Groundwater Recharge: A Role for Almonds?

December 9, 2015

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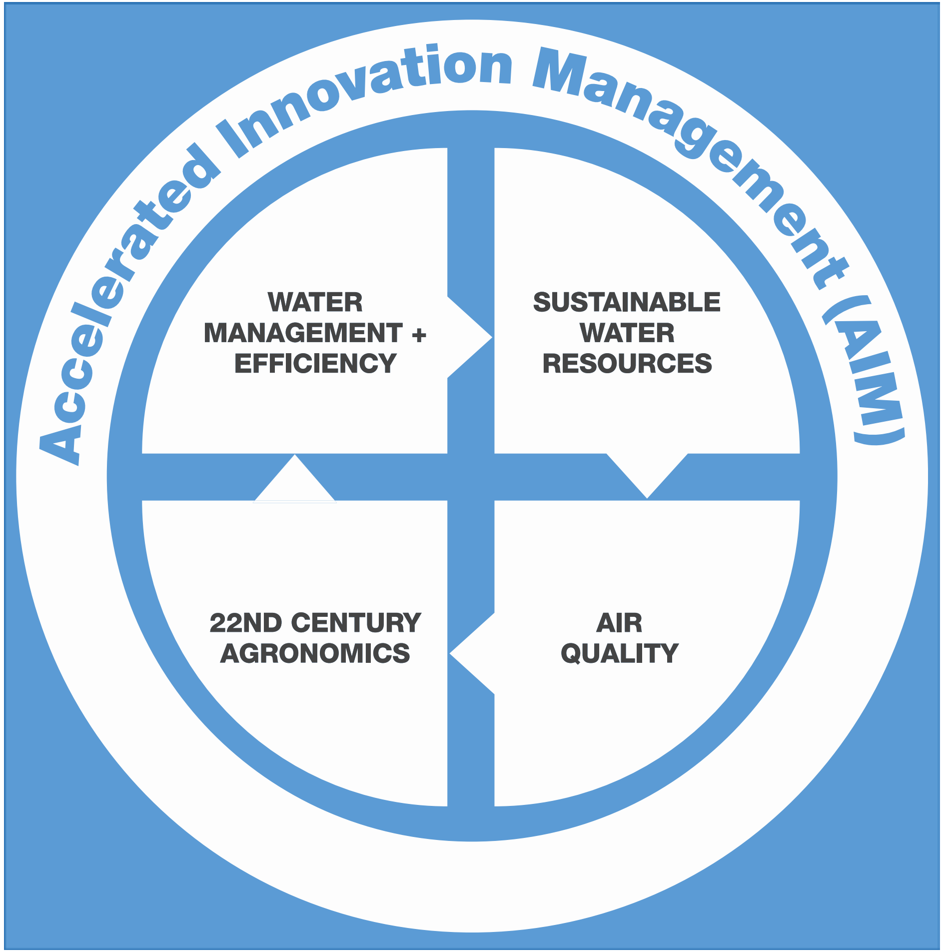
Accelerated Innovation Management (AIM)
WATER MANAGEMENT + EFFICIENCY
SUSTAINABLE WATER RESOURCES
22ND CENTURY AGRONOMICS
AIR QUALITY

Speakers

Gabriele Ludwig, Almond Board (Moderator)

Daniel Mountjoy, Sustainable Conservation

Joel Kimmelshue, Land IQ

Helen Dahlke, University of California, Davis

Gabriele Ludwig, Almond Board

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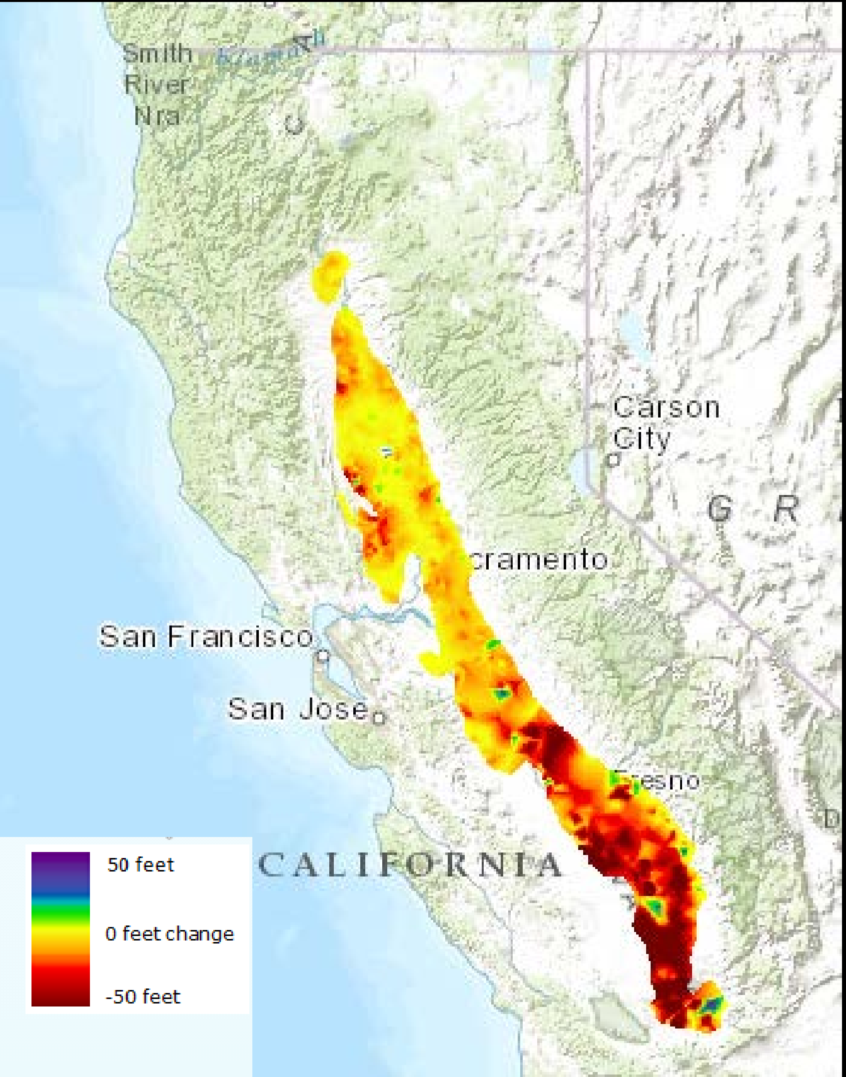
Daniel Mountjoy, Sustainable Conservation

Groundwater Recharge: A Role for Almonds?

Sustainable Conservation

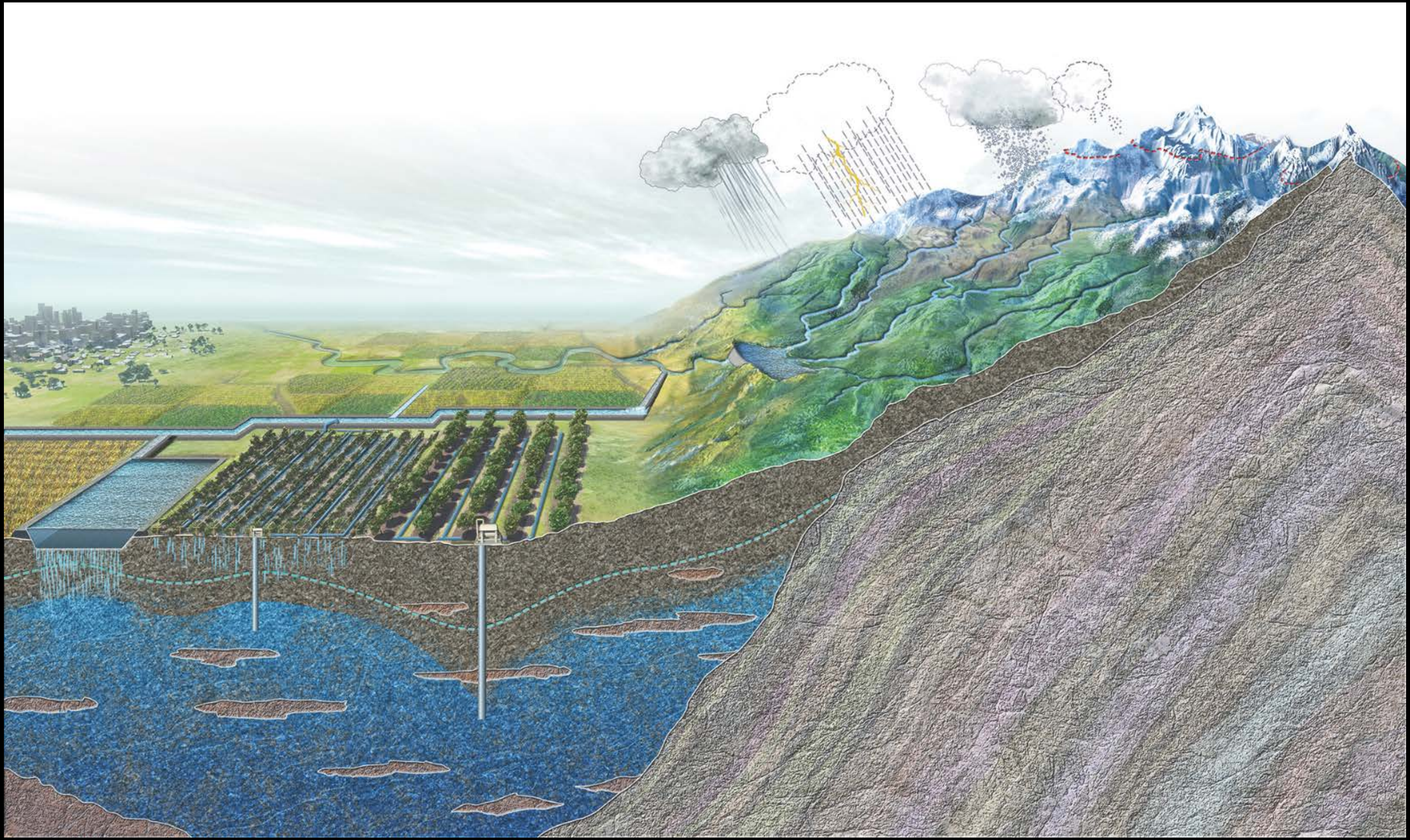
Daniel Mountjoy, Ph.D.
Director of Resource Stewardship



Groundwater Level Change

Spring 2012 to Spring 2015

Change in Groundwater Storage in the Central Valley

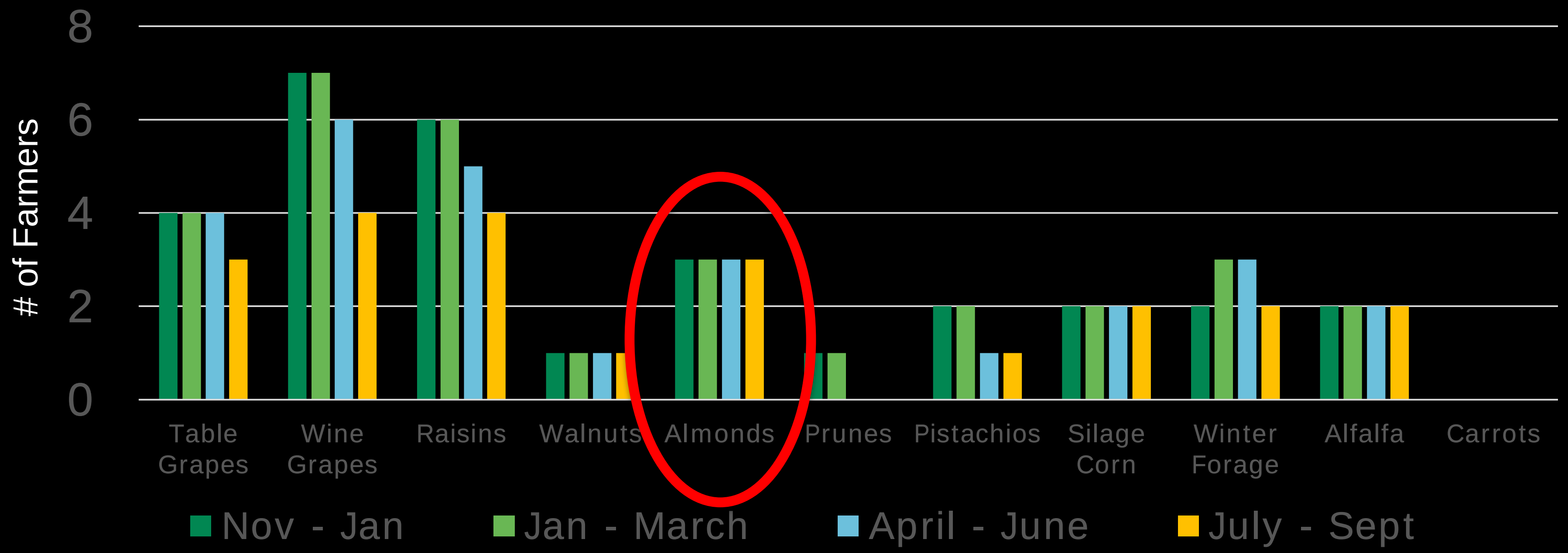


On-Farm Recharge: Proof of Concept

2011: The Kings River returns to its flood plain

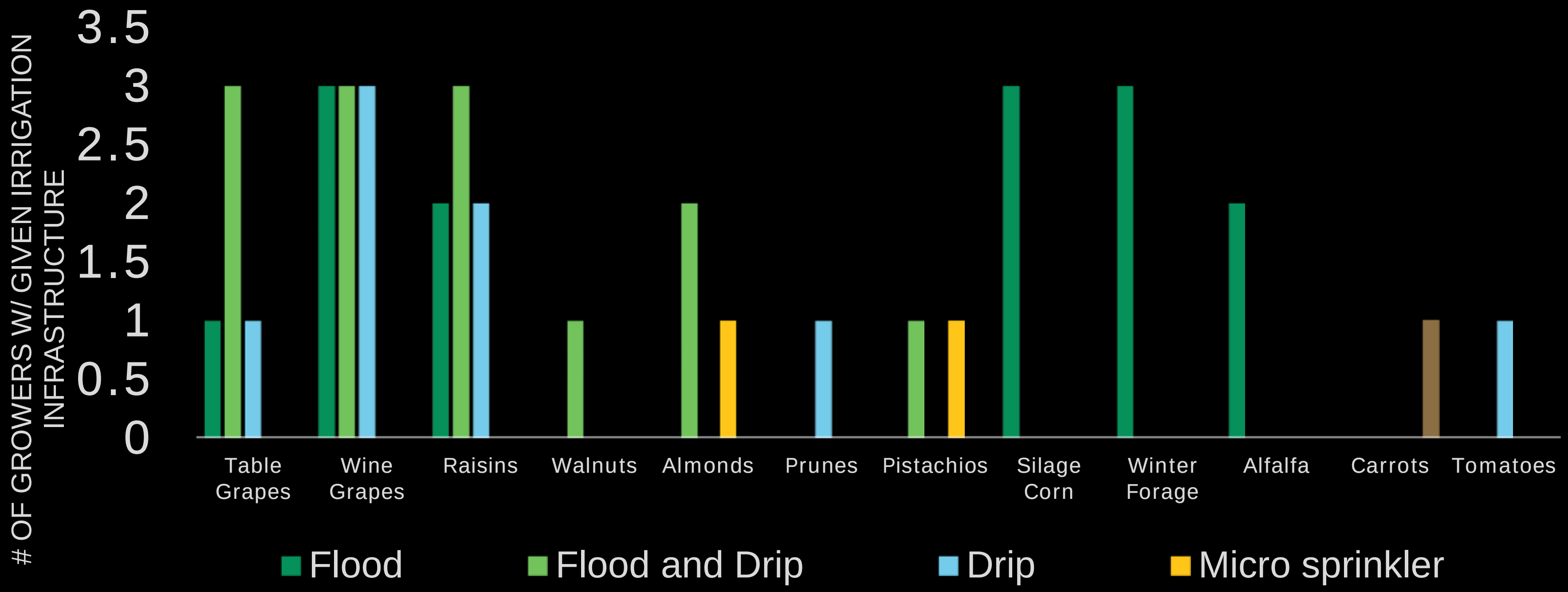

Grower Workshop
Partners
KRCD

When are farmers willing to recharge?



Growers interviewed are willing to divert floodwater to their crops well into the summer.

What irrigation infrastructure exists?

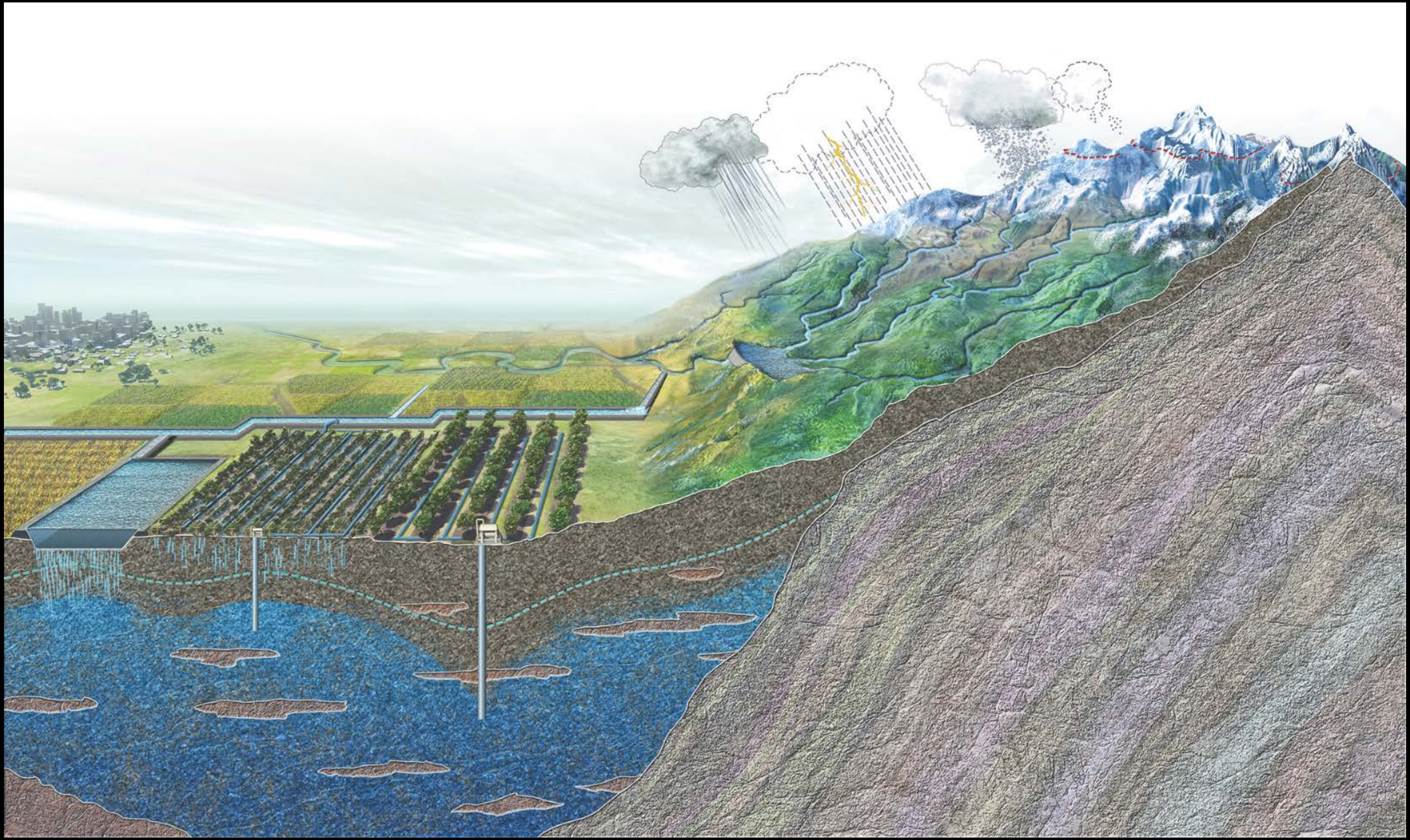


Most crops grown, and acreage represented, have existing irrigation infrastructure compatible for on-farm recharge but may require expanded capacity.

Cost Comparisons of Configurations

	Permanent on-farm with new pump	Permanent on-farm with existing pump	Temporary on-farm pump rental
Annualized cost per AF	$107	$99	$89

Source: M.Cubed



Cost Comparison of Recharge Options

$40 - 107/AF

Dedicated basin

$124/AF

Incentive Options for On-farm Recharge

Preferential pumping

Credit for replenishing aquifer

Direct payments to participants from beneficiaries

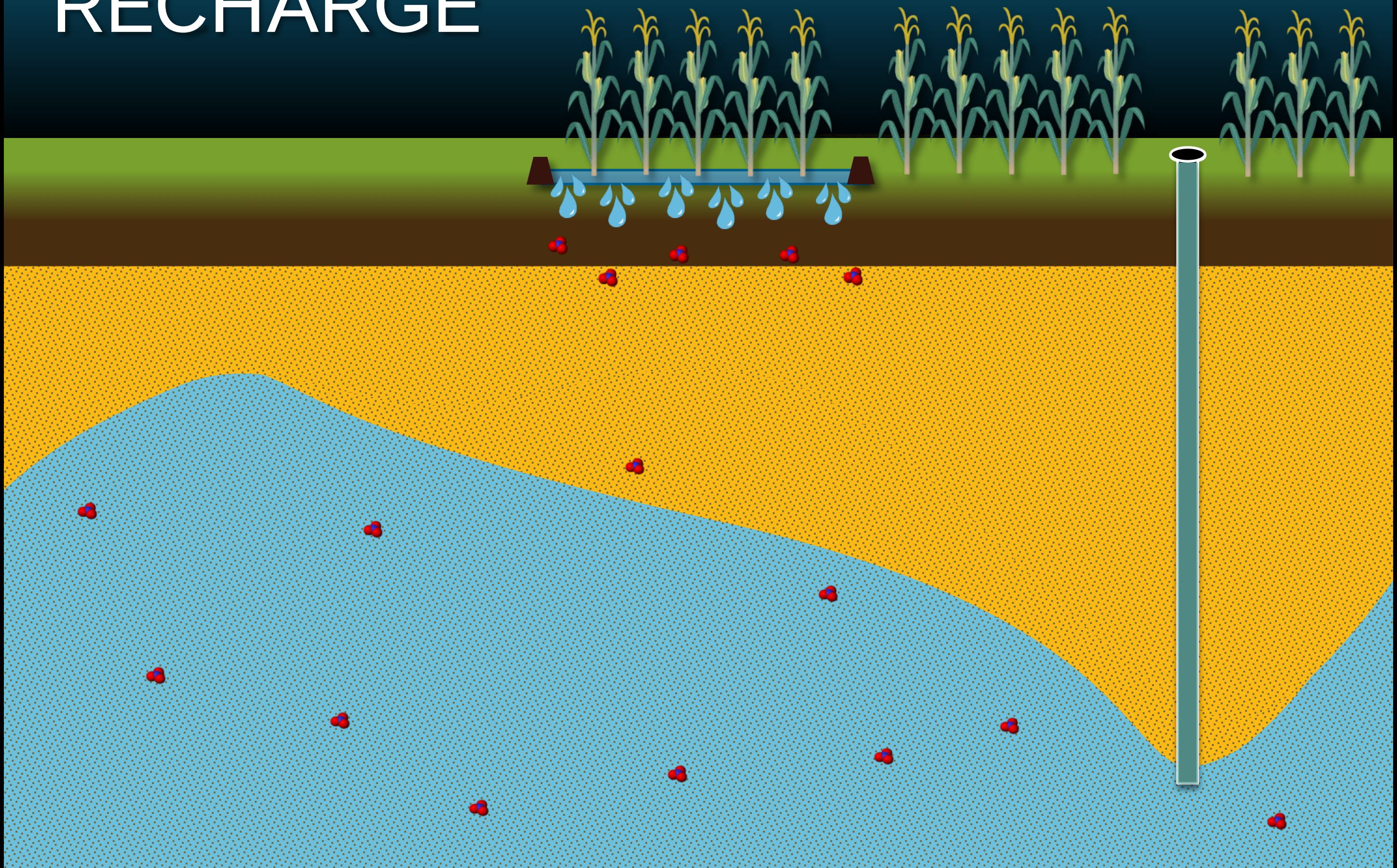
Assessment districts, conjunctive use payments, flood mitigation fees

Crop insurance and flood easements

Flood control beneficiaries compensate growers for taking water

Source: M.Cubed

ON-FARM RECHARGE



Sustainable Conservation

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PARTNERSHIP AGREEMENT

- Aim to make the almond industry a key player in California’s water solution
- Identify viable approaches for creating a sustainable water future

CALIFORNIA WATER ACTION COLLABORATIVE

MillerCoors

Anheuser-Busch

Coca-Cola

OLAM

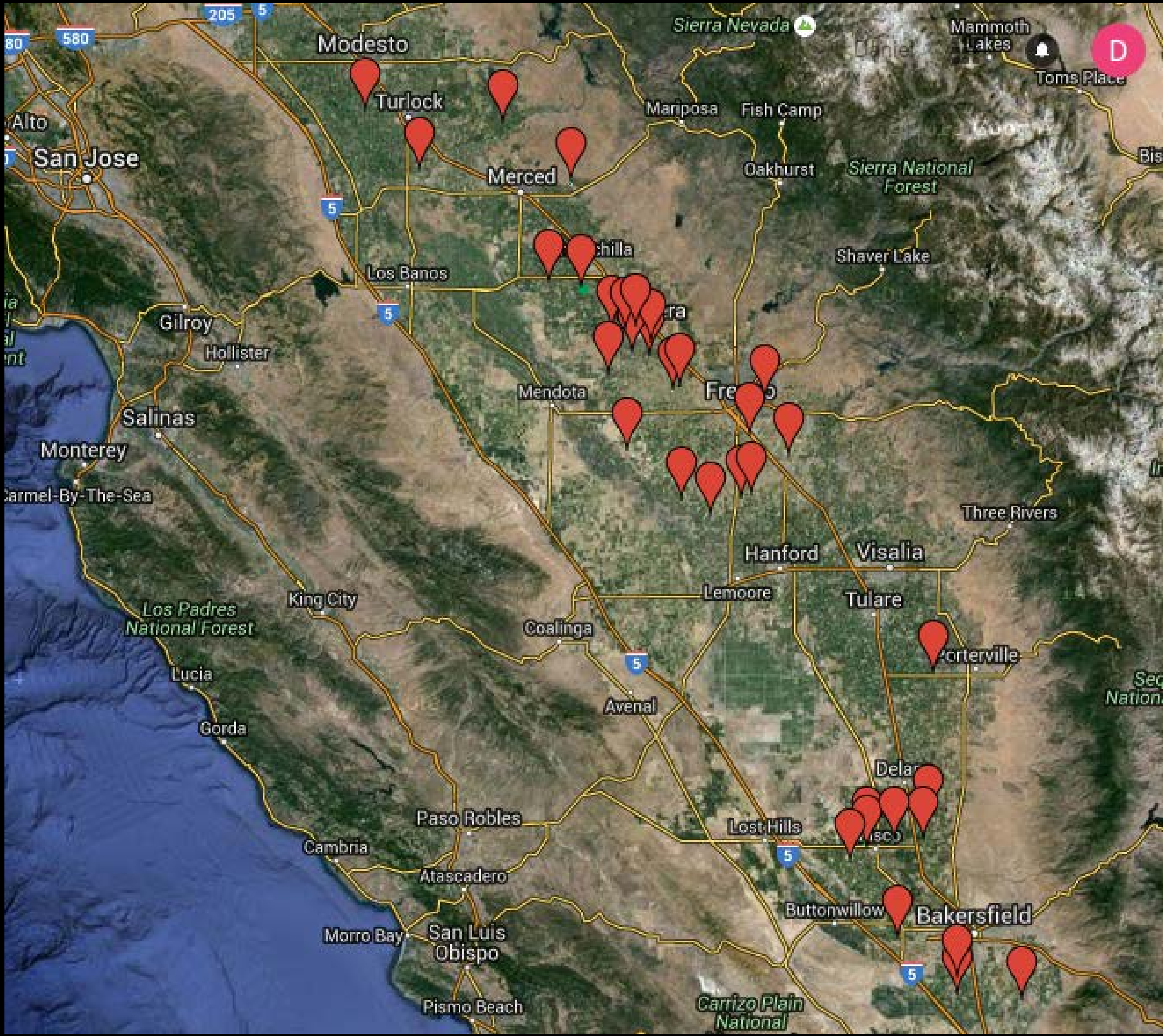
Nestlé

General Mills

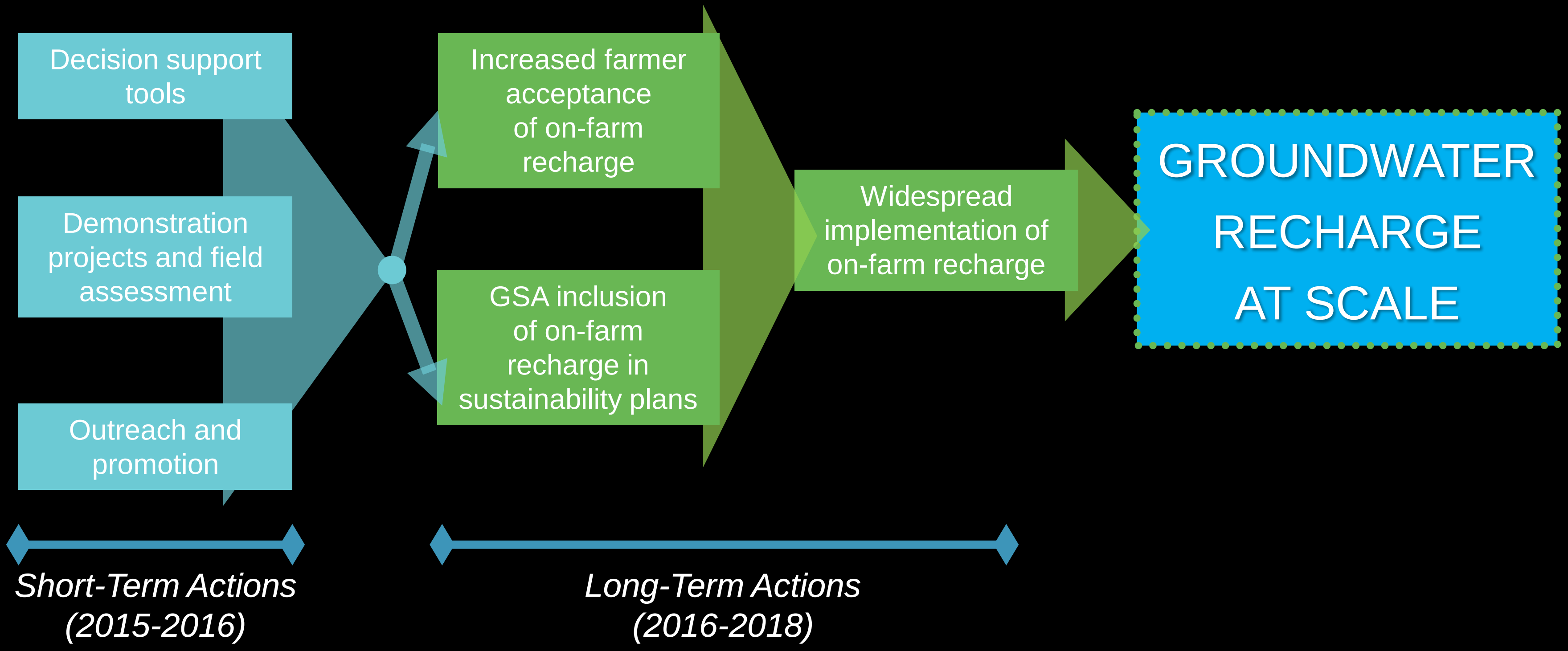
Campbell's

Demonstration Sites 2015-16

- 10 crops
- 6500 acres
- Almonds: 2000 acres



Leveraging Knowledge and Partnerships for Groundwater Recharge



Groundwater Recharge Suitability – Statewide Almond Production

Mica Heilmann, CPESC
Joel Kimmelshue, PhD, CPSS
Matt Twietmeyer, MS

LAND IQ

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Almond Groundwater Recharge Suitability

- Overview of Data Inputs
- Explanation of Suitability Rating Methods
- Statewide Almond Mapping
- Almond-Specific Groundwater Recharge Suitability Results

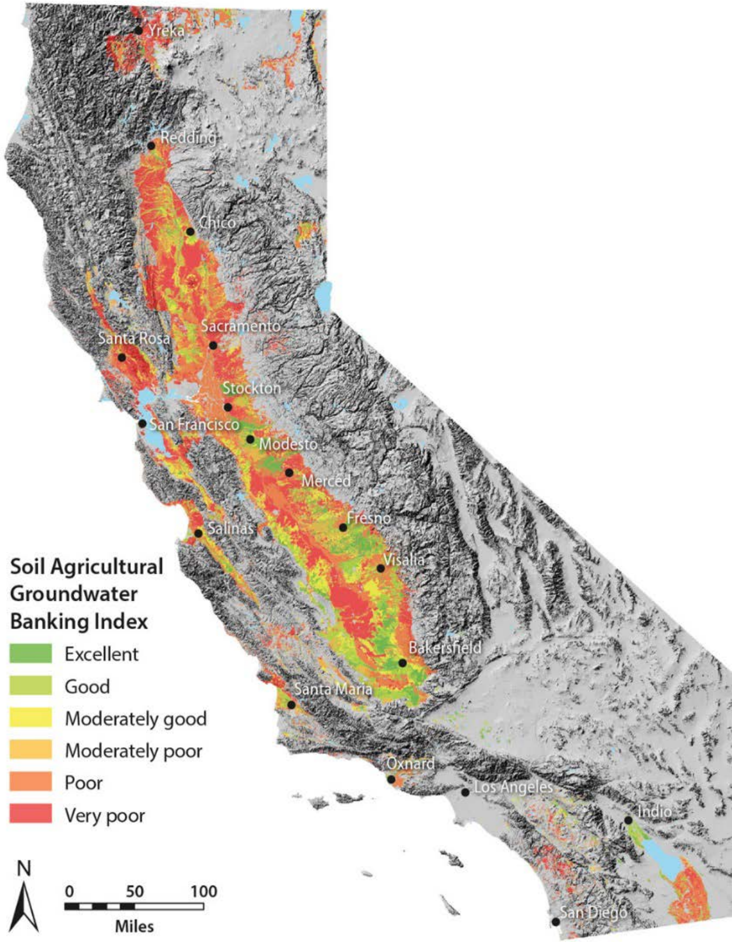
Almond Groundwater Recharge Suitability

Input Data:

- Soil Agricultural Groundwater Banking Index (SAGBI)
- California Department of Water Resources (DWR) Groundwater Levels
- United States Geological Survey (USGS) Central Valley Hydrologic Model (CVHM) well logs
- California Department of Water Resources (DWR) Irrigation District Coverage
- Hydrology & Points of Diversion

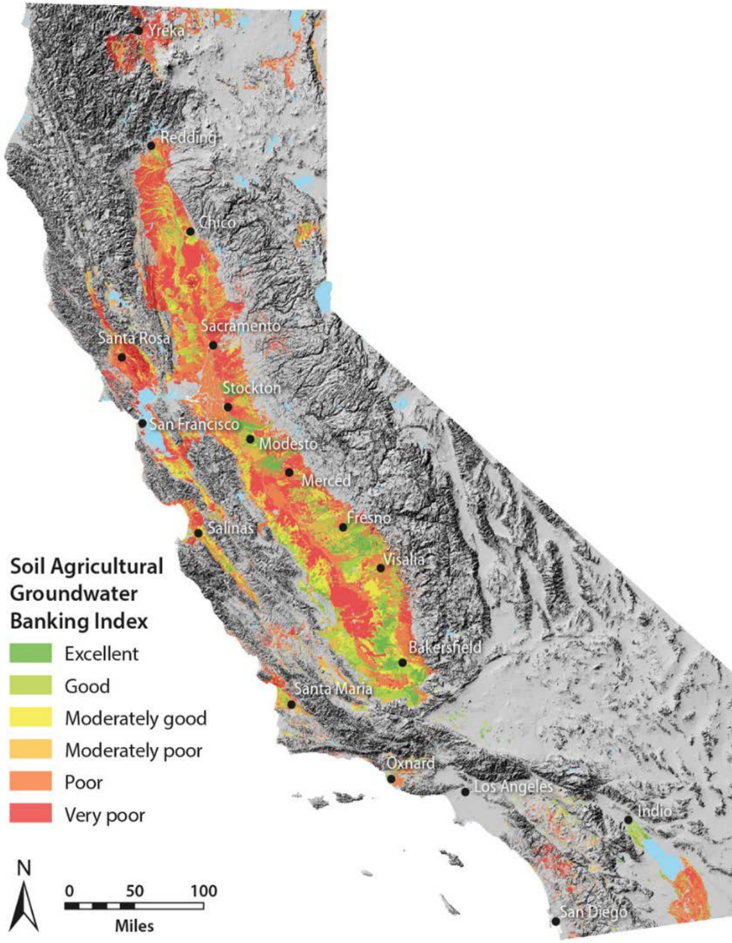
Input Data – Soil Agriculture Groundwater Banking Index (SAGBI)

- Soil infiltration rate
- Soil drainage capacity
- Topography
- Soil salinity
- Soil surface condition (propensity to erode or form crust)



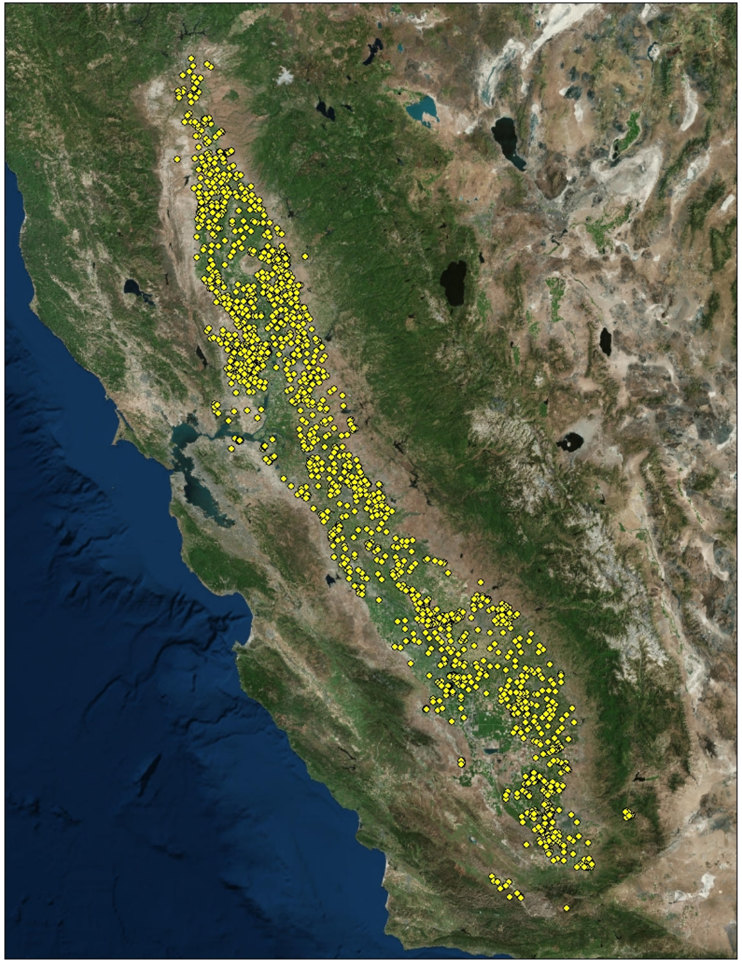
Input Data – Soil Agriculture Groundwater Banking Index (SAGBI)

- Identified about 3.6 million acres with good potential for groundwater banking
- Focused on surface soils (top 5 feet)
- Did not account for subsurface factors



Input Data – DWR Groundwater Levels

- Deeper groundwater allows greater capacity for storage
- Even with excellent SAGBI scores, shallow groundwater can be a concern



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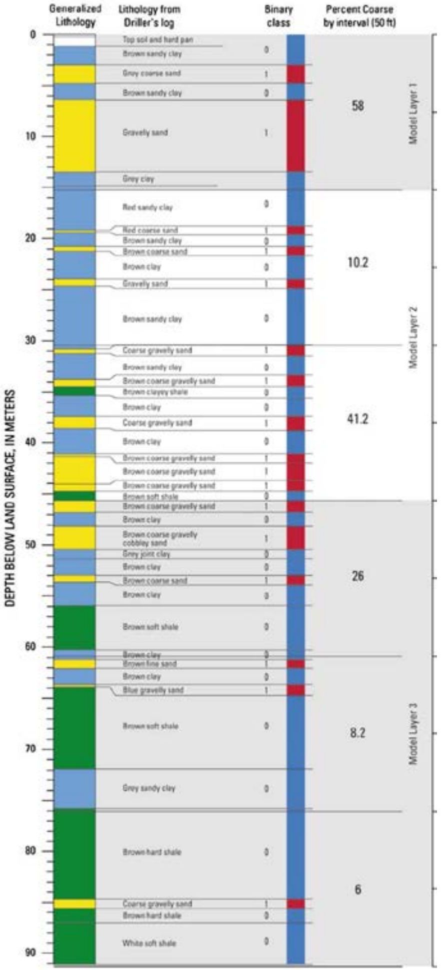
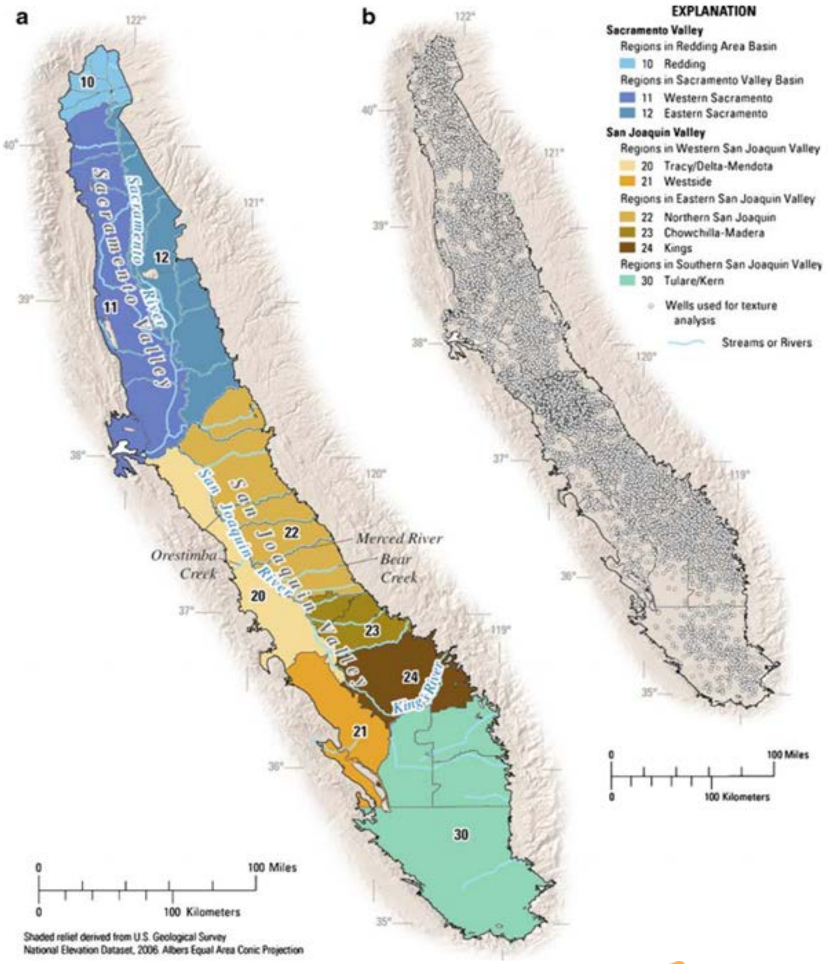
Input Data – USGS CVHM Sediment Data

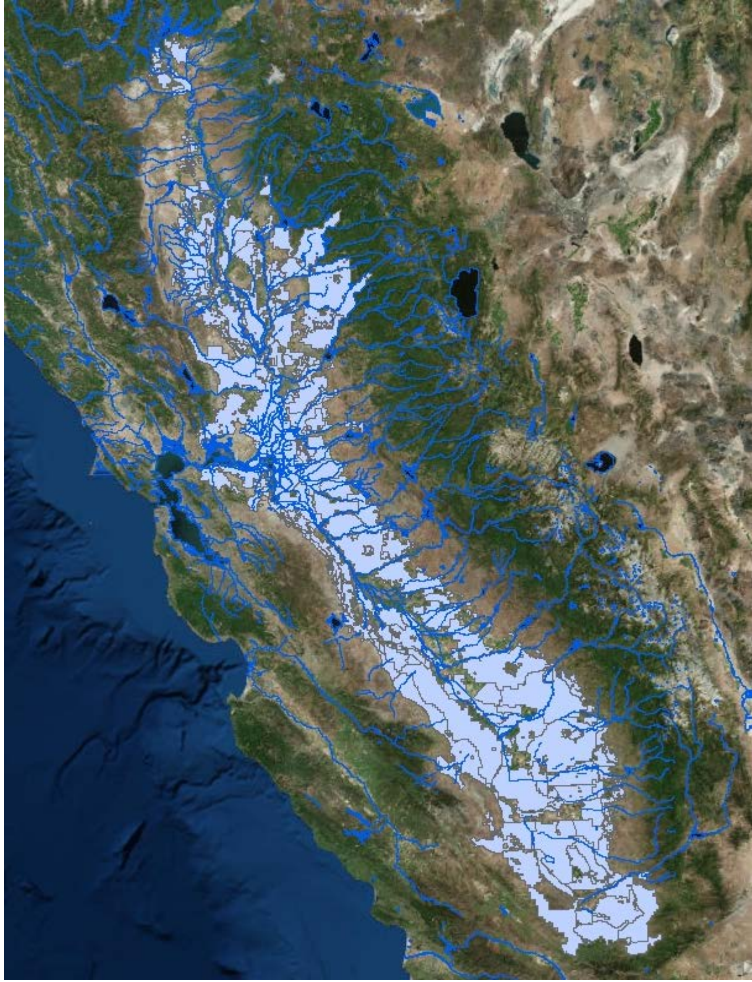
- Purpose is to include deeper sediment analysis
- Consider depth (if any) to restrictive horizons or less permeable sediments below the root zone





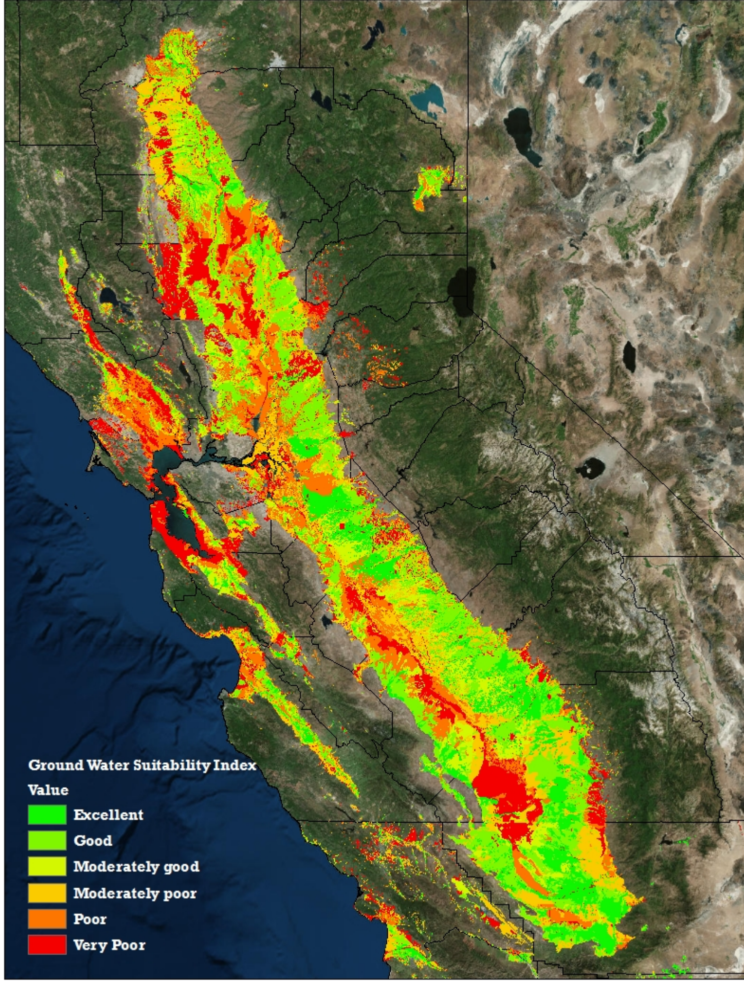
Input Data – Irrigation Districts, Hydrology, and Points of Diversion

- Areas served by water districts are more likely to have infrastructure needed for recharge implementation
- Areas solely served by groundwater were assumed to not have surface water supplies



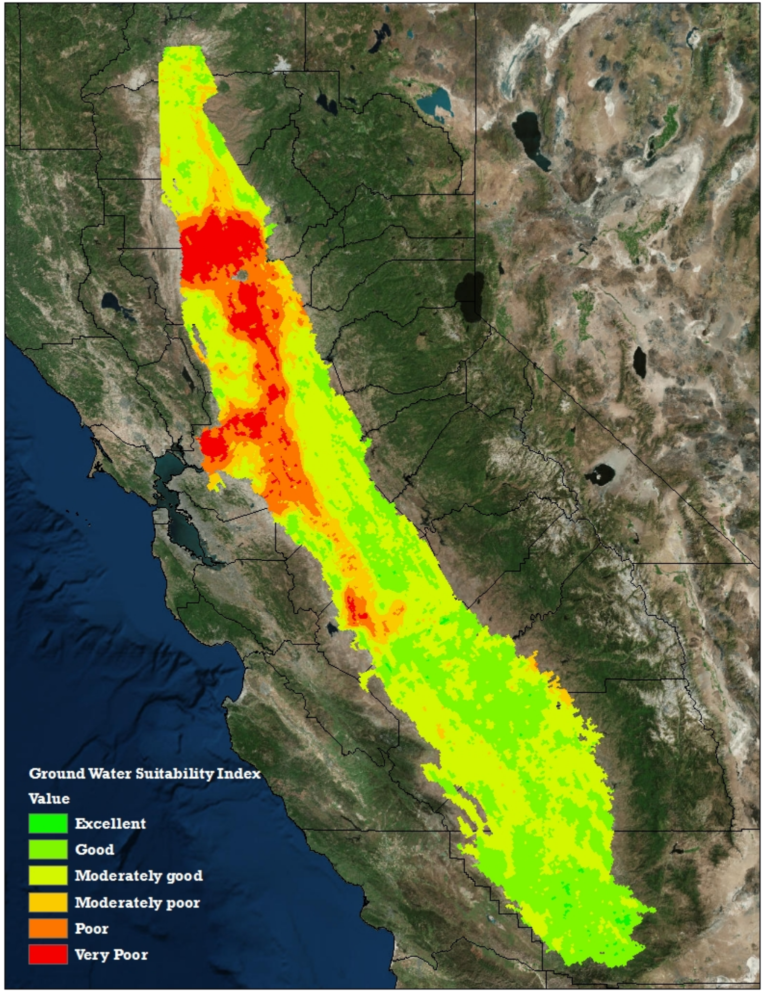
Results – Soil Agricultural Groundwater Banking Index (SAGBI) Surface

- Surface Soil Suitability Index
- Can you infiltrate and percolate water through the root zone



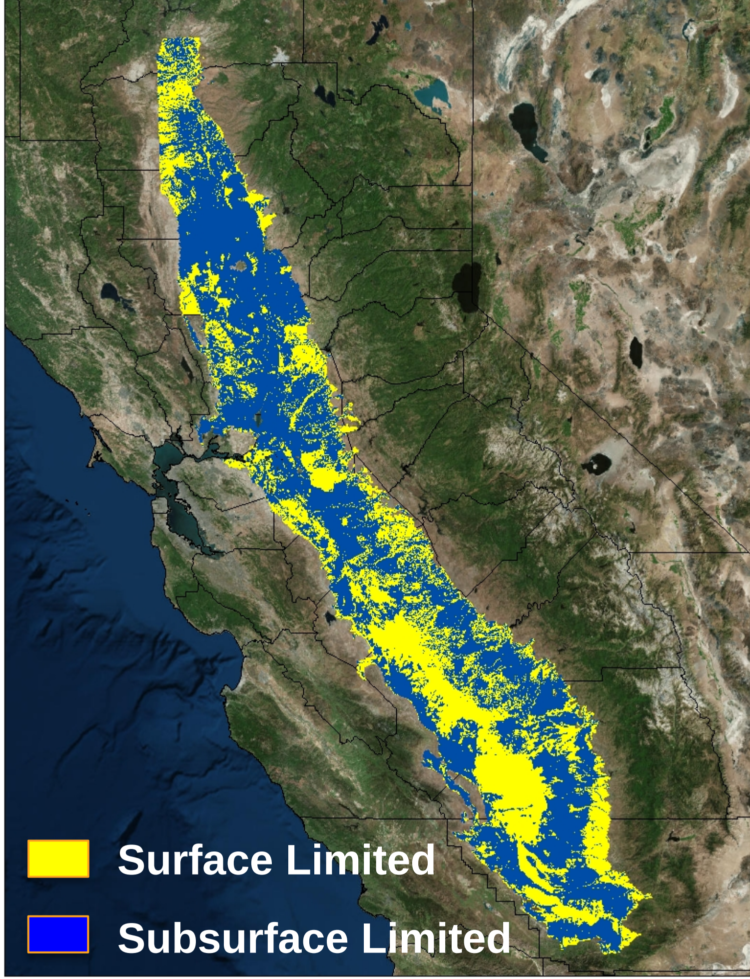
Results – Land IQ Subsurface

- Sequential Approach – Top to Bottom
- Once you infiltrate and percolate water through the root zone, can it be stored?



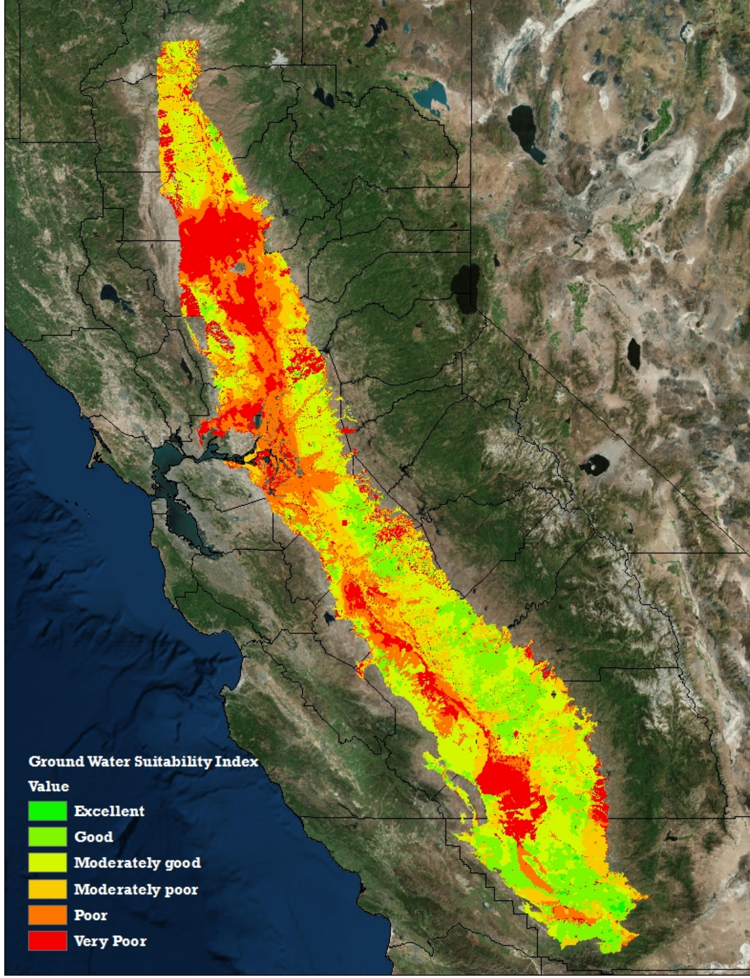
Surface or Subsurface – Limiting Index Result

- Groundwater recharge requires suitable conditions in both surface and subsurface soils
- Start from top and work down



Results – Combined Suitability Index

- Combines both surface and subsurface conditions in a sequential and logical approach
- Provides a conservative approach
- Classifies into six categories

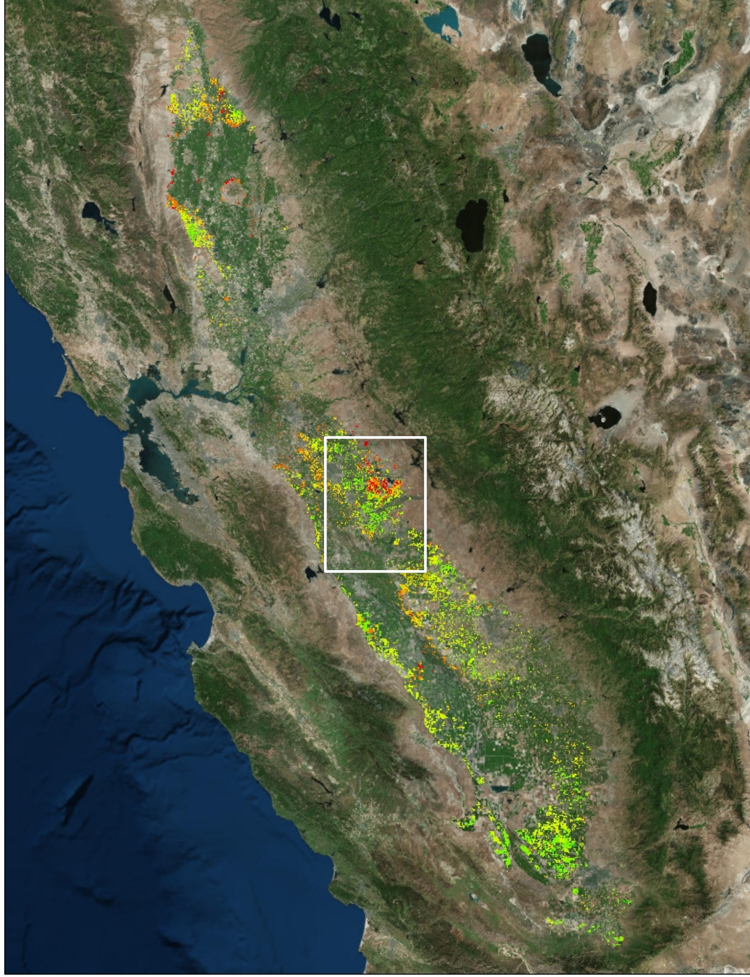


Results – Statewide Almond Mapping – Orchard by Orchard

- Performed for the 2014 growing season
- To be updated in 2016 to assess change
- 97+% accurate

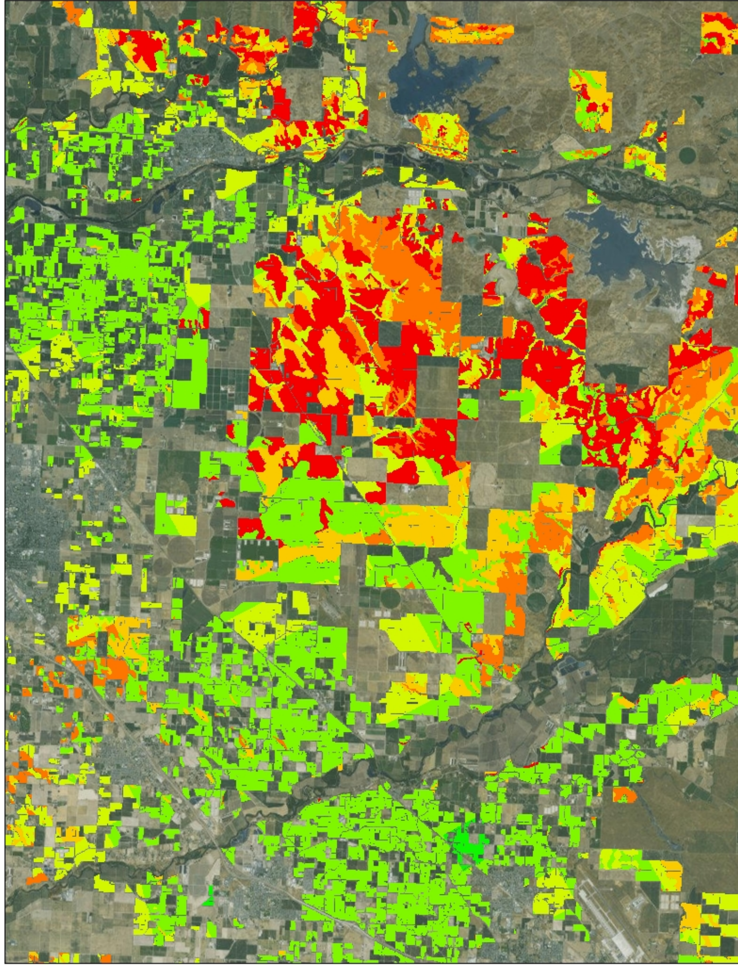
Results – Almond-Specific Groundwater Recharge Suitability

- Overlay and removal of suitability with almond mapping
- Combination of the two datasets result in an orchard by orchard spatial map for suitability
- Acres Suitable
  - Very Good (4,119 acres)
  - Good (271,509 acres)
  - Moderately Good (396,790 acres)



Results – Almond-Specific Groundwater Recharge Suitability

- Zoomed In area east of Modesto showing diversity of suitability
- Detail of classification can be seen according to surface soil type and underlying conditions
- Overlay of water supply infrastructure and communications with irrigation districts is ongoing



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Helen Dahlke,
University of California, Davis

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Groundwater Recharge: A Role for Almonds?

Surface Water Availability and Crop Suitability

Helen Dahlke, UC Davis, hdahlke@ucdavis.edu

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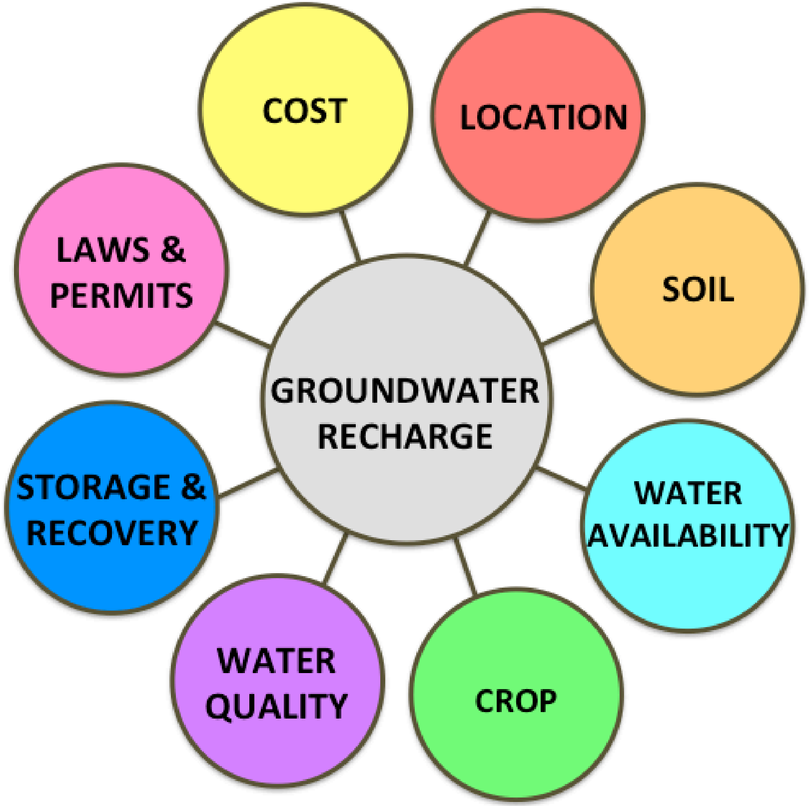
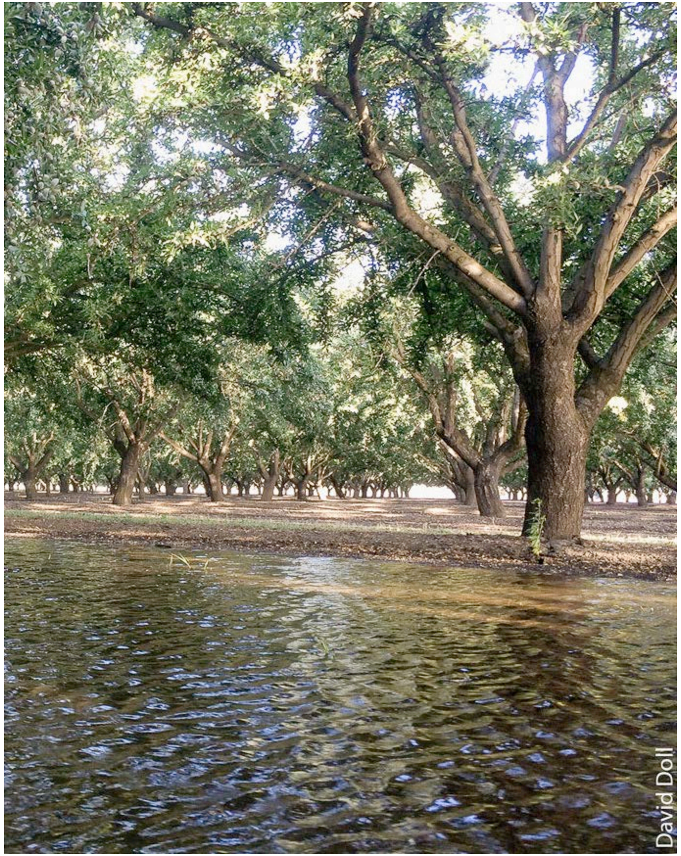
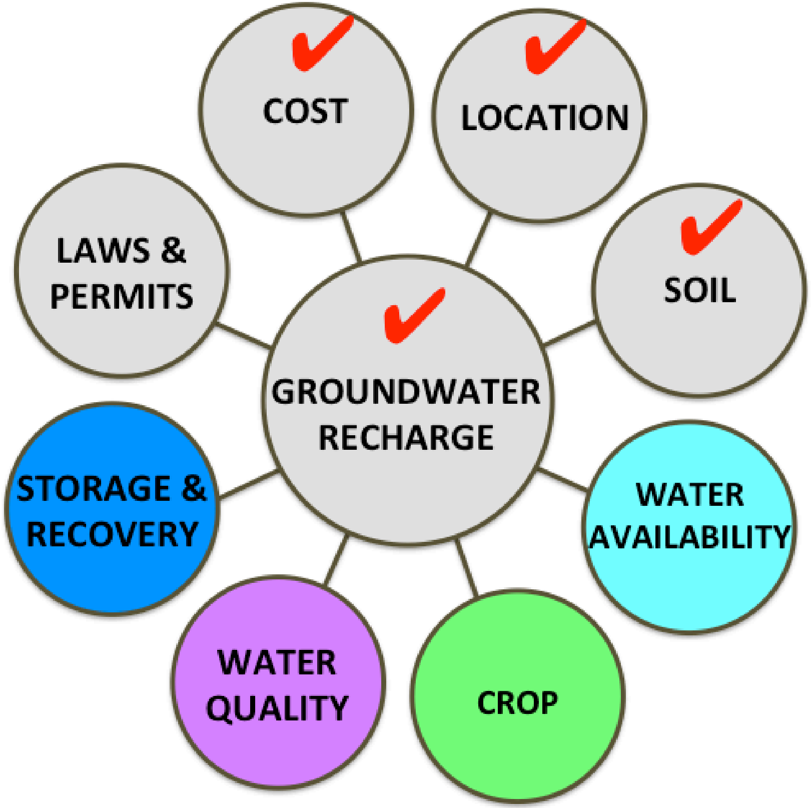
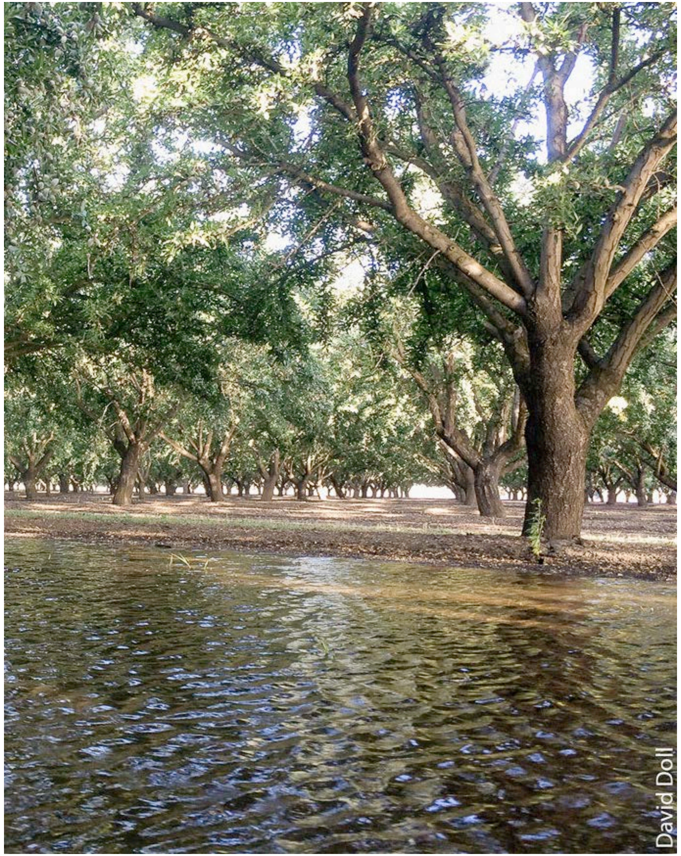
Groundwater Recharge Wheel of Questions





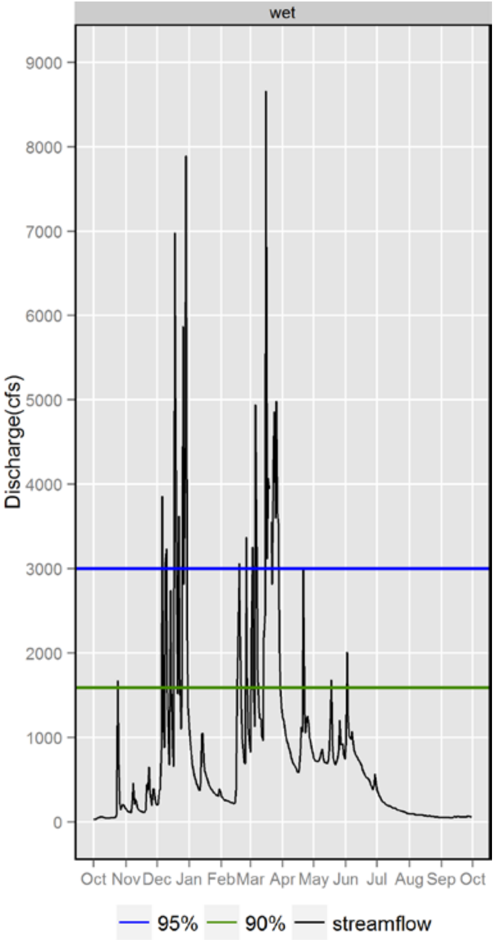
Groundwater Recharge Wheel of Questions





Water Availability Analysis

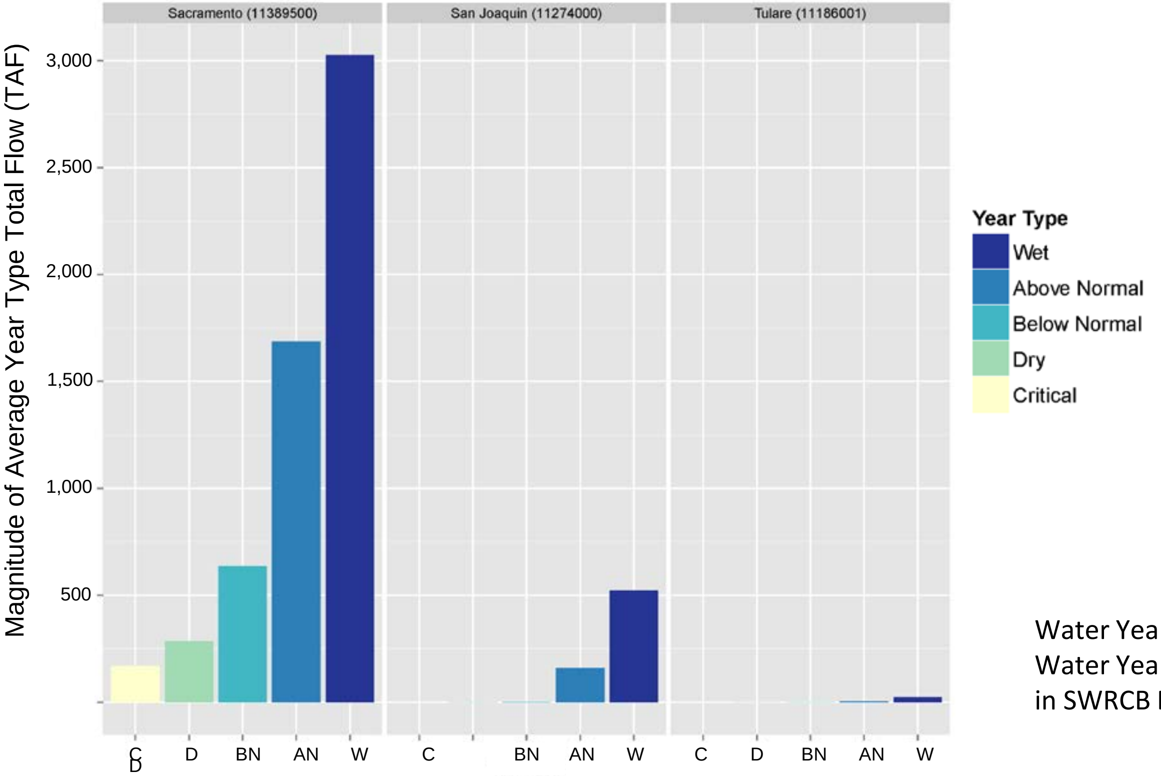
- Estimate the current and forecast the future availability of winter (Nov – Apr) "excess" streamflow for on-farm recharge
- ***"Excess" streamflow:*** Flood flows or flows above 90th percentile of the hydrograph
- 90th percentile threshold is determined from full historical record
- **Water availability metrics:** ***magnitude***, ***frequency***, ***timing***, and ***duration*** of winter flood flows above the 90th percentile
- Long (>50 years) historic daily streamflow records for 93 stream gauges on streams within the Central Valley
- Estimates are summarized for different analysis periods (e.g. monthly, seasonal, 6-months, annual) and water year types (e.g. dry, below normal, wet years)



Water Availability Analysis

Average total flows above 90th percentile for each water year type

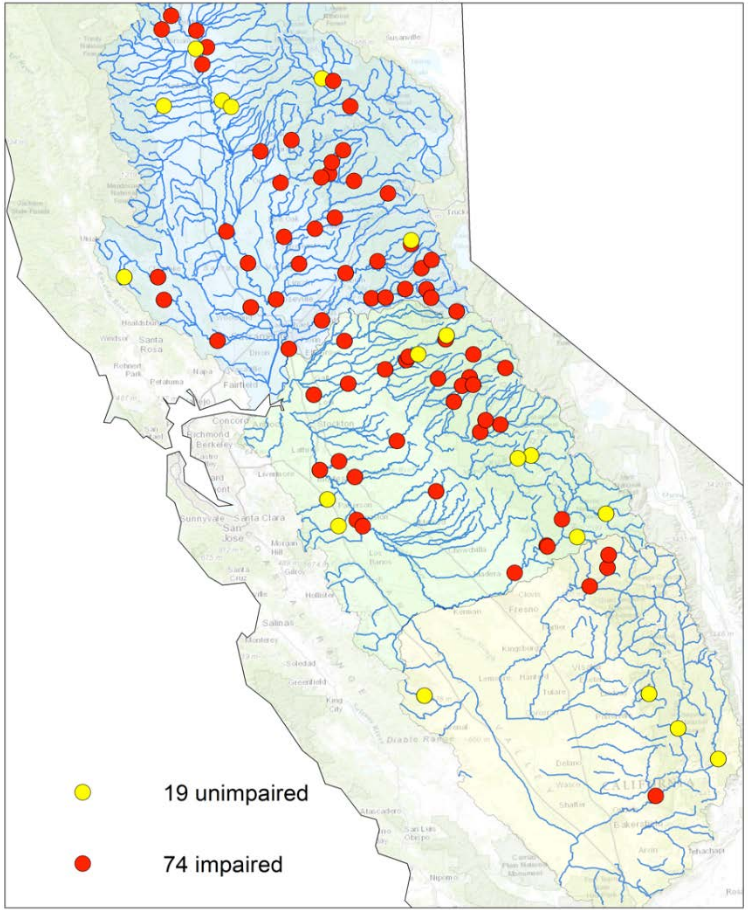
100 yrs of data, December to February



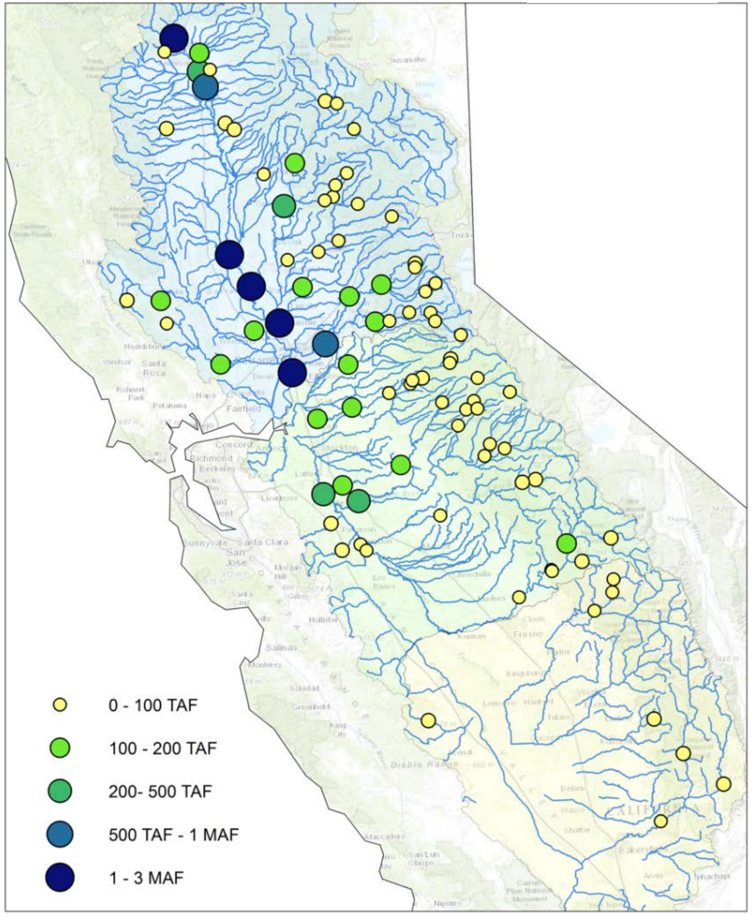
Gauge Location:

Water Year Type (Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices) as defined in SWRCB Decision 1641

Stream Gauge Stations >50 Years Data
Central Valley, CA



Stream Gauge Stations >50 Years Data
Average Volume Above 90% (Dec - Feb)



Water Availability Metrics for Trend and Future Availability Analysis

Magnitude:

- Volume of flow above the 90th percentile

Duration:

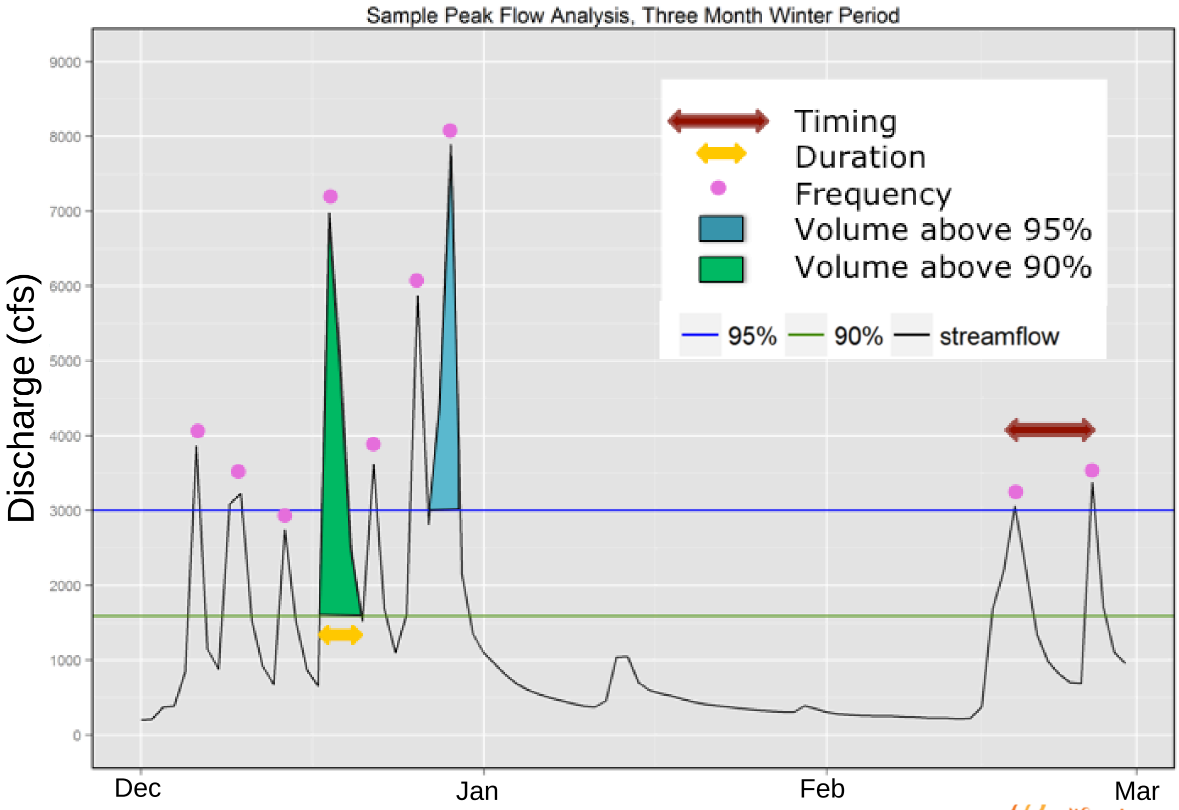
- Number of days above the 90th percentile

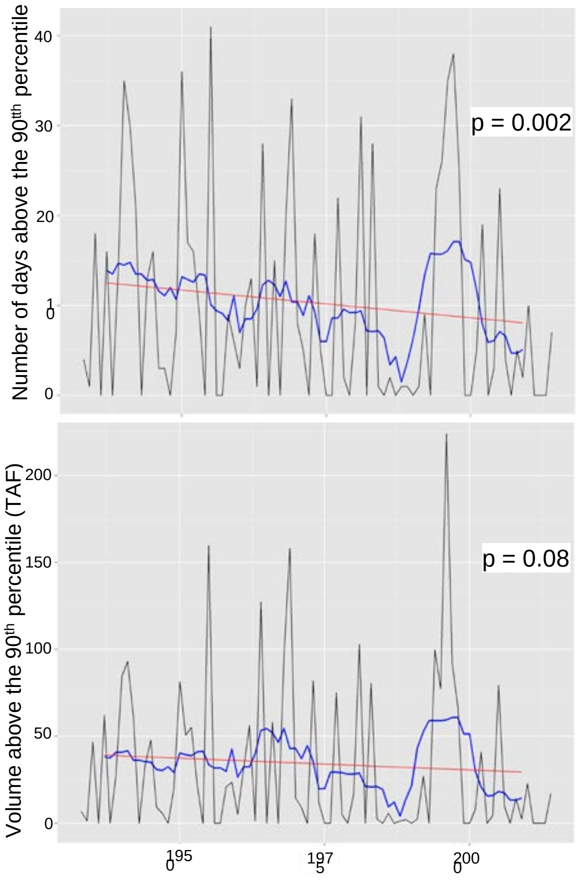
Frequency:

- Number of peaks above the 90th percentile

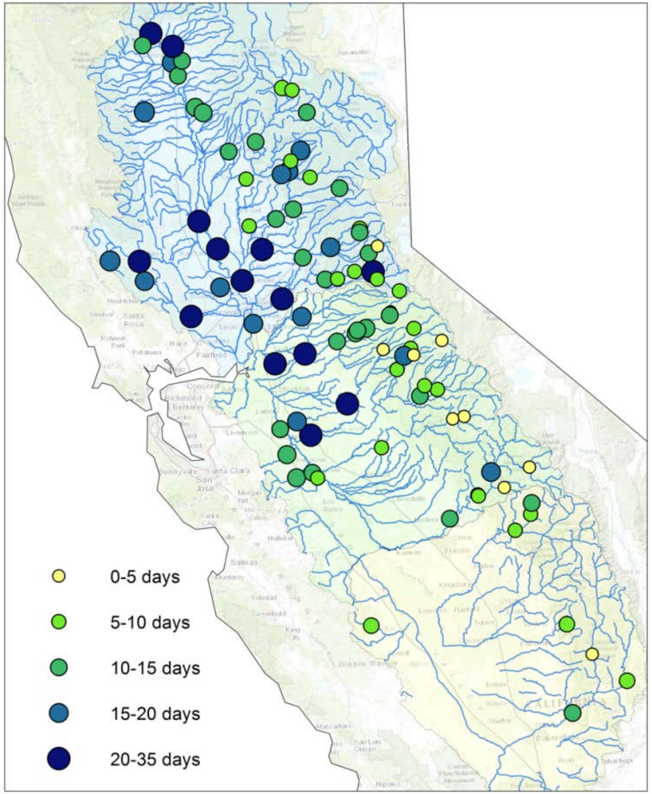
Timing:

- Number of days between peaks above the 90th percentile

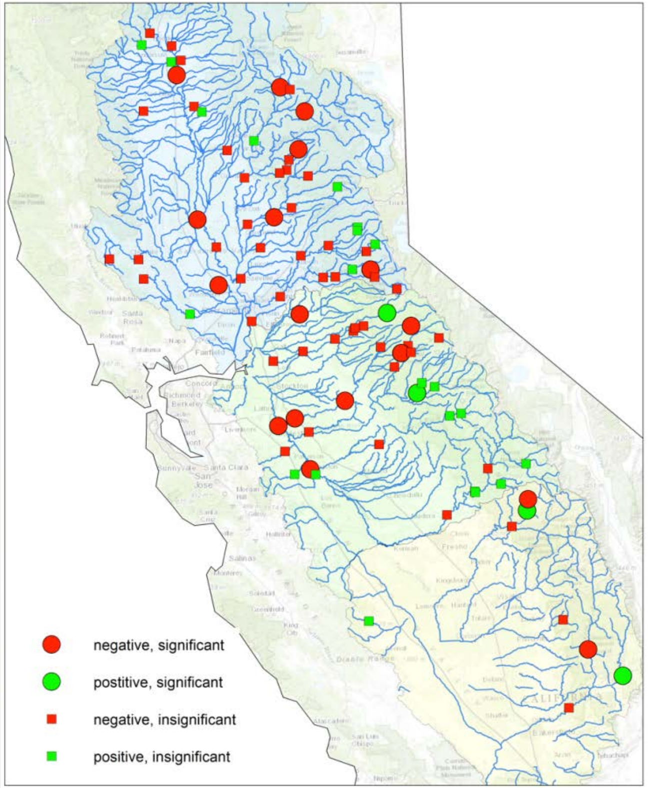




Average Number of Days above 90% (Dec – Feb)



Average Volume above 90% (Dec – Feb) Trends (~1970 to present)



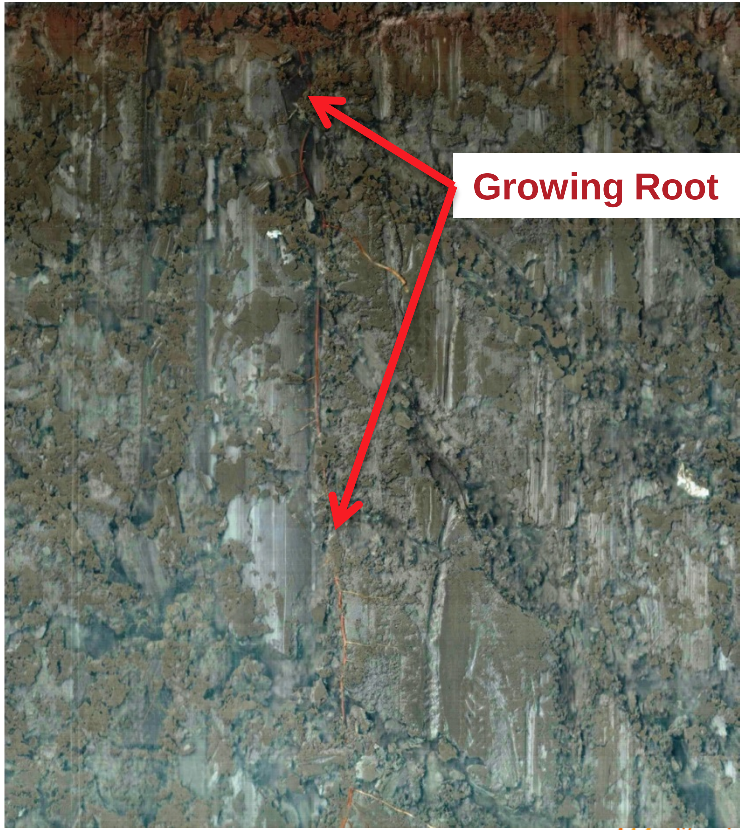
Crop Physiology and Tolerance of Almonds to Winter Irrigation

- **Main Question:** Is applying excess winter irrigation to recharge groundwater supplies detrimental to root and tree health?
- Winter floods and extended periods of standing water can cause the loss of almond and other fruit trees on poorly drained soils
- Anecdotal evidence indicates that saturated soils may have no effect on tree health during dormancy (might be beneficial for leaching salts)
- ***How much water is too much?***
- Our understanding of when physiological activity, particularly in roots, resumes in the late winter/early spring is limited
- In December/January almonds are expected to have reliably low, although not zero, root growth activity

Profs. Astrid Volder (left) and Ken Shackel (right), Dept. of Plant Sciences, UC Davis

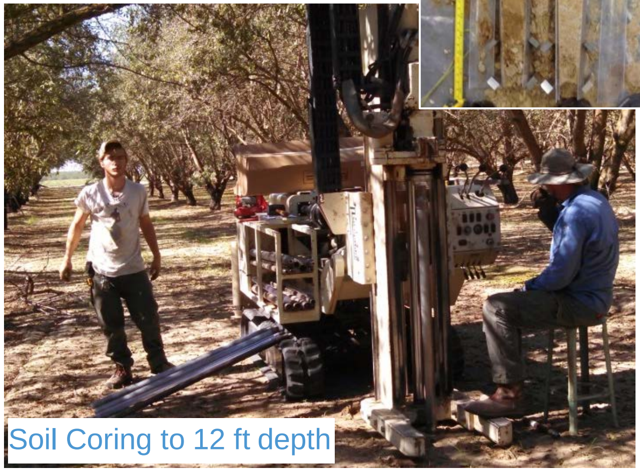
Crop Physiology and Tolerance of Almonds to Winter Irrigation

- Measure the degree of stress in dormant almond twigs using the pressure chamber
- Install minirhizotron tubes to monitor root growth during dormant and growing season
- Compare root growth between treatments: 1) recharge, 2) no winter irrigation, 3) control



Water Quality, Storage, and Recovery

- Site-specific analysis of *soil properties*, *soil water balance* and *soil chemical parameters*
- Will provide a better understanding of:
  - soil water holding capacity and risk of prolonged waterlogging of the root zone due to on-farm flood flow capture
  - percolation rates passed the roots zone
  - nitrate leaching risk
- Site-specific modeling of groundwater – surface water interaction using the C2VSIM model to estimate impact of recharge on groundwater storage and recovery



Ongoing and Future Work

- **Compare "excess" surface water estimates to:**
  - ***infrastructure capacity*** at points of diversion to assess what fraction of flood flows can be diverted locally onto agricultural land
  - ***eWRIMS data*** (Electronic Water Rights Information Management System, SWRCB) to determine what fraction of flood flows can be allocated for groundwater banking in addition existing allocations
- **Complete field experiments at three test sites:**
  - Crop physiology study in relation to soils properties and soil water content
  - Site-specific soil analysis
  - Water balance monitoring

THANKS!

Helen Dahlke (hdahlke@ucdavis.edu)