1.14.2025

Mapping Individual Vernal Pools within the California Central Valley

Regan Murray
San Francisco Estuary Institute

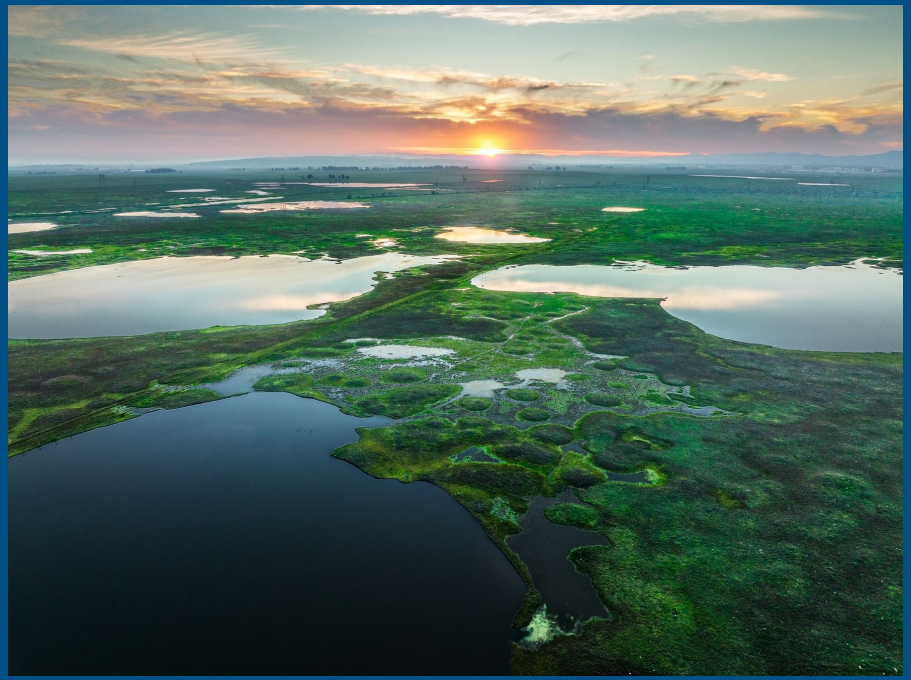


Photo Source: Backcountry Press

1. Ecological Context
2. Mapping Methods
3. Future Work
4. Learn more

Vernal pools are ephemeral wetlands formed when rainwater pools in small depressions with an impervious soil layer

Photo Source: UC Davis

Photo Source: Backcountry Press

Flowering

Aquatic

Drought

Photo Source: UC Davis

Ecosystem Functions of Vernal Pools

- Critical breeding habitat
- Sustain native plant communities
  - 200+ California natives
  - 100+ endemic plant species
- Support 30+ state / federally listed endangered species
- Erosion control and water filtration
- Support uniquely adapted plant species

Photo Source: USFWS

Photo Source: Natomas Basin Conservancy

Photo Source: Northeast Turtles

Photo Source: UC Davis

Photo Source: Calscape

Photo Source: USFWS

Photo Source: iNaturalist

Photo Source: USFWS

Photo Source: Calflora

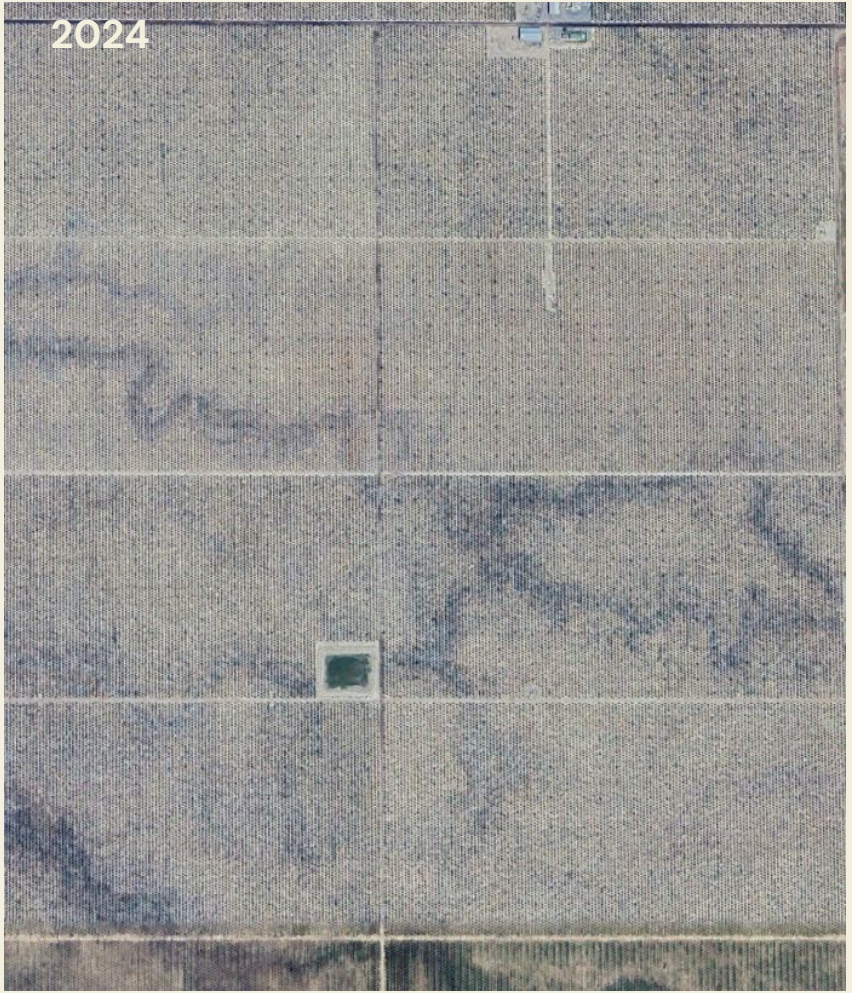
Photo Source: CNPS

Threats to Vernal Pools

- As of 1976, 90% of vernal pool habitat in California has been destroyed
    - In 2005, it was determined that 13% of the remaining vernal pools were destroyed
- Agricultural expansion within California's central valley
- Urban development
- Man-made changes in hydrology

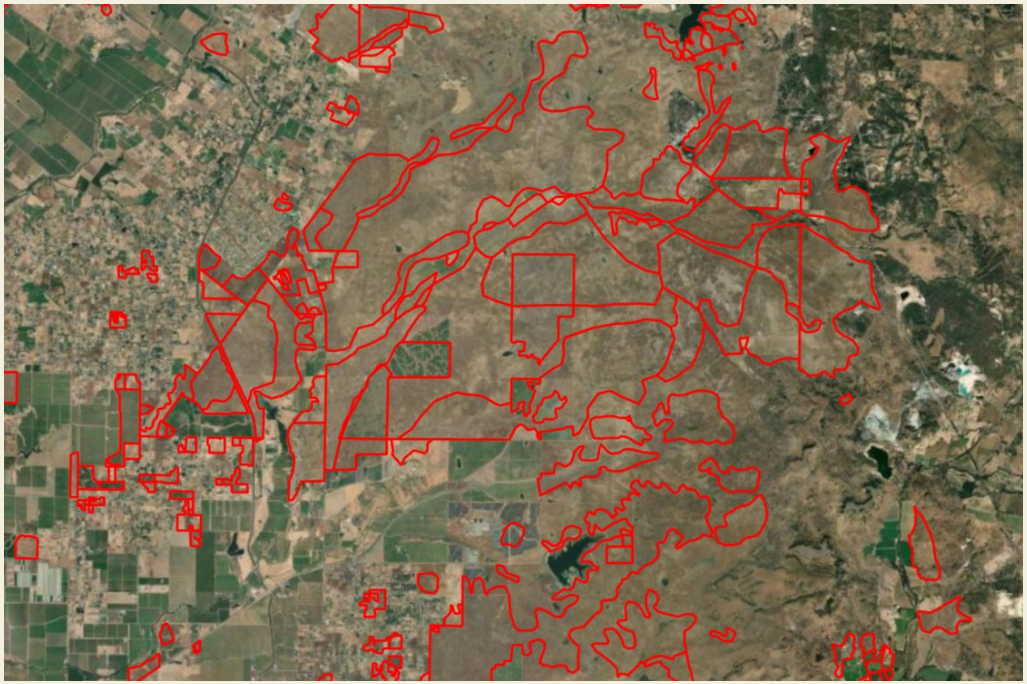
Photo Source: USFWS


1998


2024

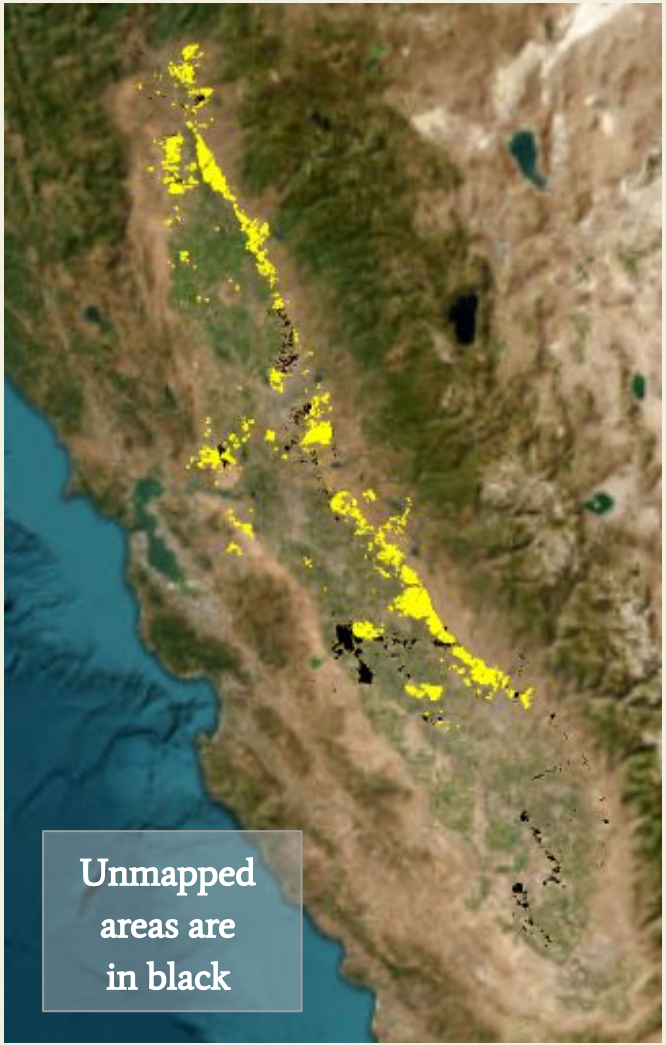
Project Overview

The challenge: We want to restore and conserve critical vernal pool habitat, but our knowledge of on-the-ground conditions is limited by data availability



Project Overview

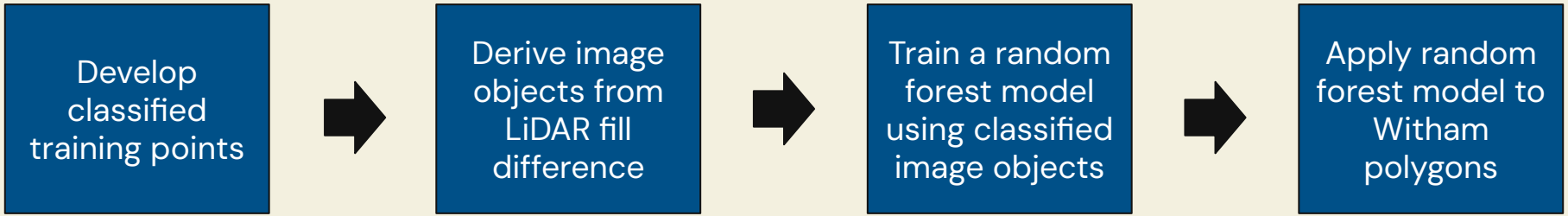
- **Goal**: Map individual vernal pool polygons within existing vernal pool complex polygons
  - Witham, 2005
- **Approach**: classification with an object-based random forest model trained on over 1,100 points using eCognition
- **Results**: mapped individual vernal pools for 83% of the total Witham complex polygon area



Approach

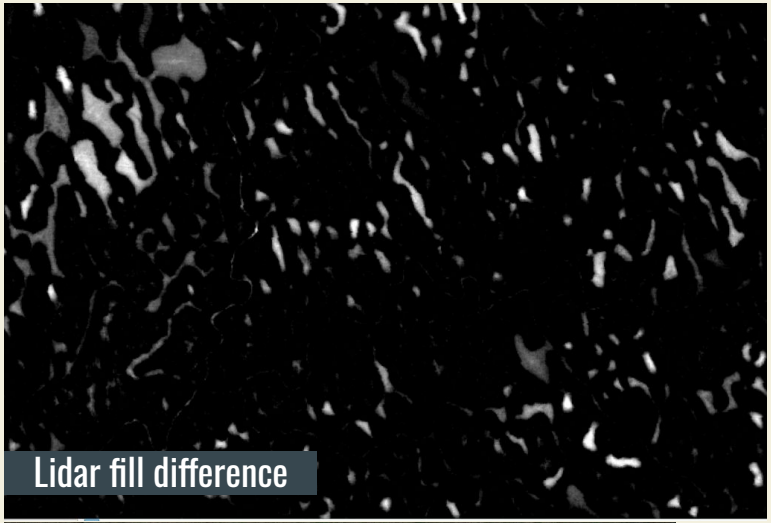
“Classification with an object-based random forest model trained on over 1,100 points using eCognition”

Approach


Develop classified training points
Derive image objects from LiDAR fill difference
Train a random forest model using classified image objects
Apply random forest model to Witham polygons

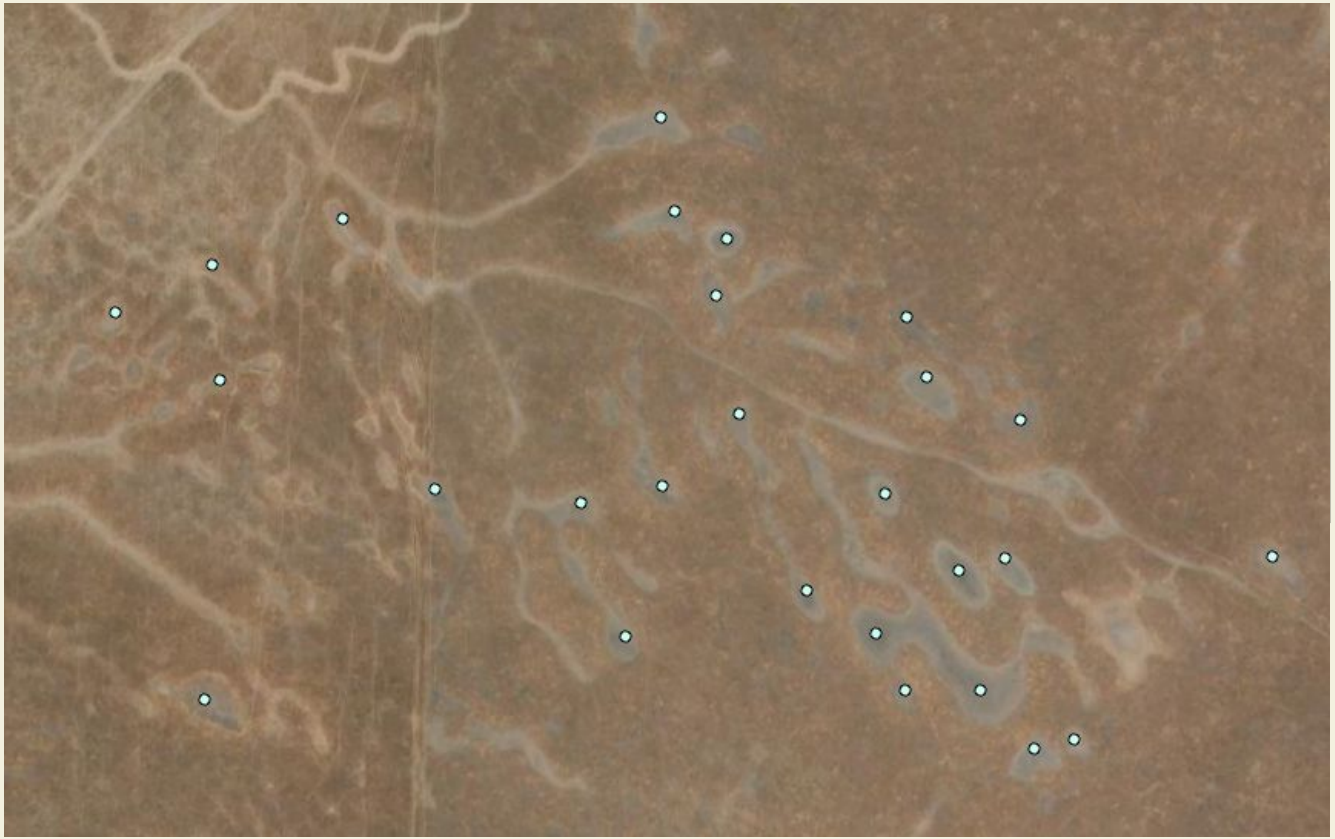
Data Inputs

- High resolution (<=2.5m) 3DEP LiDAR
  - Fill difference
- High resolution (0.6m) NAIP 2020 imagery
  - NDVI
  - NDWI



Approach

Develop classified training points



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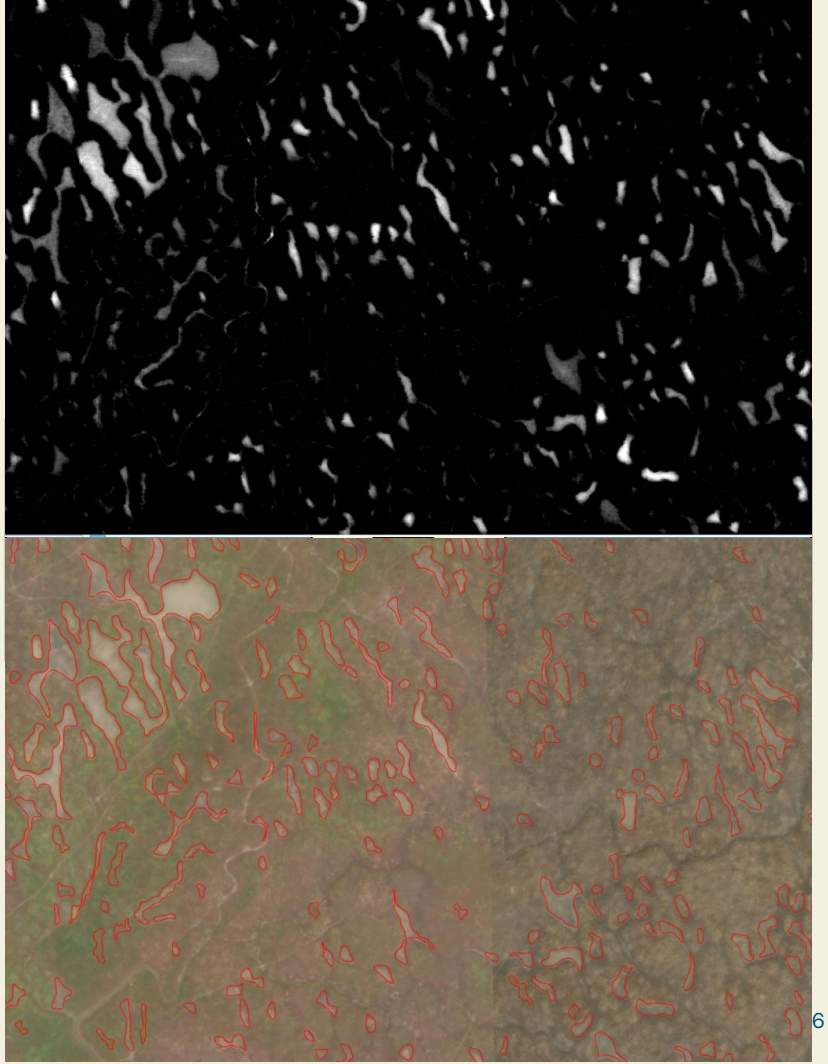
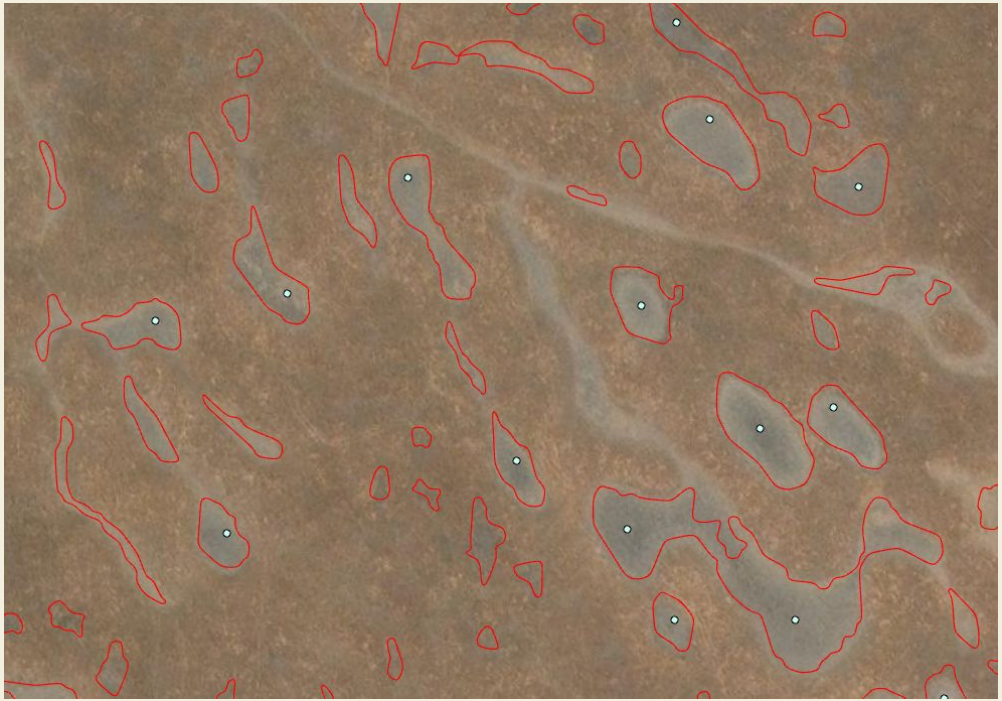
Derive image objects from LiDAR fill difference



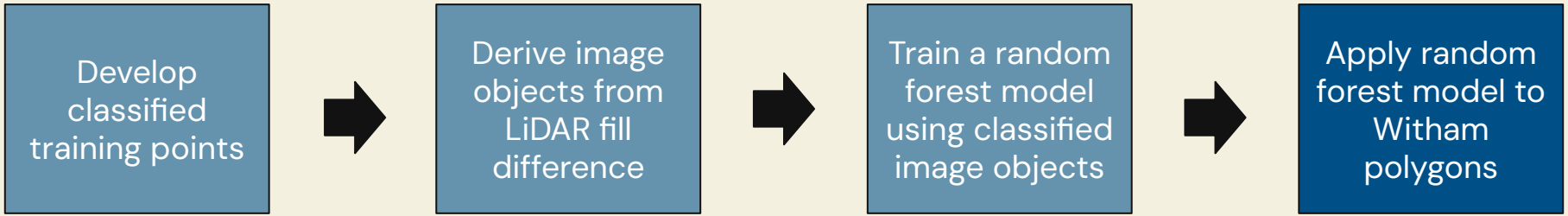
Approach



Train a random forest model using classified image objects

Apply random forest model to Witham polygons

Approach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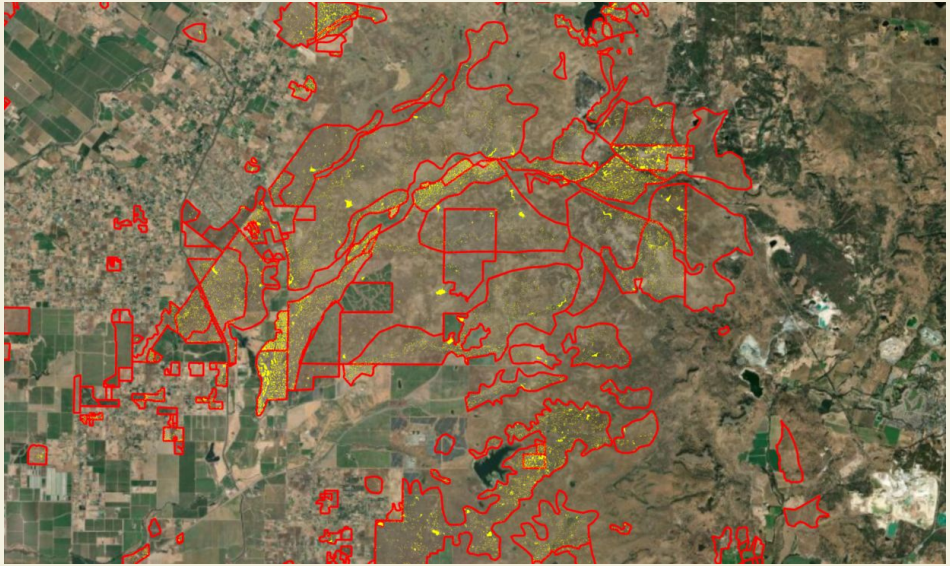
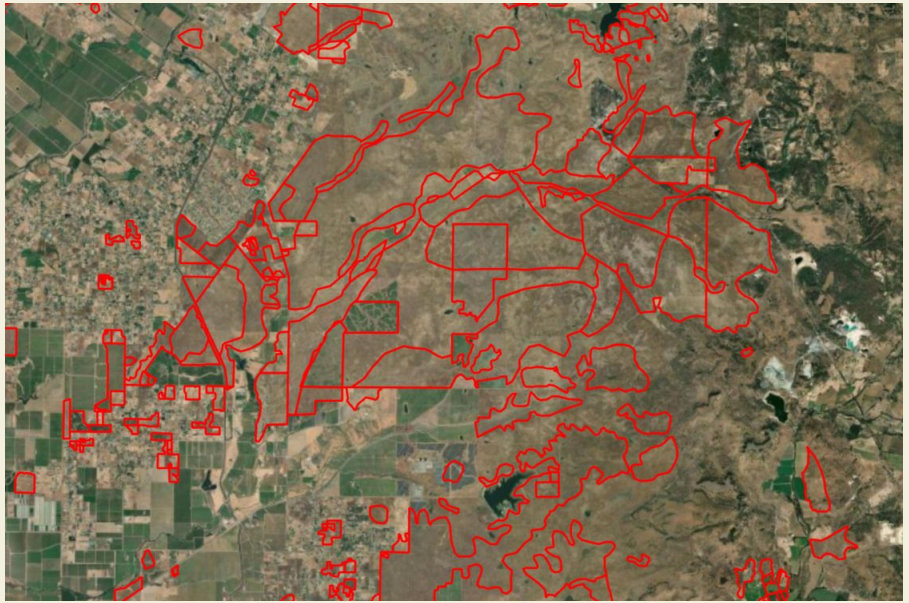
The good news!





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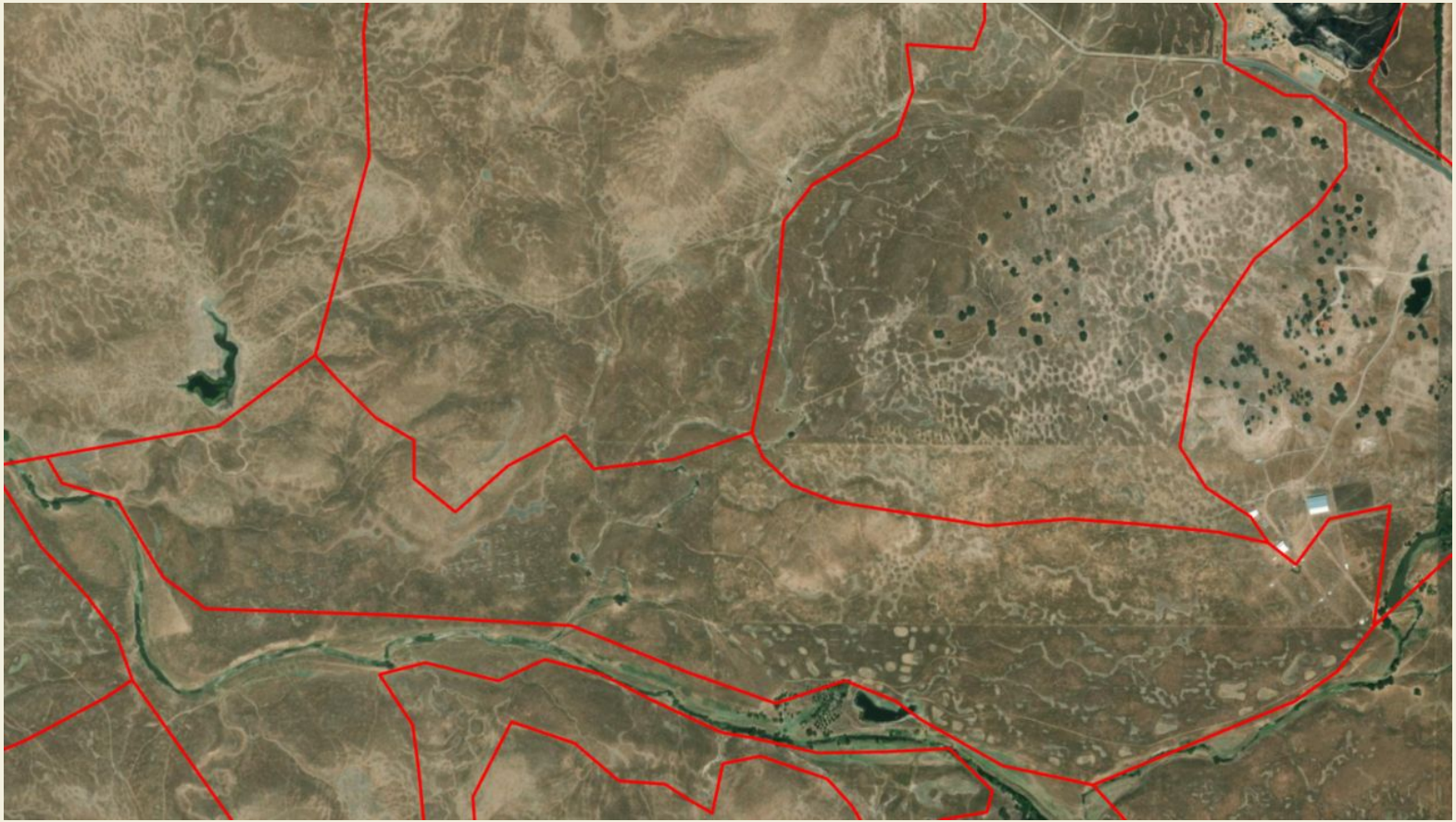

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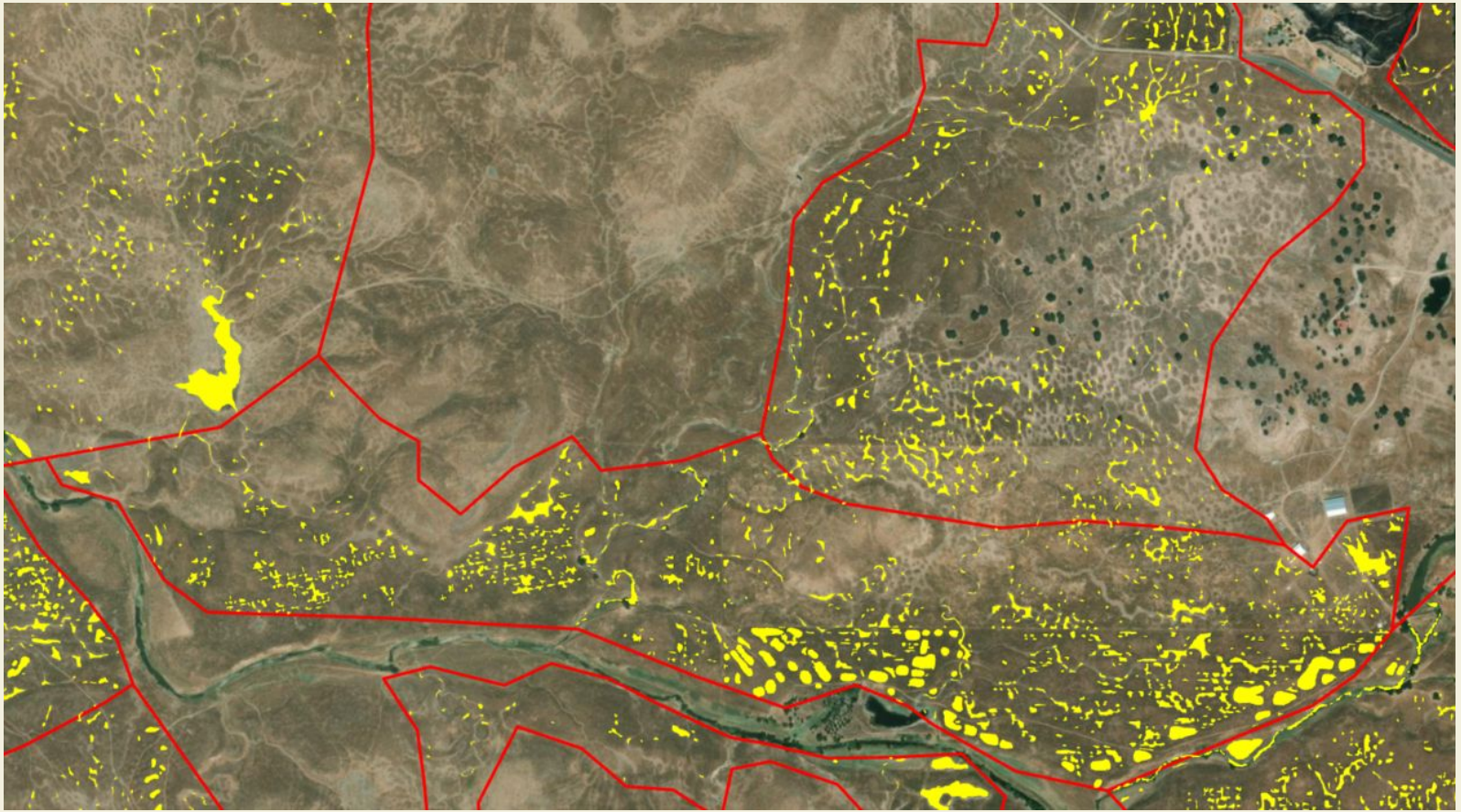
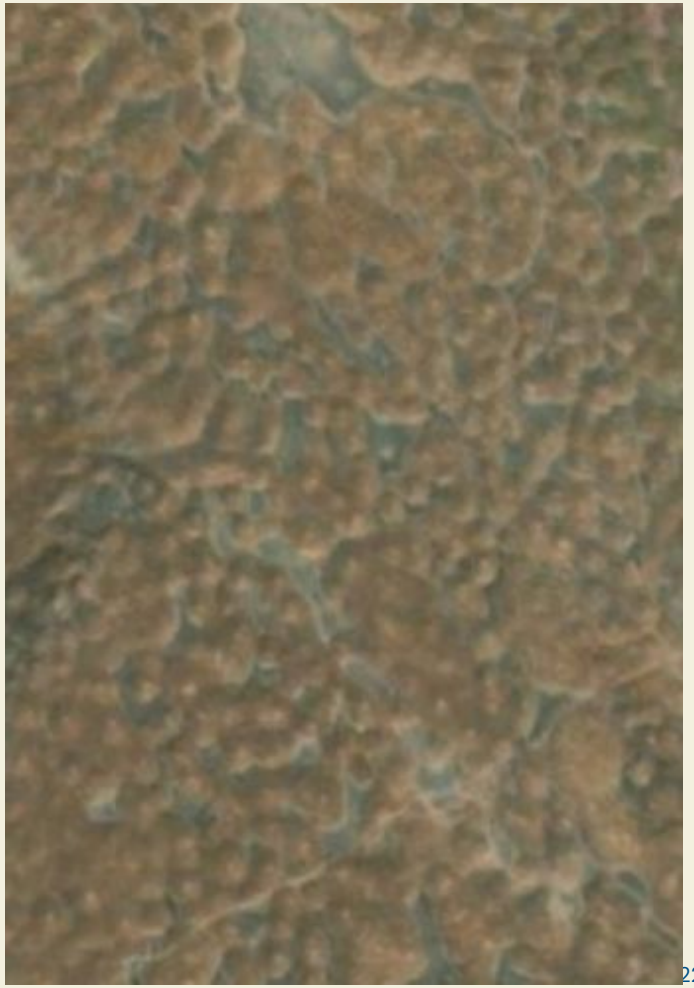


Results



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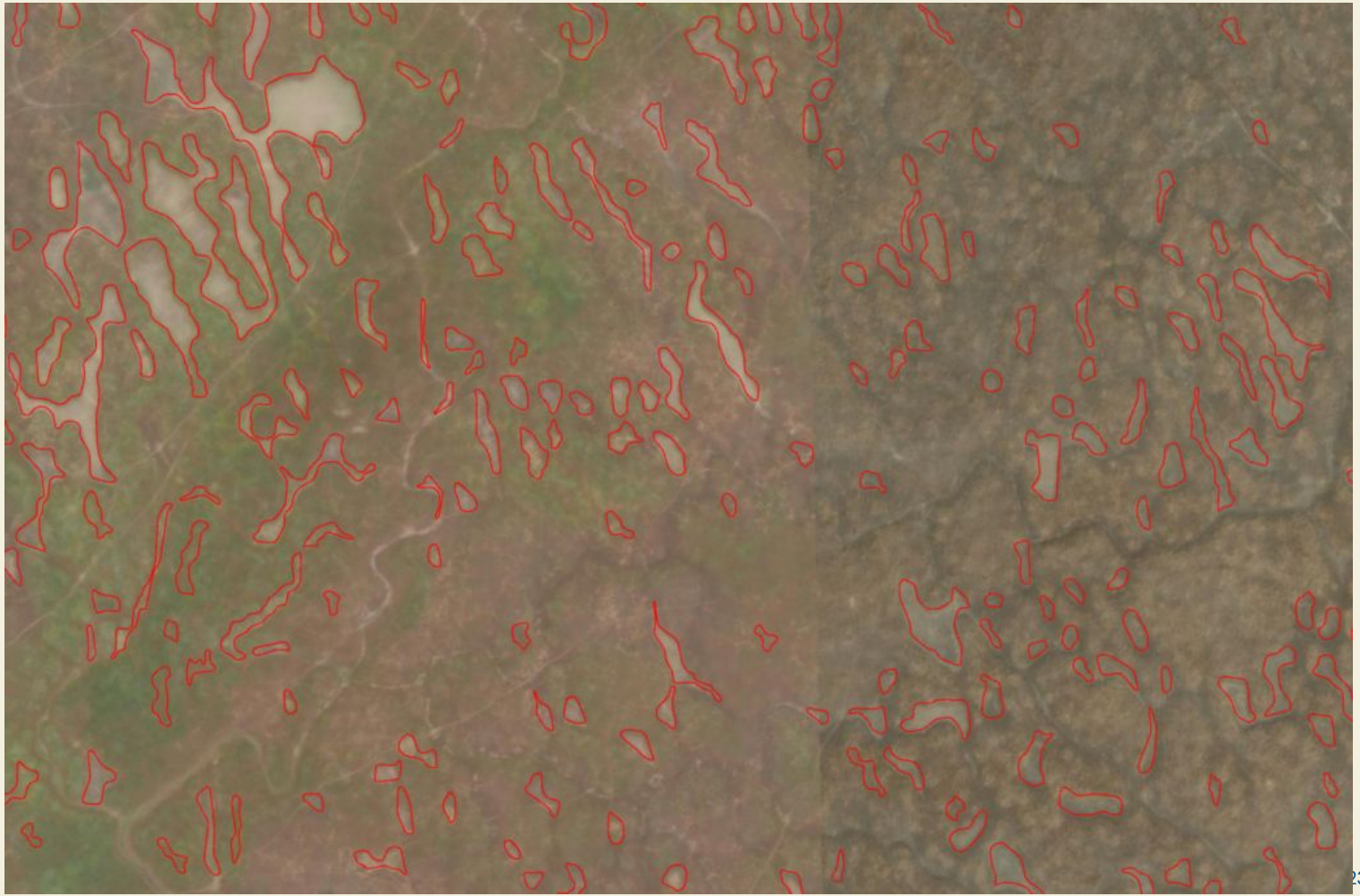

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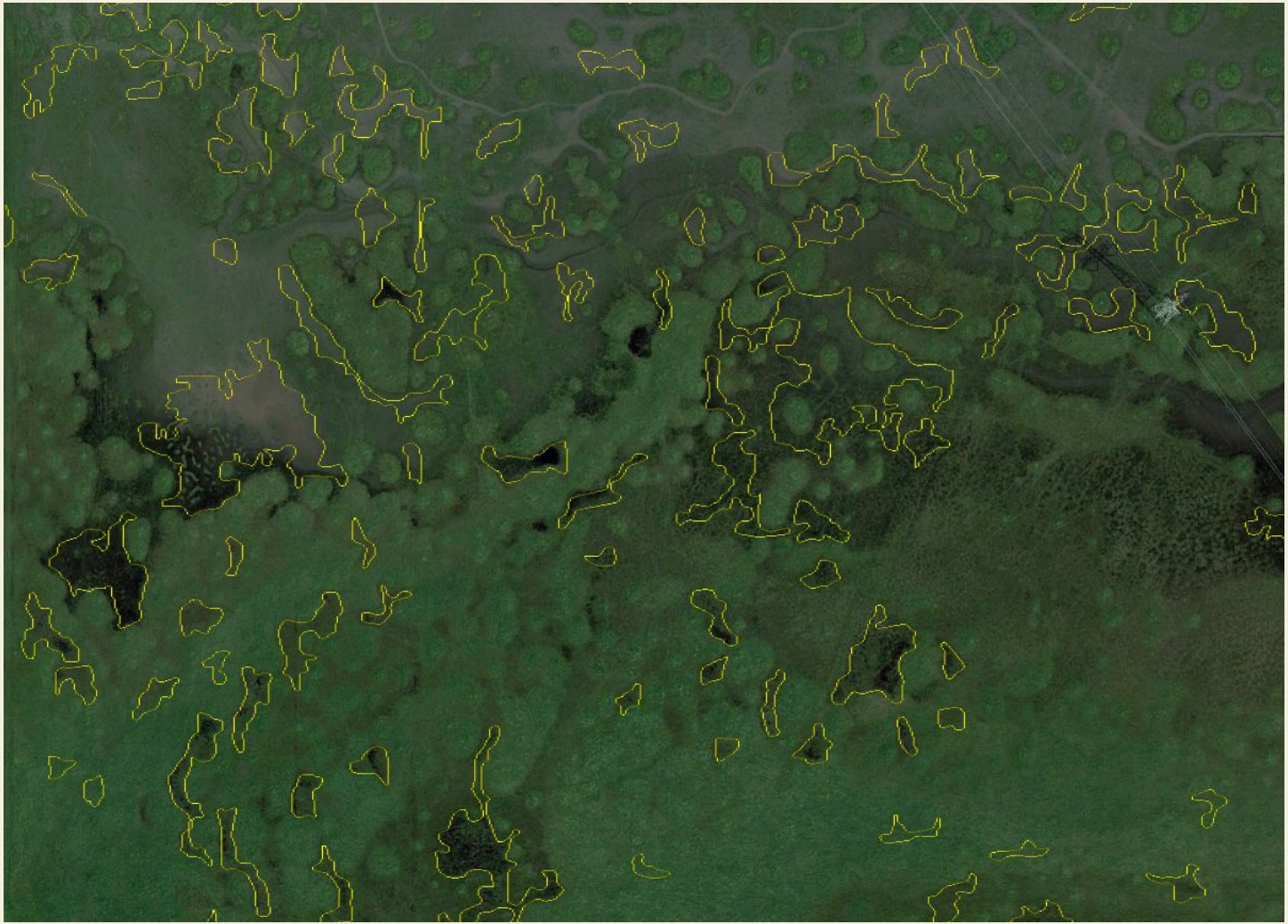

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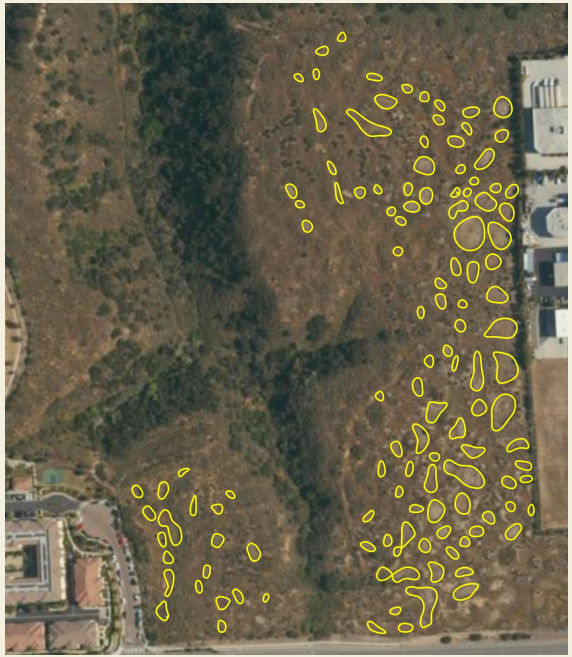
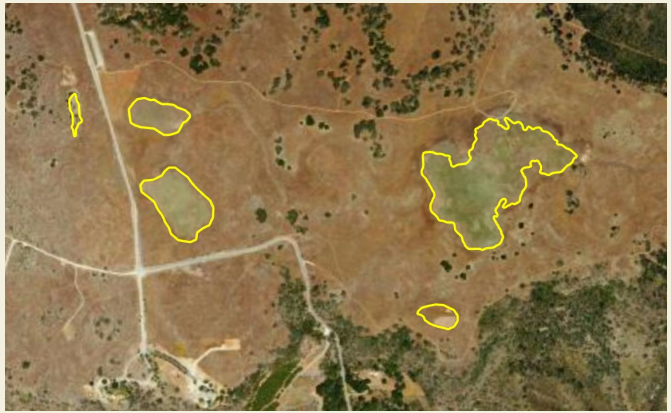
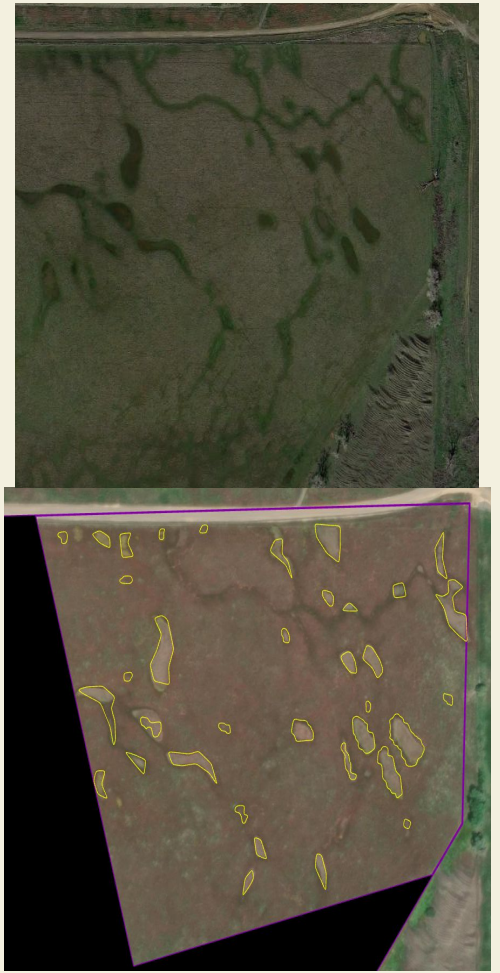




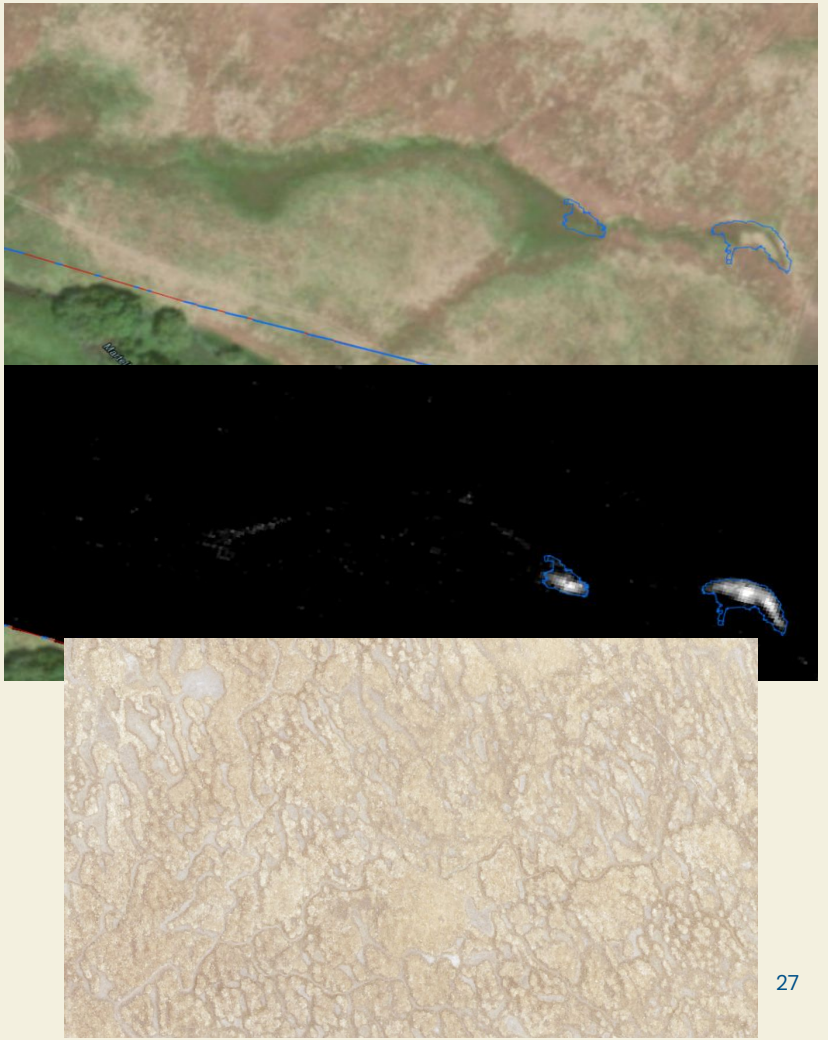
Results

- 675,000 acres of the central valley mapped (83% of Witham complex polygons)
- Data gaps in lidar coverage and high resolution multi-temporal imagery resulted in 17% of study area being unmapped
- Tried:
  - Object-based classification in eCognition with NAIP 2018 + 2020
  - Time-series pixel / phenology-based classification with Sentinel 2 2015 - 2022
- Issues:
  - Free single-date imagery does not capture phenology
  - Free multi-date imagery is too low resolution to capture individual vernal pools



Shortcomings

- Data gaps in lidar coverage
- Only works within predefined complex polygons
- Areas with low quality or outdated lidar not mapped as well
- NAIP taken after complexes have dried out and doesn't represent phenology
    - Polygon refinement difficult without aquatic-phase imagery
- Swales not mapped



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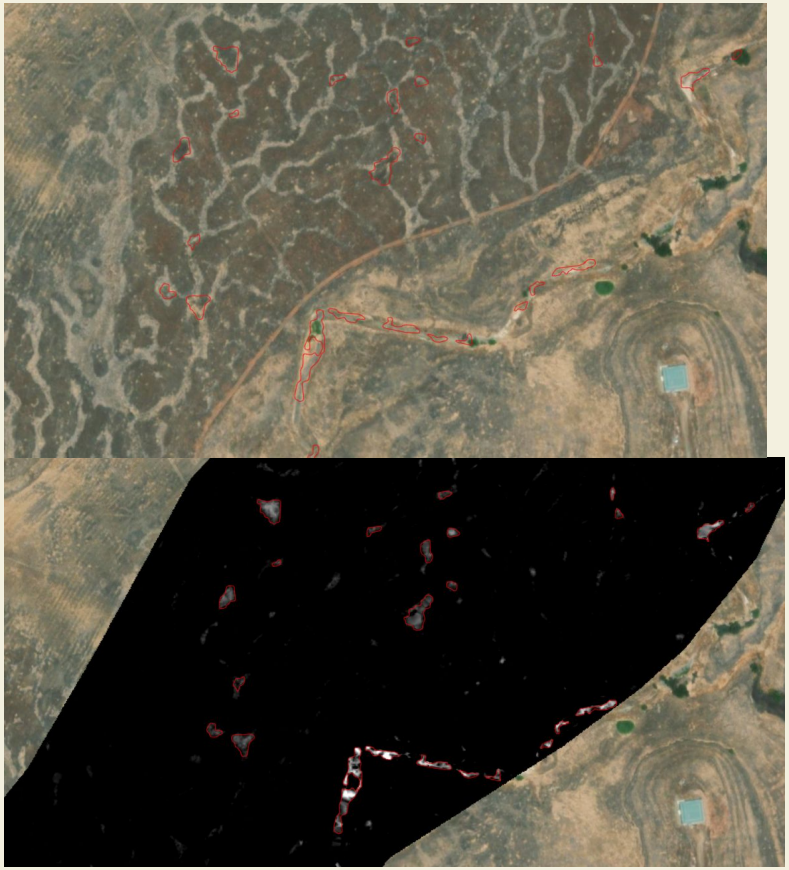
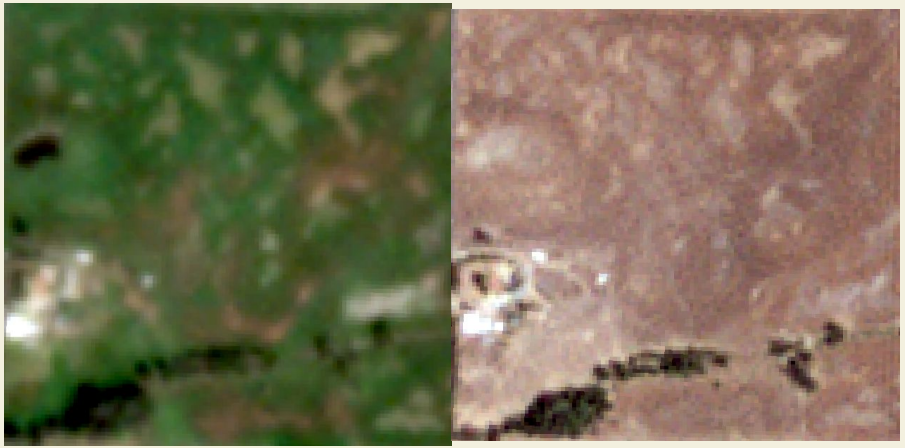
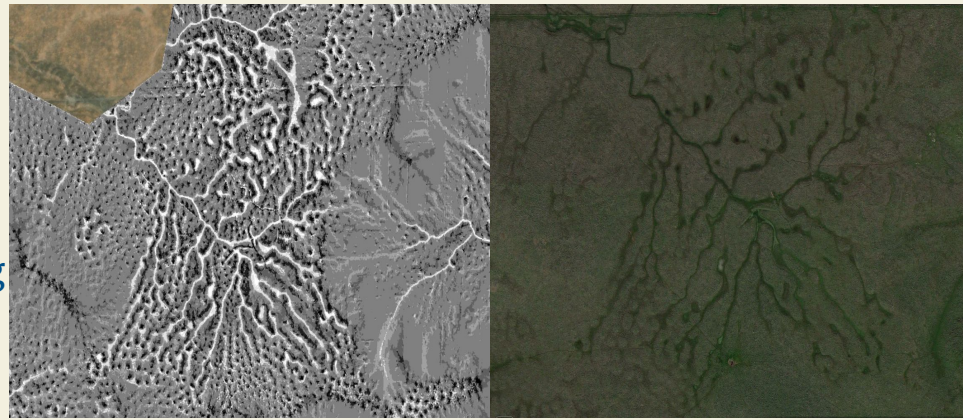


Future Work

- Individual pool mapping improvements
  - Improve identification, classification, and polygon refinement with high-resolution multi-temporal imagery
    - Planet imagery (wet season weekly composites?)
  - Test method with improved imagery input on test area with ground-truthing
  - Use of Geomorphon Landforms
  - Rescaling fill difference to emphasize small depressions
- Automated mapping of complexes
  - Leverage high resolution lidar, Witham complex polygons, and pattern recognition with eCognition deep learning to classify vernal pool complexes





Learn more

- Download the individual vernal pools dataset: https://www.sfei.org/data/sfei-individual-vernal-pools-2023
  - Also incorporated into the California Aquatic Resource Inventory (CARI): https://www.sfei.org/projects/california-aquatic-resource-inventory-cari
- Visit a vernal pool complex / system!
  - $5.00 Jepson Prairie tours
  - Prairie City State Vehicle Recreation Area vernal pool tour
  - Phoenix Park vernal pools
  - Illa M. Collin Conservation Preserve

Prairie City State Vehicular Recreation Area
Vernal Pool Wildflower Reference Guide

Vernal Pool Endemic | California Endemic | California Native | Introduced

Woolly Marbles
Psilocarphus brevissimus

Soap Root
Chlorogalum pomeridianum

Coyote Thistle
Eryngium castrense

Pale Spikerush
Eleocharis macrostachya

Vernal Pool Monkeyflower
Diplacus tricolor

Dwarf Sack Clover
Trifolium depauperatum

Valley Checkerbloom
Sidalcea hartwegii

Red Maids
Calandrinia menziesii

Harvest Brodiaea
Brodiaea elegans

Winter Vetch
Vicia villosa

Purple Sanicle
Sanicula bipinnatifida

Royal Larkspur
Delphinium variegatum

Miniature Lupine
Lupinus bicolor

Folded Downingia
Downingia ornatissima

Horned Downingia
Downingia bicornuta

Sacramento Beardstyle
Pogogyne zizyphoroides

Images Courtesy of Lora Caldwell, Alex Daharsh, and Nick Fox

Prairie City State Vehicular Recreation Area
Vernal Pool Wildflower Reference Guide

Vernal Pool Endemic | California Endemic | California Native | Introduced

White Meadowfoam
Limnanthes alba

Wild Hyacinth
Triteleia hyacinthina

Spokepod
Thysanocarpus radians

Valley Tassels
Castilleja attenuata

Spanish Clover
Acmispon americanus

Bractless Hedge-hyssop
Gratiola ebracteata

White Navarretia
Navarretia leucocephala

Vernal Pool Popcorn Flower
Plagiobothrys stipitatus

Vernal Pool Buttercup
Ranunculus bonariensis

Hawkbit
Leontodon saxatilis

Hop Clover
Trifolium dubium

Fremont's Tidy-tips
Layia fremontii

Field Owl's Clover
Castilleja campestris

Butter 'n Eggs
Triphysaria eriantha

Frying Pans
Eschscholzia lobbii

Vernal Pool Goldfields
Lasthenia fremontii

Images Courtesy of Lora Caldwell, Alex Daharsh, and Nick Fox

Photo Source: California State Parks


Thank you!
gis@sfei.org
Photo Source: Backcountry Press