

Spread of exotic cordgrasses and hybrids (*Spartina sp.*) in the tidal marshes of San Francisco Bay

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Acknowledgements

Vince Battaglia

Kin Fai Lee

Janie Civile

Mary Pakenham-Walsh

Heather Davis

Marcel Rejmanek

Alan Hastings

Fred Ryan

John Lambrinos

Christina Sloop

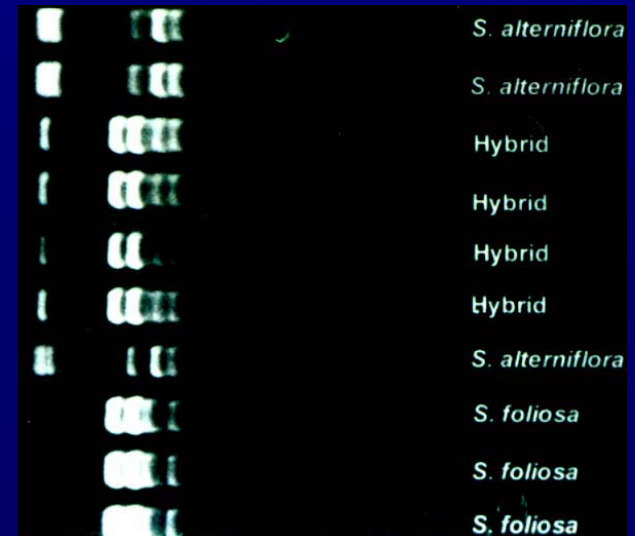
Bodega Marine Laboratory, California Sea Grant,
California Coastal Conservancy, CALFED,
National Science Foundation

Methods

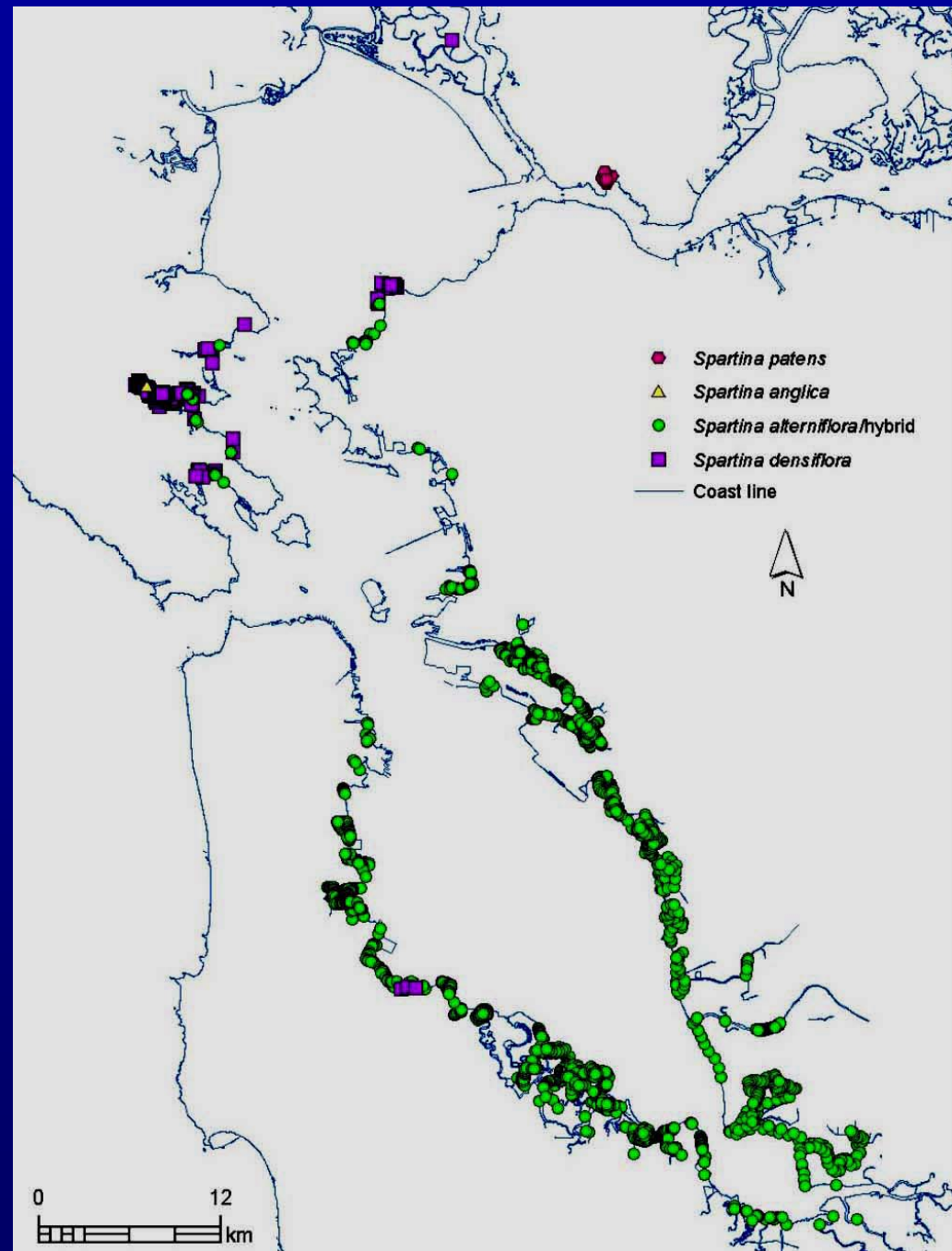


Field surveys
GPS locating

Hybrid characterization and
detection using RAPD markers



S. anglica



Spartina anglica



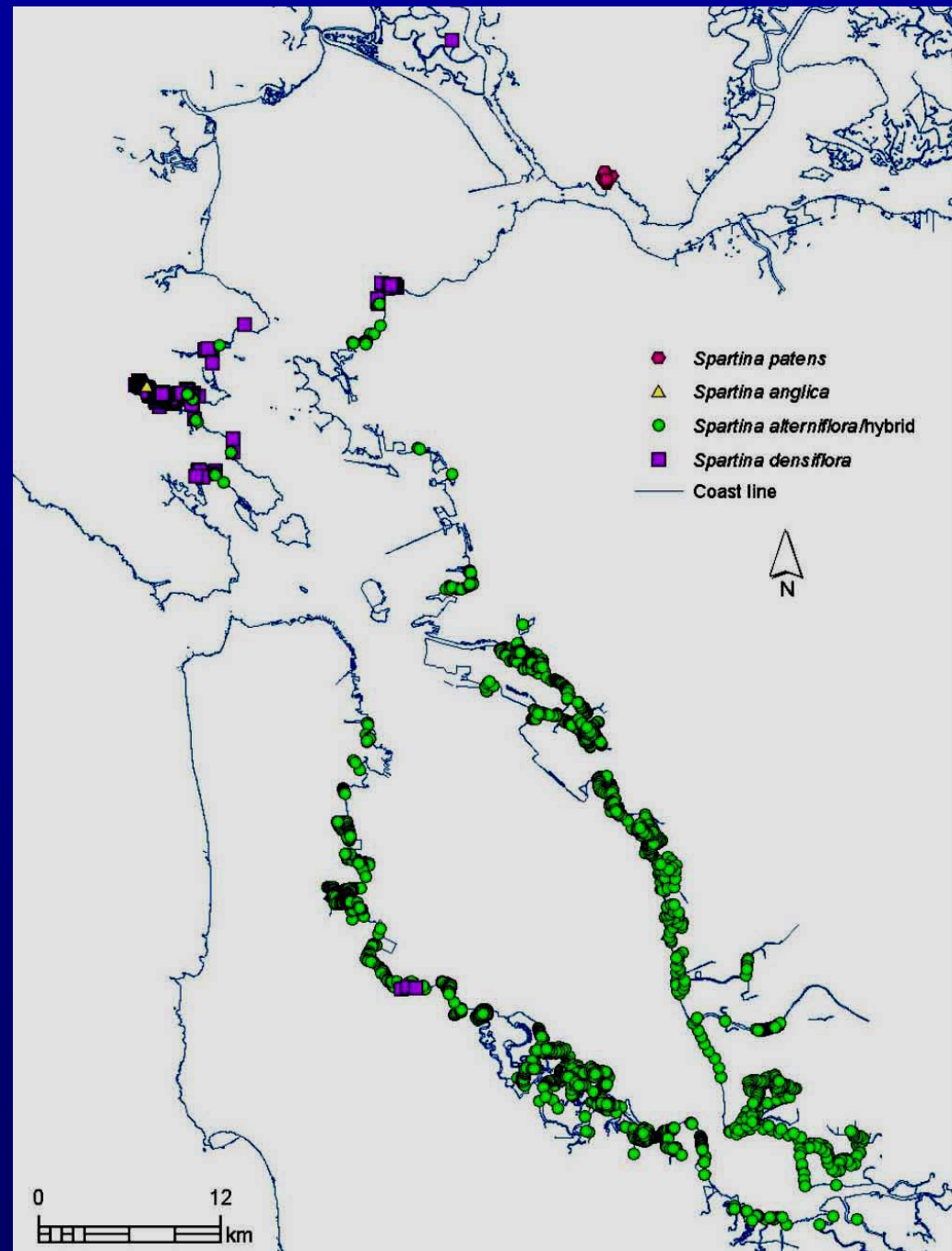
E. Boschker

- English cordgrass
- originated in 1800s as a hybrid between *S. maritima* and *S. alterniflora*
- caused ecosystem changes in England, New Zealand, Australia, Tasmania, the Netherlands (photo), and Willapa Bay WA
- sown by seed during the 1977 restoration of Creekside Park, Marin County, CA

Spartina anglica

- 24 individuals of *S. anglica* covering 364 m²
- found only at Creekside Park
- all plants were within 100 m of the first known clone along the course of 2 linked channels
- plants were growing next to the channel bottoms, alongside and sometimes intermixed with *S. foliosa*

S. patens



Spartina patens



K. Zaremba

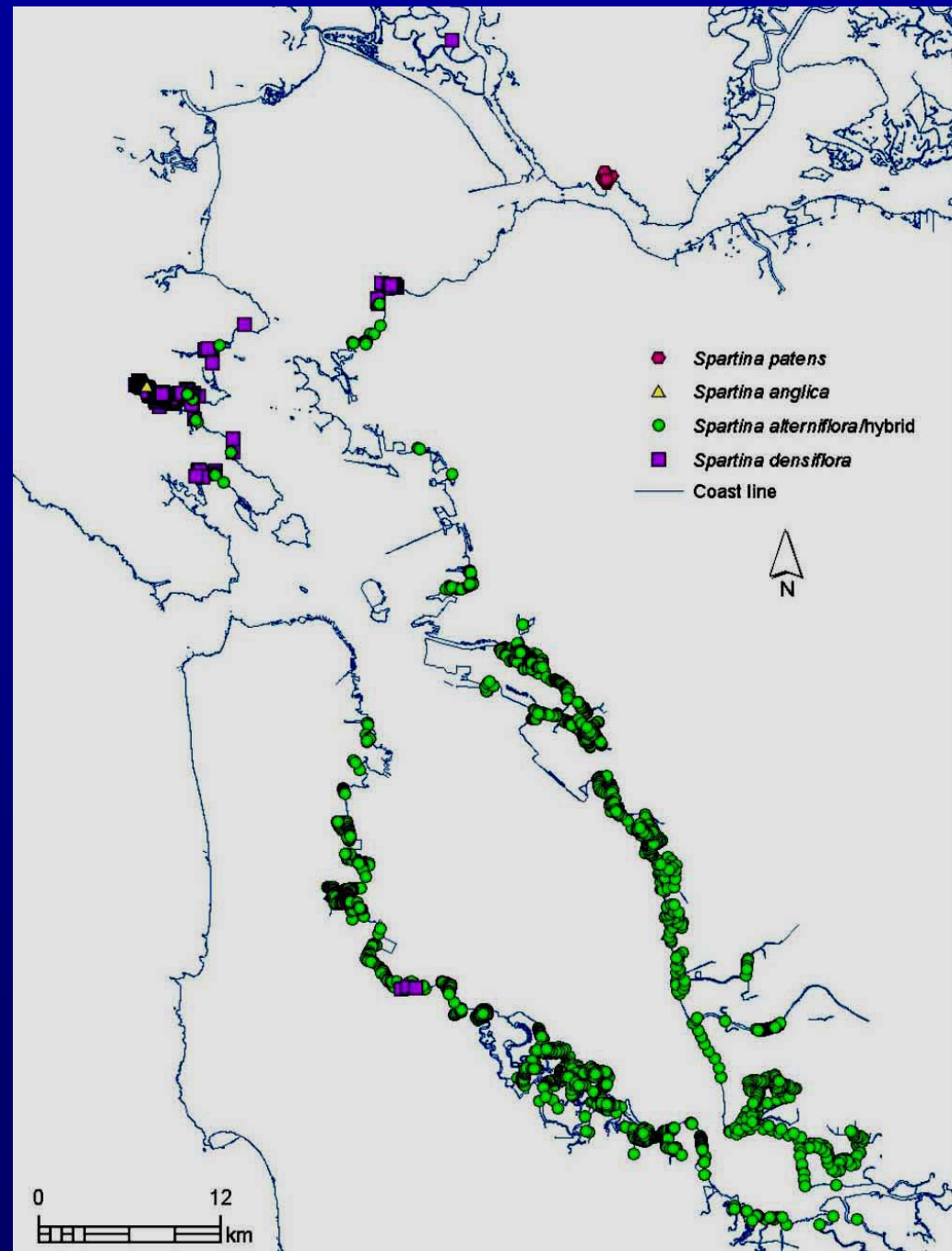
- Salt marsh hay
- native to eastern US
- exponential spread in an exotic population in Oregon
- 2 clones near Benicia, CA in 1970

Spartina patens

- 42 plants spread over 6.5 ha in 2001
- occurs in the mid- to high- marsh
- threatening a population of a federally-listed plant species, *Cordylanthus mollis* ssp. *mollis*



S. densiflora



Spartina densiflora

- native to Chile
- has spread to all salt marshes in Humboldt Bay, Ca since its 19th Century introduction
- was introduced into the San Francisco estuary at least twice
 - seed was sown into Creekside Park
 - planted in Greenwood Cove, Marin County





Spartina densiflora

- has spread widely where originally planted and beyond
- in San Francisco Bay 5.3 ha was spread out over 118 ha
- was found at Tomales Bay on the outer coast



A photograph of a coastal landscape. In the foreground, there is a field of tall, green cordgrass. A woman in a white shirt and blue overalls stands in the grass, holding a tool. Behind her is a dark sandy beach with many white seagulls. The ocean extends to the horizon, with a city skyline visible in the distance under a clear blue sky.

Smooth Cordgrass

California Cordgrass

Spartina foliosa and *Spartina alterniflora*

- *S. foliosa*:
 - Native to California
- *S. alterniflora*:
 - Native to Eastern & Gulf Coasts, North and South America
 - Brought to San Francisco Bay mid-1970s
- **species hybridized ca. mid-'80's**

Traits of hybrids:

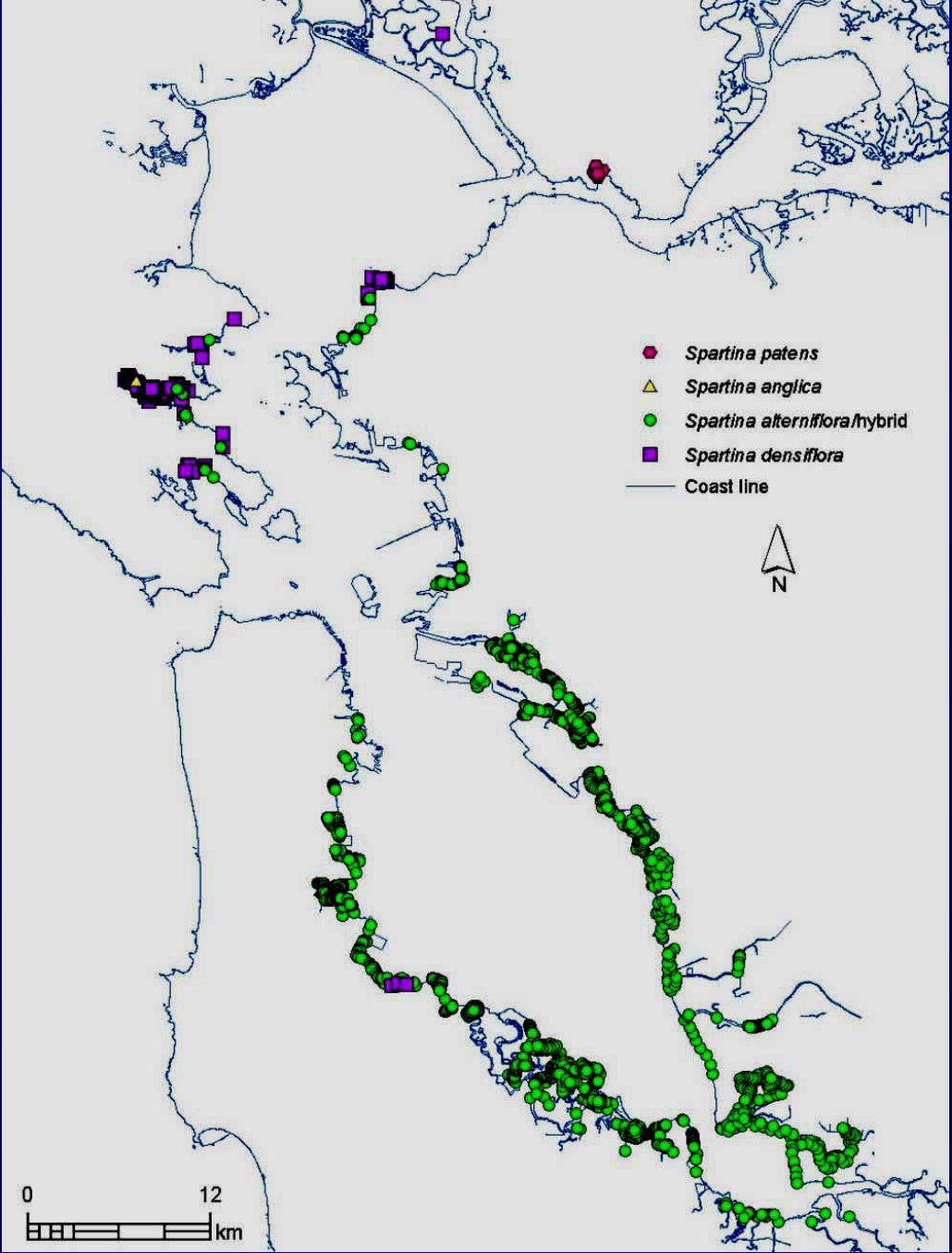
Tall culms

Wide culms

Red culm color



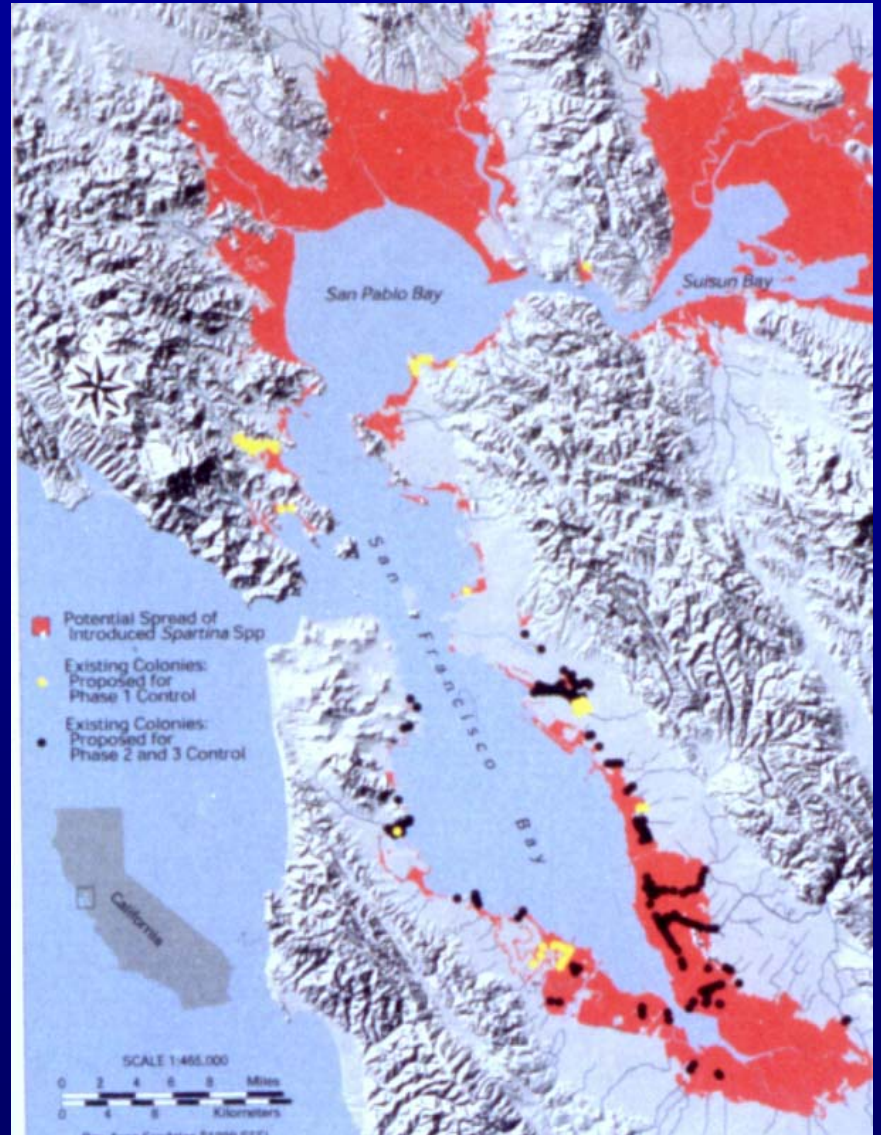
Hybrids and *S. alterniflora*



Spartina alterniflora and hybrids

- 190 ha of net cover spread over
- 1,509 ha
- 28,098 ha of mudflat and marsh habitat in SF Bay

Seed Dispersal and Predicted Spread



South San Francisco Bay Nominated Globally Important Bird Area

(Audubon Society, Nov 2001)

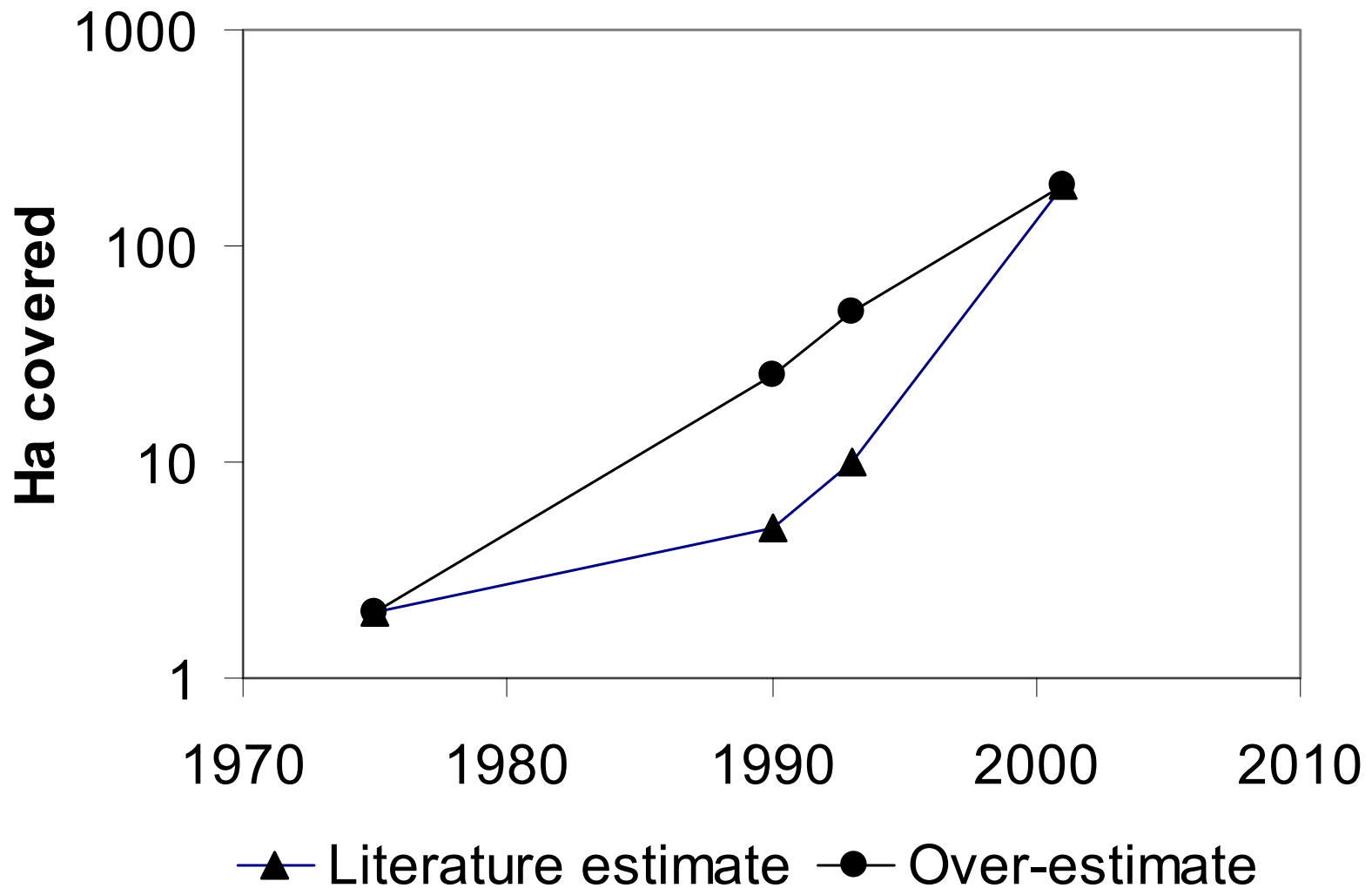


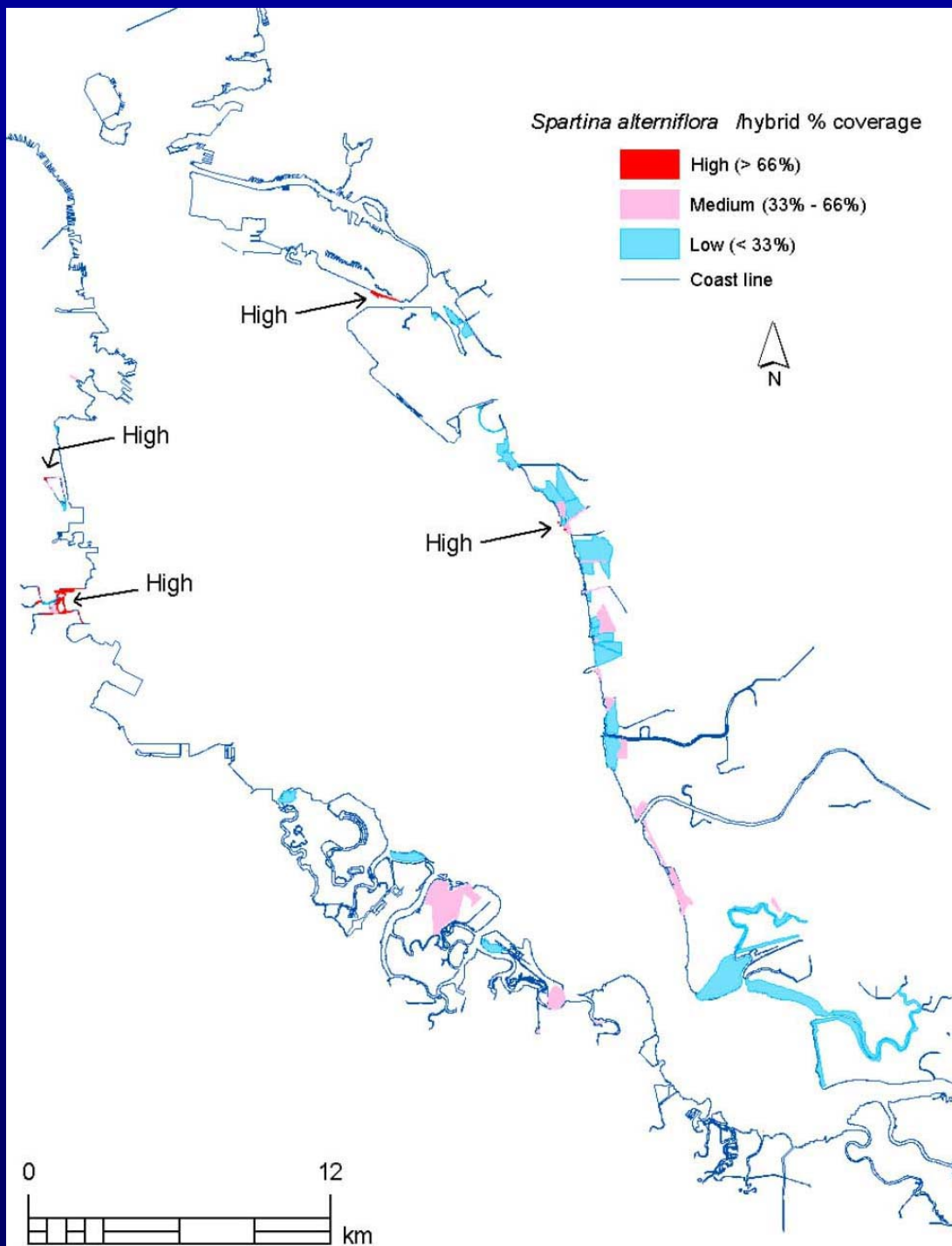


Photo by K. Sayce

- **Indirect pollen swamping of *S. foliosa* by hybrids**
 - Anttila, Ferris, King, Ayres and Strong (2000)
Molecular Ecology
- **F1 formation is rare due to temporal separation of flowering between the 2 species and probable genetic incompatibility**
- **Hybrids vigorously pollinate abundant *S. foliosa* ovules in native marshes**
- **Hybrids are driving the invasion in SF Bay**
- **The native species may become extinct**

Spread of hybrids





We predict it will take 30 years for all areas to be solid red

Accelerating rate of growth

- Greater-than-exponential increase
- Due to evolution of super-invasive hybrids:
 - Robust stature
 - Rapid lateral expansion
 - exceptional sexual reproduction



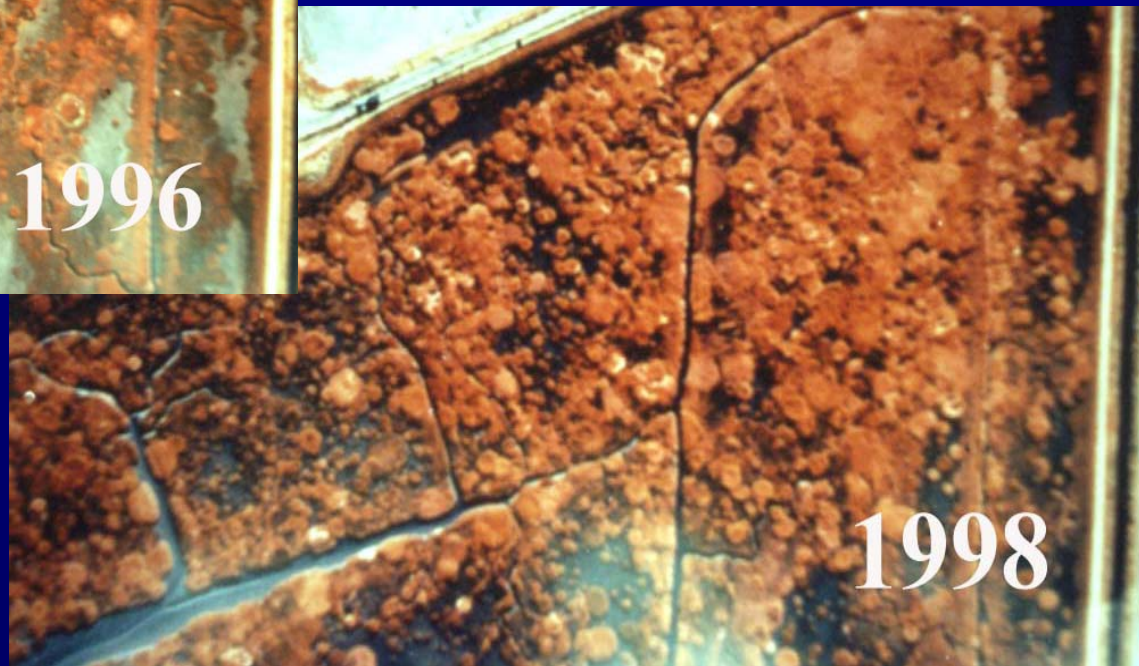
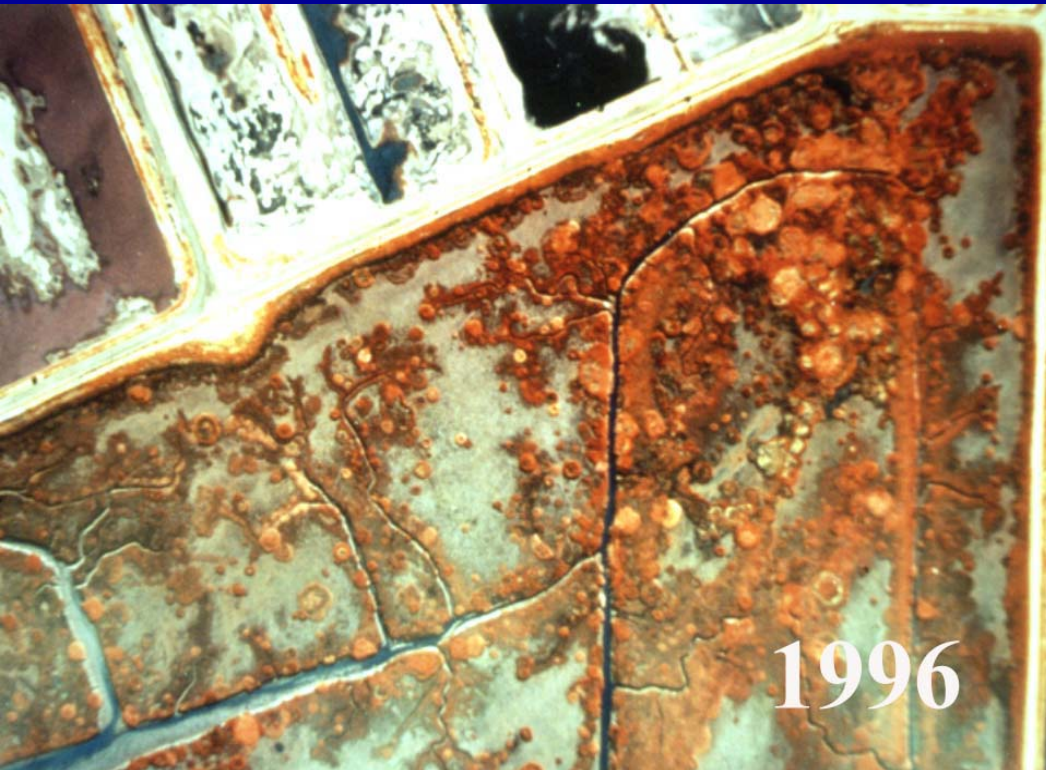
Uninvaded Marsh China Camp

Photo by D. Garcia-Rossi

Invaded Marsh San Bruno



Spread at Cogswell Marsh



Seed/Seedling Reproduction

- Hybrids were equal to, or greater than, *S. foliosa* in:
 - seed set
 - seed germination
 - seedling survivorship
 - seedling growth
- Isolated *S. alterniflora* set virtually no seed

Summary

| Taxa | Marsh elevation | Marsh habitat/species affected | Predicted impact |
|----------------------|------------------------|--|--------------------------|
| <i>S. anglica</i> | Low | <i>S. foliosa</i> | Low |
| <i>S. patens</i> | Mid-High | <i>Salicornia, Cordylanthus</i> | Moderate to high locally |
| <i>S. densiflora</i> | Mid-High | <i>Salicornia, Distichlis</i> zones | High, region-wide |
| Hybrids | Low-Mid-High? | Mudflat, <i>S. foliosa</i> , <i>Salicornia</i> | Very high, region-wide |

Conclusions

- **Hybrids most invasive *Spartina* taxon**
 - Spread 10s of km from introduction points
 - Greater-than-exponential growth
- **Hybrids most threatening to SF estuary ecosystem**
 - Ecosystem engineer
 - Threatens native with extinction