



Detecting Floating Aquatic Vegetation in the Sacramento-San Joaquin River Delta using the Sentinel-2 Satellite

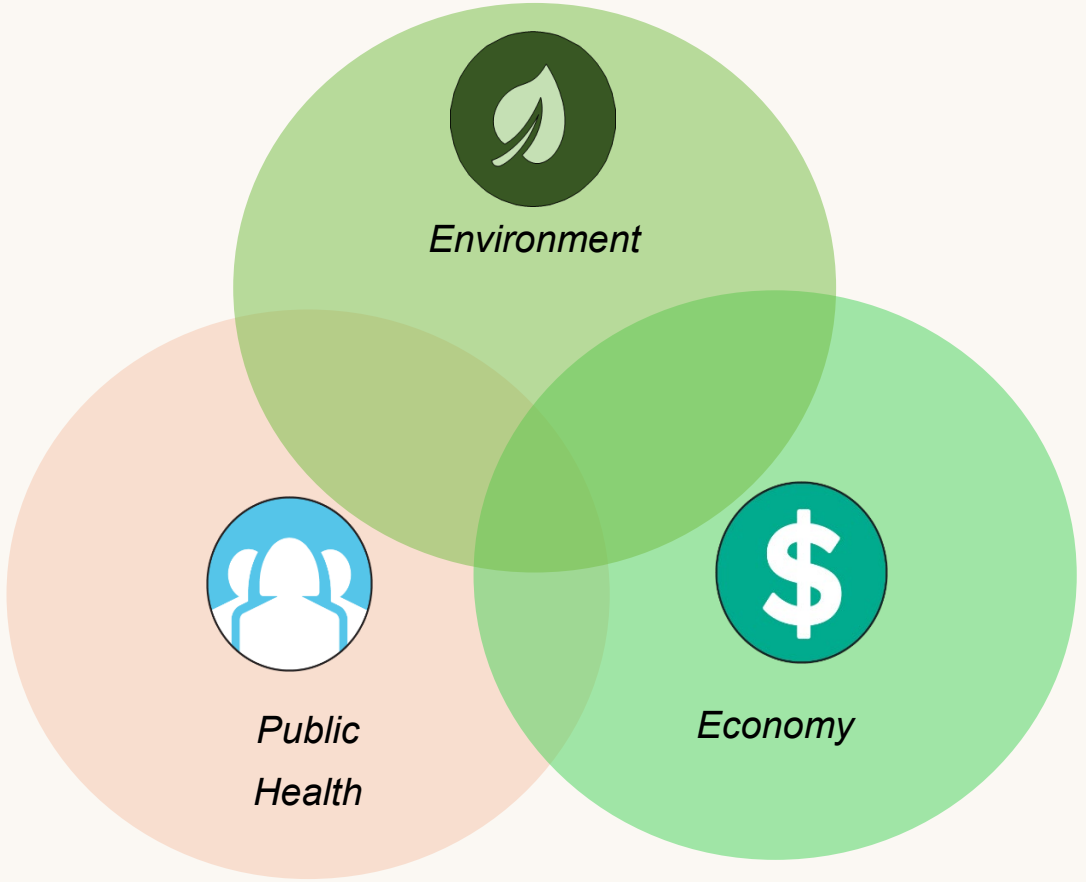
By: Maxwell J Sadowski, Guphy Gustafson & Abdul Manan Ahmadzai

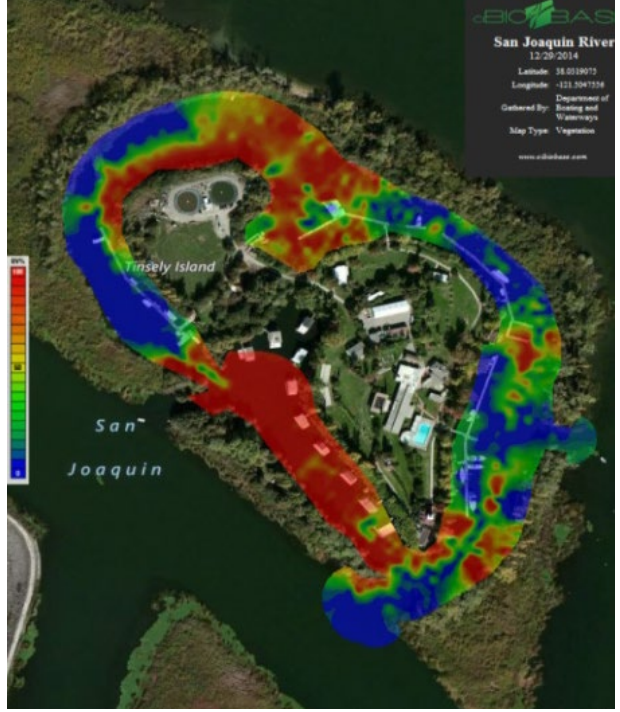
MISSION

Aquatic Invasive Plant Control Program

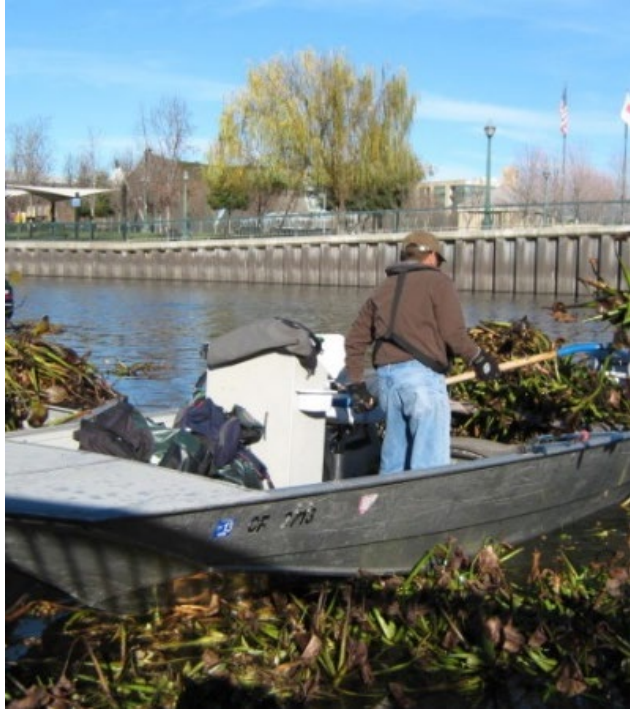
The lead agency for controlling aquatic invasive plants in the California Delta through cooperation with Local, State, and Federal agencies.

- Purpose: detect, identify, control, administer, and manage
- Eradication where possible
- Permissive program













Integrated Control Strategy
Floating and Submersed Vegetation

- Herbicide Treatments
- Mechanical Harvesting
- *Biological Controls*
- Physical Removal
- *Physical Controls*

AIPCP Target Species Timeline



Water hyacinth

1983



South American spongeplant

2013



Uruguay waterprimrose

2016



Alligatorweed

2018

2001

2015

2016

2017

2022



Brazilian waterweed



Curlyleaf pondweed



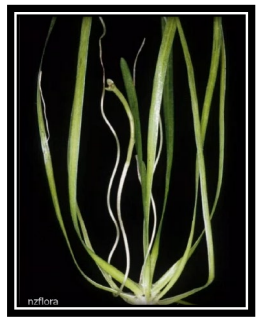
Eurasian watermilfoil



Coontail



Carolina fanwort



Ribbonweed

Floating Aquatic Vegetation (FAV) Target Species



Water hyacinth
(1983)



South American spongeplant
(2013)



Uruguay waterprimrose
(2016)



Alligatorweed
(2018)

Detect / identify:

- FAV are highly visible but grow together

Control:

- Herbicides: primary method of control
- Biocontrol: Weevils & Planthoppers
- Mechanical harvest: high cost, high disturbance

Manage:

- Utilize satellite imagery for monitoring FAV growth

FAV Impacts in California

- Waterway access
- Commerce
- Agriculture
- Water availability
- Public Health
- Environmental Health
- Restoration efforts

- Port of Stockton & Port of West Sacramento
  - The Ports serve the agricultural, natural resources, and construction sectors in Northern California.





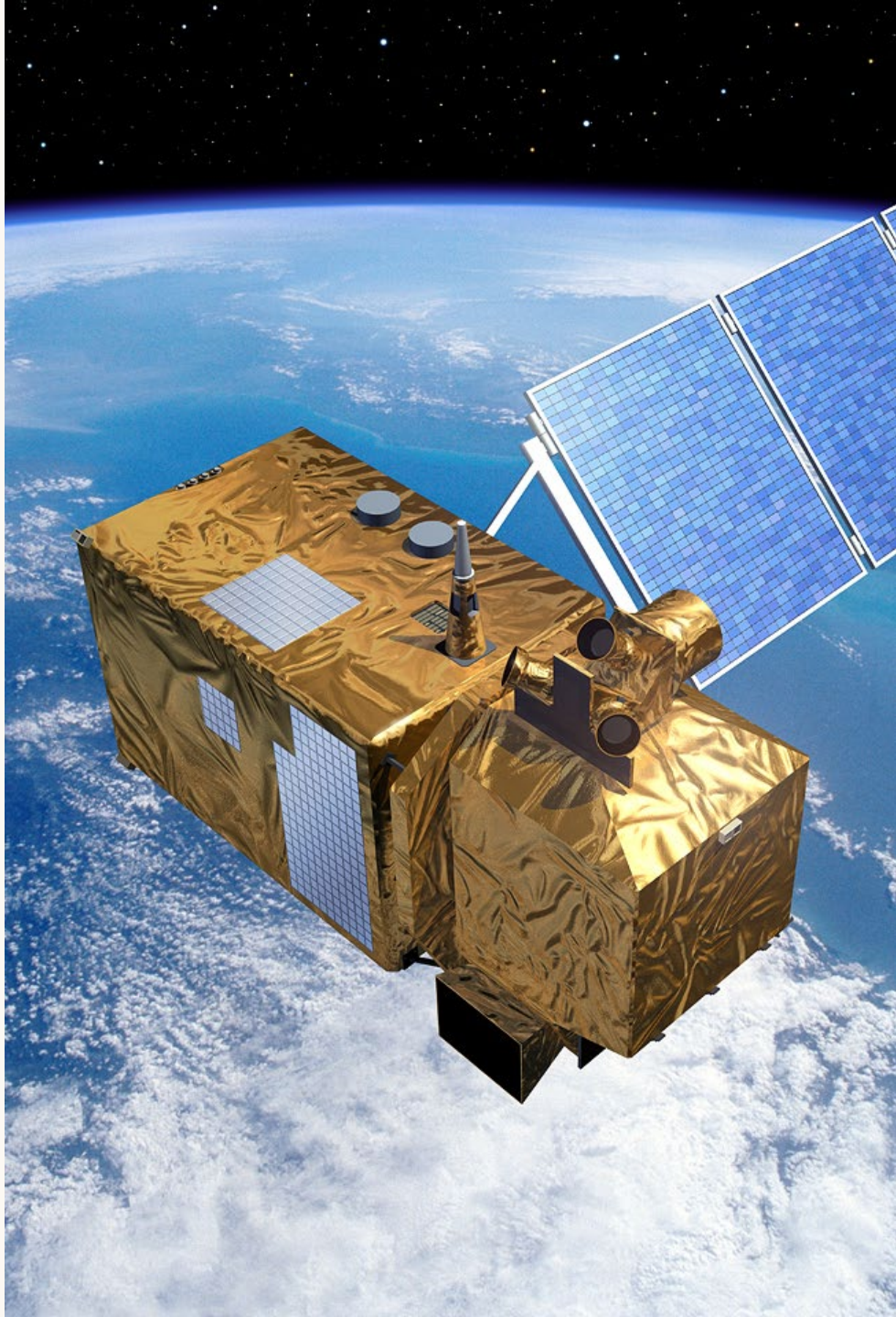
FAV Remote Sensing Goals

- Awareness of FAV growth within treatment areas
  - Monitor FAV movement
  - Identify & monitor FAV nurseries
- Streamline ESRI Dashboards and Fieldmaps used by treatment staff.
  - Operations managers informed of FAV growth.
- Share FAV management progress with policy and decision makers.



Sentinel-2 Satellites

- European Space Agency launched Sentinel 2A, 2B and 2C from 2015 -2024.
- Satellites photograph the AIPCP treatment area in 10-day cycles.
- The Division of Boating and Waterways (DBW) signed it's first contract with NASA in 2021.
  - Developed current process of utilizing satellite imagery to track FAV.



Initial Challenges

- Our treatment area encompasses over 200 miles.
  - Ranging from Sacramento to Fresno.
- NASA suggested only processing data that contains less than 50% cloud cover.
  - 2/5 tiles include the Sierra Nevada mountains
    - There are often more clouds in these tiles due to the mountain range.
  - However, these clouds do not cover our treatment areas.

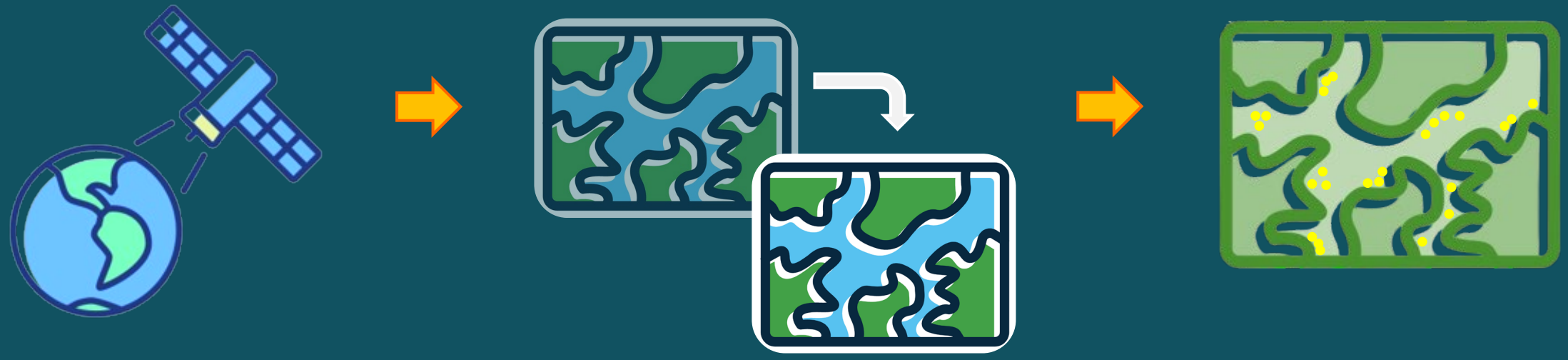


NASA Partners Created Landcover Map of FAV using FAI

Satellite Imagery

ACOLITE Correction

FAI (Floating Algal Index)



Atmospheric Correction of Sentinel-2 Imagery using ACOLITE

- Removes atmospheric effects (haze, aerosols).
- Enhances surface reflectance accuracy.
- Essential for landcover classification and change detection.



Mapping Floating Aquatic Vegetation (FAV) Using FAI Outputs for the Delta Region

FAI

(Floating Algal Index): quantifies the presence of floating algae in water

FAI is calculated using surface reflectance values from Sentinel-2.

Thresholds of FAI > 0.15 are applied to identify floating vegetation.

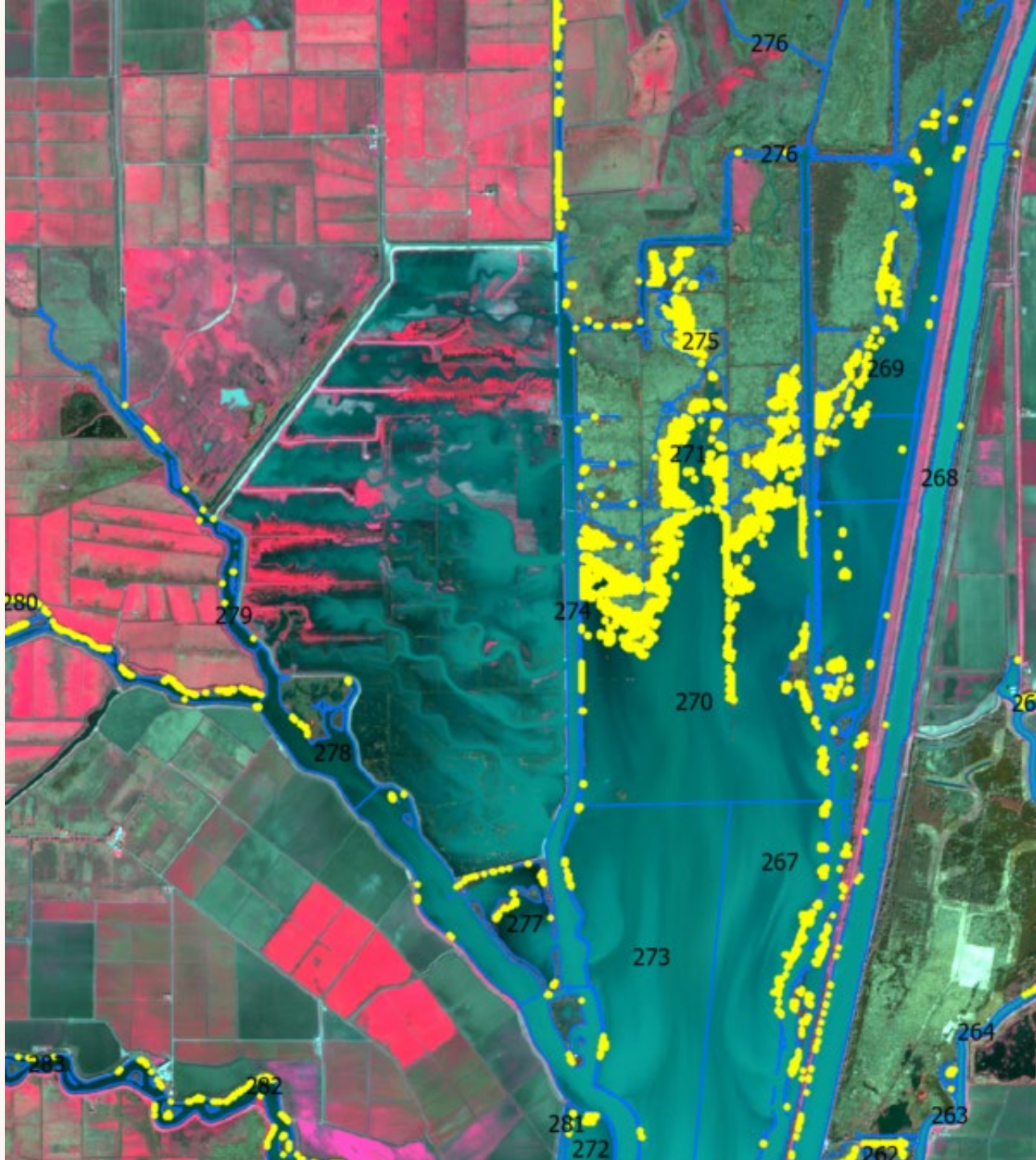
FAI

Advantages

FAI is less affected by atmospheric interference.

FAI works well in turbid or complex water where traditional chlorophyll-based indices may fail.

FAI is specifically designed to detect floating vegetation.



FAI Hurdles

- Treatment boundaries
  - Boundary lines influence FAV detections.
- Senescence
  - Treated plant matter takes a while to disappear from the waterway and therefore satellite imagery.
- Tules & topped out SAV
  - Tules appear as FAV in satellite imagery and imitates similar growth patterns.
  - Topped out SAV on the surface of the water can be confused for FAV.
- Riparian overhang
  - Appears as FAV in satellite imagery.
- Clouds
  - The sentinel cannot see through clouds.
  - Seasonal weather impacts our usual 10-day cycle of imagery.





Hurdle 1:

Treatment boundary

Treatment boundaries need to be updated to prevent misidentification of FAV.

Proposed Solution:

- Manually correct treatment boundary.

- Example: identify and exclude newer built boating facilities.





Hurdle 2:

Senescent FAV

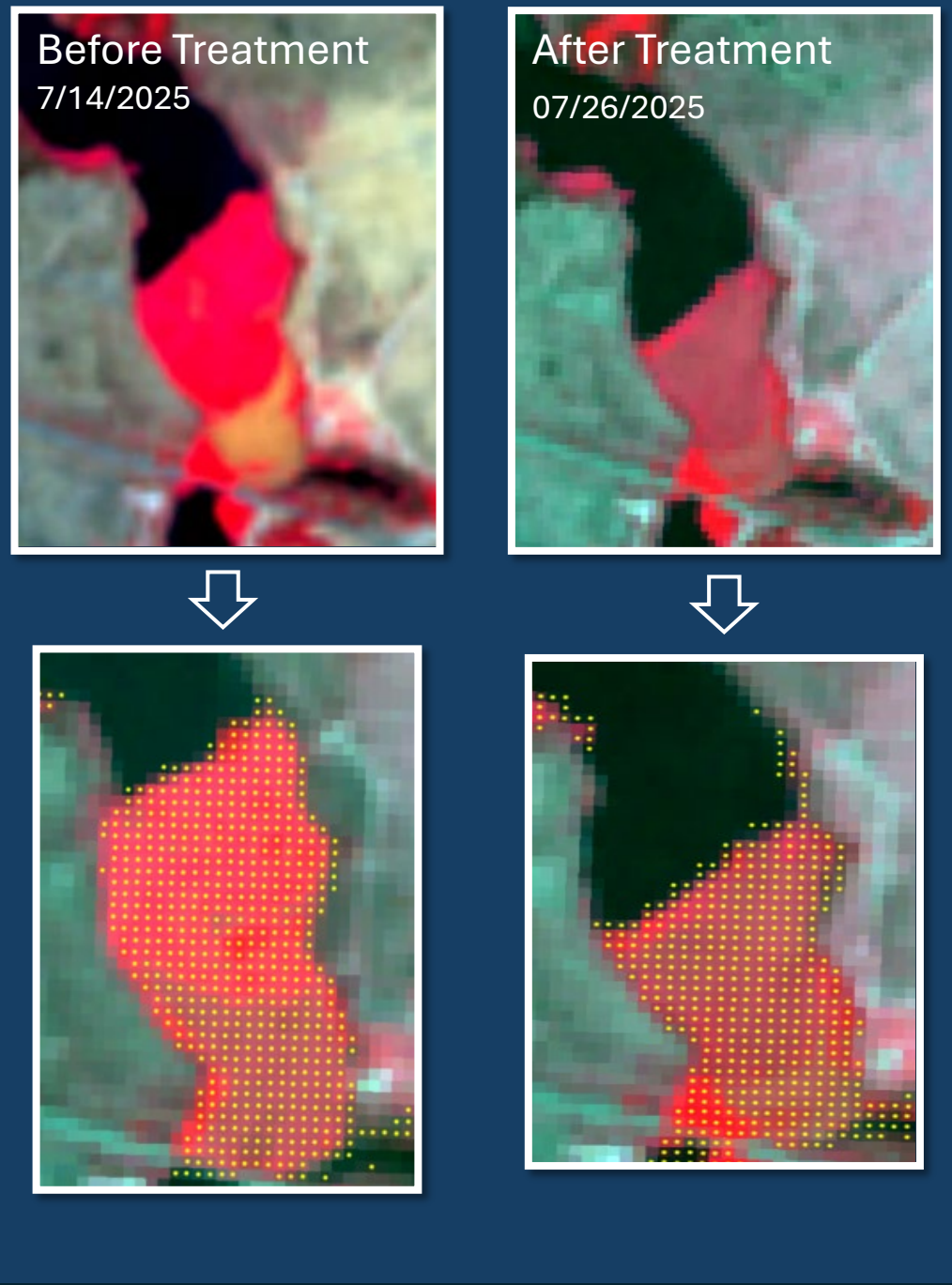
After treatments, FAV in its senescent stage is still classified as live FAV.



Treatment Date: 07/16/2025

Proposed Solution:

- Explore image classification with Convolutional Neural Networks (CNNs) to distinguish senescent vs Healthy FAV



Note: CNNs can learn texture and spectral differences that thresholds miss

Hurdle 3:

Addressing Tules and Topped Out SAV

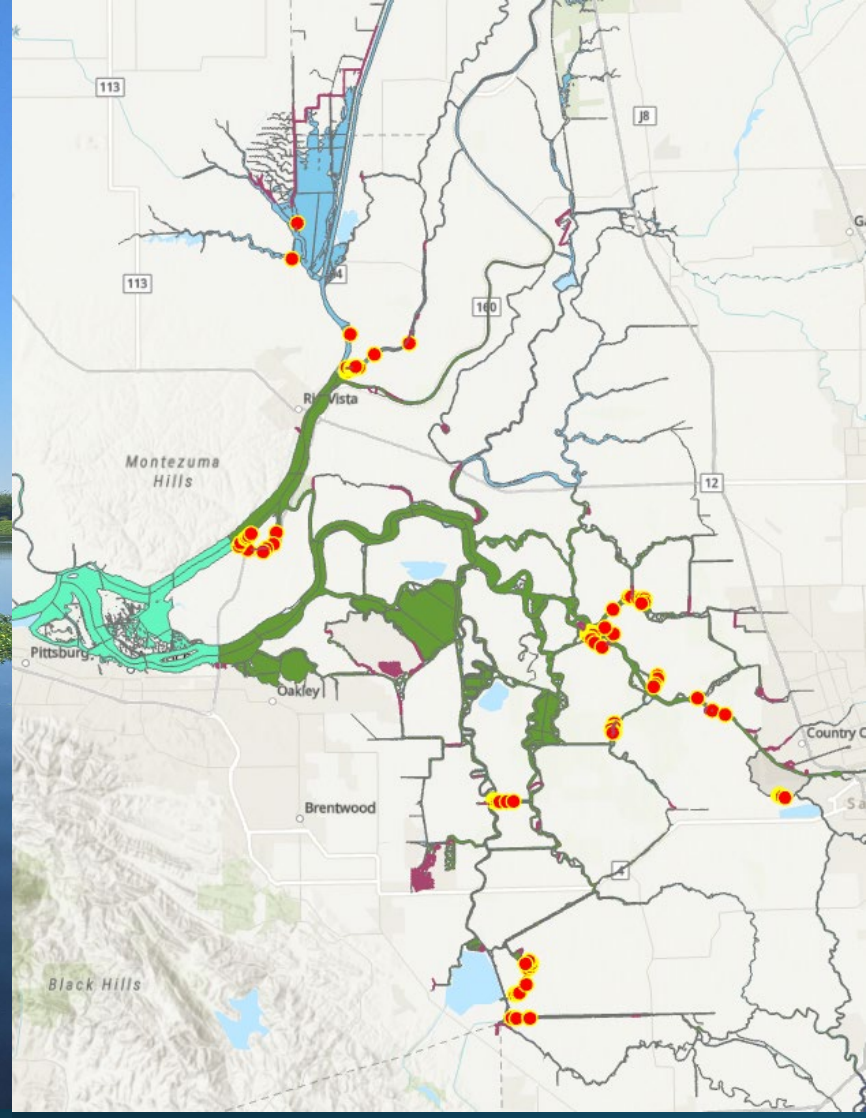
Tules and topped-out SAV can be misclassified as FAV.

Proposed Solution:

- Exclude permanent tules using high resolution imagery.
- Refine the FAI threshold using ground-truth data to distinguish topped out SAV from FAV







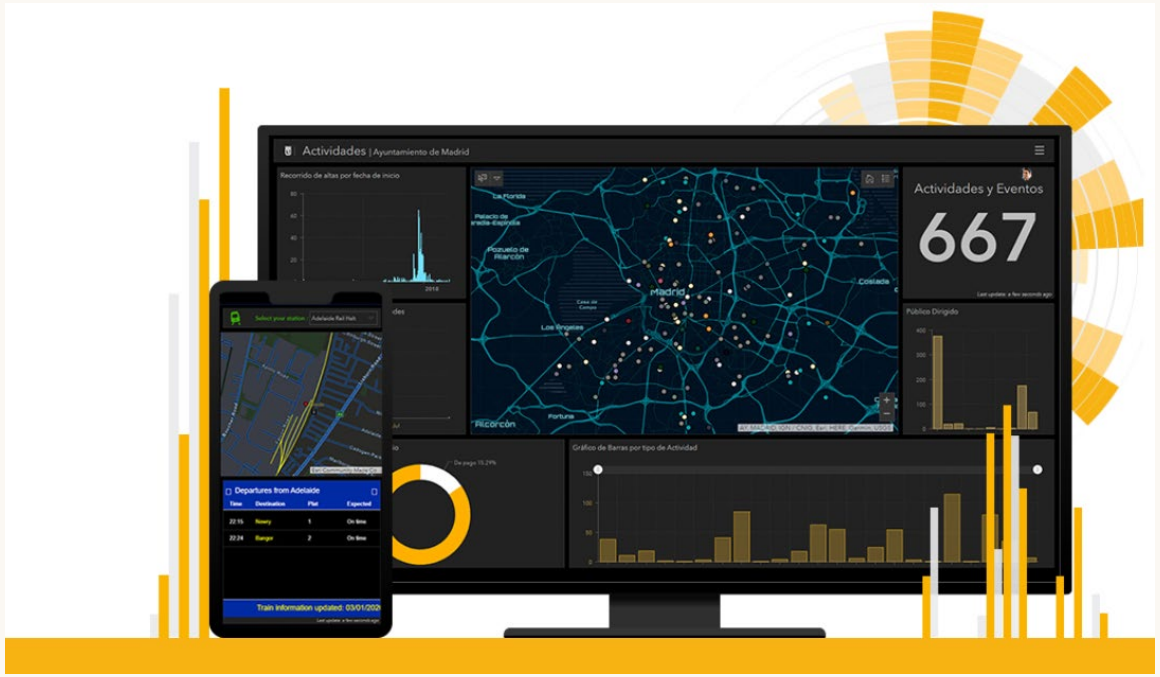
Ground Truthing Data Solutions

Data collected from 16 sites

Original



Refined





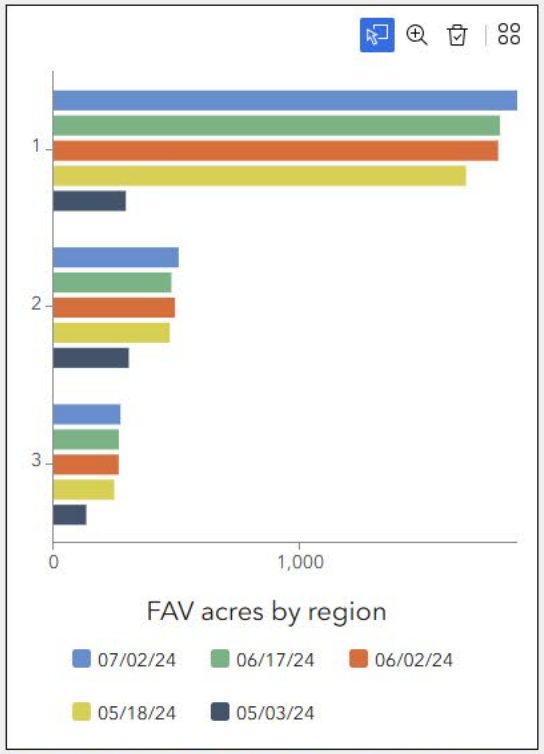
FAV Dashboard

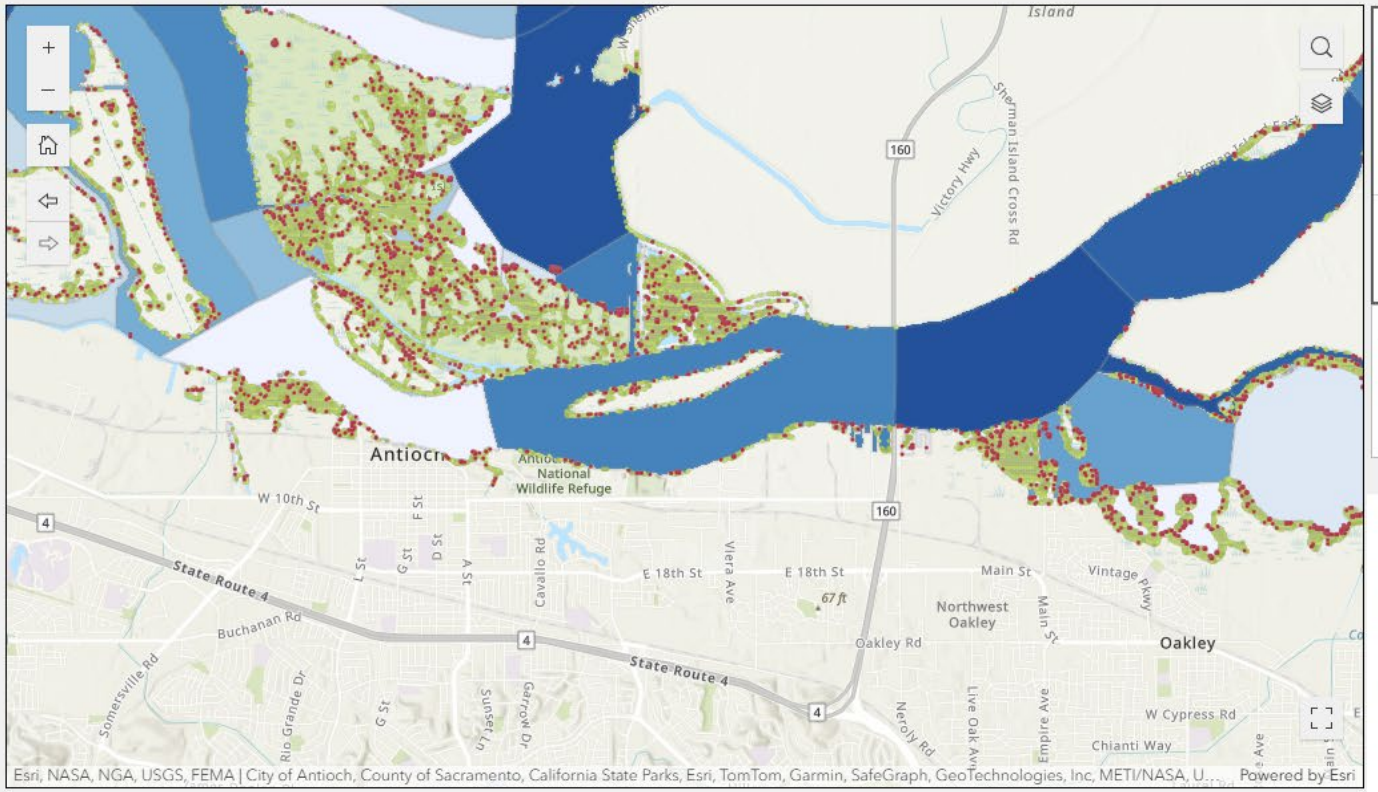
Created for DBW managers to monitor treatment success and FAV growth, using satellite imagery.

How AIPCP Uses the Data

FAV area in 2024

Home page | FAV area, 2024





FAV change pts 06172024 07022024

- Increase
- Decreased
- Stable

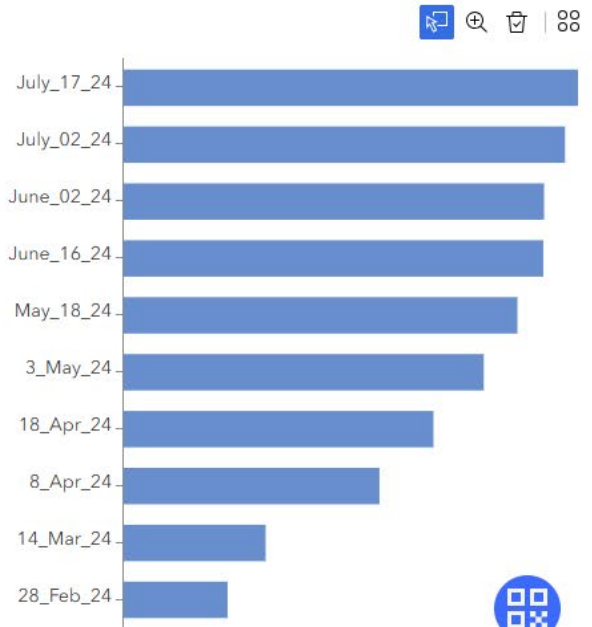
FAV change deduction 01042024 to 07022024

FAV by sites

FIRST_Site is

Barker Slough, Calhoun Cut, Lindsey Slough



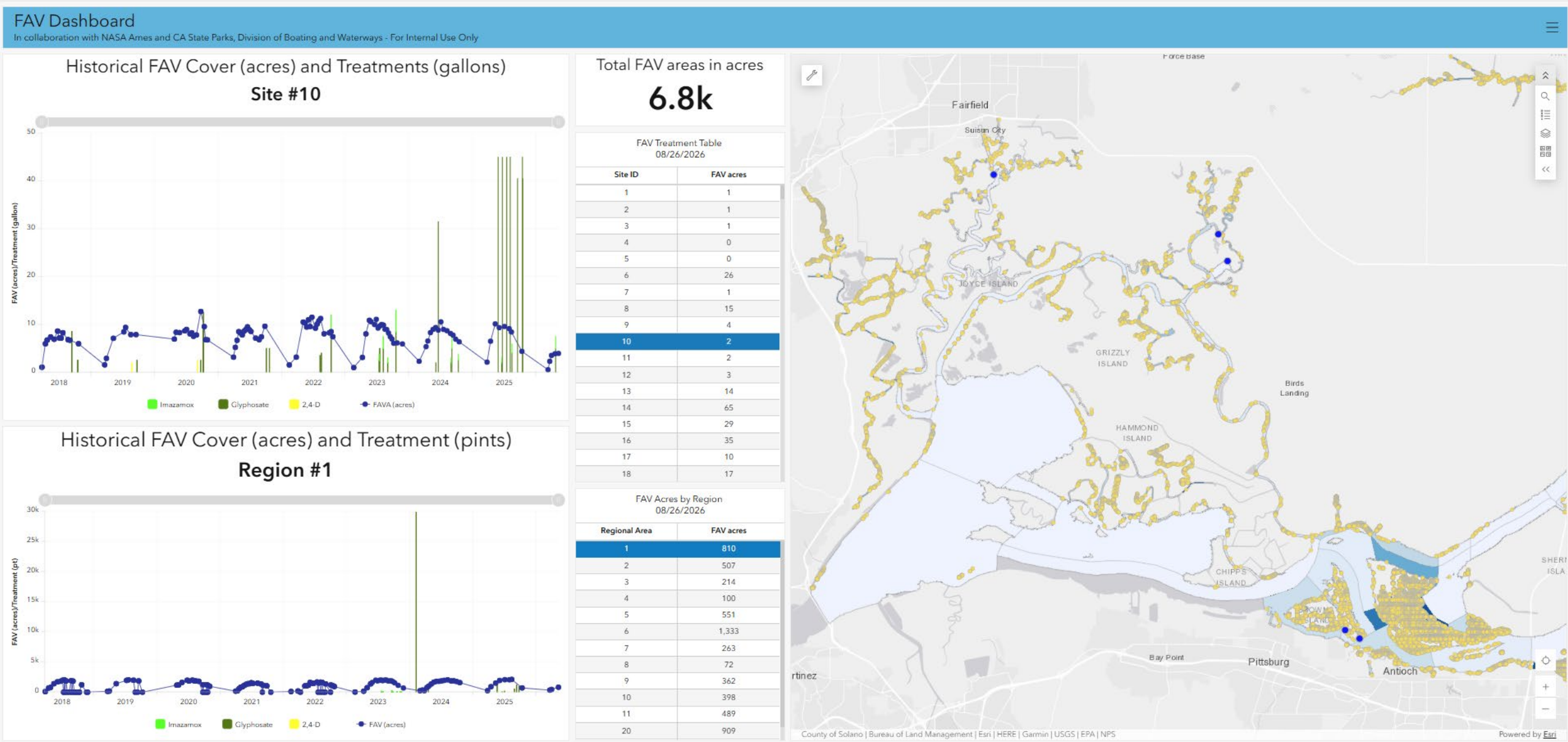


FAV acres by Treatment site, Feb - July 2024

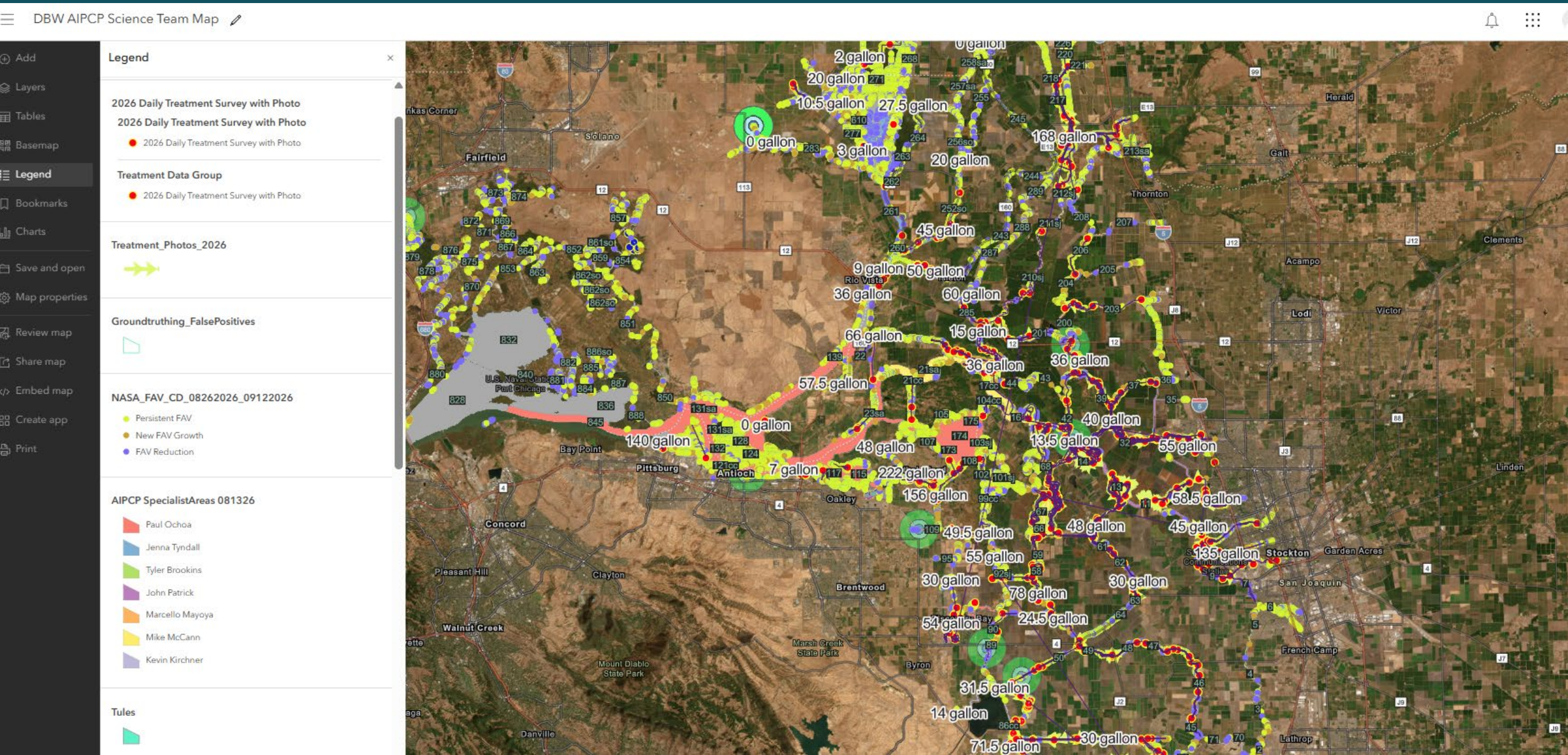
Search

SiteID	FIRST_Site	28_Feb_24	14_Mar_24	8_Apr_24
1	San Joaquin River, Mossdale	1.31	1.78	3.16
2	San Joaquin River, San Jo...	0.32	1.41	3.83
3	San Joaquin River	0.25	0.37	1.85

How AIPCP Uses the Data



How AIPCP Uses the Data



AIPCP Plans for Sentinel -2 data

- Riparian mask
- Speciation
- Ground truthing projects
- Identifying long-term trends
  - Compare drought years vs. higher rainfall years and their FAV trends.
- Automation



Thank you

Sadowski Maxwell J
Environmental Scientist
Maxwell.Sadowski@parks.ca.gov

Guphy Gustafson
Senior GIS Specialist
guphy.gustafson@parks.ca.gov

Abdul Ahmadzai
Research Data Analyst II
abdul.ahmadzai@parks.ca.gov