Biology and Ecology of Yellow Flag Iris: Research Updates to Support Integrated Weed Management



Cal-IPC Symposium: Reuniting for Resilience, Oct. 26, 2023, CSU Chico

isph INVASIVE SPECIES AND POLLINATOR HEALTH RESEARCH UNIT

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The magnitude of global *Iris pseudacorus* invasions has increased dramatically in recent years

Lazo Marsh, Vancouver Island, B.C.


King County, Washington

Deschutes River Watershed, Oregon

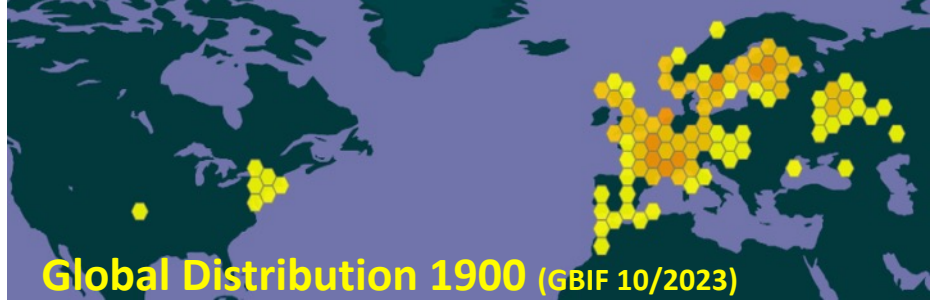

Golden Gate National Recreation Area, CA

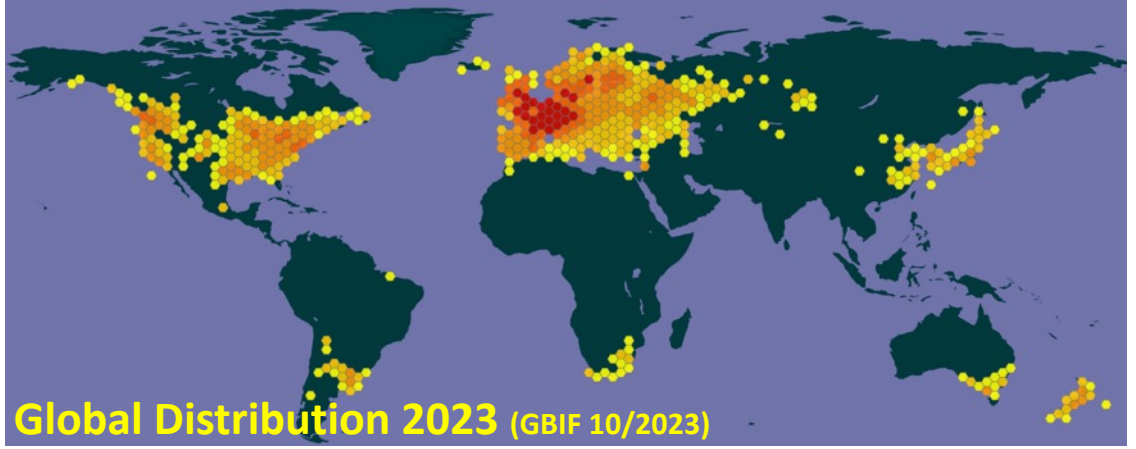
Haenertsburg, Limpopo, South Africa

Buenos Aires Province, Argentina

Suisun Marsh, San Francisco Estuary, California

Invasive plant populations are often observed to grow and spread more vigorously than conspecific populations in the native range



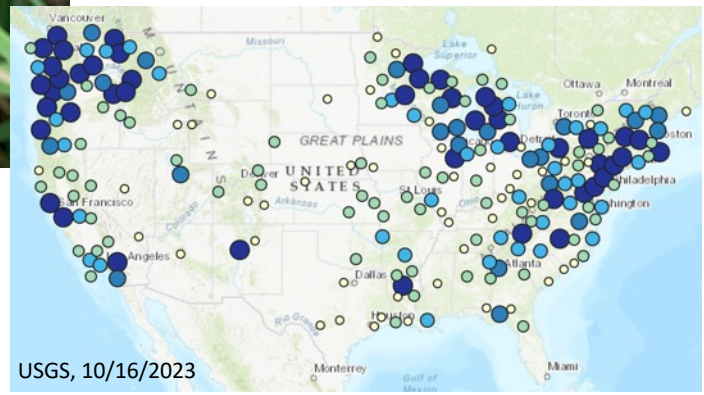


President Thomas Jefferson widely recognized as a Francophile, embraced all things French including art, culture, wine, cuisine, ***and gardens***). He imported and grew ***Iris pseudacorus*** at his Monticello plantation, **Virginia before 1771** (Wells et al. 2020 *Castanea*). His well-documented gardens contained many exotic seeds and plants from his travels abroad.

Arctic, Temperate and Subtropical Climate Zones
Freshwater and tidal wetlands, shallow lakes, ponds, rivers, ditches,

Yellow Flag Iris, *Iris pseudacorus* L.
Emergent Wetland Macrophyte

Iris pseudacorus **spread from Virgina**, USA*:* Virginia by 1771. By the 1860s, it was a naturalized **invasive alien species** along the Delaware River, Hudson River Valley; In Lake Ontario-Great Lakes region by 1886, Chesapeake Bay by the early 1900s, and in Oregon, Pacific Northwest and **California by 1948. (Consortium California Herbaria)**



Naturalized Range-USA

How did it get to my wetland???

Highly Attractive Plants Imported for Water Gardens and Aquaria escape and naturalize as invasive weeds

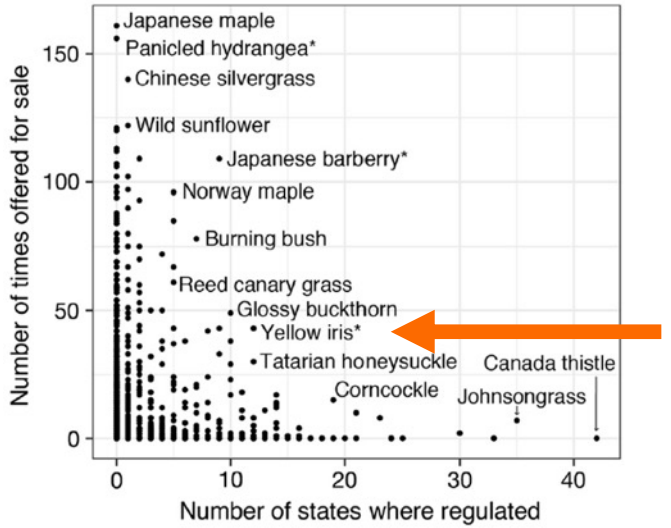
Intentional Introduction → **Unintentional Consequence**

Historic import of plants for private ponds and botanical gardens, and **modern global trade in horticultural and aquarium plants** have been pathways of alien plant species introductions to wetland and riparian ecosystems

1. Iris pseudacorus, a **showy wetland plant** with yellow flowers, has been transplanted into gardens and ponds all over the world and has **widely escaped and displaced native vegetation**.

2. It is used in water and sewage treatment for metals removal, but it **escapes wastewater treatment areas.**

3. Ballast water discharge of yellow flag iris seeds into estuaries documented 1880s.



As a **noxious weed**, sales and transport of *I. pseudacorus* have long been prohibited in many states, but **enforcement is difficult**, particulary with internet sales

ebay

3 YELLOW FLAG WATER IRIS PSEUDACORUS bulbs/ rhizomes
Price: **US $13.00**
$11.60 Expedited

amazon prime 10/2023

Yellow Pond Iris
4.4 out of 5 stars
-23% $11.95
•We are unable to ship this product to AE, AK, BC, GU, HI, PR.
•* Very Hardy. Laughs at cold weather.

Beaury et al. (2021): 61% of 1285 plant species identified as invasive in the US remain available through the plant trade, including 50% of state-regulated species and 20% of federal noxious weeds.

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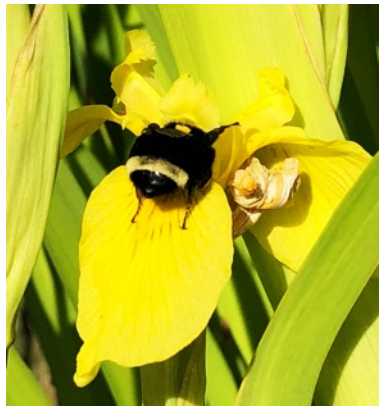
Establishment and Spread: Sexual and Asexual Reproduction

SEX!

Obligate Outcrosser



Bombus sp. *Apis* sp. long-tongued flies, Hummingbirds

Capsules obscurely 3-angled with obvious groove at each angle

High seed production (400-1500 per plant) Smooth, reddish to dark brown seeds (depending on maturity) which are flat and D- to circular shaped, with hard seed coats

Seeds disperse summer

Bouyant Seeds

Seeds release from dihisced capsules often hanging **directly over water**

Rhizomes are drought tolerant, but during floods, both rhizomes and seeds may be transplanted downstream. Bank erosion can mobilize rhizome fragments

Clones expand quickly via tuberous rhizomes, spreading radially to form dense stands.

Dense **root mats** compact soil, inhibit seed germination of other plants.

Rhizomes exposed with bank erosion

Early below ground allocation

Rhizomes pink, freely branching

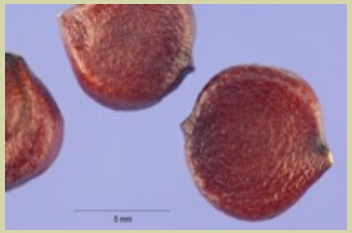
An unusual case of seed dispersal in an invasive aquatic; yellow flag iris (*Iris pseudacorus*)

Gaskin et al. 2016, *Biological Invasions*

Dr. John Gaskin, USDA

Molecular ecology enables better understanding of introduction events, matching invasive populations to source populations, and knowledge of how species are spreading.

99.1 % of seeds collected in MT were viable



Big news for management!

Genetic studies in Pacific Northwest states revealed *I. pseudacorus* **disperses almost entirely by seed, not by rhizome fragmentation**

Seeds – Sexual Reproduction Drives Dispersal - Recruitment of yellow flag iris!

Almost all plants were **not** clonally related

Population genetic study
Found 167 unique genotypes in n=171 plants

Even when collected at 2 m apart (40m transect), only one pair of plants was clonally related

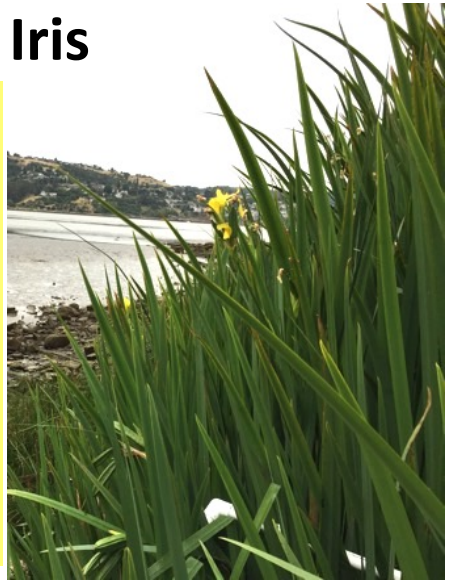
TIMING OF TREATMENT: BEFORE SEED PRODUCTION

PROPER IDENTIFICATION: ***First Step for Management***

Erect Emergent Wetland Plant Species

Alien: Yellow Flag Iris

Leaves deciduous, stiff **erect** with upper part arching; leaves **flattened**, arising in a **fan** from the soil; **raised midrib**; sword-like, **fine-pointed**; 3-5 feet in height



EDRR!
Plants do not bloom and set seed until 2 yrs old. MANAGE EARLY!
Learn to I.D. prior to flowering!

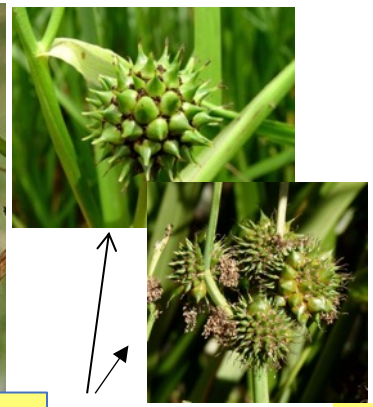
Once reproductively mature, best **timing for effective management** is in the pre-reproductive stage, or at least prior to seed production.

When not in bloom, it can be difficult to distinguish from cattails, bur-reed, and native irises.

Douglas Iris *I. douglasiana*
Native to the California coast from Santa Barbara to Oregon
Moist soil, seasonal wetlands, wet meadows

IMPORTANT!

MANAGE BEFORE SEED FORMATION



Iris Capsules obscurely 3-angled with obvious groove at each angle

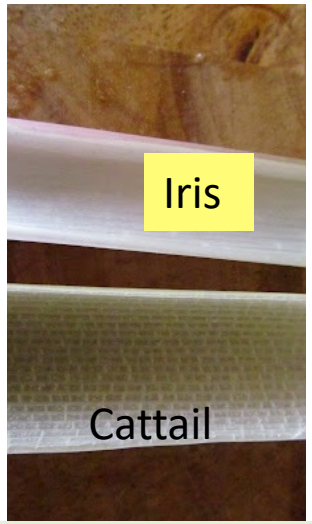
Bur-Reed fruits *(Sparganium erectum, S. eurycarpum)*

Yellow Flag Iris **Leaves flattened,** in fans, with **raised midrib**, **leaf tips pointed**

Bur-Reed, narrow alternate leaves, **triangular** x-section, flat only at tip

Leaf differences

Iris, flat diamond shaped at midrib; Cattail crescent-shaped, not flat



Iris, vertical veins, Cattail honey-combed veins

Plant Invasions in Changing Environments

With global climate change, plant species in tidal marshes are being exposed to increasing salinity and longer inundation periods related to concomitant sea level rise (**SLR**) and alteration of local watershed runoff, and precipitation amounts and patterns.

SLR exposes plants to increased physiological stresses and influences their survival, distribution and productivity along intertidal gradients, depending on their elevation relative to tides

Alternative Plant Responses to Environmental Change

Extinction | **Dispersal, Migration** Range Shifts | **Persistence**

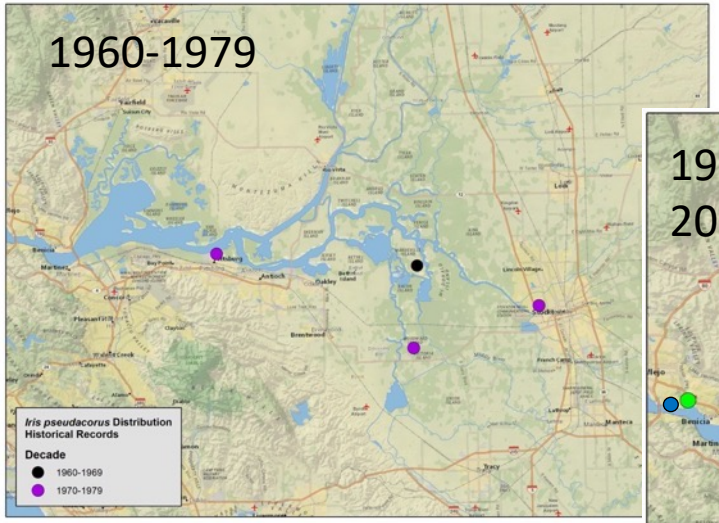
EDRR - consider **rapid range expanders** AND new alien invasive species

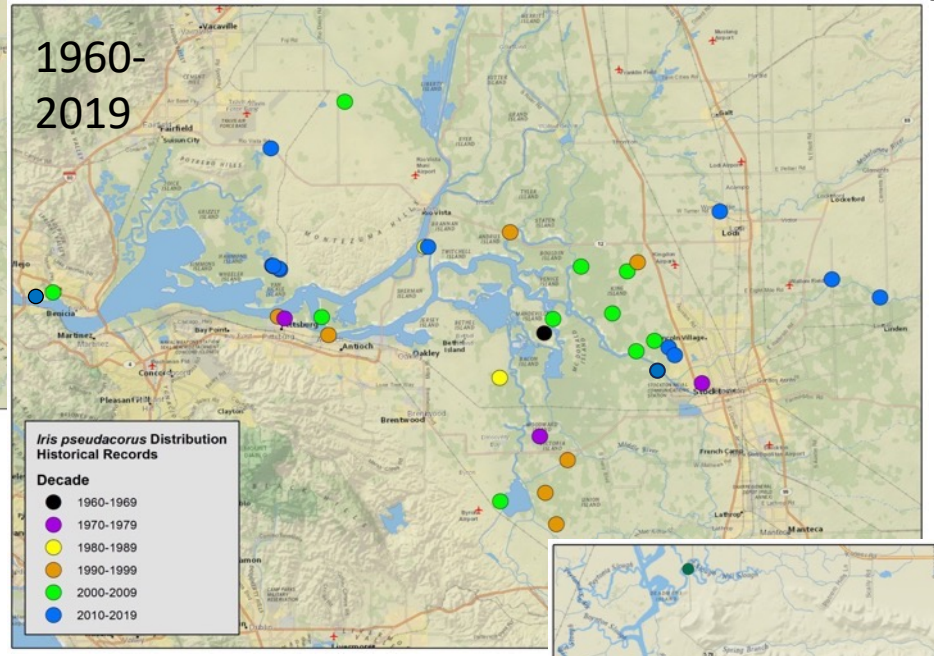
Weed invasions and their impacts are the outcome of both changing environmental conditions and plant traits promoting fitness, as well as constraints on trait plasticity to adjust to change.

Global change factors are expected to alter physiological and ecological traits of alien aquatic plants, and accelerate their spread and invasion risk into new areas. Rapid evolution is measurable and well documented.

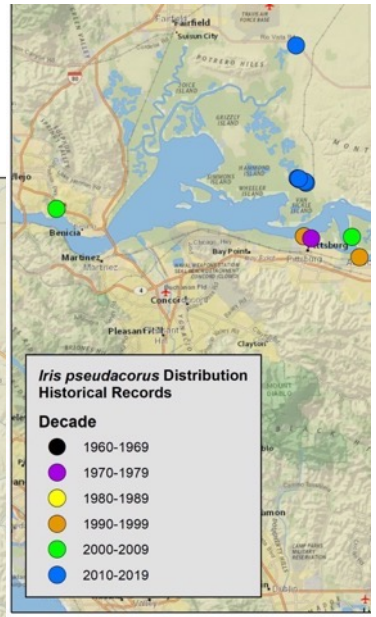
Yellow Flag Iris, long established and a presumed glycophyte, is rapidly expanding into low to high brackish tidal wetlands where it alters habitats and reduces plant species diversity

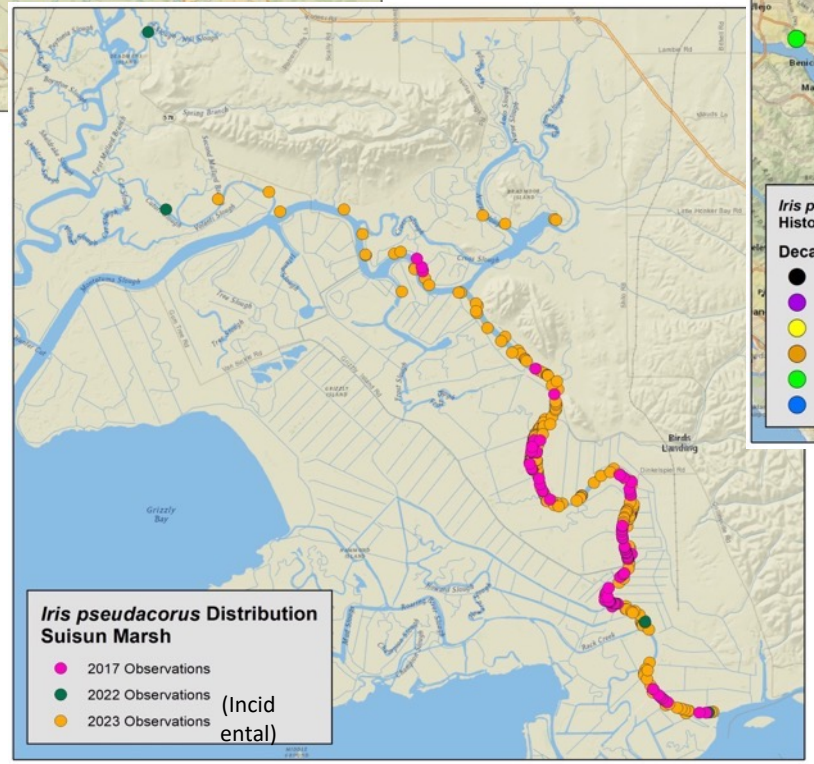
Decadal records of established alien *Iris pseudacorus* populations in the San Francisco-Bay Delta Estuary region wetlands





Recent rapid range expansion: spread and establishment of *Iris pseudacorus* along Suisun Marsh tidal sloughs





2017 Glen Cove/Vallejo Shoreline, Carquinez Strait

Montezuma Slough

Managed Water Flow Directly Influences spread of buoyant seeds dispersing into water in summer.

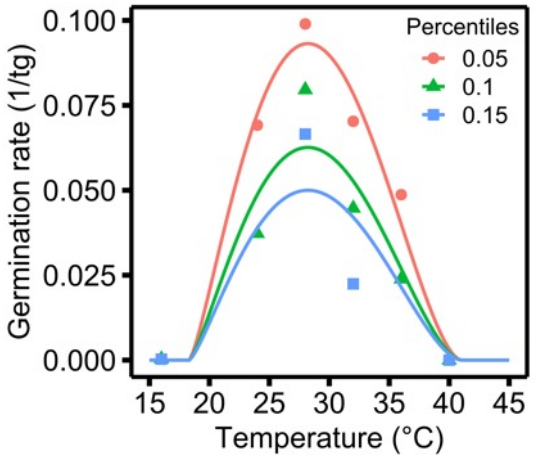
Germination niche breadth of invasive *Iris pseudacorus* (L.) suggests continued recruitment from seeds with climate warming

Gillard, Castillo, Mesgaran, Futrell, & Grewell. 2022

American Journal of Botany

Climate warming is altering cues that drive germination, yet studies on the invasion of wetland macrophytes often ignore germination ecology despite its importance to establishment

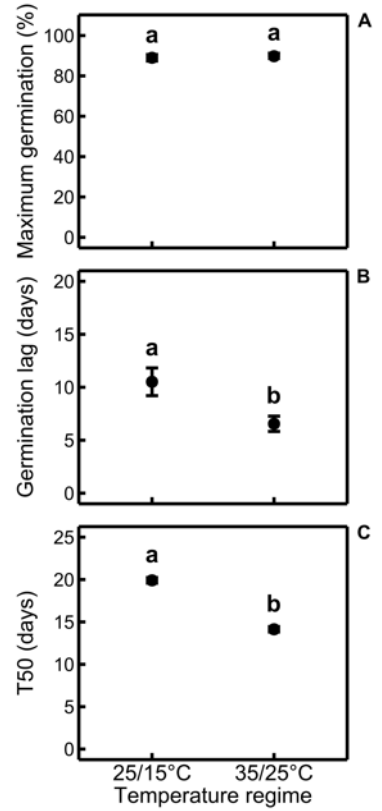
We explored germination of seeds from *I. pseudacorus* populations in California



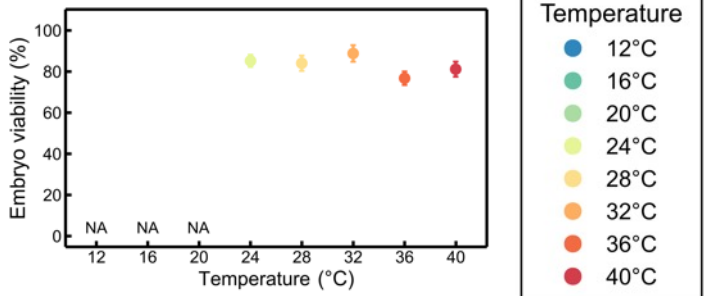
Using experimental results in a thermal time model, we derived germination temperature thresholds.

Seeds did not require cold or warm stratification to germinate

***I. pseudacorus* has a broad germination niche supporting its establishment in a relatively wide range of environments, including at high temperatures more frequent with climate change.**



Embryo viability still high at high temperatures



Germination occurred in the dark, germinability was 2 to 3 times greater under light, and highest with alternating temperatures

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High aqueous salinity does not preclude germination of invasive *Iris pseudacorus* from estuarine populations

Morgane Gillard, Jesús M. Castillo, Caryn J. Futrell, Brenda J Grewell

Ecosphere 2021

We tested germination under fresh to seawater salinity levels (0, 12.5, 25, and 45 dS/m) and under moist and flooded hydrological conditions

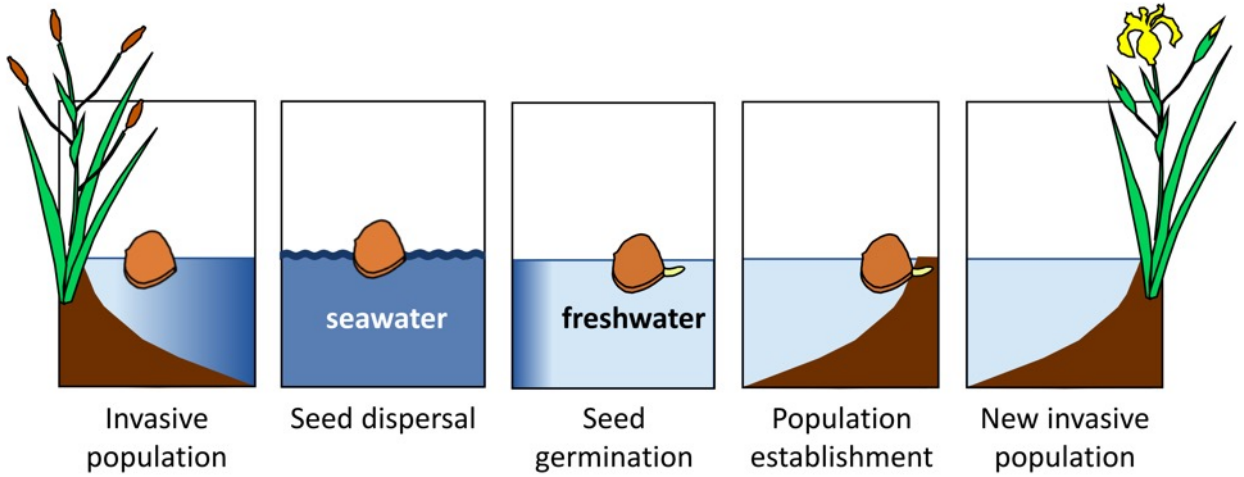
Dispersal

Highly buoyant seeds allow for dispersal by water

Dr. Morgane Gillard, Post-Doc, UCD,USDA now Sitelécom, Dijon, France

Brackish salinity >12.5 dS/m inhibited germination of seeds, but 56% germinated.

After 55 d floating in seawater, buoyant seeds of *I. pseudacorus* retain their ability to germinate, and germinate quickly with freshwater exposure. (FGP 96%)



Increased salinity with Sea Level Rise won't solve our problem

High aqueous salinity exposure does not preclude germination of yellow flag iris

Results inform risk assessments, suggesting invasive populations of *I. pseudacorus* can colonize new sites following **potentially long-distance dispersal with tidal currents**, and highlight the need for management with sea level rise.

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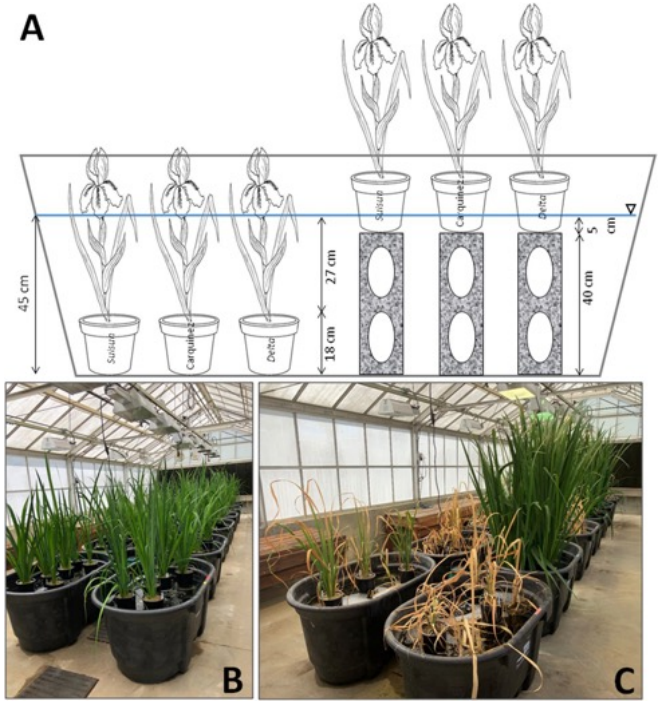
Salinity and inundation effects on *Iris pseudacorus* (yellow flag iris): implications for tidal wetland invasion with sea-level rise

Grewell, Gallego-Tévar, Gillard, Futrell, Reicholf, & Castillo **2021** ***Plant and Soil***



Greenhouse experiment
3 salinity X 2 inundation levels X 3 populations X 4 replicates from an estuarine gradient San Francisco Bay-Delta Estuary

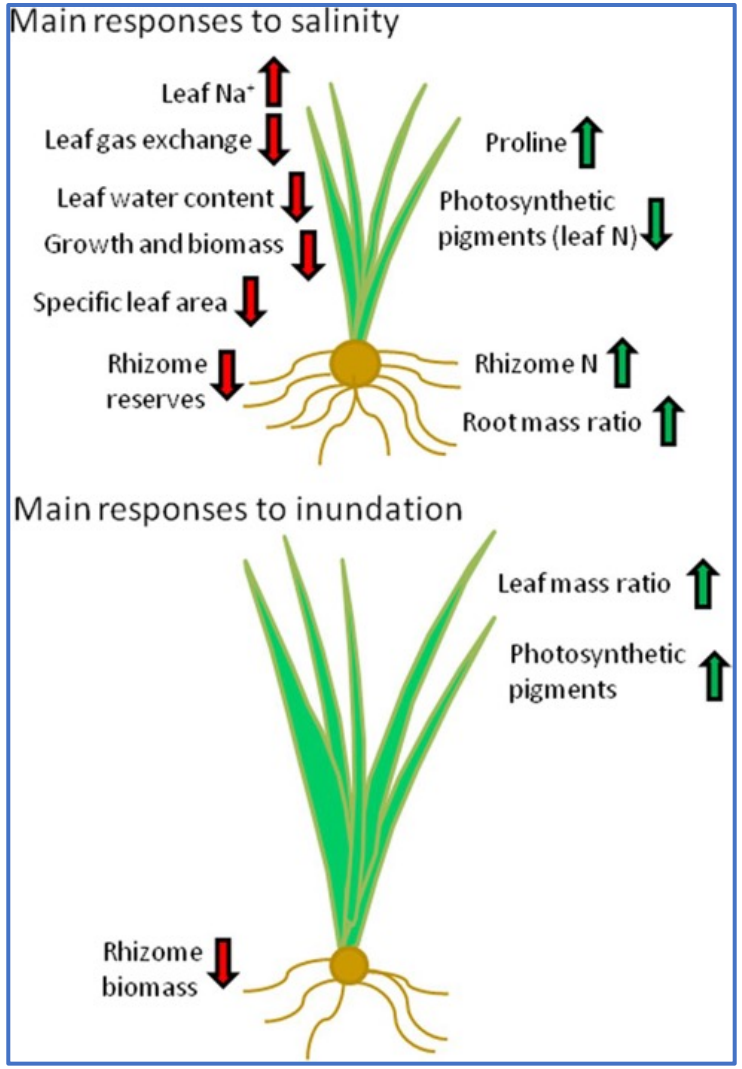
Establishment Life Stage

Early life stage *Iris pseudacorus* is best adapted to freshwater condition :
functional traits are optimal, with significant production of biomass

In freshwater conditions, tolerance of permanent inundation

At the pre-reproductive, colonizing life stage, the high sensitivity of *I. pseudacorus* to salinity limits its capacity to acclimate to increasing inundation

Allocation to below ground reserves in benign (freshwater) conditions may support survival through suboptimal high salinity/indundation periods



Management Implications: Efforts to control the invasion of *I. pseudacorus* in estuaries should focus on rapid management of newly colonizing populations in freshwater tidal locations prior to reaching seed production stage at age 2 yrs. Successful establishment and growth of juvenile *I. pseudacorus* is best supported in these benign environments.

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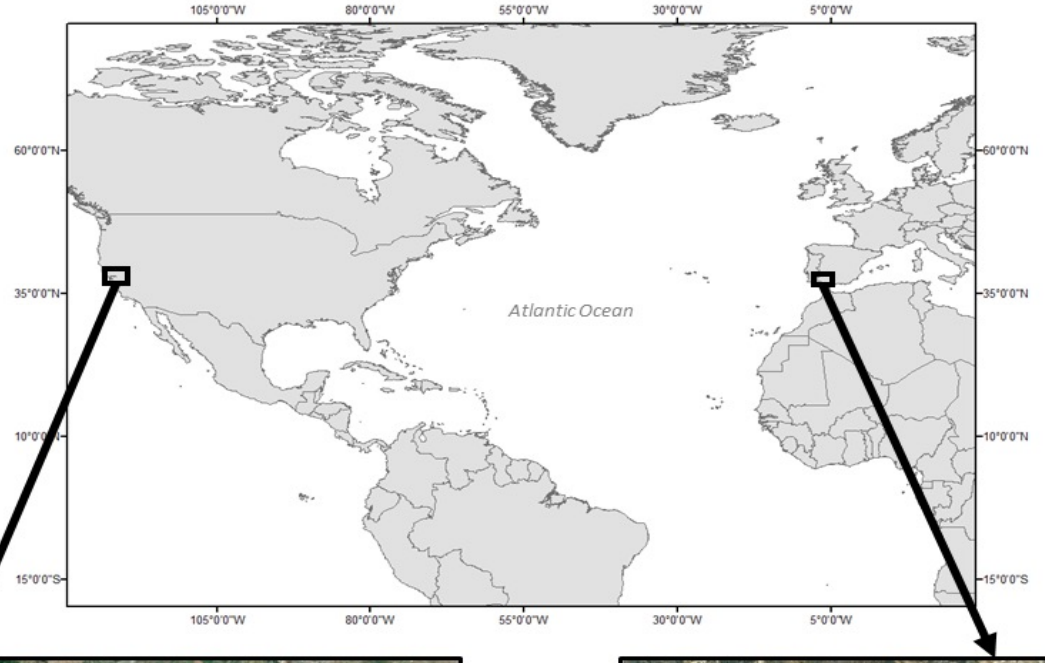
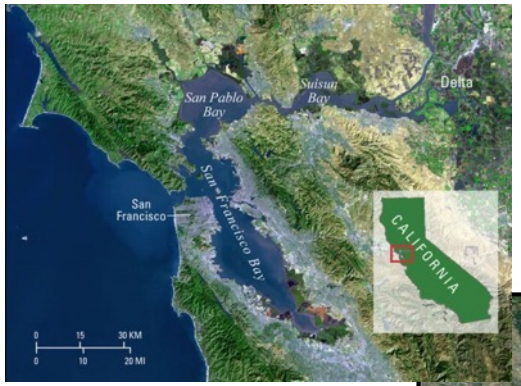
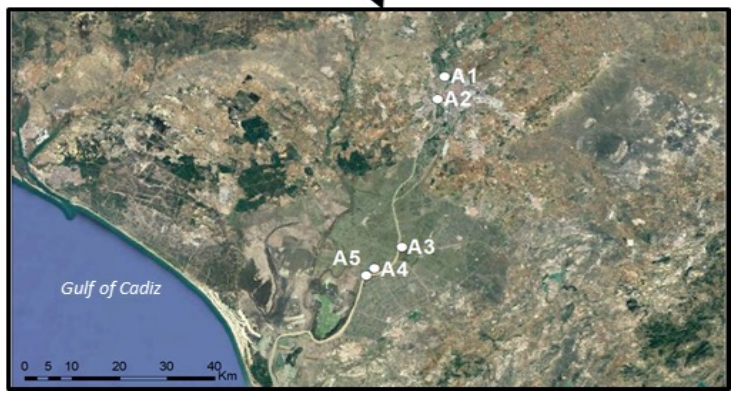
Comparative Biogeographic Research
Yellow Flag Iris
Native vs. Introduced Range



Monumento a Cristóbal Colón, Huelva



STUDY SITES



Populations C1-C5:
San Francisco Bay-Delta Estuary,
California, USA

Populations A1-A5:
Guadalquivir Estuary, Andalusia,
Spain

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Dr. Jesús M. Castillo
Dr. Blanca Gallego-Tévar
Universidad de Sevilla

Contrasted impacts of yellow flag iris (*Iris pseudacorus*) on plant diversity in tidal wetlands within its native and invaded distribution ranges

Gallego-Tévar, Grewell, Whitcraft, Futrell, Bárcenas-Moreno, Castillo **2022**, *Diversity*

INVADER IMPACTS

In a recent study, we assessed the impact of of *I. pseudacorus* populations along estuarine gradients on resident plant communities in its native and invaded ranges

In the native range (Andalusia), *I. pseudacorus* was associated with high plant species richness, evenness, and diversity

Shannon–Wiener α-diversity, species richness and evenness were evaluated in patches with and without *Iris pseudacorus* in its native (Guadalquivir Estuary) and invaded (San Francisco Bay-Delta Estuary) distribution ranges, to investigate the effects on the plant community.

Iris pseudacorus **greatly reduced plant species richness and diversity** in the naturalized California range at local and watershed scales. Effects were independent of variation in soil salinity.

IMPACTS

Populations of yellow flag iris can create a positive feedback loop increasing its spread and negative environmental impacts

I. pseudacorus in Mission Valley, Montana has been reported to reduce a stream's width by up to 10 inches a year (Tyron 2006 in: Washington Noxious Weed Control Program 2009).

Consumptive use of water supports biomass production and reduces water supply for beneficial uses

Roots trap sediment

Sediment raises local elevations, clogs irrigation canals, narrows waterways, decreases flood capacity

Sediment increase enables new seedling growth, + shrubs and trees altering to drier ecosystem

Reduces food supply, nesting habitat of many wetland dependent fish & wildlife, changes ecological functions

Iris pseudacorus out-competes native plants for pollinators.

Reduces species richness and diversity of native plant communities

Decomposition of biomass can degrade water quality, eutrophication fuels more growth

Yellow iris was found growing to the complete exclusion of *Typha* and other native marsh plants along the Merced River in California (Raven and Thomas 1970).

(Dieringer 1982, Sarver et al. 2008, WA Noxious Weed Control Program 2009, Lui et al. 2010, Jacobs et al. 2011, ODA 2012, Gallego-Tévar et al. 2022).

Phenotypic trait differences between *Iris pseudacorus* in native and introduced ranges support greater capacity of invasive populations to withstand sea level rise. Grewell et al. 2023 *Diversity and Distributions*

Do functional traits of alien *I. pseudacorus* explain its invasive success compared to its growth and fitness in the native range?
Do environmental factors explain the phenotypic differences?

METHODS We compared 15 growth, morphological, biochemical, and reproductive plant traits from populations in the native and invaded range, and explored their relationships to measured and modeled environmental factors.

RESULTS: Alien invasive *I. pseudacorus* plants in California **were more robust than those from the native range**, in response to differences in environmental conditions and genetic processes.

RESULTS: Alien *I. pseudacorus* plants in California were **less affected by increasing salinity and were exposed to deeper inundation** water along the estuarine gradient than those native in Andalusia.

RESULTS: The **vigor of the invasive plants** was reflected by higher specific leaf area, less leaf turnover, more **rhizome carbon storage reserves**, higher fruit and seed production, and greater seed mass than expression of these traits by native plants.

Conclusions Functional trait differences suggest established populations of **alien *I. pseudacorus*** in the San Francisco Bay-Delta Estuary have adapted **greater physiological capacity to adjust to environmental stresses induced by rising sea level** than those in the native range (Guadalquivir Estuary, Spain).

Knowledge of these trait responses can be applied to **improve weed risk assessments and protect estuarine ecosystems thru science-based IWM plans**

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THANKS TO Cal-IPC and all COOPERATORS/PRACTITIONERS striving to improve weed management, environmental quality, and conservation of native California flora.

Thanks for your interest!

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