AGRO DAY 24

El hombre, el agua y el suelo

29 OCTUBRE | 10.00 – 17.30h

UPV - Universitat Politènica de València

CÁTEDRA TIMAC AGRO-UPV PIONEROS POR NATURALEZA

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Escuela Técnica Superior de Ingeniería Agronómica y del Medio Natural

Timac AGRO

Advances in Water Limited Irrigation Management in California

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Dept. Land, Air, and Water Resources
Dept. Biological and Agricultural Engineering

Outline

A brief overview of California agriculture

Regional/Basin scale water management

Farm level water management

Soil Management

California

California agriculture

Farms and ranches cash receipts in 2023: over $59.4 billion dollars

- **Dairy, Milk: $8.13 billion**
- **Grapes: $6.52 billion**
- Cattle: $4.76 billion
- Lettuce: $3.93 billion
- Almond: $3.88 billion
- Pistachios: $2.98 billion
- Strawberries: $2.97 billion
- Tomatoes: $2.01 billion
- Carrots: $1.67 billion
- Broilers: $1.24 billion

Sources: CDFA,2023

Regional scale/Basin scale water management

English to Metric Unit Conversion

1 acre – 0.406 ha

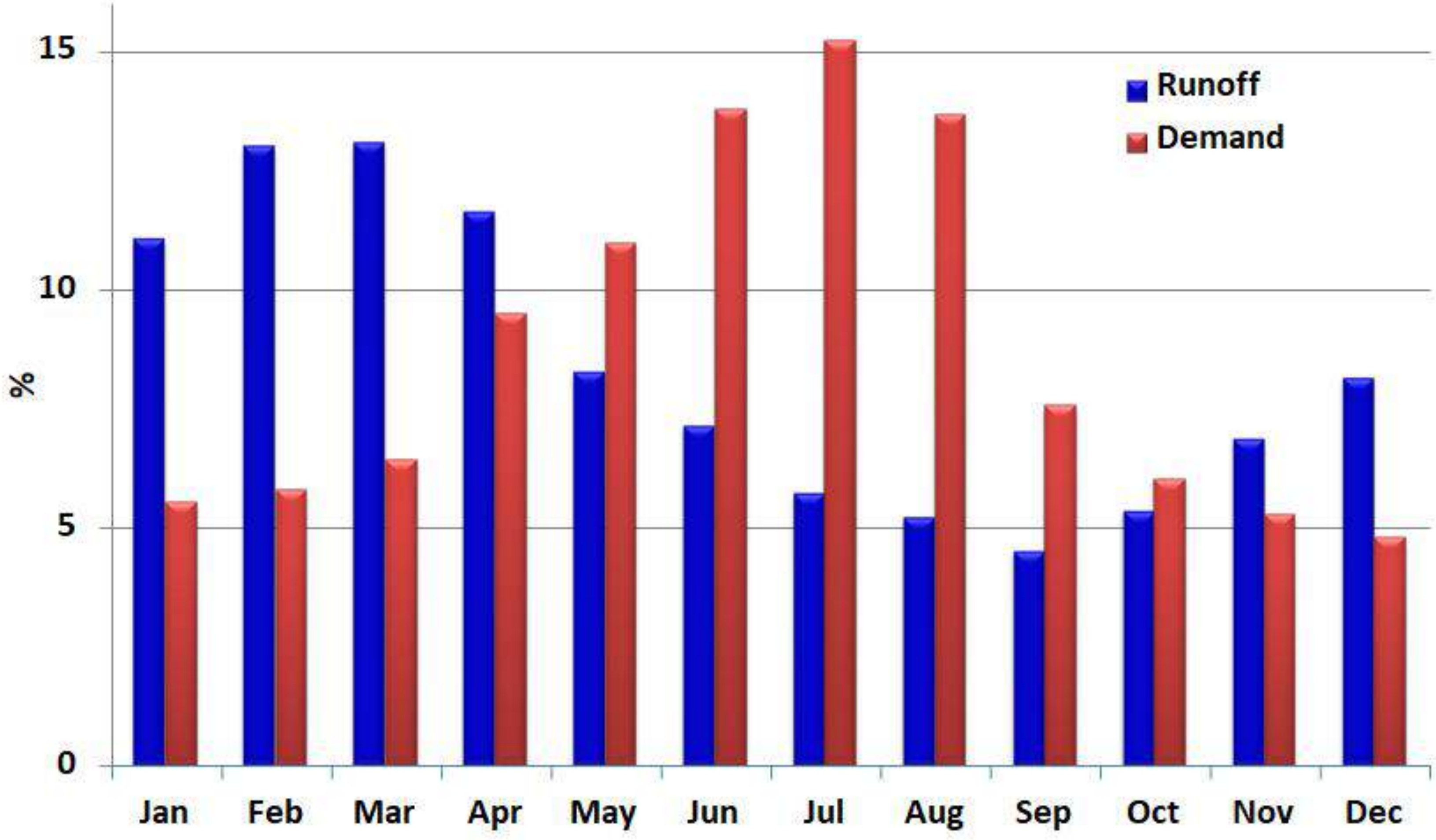
1 inch – 25.4 mm

1 acre-ft – 1233.4 m^3

1 US ton – 0.907 metric ton

1 Ibs – 0.454 kg

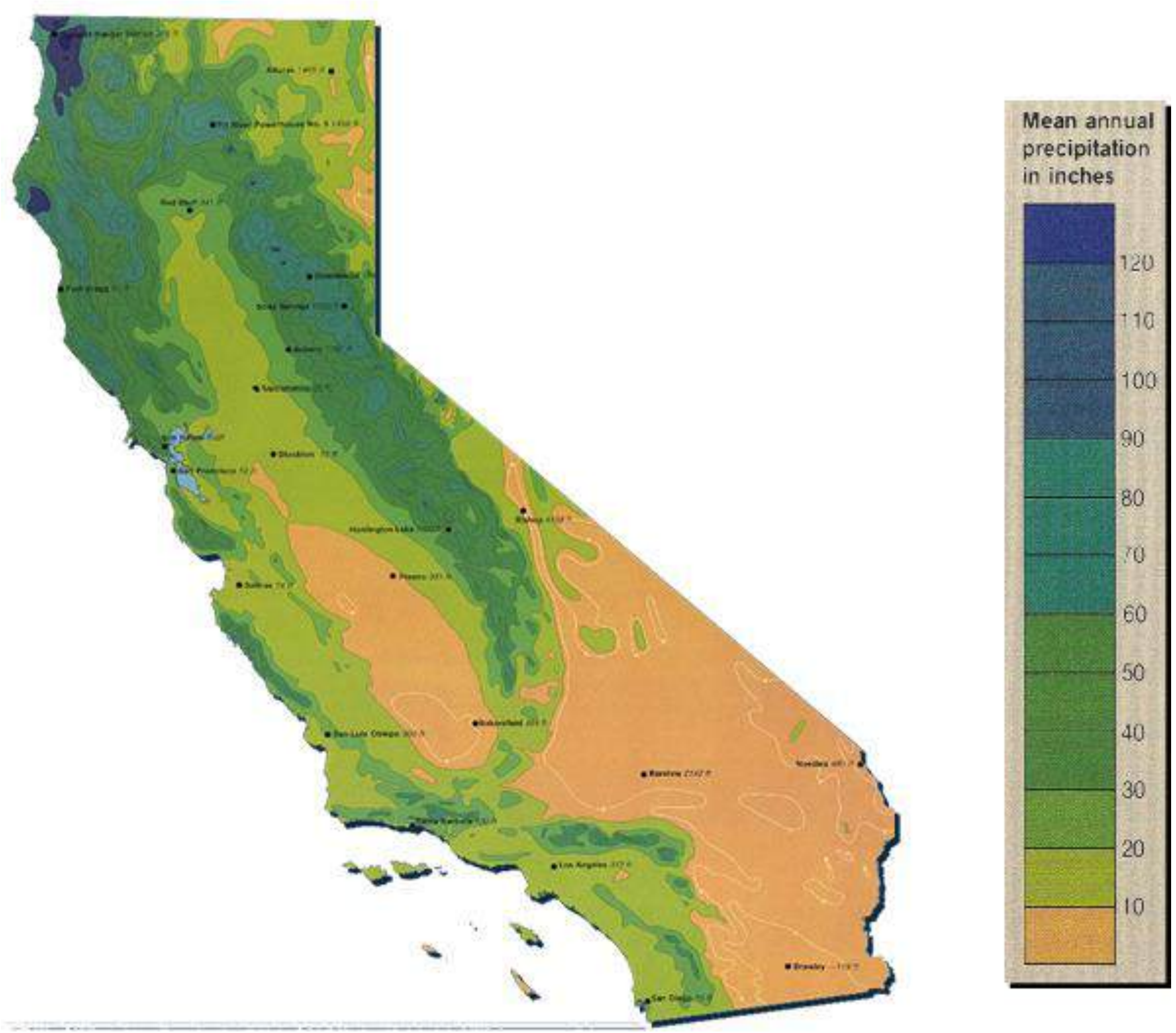
Temporary variability between supply and demand



California water supply

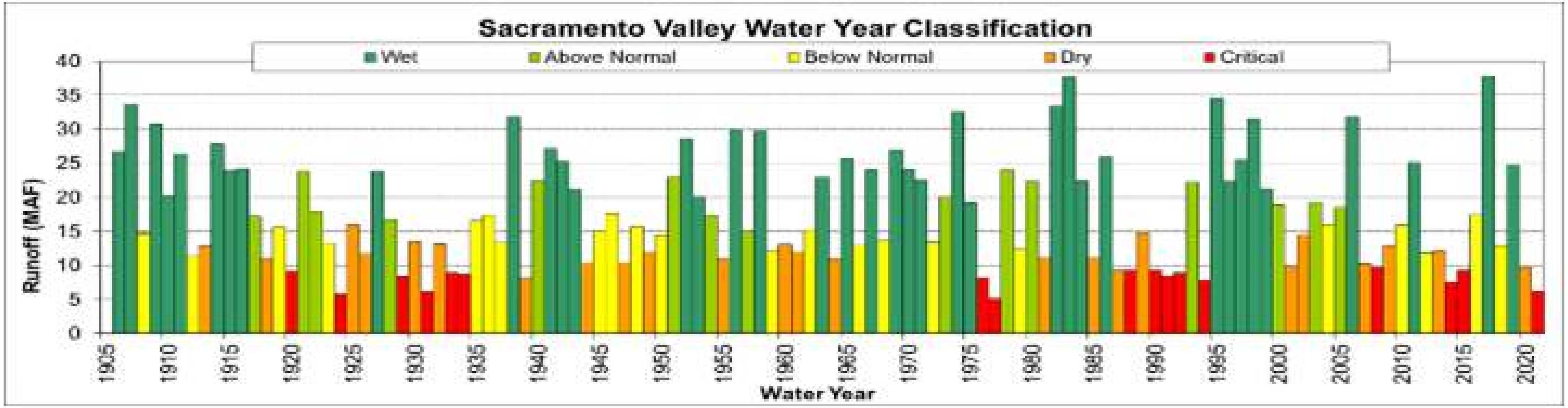
DWR, 2024

Spatial variability in precipitation



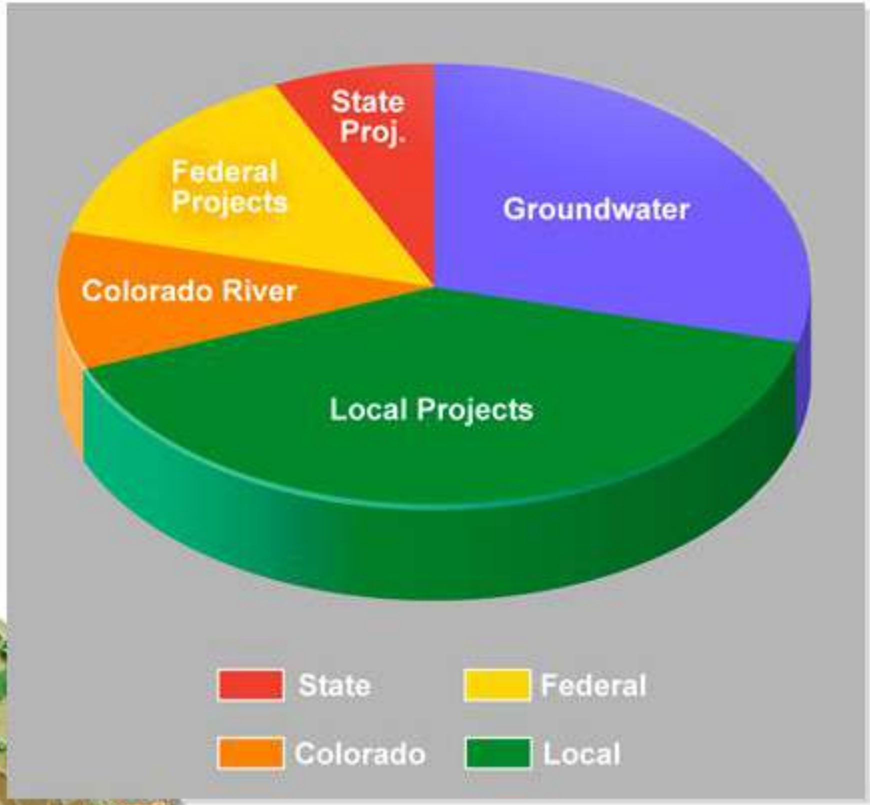
DWR, 2024

Climate variability



DWR, 2024

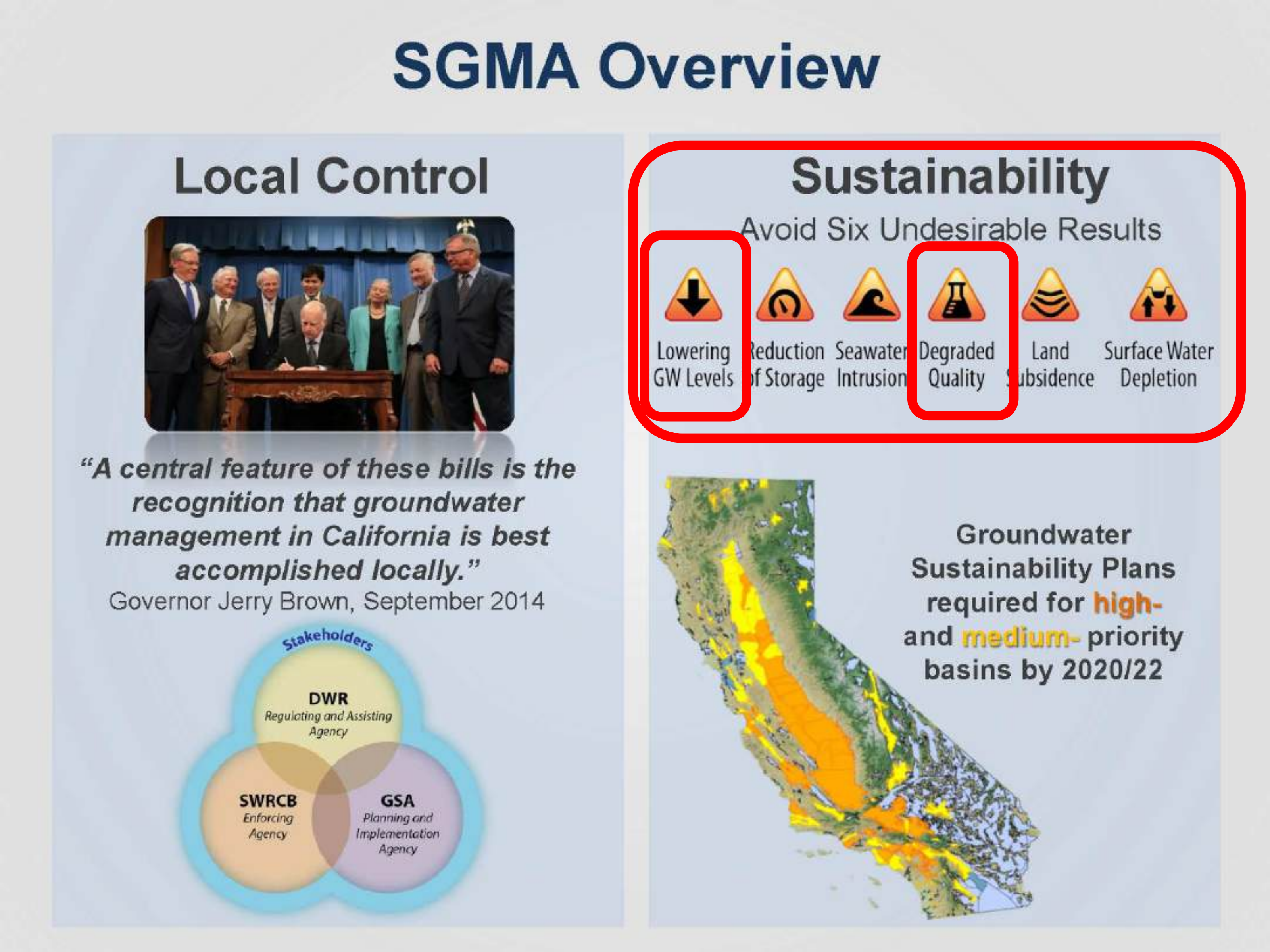
California water supply



DWR, 2024

Water is stored in reservoirs and transported using a network of canals

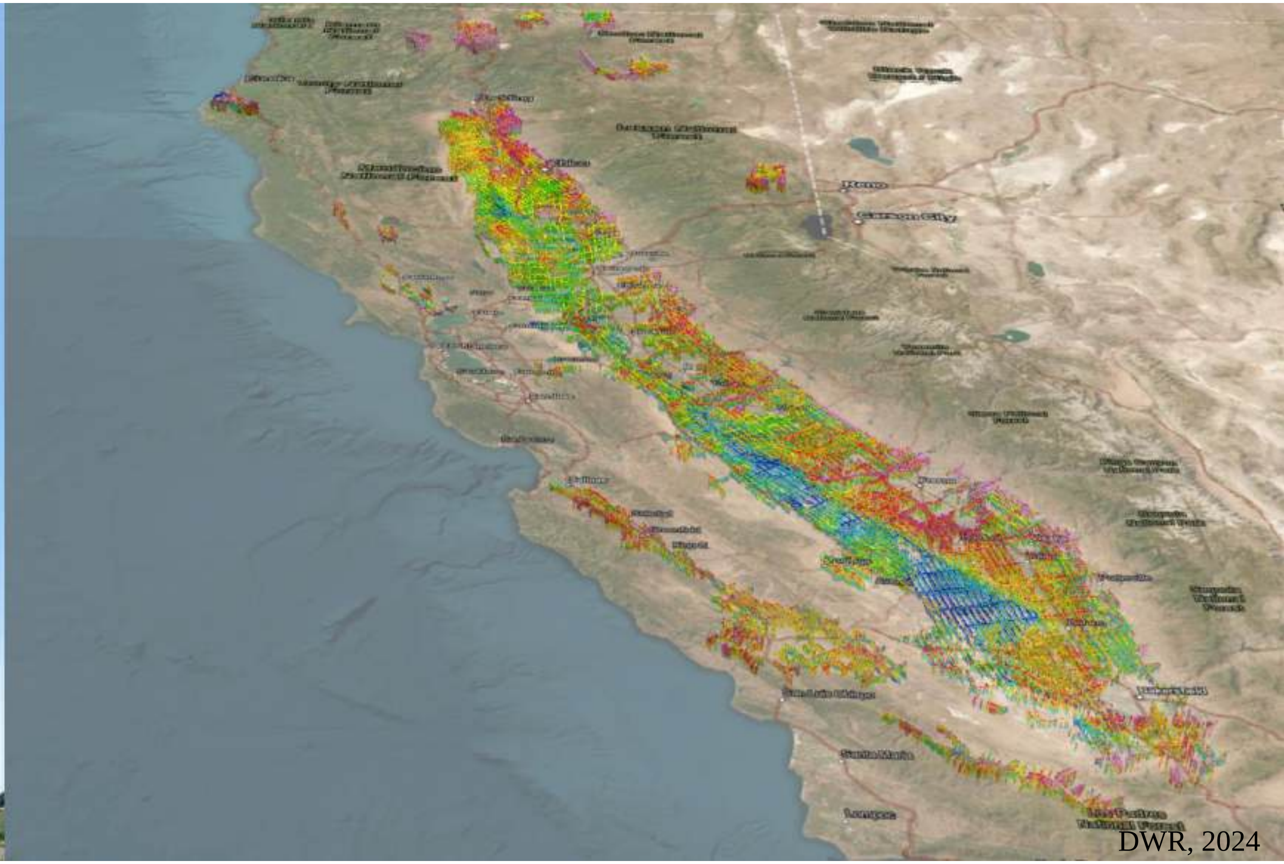
DWR, 2024



Sustainable Groundwater Management Act (SGMA)

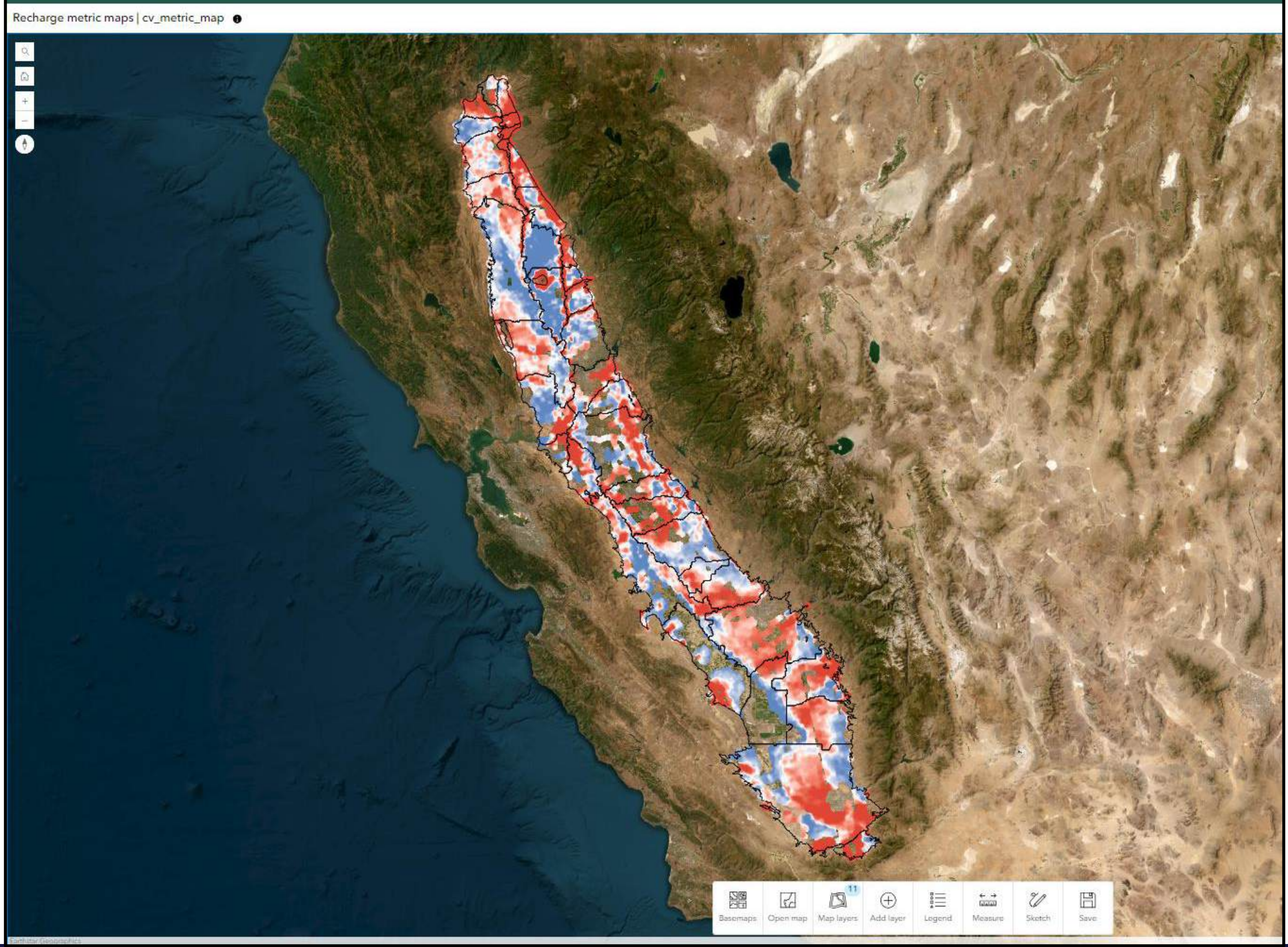
DWR, 2024

Statewide Airborne Electromagnetic (AEM) Survey: Underground Aquifer Mapping



DWR, 2024

Developed by the state to help local water managers determine the best places to implement groundwater recharge projects



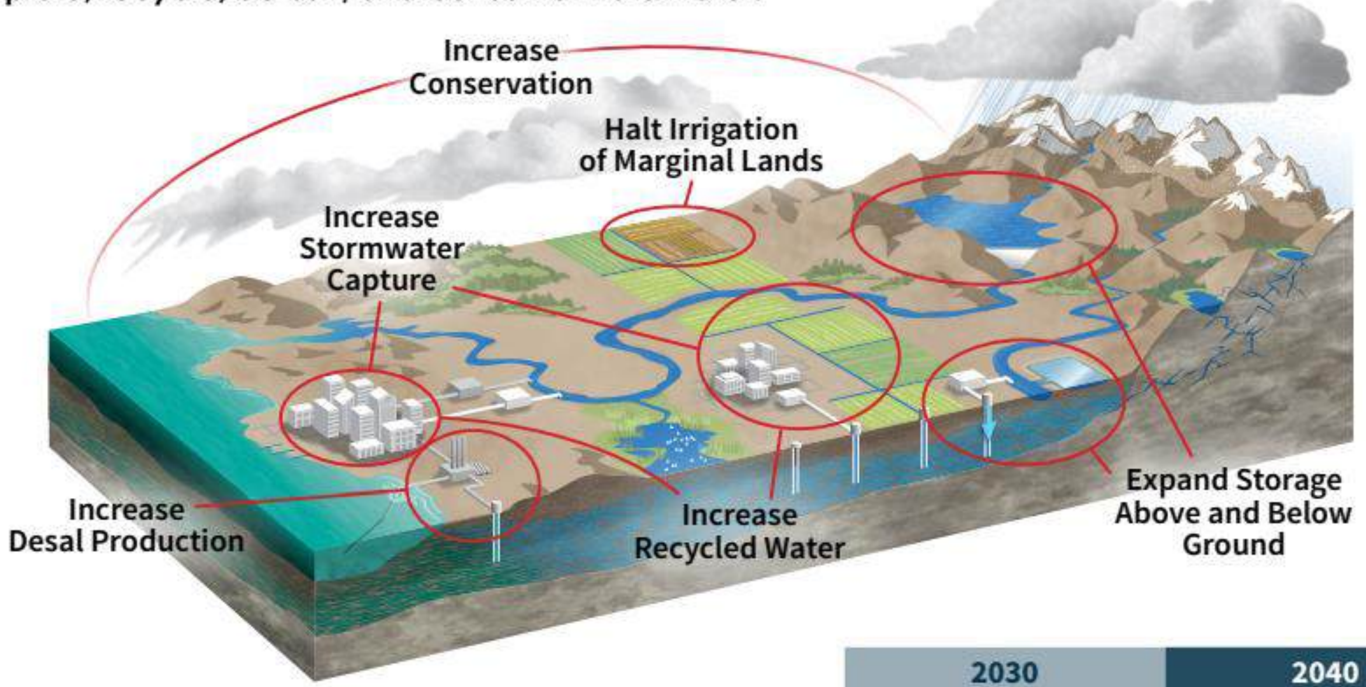
Resistivity from AET is transformed into a coarse fraction.

Red areas on the map have high coarse fraction and are good for groundwater recharge

https://stanford.maps.arcgis.com/apps/instant/atlas/index.html?appid=46573c5fd37a401a8dbca384b19cb8a0

Closing the evaporative gap

To offset increased evaporation tied to warmer average temperatures, California must capture, recycle, de-salt, and conserve more water.



	2030		2040	
Increase Recycled Water	.8 MAF	About 5 MAF	1.8 MAF	About 7 MAF
Increase Desal Production	28,000 AF		84,000 AF	
Increase Stormwater Capture	.25 MAF		.5 MAF	
Increase Conservation	.5 MAF		.5 MAF	
SUBTOTAL FOR RECYCLED, DESAL, STORMWATER AND CONSERVATION	1.6 MAF		2.9 MAF	
Expand Storage Above and Below Ground*	3.7 MAF		4 MAF	
Total	4.8 MAF		6.9 MAF	

*Additional storage capacity does not equate to a similar volume of new water supply. MAF – million acre-feet.

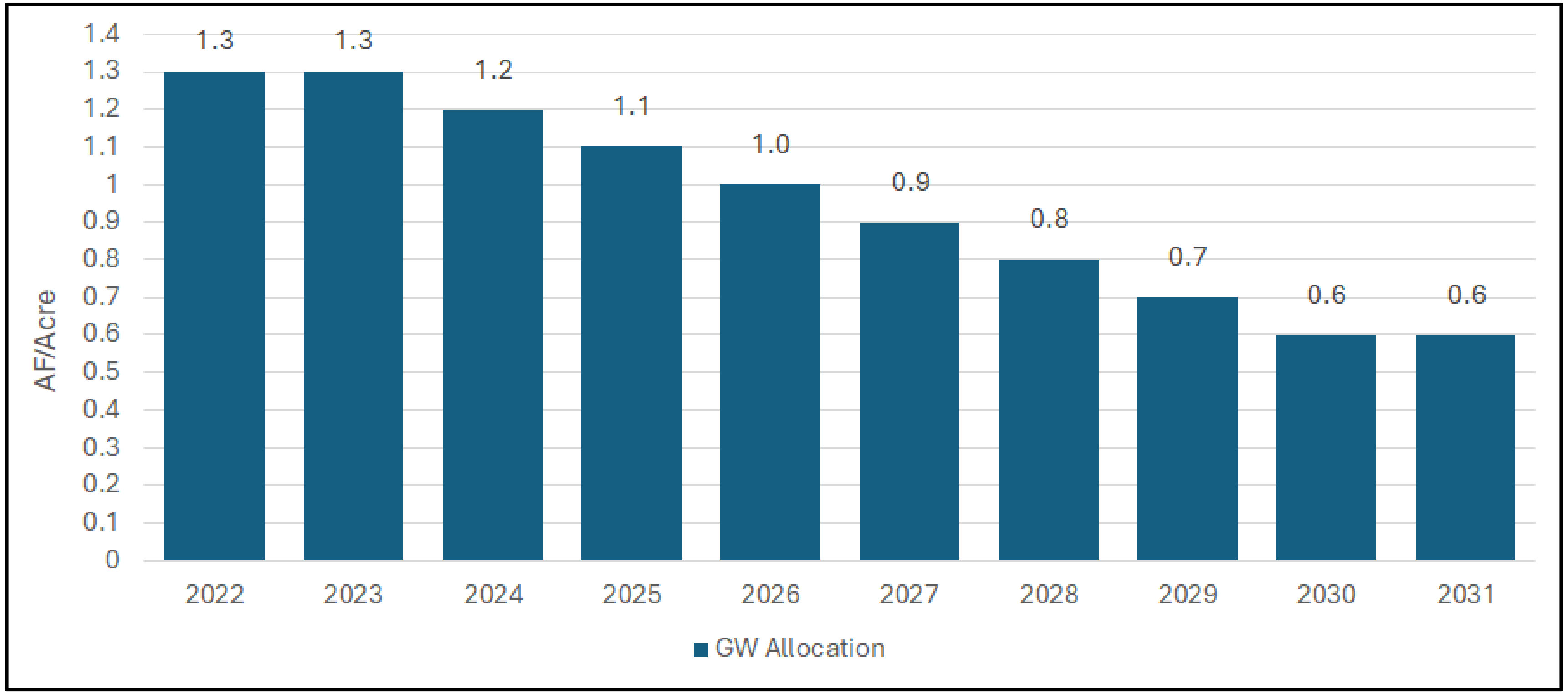
California water supply strategy for adapting to climate change

DWR, 2022

Farm level water management

Recharged: 275,000 acre –ft by February 2024

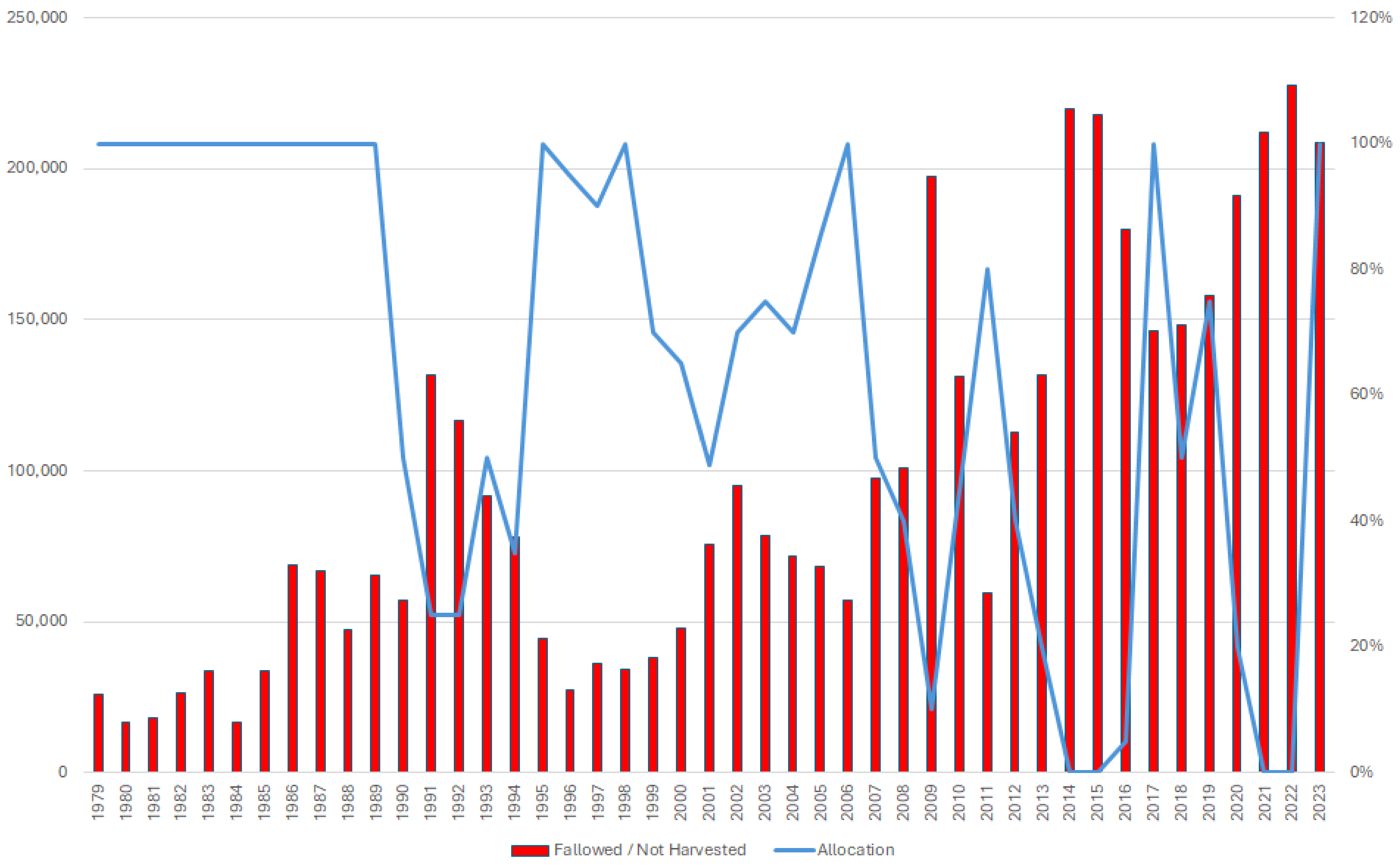
Groundwater Allocation and Transition Period



Water Year	Allocation Cap
2022	1.3 AF per acre
2023	1.3 AF per acre
2024	1.2 AF per acre
2025	1.1 AF per acre
2026	1.0 AF per acre
2027	0.9 AF per acre
2028	0.8 AF per acre
2029	0.7 AF per acre
2030	0.6 AF per acre

- Sustainable yield of 305,000 AF/year
- ~525,000 acres eligible to receive allocation
- Starting 2022, "Transition Period"
- **1.3 AF/acre taper to 0.6 AF/acre allocation (from 396 to 183 mm)**

Febbo, 2023



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Westland Water District: Surface water allocation and land fallowing

Febbo, 2023

Penalties for exceeding groundwater allocation

Madera County GSA			
Madera Subbasin	Inches of ETAW		
Year	SY	TW	Total
2024	12.7	14.7	27.4
2025	12.7	14.4	27.1

Madera County GSA			
Chowchilla Subbasin	Inches of ETAW		
Year	SY	TW	Total
2024	7.1	18.4	25.5
2025	7.1	18.0	25.1

Madera County GSA			
Delta-Mendota Subbasin	Inches of ETAW		
Year	SY	TW	Total
2024	8.6	10.5	19.1
2025	8.6	10.3	18.9

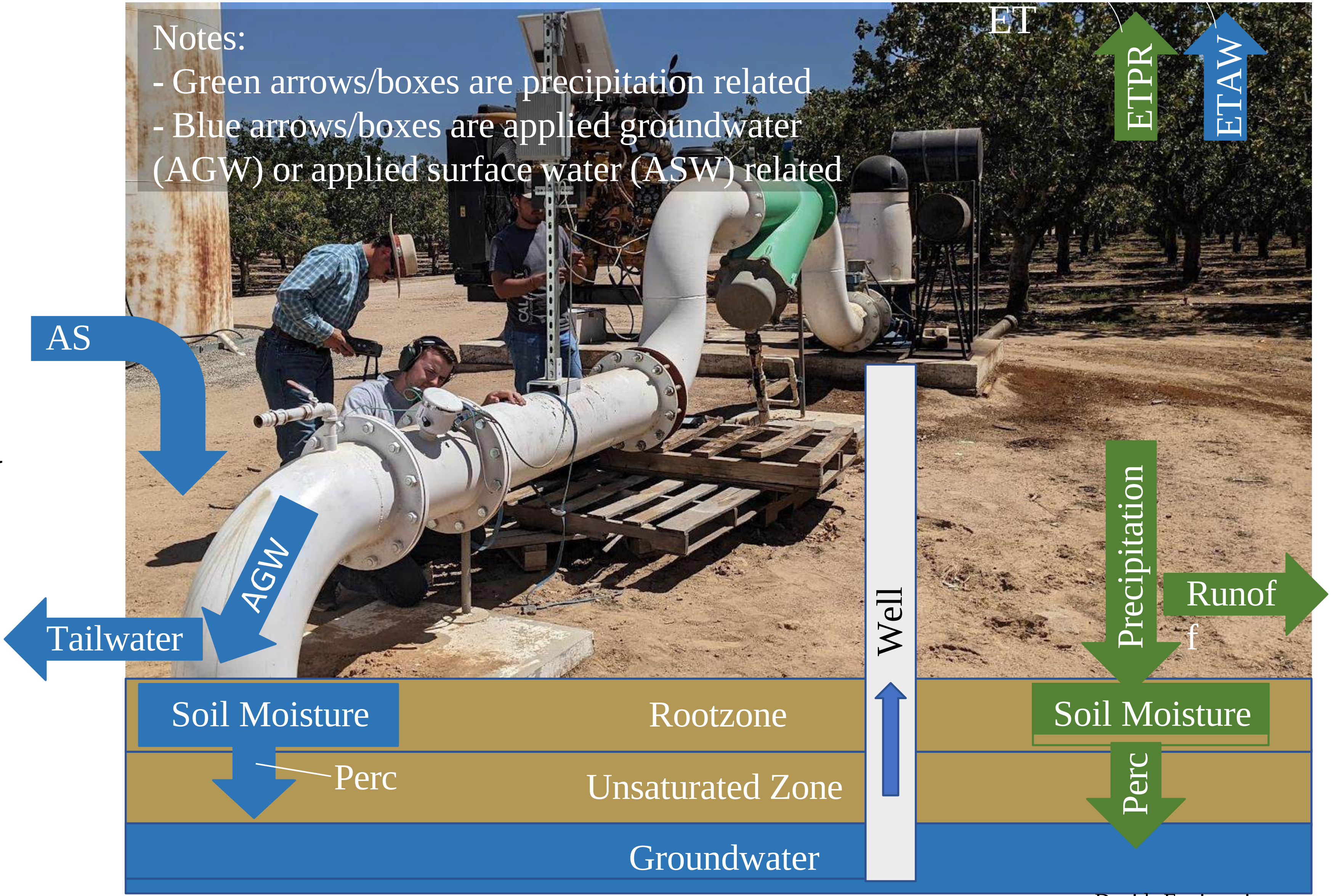
Madera County GSA	
Madera Subbasin	Resolution 2022-145
Year	Amount Over the Farm Unit Allocation Penalty
2023	$100 / AF
2024	$200 / AF
2025	$300 / AF
2026	$400 / AF
2027	$500 / AF

Madera County GSA		
Chowchilla Subbasin	Resolution 2022-143	
Year	Amount Over the Farm Unit Allocation Penalty	Additional Penalty
2023	$100 / AF	$1000/Farm Unit
2024	$200 / AF	$1000/Farm Unit
2025	$300 / AF	$1000/Farm Unit
2026	$400 / AF	$1000/Farm Unit
2027	$500 / AF	$1000/Farm Unit

Madera County GSA	
Delta-Mendota Subbasin	Resolution 2022-144
Year	Amount Over the Farm Unit Allocation Penalty
2023	$100 / AF
2024	$200 / AF
2025	$300 / AF
2026	$400 / AF
2027	$500 / AF

Madera County GSA

- Groundwater Allocation is based on **ETAW**
- Flowmeters measure **AGW**
- Remote sensing measures **ET** and calculates **ETPR** and **ETAW**

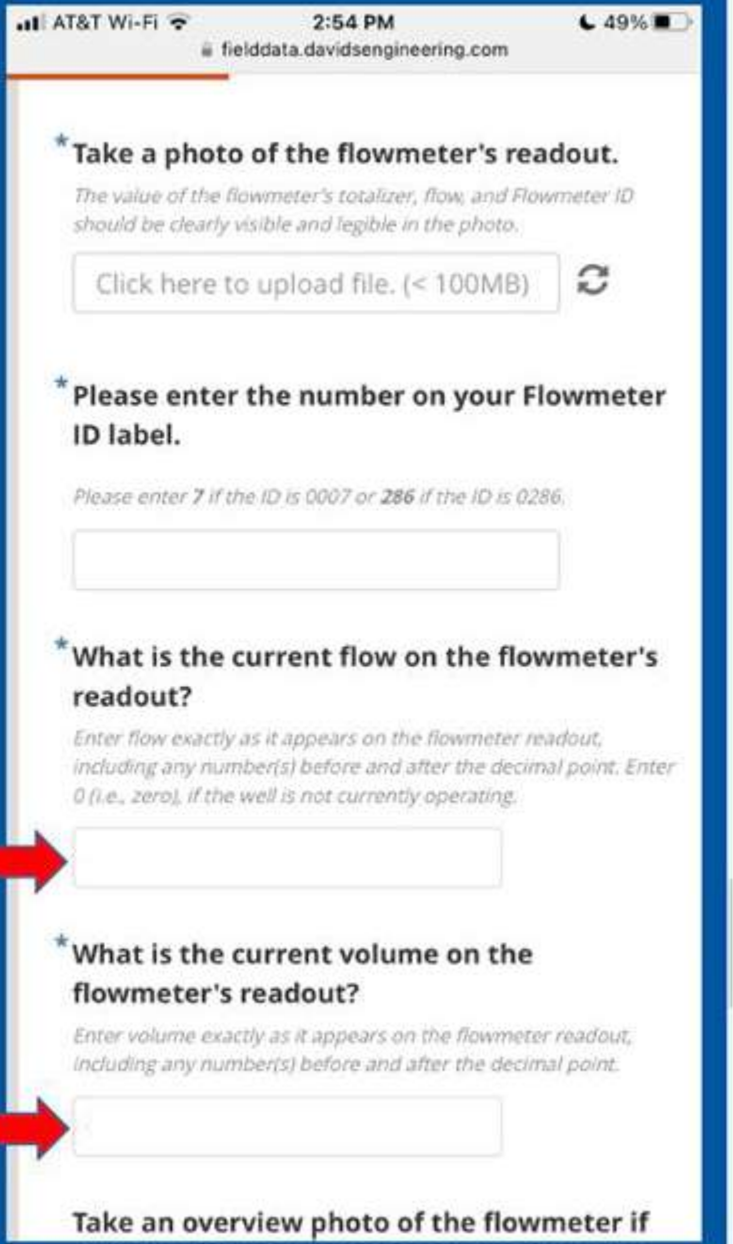


Davids Engineering

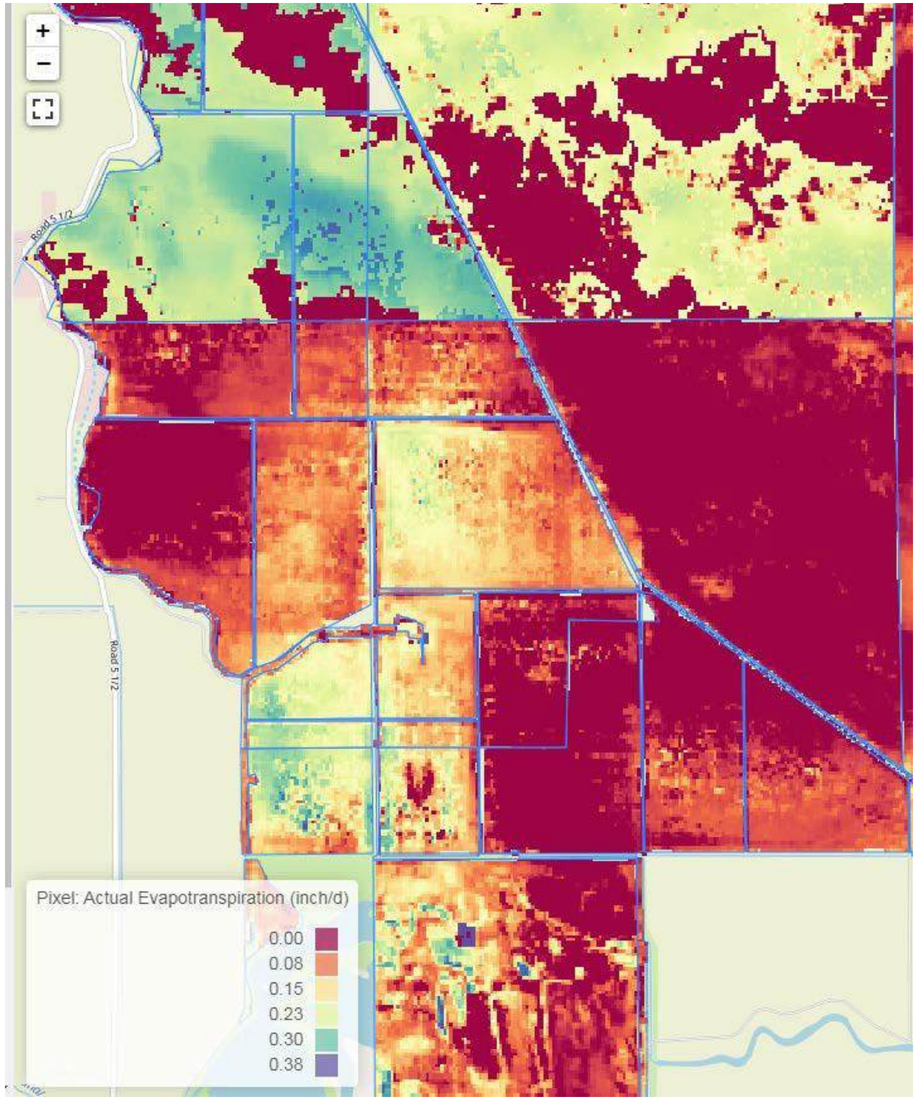
Madera County Grower Flowmeter Readings (Continued…)

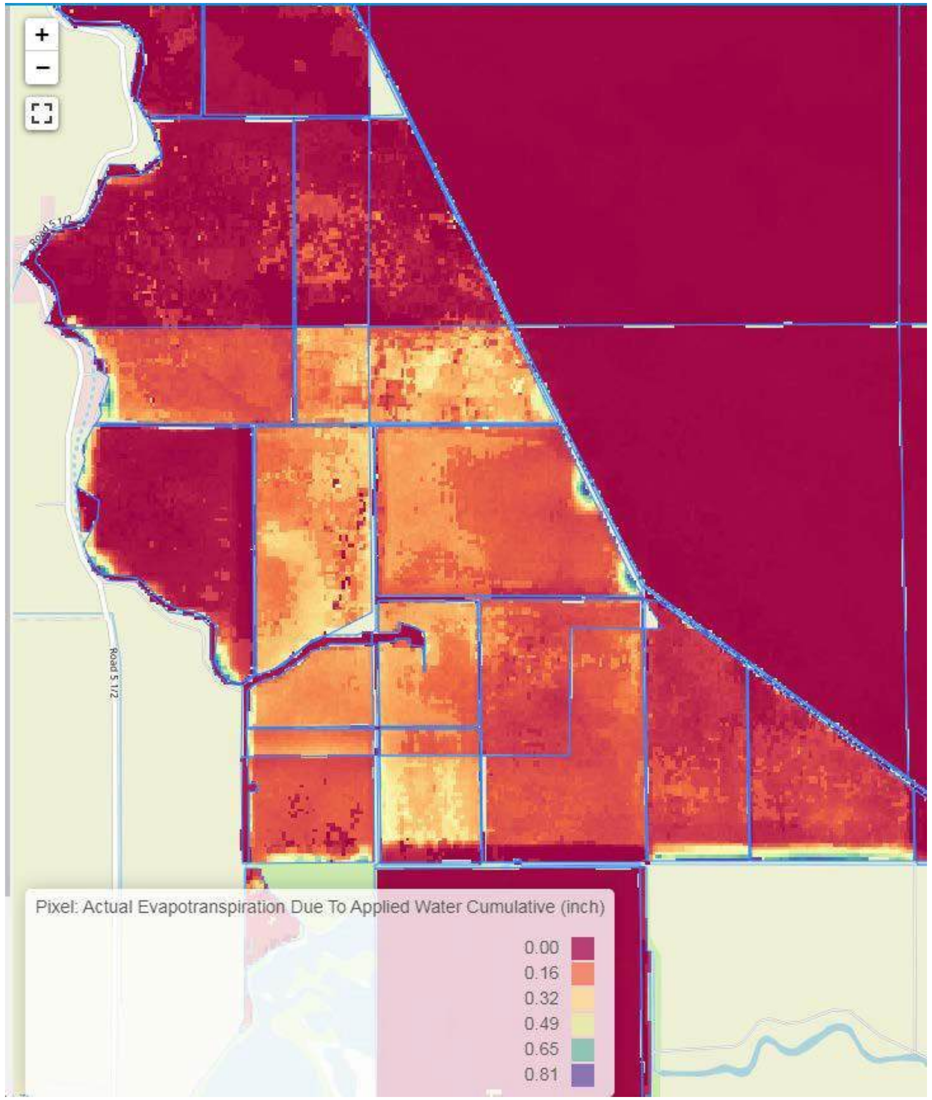
Enter the current flow from the flowmeter readout exactly as it appears. Flow volume units (*e.g.*, GPM, CFS) must remain static. If possible, have pump running under steady state while capturing flow.

Enter the current volume from the flowmeter readout exactly as it appears. Totalizer units (*e.g.*, AF) must remain static.



Groundwater Allocation Monitoring using Satellite-based Remote Sensing

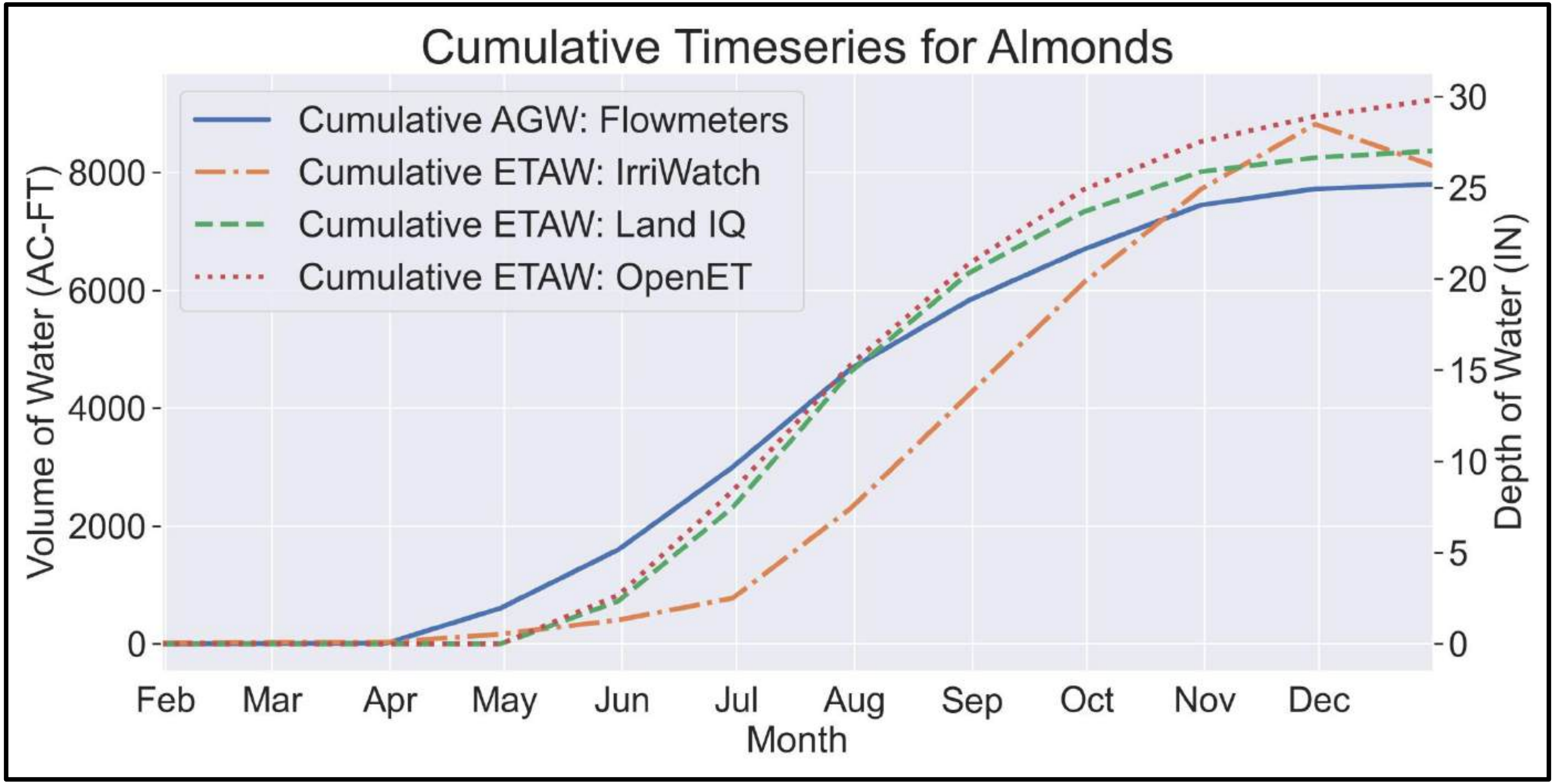




ETAW = ET -ETp

Madera County GSA

Groundwater allocation monitoring using satellite-based remote sensing

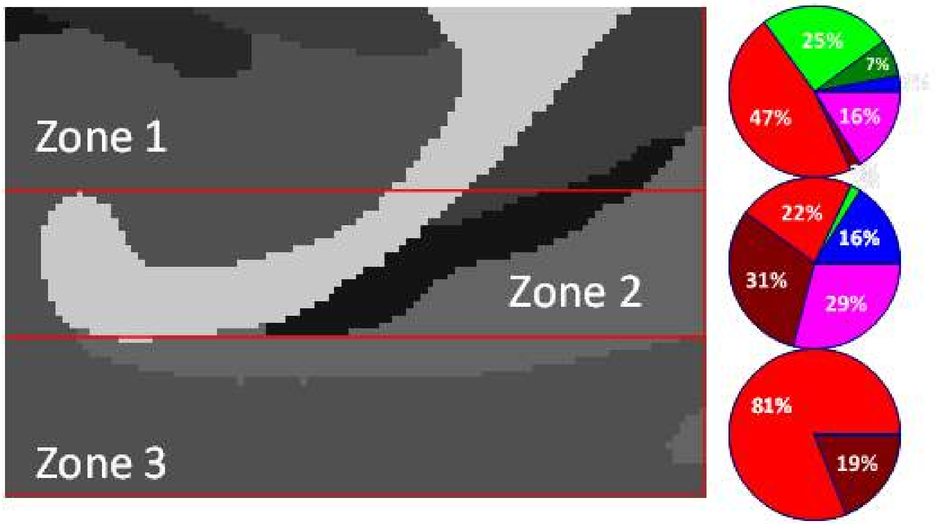


Davids Engineering

Strategic water management at the farm level

What crop should I grow and how much land should I irrigate?

Land-Water-Crop Allocation Optimization under water allocation and agronomic constraints



Sample farm with different zone types in each zone based on the NRCS soil survey

Optimization of water allocation

$$\max_{w_{1,q},w_{2,q},\ldots,w_{N_z,q}} P_q = \sum_{k=1}^{N_z}\sum_{i=1}^{N_c}\left(\phi_{i,k}\left(w_{k,q}\right)\cdot\lambda_{i,k,q}\cdot A_k - \lambda_{i,k,q}\cdot A_k\cdot F_{i,q} - p_q\cdot w_{k,q}\cdot A_k\right)$$

$s.t.$

$$\sum_{k=1}^{N_z} w_{k,q}\cdot A_k \le Q_q \qquad \forall q$$

Water allocation constrain

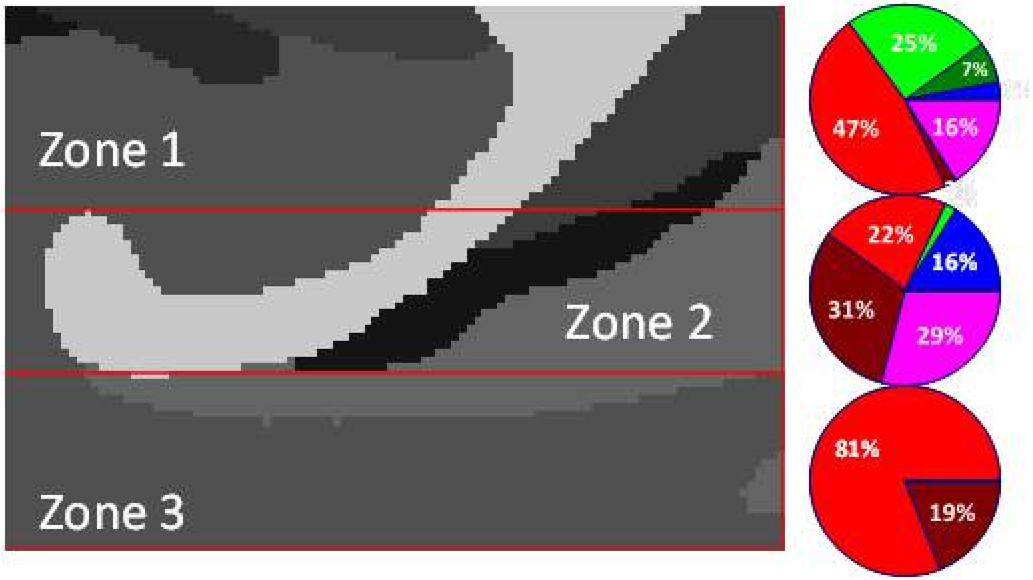
$$S_1 = \{C_i, C_k, C_j, C_i, C_k, C_j, \cdots\}$$
$$S_2 = \{C_i, C_i, C_i, C_i, C_i, C_i, \cdots\}$$
$$\vdots$$
$$S_{Ns} = \{C_k, C_j, C_k, C_j, C_k, C_j, \cdots\},$$

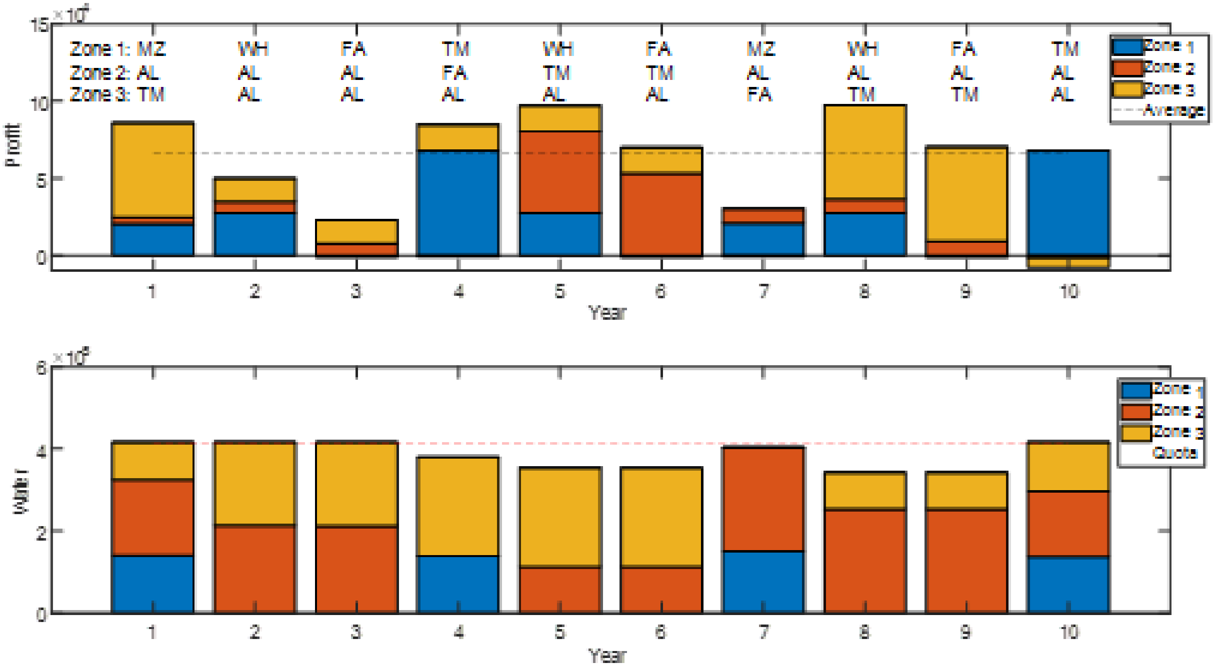
Crop rotation constrains

Linker and Kisekka (2024)

What crop should I grow and how much land should I irrigate?

Land-Water-Crop Allocation Optimization under water allocation and agronomic constraints





Each zone has different soil types

Linker and Kisekka (2024)

Tactical water management for tree crops

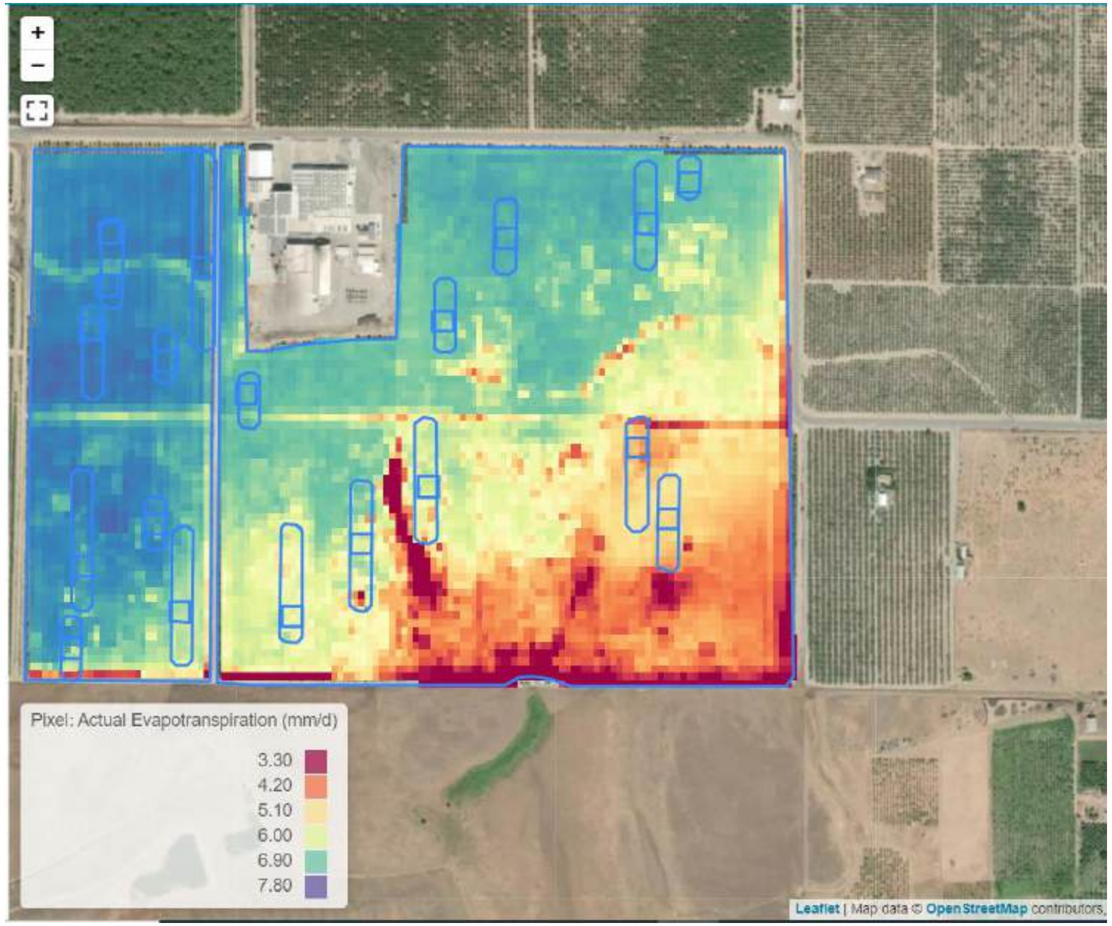
Adoption of irrigation scheduling technologies by almond growers in California

How irrigation decisions are made by our growers	Percentage of adoption (%)
ETc Based Scheduling	75%
Water District Influenced Schedule	23%
Deficit Irrigation Used at Hull Split	76%
Remotely Read Soil Moisture Sensors	61%
Manually Read Soil Moisture Sensors	59%
Pressure Chamber Used	31%
Pressure Chamber to Determine First Irrigation	20%
Use Flow Meters	43%
Growers Estimate Water Use	57%
Hand Feel Method Used to Determine Moisture	89%
Use Soil Auger to Check Moisture:	49%

Source: Almond Board of California

Integration of remote sensing and ground-based ET measurements to reduce errors

Data driven Irrigation scheduling. Apply the right amount, at the right time in the right place.



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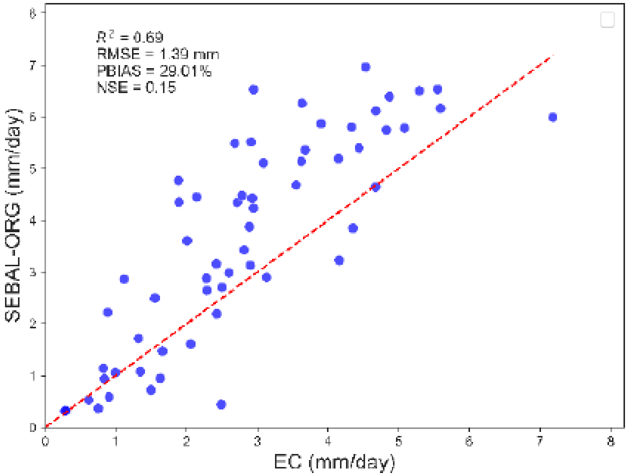
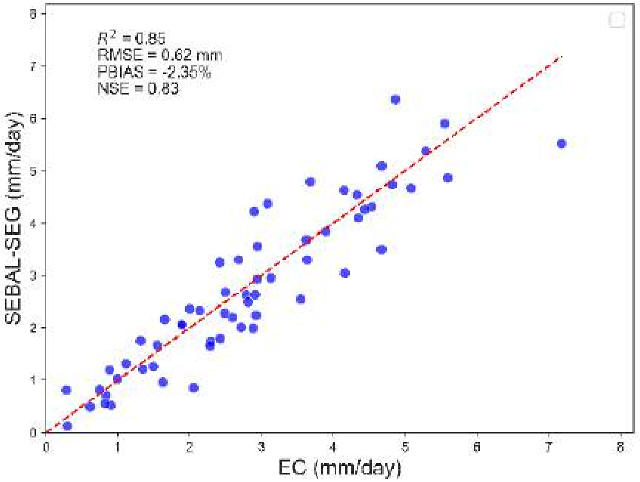
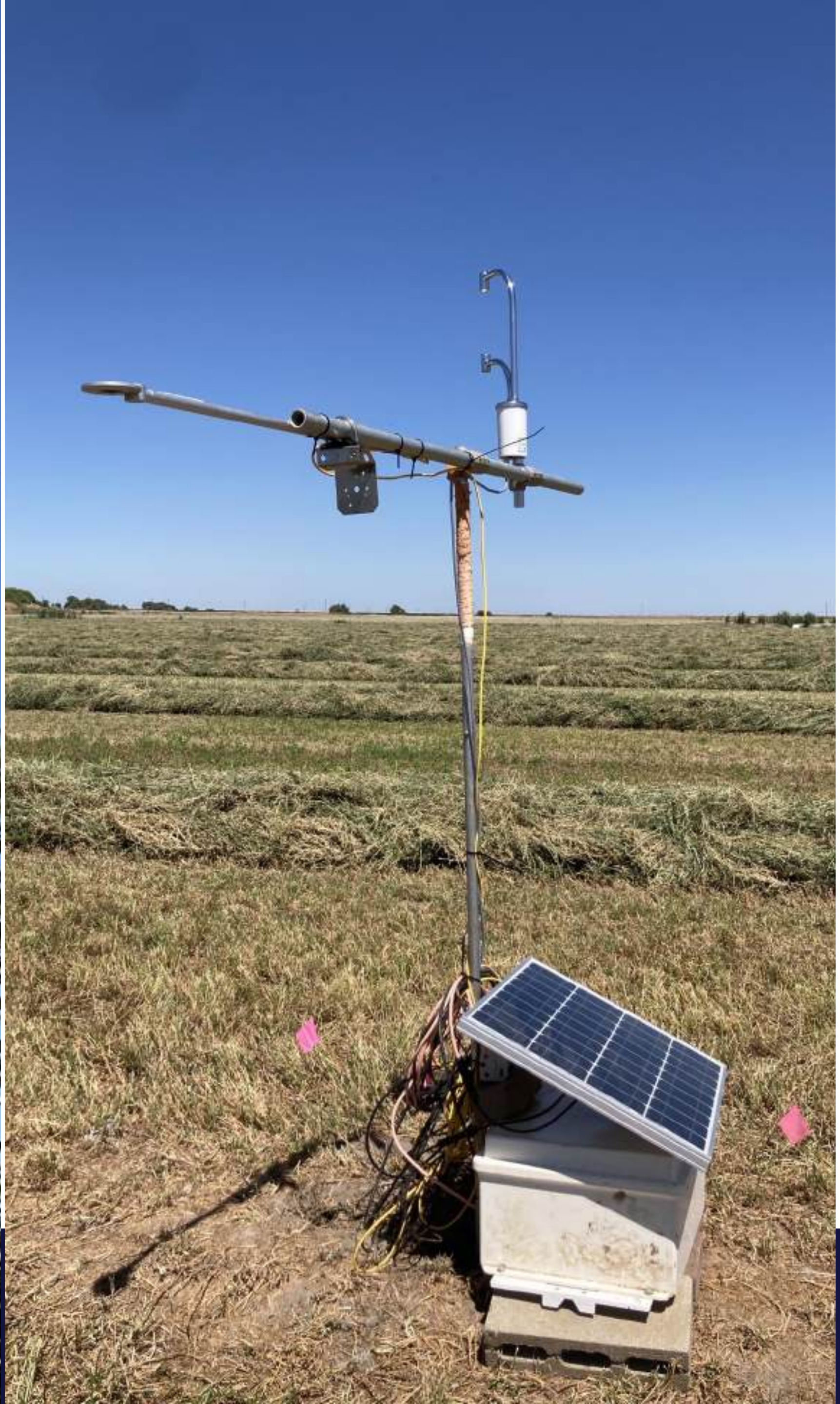
Without ground data assimilation



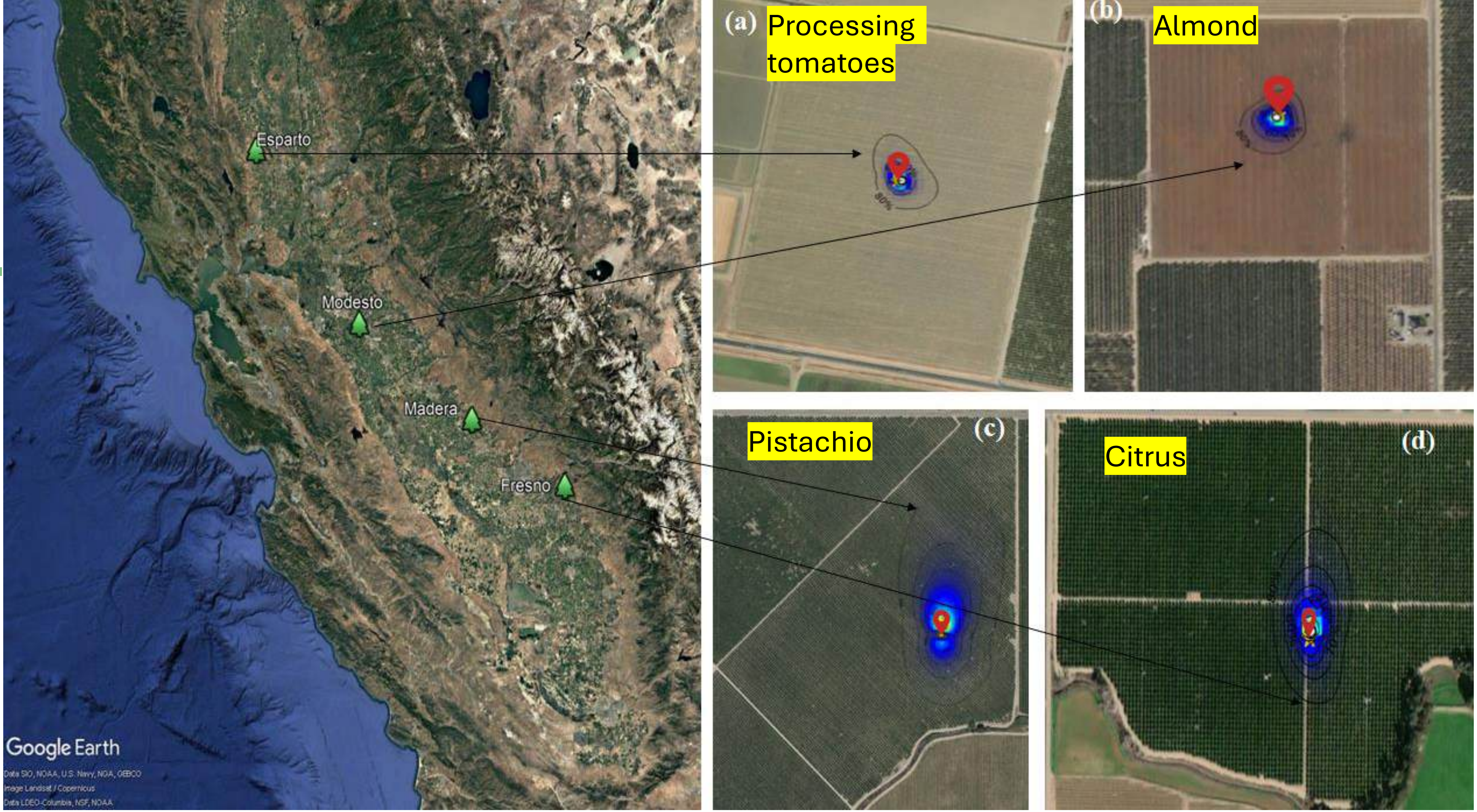
With ground data assimilation

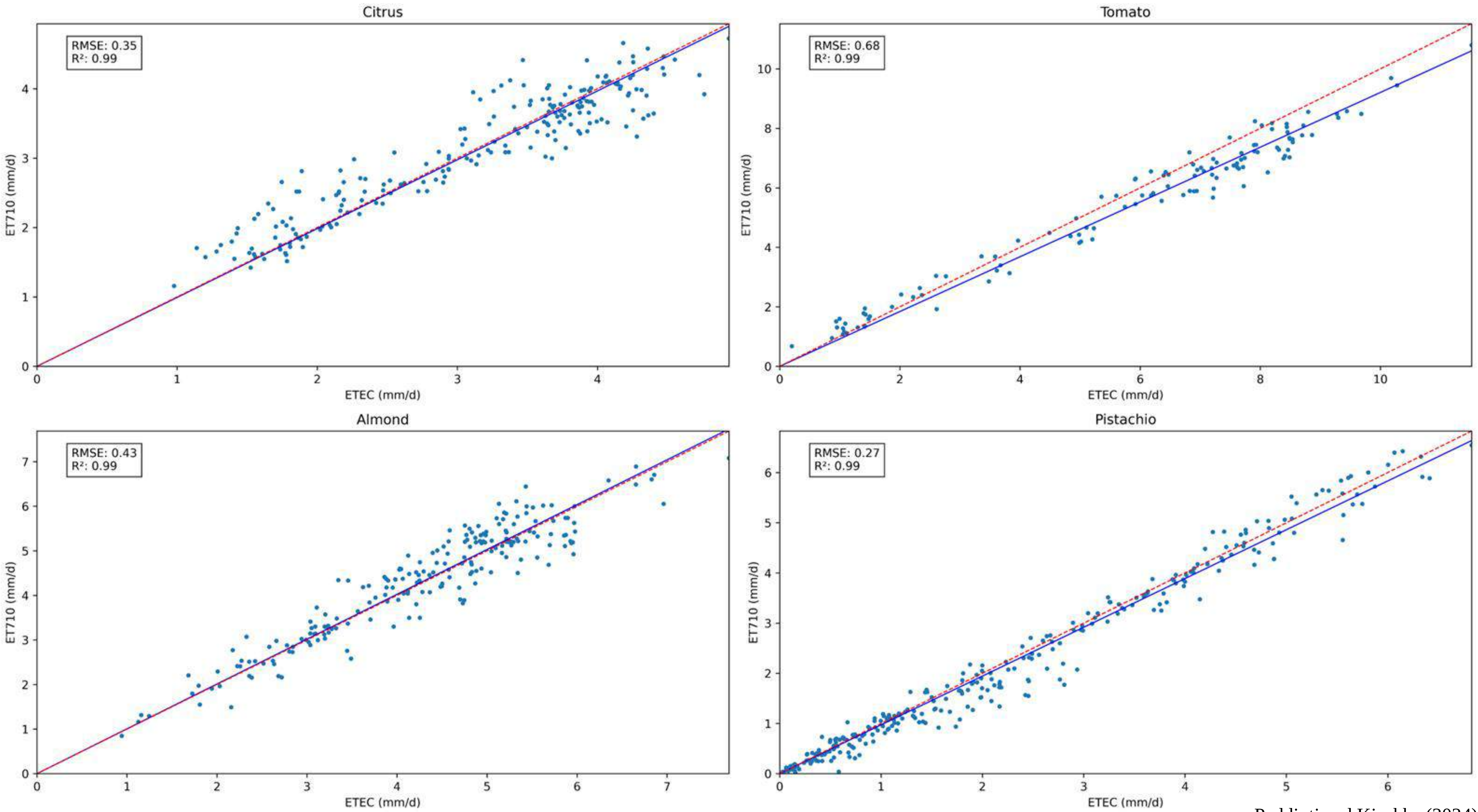


Ghorbanpour and Kisekka, (2024)

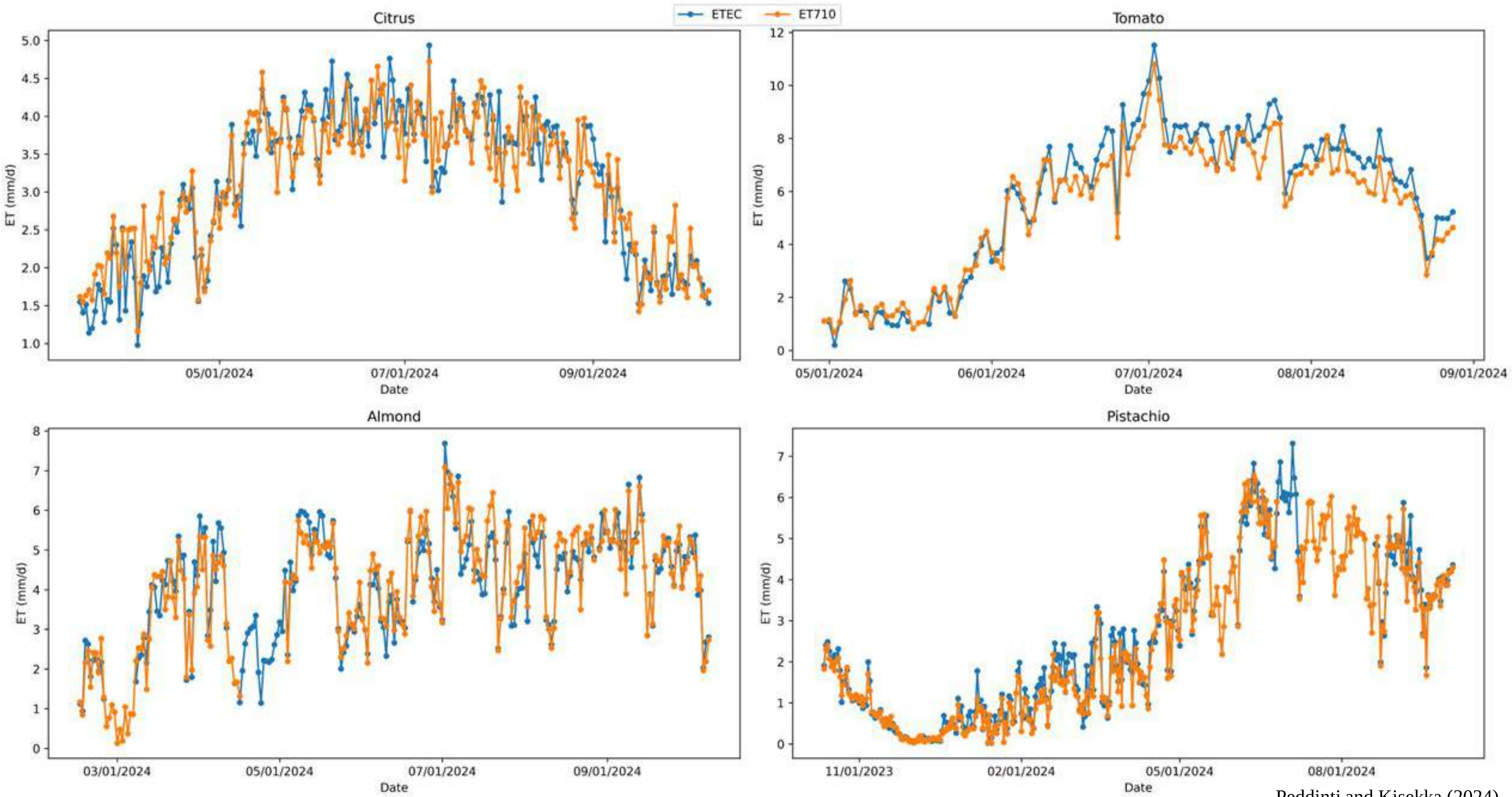


LI-710 Low cost ET sensors

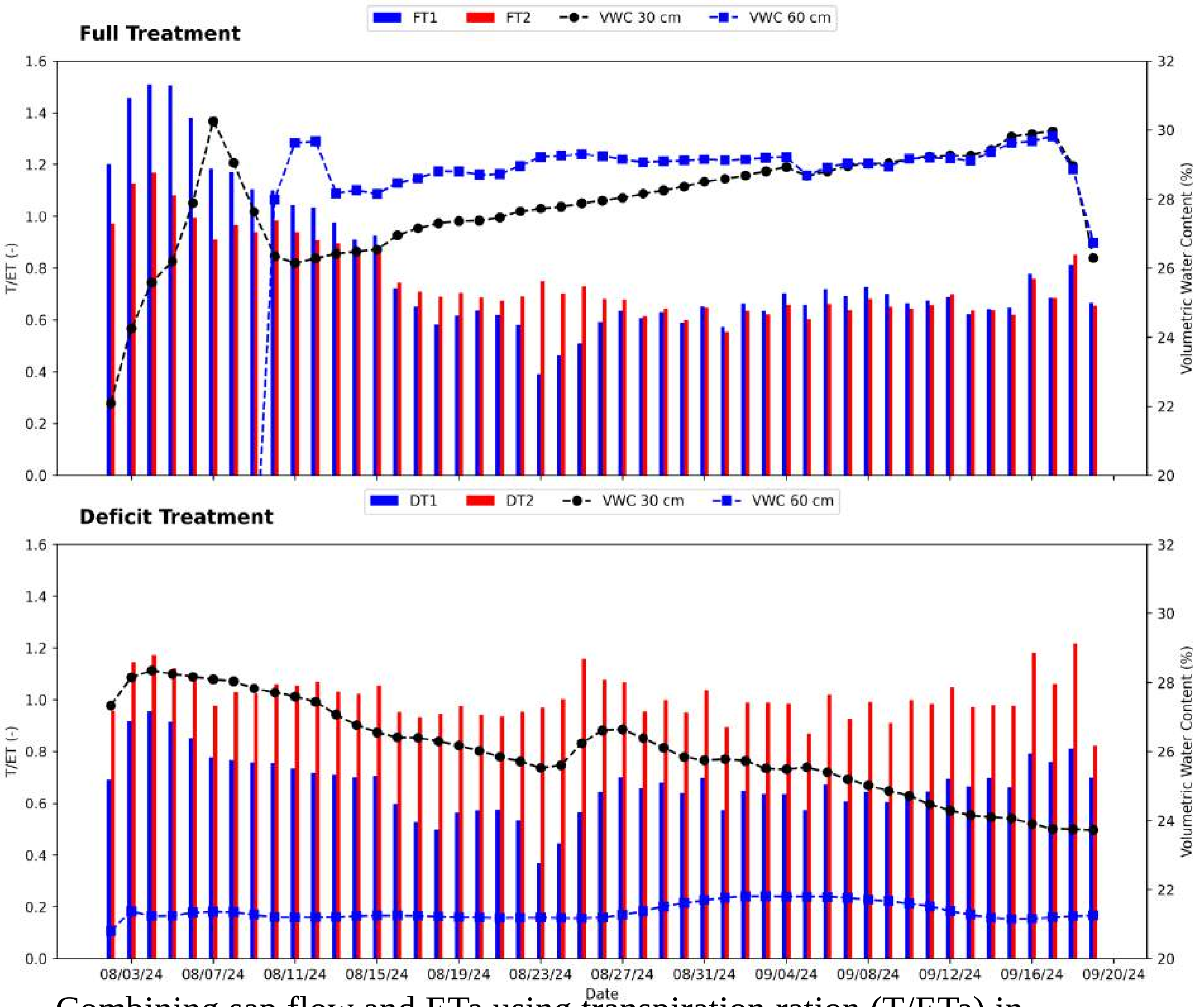

Esparto
Modesto
Madera
Fresno
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Data LDEO-Columbia, NSF, NOAA
(a)
Processing tomatoes
(b)
Almond
(c)
Pistachio
(d)
Citrus



Peddinti and Kisekka (2024)



Peddinti and Kisekka (2024)



Combining sap flow and ETa using transpiration ration (T/ETa) in pistachio. T/ETa < 1.0 indicates water stress

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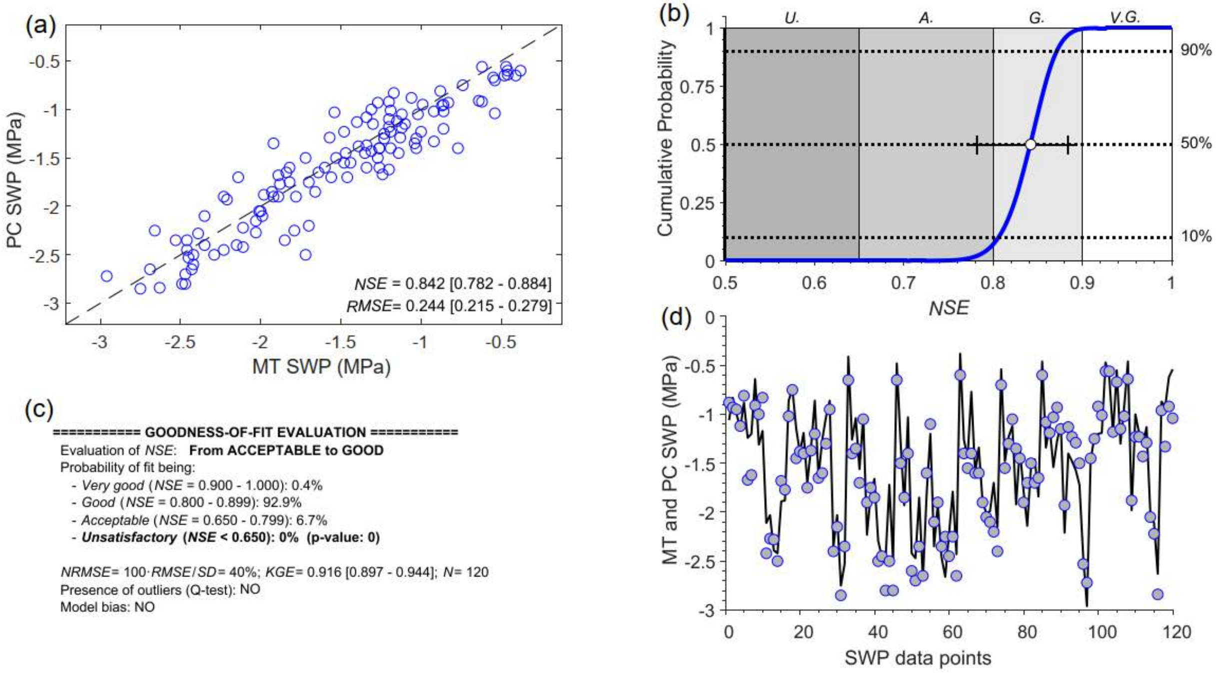
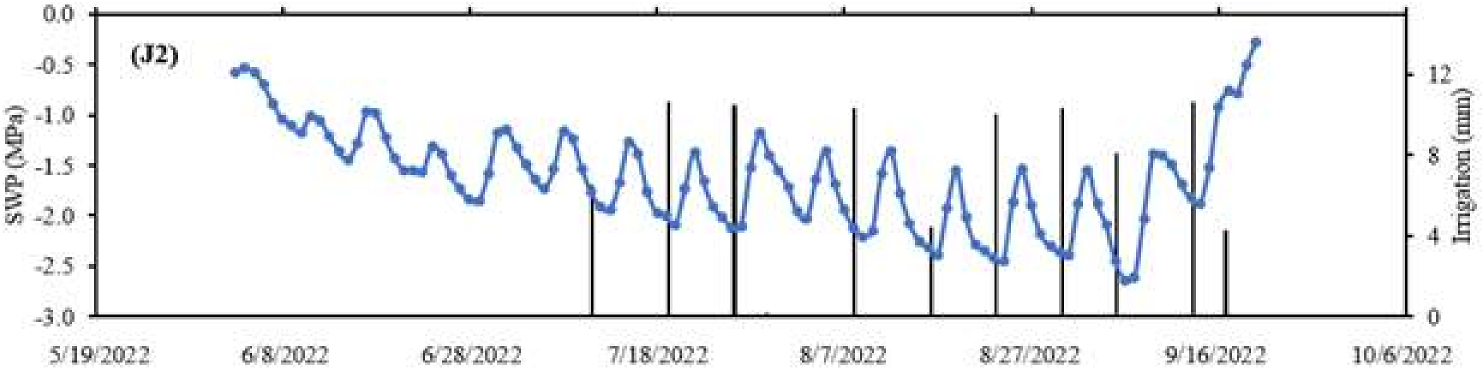
Automated stem water potential sensors

Microtensiometers
Osmometers





Kisekka et al. (2024)

Stem water potential (SWP) is widely used as a water status indicator in woody perennial crops

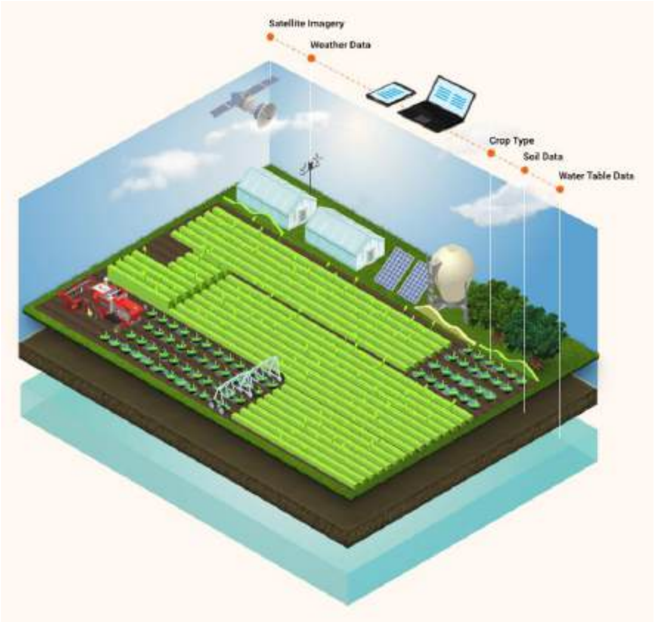
Continuous SWP sensor provides feedback on tree response to water management

Many citrus growers in California still use tensiometers to make irrigation scheduling decisions due to the ease of data interpretation, and familiarity

Uncertainty in Kc to guide ET-based scheduling

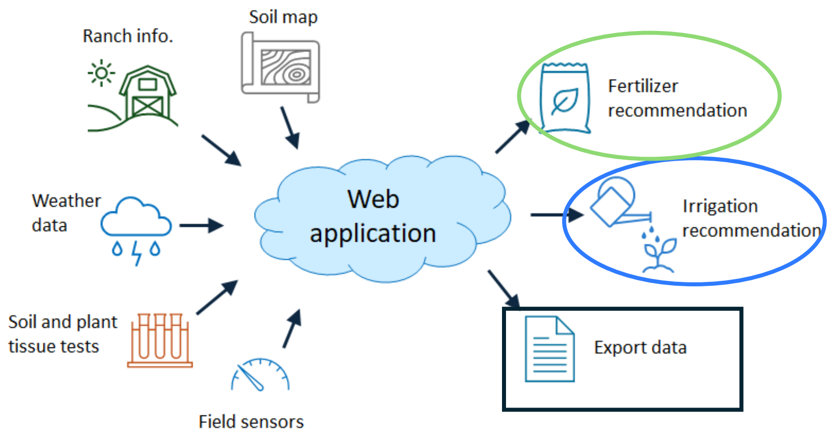
Tactical water management for vegetable crops

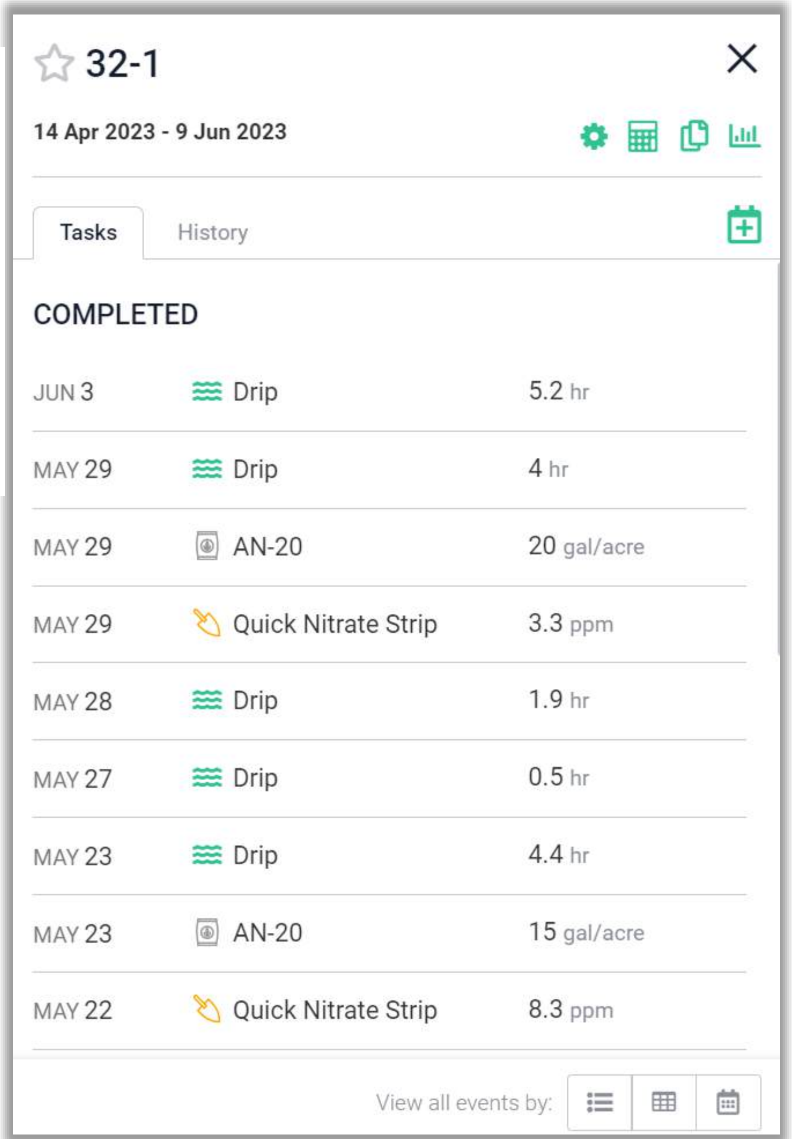
- ✓ Provides site-specific recommendations for irrigation and nitrogen management based on soil type, climate, crop type, and crop development stage
- ✓ Uses science-based algorithms for developing recommendations
- ✓ Maintains records on water and nutrient management (export for regulatory compliance)



cropmanage.ucanr.edu

Michael Cahn


Ranch info.
Soil map
Weather data
Soil and plant tissue tests
Field sensors
Web application
Fertilizer recommendation
Irrigation recommendation
Export data


32-1
14 Apr 2023 - 9 Jun 2023
Tasks
History
COMPLETED
JUN 3 Drip 5.2 hr
MAY 29 Drip 4 hr
MAY 29 AN-20 20 gal/acre
MAY 29 Quick Nitrate Strip 3.3 ppm
MAY 28 Drip 1.9 hr
MAY 27 Drip 0.5 hr
MAY 23 Drip 4.4 hr
MAY 23 AN-20 15 gal/acre
MAY 22 Quick Nitrate Strip 8.3 ppm
View all events by:

Soil management

Salinity Management

- Need to develop simple decision support tools for assessing the impact of irrigation water salinity on yield and profitability

- Geospatial maps of salinity impacts on yield could be used to inform multi-benefit land repurposing decision making.

Crop response function to irrigation and salinity

Biophysical properties
(K_s, δ, η, θ_r, θ_s, EC_{e50}, T_p, ψ_w, ψ_{root}, b, p)

Management factors
(I and EC_{iw})

$$T = \frac{\min\left\{T_p, \left[\left(\psi_{root} - \frac{\psi_w}{\left(\frac{(I-T)}{K_s}\right)^{1/\eta}}\right)^{(I-T)*b}\right]\right\}}{1+\left(\frac{EC_{iw}*I*\left(\theta_r + (\theta_s+\theta_r)\left(\frac{(I-T)}{K_s}\right)^{1/\delta}\right)}{EC_{e50}*(I-T)\theta_s}\right)^{p}}$$

$$Y_r = T_r$$

$$\frac{Y}{Y_p} = \frac{T}{T_p}$$

Shani, Ben-Gal et al. (2007, 2009)

Assessing salinity impacts on crop yield and economic returns in the Central Valley

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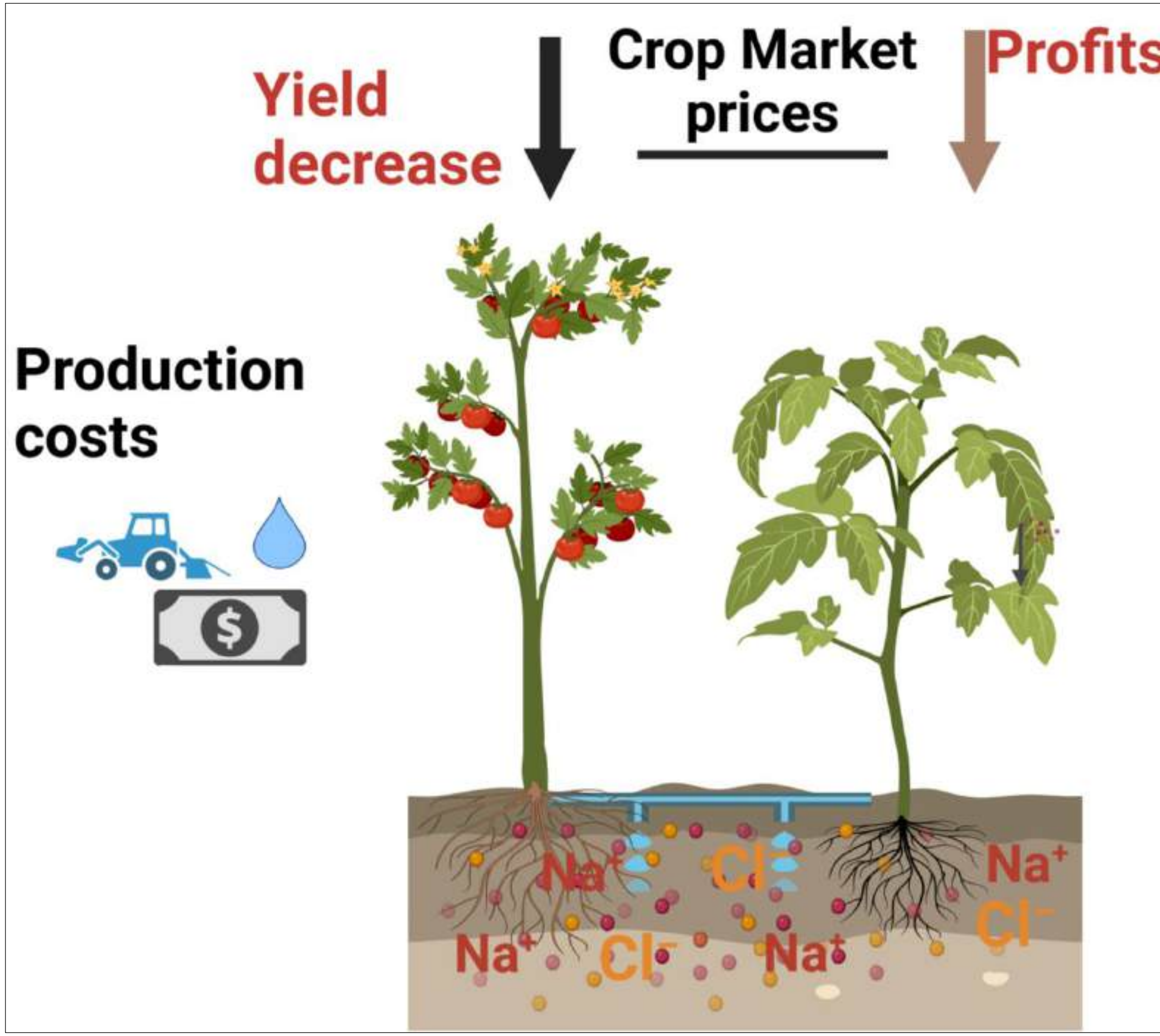
Agricultural Water Management
Volume 287, 1 September 2023, 108463

Assessing salinity impacts on crop yield and economic returns in the Central Valley

Floyid Nicolas [a], Tamir Kamai [c], Alon Ben-Gal [c], Jose Ochoa-Brito [d e], Andre Daccache [a], Felix Ogunmokun [b], Isaya Kisekka [a b]



Crop Yield and Profitability Response to Salinity Model

This decision support tool is intended to help policymakers and Groundwater Sustainability Agency (GSA) managers identify areas unsuitable for sustainable and profitable agriculture and prioritize them for multi-benefit land repurposing to reduce agricultural water demand. The tool is also intended to help growers predict yield and profitability as a function of irrigation water salinity.

1

Model

Calculate relative yield and profitability response to irrigation water salinity

Metric Units | English Units

2

Maps

Explore geospatial data on map for relative yield and profit

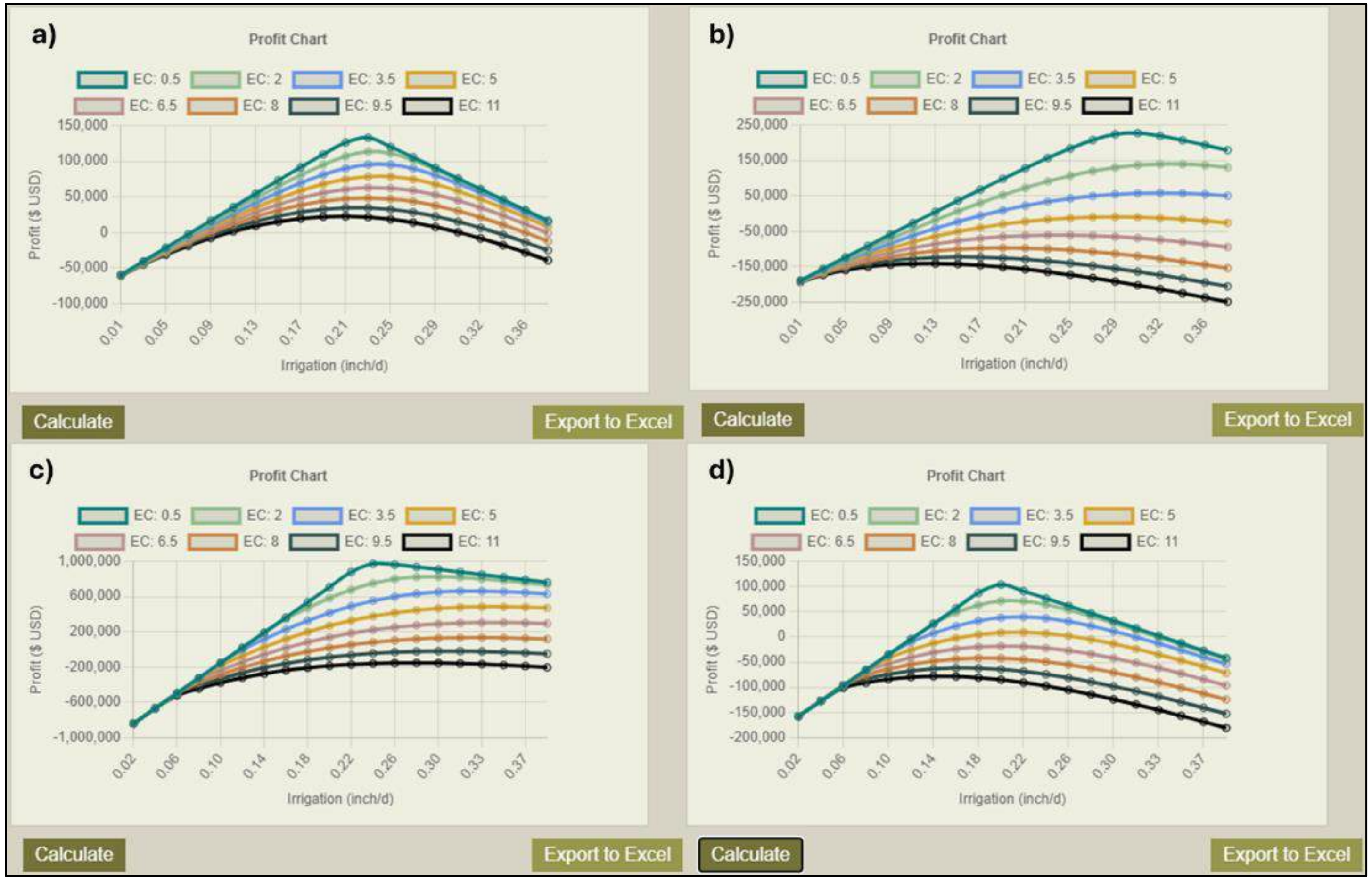
View Maps

3

Information

View guidance and information about this web application

Review

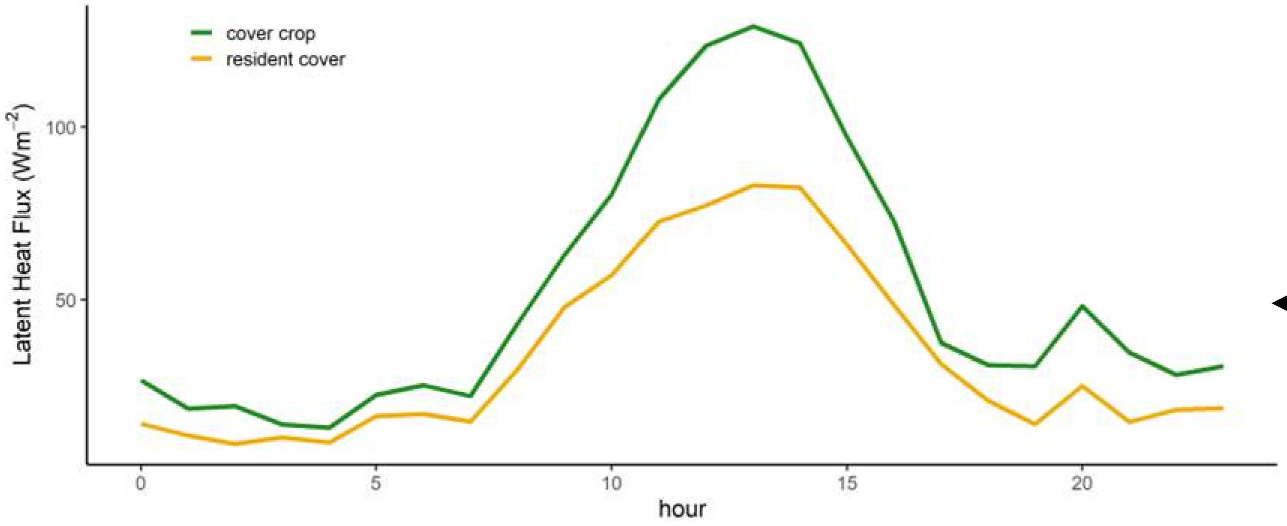


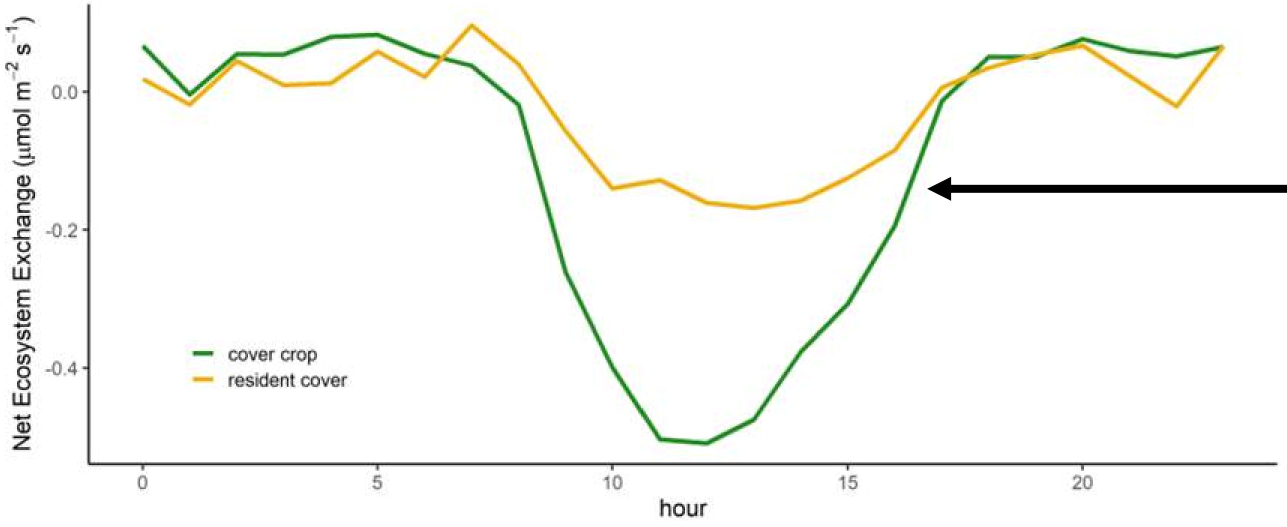
Profits for a) alfalfa, b) almonds, c) table grapes, and d) processing tomatoes using the web tool.

https://yieldprofit.ucdavis.edu/

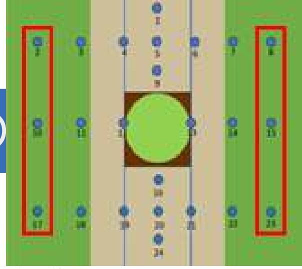
Soil health

Soil Health: Cover Crops

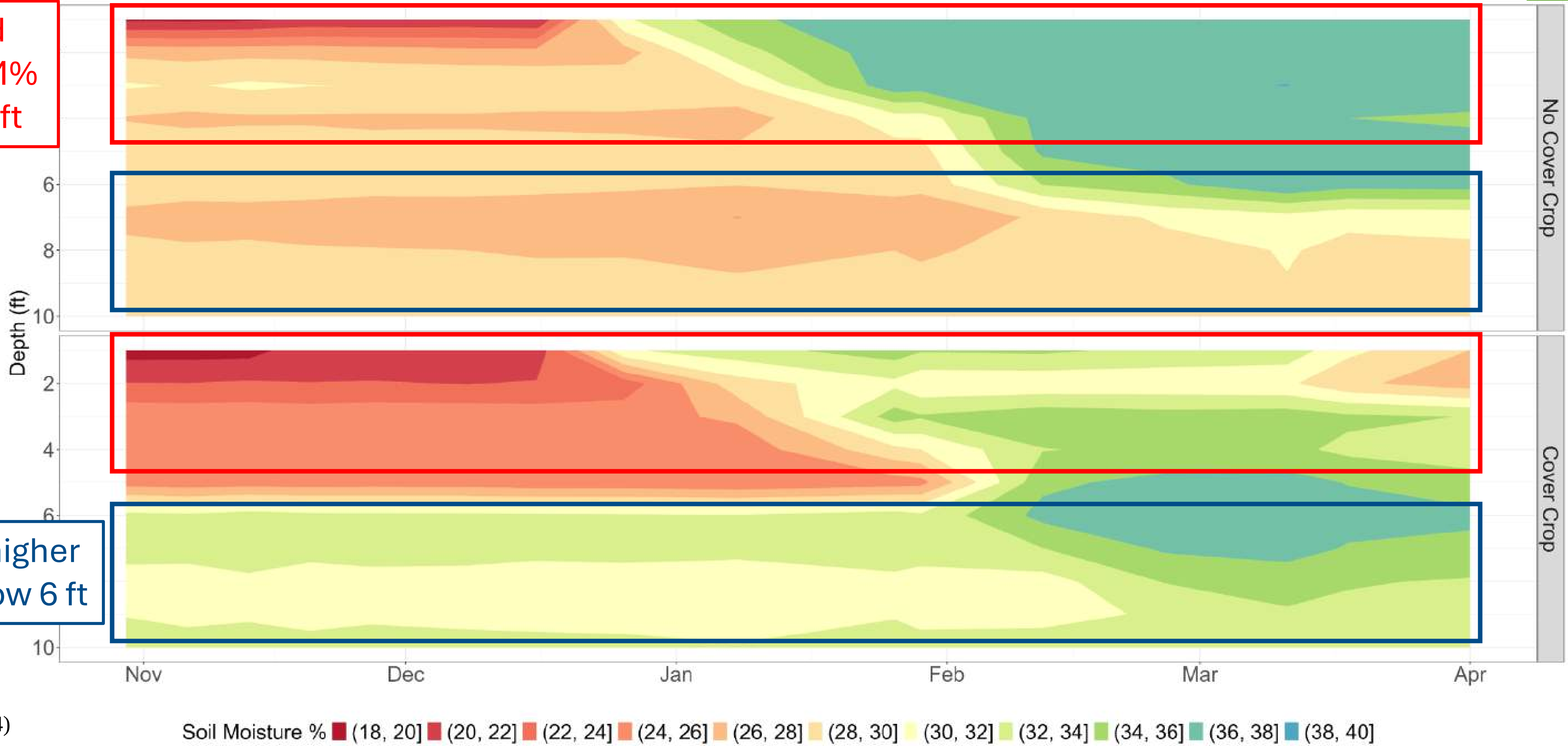




Cover crops increased soil moisture storage below six feet



NC had higher SM% above 5 ft



CC had higher SM% below 6 ft

Chen et al. (2024)

Conclusion

- Increase in water supply is needed to increase climate resilience
- Enhance demand management is critical for sustainable irrigation
- Conservation practices and technologies exist that can help growers improve water use efficiency at the farm scale
- Where it exits, salinity poses a major threat to irrigated agriculture
- Irrigation management needs to be implemented to provide multiple benefits including crop production and soil health

Acknowledgments

USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

Groundwater SAS Project: USDA NIFA Grant Award # 2021-68012-35914

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