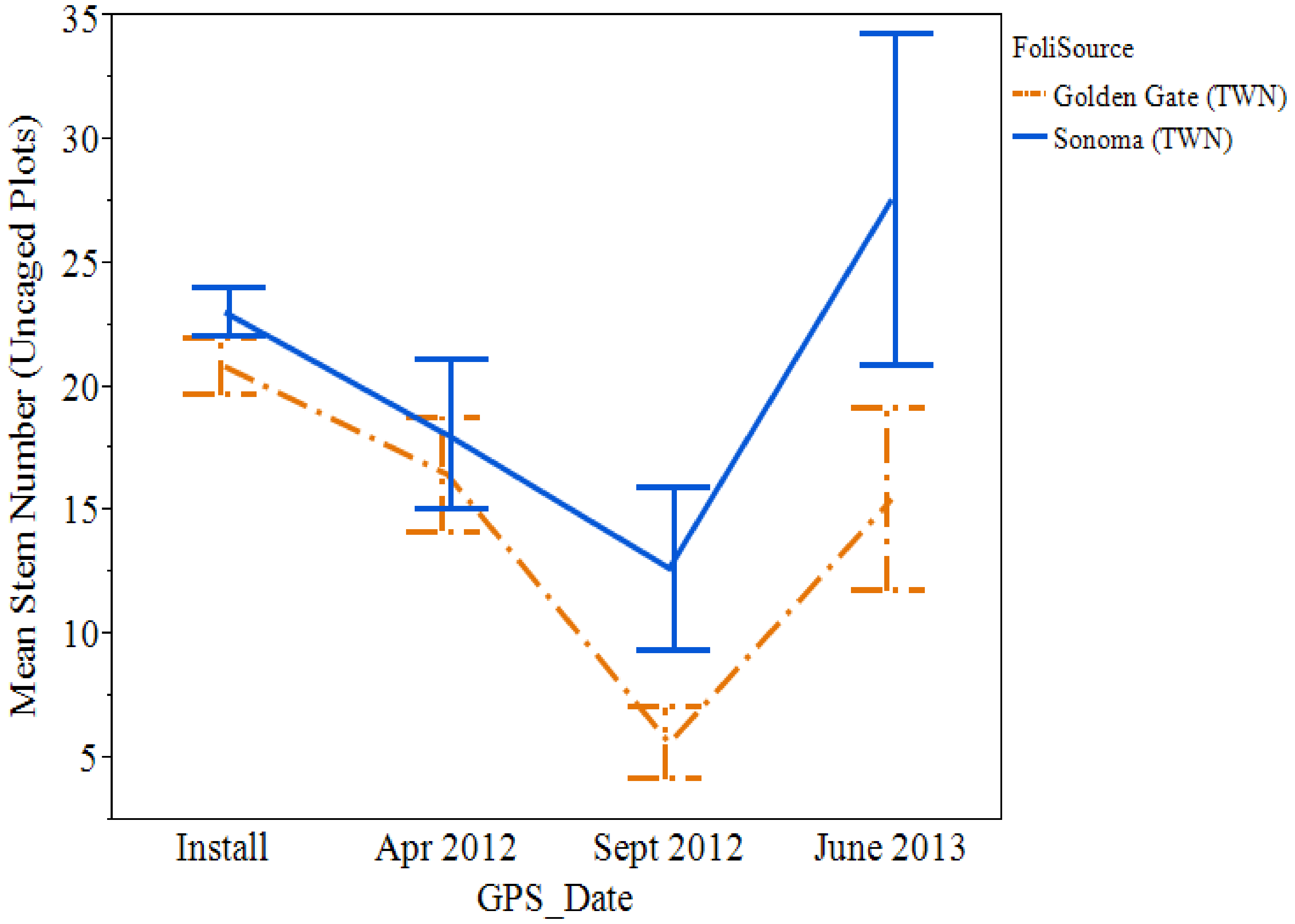
ELRO and WTS
Caged
Caged Control
Uncaged
OctPlugNum
3.0
2.5
2.0
1.5
1.0
0.5
0.0
low low
med. low
med. high
high high
Elevation



North Creek
Caged
Caged Control
Uncaged
OctPlugNumber
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
low low
med. low
med. high
high high
mudflat
Elevation

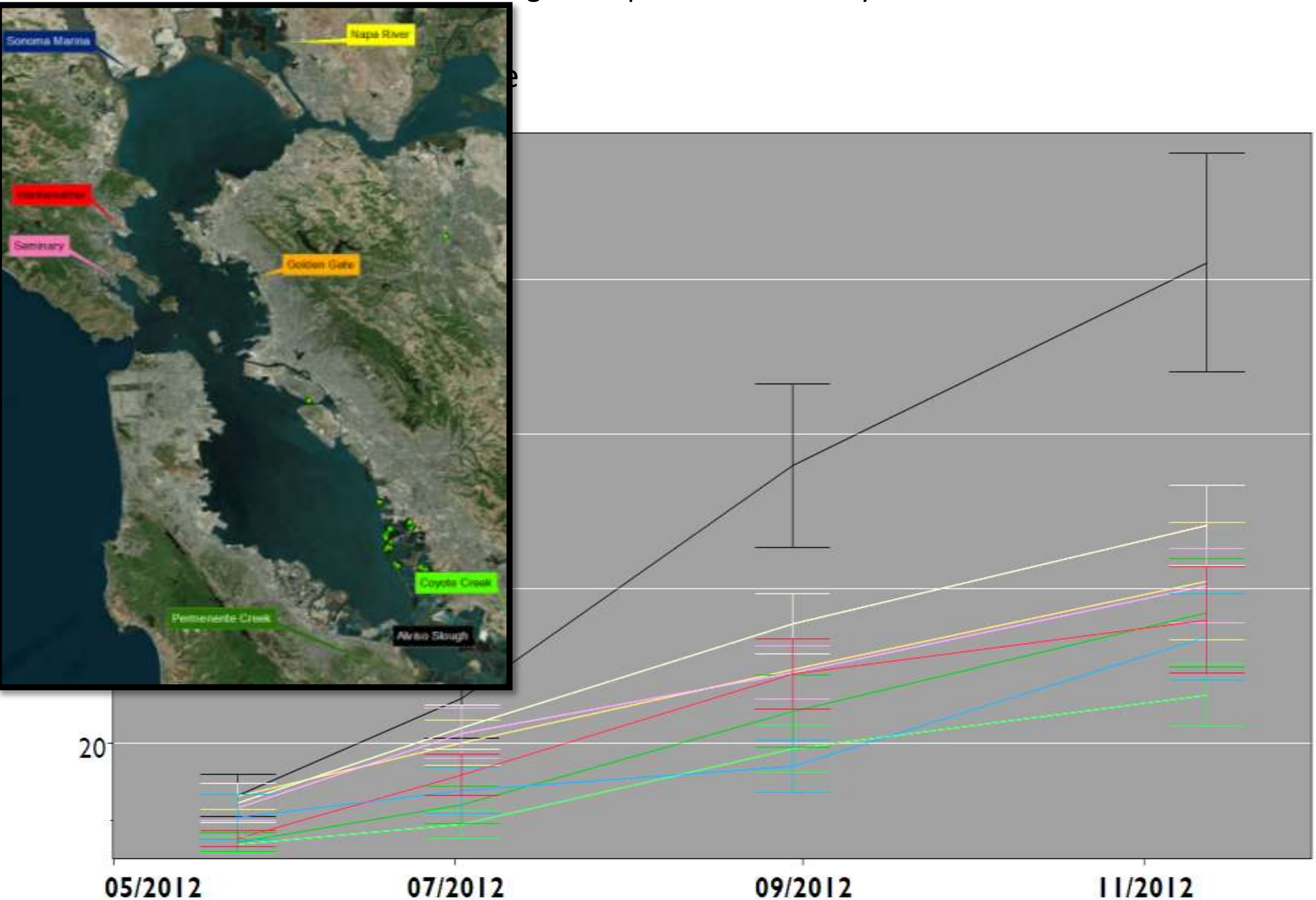

SiteName
ERL
NCM
WTS
Average Stem (October)
0
5
10
15
20
25
30
low low
med. low
med. high
high high
mudflat
Elevation

What sources should we plant of native cordgrass?



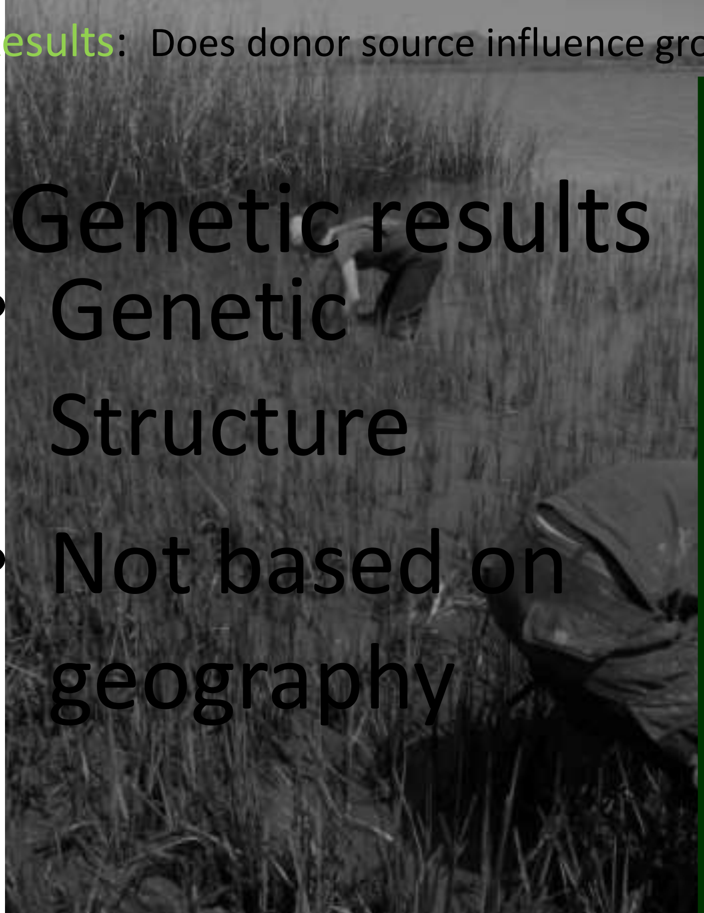
Each error bar is created as 95% confidence interval from the mean

Results: Does donor source influence growth patterns in nursery conditions?



Each error bar is constructed using a 95% confidence interval of the mean.

Results: Does donor source influence growth patterns in nursery conditions?



Genetic results

- Genetic Structure
- Not based on geography