# Native vs. Non-native *Phragmites australis*: Genetic and morphometric traits clarify identity of populations in the Sacramento-San Joaquin Delta - Suisun Marsh - Carquinez Strait






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**CAL-IPC 10/21/2026**

**ACCURATE TAXONOMIC INDENTIFICATION OF WEED SPECIES IS THE *ESSENTIAL* FIRST STEP IN DEVELOPING PRECISE and EFFECTIVE WEED and RESTORATION MANAGEMENT STRATEGIES**

# *Phragmites australis (Cav.) Trin.* ex *Steudel* (Poaceae; "Common Reed")

***Phragmites australis* is considered one of the most widespread plant species on the planet (Barkworth et al FNA 2003)**
**Native and non-native lineages identified as subspecies occur in a wide range of wetland habitats**

*P. australis* invasions had been intensively studied elsewhere in the US,
but ***distribution of the lineages in northern California had been uncertain***.
**Experts cautioned:** Taxonomic keys developed regionally in the U.S. do not universally apply.

**"The characteristics** (reported here) **should NOT be used to distinguish populations in** areas (Gulf of Mexico, AZ, NV, **California)** where the Gulf Coast type may be present as it is very similar to the introduced (Eurasian) lineage" (Swearingen & Saltonstall 2010)."

## OBJECTIVES

**1.** Assess genetic identity and morphological plant traits and of *P. australis* in San Francisco Bay-Delta Estuary

(Study focus: Delta – Suisun – Carquinez Strait – North Bay)

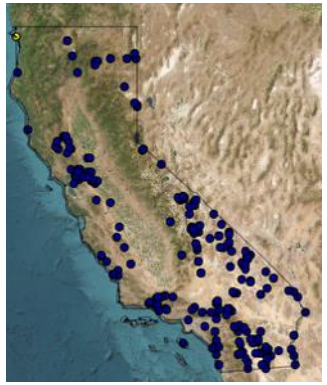
**2.** Evaluate diagnostic approaches for field identification by managers.

**3.** Apply results to clarify distribution of native vs. non-native taxa across the estuarine study area.

# BACKGROUND

**Jepson eFlora Map**
Native vs. Non-native "*Phragmites australis*" subspecies not differentiated **(confirmed Common Reed specimens)**

**Common Reed**





**Other REED GRASSES <u>often</u> misidentified as *Phragmites australis* *(including "research grade" IDs in online databases):***

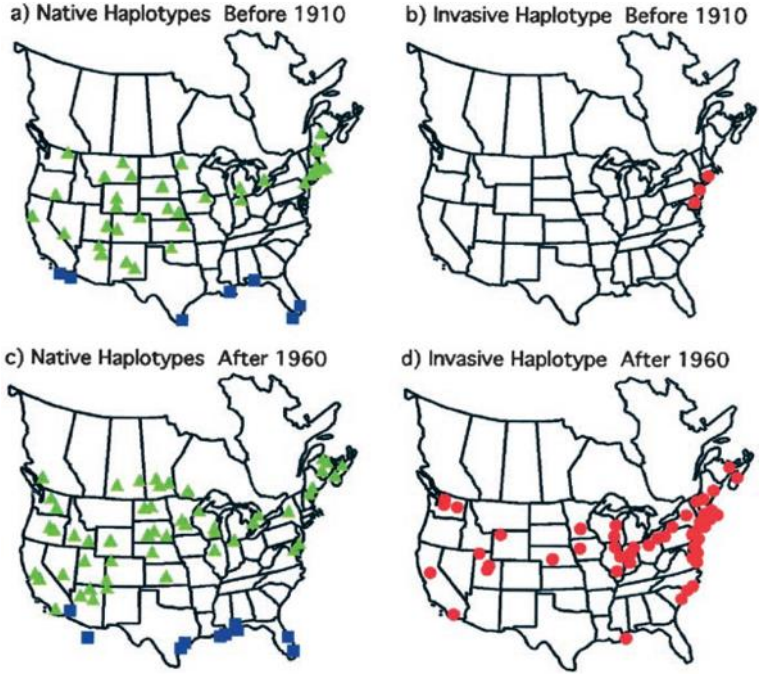


***Arundo donax***
**Giant Reed**



***Phalaris arundinacea***
**Reed Canary Grass**

## HISTORIC DISTRIBUTION OF *PHRAGMITES* HAPLOTYPES

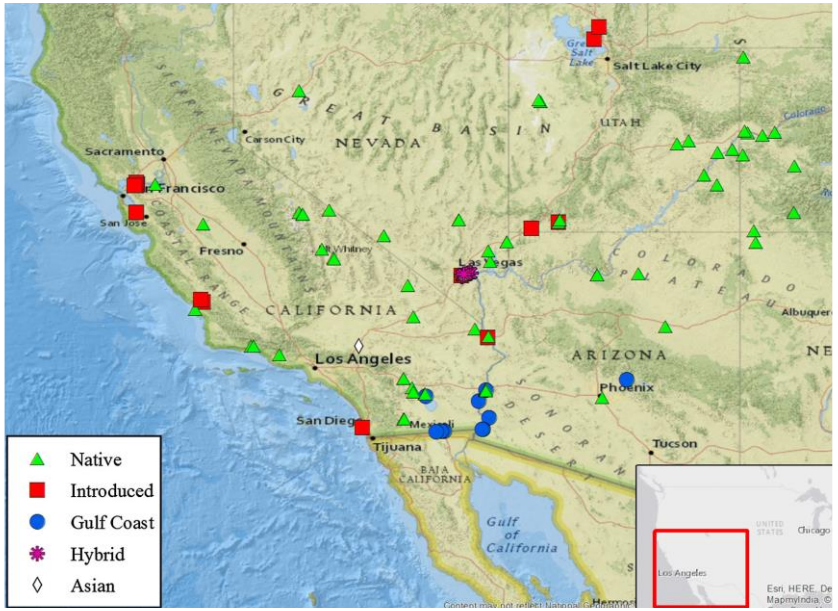



**Before 1910**

**After 1960**

**Green** : NATIVE HAPLOTYPES
**Blue: "GULF COAST" Haplotype**

**Red** : **EURASIAN haplotype**
(Saltonstall 2002 PNAS)




**Native haplotypes of *P. australis* (green symbols) are common in western states**; do not occur south of Carolinas on the east coast, or along the Gulf Coast.
(Lambert et al. 2016, Meyerson et al. 2012)

***Meyerson, Lambert & Saltonstall 2010. IPSM***

←***Lambert et al. 2016. Biol Invasions*** (hybrids added)

**Note:** High sample size variation among locations; **very few Northern CA** (4 sites, n=2 to 4 sampled plants)

"Gulf Coast" taxa (**blue**) now recognized **non-native hybrid** between the tropical African species *P. mauritianus* and *P. australis (Meyerson et al. 2012 AoB Plants)*

BACKGROUND

# Four Potential Taxa – Northern CA

## 1. Native N. Am. lineage: *P. australis* subsp. *americanus*

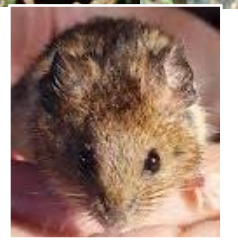
Present sw US at least 40,000 yrs; Suisun-Browns Island ≥ 3,800 yr B.P.
**Marsh-building foundation species.** Important wildlife habitat, erosion control, nutrient cycling/carbon sequestration.
**Genetically diverse; most common lineage in western states**
(*Atwater 1979, Goman & Wells 2000, Swearingen & Saltonstall 2010, Meyerson et al. 2010, Ketterning et al 2012*)

## 2.Introduced Eurasian lineage: *P. australis* subsp. *australis*

Arrived east coast US late 19th c., lag but widespread by 1960s; West coast expansion recent – present Utah by 1980s **invasive spread in CA recent ~20+yrs. Noxious weed. Degrades wetland habitat functions, values**. Multiple genetically diverse haplotypes. Converts botanically diverse wetlands into dense, low-diversity reed stands.
*(Chambers et al. 1999; Meyerson et al. 2000, 2012, Lambertini et al. 2012).*





3 T&E species in *P. australis* habitat




**Foundation marsh-building species San Francisco Bay-Delta Estuary – coexists with native plants and wildlife**

**Aggressive invader of managed seasonal wetlands and levee-breach tidal restoration sites; co-occurrence with threatened/endangered species.**

## 3. "Gulf Coast" lineage: *P. australis* subsp. *berlandieri*

***Florida to California.*** An **interspecific hybrid between the tropical African species *P. mauritianus* and *P. australis* established** in South America and on the Gulf Coast of the USA. (Meyerson et al. AoB Plants) (formerly considered US native lineage)

Uncommon in US but **present in s. California and Arizona complicating reliance on identification keys** developed elsewhere

## 4. Introduced X Native Hybrids

Hybrid *Phragmites* now widespread Las Vegas Wash wetlands; **seed viable**. **Expect where lineages grow sympatrically** *(Williams et al 2018).*
**Hybridization is a threat to native *P. australis subsp. americanus*** and invaded wetland ecosystems

**Hybrids are Rare at continental scale, but present in Nevada**, and possible where native and introduced subspecies co-occur (e.g. Suisun Marsh)

# METHODS

**Sampling Scheme** ✓
1. Proposal, Design, Funding (2019-20)
2. Refine Design, Survey/site selection, permits/access, test methods (2021)
3. Sample **20 population sites**, Within populations: **(n=20) 4x4m plots**, tag plants (2022)

**Field Samples/Data** ✓
Leaf tissue: archive - genetics + biochemistry + field measures
Panicles: for lab assessments
*In situ* measures: morphological (subsample replicates) and plant community traits. (2022)

**Laboratory Analyses** ✓
Plant tissue biochemistry

Microscopic panicle trait& ligule measurements (2022-2023)

**Genetic Analyses** ✓
1. Genomic DNA extraction (**n= >400 samples**)
2. Nuclear microsatellite (SSR) markers (9 loci; Saltonstall et al. 2014).
3. cpDNA (*rbcL*) sequencing, Restriction site analysis (RFLPs), Bayesian clustering, STRUCTURE 2.3.3. (2023)
4. Within and Among Population Distribution of native vs alien taxa per genetic results (2023-2024)

X

**Morphometric Analyses** (2022-2023) ✓
Plant community variables (species, environment)
Plant traits – field measured and Dissections/microscopic measures
Multivariate analyses

***Focus: this presentation**

***PUTTING IT All TOGETHER***

Diagnostic Traits X Native vs. Alien Subspecies specific to study region, Apply results to regional distribution mapping of native vs. alien taxa 2023 – 2025 ✓



**FIELD STUDIES 2022-2025**

**Phenology:** ✓
**Trait Expression**

**Native vs. Naturalized Alien Distribution Surveys**
**Delta - Suisun Marsh – Carquinez – North Bay**

# GENETIC RESULTS: 20 Population Sites

## NATIVE
(% native SAMPLES)

***Suisun Marsh:***

**Suisun Slough (100%)**
**Peytonia Slough (100%)**
**Denverton Slough (100%)**

***Suisun Mixed, mostly native:***

**Chadbourne Slough (75%)**
**Nurse Slough (63%)**
**Luco Slough (58%)**



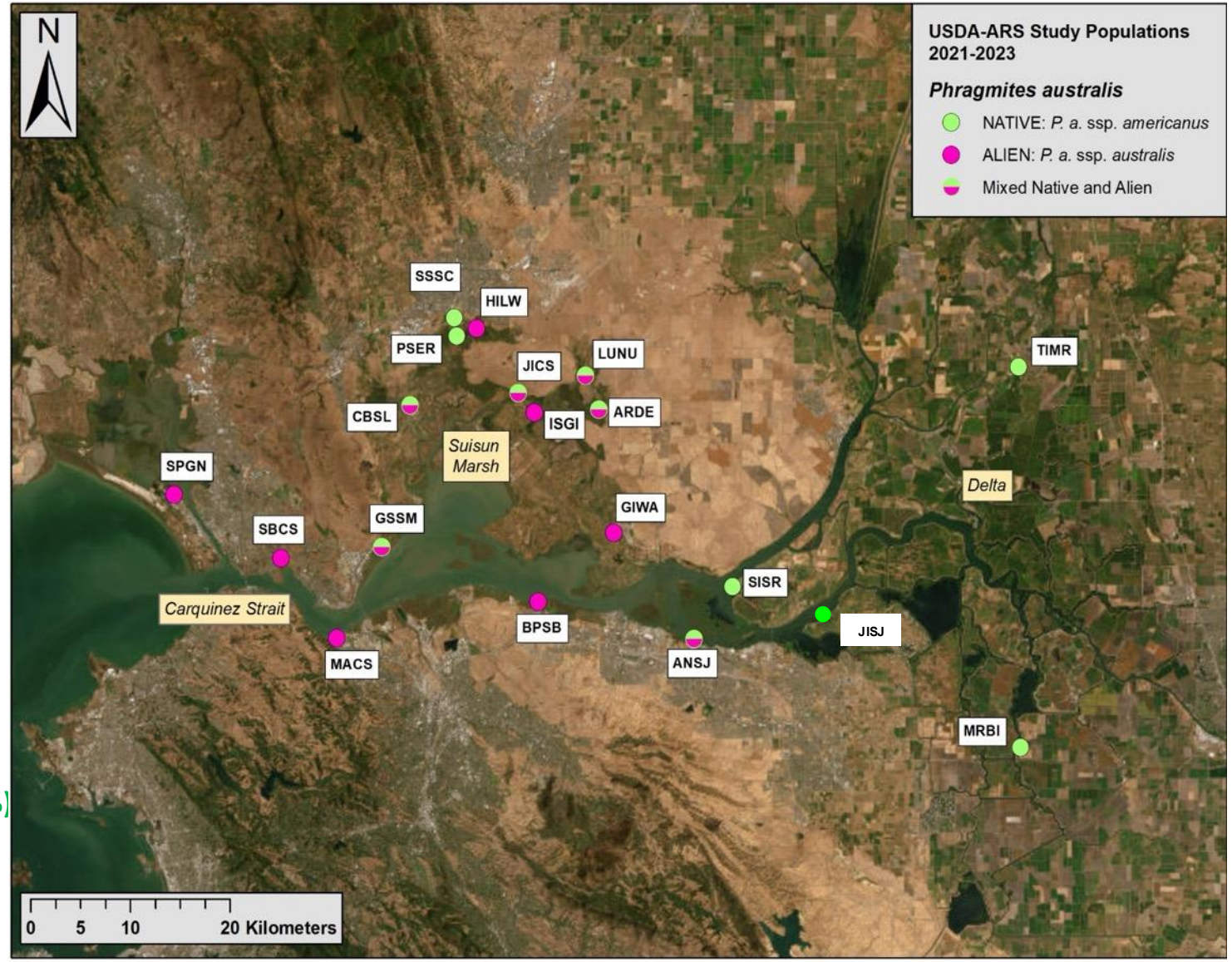
***Delta:***

**Tyler Island, Mokelumne R.(100%)**
**Middle River, Bacon Island (100%)**
**Sherman Isl., Sacramento R.(100%)**
**Jersey Island, San Joaquin R. (100%)**

***CC_Carquinez Strait- Mixed***

**San Joaquin R., Antioch (85%)**

*Note: P. australis* not observed in many Delta areas

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## NON-NATIVE
(% alien SAMPLES)

***Suisun Marsh:***

**Grizzly Island** WA- dmw (100%)
**Island Slough** – dmw (100%)
**Hill Slough** -tidal restor. (100%)

***Suisun Mixed, mostly alien:***

**Arnold Slough** (pre-breach) (94%)
**Goodyear Slough**-*GIWA* (80%)

***Suisun Bay-Carquinez Strait-North Bay:***

**Bay Point shoreline** (100%)
**Martinez** (diked+tidal) (100%)
**Southampton Marsh** (100%)
**(Field surveys -Natives also present)**

**Guadalcanal** (tidal restor.) (100%)

Genetic sampling site: diked managed wetlands (**dmw**), levee breach- tidal restoration sites, relict tidal marsh plains and slough- fringing tidal wetlands

***Confirmation: P. australis* subsp. *americanus*; *P. australis* subsp. *australis*** **(n= 402 individual plant samples)**

**Gulf Coast lineage** (*P. australis* subsp. *berlandieri*): **Not Detected**; **Hybrids: Not Detected**

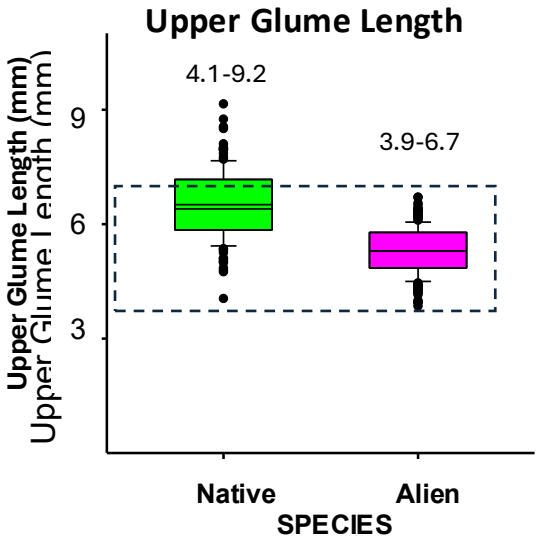
# Results: Select Plant Traits

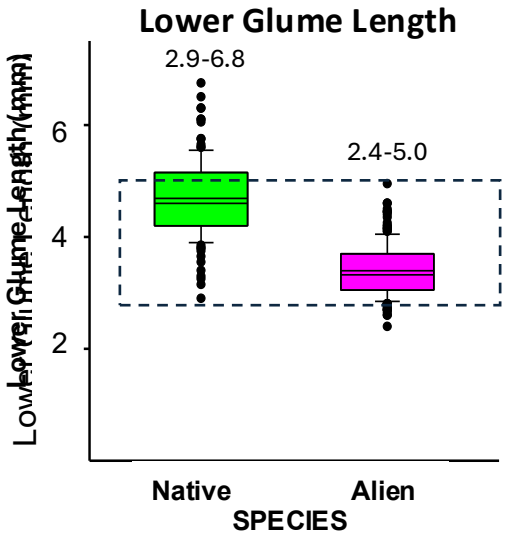
## *Phragmites australis* Floral Traits

**Mean differences but high overlapping variance!**



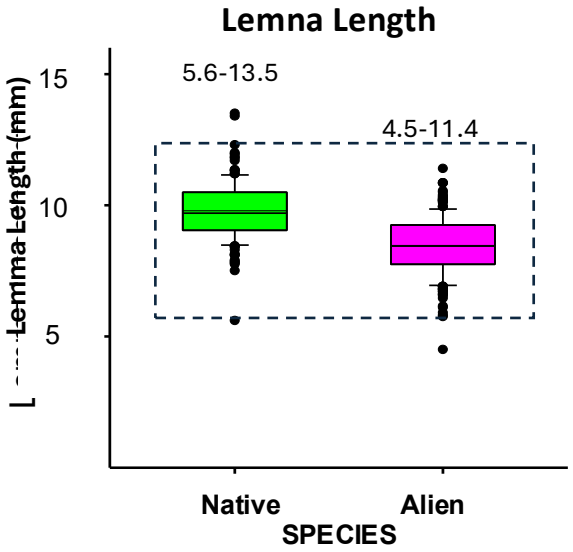
**Glume:** Two lower most bracts surrounding a grass spikelet






**Lemma:** larger outer bract with awn enclosing the florets




Box and whisker plots showing data max., min., median, mean, interquartile range 25th/75 percentiles, and outliers



**Plume-like Inflorescence**




Spikelet



Seed (2-3mm long) from floret

3 - 11 florets per spikelet
Fruit with seed in floret
100s of spikelets per plume-like inflorescence

High Propagule Pressure
Invasive *P. australis* in Suisun Marsh
**Seed Production**
**Mean ~4,500 to max >10,000 seeds/m²**
(V. Matzek 2023, CALIPC Symposium)

Sexual reproduction - **seed is the primary mode of long-distance dispersal and establishment**, then rhizomatous clonal expansion

**Feedback Mechanisms Drive Invasion**

As *Phragmites* invasion increases, flowers among stands cross-pollinate & genetic diversity increases; seed viability also likely increases driving increase in clonal stands and invasion spread.

(Byun et al. 2023 *Ecological Engineering*; Kettenring et al. 2011. *J. Applied Ecology*)

**High Variation in Inflorescence Appearance:**

NATIVE

ALIEN

**Inflorescence color monitored though seasonal phenological development**

**Early season**
Pre-Reproductive
Life Stage









**Late Season**
Reproductive
Maturity and
Seed Disperal










**There is high genetic diversity and variation in reproductive trait expression in our study region**

As seeds begin to mature, the panicles can begin to look “fluffy” due to hairs from the spikelet, and can take on a grey sheen (Saltonstall 2005).

***ALL shown are Phragmites australis* subsp. *australis***

**NON-NATIVE**

## Intraspecific Variation in color and form of non-native Inflorescence plumes: Summer








**– Semi-Dormant/Dormant Season (inflorescence but intraspecific variation in color/form continues)**



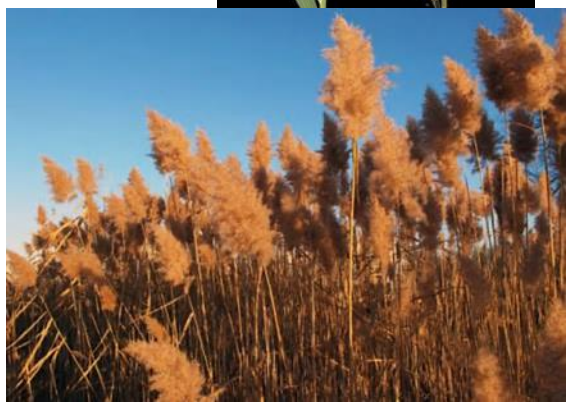

4 phenotypes observed Carquinez Strait tidal wetland study population




**Expansion Strategy:** The clonal stand expands primarily through a dense network of rhizomes (below-ground runners) and stolons (above-ground runners), allowing for rapid colonization.

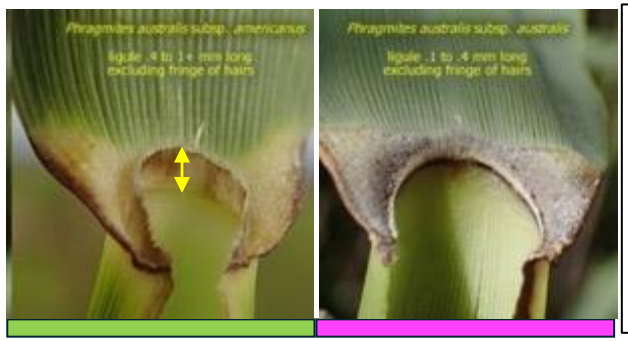
**Do not measure newly emerging shoot traits at stand edge to determine I.D.**





# *Phragmites australis Select* Leaf Traits

## Mean differences but high overlapping variance!



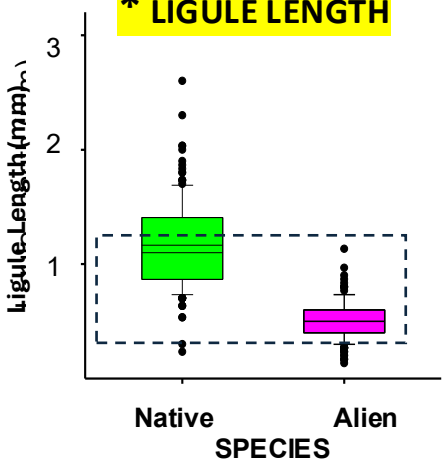
**Ligule:** membrane at junction of grass leaf blade and leaf sheath. Arrows show length to measure (does not include fringe hairs)

***Measure ligule on leaves from ~ middle third of a plant stem within a clonal stand.***

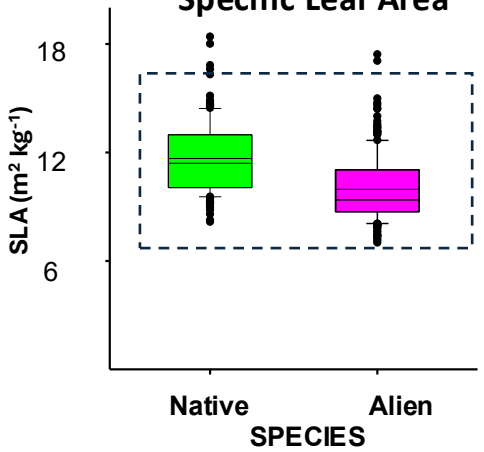
Ligules on upper, newly emerging leaves and on leaves on short new shoots emerging at edge of clone are not as well-developed.



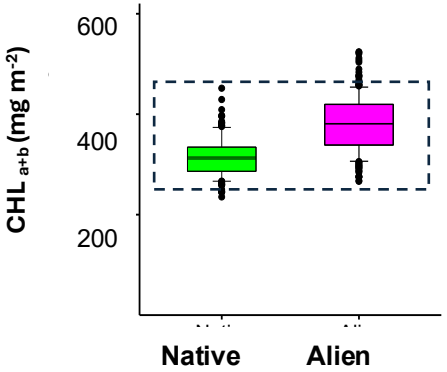
*** LIGULE LENGTH**

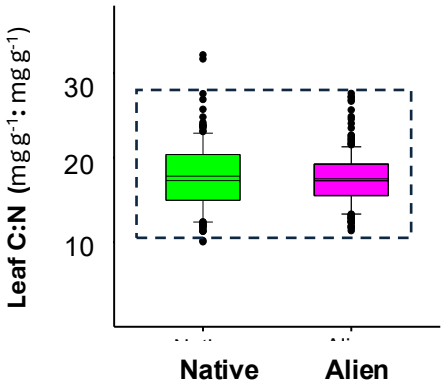



**Specific Leaf Area**




**Leaf Chlorophyll a+b**



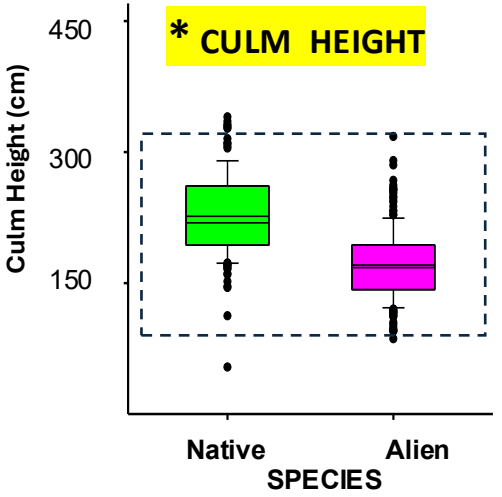



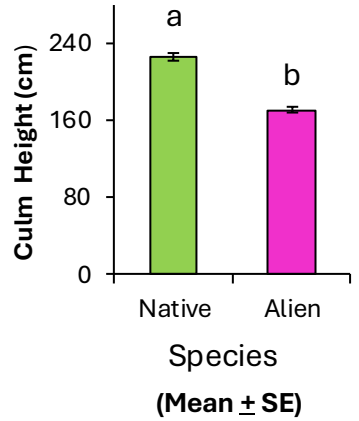

## Culm Traits

### Field Measured

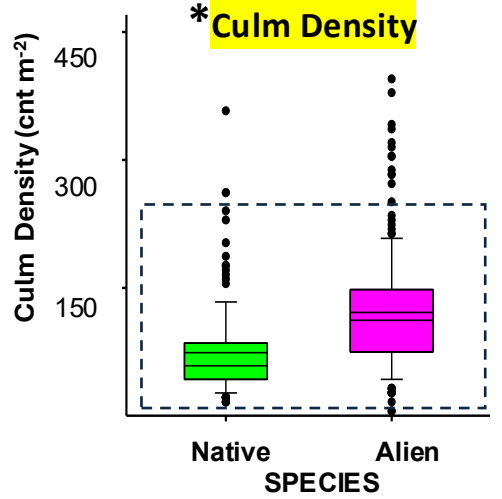
**Michigan, Minnesota report Alien taller than Native.*

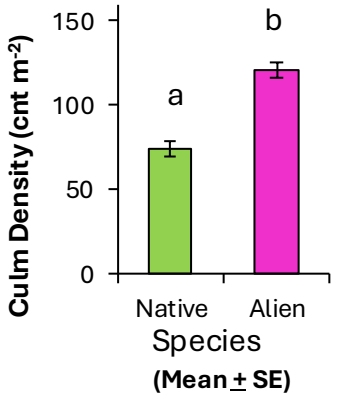
*** CULM HEIGHT**




***Culm Density**




On average, Native was <u>taller</u> with <u>lower culm density</u> than Alien

***Age of shoots within to edges of expanding clonal stand influence culm height and density traits.**

# RESULTS: OBSERVTIONAL PLANT TRAITS FOR FIELD IDENTIFICATION

## LEAF SHEATH and CULM TRAITS

NATIVE

**Early season – dead stems persist in stands**

NATIVE




**Leaf sheaths detaching during season, fall off culm as lower leaves die**









ALIEN










ALIEN

Leaf Sheaths stay tightly attached to culm throughout the season, persisting through year

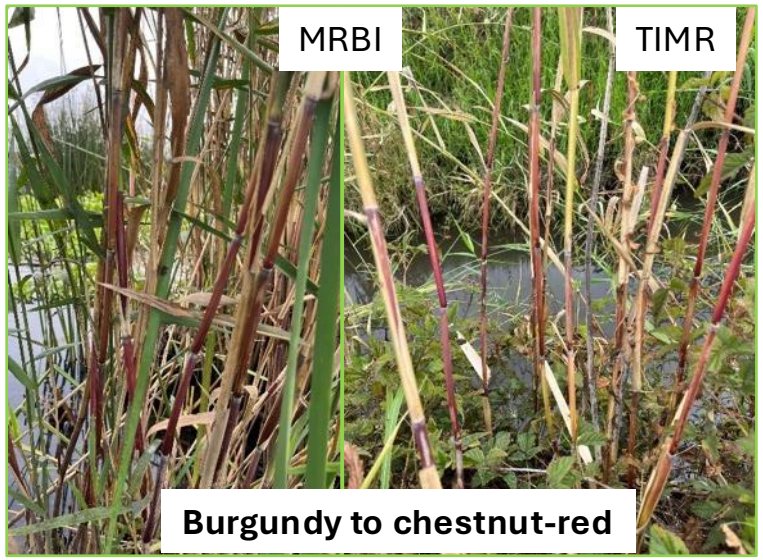
**CULM TRAITS** Examine from the Base!

# RESULTS: PLANT TRAITS FOR FIELD IDENTIFICATION

NATIVE

ALIEN

**Native:**
**Lower Culm Color**
**Burgundy to Chestnut-red**







**Non-native:**
**culm color yellow-green to tan**

**Native**
**Culm Texture Smooth**
NOT ridged













**Non-native:**
**Ridges on culms;**
can be subtle to moderately pronounced

**"Gulf Coast" hybrid *P. australis* subsp. *berlandieri* also has smooth culms**

**REVIEW: Putting it all together**

## Typical culm characters of native populations:

NATIVE

Loose leaf sheath adherence

Smooth, shiny culm surface

Chestnut-red to burgundy mid-culm to base culm color (**fades out to tan in autumn)**


ANSJ-3




MRBI


TIMR


SISR


LUNU-6

**REVIEW: Putting it all together**

ALIEN

## Typical culm characters of non-native populations:

Ridged, dull stem surface

Yellow-green to tan stem color mid-culm to base culm

Tight leaf sheath adherence







Leaf sheath clings tightly to stem

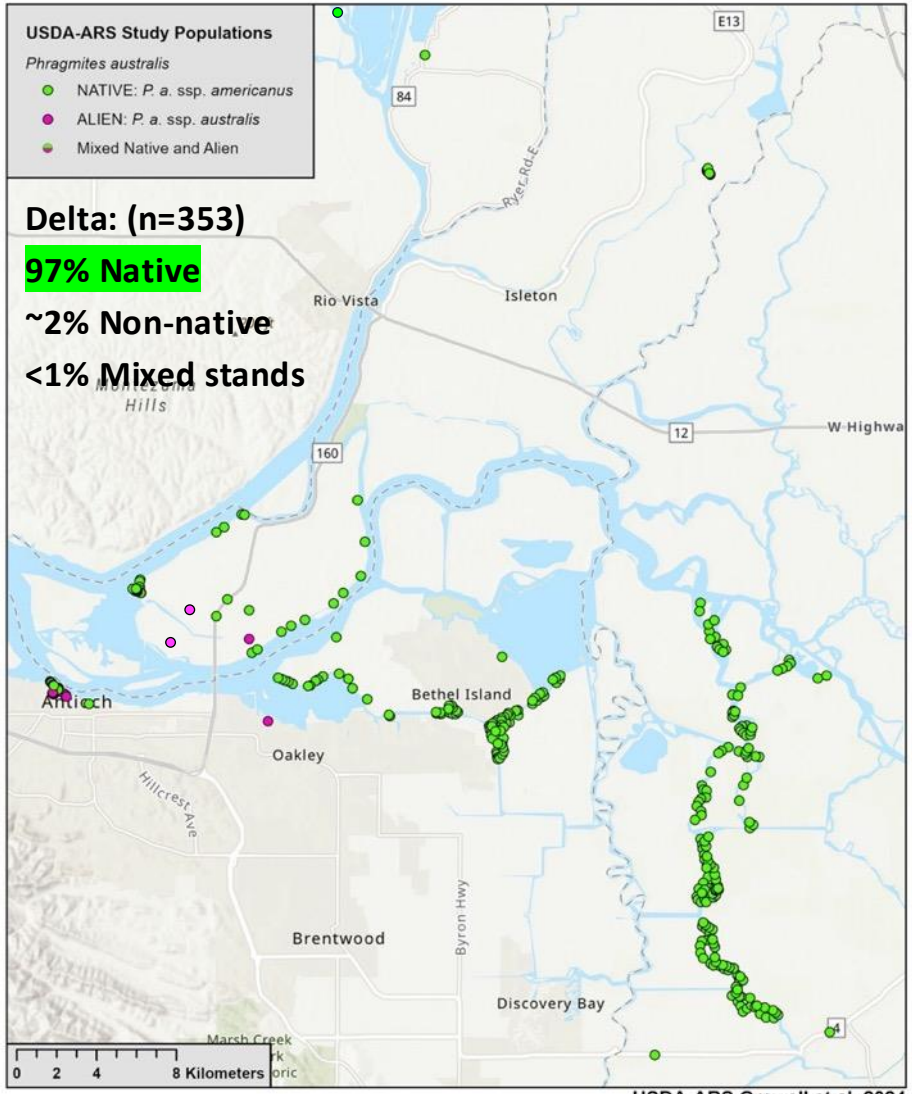





# RESULTS: Putting it all together

*% Occurrence Data of **sampled** points per study reach*

## Sacramento – San Joaquin Delta

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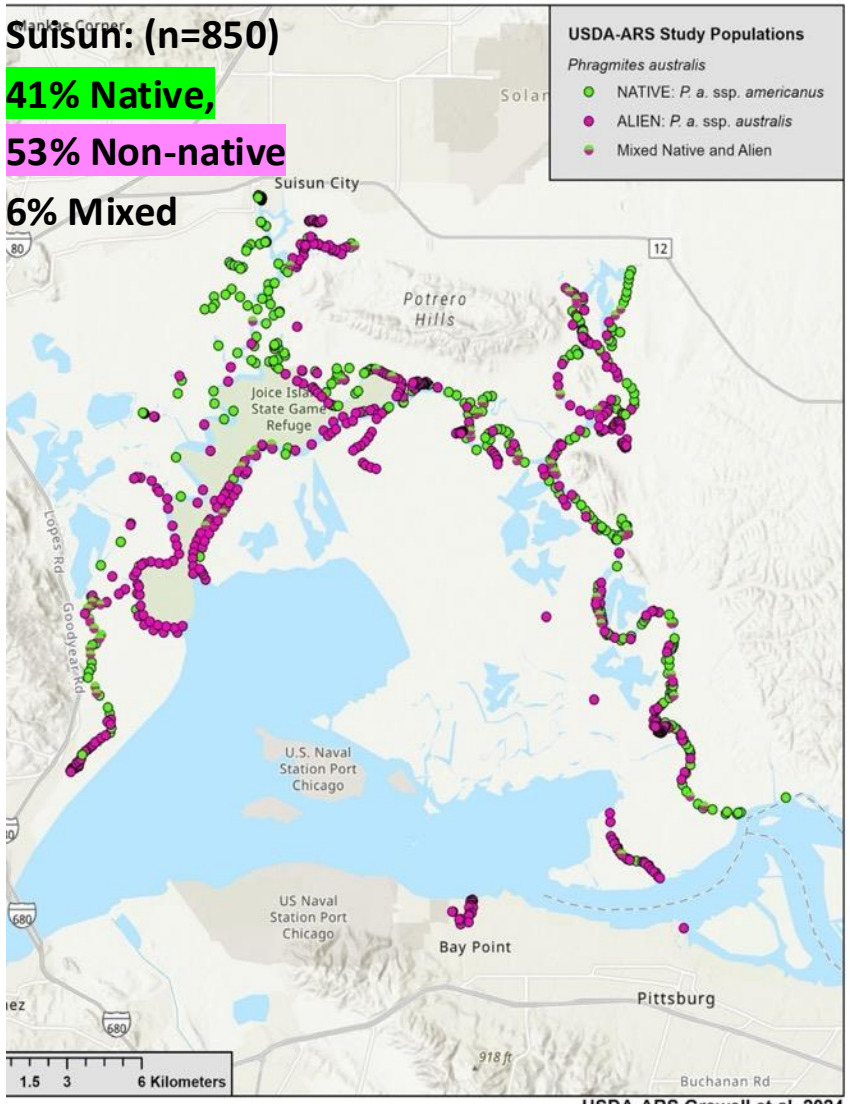
## Suisun Marsh – Suisun Bay to Bay Point

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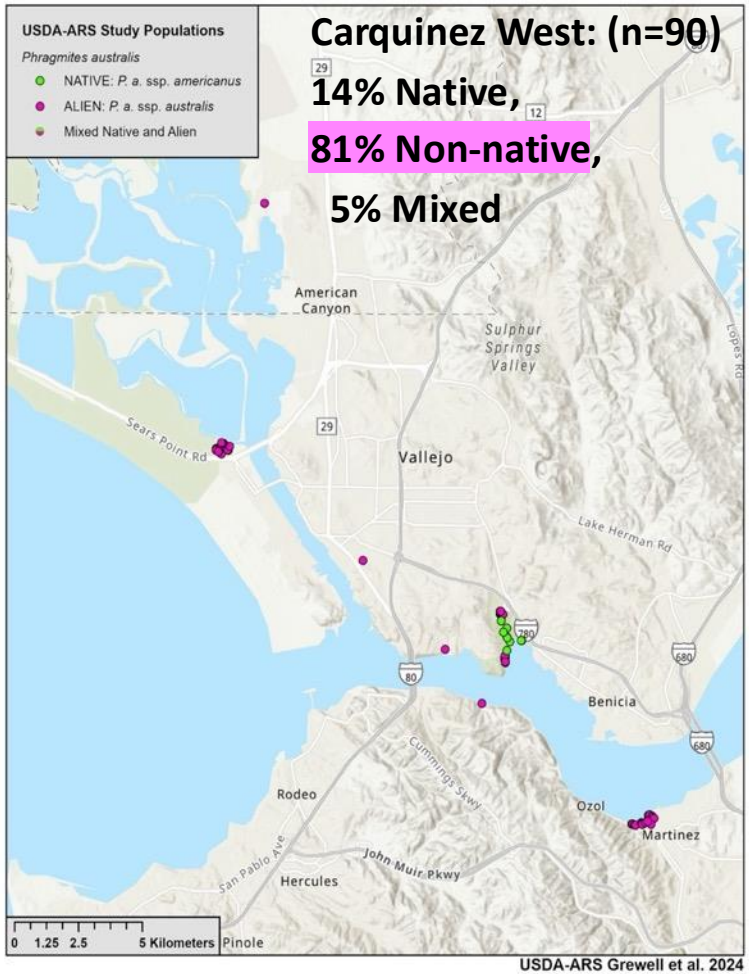
## Carquinez Strait –North Bay

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*Some areas shown on maps were not surveyed. Significant private and state-managed wetlands were not surveyed.*

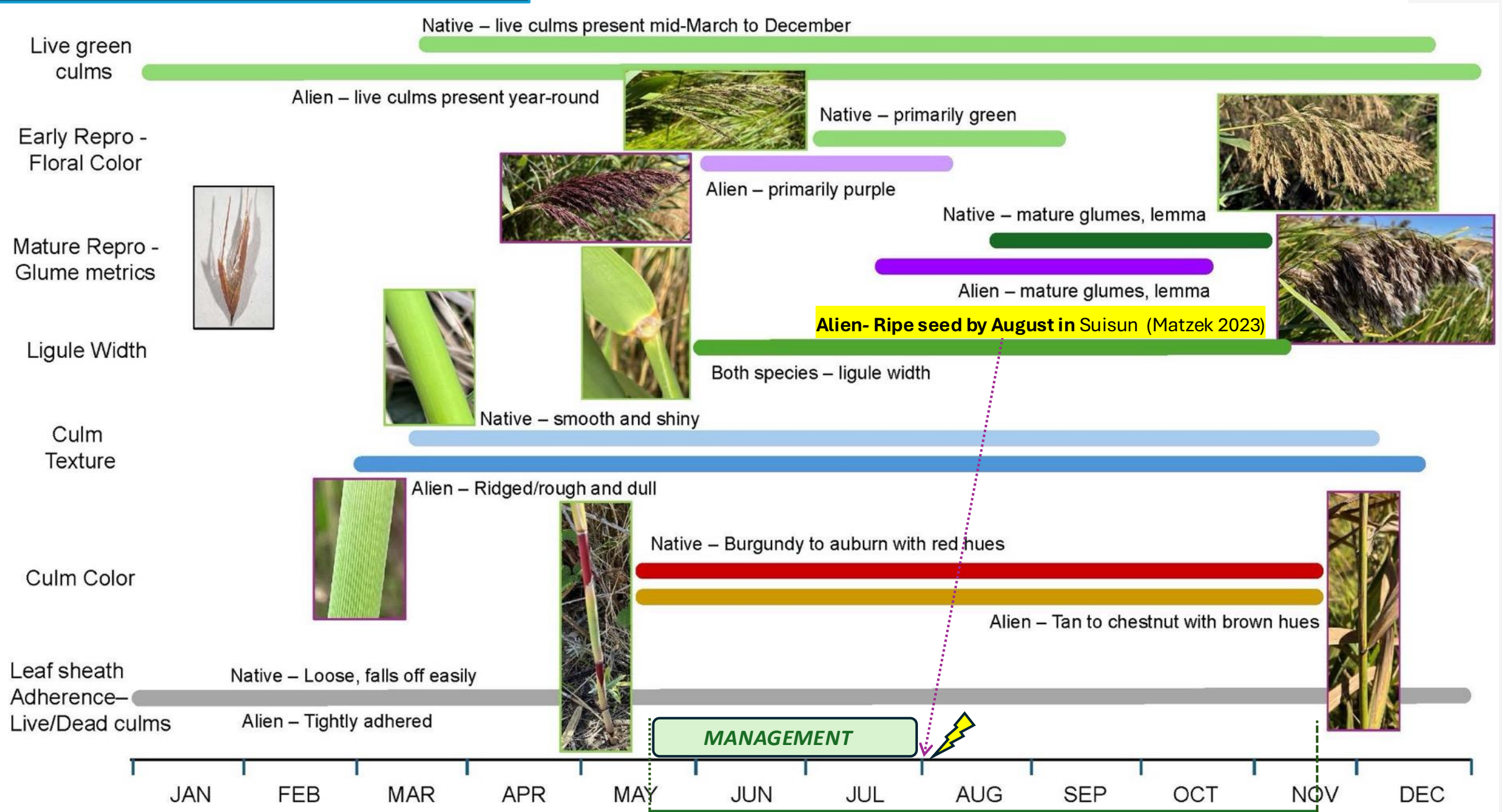
**Application of Field Diagnostic Methods to Determine Regional Distribution: Native** *P. australis* subsp. *americanus*, **Non-native** *P. australis* subsp. *australis,* or **Mixed** population patches (Native and Non-Native) of *Phragmites australis.*

(Surveys by boat, kayak, public roads, hiking/wading in public access and permitted access areas.) **FIELD SURVEYS 2023-2024; Updates 2025 -2026**

# Results: Phenological Development

## WHEN?

***Non-native flowering begins 4 to 6 wks earlier than Native***
***Some overlap in flowering phenology and floret/seed dispersal***




( 9 Sites Carq. – Suisun -Delta; Biweekly 3/2024-3/2025)

Effective management of ***P. australis* subsp. *australis*** in a wide range of invaded habitats **requires accurate identification** of the target weed and **avoidance of non-target negative effects** to support **ecosystem restoration** and the **conservation of native *P. australis* subsp. *americanus*.**

## ACCURATE IDENTIFICATION OF *PHRAGMITES* TAXA BASED ON FIELD-OBSERVED PLANT TRAITS IS RELIABLE

Given phenology of trait expression, **optimal time for I.D. is mid-May – mid-Nov.**, though I.D. into winter is possible. Check throughout the population stands. Avoid quick observations limited to clone edges where young shoots emerge.

- There are **overlaps in key morphological characteristics used for i.d. across range; look at multiple traits** when making a determination based on morphology**.**
- It important to examine *Phragmites* populations throughout their **life cycle**: **Observe YOUR** populations and **traits following their phenological development.** Expect interannual and seasonal differences in trait expression that may vary with climatic and other environmental conditions.

*****Management Challenge:*** Long-term control requires the removal of pollen and seed sources *prior to seed dispersal* within entire individual sub-estuaries to avoid reinvasion of actively managed areas**

(e.g. Ketterning et al. 2011*. J. Applied Ecology.)*

NON-NATIVE **SEEDS typically MATURE BY AUGUST** IN INVADED AREAS OF SUISUN MARSH

Science-based **TIMING of management** applications for EFFECTIVE REGIONAL CONTROL and prevention of reinvasion of managed areas IS CRITICAL

**In this study region, manage May – July prior to seed maturation and dispersal.**

**IWM methods removing standing biomass before sexual reproductive stage may extend this time frame**

*Thanks to CAL-IPC and all who strive to control weeds and restore native habitats!*

# ACKNOWLEDGEMENTS

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***Support:*** ***Thanks!***

**ARS NP 304 Crop Protection & Quarantine Projects**

**Invasive Species & Pollinator Health Research, Davis CA**
**Pest Management Research, Sidney MT**

**University of Seville**
**Dept Plant Biology & Ecology**
**Seville, Spain**

**UC Davis**
**Center for Plant Diversity**

**WE THANK: CA Dept of Water Resources, CA Dept of Fish & Wildlife, CA Dept of Food & Agriculture, CA State Parks, East Bay Regional Parks, San Pablo Bay NWR, Solano Co. Parks, Canyon Creek Resort, and private marinas for Research and/or Access Permits or Permissions**