Breach it and they will come:
Protecting SBSP restoration marshes from invasive plants, the uninvited guests to the party

South Bay Salt Ponds
Brown Bay Series
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Coastal Conservancy

San Francisco Estuary Invasive Spartina Project
Preserving native wetlands

Cal-IPC

National Fish and Wildlife Foundation
NFWF

Presentation Map

Covers three non-native invasive plants that threaten various zones of our tidal marsh ecosystems in San Francisco Estuary and within the South Bay Salt Ponds Restoration Project.

The management efforts for these three noxious weeds are separate from one another.

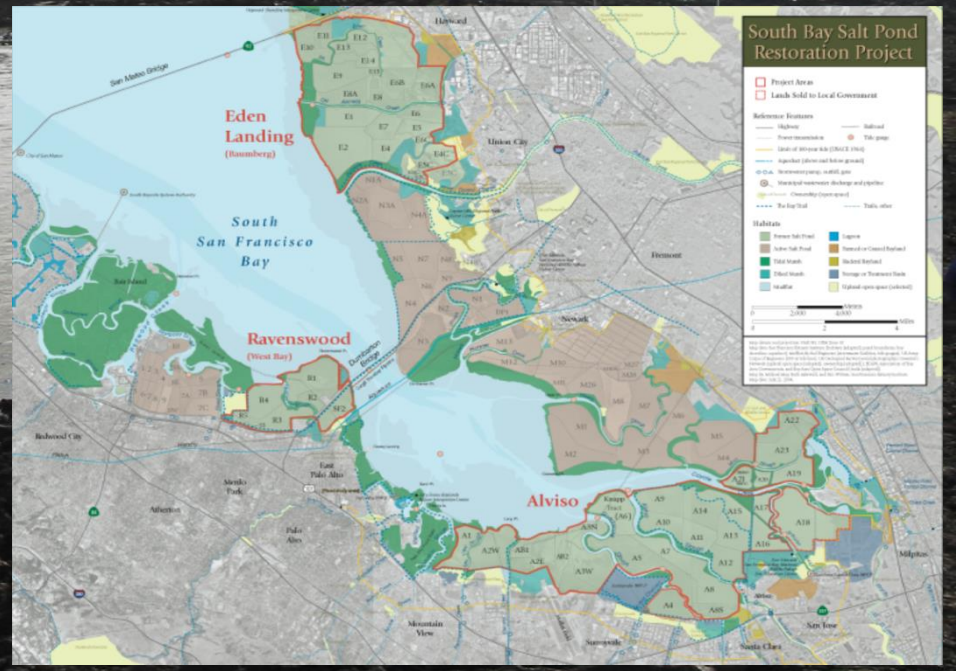
- Hybrid *Spartina* (*S. alterniflora* X *S. foliosa*) & the Coastal Conservancy's Invasive *Spartina* Project

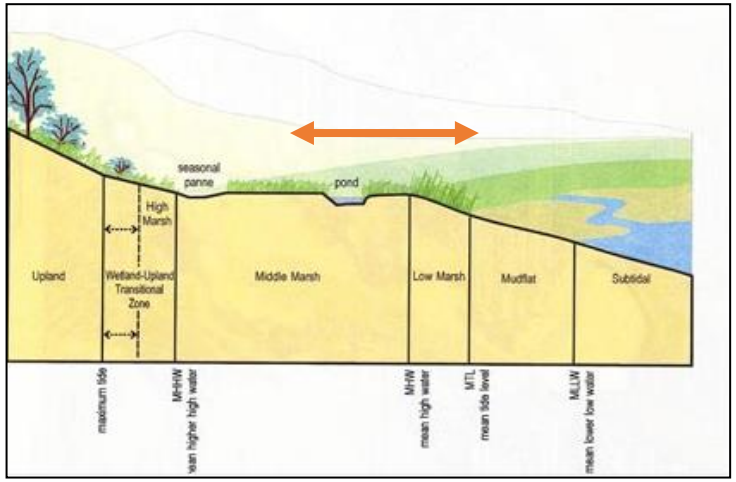
- Seashore paspalum (*Paspalum vaginatum*; PAVA)

- Invasive sea lavender (*Limonium* spp.)

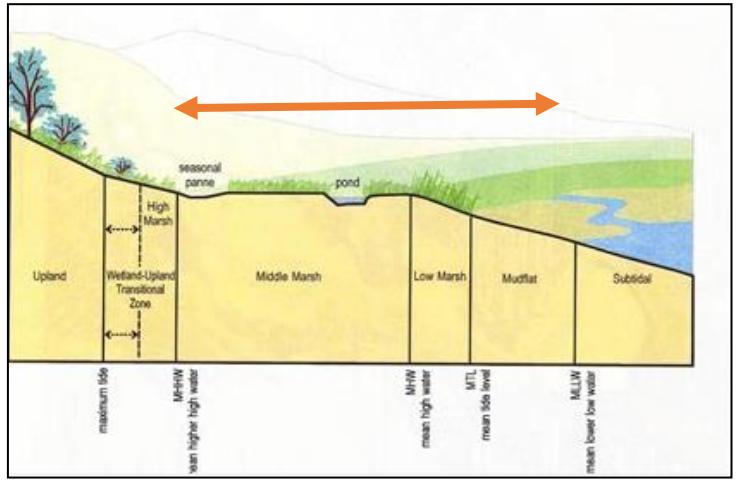
Mt Eden Creek Marsh breach 2008

Since 2006, 1000's of marsh acres added to ISP's annual monitoring & treatment work area





East Coast *Spartina alterniflora* introduced 1970's hybridized with native Pacific cordgrass, *S. foliosa*



UC Davis Strong Lab:
20 years of research into this hybridity
> 2 dozen published papers

Hybrid can pollen-swamp the native, forcing it to become a factory of hybrid seed production,
facilitating & accelerating spread

Spartina foliosa

Spartina alterniflora × *foliosa*

Native Pacific Cordgrass *Spartina foliosa*
Pond A20 by 2019 (breached 2006)

Why is hybrid *Spartina* a problem?

- Displaces native plants, degrading tidal marsh ecosystem
- **Dominates mudflats, impacting shorebird foraging**
- Alters benthic invertebrate community
- **Threatens native tidal marsh restoration**
- Endangers native Pacific cordgrass
- Reduces flood control capacity
- Creates mosquito breeding areas

Invasive *Spartina* Project began in 2000 as a partnership between USFWS & California Coastal Conservancy

U.S. FISH & WILDLIFE SERVICE

"Working with others to conserve, protect and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people."

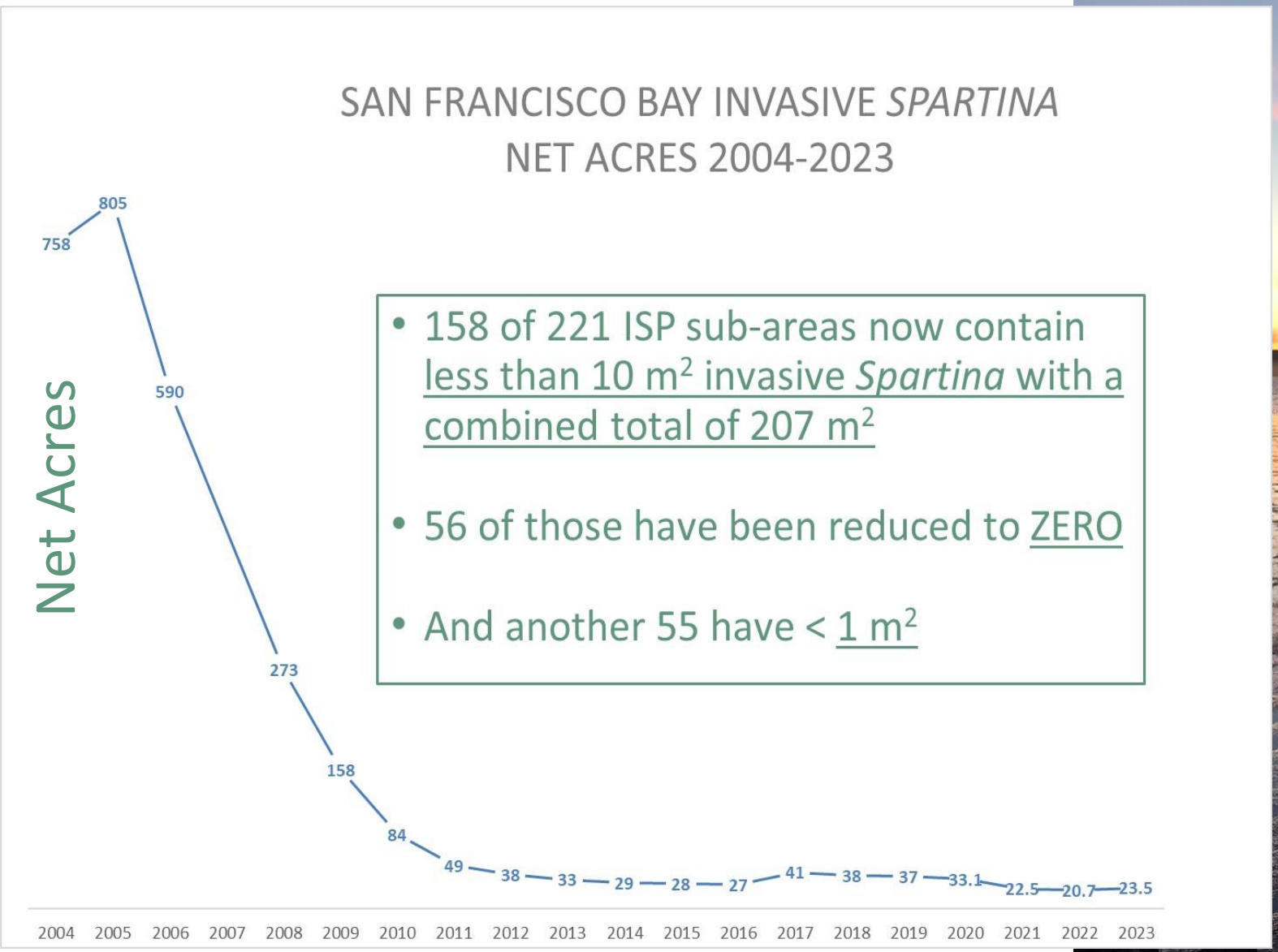
SAN FRANCISCO ESTUARY INVASIVE SPARTINA PROJECT

Preserving native wetlands

Coastal Conservancy

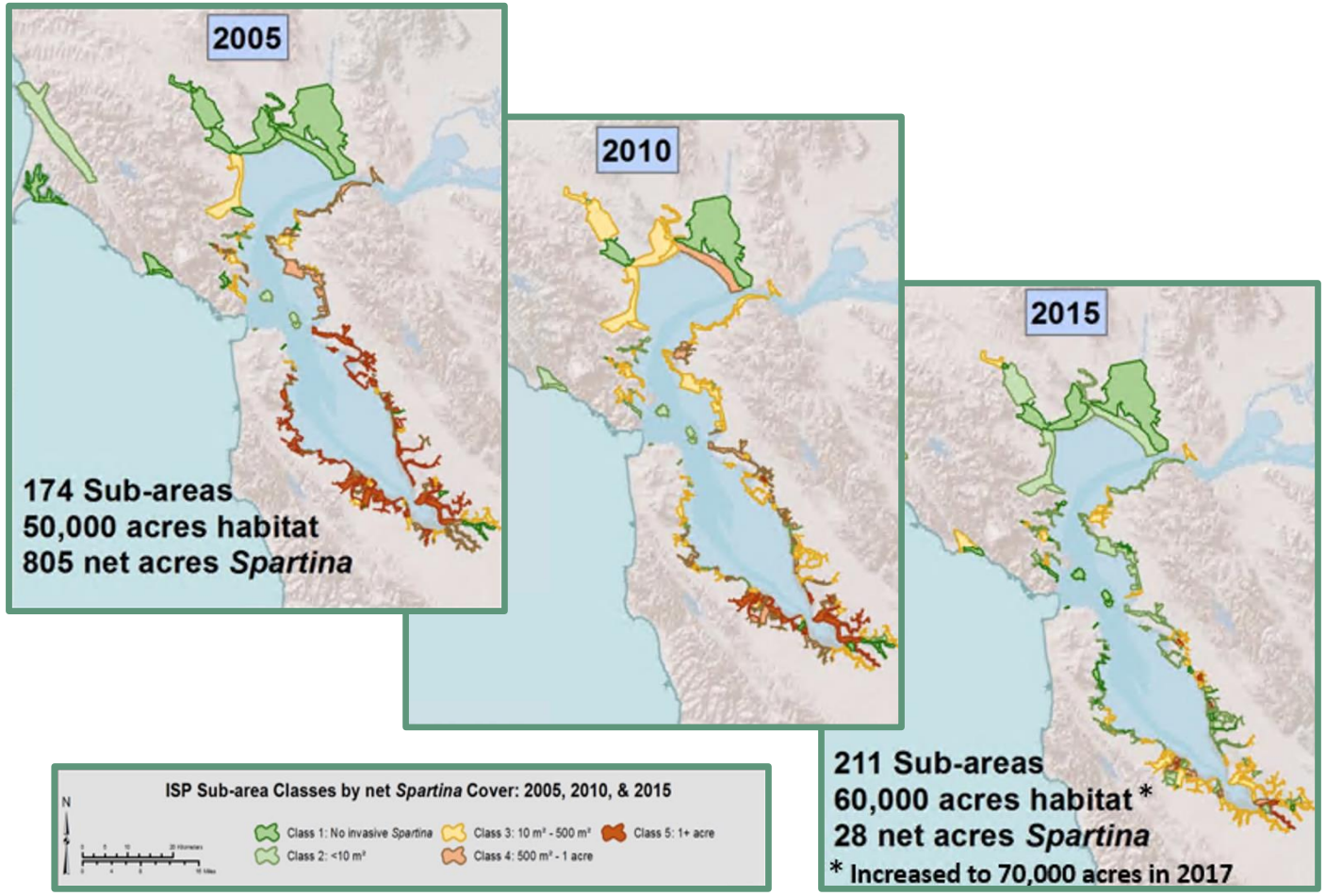
Established "to protect and improve natural lands and waterways, to help people get to and enjoy the outdoors, and to sustain local economies along **California's coast**."

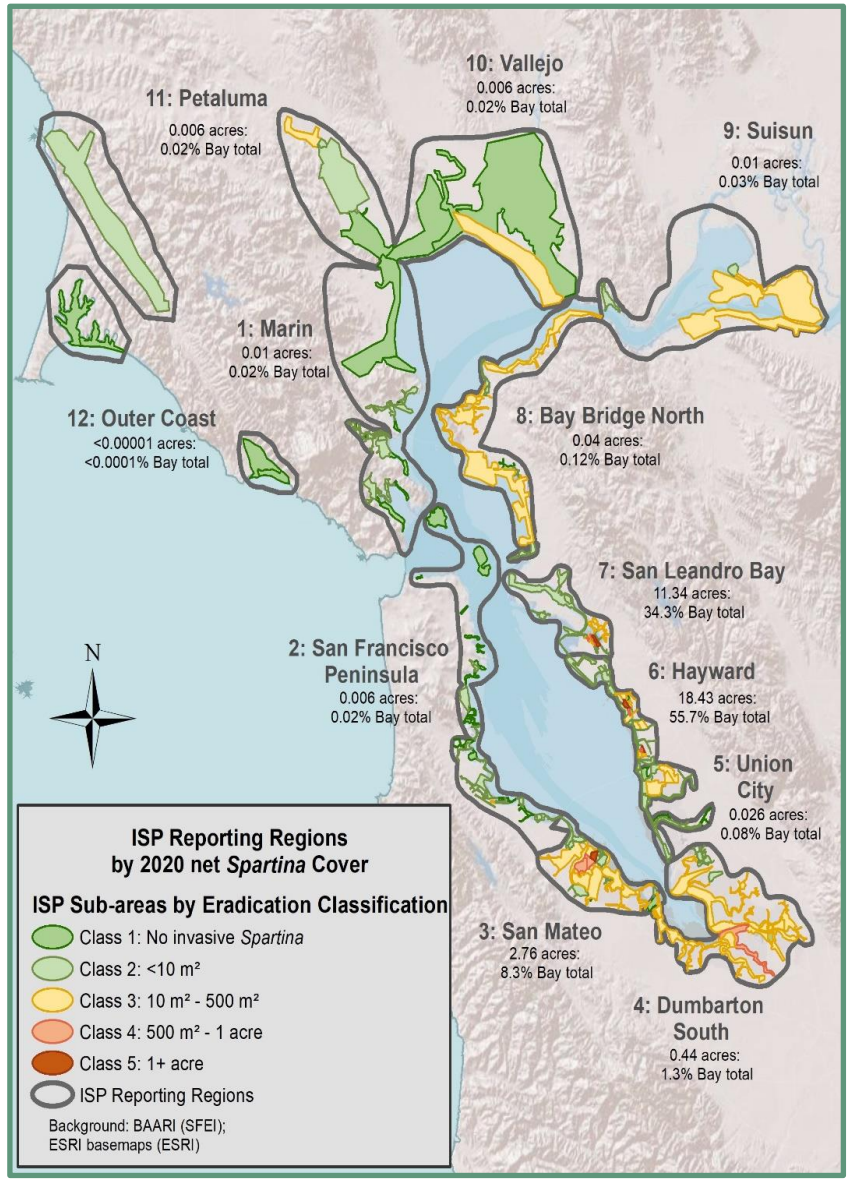
Hybrid Spartina reduced by 97% Estuary-wide



- 158 of 221 ISP sub-areas now contain less than 10 m^2 invasive *Spartina* with a combined total of 207 m^2
- 56 of those have been reduced to ZERO
- And another 55 have < 1 m^2

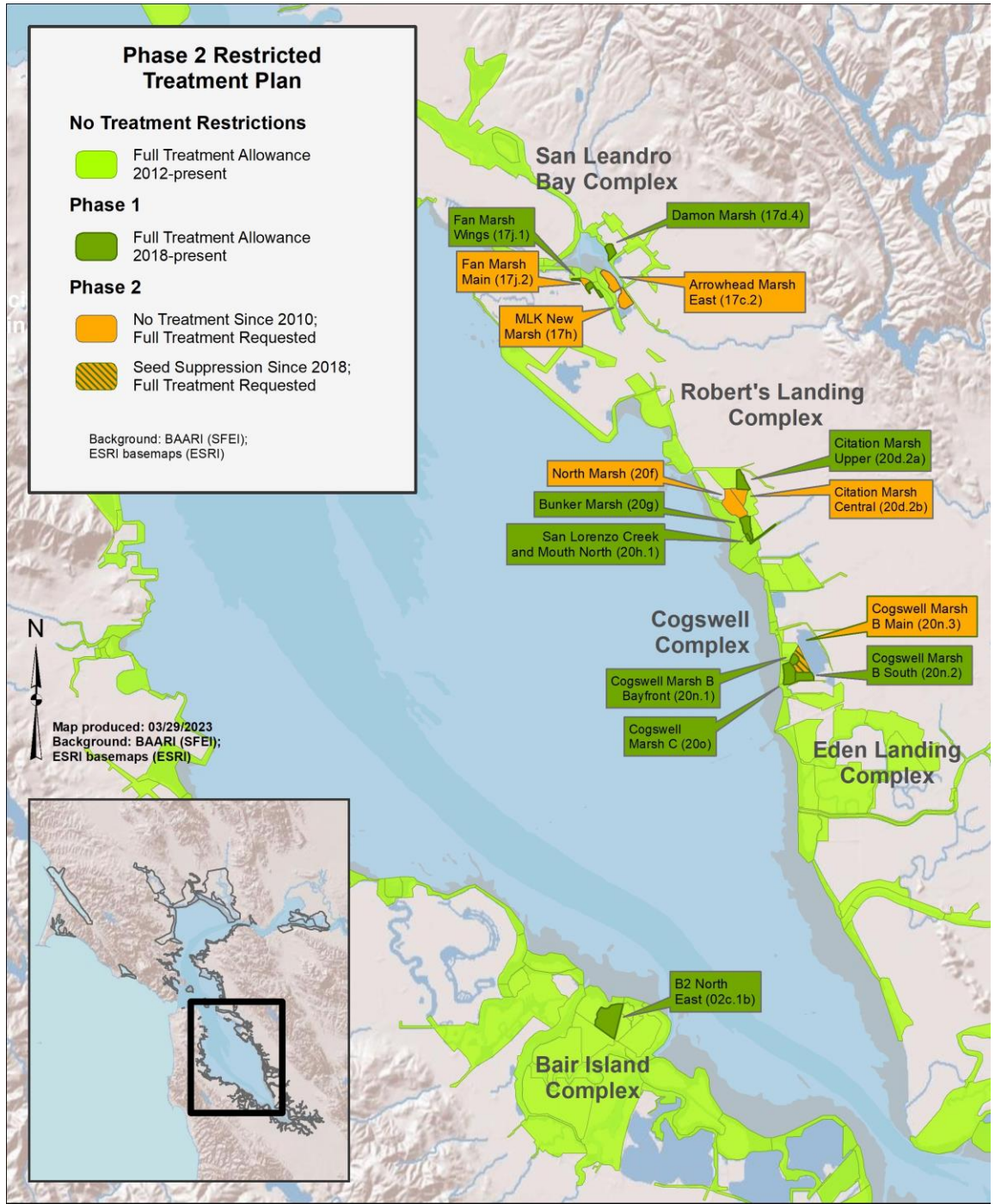
Invasive *Spartina* Cover Reduction 2005-2020





Phased Treatment to protect Ridgway's Rail in San Francisco Bay

- As predicted in ISP's EIR/S, removing hybrid *Spartina* monocultures in this urbanized system reduced the artificially dense cover for rails; more problematic in fragmented marshes & those with low biodiversity
- Treatment was restricted at subset of sites in 2011-2012 Biological Opinions to proceed with caution & not risk jeopardy for rails
- Unfortunately, in the absence of management, infestations sprang back to pre-treatment levels (or MUCH worse, up to 350% increases)
- Resumed treatment at 7 sites in 2018 Biological Opinion (Phase 1, dark green on map);
  By 2022, **7 of 10 sites already >94% reductions**
- Phasing in treatment initiation at final 6 sites 2023-2027 (Phase 2, orange on map);
  Resumed treatment of 3 marshes in 2023
  2024: found 93%, 85% & 73% reductions



Inventory Monitoring

OEI biologists survey
up to 40,000 of San Francisco Bay
marsh & shoreline
June – November each year to
inform invasive *Spartina* treatment

ISP does extensive genetic testing
each year (≅ 200-300 samples) to
help identify hybrids before
treatment and preserve native
Spartina foliosa

Can you spot the more robust, bright green
hybrid growing amongst the native *Spartina*?
She can!


Mapping Hybrid *Spartina*:
"Inventory Monitoring"
on Greco Island

Diversity of **native** cordgrass

Regional differences in size and other morphological characteristics of **native** *Spartina foliosa* can make hybrid ID challenging

Discerning hybrid from native often requires mature plants (later in growing season)

Definitive characteristics sometimes take several years to develop, during which time hybrids were hiding amongst the native and dispersing pollen/seed

Takes a diversity of people and partners!

ISP Treatment Program

- Narrow treatment timing window after Ridgway's rail breeding season for their protection
- Tough to fit in mapping & treatment of the entire Bay into such tight window before *Spartina* senesces
- Targeted spot treatment, minimizes impacts to habitat
- Airboat access is essential at new restoration marshes and complex DENWR sites

ISP Treatment Program

Majority of sites treated by backpack

Larger infestations are treated by hauling hose out from an airboat or truck

Approaching from mudflat reduces disturbance to wildlife associated with marshplain

Challenges: Drought vs. Rainfall – The "*Scirpus* Effect"

- The "*Scirpus* effect" – named after our native bulrush (*Bolboschoenus maritimus, previously Scirpus maritimus)* a brackish plant that cycles w/ rainfall & freshwater flushing. From complete absence ***aboveground*** to scores of acres that emerge from perennial root structures
- *Spartina* thrives in higher salinity but can also remain alive belowground but produce no/little aboveground biomass **for years**, especially during multi-year drought cycles.
- Higher rainfall stimulates emergence from these rhizomes, as well as short-lived seedbank, and can also allow cryptic hybrids to "perk up" & display recognizable morphological traits in rainy years
- Without aboveground biomass, no mapping or treatment is possible

ISP Restoration Program

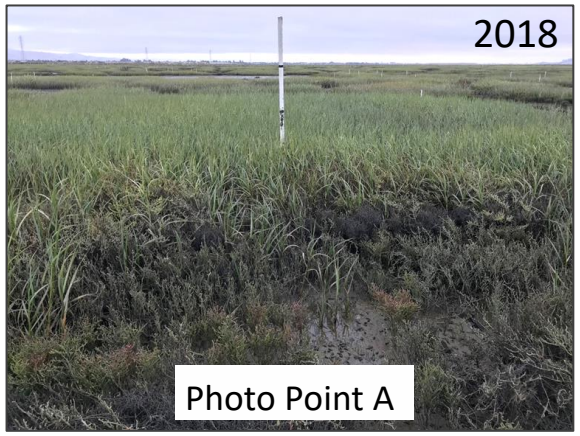
- 12 years: 2011-2023
- Focus on critical components of Ridgway's rail habitat: cover from predators for foraging, nesting, high tide refuge
- **Planted 600,000+ at 40+ sites**
- Re-establishing native *Spartina* where extirpated by hybrid swarm
- Planting marsh gumplant (*Grindelia stricta*) along tidal channels/etc.
- Constructed 72 high tide refuge islands at 16 sites

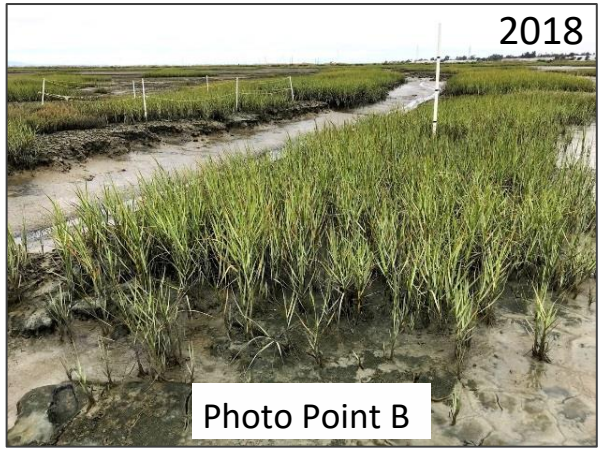
Eden Landing Ecological Reserve – North Creek Marsh
Early restoration of former salt pond: largely unvegetated 2011

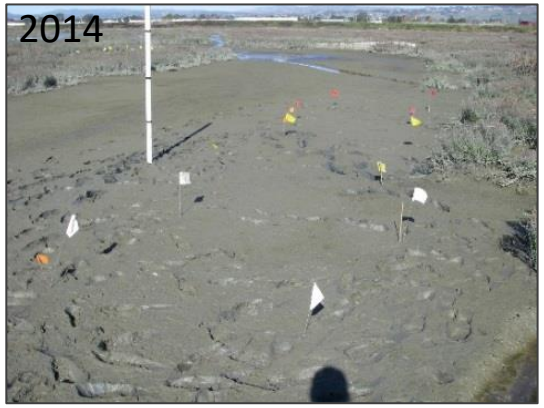
Eden Landing Ecological Reserve

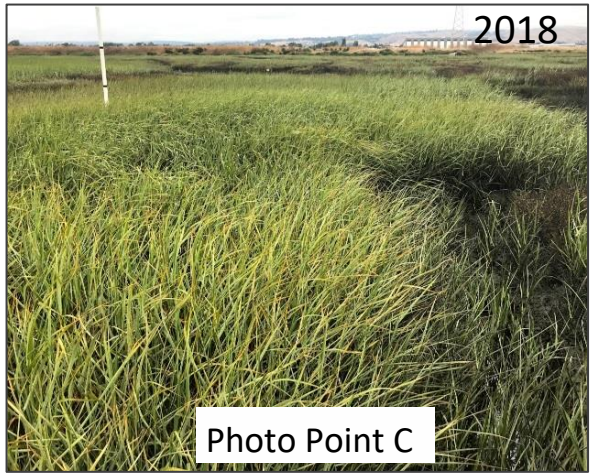
Active planting native *Spartina* in the absence of propagules

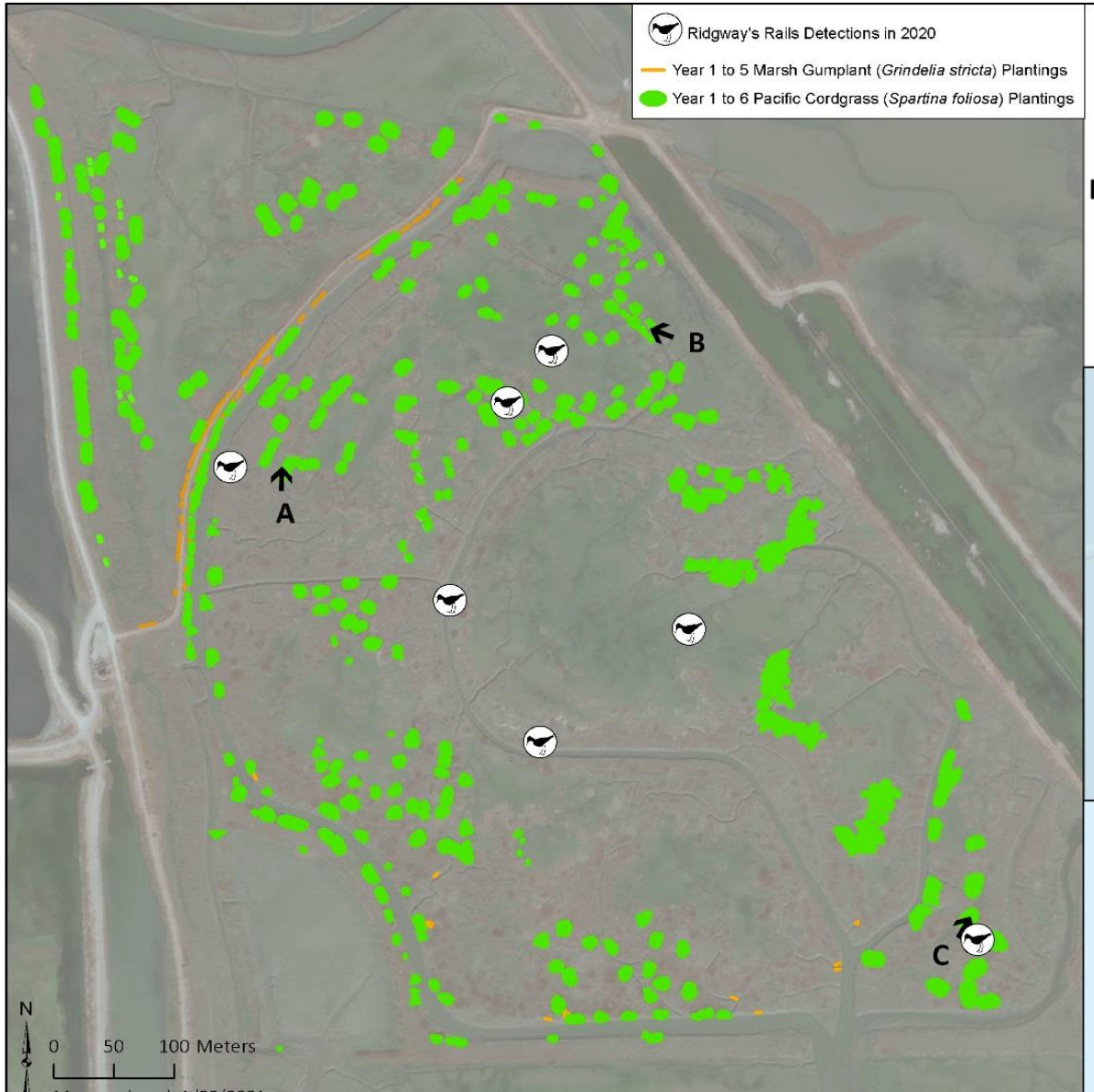
Adjacent to hybrid invasion epicenter











Successful rapid habitat enhancement at Eden Landing

Spartina foliosa plantings accelerated conversion of former salt pond into a marsh

13 Ridgway's Rail detected 2021 (first 1 in 2018)

North Creek Marsh 2019

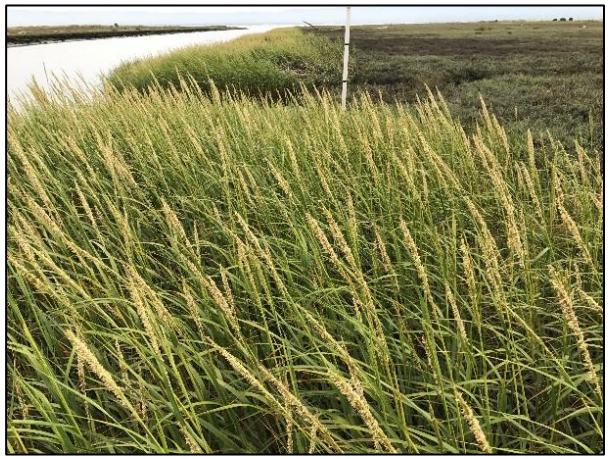
Alameda Flood Control Channel

Original *Spartina alterniflora* introduction site in 1970's

It is easy for folks to forget the scale of these monocultures (& threats posed) once the ISP partners had eliminated them.

SBSP sites are open mud & vulnerable in early stages JUST like this site was

Alameda Flood Control Channel in 2019



Most tidal restoration in San Francisco Bay relies on **passive** native vegetation

Ongoing stewardship monitoring for hybrid *Spartina* invasion so we can respond rapidly

Sites are most vulnerable to invasion at EARLY stages of development w/ less biotic resistance

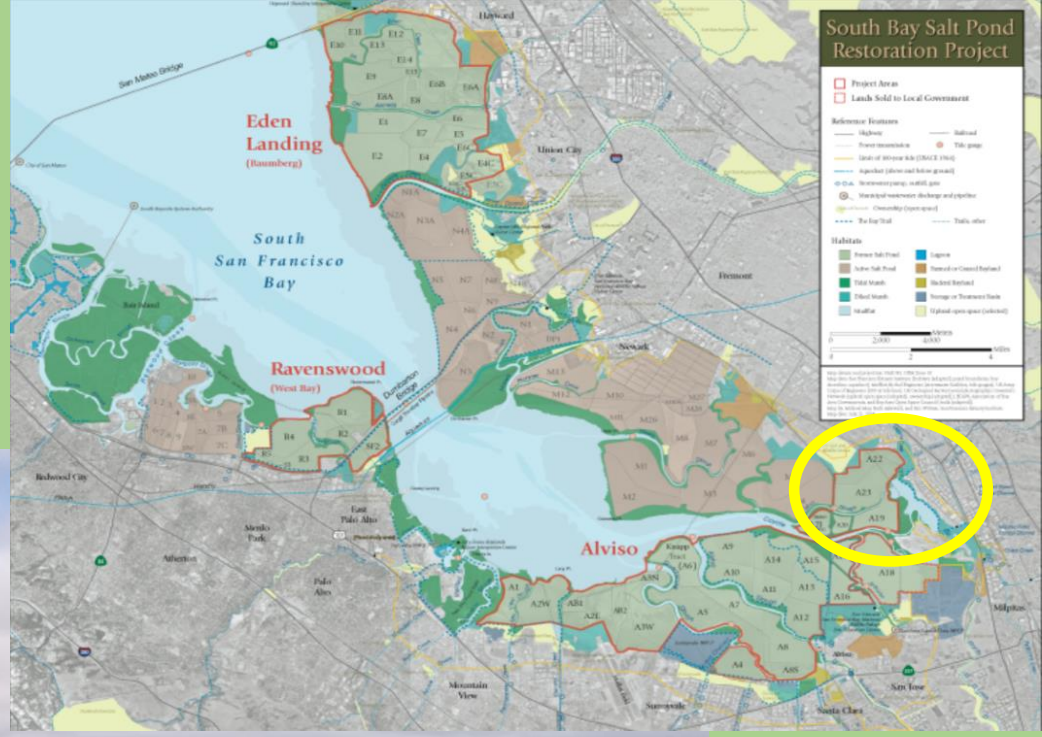
As these sites develop a thriving native plant community, the time burden to effectively monitor them for hybrid Spartina (& treat if necessary) increases exponentially

Chronology of a (relatively) Early Detection & Rapid Response for *Paspalum vaginatum* (PAVA) in San Francisco Estuary

- Drew saw it called out in the annual Weed Alerts at the 2020 Cal-IPC Symposium 
- Subsequent field confirmation of PAVA (Simon Gunner [OEI/ISP]) generated conversations with relevant landowners & managers
- South Bay Salt Pond Restoration Project stepped up with interim funding in 2021 (& 2022) to begin to delimit the scope of the problem and initiate management actions
- DENWR awarded an ED/RR grant from USFWS for 2023-2024 PAVA management and Cal-IPC team was selected as the contractor **(funding renewed for 2025-2026)**

Story illustrates importance of vigilance by knowledgeable biologists/stewards to protect marsh biodiversity

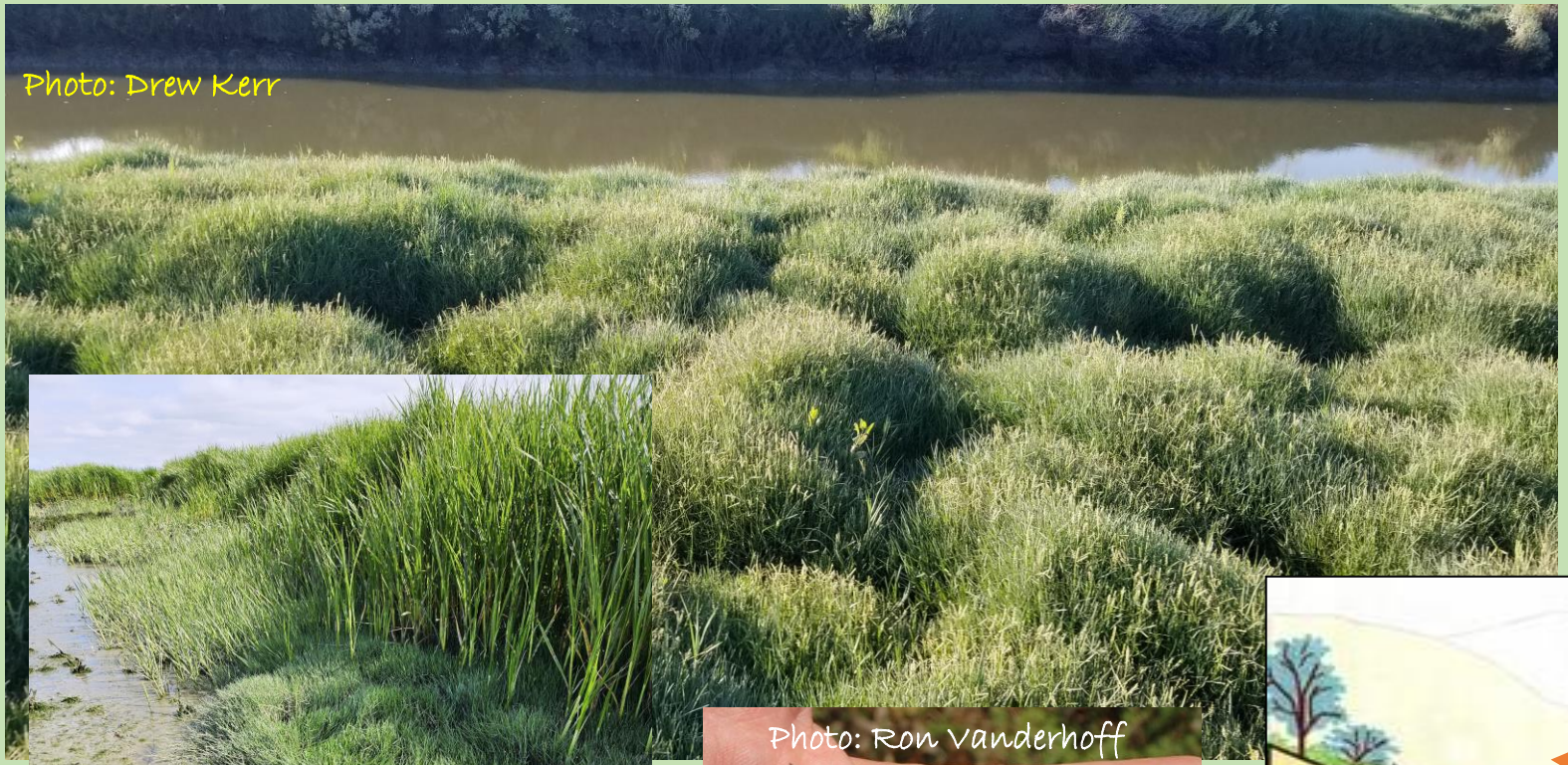
Impetus for Action in San Francisco Bay

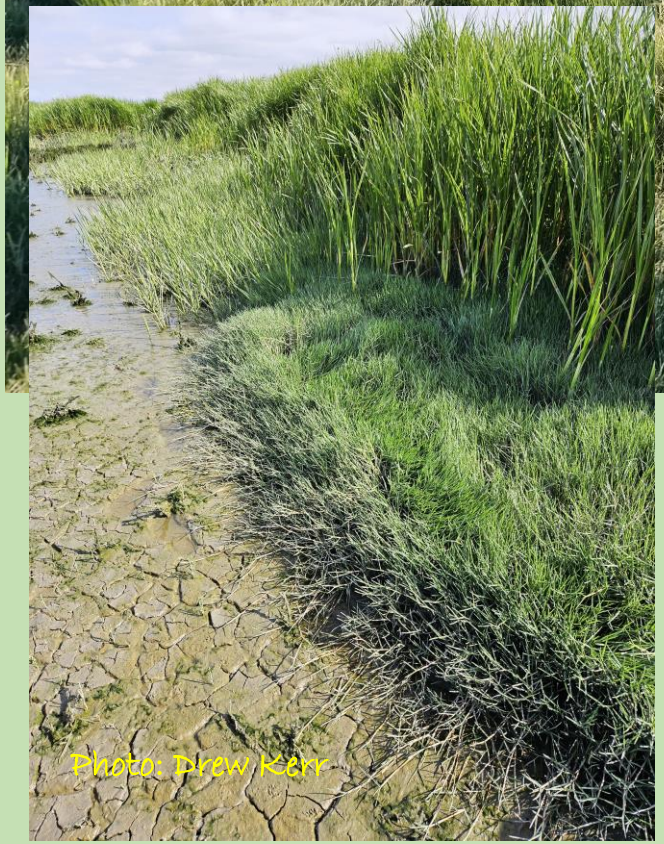


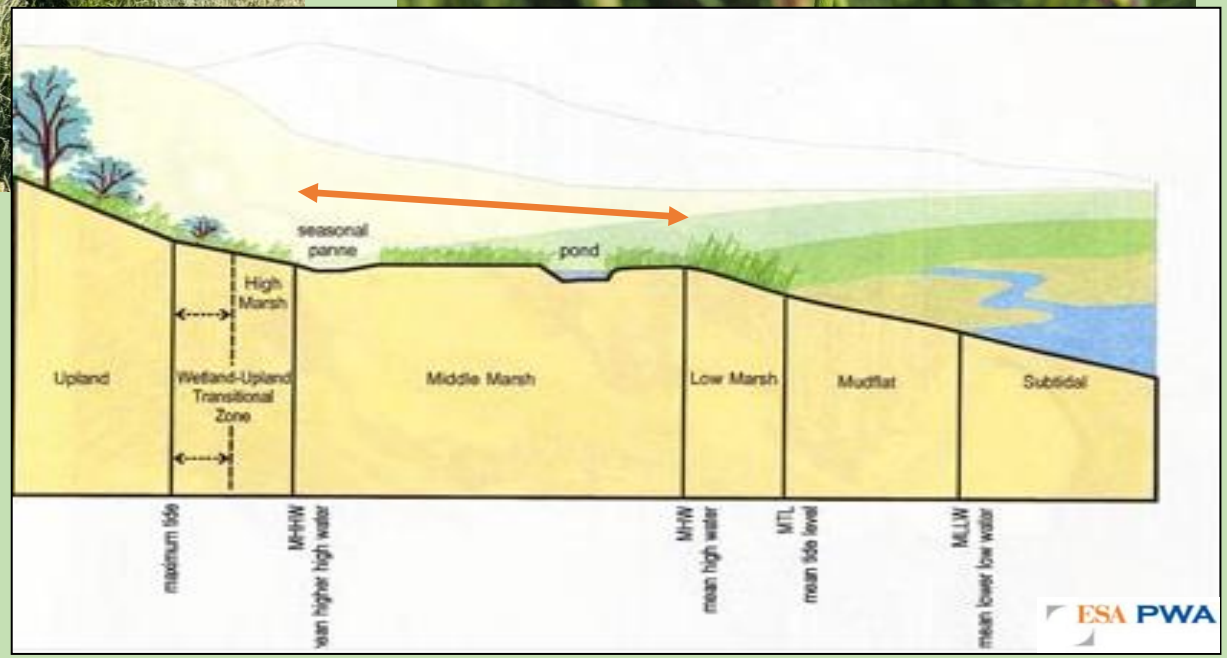
- Planned 2021 breach from Mud Slough into Island Pond A19 (shown July 2022)
- Intended to speed sediment accretion and marsh development at this restoration

- PAVA presence in Mud Slough (green arrow above) generated the impetus for funding an initial management effort to reduce dispersal to A19
- South Bay Salt Pond Restoration Project interim funding

Invasive *Paspalum vaginatum*







Invasive *Paspalum vaginatum*/PAVA Literature

- Riefner & Columbus reporting for the 1st time for California in 2008 referred to PAVA as "now widespread & highly invasive in estuarine wetlands in southern California" from Journal of the Botanical Research Institute of Texas
- "Likely unrecognized in the field for decades…" in SoCal

- Shaw & Allen (2003) confirm what is already evident in the San Francisco Estuary
- "[PAVA is]…an early and effective colonizer of disturbed, bare or ephemeral soil deposits and once established it can exclude indigenous species recruitment for many years"

- **Rarely produces viable seed in significant quantities**; PAVA must propagate vegetatively (Hall 1994, Duncan & Carrow 1999)

- Dispersed primarily by water; fragments of stolon or rhizome can be carried long distances **and root easily**, forming new infestations (Weber 2003)

Invasive *Paspalum vaginatum* Fun/Disturbing Facts

- Sold commercially by the turf industry, as early as 1970's & 80's in SoCal
- Similar appearance to Bermuda grass (which is relegated to above MHHW)
- One common name is "marsh couch" ***Comfy!!***
- Used as bedding in trade ships sailing b/w Africa and New World in 1700's

- Can survive being waterlogged or submerged for several days at a time
- So salt-tolerant that can even be irrigated with saltwater!!
- As worldwide water shortages worsen, a turf grass that can be irrigated w/ saltwater IS an amazing advancement, **just not for our native tidal marsh plants and the wildlife they support!!**

- Been shown to survive pollution with crude oil!!
- USDA NRCS stated "No environmental concerns"; illustrates a common problem with new introductions, especially to novel habitats

Invasive *Paspalum vaginatum* at Coyote Lagoon

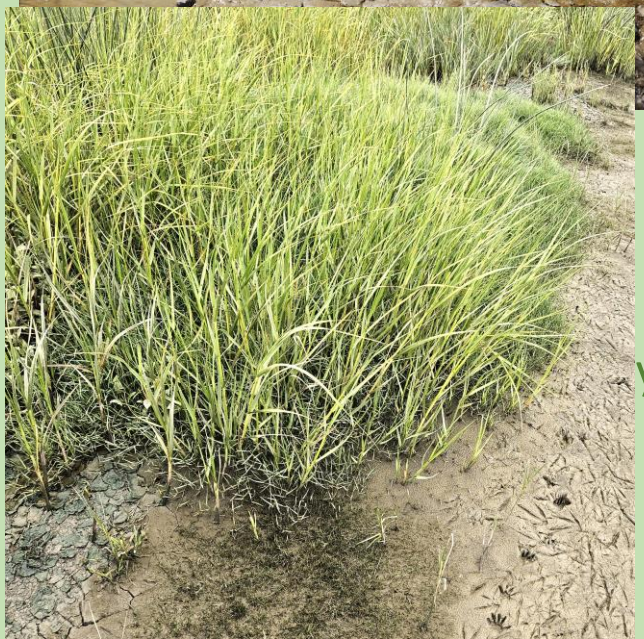
Expands by stolons (aboveground runners)
Engulfing & entwining the adjacent native mid-marsh vegetation such as these *Grindelia* (left), and bulrush (below)

Thick mats will likely inhibit native regeneration

Invasive *Paspalum vaginatum*

Northern interior of A20 (Mud Slough just beyond the levee). OEI biologists demonstrating that the invasive PAVA is penetrating back into the thick bulrush stand via stolons.

PAVA colonizing bare mud bench below the marsh scarp along upper Coyote Creek



PAVA crawling through base of young bulrush stand that it is likely to displace once fully established

Invasive *Paspalum:* southeastern corner of Estuary

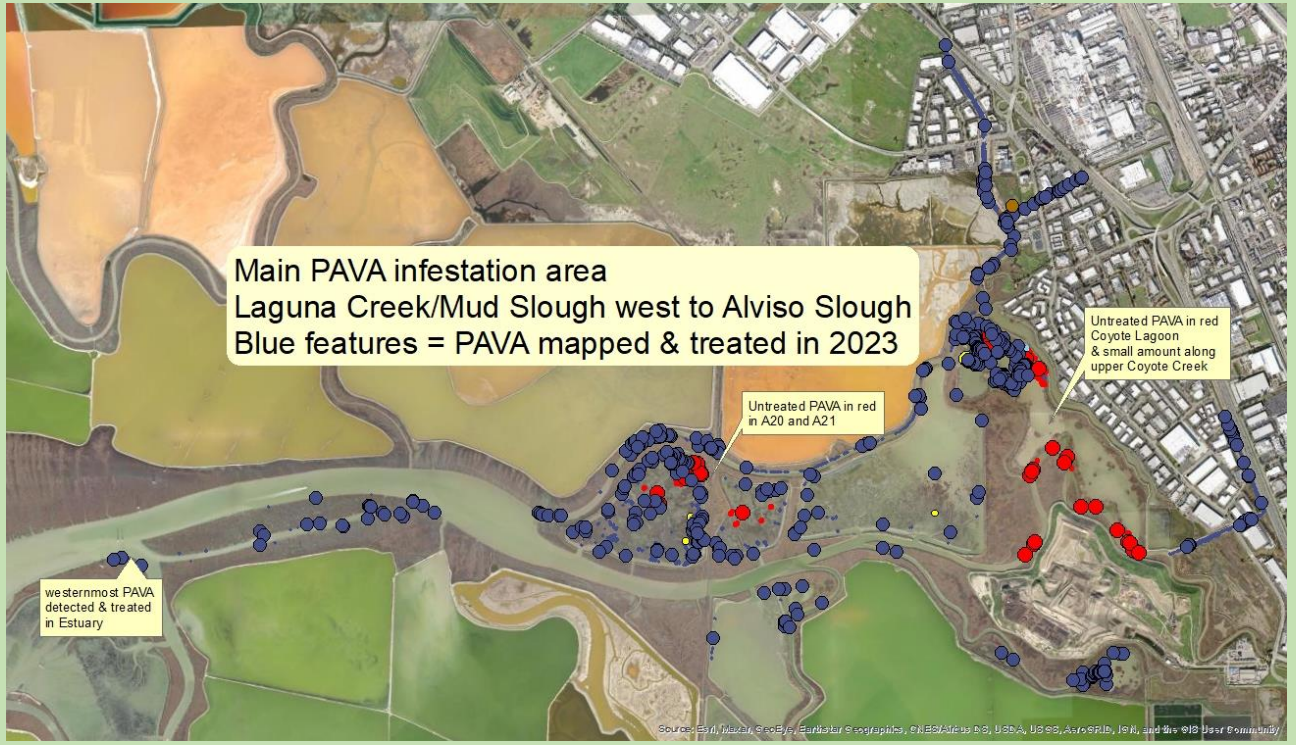
Total peak *Paspalum* infestation, summing the data from initial mapping events at all known sites over the three-year discovery/delimiting period from 2021, 2022 & 2023 =

Approximately 40,000 m²
(10 acre) baseline infestation

Epicenter appears to be flood control channels above Coyote Creek Lagoon

2nd major infestation in A21; seems to be independent introduction based on amounts in surrounding area

Upstream Alviso Slough may be 3rd introduction (based on minimal overall size, and complete absence of PAVA for 2 miles upstream of mouth)



Invasive *Paspalum* Sites & Management

In 2023 a total of 20,736 m^2 PAVA was mapped across all sites in the southeastern Estuary, with 93% treated that year under the USFWS grant & Santa Clara CAC.

This represents reduction from the peak PAVA treatment cover of ~ 50%, as the discovery phase added sites 2021-2023 but reductions were also realized from the initial two years of treatment.

With the grant funding limited and a BIG task to accomplish, 2023 mapping was used to guide crews in 2024 treatment as well (no updated #'s)

All previously identified infestation footprints & areas were revisited for the 2024 treatment season, and any new patches/stands added as well

PAVA Sites	PAVA treatment cover (m^2)
Coyote Creek Lagoon north	3572
Coyote Creek Lagoon south	150
Coyote Creek & tributaries	81
Tributary Marsh	1236
Mud Slough - upstream Amtrak Bridge	606
Mud Slough - downstream Amtrak Bridge	344
A17	83
Island Pond A19	330
Island Pond A20	988
Island Pond A21	5837
Ogilvie & Coyote Creek Mainland	348
Alviso Slough	210
Alviso Slough mouth (periphery of Knapp Tract)	25
Laugna Creek	5471
Agua Caliente	401
Zone 6 Line B (southern ACFCD channels)	1054
Total 2023 PAVA	20,736

Imazapyr treatment from airboat & backpack

Invasive PAVA

Example of the “Scirpus/rainfall effect” mentioned previously.
Apparently, higher rainfall stimulated the emergence from established perennial roots

*NOTE: literature says PAVA **doesn’t produce much viable seed***

Above: *2023* at Coyote Creek Lagoon, an area of lighter infestation, primarily on channel edges. Note the extensive open mud, lightly vegetated by pickleweed

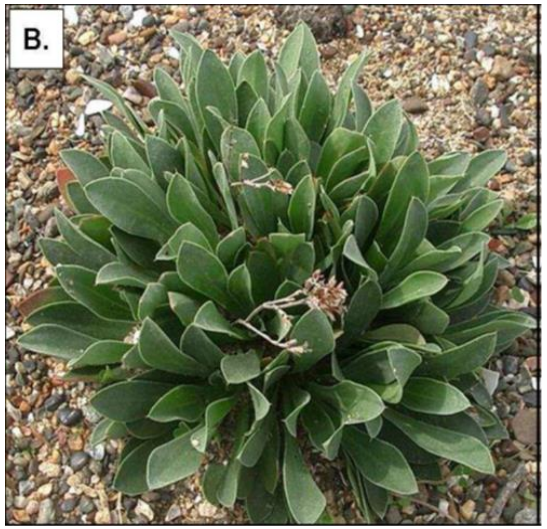
Right: *2024* in same area of Coyote Creek Lagoon. Note the abundant, established PAVA on what was open mud in 2023. Not just nascent new colonizer patches but extensive stands that had no aboveground biomass showing the prior year.

Invasive PAVA

Establishing in A19 on open mud at mid-elevation
1st colonizer can OWN the space & inhibit native plants
As native plant establishment becomes denser & more widespread, there are many nooks & crannies for nascent PAVA to “hide” from detection & management

Many PAVA patches were found on the open mudplain after 2023-2024 rains; not previously detected but not “brand new” spread

Limonium ramosissimum (LIRA; Algerian sea lavender) in the San Francisco Estuary



From Archbald & Boyer 2014

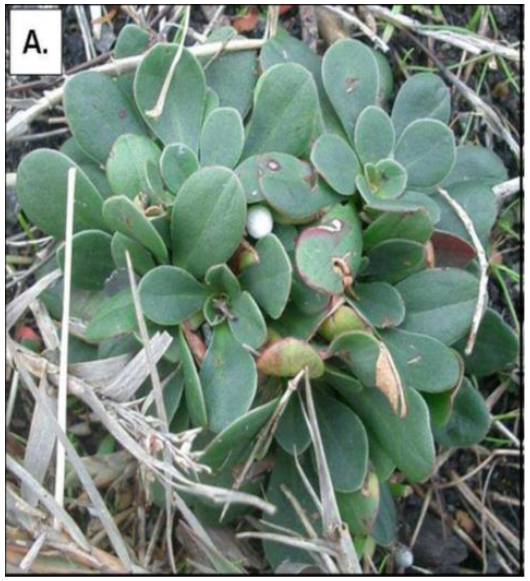
- First discovered in the San Francisco Estuary in 2006-2007 (Sanchez Marsh in San Mateo County, just south of SFO)
- LIRA grows most vigorously (and produces the most seed) in the high marsh and the estuarine-terrestrial transition zone
- Vast majority found above Mean High Water (MHW), although LIRA has thrived at marshplain and along channel banks when established at intact marshes
- Can grow as a dense substratum ***beneath*** native marsh veg, eventually displacing it, especially at regeneration cycles

Limonium ramosissimum (LIRA; Algerian sea lavender)

Photos from Ron Vanderhoff

LIRA acute (pointed) leaf tips; while *LIDU has rounded*

Limonium duriusculum (LIDU; European sea lavender) in the San Francisco Estuary



From Archbald & Boyer 2014

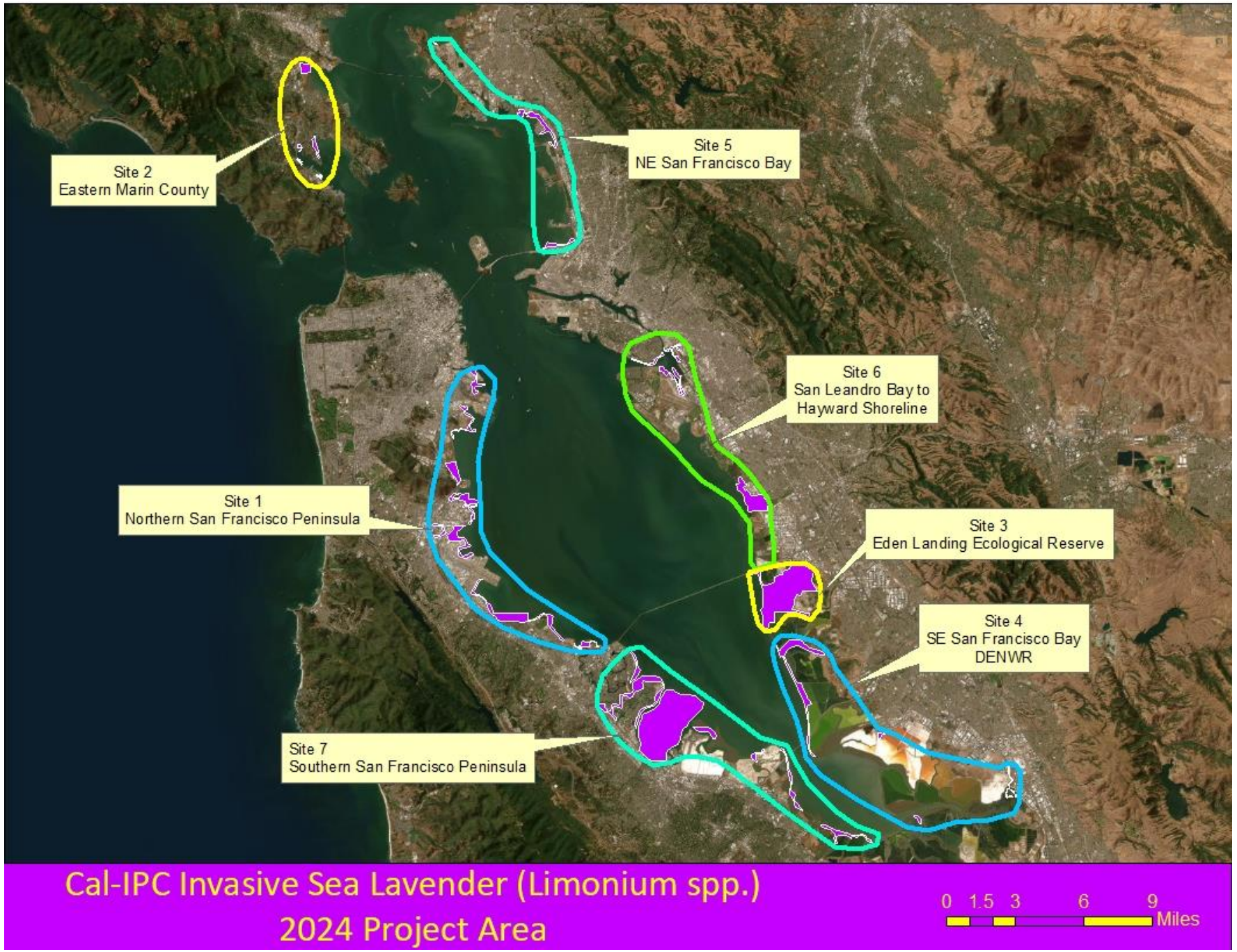
More rounded leaf tips compared to LIRA. And more compact, almost succulent

- First documented in the San Francisco Estuary in 2006-2007 (Richardson Bay in Marin County)
- Cal-IPC recently discovered established infestation on Bair Island (Deepwater Slough) likely an independent introduction
- Not likely to have been natural dispersal since LIDU is not previously known outside Marin area
- More widespread in SoCal where it is the bigger problem of the two invasive *Limoniums*; able to grow lower in tidal elevation into *Spartina* zone

Invasive *Limonium ramosissimum* (left)

& native *Limonium californicum* (right)

both plants shown are bolting (generally throughout May)



Cal-IPC received 1st National Fish & Wildlife Foundation (NFWF) grant in 2015 for pilot (then 2017, 2020 & 2022)

CDFA Noxious Weed funding through 3-5 Counties

Sites were mapped over time as our modest budget would allow (& incorporated into regular treatment as funding would allow)

Peak infestation baseline ~ 25 net acres

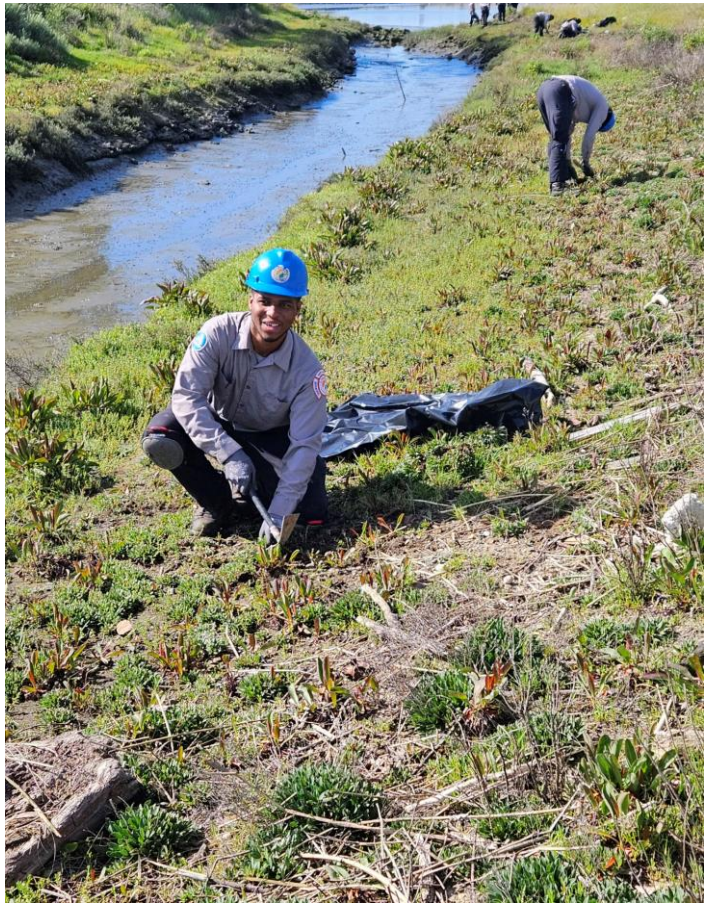
Most of the Top 10 largest sites have been reduced 70-85%+ since 2016-2018

Data-Driven Prioritization of Targets

- SFSU research (Boyer lab) was critical in the **decision to take action; i**mpacts to native marsh & vigorous spread were well documented
- USFWS had identified LIRA as one of three "Highest Concern" plant species in the South San Francisco Bay Weed Management Plan

- **Carpets of short rosettes of LIRA/LIDU cannot provide our native wildlife vertical plant structure comparable to natives for refugia from predators (esp. at high tides when** California Ridgway's rail and salt marsh harvest mouse **are most vulnerable)**
- **Manual removal** very effective at an appropriate scale; local stewards (including volunteers) can deal with nascent infestations
- Can be used for long-term management once large infestations are reduced to a manageable level
  One example: Literacy for Environmental Justice (LEJ) at Heron's Head Park with Port of SF
- **Volunteer appreciation:** Martin Cooper (STB), Melissa Grush (Hayward Shoreline and Roberts Landing), Friends of Five Creeks, Marin Audubon (Jude Stalker lead), GGBA, Greens @ Work, & others

Civicorps crew manually removing invasive *Limonium ramosissimum* MLK Shoreline in Oakland



- Manual removal very effective on LIRA at accessible sites
- New outliers, or where infestations have been reduced by contractor/agency management over several seasons

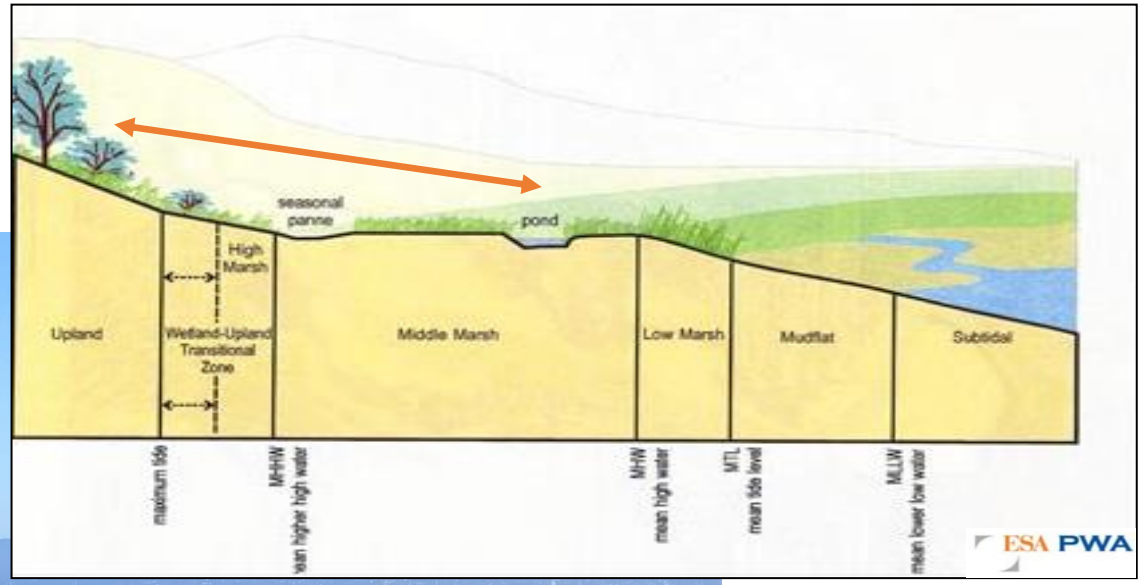
Shoreline infestation of invasive *Limonium* in San Francisco Estuary

Colonizes areas of disturbance like wave-swept shorelines or along slough banks

Then dominates and excludes future native plant regeneration OWNS THE SPACE

Expands along channel banks in years when *Grindelia* cycles

Invasive *Limonium ramosissimum*

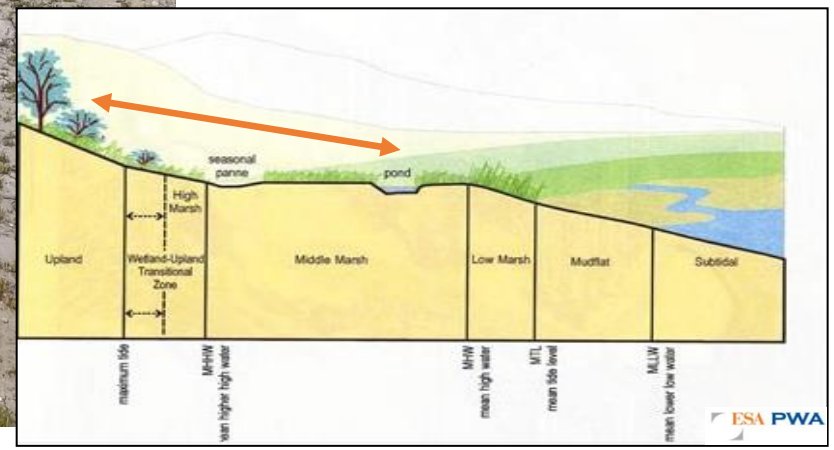


Invasive *Limonium* & SBSP

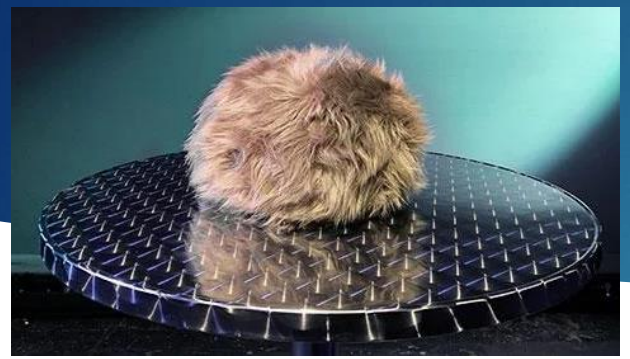
LIRA thrives on these edges around the Estuary, above MHHW

SBSP has MANY MILES of these edges that can harbor LIRA

Act as loci of dispersal to existing marshes and can inhibit future high marsh vegetation at developing SBSP sites



The Trouble with Tribbles/LIRA



With high seed production & viability, relatively long seedbank life, and virtually 12-month growing season, LIRA can feel like the Tribbles from Star Trek

The carpets of tiny red leaves in the photo (left) are 1000's MORE seedlings

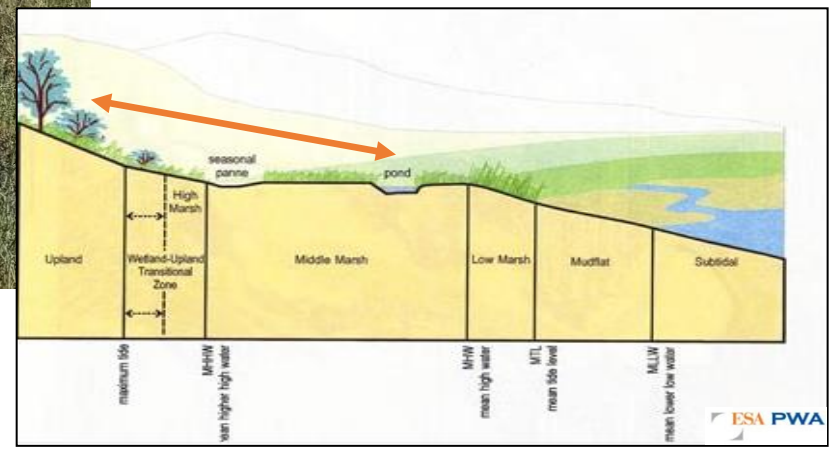
130,000 seeds/m^2
(Archbald & Boyer 2014)

Invasive *Limonium ramosissimum* at Knapp Tract (A6)

LIRA thrives at the elevation of these eroded old berms & decommissioned levee roads around the Estuary, which mimic high marsh and estuarine-terrestrial ecotone

Displaces *Grindelia stricta* (marsh gumplant), *Frankenia salina* & others

Corrupted UTZ seed mix (~2014) dispersed it to remote parts of Estuary



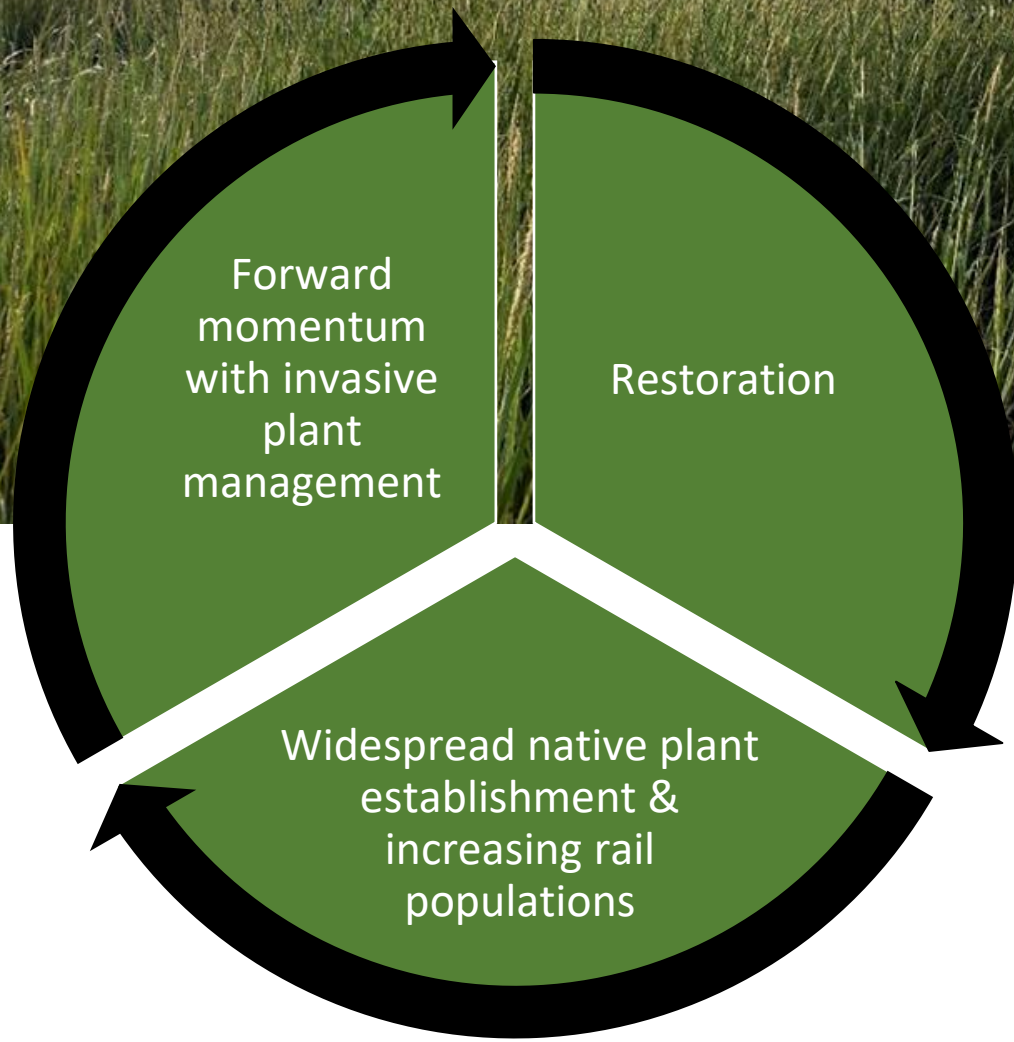
Other tidal marsh invasives in the Estuary: *Puccinellia maritima* – seaside alkali grass

Puccinellia (above) smothering native gumplant & dominating every inch of both channel banks, excluding all native vegetation & regeneration of the gumplant

Puccinellia (below) already forming a solid monoculture of the bunchgrass over many acres at Deepwater Slough (Bair Island Ecological Reserve). Widely established at other Bair sites, as well as Ideal Marsh (DENWR), Sanchez Marsh, Seal Slough, and others

www.spartina.org

www.cal-ipc.org/project/sea-lavender-sf-bay/



Goal of allowing healthy, resilient NATIVE marshes to mature & fourish

Ongoing stewardship is essential

to maintain the health of our marshes & guard against future threats

Prevention is key!!