Managed aquifer recharge on agricultural land

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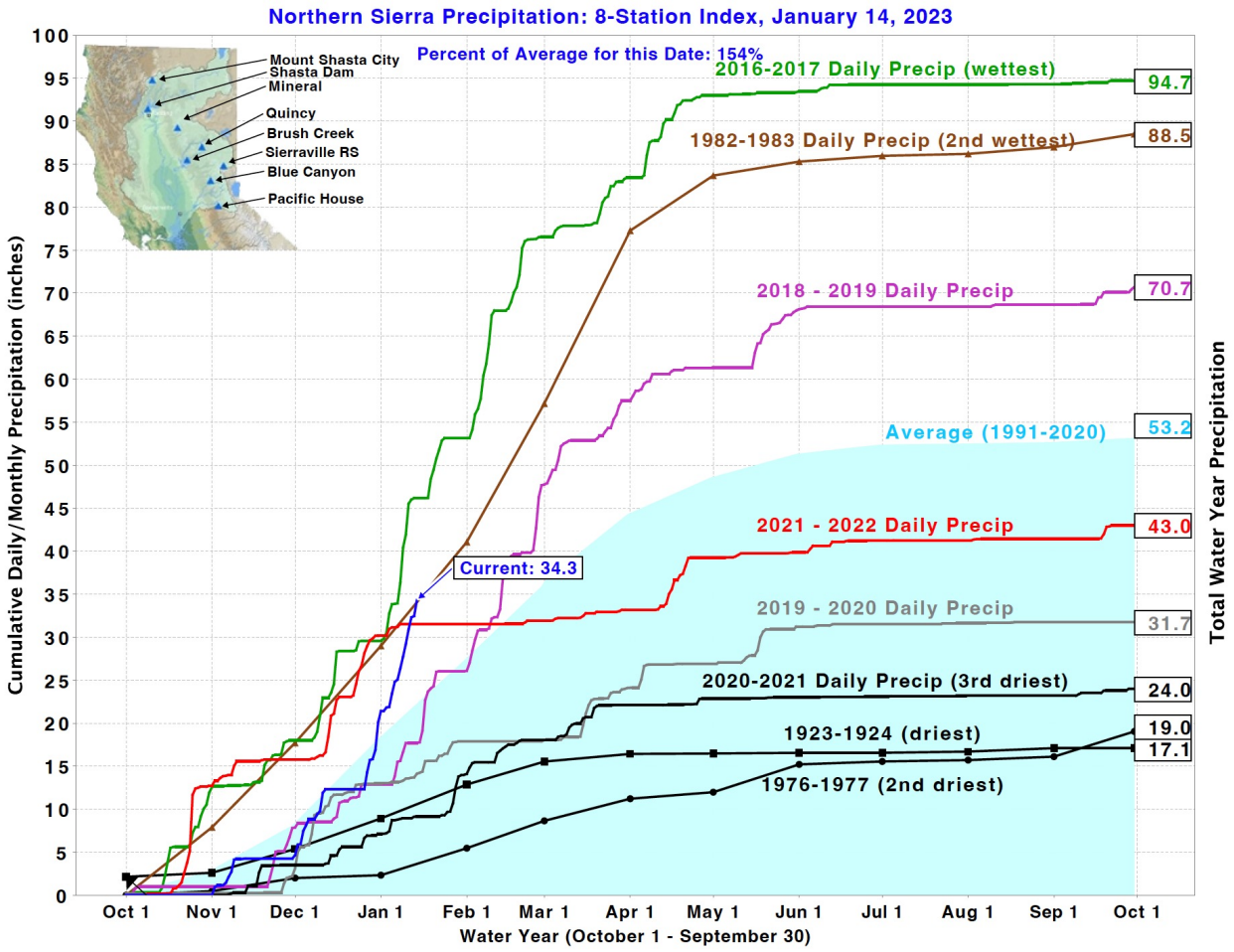
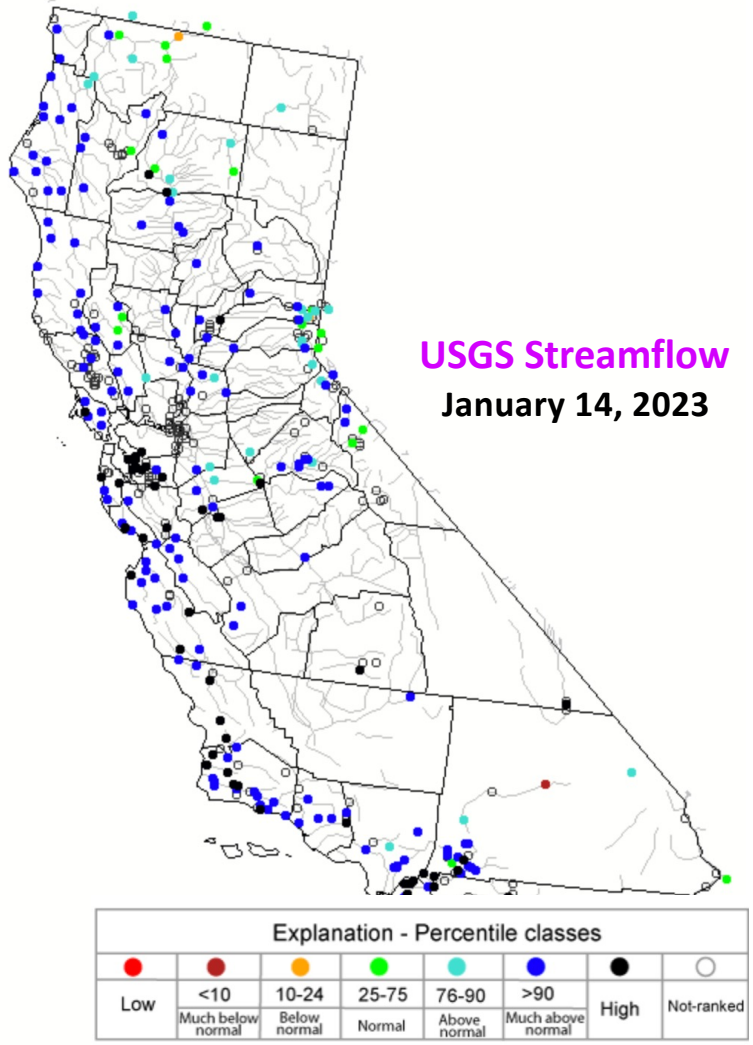
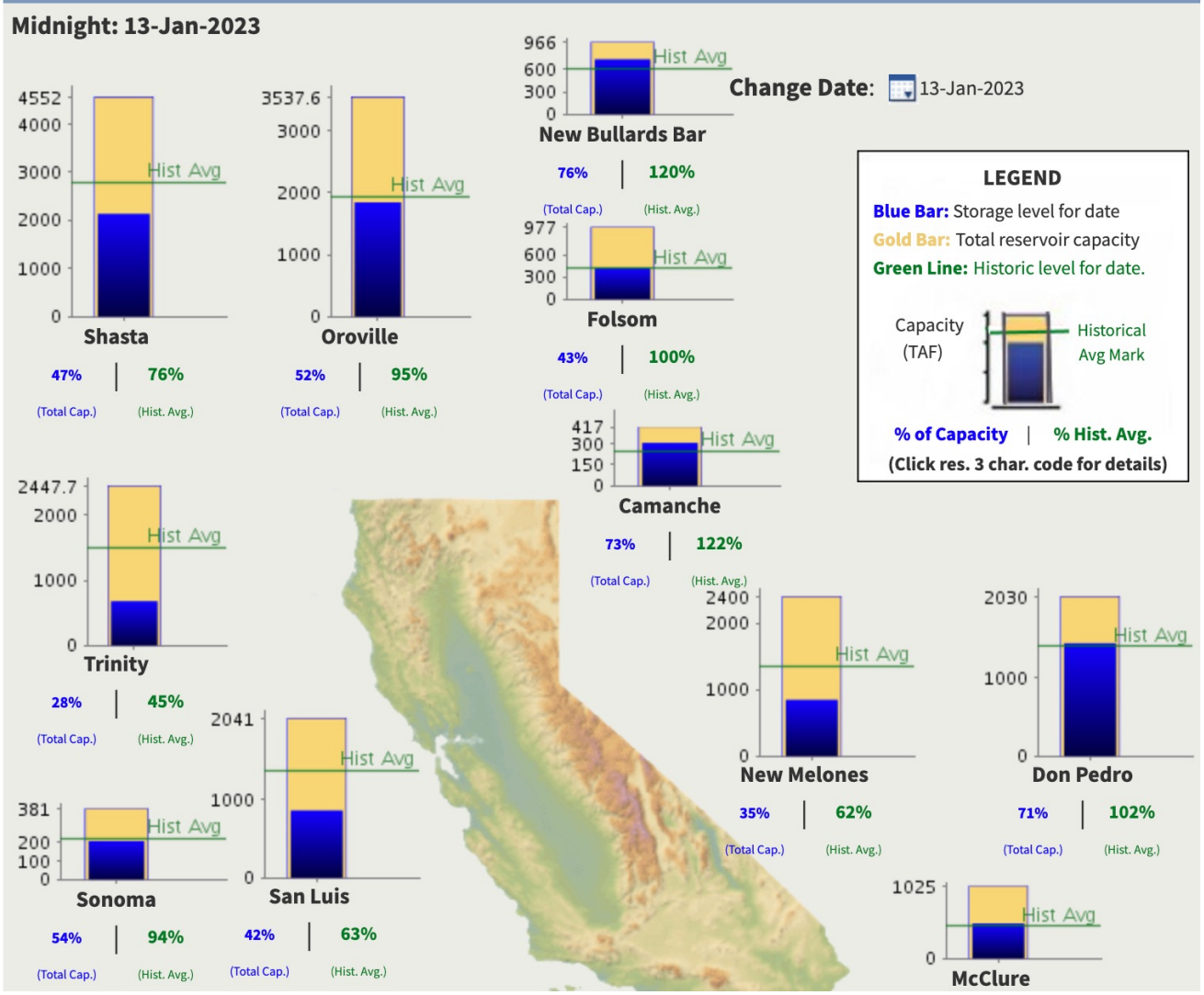
Current surface water & groundwater situation

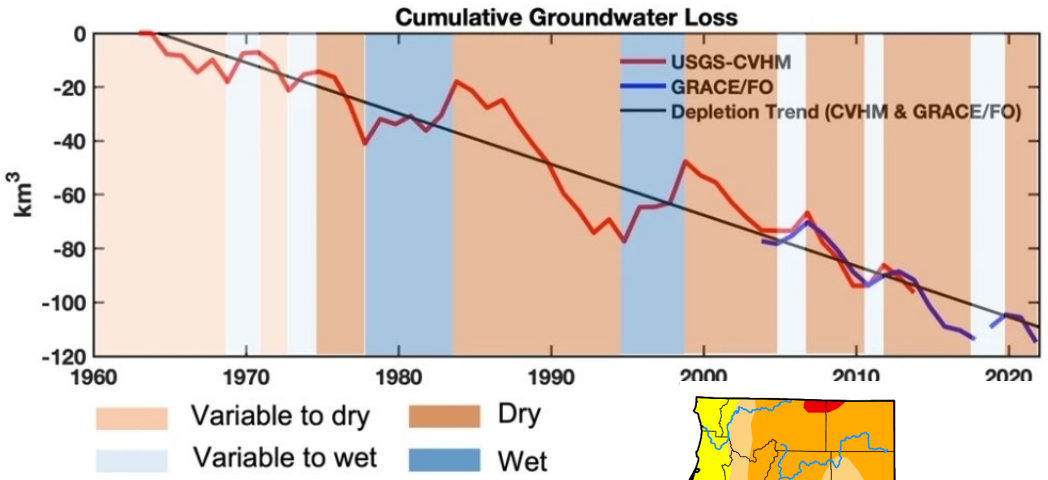


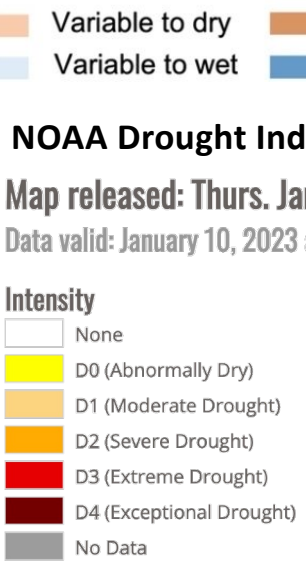


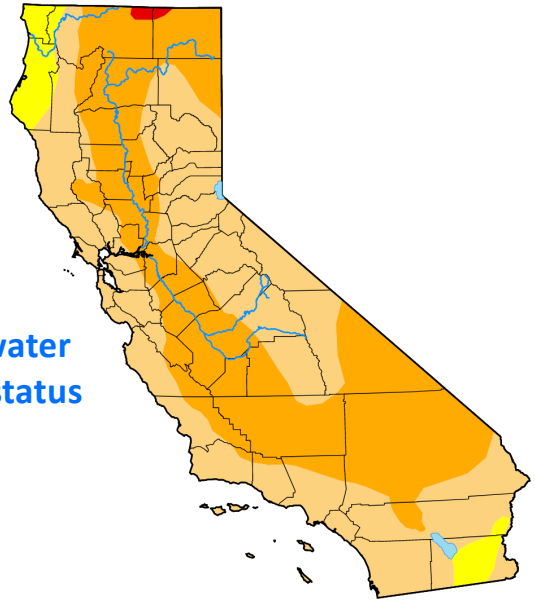
CURRENT CONDITIONS: MAJOR WATER SUPPLY RESERVOIRS:13-JAN-2023



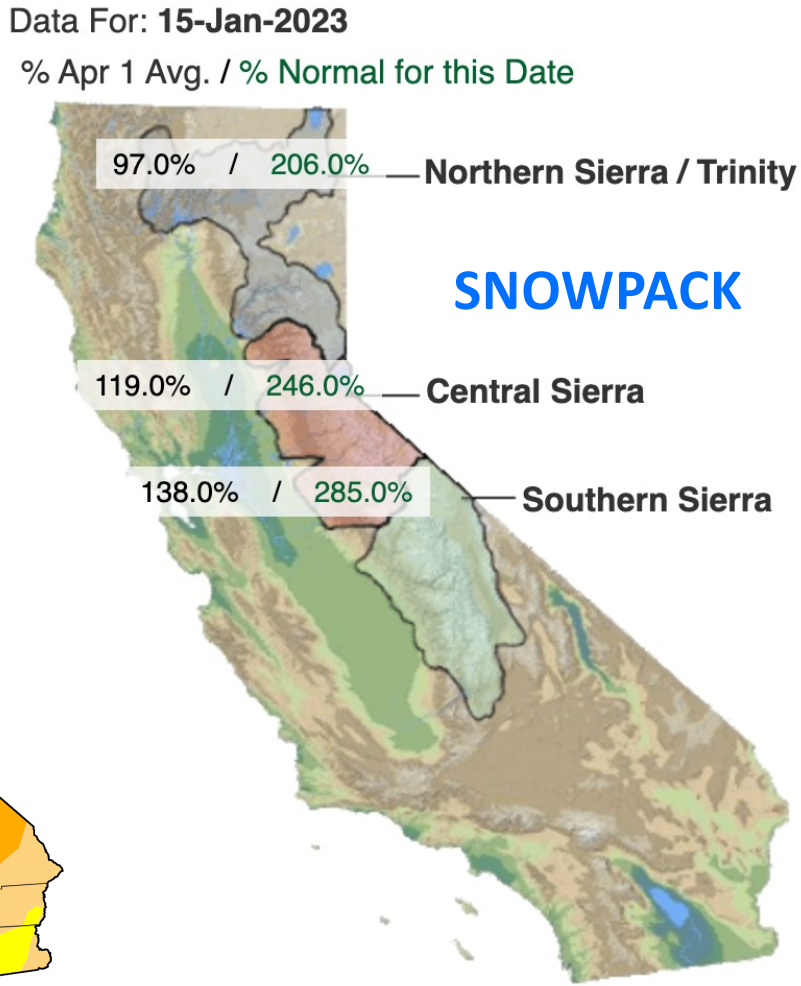
Current surface water & groundwater situation





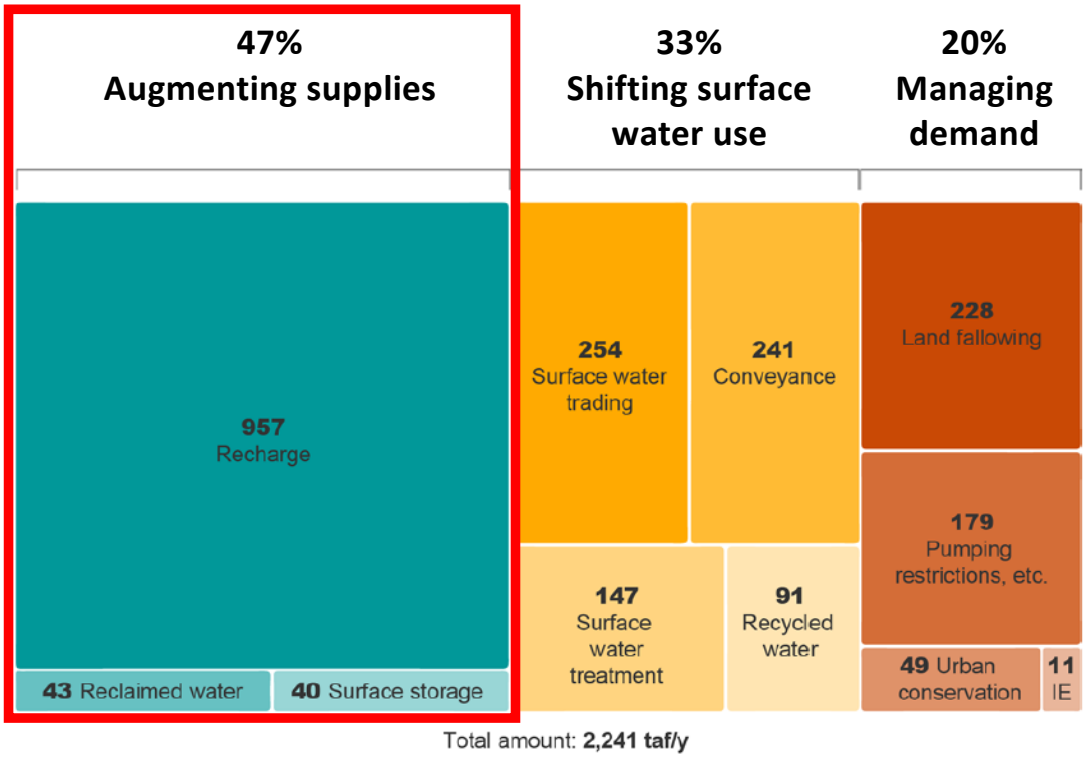


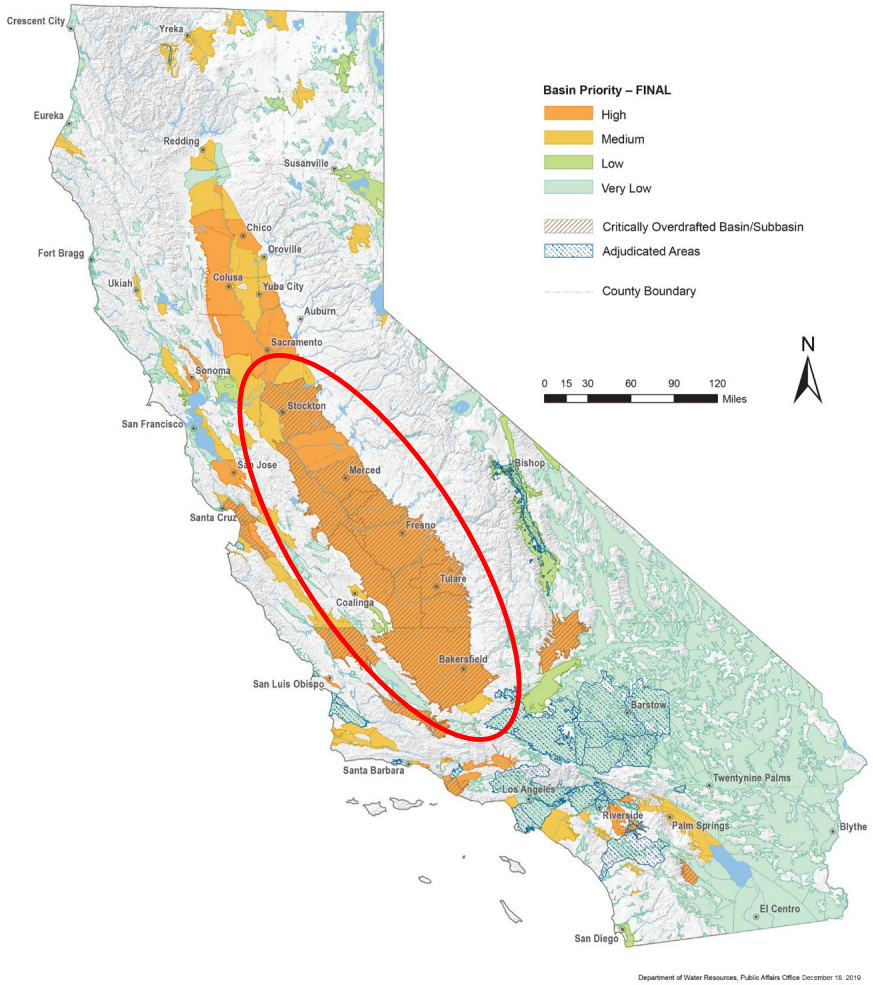
Surface water drought status




How do we remedy groundwater overdraft of 2-4 MAF per year?

Current plans to address groundwater overdraft

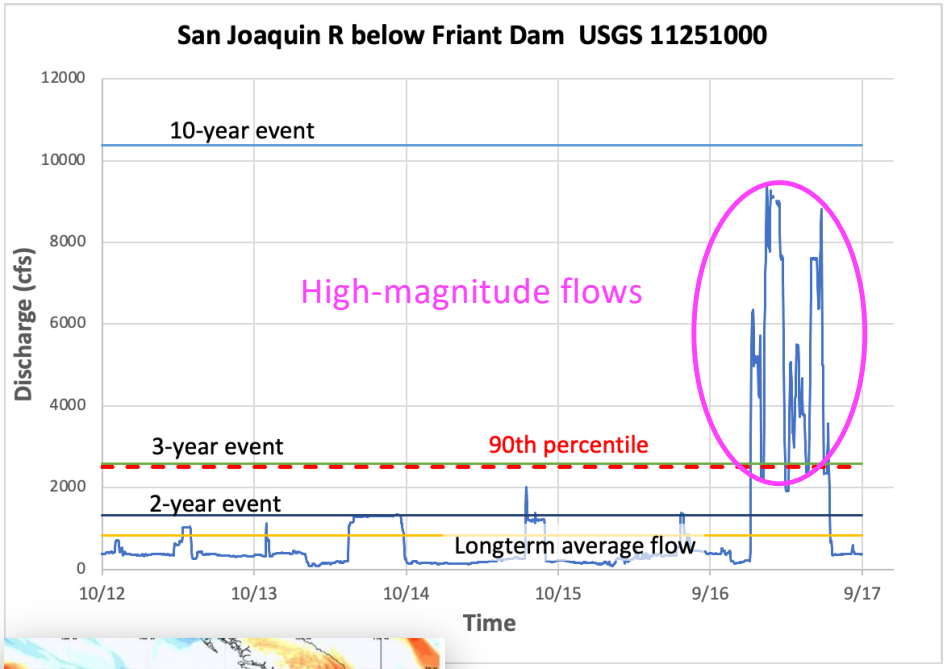




PPIC, 2020, A Review of San Joaquin Valley Groundwater Sustainability Plans


How do we capture large amounts of water in a short time?

Capture high-magnitude flows



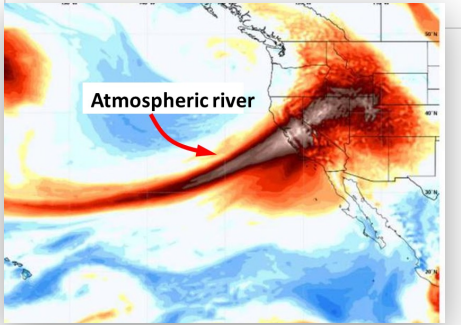
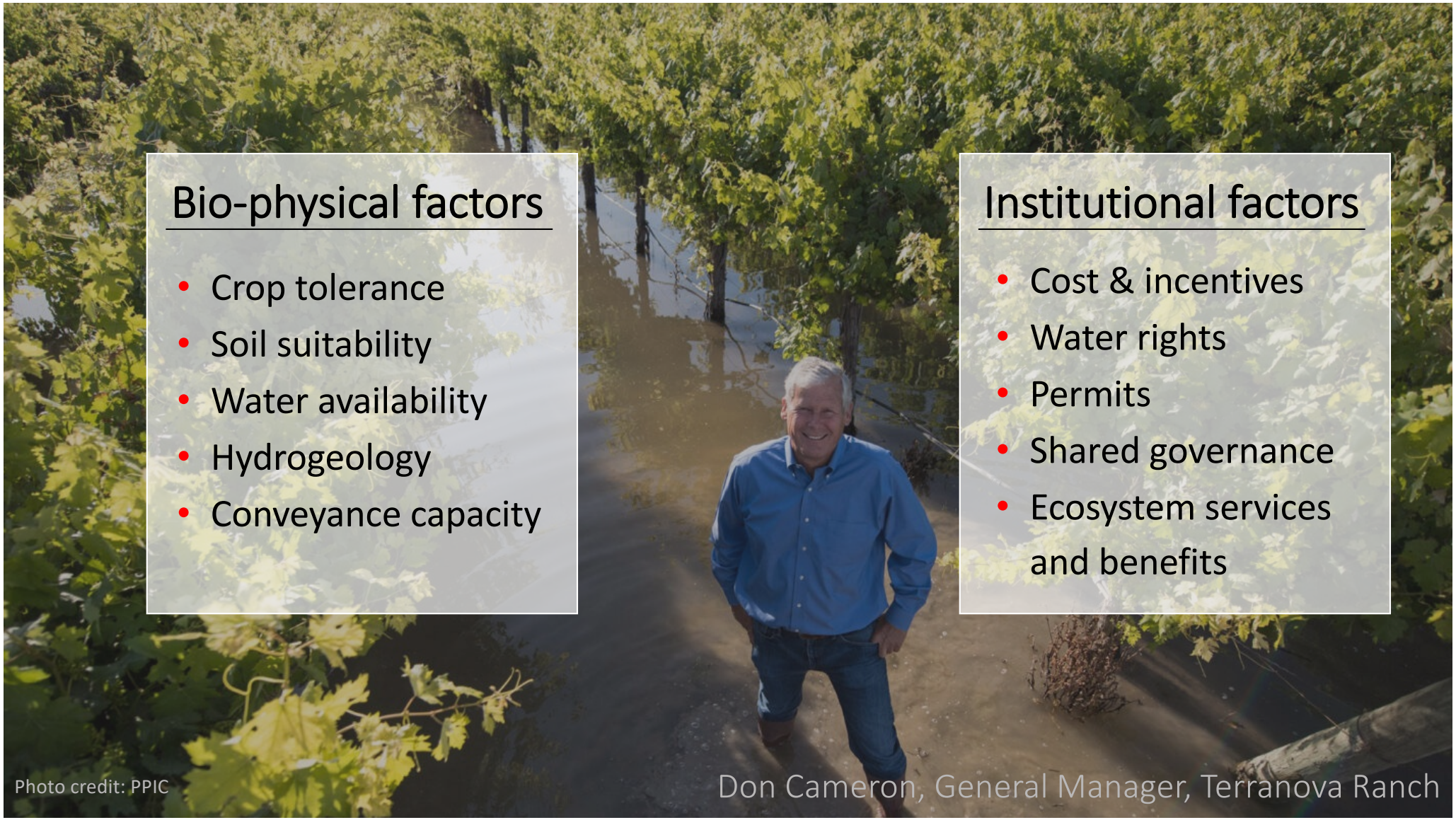
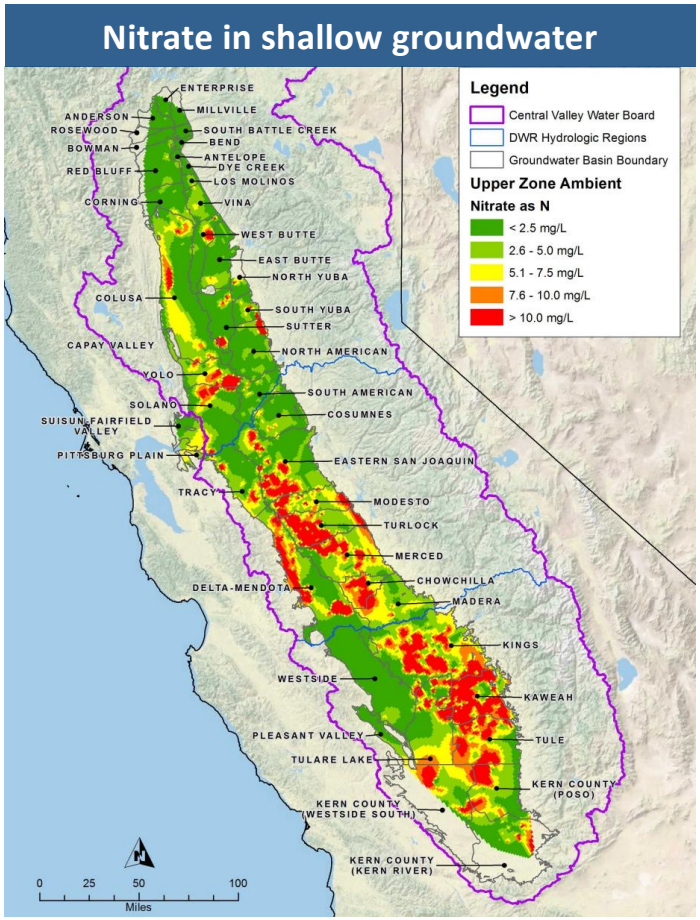


Photo credit: Sustainable Conservation

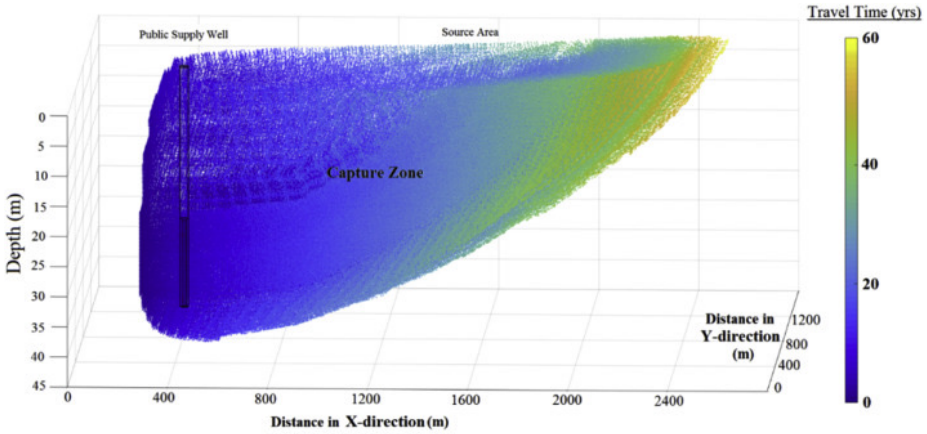

Photo credit: PPIC
Don Cameron, General Manager, Terranova Ranch

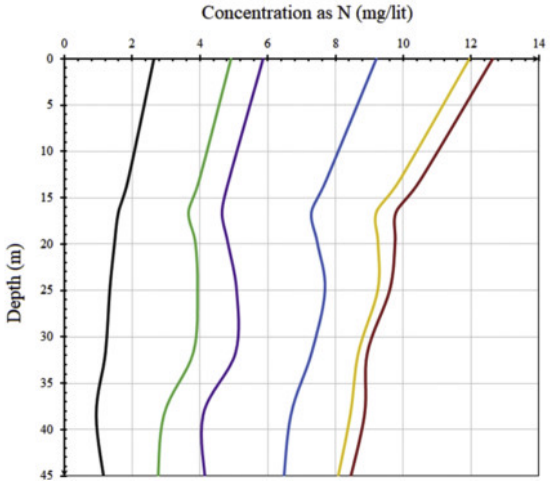

Bio-physical factors
• Crop tolerance
• Soil suitability
• Water availability
• Hydrogeology
• Conveyance capacity
Institutional factors
• Cost & incentives
• Water rights
• Permits
• Shared governance
• Ecosystem services and benefits
Photo credit: PPIC
Don Cameron, General Manager, Terranova Ranch

Risk of groundwater contamination



Source: CV-Salts Coalition



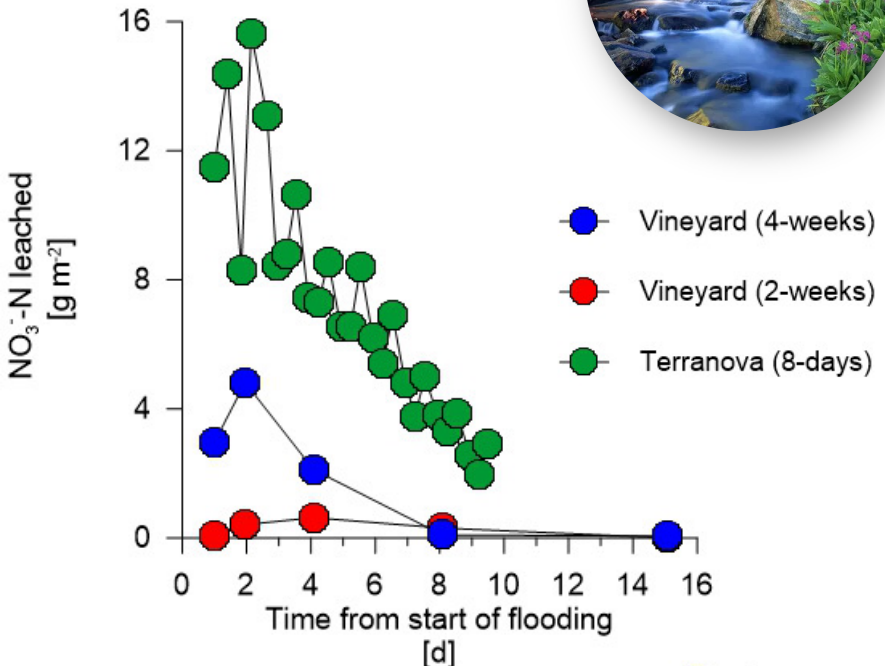


- Low intensity crop
- Winter recharge (irregular)
- BAU
- Winter recharge (regular)
- Low int. & winter recharge (reg.)
- Low int. & winter recharge (irreg.)

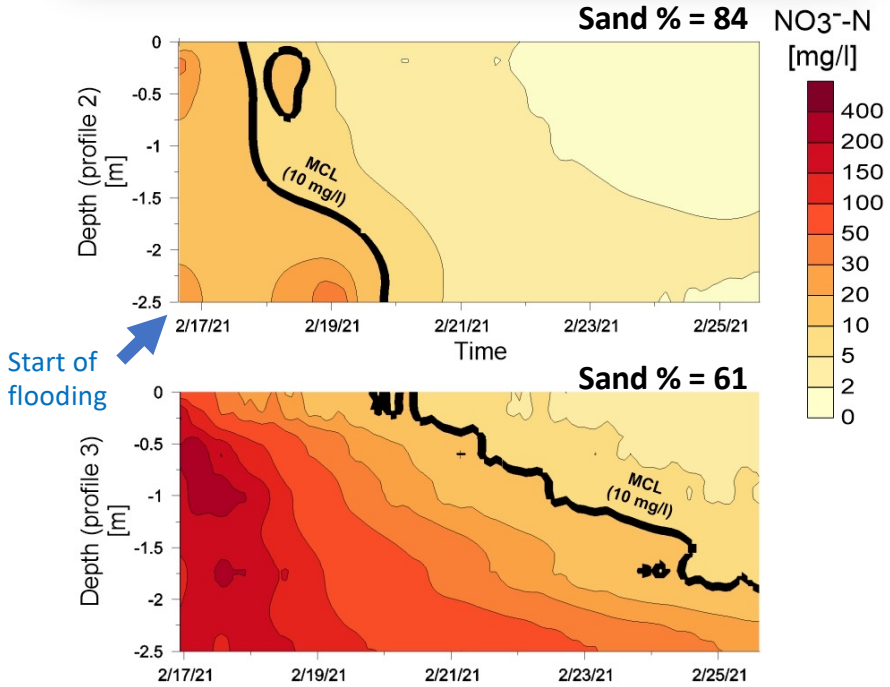
Bastani & Harter, 2019, *J Cont. Hyd*

Nitrate leaching risk

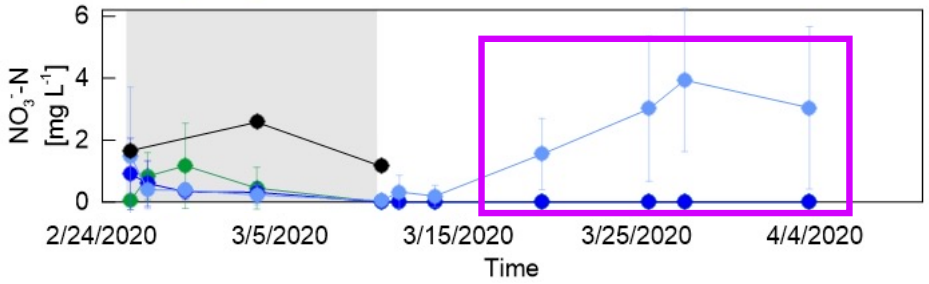
Low N source water



Terranova Ranch



Mineralization of new nitrate



Levintal et al. 2022, *ES&T in prep*

Nitrate leaching risk

Soil surface

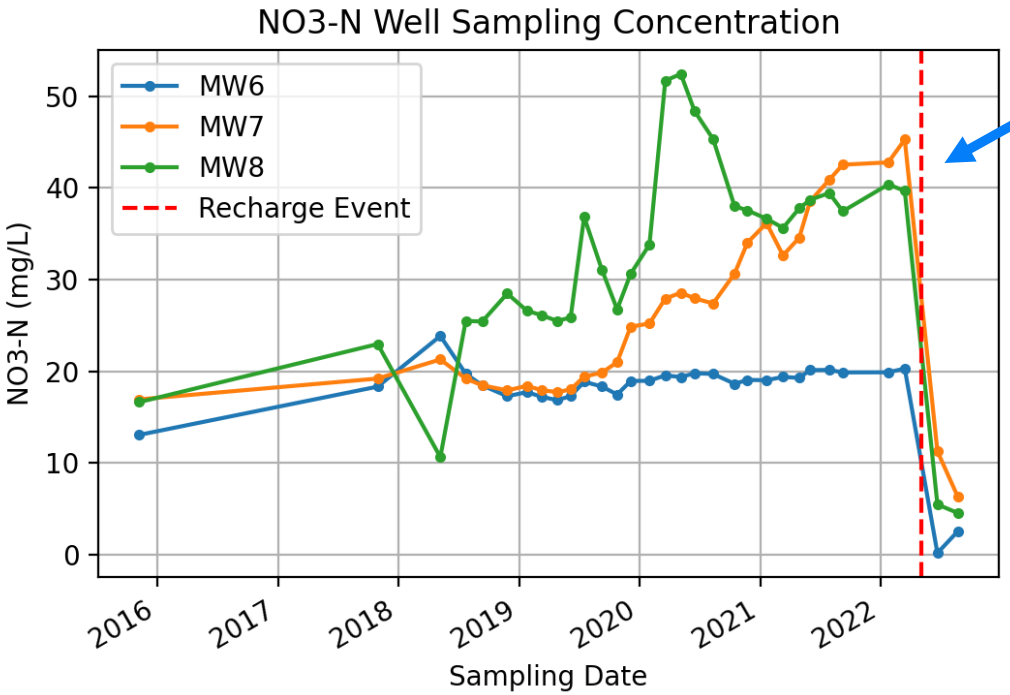
8 in	0.2 m	**Flooding** • 4-weeks • 3 plots, 7785 sqft each • 10m average recharge
2 ft	0.6 m	
3.3 ft	1 m	**Sensors** • Soil moisture, EC, temperature • O_2 (gaseous) • Redox potential • Ponding depth • Water level
9.8 ft	3 m	
16 ft	5 m	**Sampling** Soil samples Soil pore water Groundwater

Groundwater table at 21 ft

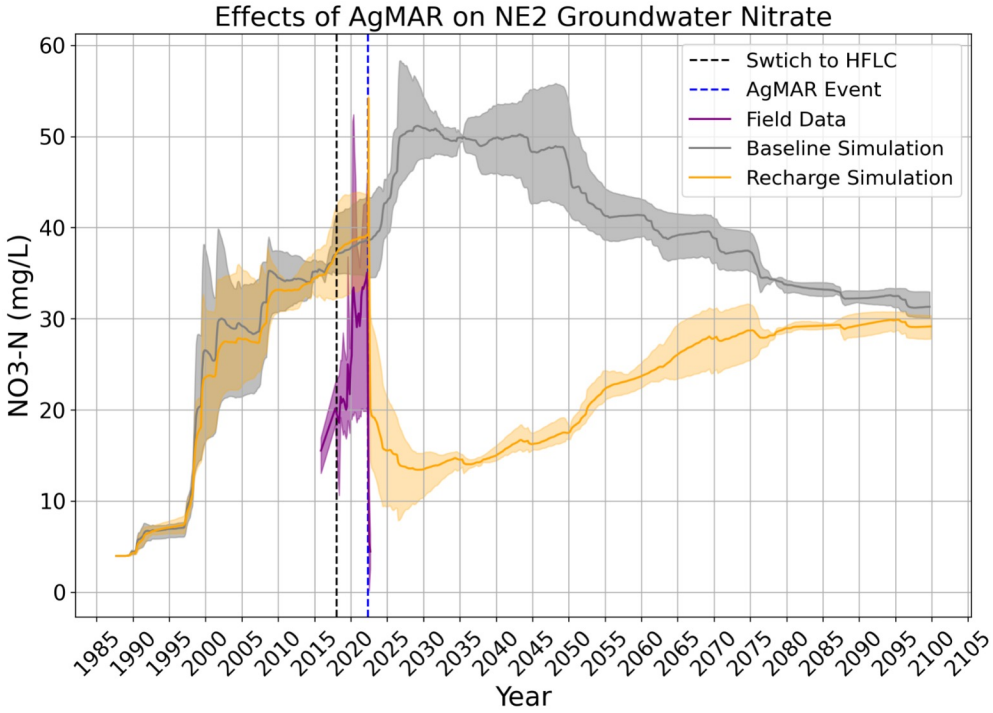
Almond orchard - Modesto

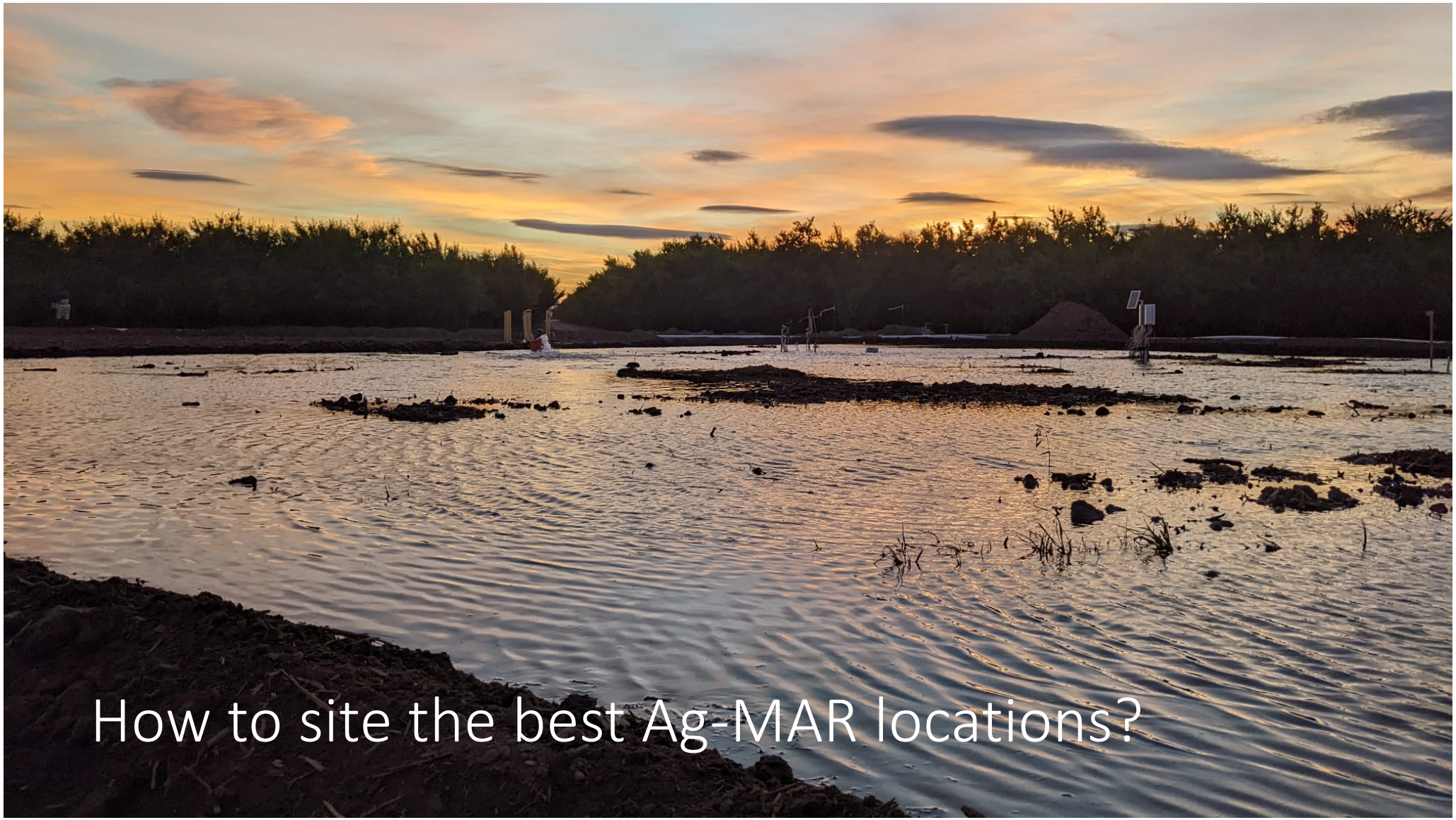

Effect of Ag-MAR on groundwater nitrate?

Effect of Ag-MAR on groundwater nitrate

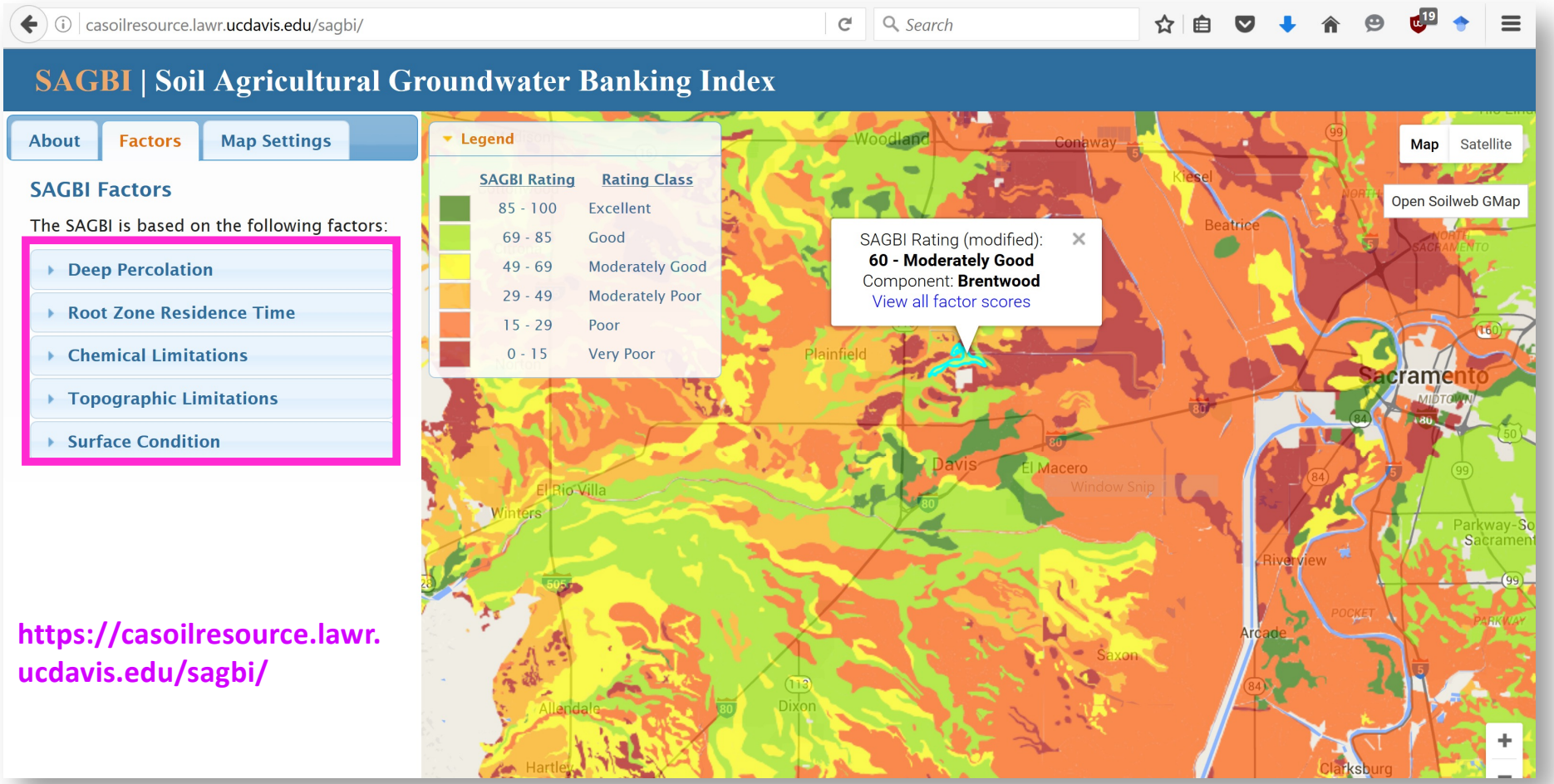


Recharge effect on ambient groundwater nitrate concentration




How to site the best Ag-MAR locations?

Decision support



O'Geen et al. 2015, CalAg

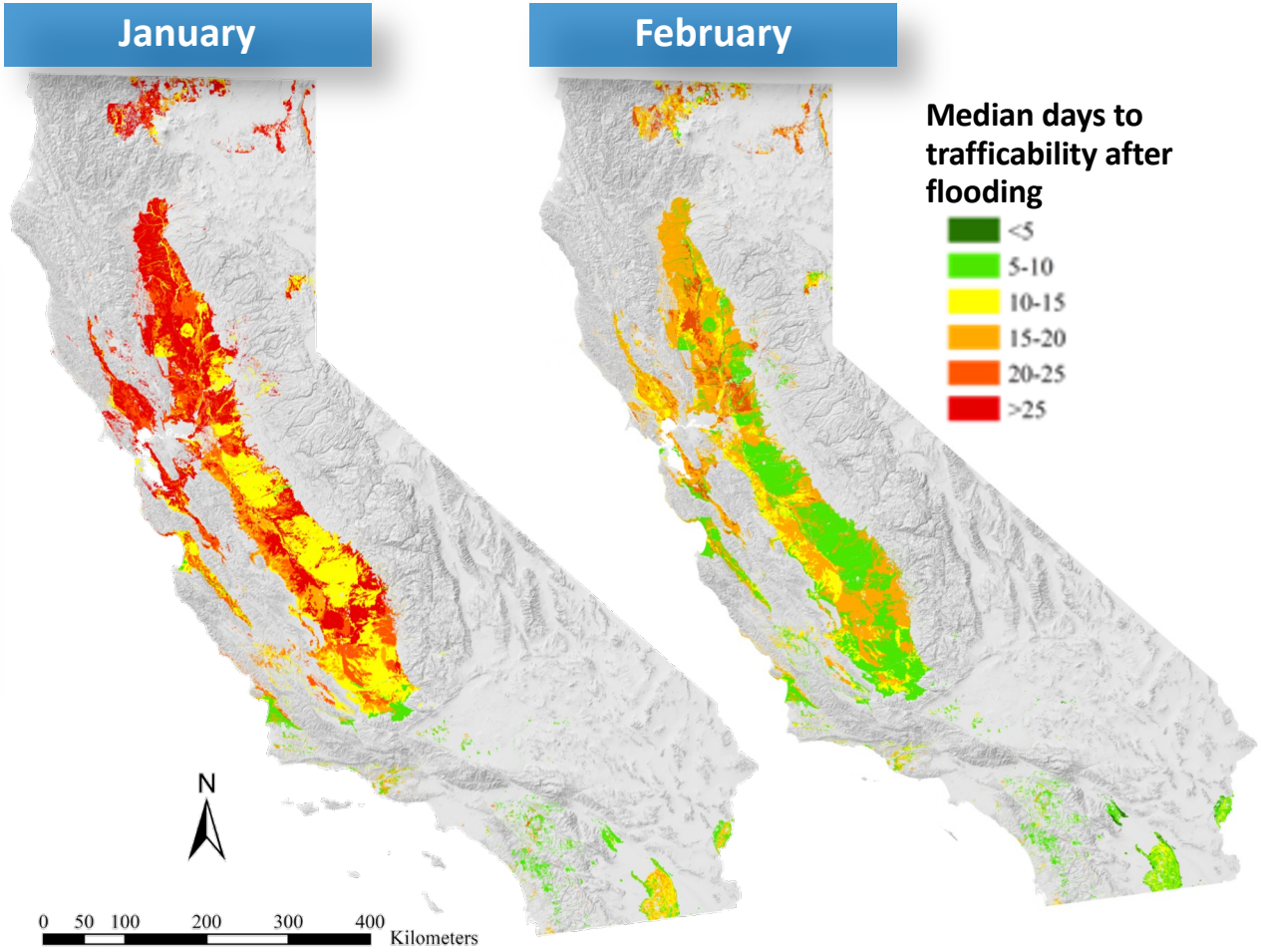
Soil-crop relationships

Crop	SAGBI rating	Soil texture	Infiltration rate (in/hr)	Water applied (ft)	Deep percolation (%)	Yield - compared to control (%)
Almond	Excellent	Dune land	13	2.1	99	125
Alfalfa	Good	Stoner gravelly coarse loam	3.9	28	99	90
Almond	Moderately good	Dinuba fine sandy loam	2.7	2	87	99
Tomato	Moderately poor	Traver fine sandy loam	0.24	1.95	85	125
Almond	Moderately poor	Tehama silt loam*	0.25	0.4	77	-
Grape	Poor	Hanford sandy loam*	0.32	6.7	98	88
Grape	Poor	Hanford fine sandy loam*	0.16	5.8	95	60

* Soil with hardpan

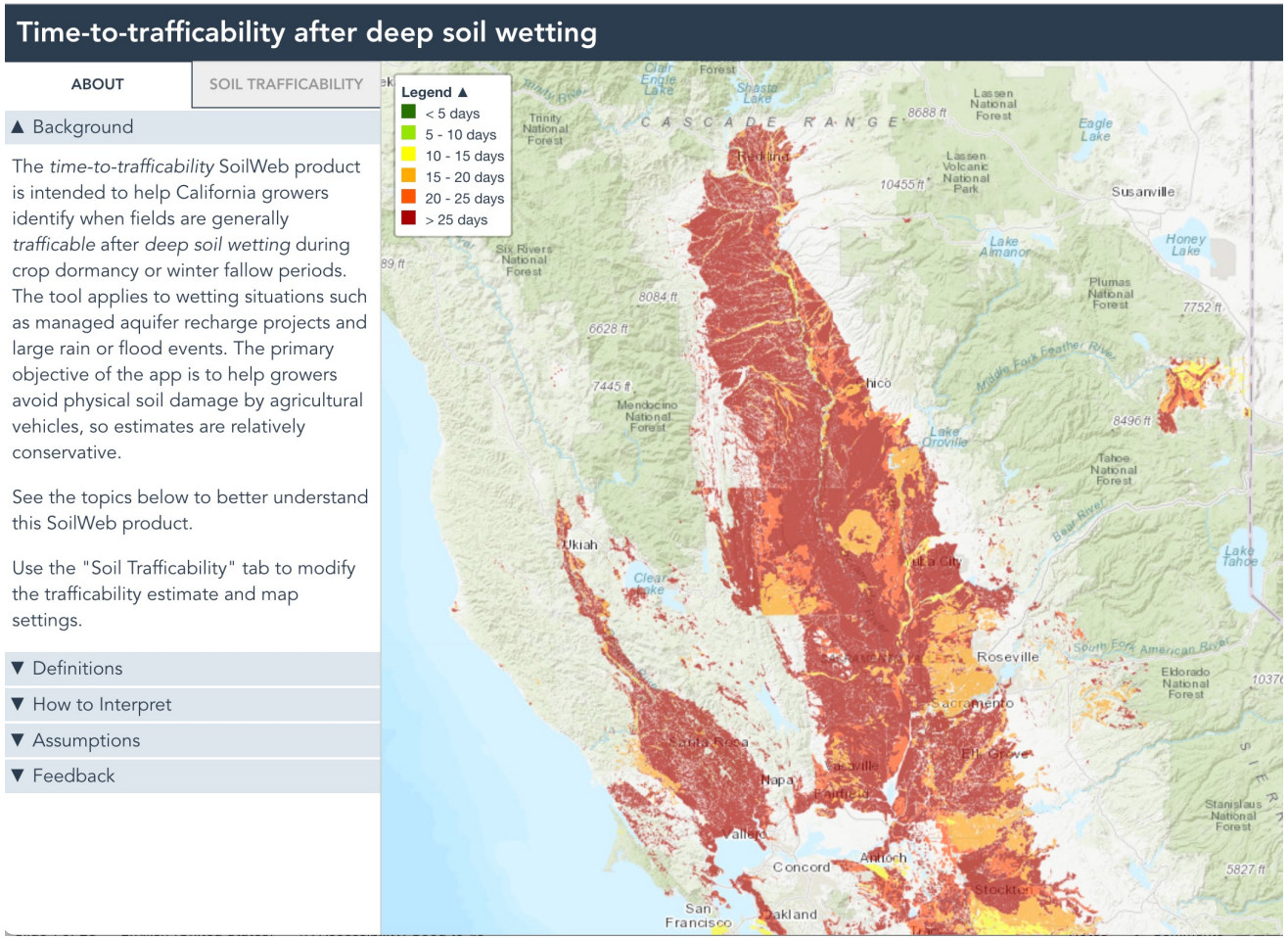
Soil trafficability after deep wetting

Trafficability and risk of soil compaction



Devine et al. 2021, J. of Soil & Tillage Research

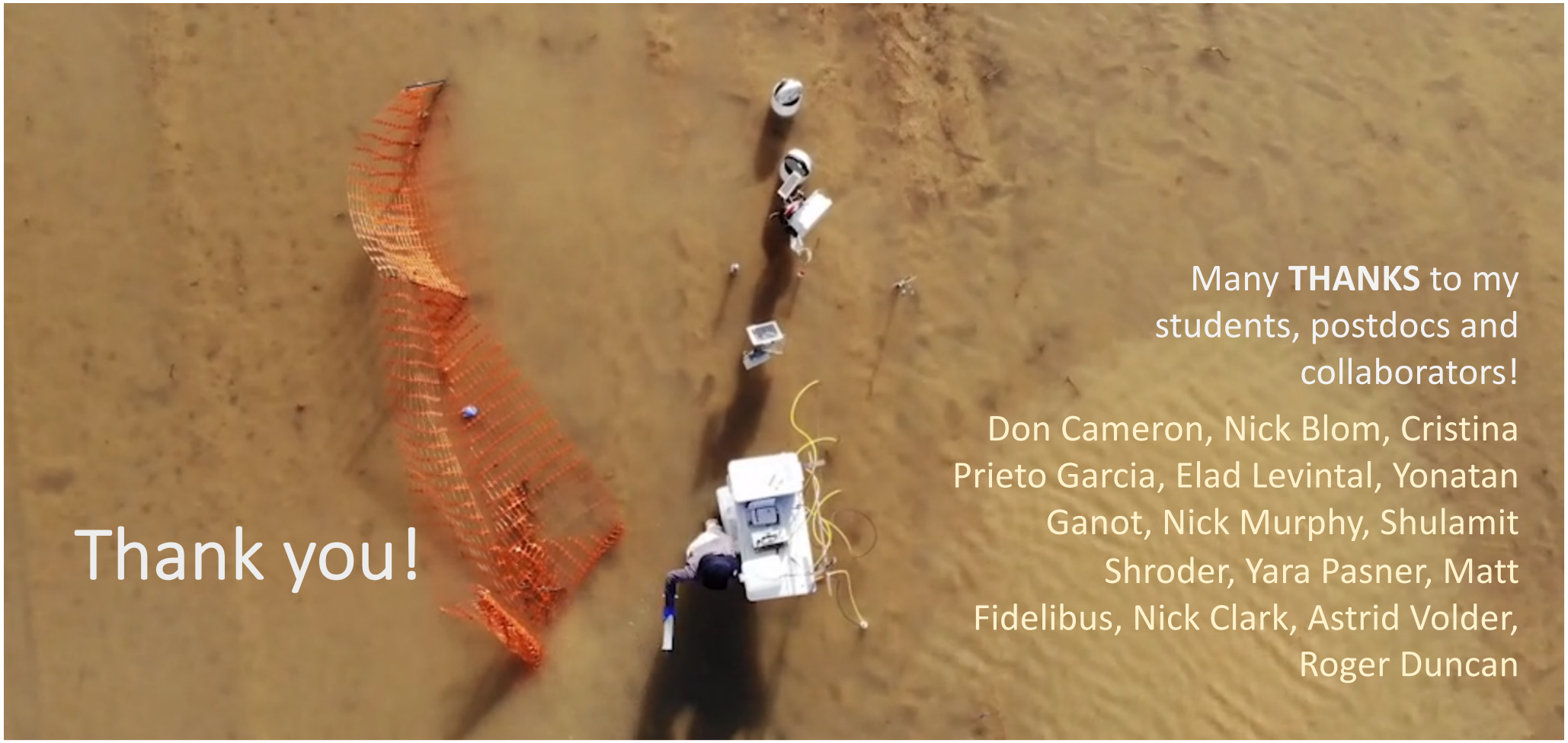
Soil trafficability after deep wetting



https://soilmap2-1.lawr.ucdavis.edu/soil-trafficability/

Why should I consider Ag-MAR

- Increased groundwater storage for next drought
- Fill up soil profile prior to growing season
- Frequency of wet years is decreasing (every 5-7 years)
- Additional moisture stimulate mineralization (natural production of nitrate in soils)
- Recharge with low nitrogen source water does dilute elevated groundwater nitrate concentrations



Thank you!

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Don Cameron, Nick Blom, Cristina Prieto Garcia, Elad Levintal, Yonatan Ganot, Nick Murphy, Shulamit Shroder, Yara Pasner, Matt Fidelibus, Nick Clark, Astrid Volder, Roger Duncan

NSF

USDA NIFA

Gordon and Betty Moore Foundation

NRCS Natural Resources Conservation Service

ERS Economic Research Service, United States Department of Agriculture

U.S. Department of the Interior, Bureau of Reclamation

RECLAMATION Managing Water in the West

California almonds, Almond Board of California

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