

New Yolo County Weed Alert: Alligator Weed (*Alternanthera philoxeroides*)



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**YOLO WMA
4-29-2020**



New Discoveries, Range Expansion? New Introduction? Risk - Threats? Management?

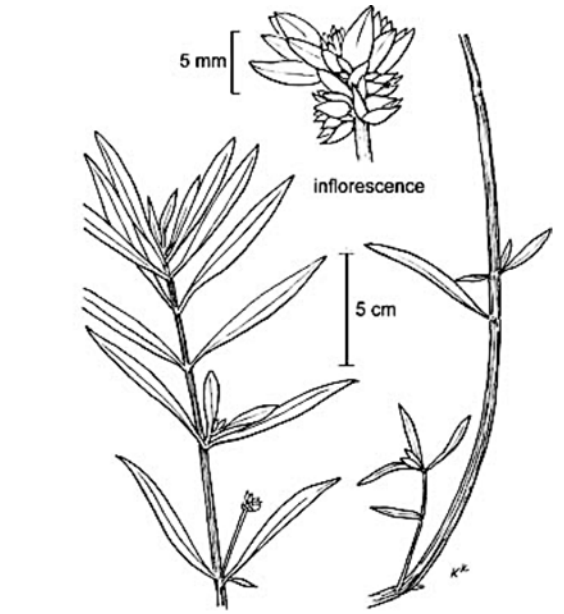
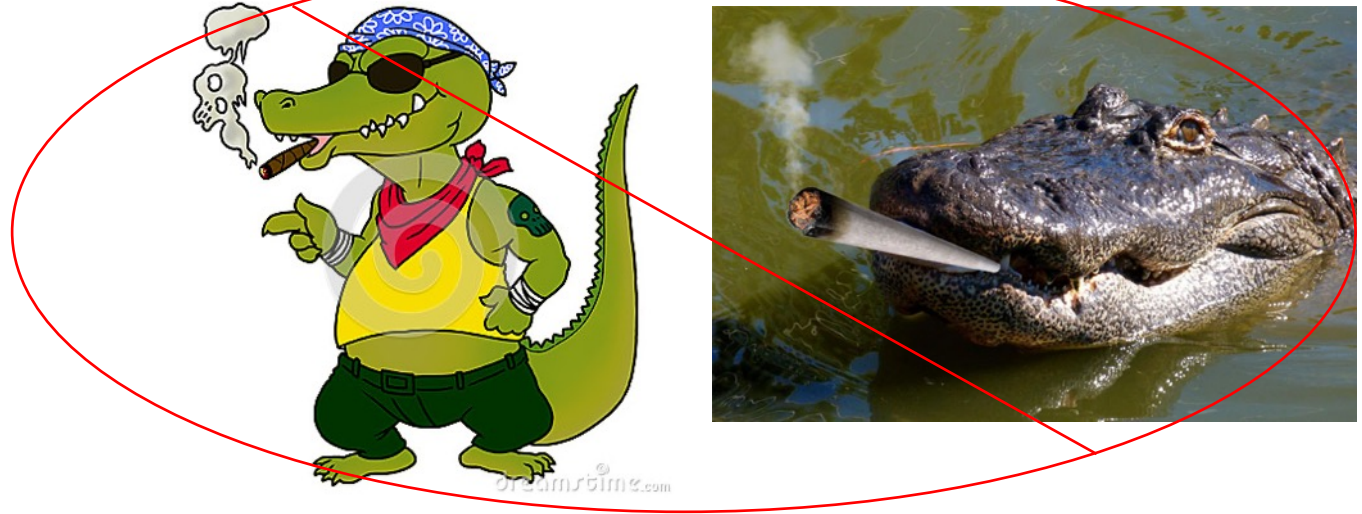


Search Term: **Alligator Weed**



Ommundsen

“It doesn’t seem to be covered in our invasive species management plan.”



Alternanthera philoxeroides

Taxonomy *Alternanthera philoxeroides* (Mart.) Griseb. (Family: Amaranthaceae)

Globally accepted common name: Alligator weed (EPPO, CABI, ITIS) Synonyms: pig weed, alligatorweed



LEAVES: Opposite; Elliptic, glabrous



STEMS: HOLLOW



INFLORESCENCE: cluster of white flowers, terminal and axillary, 1.4-1.7 cm diameter on short stalk

Reproduction and dispersal: Asexual reproduction from axillary buds at each stem node

Rapid hydrochorous dispersal of fragments.

Flowering observed in California Spring – fall and even in winter. In the native range viable seed is produced, *no observations of viable seed in naturalized US range* **HOWEVER:** Lui-qing *et al.* (2007) cite Zhang *et al.* (2004) (in Chinese) documenting 6.5% viable seed set in China



***Alternanthera caracasana* - only close relative in California**

“Washerwoman” or “Khaki Weed” or “Chaff flower”

Escaped cultivar S. CA, native to South America



Growth Form: Forb/herb; heavily stemmed, woody root, spreading along the ground (procumbent), forming mats.

Leaves: Bright green; opposite, glabrous, leaves variable, oval or obovate with short sharp flexible point, paired leaves of unequal size throughout, petioles, clasping.

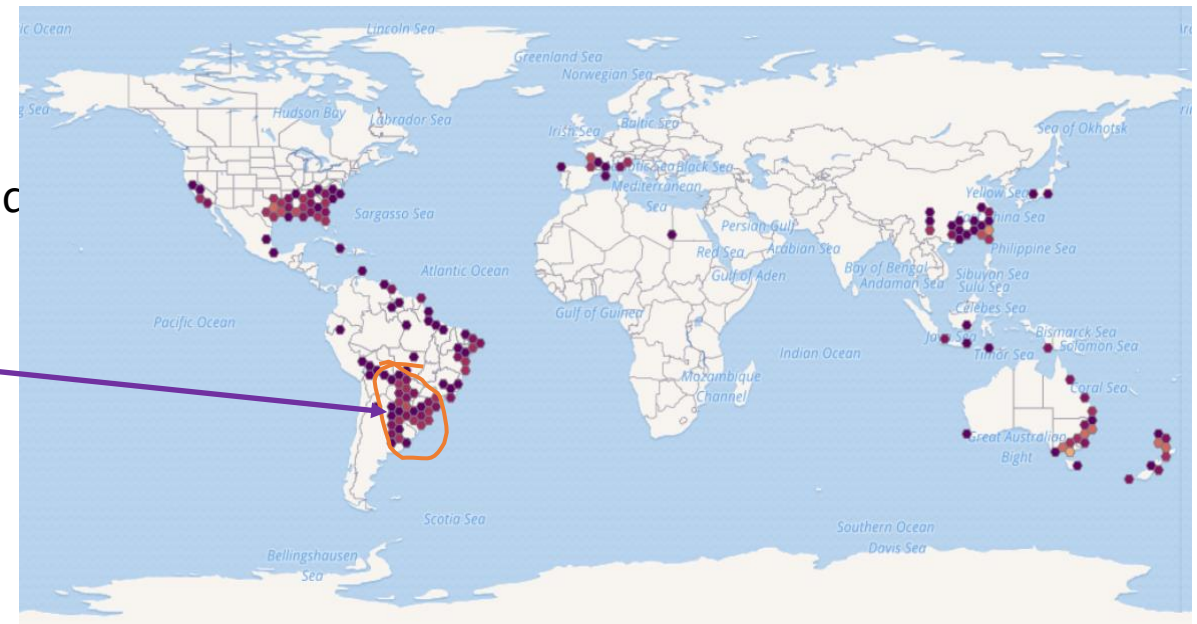
Stem is NOT hollow



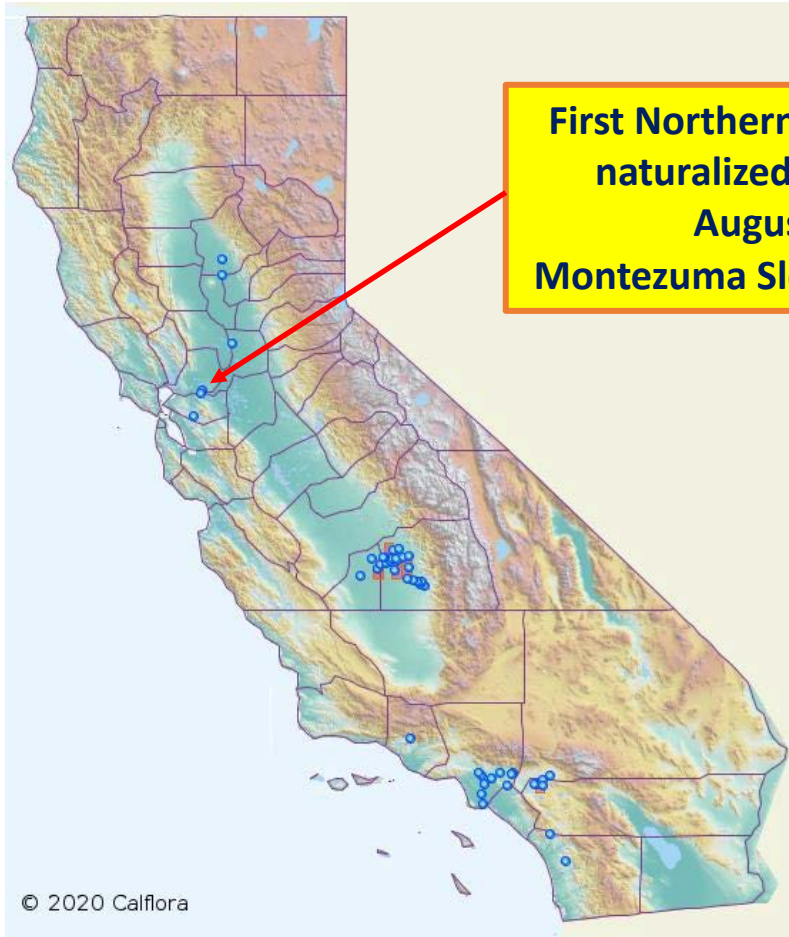
Habitat Preferences: Gravel, sand bars, sidewalks; 0–2000 m; **Generally waste places.** Desert flora. (not wetlands)

Where is it? Alligator Weed Distribution

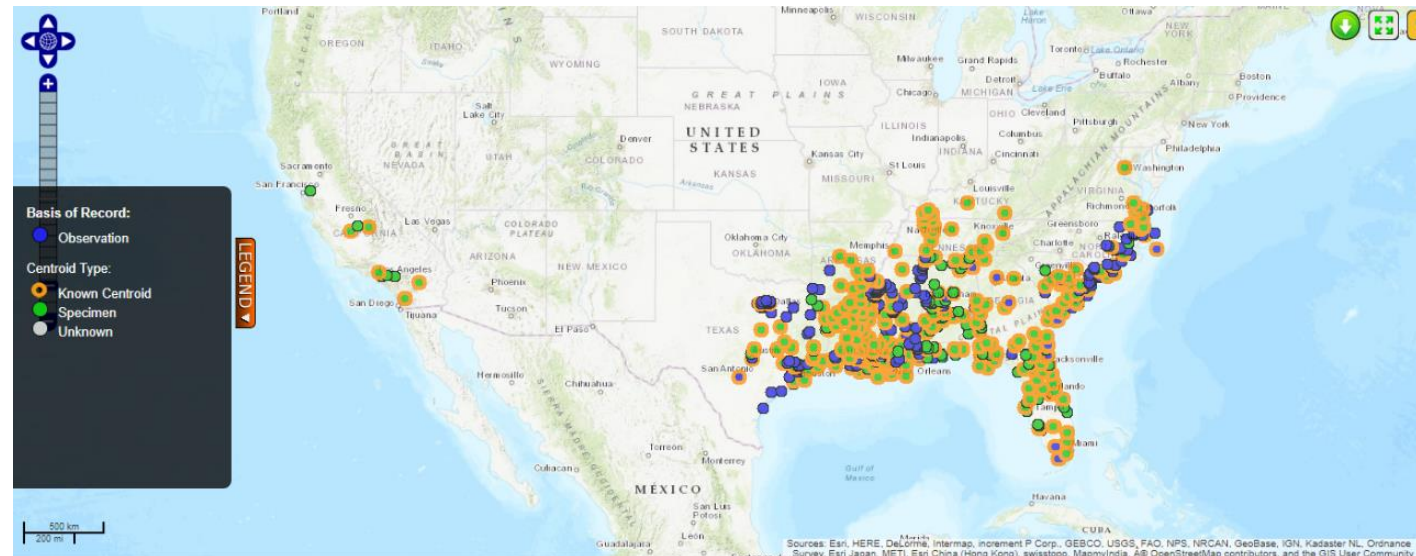
Native Range: The Parana River region of South America (Brazil, Paraguay, Argentina, and Uruguay) and has spread to other regions of S. America (Vogt et al. 1979; Julien et al. 1995).



**First Northern California Record:
naturalized Alligator Weed,
August 25, 2017
Montezuma Slough, Suisun Marsh**



A. *philoxeroides* is found in the USA, Australia, New Zealand, much of Asia and more recently Europe (France, Italy, Spain)

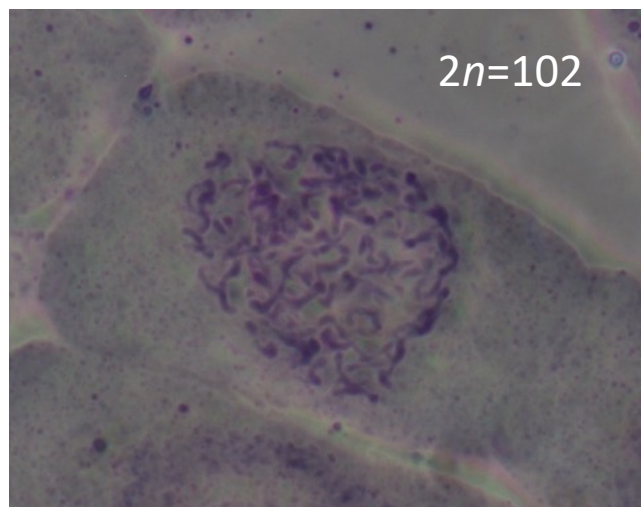


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California Invasion History: known to Visalia, LA County – S. CA since 1940's)

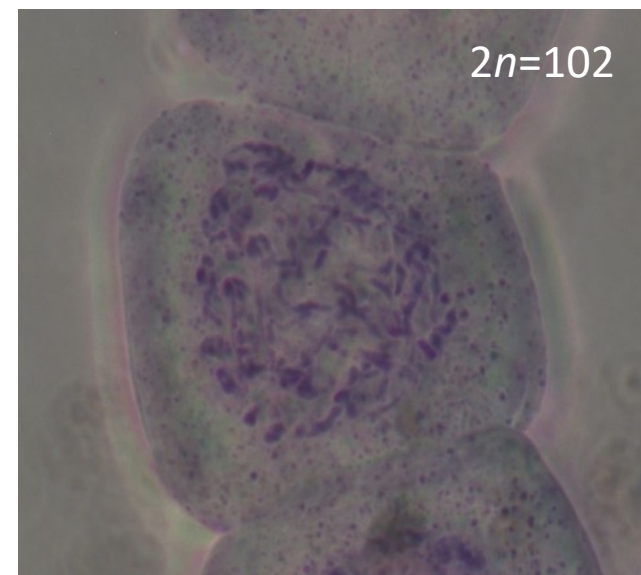
Alternanthera philoxeroides (Mart.) Griseb.

Genetic diversity in US



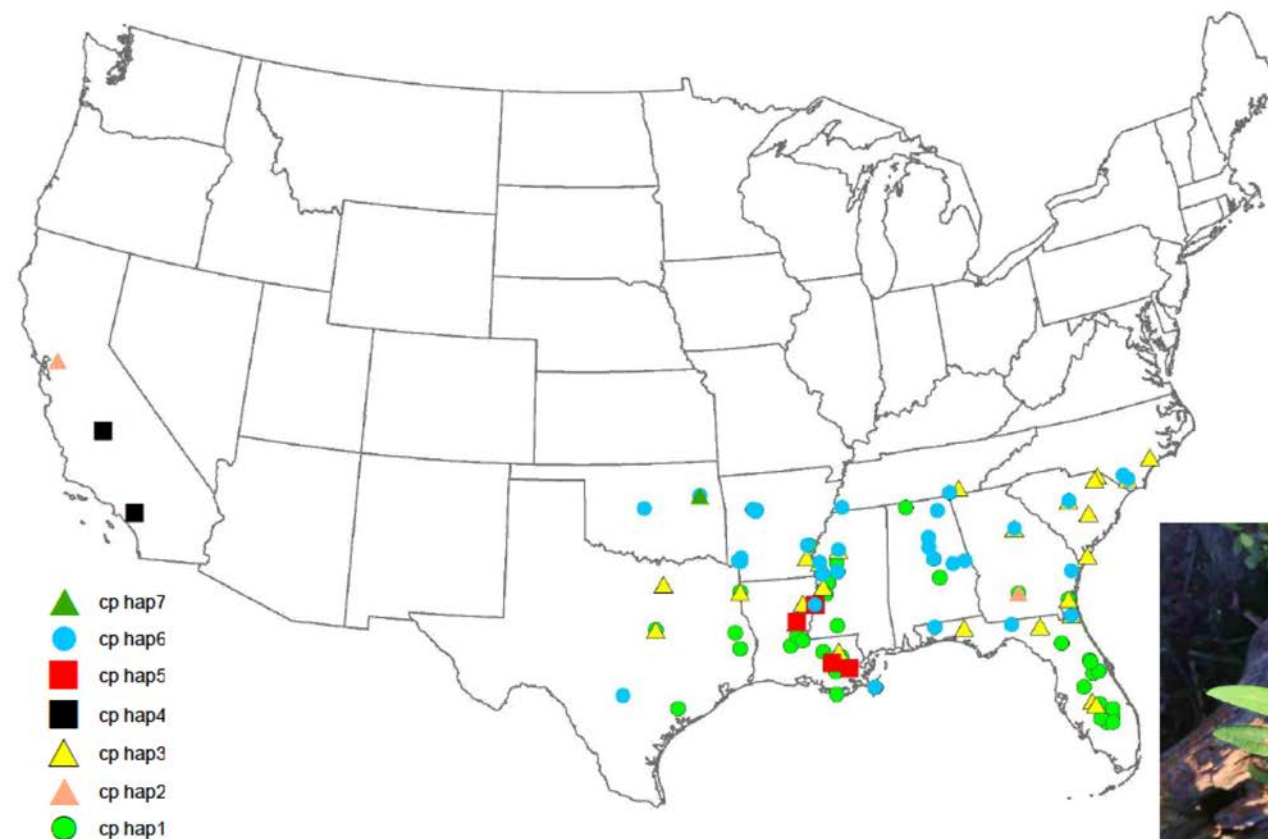
2n=102

Alternanthera philoxeroides cp hap2
1.5 Mallard Br. Sl, Suisun Marsh, Solano Co.



2n=102

Alternanthera philoxeroides, cp hap4
Visalia, CA (Tulare Co.)



- ▲ cp hap7
- cp hap6
- cp hap5
- cp hap4
- ▲ cp hap3
- ▲ cp hap2
- cp hap1

Dr. Dean Williams, Texas Christian University

Allopolyploid
Two Cytotypes, Argentina:
tetraploid (4X = ca. 68);
hexaploid (6x = ca. 102)
(Krug and Sosa 2019)



Growth form: Amphibious and terrestrial forms

Emergent aquatic stoloniferous perennial herb rooted in soil or sediment below shallow water;

Free-floating mats can persist; Floating stems to 15 meters long; terrestrial: tall emergent >2m tall



Free-floating Aquatic, Suisun Marsh



Floating-leaved Emergent Mat (rooted in sediment) in fringing tidal wetland, to Tall Emergent Macrophyte in aerated soil on levee

Montezuma Slough, Suisun Marsh **invading with *Ludwigia hexapetala*, water hyacinth – AND co-occurs with native wetland plants**

Emergent floating-leaved wetland macrophyte



Terrestrial herb: Pasture, Australia



Sediment-rooted Emergent Macrophyte: Arno River, Italy



TOLERANT OF A WIDE RANGE OF ENVIRONMENTAL CONDITIONS

AQUATIC TO TERRESTRIAL: Making it one of the world's most invasive weed species

Introductions have been linked to ballast water discharge, contaminated bird seed, contaminant in plants (i.e. contaminant in Bonsai plants exported from China), aquaria trade

Has invaded several climatic zones. Frost kills exposed stems and leaves, but protected stems enable the species to persist into the next season.

Can ***tolerate at least moderately brackish water salinity*** (anecdotal observations reported elsewhere; experiments proposed to determine tolerance here); found in freshwater and tidal systems

Tolerant of full sun, adapted to low light/shade conditions (up to 12% of full light) (Weber, 2003).

The species can enter dormancy without light and ***survives desiccation for prolonged periods***



**RISK OF SPREAD IS HIGH GIVEN HYDROLOGIC CONNECTIVITY
AND RAPID HYDROCHORUS DISPERSAL OF BOUYANT SHOOT FRAGMENTS**

**Human-assisted spread is high risk: SPREAD CAN BE SIGNIFICANTLY ACCELERATED BY
WATER-BASED RECREATIONAL, COMMERCE AND ENVIRONMENTAL MONITORING
ACTIVITIES**

Spread to new areas may also be facilitated by water fowl as shown by other invasive species in other aquatic systems around the world

Riparian and Wetland Restoration Projects AT RISK for Invasion

POTENTIAL AGRICULTURAL IMPACTS



High vulnerability: irrigated/flooded rice crops – weed in rice in native and invasive range; also impedes irrigation and drainage – irrigation supply ditches and drains and invades adjacent vegetation.

A. philoxeroides has established as a WEED in terrestrial agricultural systems
Has reduced yields of crops species including:

Rice (45%)

Wheat (36%)

Sweet potato (63%)

Lettuce (47%)

Corn (19%)

In North Carolina, alligator weed impacted >4000 ha of crops
(Shen *et al.* 2005; van Oosterhout, 2007).

Alligator weed presents a **risk for the vegetable industry** valued at \$150 million annually in the Hawkesbury–Nepean catchment Australia (<http://weeds.dpi.nsw.gov.au/Weeds/Details/7#TOC>).

In Sri Lanka *A. philoxeroides* competed with the vegetable industry in particularly carrots in 2004

SOURCE:EPPO (2015) *Pest risk analysis for Alternanthera philoxeroides*. EPPO, Paris.

Available at http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm

Co-Invades with other aquatic invasive plants (i.e water hyacinth, Uruguayan primrose-willow)

Impacts:
Displaces open water habitat
Displaces native vegetation
Degrades water quality
Impedes water management, navigation, recreation

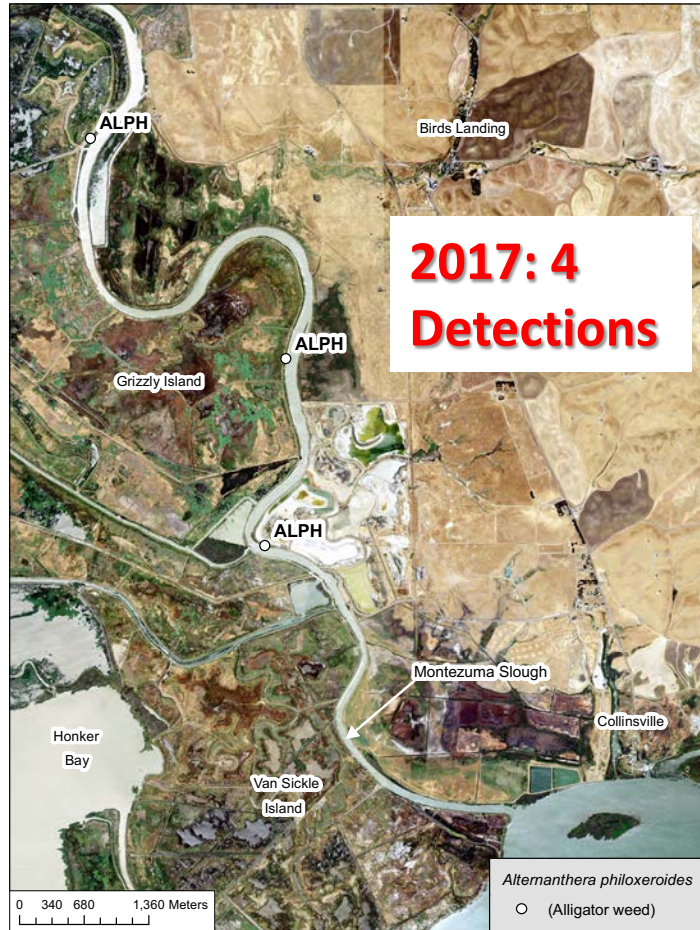


Managed Wetlands,
- Waterfowl Habitat, Wildlife Refuges – highly vulnerable.

Alligator weed pile-up outside of water control structures (Solano Co)

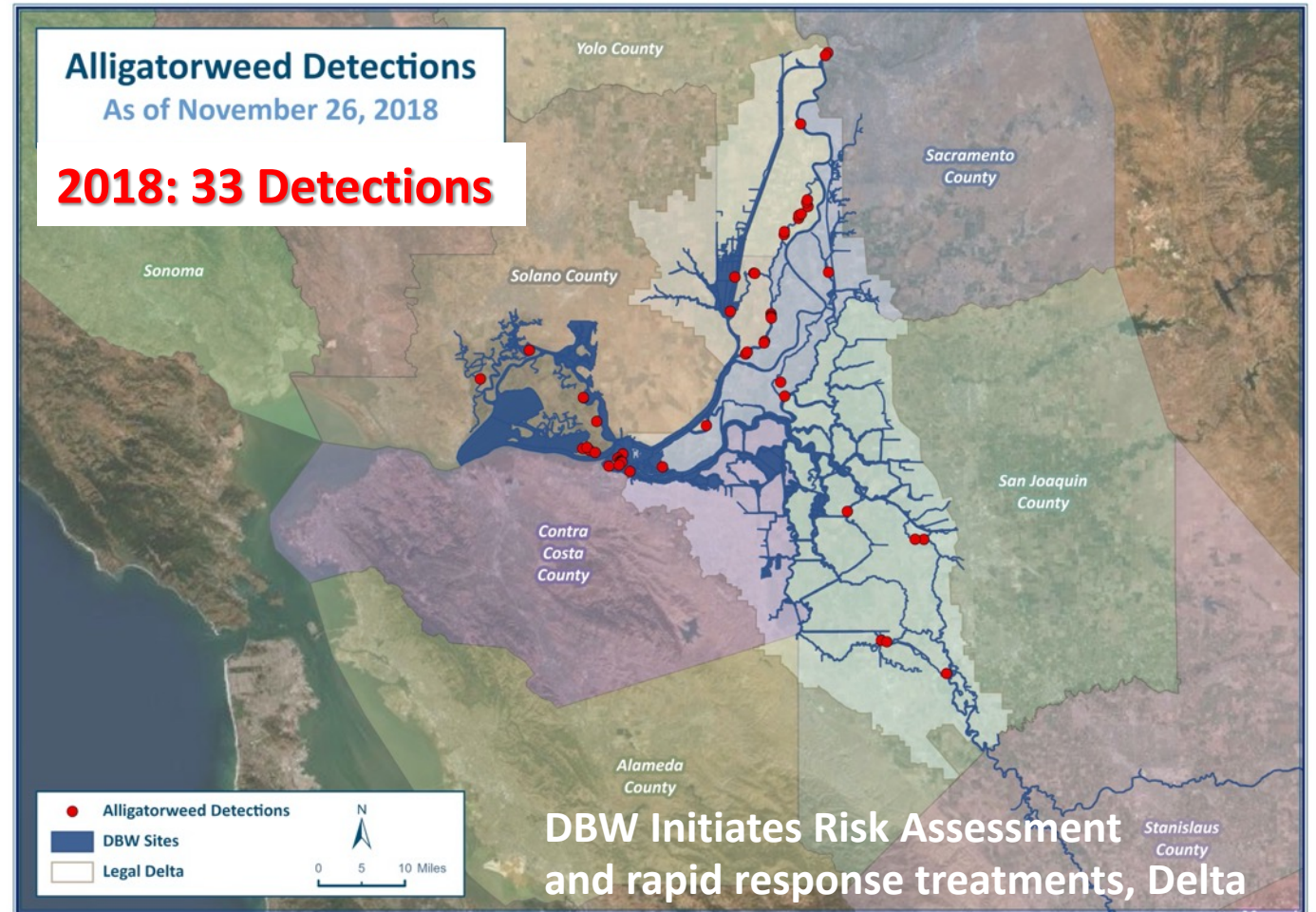


First Northern California Record:
Alligator Weed, **August 2017**
Montezuma Slough, Suisun Marsh



Also detected by Tower Bridge, Sacramento River, Sept. 2017 (Walden, CDFA)

NORTHERN CALIFORNIA DISCOVERY: 2017 First Known Occurrence



California Department of Parks and Recreation
Division of Boating and Waterways

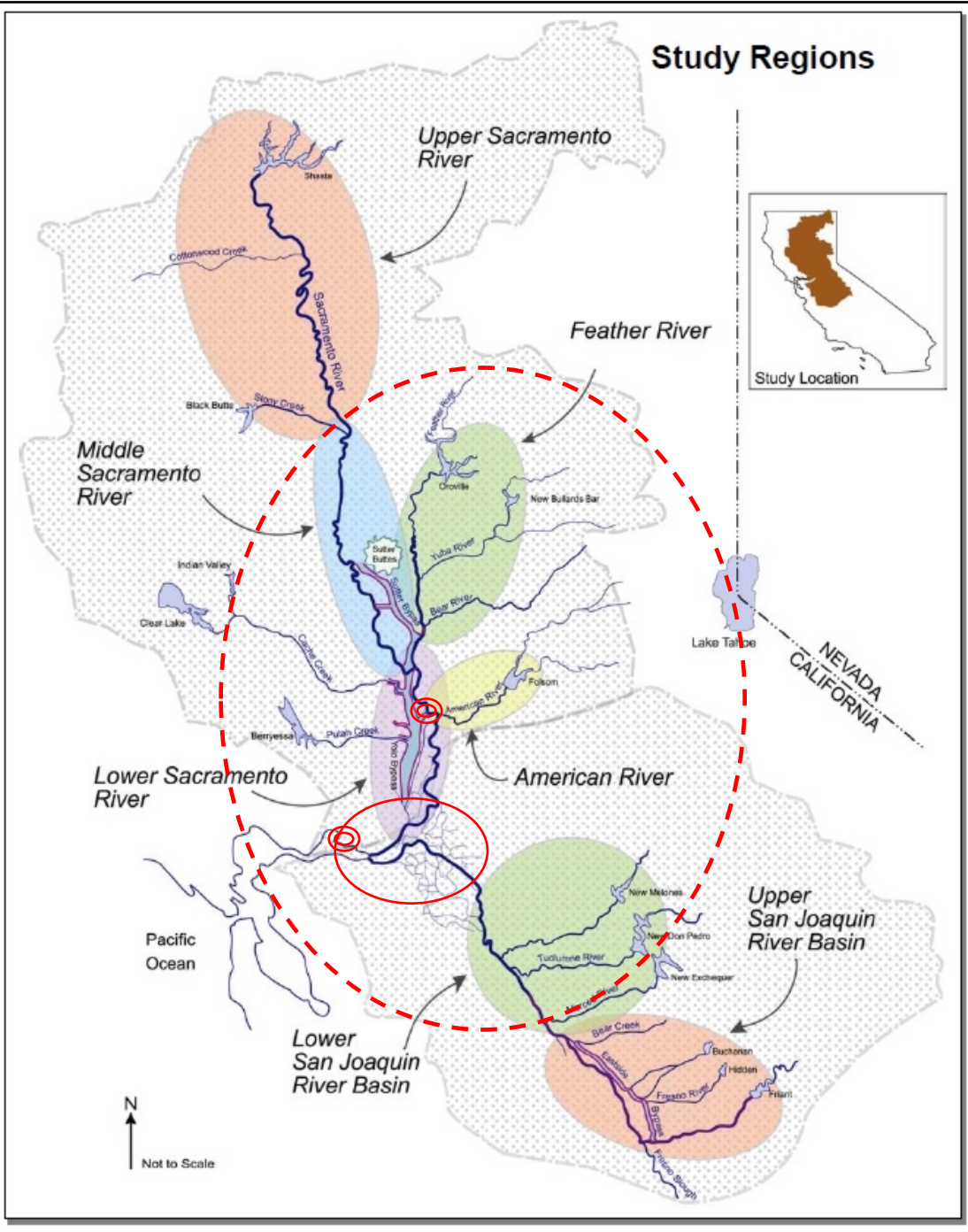
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Map credit: Michael Kwong, DBW

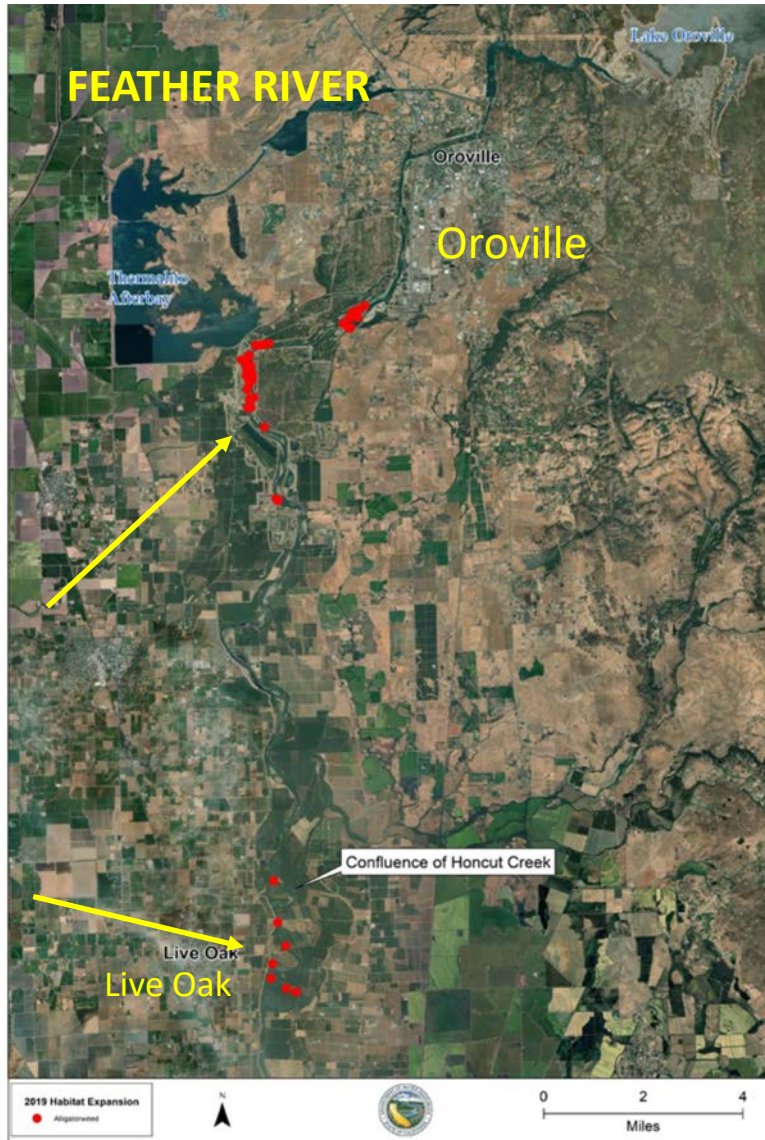
2019 Alligator Weed Blitz Survey

Increase knowledge of alligator weed distribution upstream of Delta, to prioritize and facilitate management

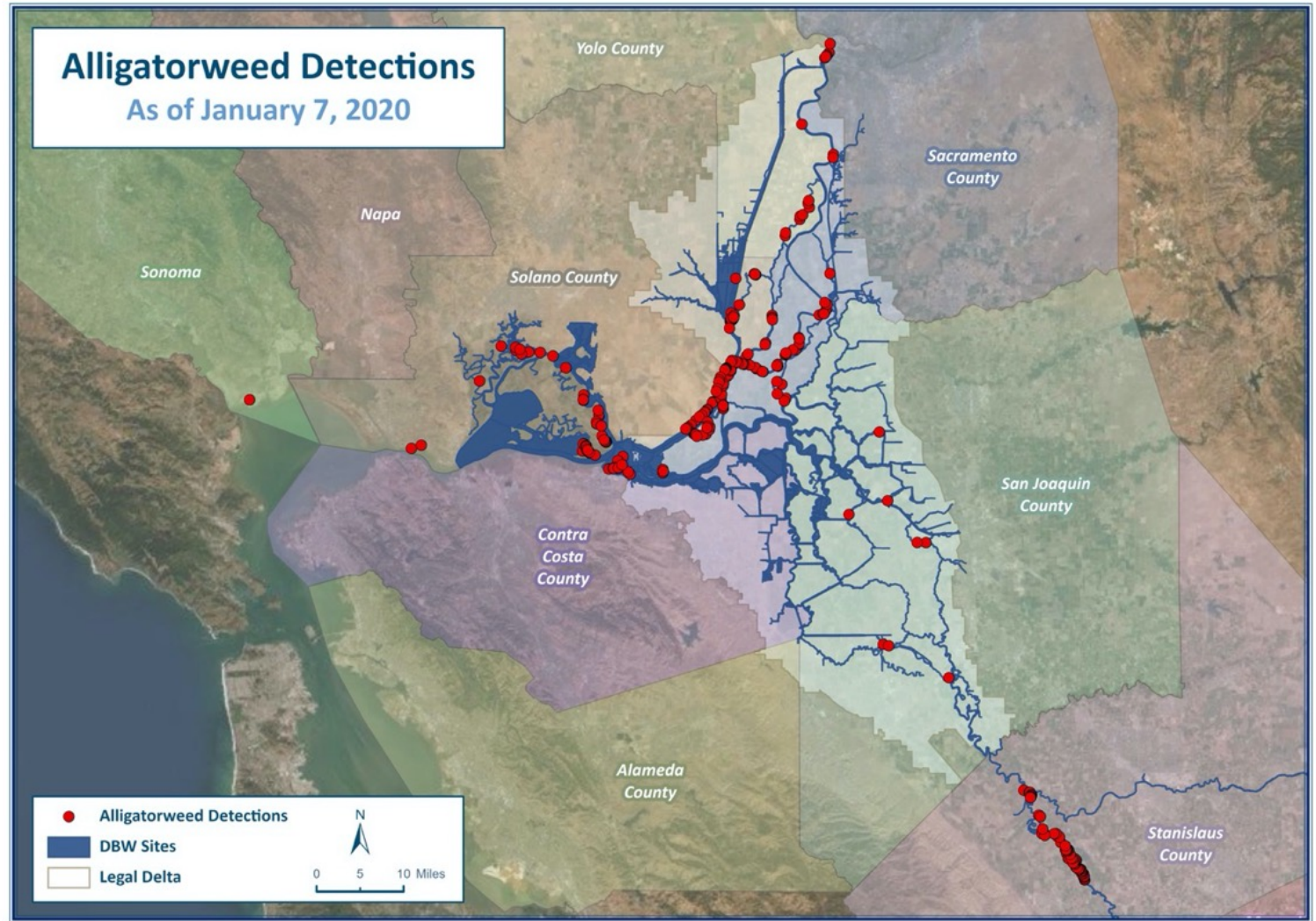
- **35 people** (multi-agency/organization volunteers participated in survey activities on 30 different combinations of teams using standardized census forms developed by the **agency/organization**) workgroup; **28 separate survey days**
- **387 total alligator weed detections** during the blitz survey period (July – Dec 2019)
- **33 Div. Boating and Waterways mgmt. sites** included in census during the blitz survey period
- **Surveyed, No detections:** Tuolumne River, American River, **Colusa Basin Drain near terminous (Yolo Co. Knights Landing)**; Suisun Marsh: boat surveys Hill Slough, Peytonia Slough, Boynton Slough, Wells Slough, Suisun Slough; spot checks public access sites Sacramento River Feather River confluence to Sacramento



2019 Alligator Weed Workgroup Blitz Survey RESULTS; **Total Detections: 387**



Map credit:
Robin Carter-Ervin, DWR and Joy Futrell USDA-ARS



California Department of Parks and Recreation
Division of Boating and Waterways

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February 1, 2020 10:41 AM Alligatorweed PowerPoint - M.Kwong

Map credit: Michael Kwong, DBW

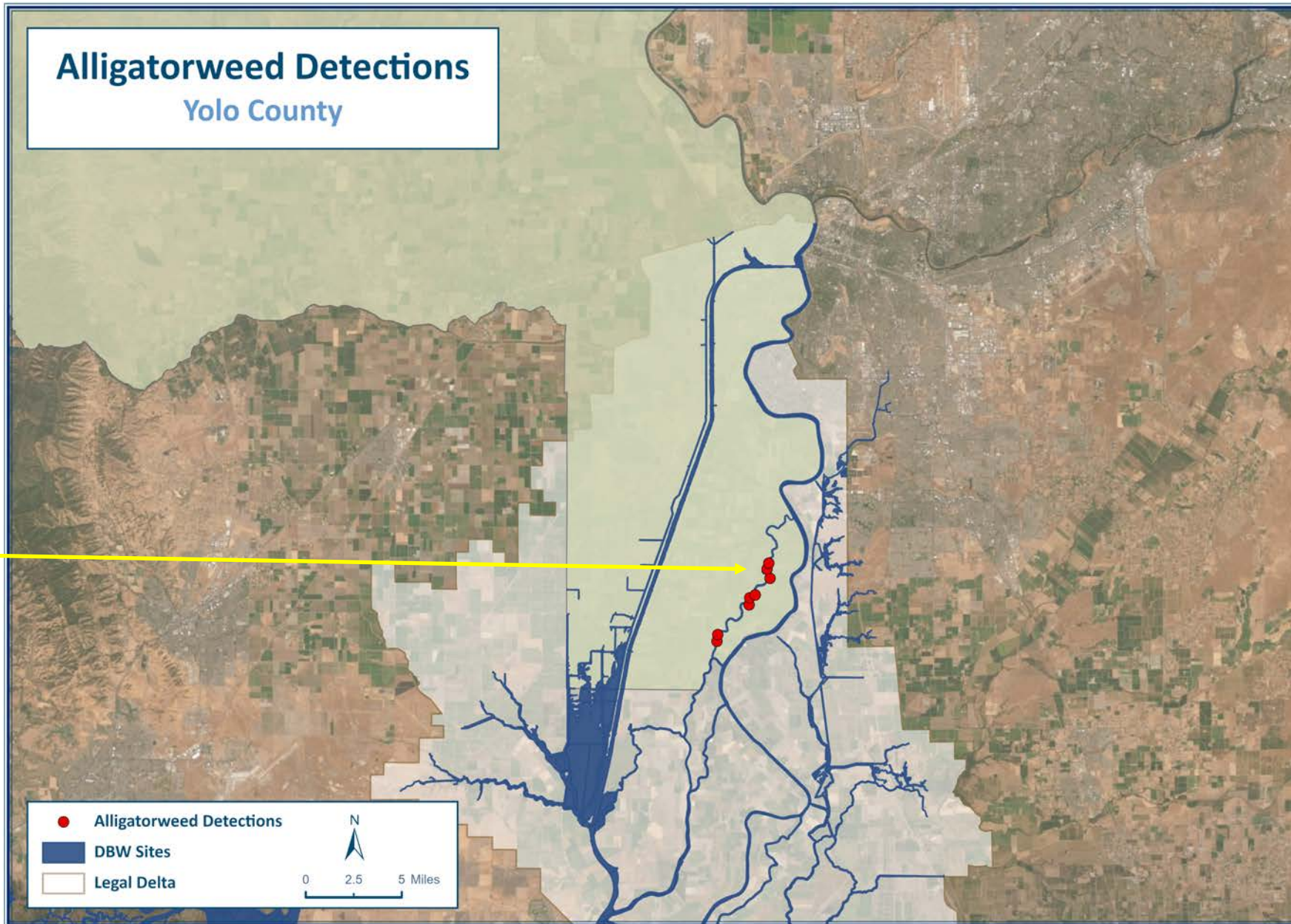
Alligatorweed Detections Yolo County

**ELK SLOUGH
(INVADED!)**

~ Courtland Rd
to Clarksburg

R.D 999
Main canal
intake at Elk Sl.,
distribution
network have
not been
checked
Prospect Sl,
Not checked

**HIGH
PRIORITY
Watch Areas:
YOLO BYPASS;
areas
diverting
water from
Sacramento
River**



California Department of Parks and Recreation
Division of Boating and Waterways

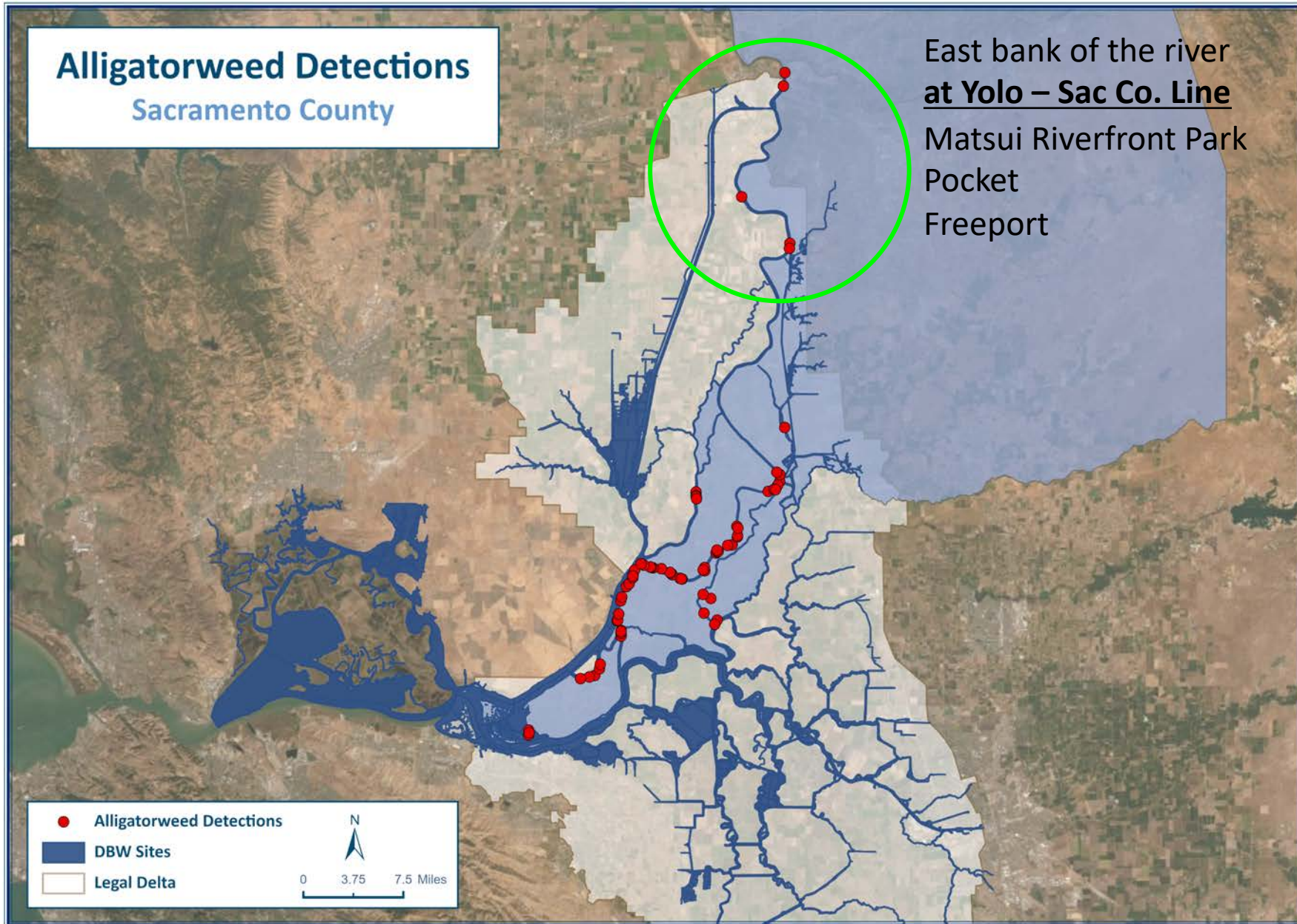
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March 4, 2020: IAV_Alligatorweed_Powpoint_Slides - D Coye

Map credit: Michael Kwong, DBW

Alligatorweed Detections

Sacramento County

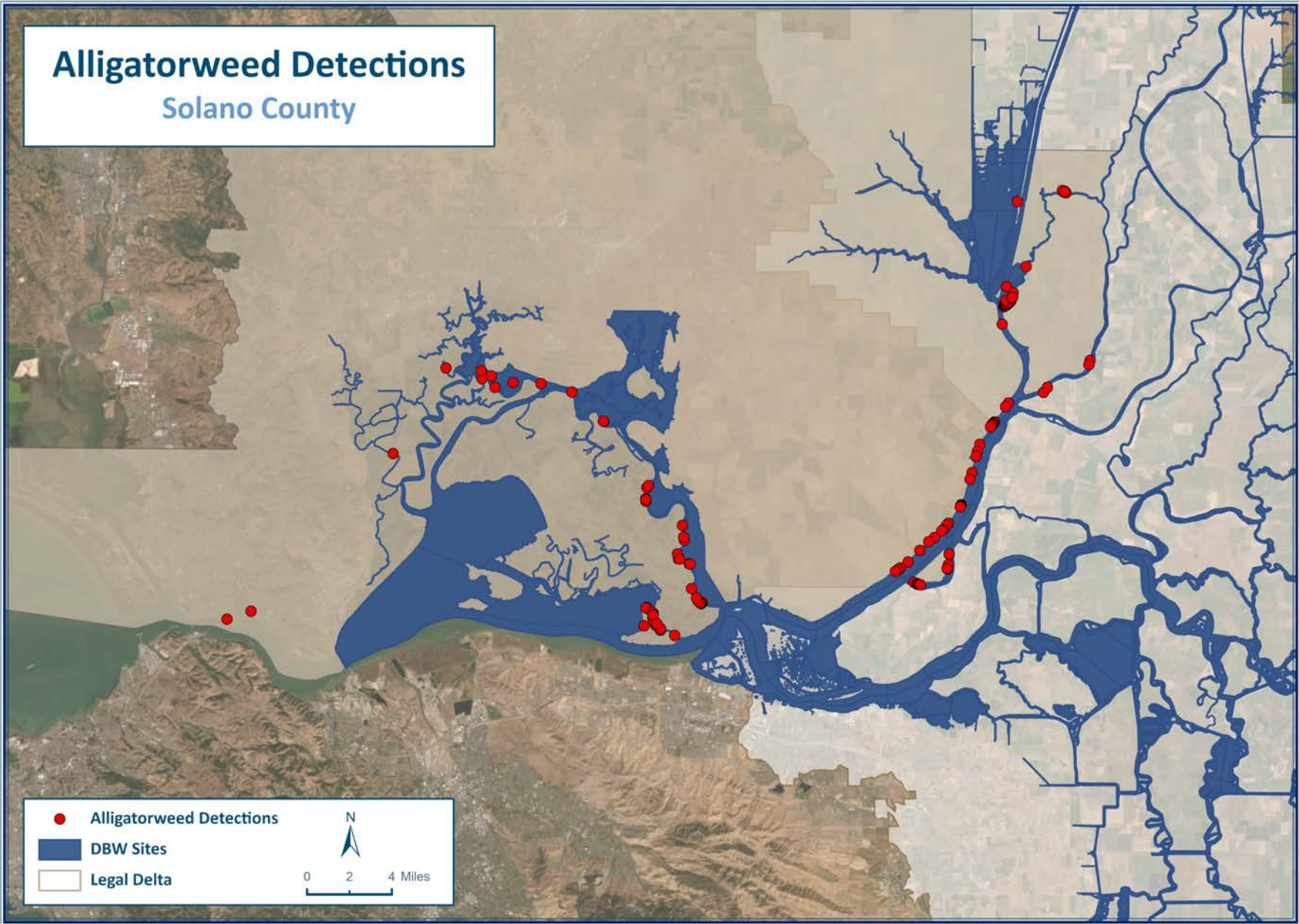
East bank of the river
at Yolo – Sac Co. Line
Matsui Riverfront Park
Pocket
Freeport



California Department of Parks and Recreation
Division of Boating and Waterways

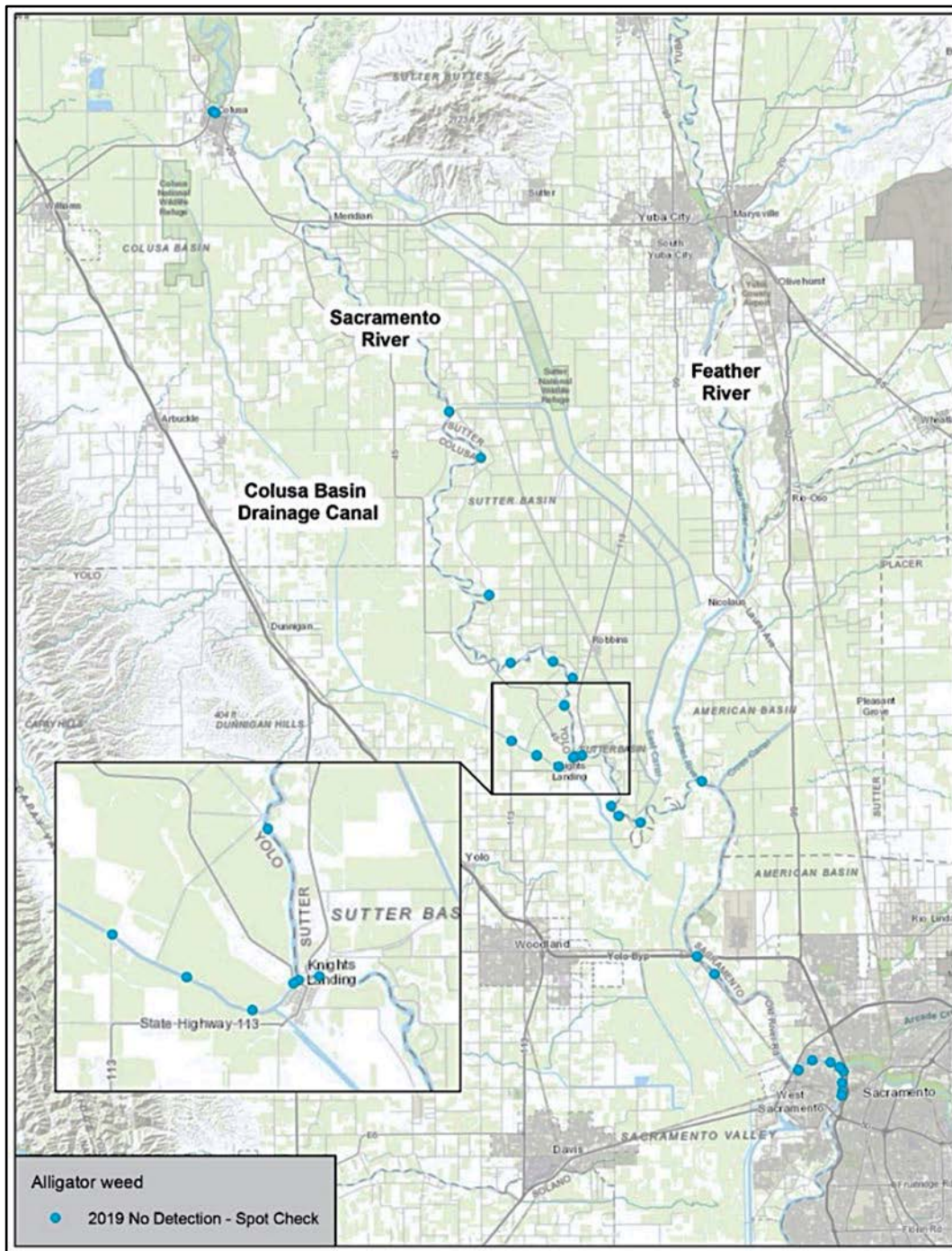
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March 4, 2020: IAV_Alligatorweed_Powerpoint_Sacramento D.Cope

Map credit: Michael Kwong, DBW



Prospect Slough, Yolo County reach should be checked





Middle Sacramento River Watershed

23 Spot observations

- Public Boat Launches
- Public Parks
- Side of road along river

Distance surveyed with spot checks:
~90 River Miles (not comprehensive boat survey)

Results:

No Alligator Weed Observed 2019

Manual, Mechanical, Chemical, and Biological Control have been used for Alligator Weed Management

Efficacy of management depends method, timing, and local environmental context
Development and testing of options are needed for local climate and habitats



China: Manual Removal, Mechanical Harvesting

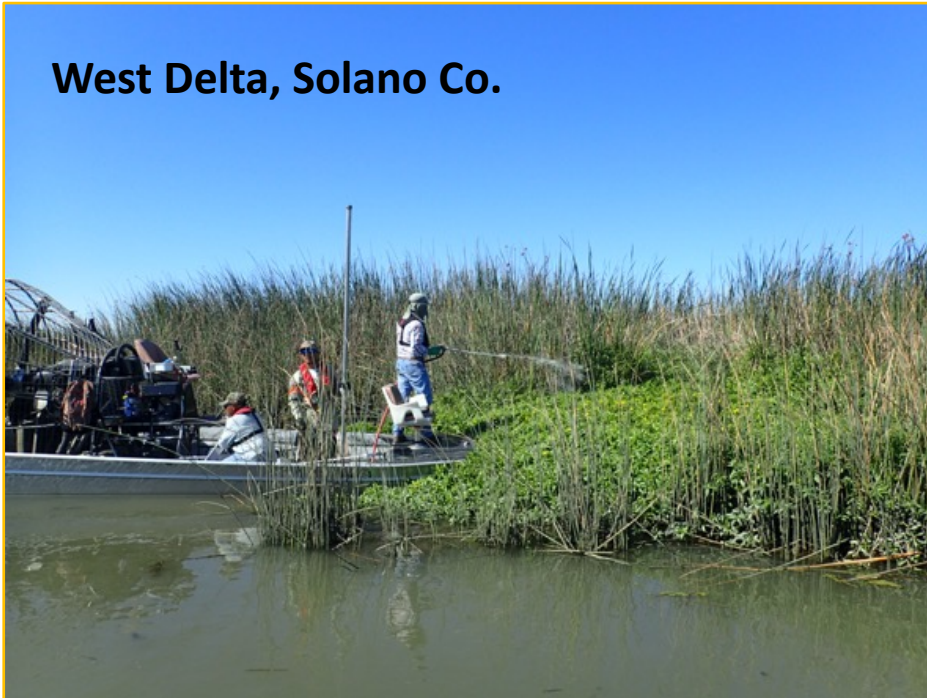


INTEGRATED WEED MANAGEMENT HAS BEEN EFFECTIVE ELSEWHERE

NSW, Australia: **herbicide application followed by mechanical removal** (using float booms to trap fragments)

Biological control coupled with herbicide followup has been highly effective in aquatic environments (Australia, New Zealand, Thailand, Florida and other warm areas of southeastern USA)

West Delta, Solano Co.



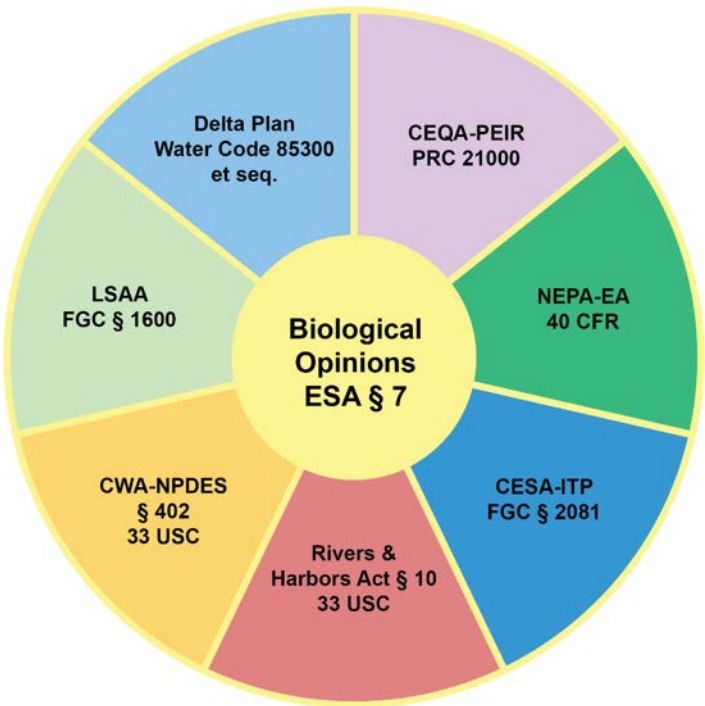
Sac-San Joaquin Delta: Biological Opinion – Permit Restricted Methods to Protect T&E Species such as Delta Smelt

Glyphosate w/AgriDex treatments, tidal Sac-SJ Delta (initiated 2018 after risk assessment; biological opinion Delta Only – Suisun prohibited) slow-acting, broad-spectrum herbicide

Glyphosate – Imazamox mix w/Competitor Small-scale field trial underway (not permitted for general use. Adds faster acting selective herbicide for floating or emergent aquatic weeds. Binds with enzyme in plant to stop growth. Low risk to food web, considered low -nontoxic to fish and wildlife

Aquatic Weed Management Limitations

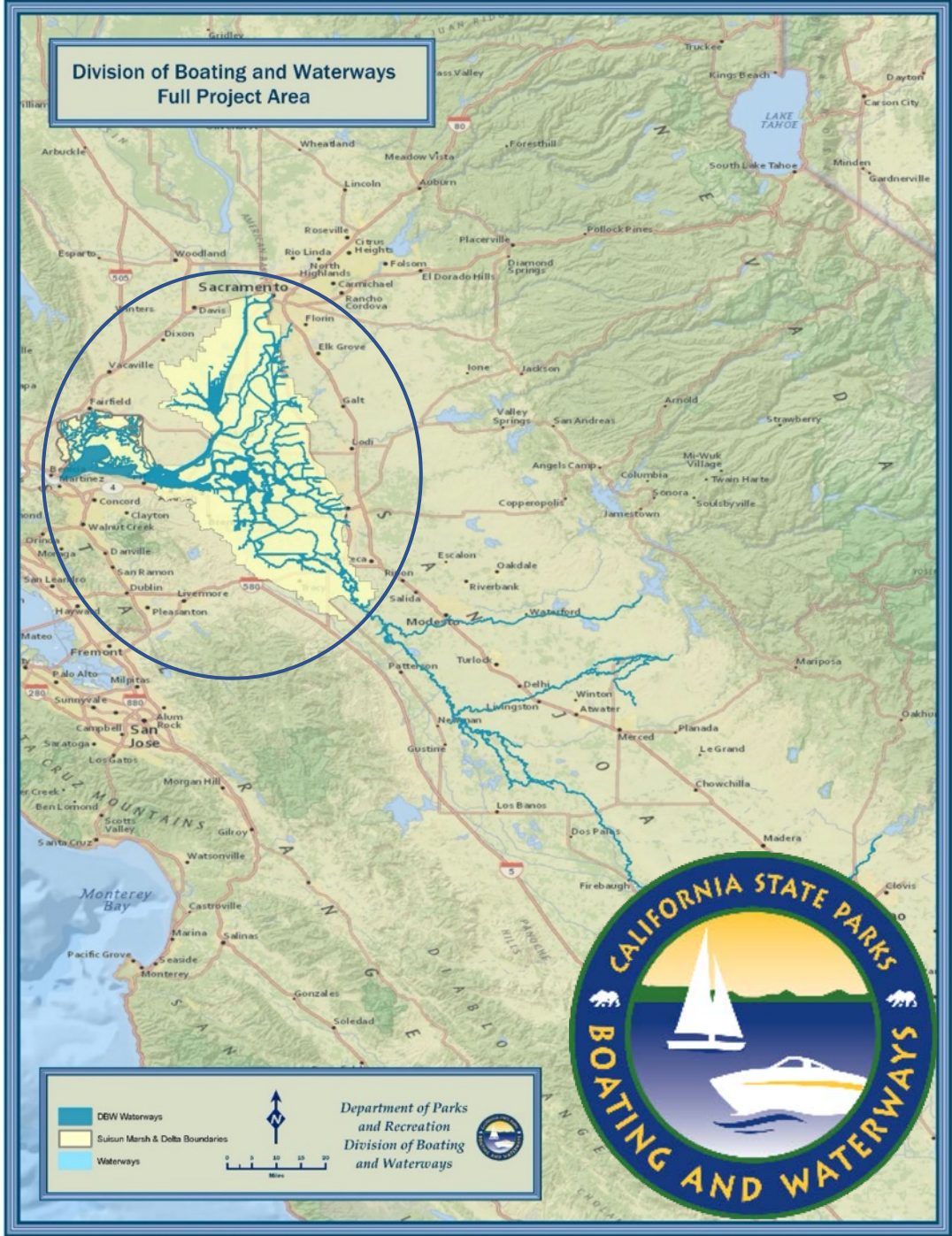
- Dept of Parks & Recreation, Div. Boating & Waterways
Current Staffing - 3 specialists and 4 technicians
- Limited jurisdiction:
 - Delta and its surrounding tributaries, currently cannot treat alligator weed/aquatic weeds in Suisun Marsh
 - Focus: Floating or Submersed (not emergent)



Current Permits Limit Target Weeds and Geographic Scope:

Focal weed species and methods that passed the California Department of Fish and Wildlife (CDFW) risk assessment Harbors and Navigation Code 64.5

United States Fish and Wildlife Service (USFWS) Biological Opinion





Treatment Limitations

- Current Staffing (March 2020)
 - Short - 3 specialists and 4 technicians
- **Limited jurisdiction**
 - Delta and its surrounding tributaries, currently cannot treat Suisun Marsh
 - Floating or Submersed (not emergent) **(!!!!)**

Treatments limited to weed species that passed the California Department of Fish and Wildlife (CDFW) **risk assessment** (Harbors and Navigation Code 64.5)

And current United States Fish and Wildlife Service (USFWS) **Biological Opinion**

Table 1 – Risk Assessment Scores

Floating or Submersed Vegetation	Common Name	Scientific Name	Score	Date of Determination
SAV	Brazilian waterweed	<i>Egeria densa</i>	*	Not Available
FAV	Water hyacinth	<i>Eichhornia crassipes</i>	*	Not Available
FAV	South American spongeplant	<i>Limnobium laevigatum</i>	*	Not Available
SAV	Curlyleaf pondweed	<i>Potamogeton crispus</i>	66	June 12, 2015
SAV	Eurasian watermilfoil	<i>Myriophyllum spicatum</i>	76	June 28, 2016
SAV	Coontail	<i>Ceratophyllum demersum</i>	58	October 14, 2016
SAV	Fanwort	<i>Cabomba caroliniana</i>	75	January 25, 2018
FAV	Uruguay water primrose	<i>Ludwigia hexapetala</i>	76	July 22, 2016
FAV	Alligatorweed	<i>Alternanthera philoxeroides</i>	74	March 1, 2018

**Egeria densa* was determined to be an invasive in 2001, prior to the use of this scoring tool.

*Brazilian waterweed, water hyacinth and South American spongeplant were determined to be invasive, prior to the use of this scoring tool.

Risk Assessment of Potential Herbicides per USFWS Biological Opinion for
 DBW Aquatic Invasive Plant Control Program – Sacramento - San Joaquin Delta waterways
 Timing/Spatial prohibitions in place for protection of T&E species (especially Delta Smelt)

USFWS Biological Opinion Risk Assessment for DBW AIPCP Herbicides

Alligator weed - Delta →

Sm Scale Pilot Test →

<u>Herbicide</u>	<u>Risk to Delta Smelt</u>	<u>Risk to Food Web</u>
2,4-D (FAV)	Moderate	Low
Glyphosate (FAV)	Low	Low
Penoxsulam (FAV)	Low	Low
Imazamox (FAV)	Low-Moderate	Low
Diquat (FAV)	Low	Moderate-High
Imazapyr (FAV)	Low	Low
Carfentrazone-ethyl (FAV)	Low	Low
Flumioxazin (FAV)*	Moderate-High	Low-Moderate
Florpyrauxifan-benzyl (FAV)	Moderate	Low
* high uncertainty toxicity		
**high uncertainty bioaccumulation		

Emergent Wetland Plants – Terrestrial forms not included in permitted program
Moratorium – No treatments 2019 to present in Suisun Marsh – new Biological Assessment Needed
2019 SMALL SCALE Pilot-scale herbicide test 2019, to support Suisun Marsh Biol. Assessment

BIOLOGICAL CONTROL FOR IWM

In Florida, in the 1940's economic costs for control of alligator weed and water hyacinth was over \$20 million per year. In 2002, the USA control costs for alligator weed were estimated at \$170 - \$370 per ha using herbicides glyphosate and fluoridone (Van Driesche et al. 2002).

In recent years (2012-2015) treated area was reduced to 62 acres with a total cost of \$9,000 in Florida due to the effectiveness of biological control agents under Florida climate conditions (pers com Jeff Schardt, 2015; EPPO 2015)

In 1960, surveys by the U.S. Department of Agriculture began in South America to search for alligator weed-feeding insects that could be used to provide control in the United States

The alligatorweed flea beetle *Agasicles hygrophila* was introduced into Louisiana in 1970. The first U.S. release of *A. hygrophila* was made at alligator weed populations in southern California in 1964 (Coulson 1977), but the beetles failed to persist and were impacted by mgmt.



Successful overwintering of *A. hygrophila* and resulting weed control is influenced by temperature, with failures occurring in areas with average minimum winter temperatures below 9°C (Coulson 1977).

Photos: Nate Harms USACE, Graham Montgomery

Research is underway to support management in California

Winter severity tied to northern range limits of at least the flea beetle
Cold-hardy insect populations are needed for n. CA



Research is underway to discover and compare cold-hardy populations of the alligator weed biological control agents and investigate their suitability for more temperate ranges of the exotic plant's distribution.

Amynothrips

Agasicles hygrophila



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Nathan Harms, US Army Engineer Research and Development Center, Aquatic Plant Control Program, Vicksburg MS

Mike Pitcairn, CDFA

WHAT CAN WE DO ?

OPPORTUNITIES FOR PARTNERSHIPS, EXPANDED DETECTIONS AND LOCAL MANAGEMENT RESPONSE EFFORTS

COORDINATE EFFORTS and SHARE KNOWLEDGE:

Participate: Northern California Alligator Weed Workgroup

\$ PURSUE FUNDING OPPORTUNITIES: CDFA. WEED MANAGEMENT AREAS, and?

SEASONAL OPPORTUNITIES FOR MANAGEMENT IN TERRESTRIAL HABITAT?

Shoreline – emergent/terrestrial growth forms

Integrate weed mgmt. and habitat restoration plans,

SUPPORT AND COOPERATION FOR RESEARCH

TO DEVELOP BIOLOGICAL CONTROL AND EVALUATE INTEGRATED WEED MANAGEMENT ALTERNATIVES

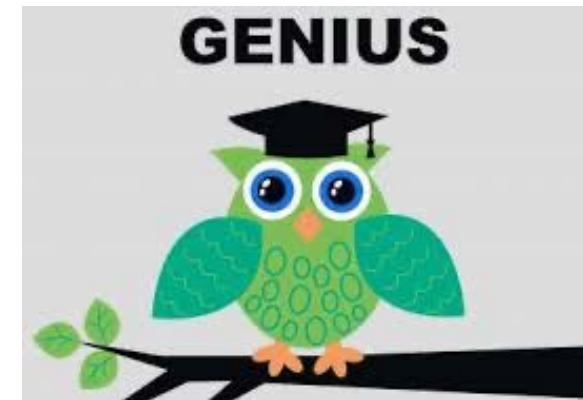
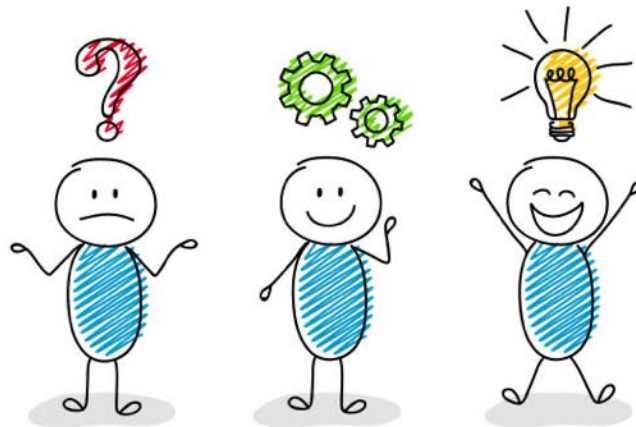


....and now for a **QUIZ** to demonstrate your brilliance!



AW-1. What are two morphological characters of alligator weed that are diagnostic for identification.

AW-2. Describe at least two growth forms of alligator weed that can occur in response to different environmental conditions.





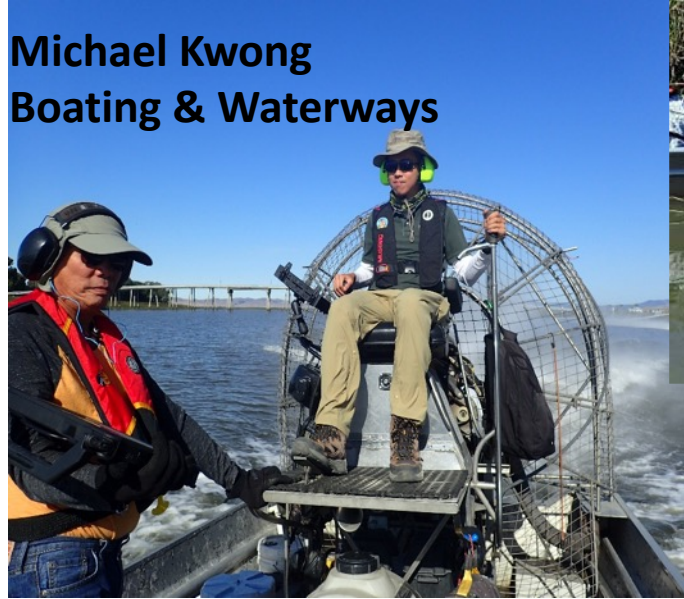
Thanks!

**CALIFORNIA
ALLIGATOR WEED
WORKGROUP**



UC DAVIS
DEPARTMENT OF
PLANT SCIENCES

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**USDA ARS Project: Integrated Weed Management and Restoration Strategies
to Protect Water Resources and Aquatic and Wetland Ecosystems in the Far Western U.S.**