



Demand Reduction Strategies

Extend Orchard Replacement (EOR) Pilot Study
Precision Irrigation (PI) Pilot Study

Vina GSA Board of Directors – March 11, 2026

Joel Kimmelshue, PhD, Land IQ

Cooperators

- Land IQ
 - Project Manager: Stephanie Tillman, MS
 - Principal Scientist: Joel Kimmelshue, PhD
 - Technical Advisors:
 - Allan Fulton, MS – Retired Irrigation/Crop Production Specialist
 - Tom Devol, BS – Retired Irrigation and Water Resources Specialist
- Independent Technical Advisor
 - Joe Connell, MS – Retired UCANR Farm Advisor
- ERA Agricultural Economics
 - Duncan MacEwan, PhD
 - Tori Laird, BS
 - Josh Virene, MS



Demand Reduction Strategies - Background

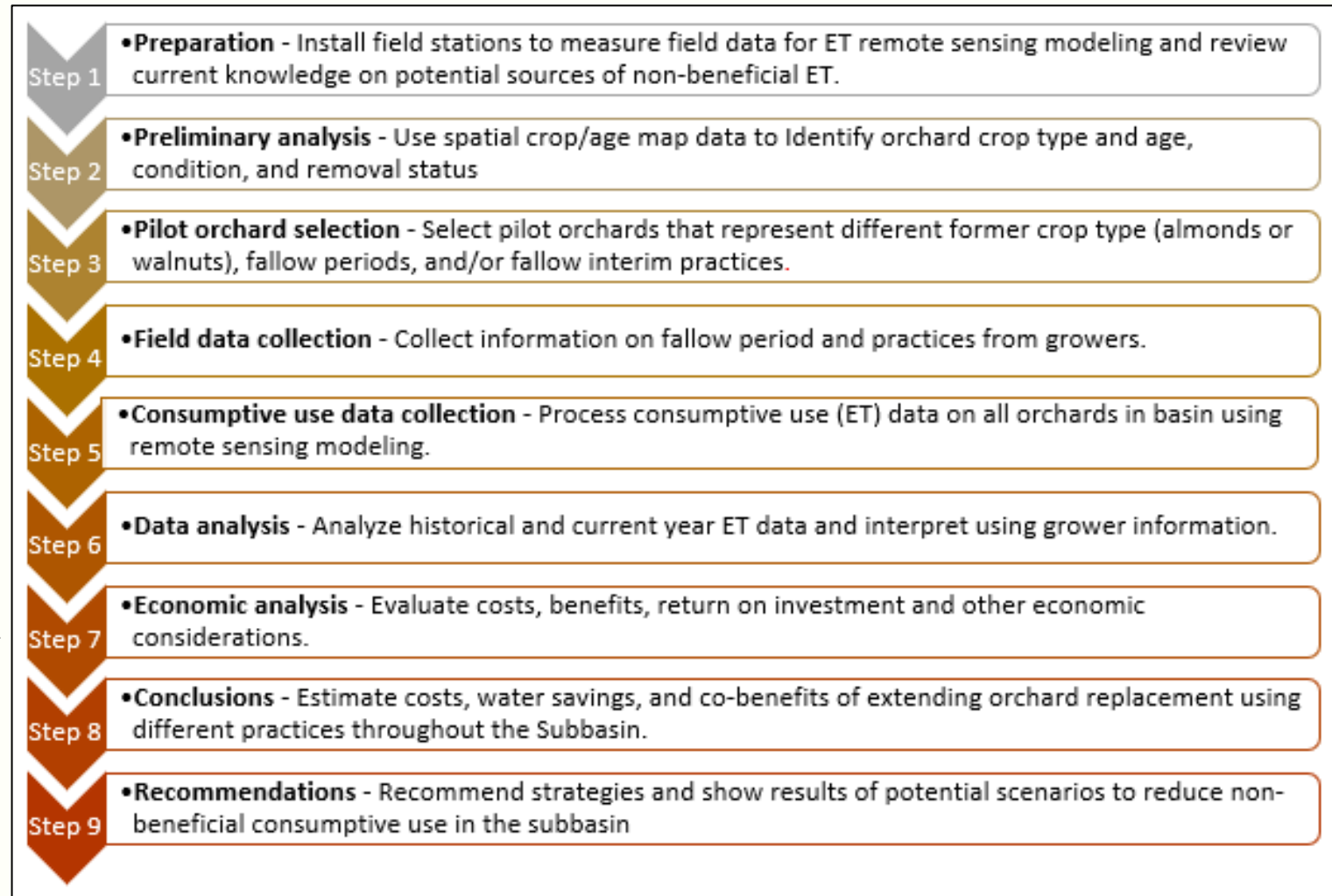
- Grant funded through DWR
- Conducted to show progress on GSP implementation actions
- For the purpose of addressing estimated 10,000 ac-ft annual overdraft
- Specifically, this is to address two main demand reduction strategies:
 - Extend Orchard Replacement
 - Precision Irrigation



Project Approach

- Both projects followed the same approach, except:

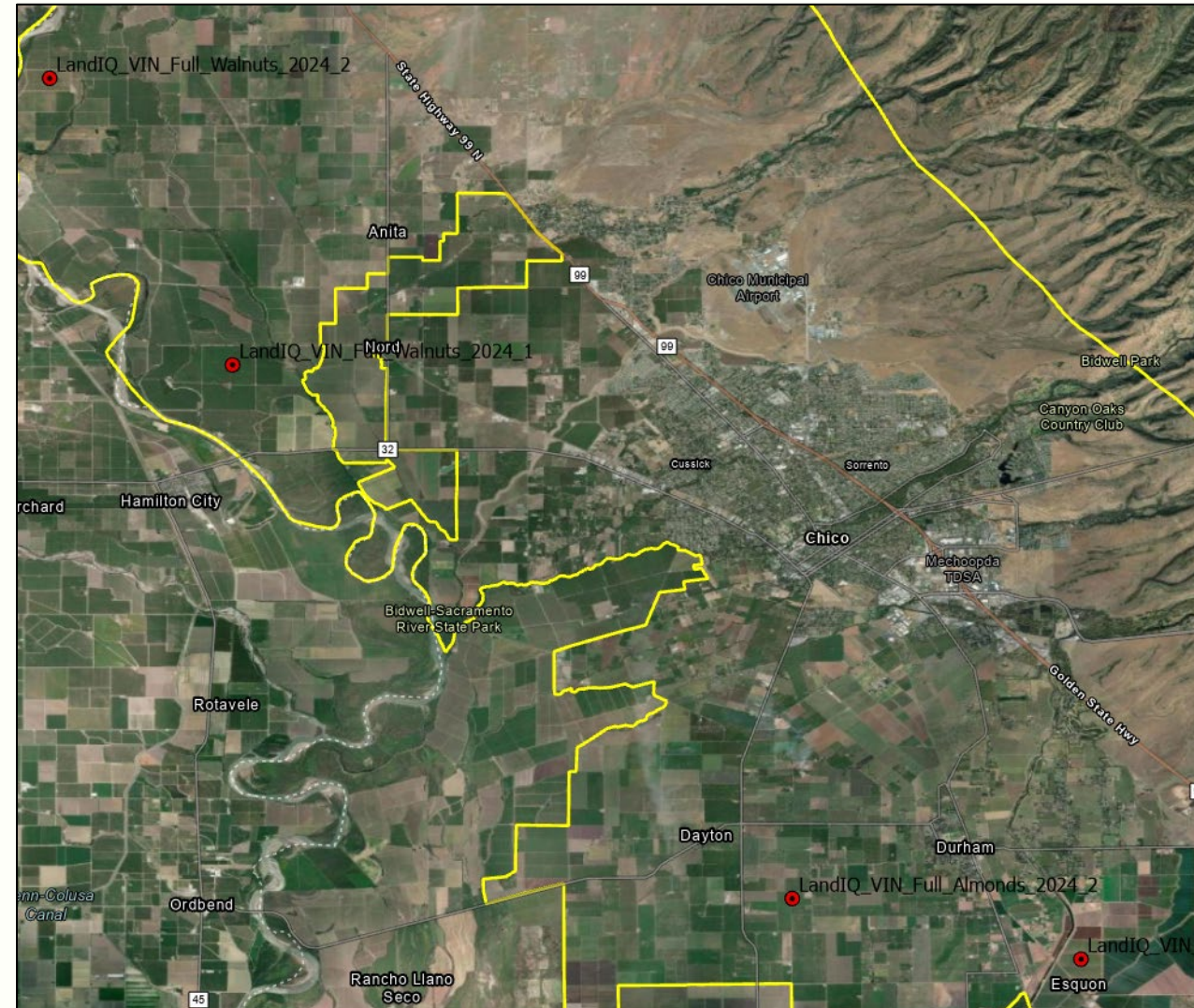
Extend Orchard Replacement Only →



Spatial Data for Pilot Studies - ET

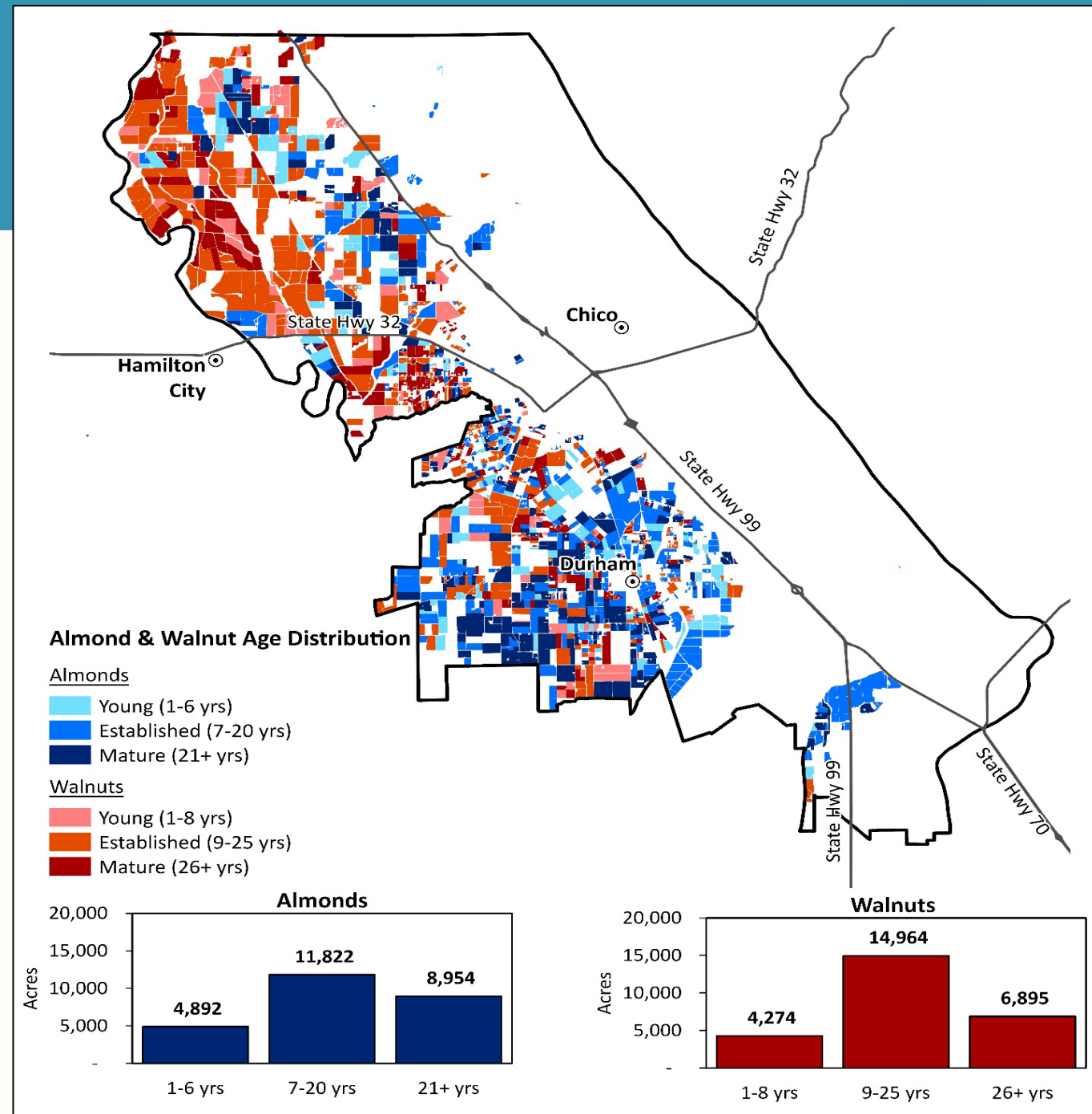


- Evapotranspiration: Fundamental Measurement Approach
 - Walnuts: 2 stations
 - 20-year old orchard in northwest
 - 9-year old orchard in west central
 - Almonds: 2 stations
 - 15-year old orchard in southwest
 - 8-year old orchard in the southeast
 - ET then modeled for every block in the subbasin from Jan-Oct
- Other variables measured or observed:
 - historical ET (2019-2024), precipitation, irrigation method and management, cultural practices, orchard condition, orchard size, soil type, crop rotations, removal status, root stock, spacing, variety, yield, etc.



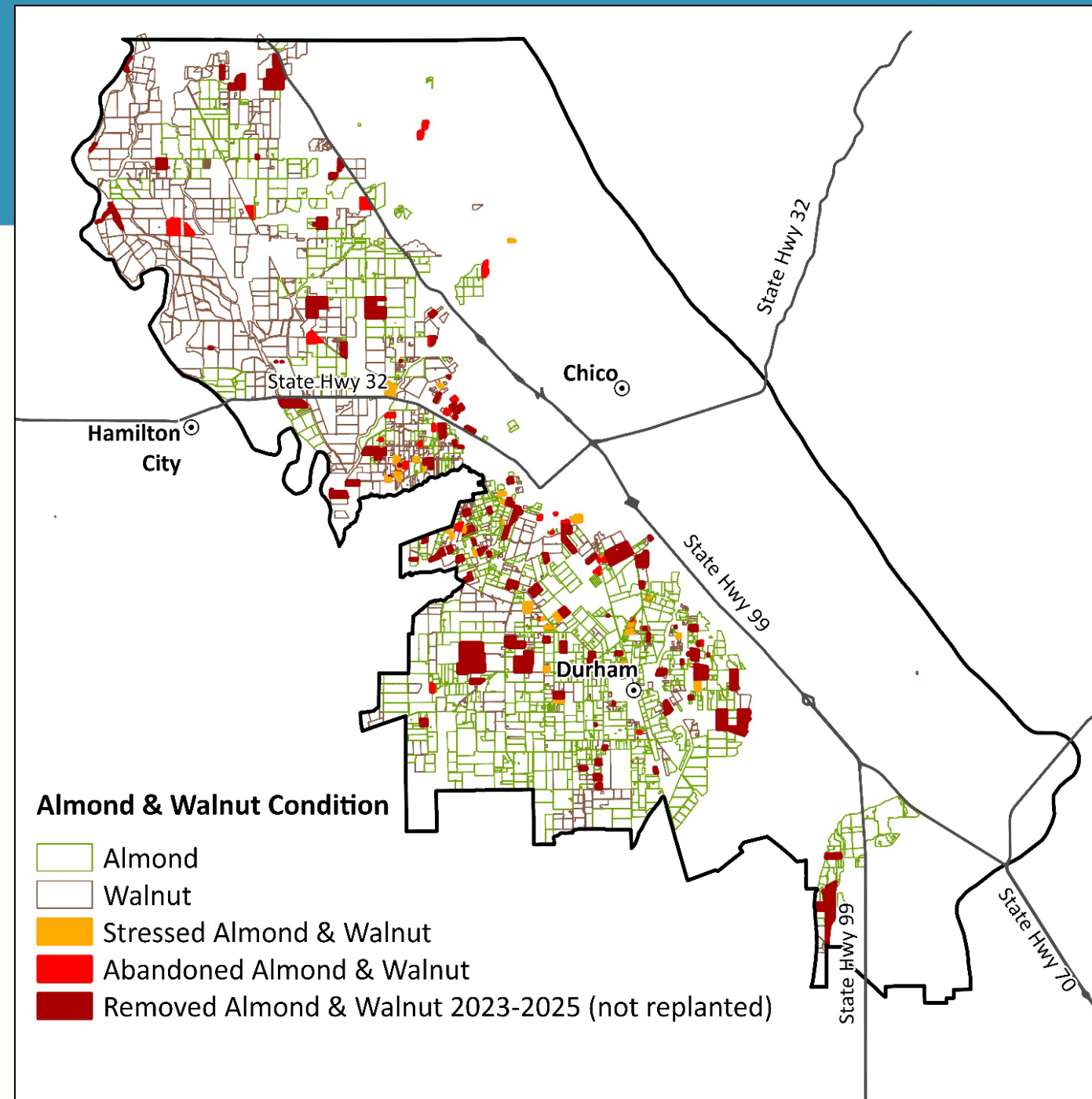
Spatial Data

- Crop type and age
 - Almonds: 25,668 acres (~35%)
 - Walnuts: 26,133 acres (~35%)
 - Other Crops/Fallow: about 20,000 acres (~30%) depending on year
 - Rice
 - Prunes
 - Tomatoes
 - Dry Beans
 - Pistachios
 - Grain and Hay



Spatial Data

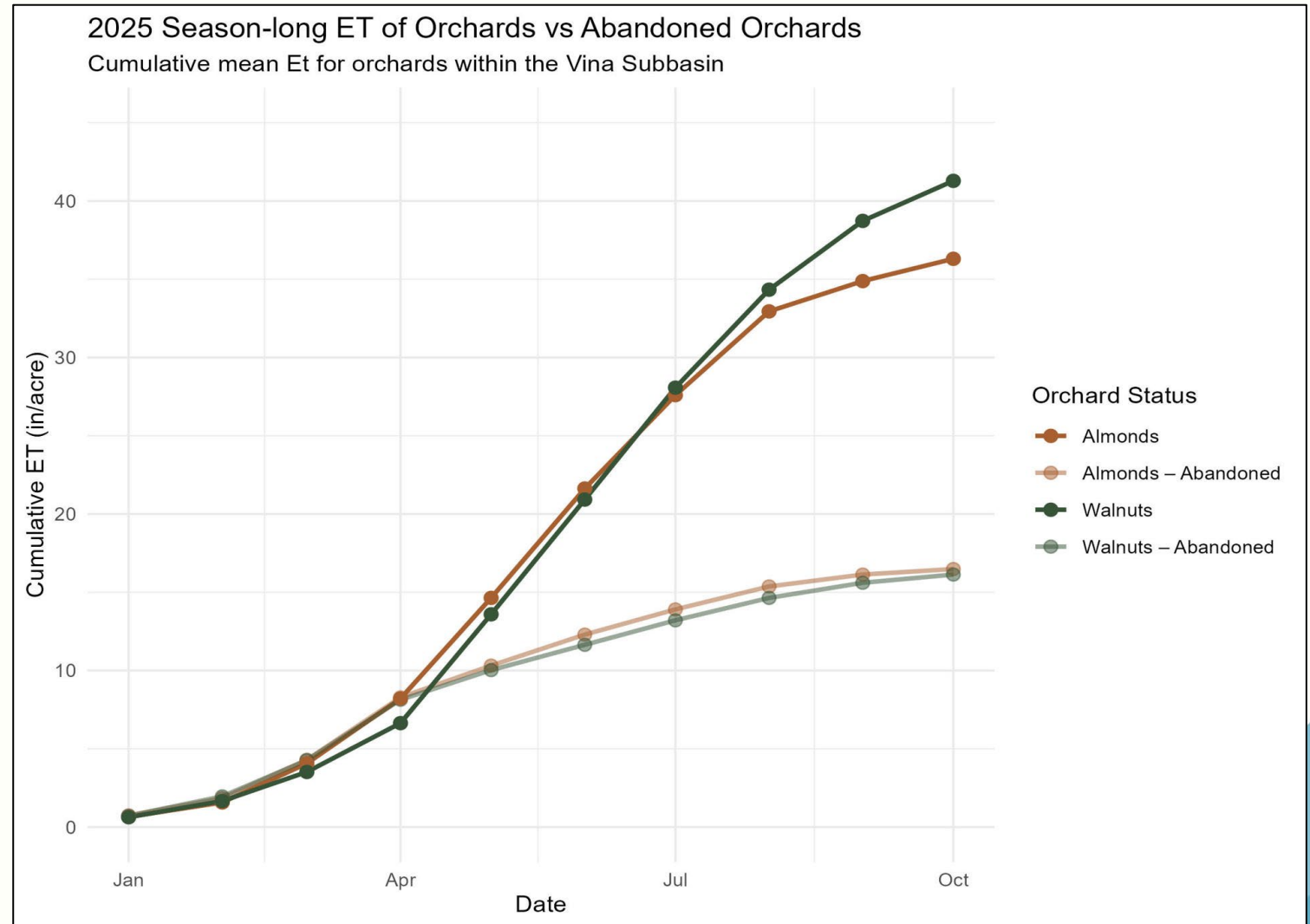
- Condition
 - Fully Productive
 - Stressed
 - Abandoned
 - Removed
- Historical Mapping – about 10 years
 - Allows for observing trends in acreage change and crop shifts



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Extend Orchard Replacement: Pilot Study Questions

- What types of practices/systems (e.g. interim or cover crops) are used on idle orchard ground and how much water do they consume?
- What are the costs, co-benefits and water savings of an extended orchard replacement period over the life of an orchard?
- How can this knowledge be used to guide the GSA in implementing programs that realize the benefits of extend orchard replacement?

DRAFT

**Vina Subbasin GSAs Demand Reduction Strategies:
Extend Orchard Replacement Pilot Study Final Report**

Prepared for
Vina Subbasin GSAs

Prepared by
 **LAND IQ**
2020 L Street, Ste 210
Sacramento, CA 95833

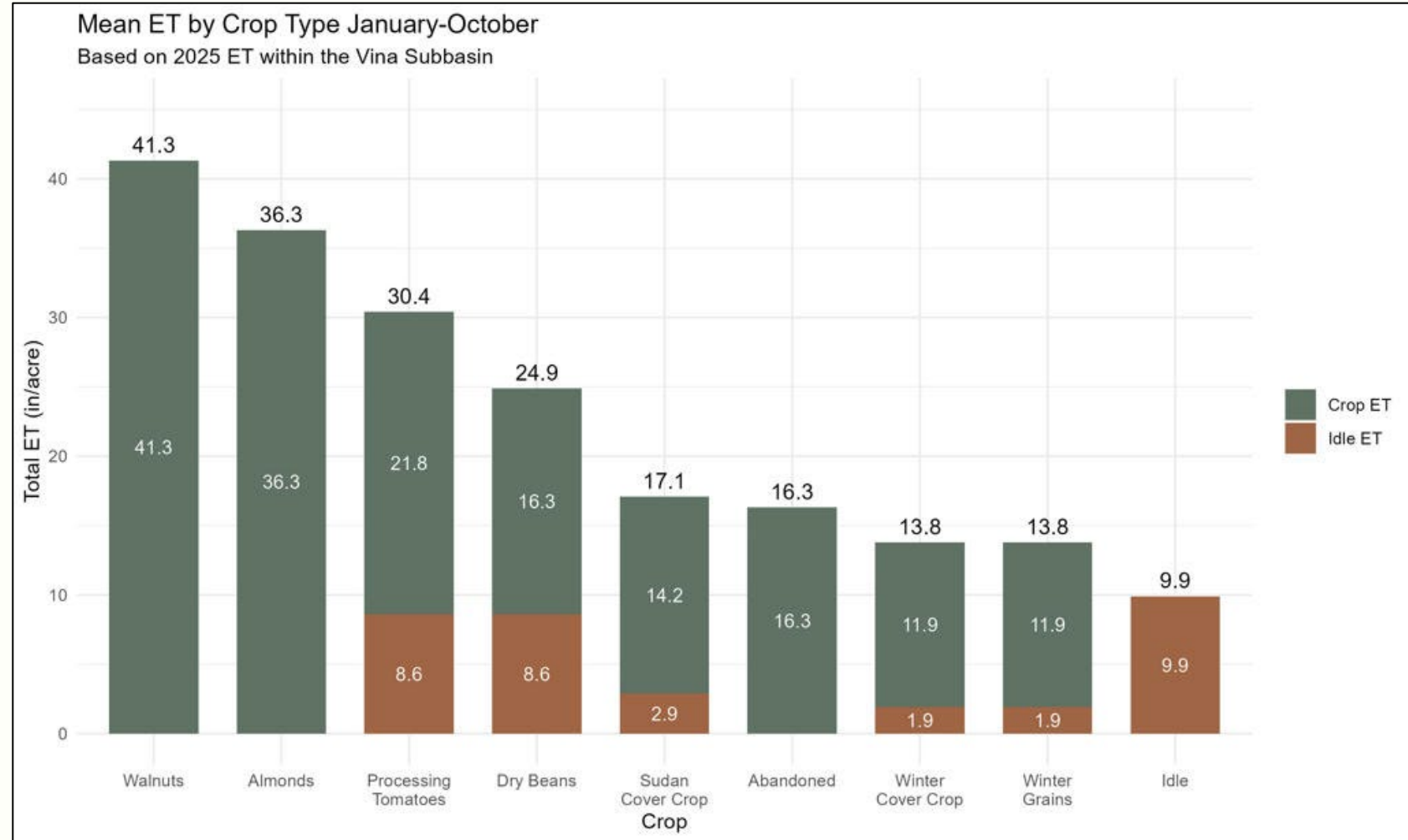
Contact: Casey Gudel
cgudel@landiq.com

MARCH 2026

Extend Orchard Replacement: ET Analysis By Land Use



- Different crops have different consumptive use
- Growing lower water use crops still saves water
- Some crops rely solely on precipitation as their water source



Consumptive use of walnut and almond orchards compared to alternative land uses during the extended replant period.

Extend Orchard Replacement: ET Analysis By Land Use



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Footprint					
	Acres Removed Per Year	Percent Practicing EOR	Percentage of 2025 Acreage	Historical 2024 Acres	Historical 2025 Acres
Almonds	1000	95%	4%	977	2,214
Walnuts	700	95%	3%	582	917
Total Acres in EOR	1615				
EOR Land Utilization					
	Historical 2024 Acres	Historical 2025 Acres	Percent of Total Fallow Acres	Acres	
Abandoned	181	284	0%	0	
Idle			50%	808	
Dry Beans	281	628	10%	162	
Processing Tomatoes	650	463	10%	162	
Sudan Cover Crop			10%	162	
Winter Cover Crop			10%	162	
Winter Grains	2,965	2,049	10%	162	
Total			100%		
Overall Use and Expected Water Savings Compared to an Average Orchard					
	Overall Use		Savings Compared to an Orchard (walnut and almond average)		
	ET (ac-ft)	Applied Water (ac-ft)	ET (ac-ft)	Applied Water (ac-ft)	Orchard Use Percent
Abandoned	0	0	0	0	0%
Idle	666	0	1,945	1,844	25%
Dry Beans	335	335	187	34	64%
Processing Tomatoes	409	450	113	-81	78%
Sudan Cover Crop	230	0	292	369	44%
Winter Cover Crop	186	0	336	369	36%
Winter Grains	186	0	336	369	36%
Total	2,012	785	3,209	2,903	

Extend Orchard Replacement: Case Studies

Extended Orchard Replacement (EOR) Case Study Abandoned Orchards



Extended Orchard Replacement (EOR) Case Study Winter Grain Crop



FINANCIAL ANALYSIS

abandoned, and it poses a public nuisance due to... states that growers must first receive notice then have thirty (30) days to rectify the issue. If the penalty is removed. If the grower does not take action within (45) days, however, the penalty amount is \$1,000 per acre. Examples of actions that would be considered following a minimal management scenario, or

Penalties for Abandoned Orchard Scenario	
30-days	\$0 - 500
45 days	\$1,000

Actual costs, yields, and returns. Actual costs and returns will vary by farming operation. A grower who will have different access to cash and borrowing that may affect operations. Actual values in this analysis. The almond yields and a price of \$2.25/lb. for almonds. Table 1 compares the financial decisions a producer could make at the end of the previous orchard's productive

Comparison by Management Scenario in Year 0

Management Scenario	Minimal Management \$/ac	Bare Ground Idle* \$/ac	Replanting \$/ac
Immediate Replanting	\$0	\$2,800	\$2,800
1-year delay	\$364	\$364	\$364
2-year delay	\$200	\$0	\$430
3-year delay	\$0	\$0	\$4,000
4-year delay	\$0	\$0	\$2,300
5-year delay	\$564	\$3,164	\$9,894
6-year delay	\$0	\$0	\$0
7-year delay	\$564	\$3,164	\$9,894

*Scenarios are available in the full Vina Subbasin Extend Orchard Replacement Program Report. Penalties for non-compliance, the amount depends on the timeline and grower response following notice of violation, and Follow Case Study.

March 2026



Extended Orchard Replacement (EOR) Case Study Winter Cover Crop - Winter Mix



DEFINITION

Here an EOR winter cover crop is assumed to be a cool-season grass and legume mixture that is planted in the fall, terminated in the spring and incorporated for green manure.

WATER USE

Winter mix cover crops consumed 11.9 inches of water during their growing season in 2025. For months when the land was idle, another 1.9 inches of water was consumed, for a total of 13.8 inches of consumed water for this land use January to October 2025.

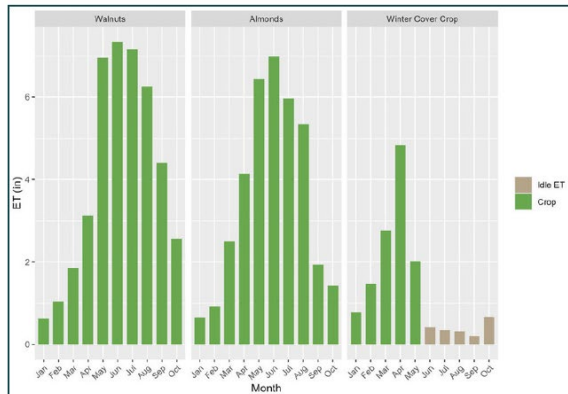


Figure 1. Mean ET by Crop Type January - October

FINANCIAL ANALYSIS

When an almond orchard that is removed and the land is left idle for a period of 1, 2, or 3 years to replant almonds. During the idle period, under this scenario, winter wheat for grain is planted. This creates water savings, provides a harvestable crop, and provides some soil and organic matter. A financial analysis was developed to compare the net income (revenue minus costs) to the net income of replanting versus delaying replanting by 1, 2, or 3 years.

If an orchard is removed in Year 0. If it is immediately replanted to almonds the next year, the grower will produce the first crop in Year 3 (3rd leaf). It would generate positive net cash flow starting in Year 1. Delaying replanting by 1 year means the block produces its first crop in Year 4 and generates its first crop in Year 7. Similar logic applies to delaying replanting by 2 or 3 years. For delayed replanting, winter wheat is planted and harvested for grain generating around \$570 per acre in Year 1.

If an orchard is removed in Year 0 at a cost of approximately \$2,800 per acre for tree removal, composting, ripping for root removal, disc, and roll. Replanting costs include trees, irrigation, and establishment. These costs are incurred in Year 1 if the block is immediately replanted, or in Years 2, 3, or 4 if replanting is delayed. For delayed replanting, winter wheat is planted and harvested for grain, excluding overhead.

Delaying replanting may provide additional soil and pest management benefits. During the replanting period some growers may be able to avoid fumigation for nematodes. Other soil and crop productivity benefits may provide cost savings through increased productivity.

Almond orchards average evapotranspiration (ET) of 2.66 acre-feet per acre over a 25-year period. Winter crop ET is assumed to be 1.67 acre-feet per acre. ET savings are 0.88, 1.77, and 2.66 acre-feet per acre in the 1-year, 2-year, and 3-year replanting delay scenarios. The corresponding water savings are \$601, \$589, and \$578 per acre-foot of water saved, respectively.

Representative costs, yields, and returns. Actual costs and returns will vary by farming operation. A grower who is also a handler, will have different access to cash and borrowing that may affect operations. Almond prices fluctuate based on market conditions and would affect the outcomes. Almond yields and a price of \$2.25/lb. for almonds. The analysis applies to representative almond yields and a price of \$2.25/lb. for almonds.

Sensitivity scenarios are available in the full Vina Subbasin Extend Orchard Replacement Program Report.



Extend Orchard Replacement: Key Findings



- Extending the period between orchard plantings can reduce ET, resulting in measurable and significant water savings ...



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- Extended replanting incentives vary depending on how the land is used ...
- Harvested cover crops partially offset idling costs ...
- Short-season cash crops can substantially reduce or eliminate incentive payments ...
- As an alternative to removal, some growers have been abandoning orchards ...



Extend Orchard Replacement: Recommendations



- Update scenario budgets and incentive payments periodically ...



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- **Improve water use and ET estimates and apply to the cost-per-acre-foot-saved ...**



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- Gather data from pilot sites and analyze the potential yield/productivity benefits ...
- Improve water use and ET estimates and apply to the cost-per-acre-foot-saved ...
- Refine time of use electrical rates ...



Precision Irrigation: Pilot Study Questions

- What are the irrigation scheduling approaches and technologies in use?
- What is the potential for demand reduction using precision irrigation?
- How can this knowledge be used to guide the GSA in implementing demand reduction programs?

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Precision Irrigation: Analysis

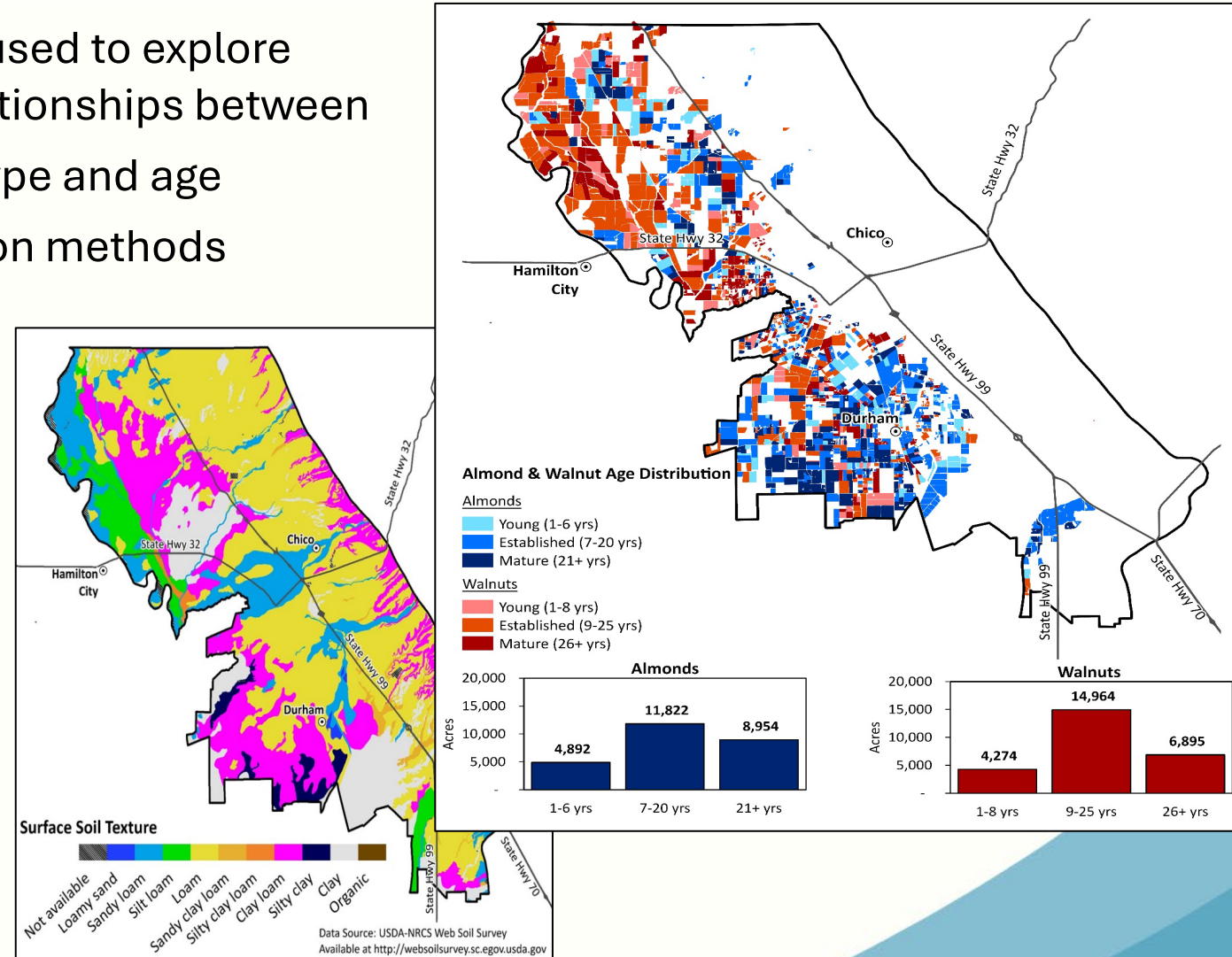


Pilot orchards used for analysis

- Pruning practices
- Irrigation types
- Irrigation scheduling technologies
- ET
- NDVI
- Yield
- Applied Water
- Soil type

All orchards used to explore potential relationships between

- Crop type and age
- Irrigation methods
- ET
- NDVI



Precision Irrigation: Analysis



- Butte County Survey (2021) - these technologies are not used as much on small farms.
- 70% of farms are <100 ac and account for 30% of acreage.
- Highest barrier to pressure chamber adoption overall is labor.

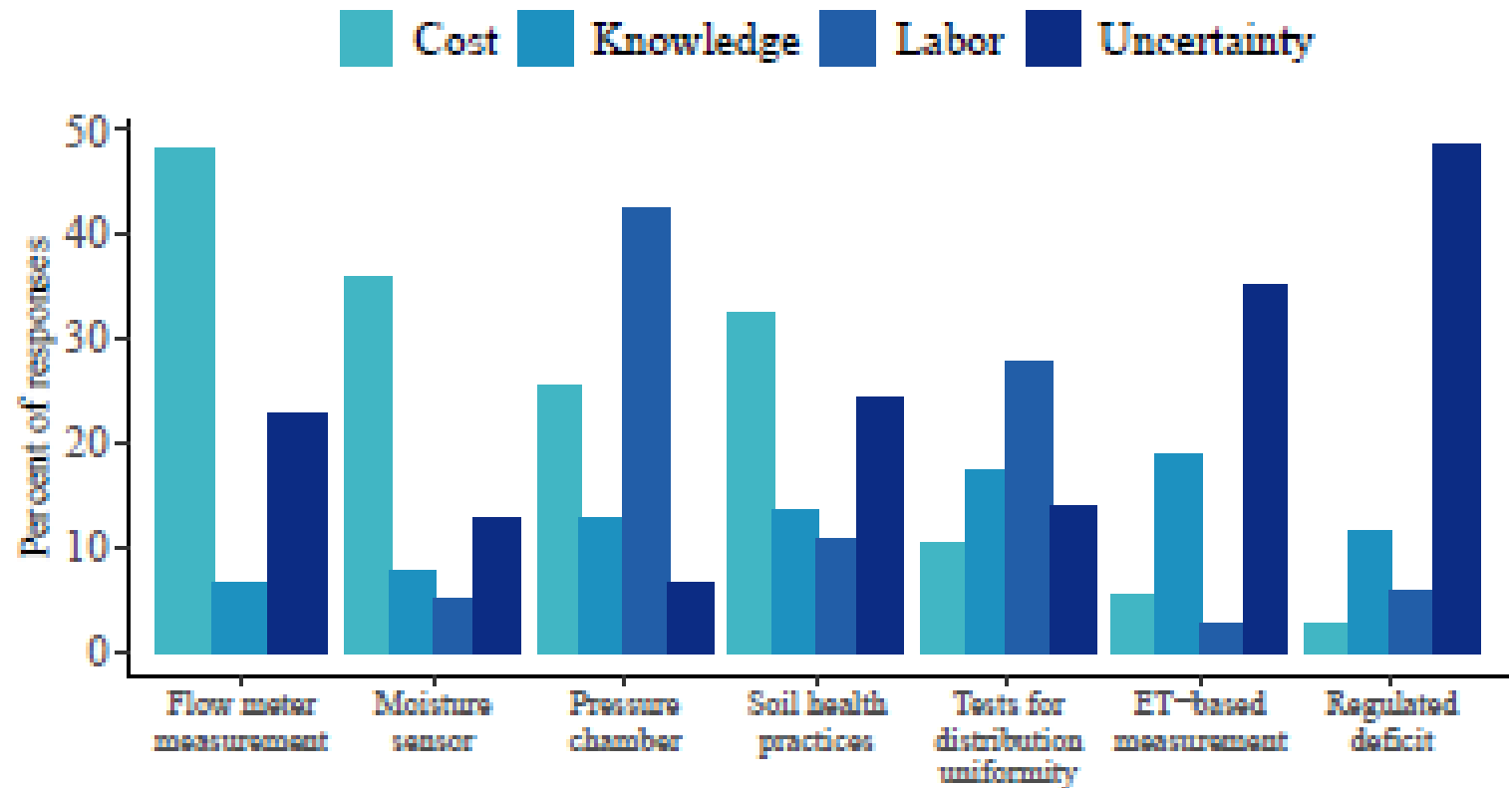


Figure 6. When considering these irrigation management practices, which of the following issues do you consider a challenge for implementation?

Precision Irrigation: Technical Bulletins



Precision Irrigation Case Study



Field Level Measurements of Applied Water and Opportunities for Improvement

INTRODUCTION

Reliable applied water data is a fundamental component of effective irrigation management. Applied water enables managers to determine whether irrigation events are delivering the intended water to the orchard, both on an event basis and over the course of the season. Flow records also help verify that irrigation systems are operating as designed. Comparing applied water to crop evapotranspiration, ETc, provides insight into whether irrigation applications are adequately meeting crop water use.

When combined with soil moisture measurements and plant-based indicators, such as stem water potential, SWP, data from a pressure chamber or data from tree-based sensors, applied water information helps confirm that irrigation events are aligned with management objectives and supporting overall irrigation plan performance.

Methods for calculating applied water are addressed in this section. The most used approach is installation of a flow meter at the pumping station. An alternative method involves a monitoring station equipped with either a flow meter or pressure transducer. This station may also be equipped with other types of sensors such as soil moisture or weather instruments.

RESULTS

Approximately 44% of growers participating in the pilot had flow meters installed at their pumping stations. Among those, there was an even split between meters that were manually read and meters that were read remotely through software platforms.

Flow meters can monitor real-time flow, typically displayed as gallons per minute (GPM), and record cumulative flow totals expressed in acre-feet. However, differences between manually read and remotely monitored meters can significantly affect the accuracy of flow records.

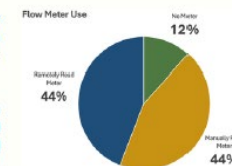


Figure 1. Flow Meter Use



Precision Irrigation Technical Bulletin



Integrating Field Technologies into Irrigation Decision Support

INTRODUCTION

As described in the section, Growers participating in the pilot project used a range of tools and approaches to address the questions of when to irrigate and how long to apply water (see **PI Case Study: Methods for Determining Irrigation Timing and Application Duration**). Selecting appropriate tools and techniques is an important decision for both small and large operations.

Each operation faces a unique combination of constraints and opportunities, including staff expertise, financial resources, existing irrigation infrastructure, and orchard layout. As a result, no single approach is appropriate for all situations. Developing a plan prior to selecting specific tools or technologies helps ensure that the chosen approach meets current operational needs while remaining adaptable to future conditions.

Developing a Framework for Success

Four key steps can help ensure that irrigation scheduling tools deliver meaningful value and support irrigation decision-making:

1. Develop an **irrigation management plan**.
2. Choose a lead person or **"champion"**.
3. Select **appropriate tools**.
4. **Validate results** with field observations.

STEP 1: DEVELOP AN IRRIGATION MANAGEMENT PLAN

With the wide range of irrigation and monitoring technologies currently available, it is increasingly important for operations to begin with a **clear irrigation management plan** before selecting and installing new tools. Bringing the full management team together to discuss goals, expectations, and constraints is strongly encouraged prior to implementation.

Although this planning step is sometimes overlooked, a well-defined irrigation management plan can lead to a more effective monitoring strategy, improved communication among staff and advisors, and more consistent use of collected data in irrigation decisions.



Methods for Determining Irrigation Timing and Application Duration in Pilot Orchards

INTRODUCTION

A variety of tools and approaches were used by growers in the Precision Irrigation pilot study to inform irrigation timing and duration. These methods ranged from relatively simple techniques, such as crop evapotranspiration (ETc) estimates provided jointly by University of California Agricultural and Natural Resources (UC ANR) and California Department of Water Resources (DWR) and making field-level observations, to more advanced approaches that integrated ET data, pressure chamber measurements, and plant-based sensing technologies (Figure 1).

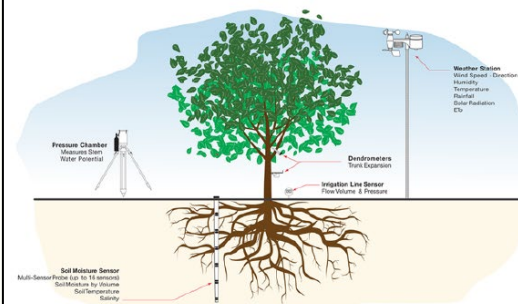


Figure 1. Example of sampling tools used to determine irrigation timings and duration.

Used by Pilot Study Growers:

- Dendrometers
- Crop Evapotranspiration (ETc)
- Irrigation Line Sensors
- Stem Water Potential Measurements
- Combination of Methods
- Consultants



Precision Irrigation: Key Findings



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- ... more potential for improved water management ... on small farms
- ... potential to reduce the evaporation portion of ET by using more nighttime irrigation



Precision Irrigation: Recommendations



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- ... The Vina GSA should investigate the potential to improve irrigation management with advanced technologies on small farms
- ... focus efforts related to specific irrigation management practices on the use of pressure chambers ... particularly in walnut production
- ... education and outreach would be needed on the associated financial savings of automation and nighttime irrigation





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