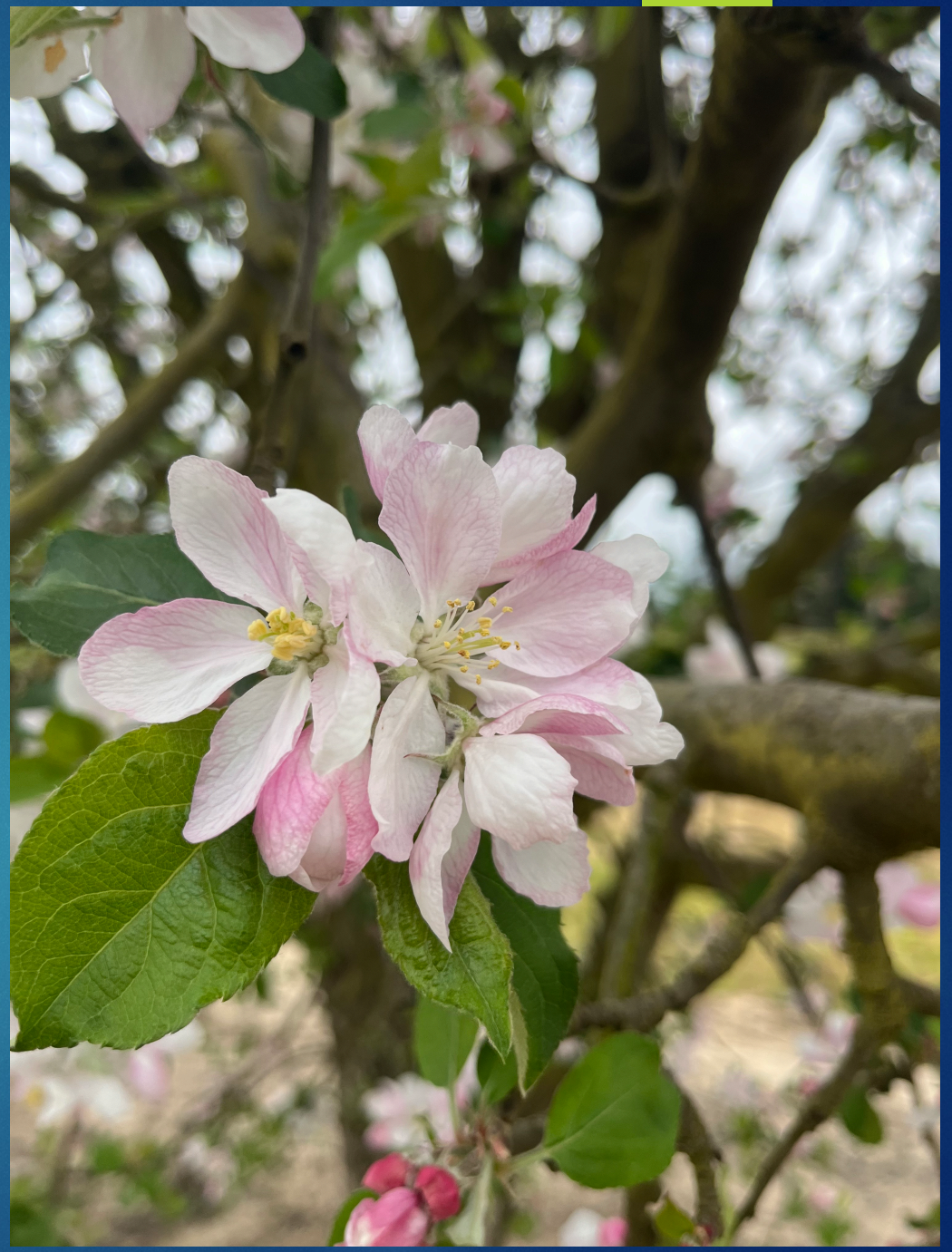
Apple Orchard Irrigation



ELLIE ANDREWS

UCCE SPECIALTY CROP ADVISOR

SONOMA, MARIN, AND NAPA COUNTIES

Learning Objectives

1. **Understand foundations** of soil-tree water dynamics

2. **Explore how to assess** water dynamics in your orchard

3. **Identify climate-resilient irrigation practices** and how to tailor them to your unique context, goals, & constraints including costs

4. **Access resources, information, & opportunities** that you can explore in the future

Dave Hale's Apple Orchard, Sebastopol

UC CE

Local Context

- Many orchards in our region contain a diversity of apple rootstocks & scions in the same orchard
- Different rootstocks & scions respond to water differently and may have different water needs and tolerance to drought
- This can make it difficult to tailor irrigation scheduling to tree needs

Dave Hale's Apple Orchard, Sebastopol

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Local Context

- Most (90%?) apple orchards in Sonoma county are dry-farmed and do not have irrigation set up at all
- Some do not have access to water

Dave Hale's Apple Orchard, Sebastopol

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Local Context

- Some apple orchards have irrigation set up, but growers only use it during extreme drought
- A very small fraction actively irrigate each year

Dave Hale's Apple Orchard, Sebastopol

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Local Context

- Given this diversity, we're going to focus on fundamental principles & strategies that can be adapted to different contexts & goals

- Water management "toolbox" approach:
  - Lots of management options & decision support tools in your toolbox
  - Choose the ones that make sense for your situation
  - There's no one-size-fits all

Dave Hale's Apple Orchard, Sebastopol

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Foundations:
Soil-Tree Water Dynamics

Foundations: Soil-Tree Water Dynamics

- The Soil-Plant-Atmosphere Continuum
- Evapotranspiration
- Apple tree water needs
- Influences of soil health practices on water dynamics

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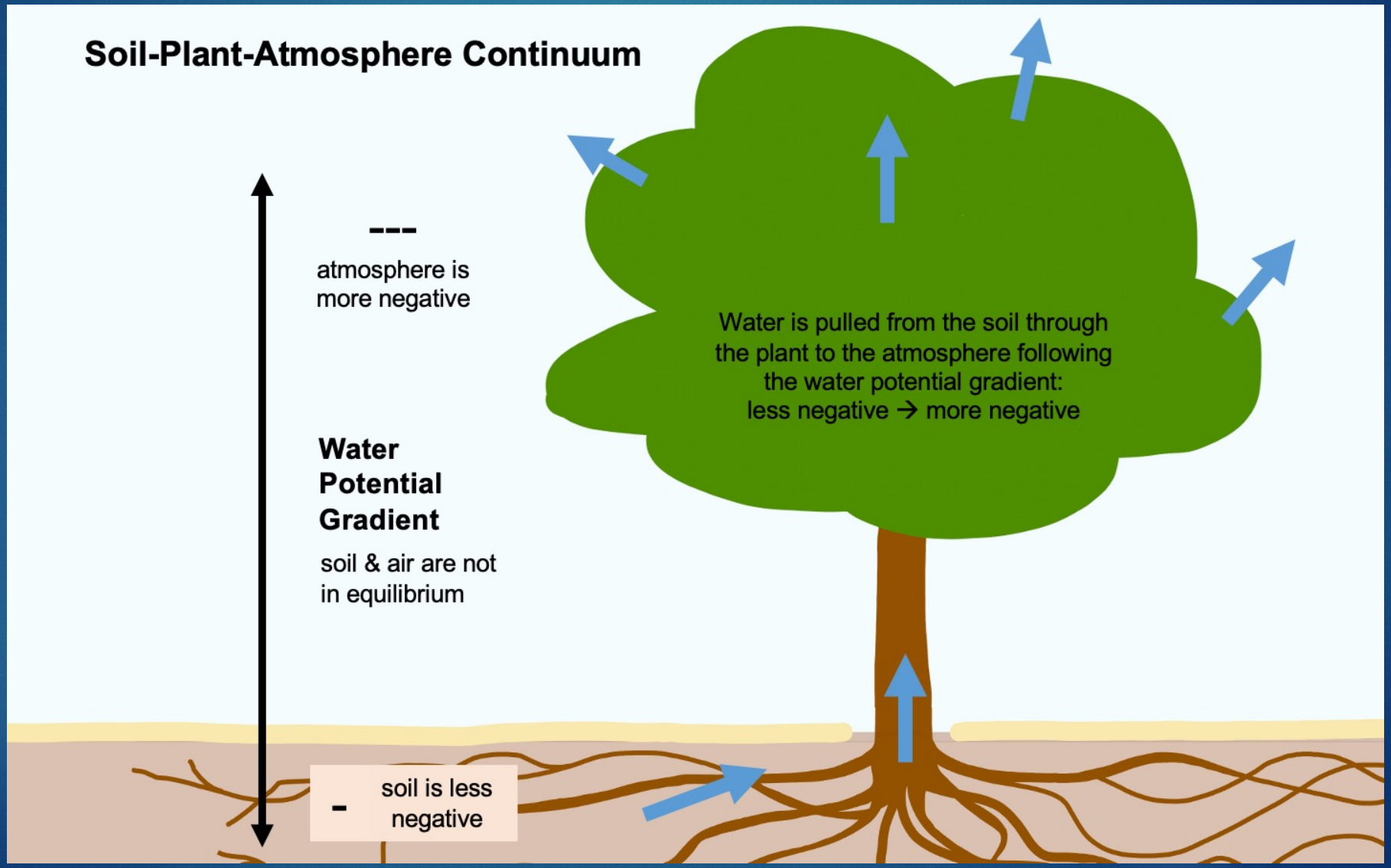
The SPAC!


Soil-Plant-Atmosphere Continuum
---
atmosphere is more negative
Water Potential Gradient
soil & air are not in equilibrium
-
soil is less negative
Water is pulled from the soil through the plant to the atmosphere following the water potential gradient:
less negative → more negative

Evapotranspiration (ET)

- ET is daily water use

Evapotranspiration water goes to atmosphere

Evapotranspiration (ET)

- ET is daily water use

ET = Water evaporating from soil surface + Water used (transpired) by the plant

??? (acre inches)

Evapotranspiration water goes to atmosphere

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Apple Tree Water Needs

- The amount of water needed depends on:
  - Tree size
  - Tree age
  - Rootstock & scion
  - Tree spacing
  - Soil type
  - Site location
  - Climate (& microclimate)
  - Other environmental factors

(Devoto Orchards)

Apple Tree Water Needs

- Regular irrigation supports good growth conditions & healthy fruit trees
- Supply water to prevent severe water stress which can damage trees permanently
- Start by choosing cultivars that have relatively low water requirements that you know you can meet

Drought stressed apple leaves (Grow Great Fruit)

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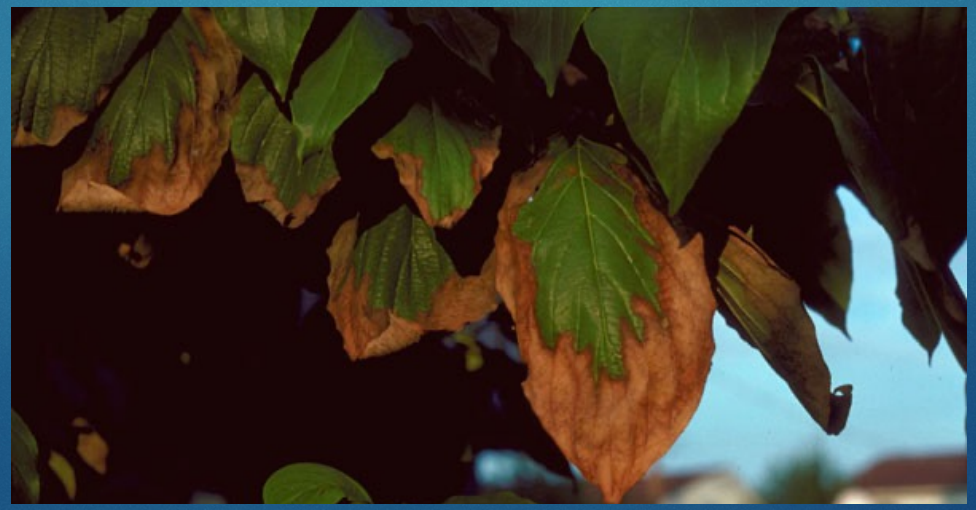
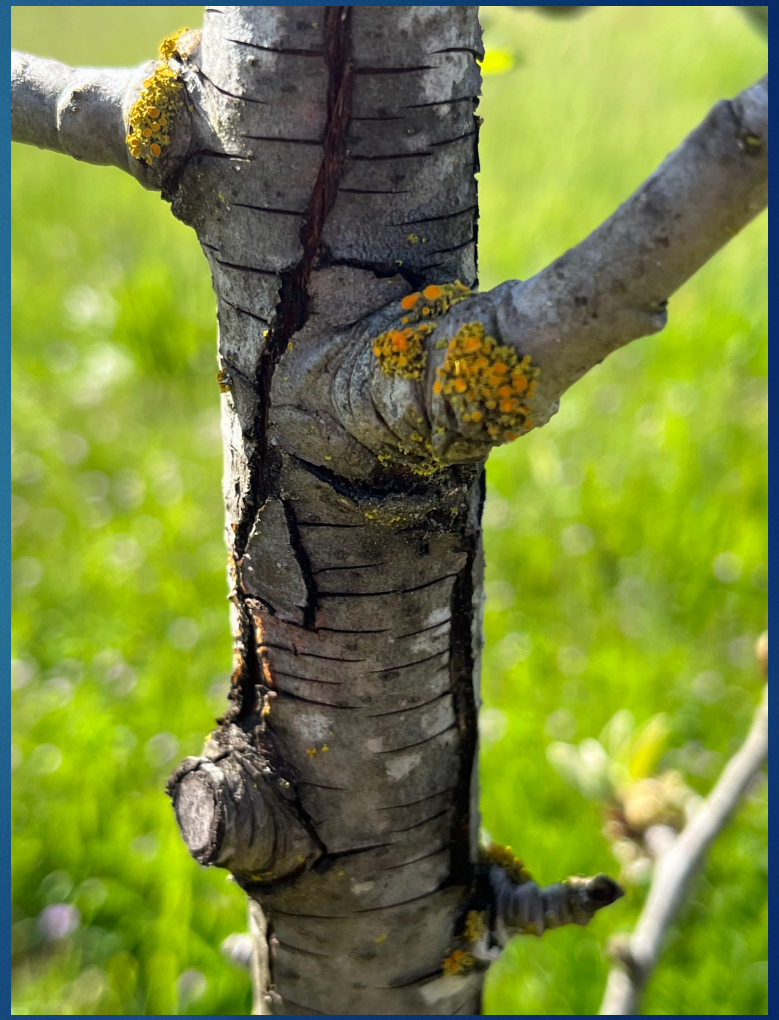
Water Stress

- Visual symptoms of tree water stress
  - Loss of turgor pressure (wilting)
  - Marginal necrosis (dead leaf tissue)
  - Bark cracking
  - Stunted growth
  - Defoliation
  - Tree death



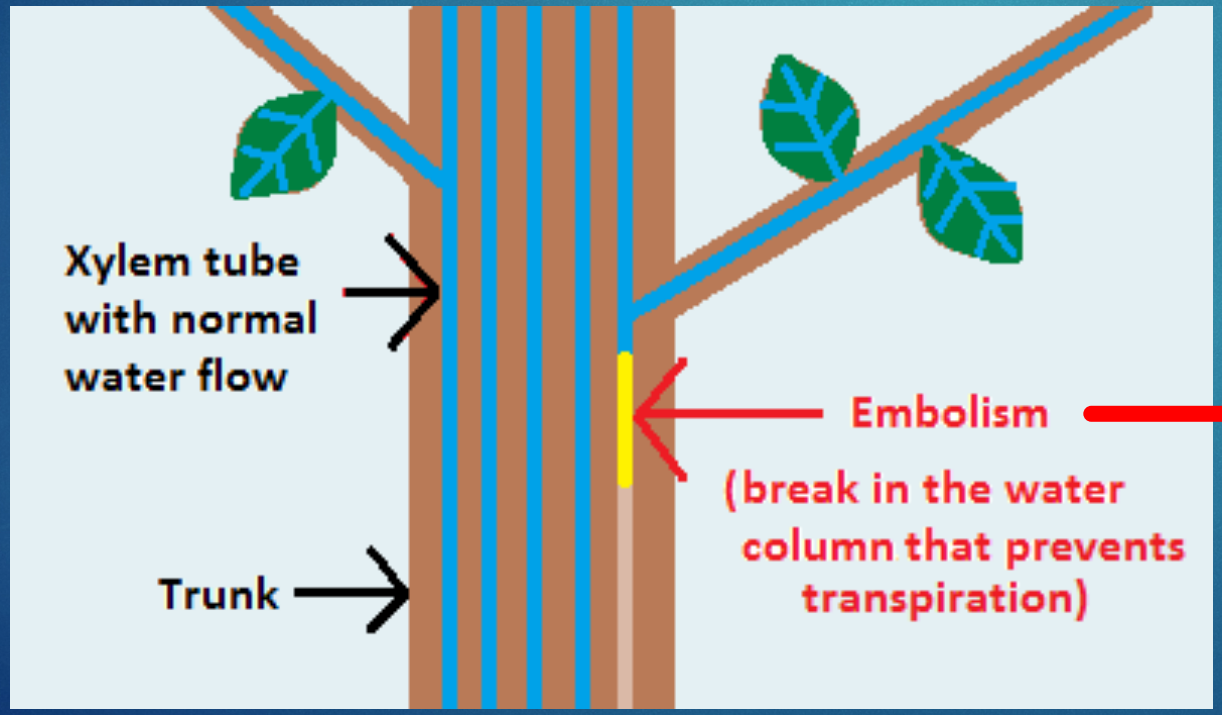
Drought stressed apple leaves (University of Minnesota Extension, Bugwood)

Drought stressed & stunted pear seedling (Ellie Andrews)



Water Stress

- Severe water stress can permanently damage trees & reduce tree health
  - Embolisms, aka hydraulic failure, air bubbles in xylem

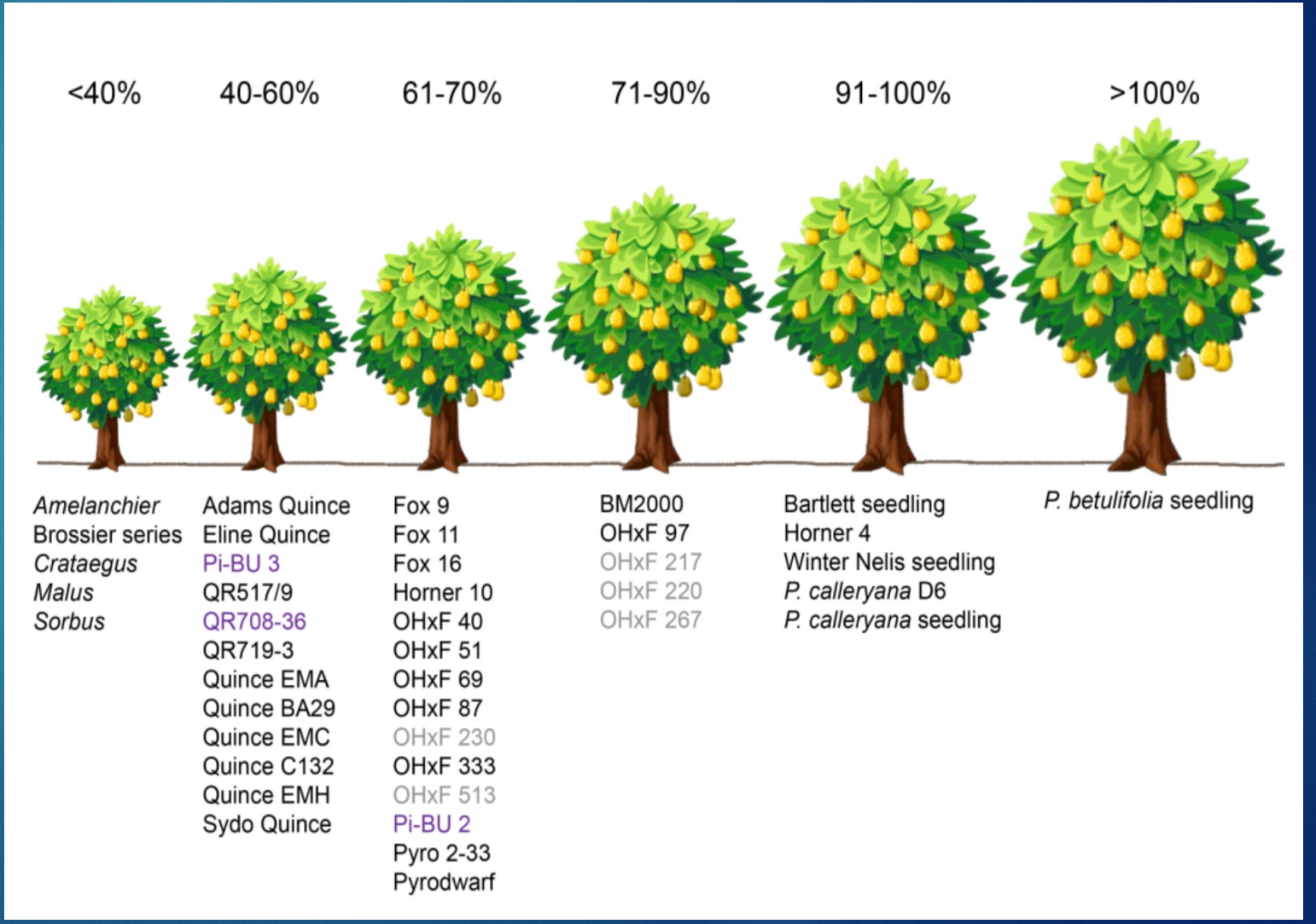


(Jessica Innes, Plantlet)

Air bubble in a leaf vein (Cochard & Delzon 2013)

Apple Tree Water Needs

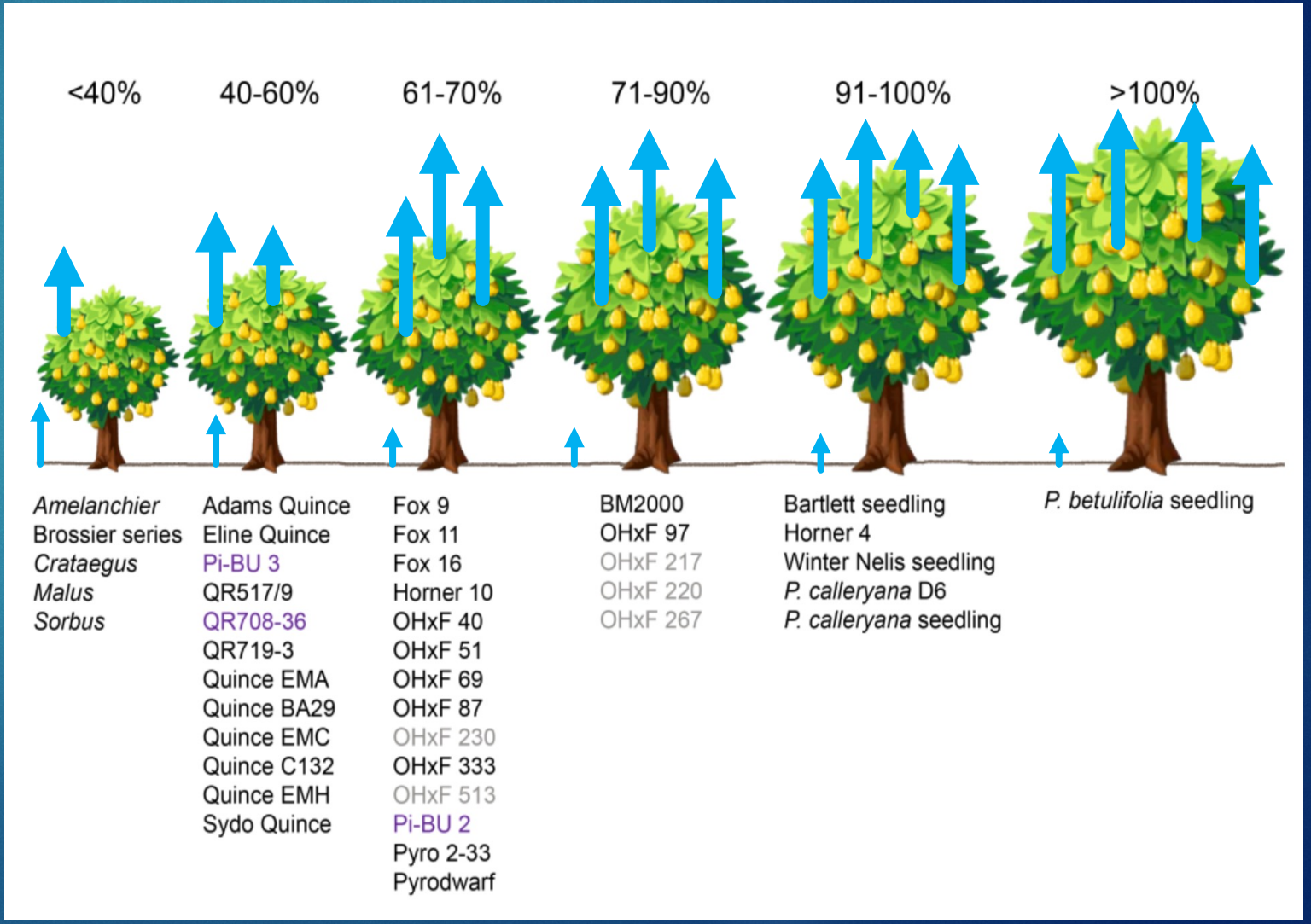
- The amount of water fruit trees need depends on:
  - Size
  - Cultivar



Examples of the effects of different pear rootstocks with the same scion on tree size (Washington State Extension)

Apple Tree Water Needs

- Example: on a hot summer day that demands ¼" of water (ET):
  - A 6 ft x 6 ft tree can use ~5 gallons of water daily
  - A 10 ft x 10 ft tree can use ~15 gallons of water daily

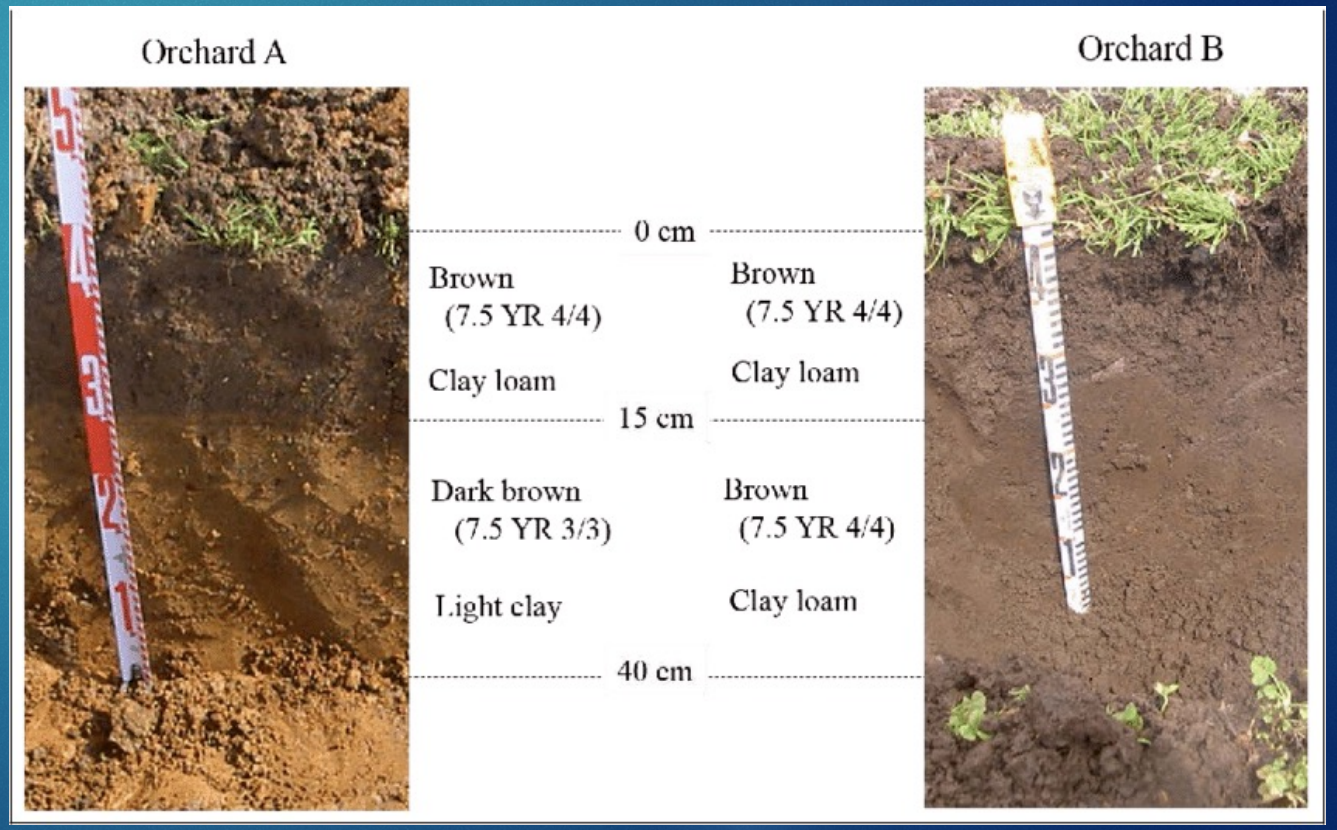


Examples of the effects of different pear rootstocks with the same scion on tree size (Washington State Extension)

Soil Water Dynamics

- Soil texture influences the soil's water holding capacity
- Clay soil will hold onto water more than sandy soil
- Know your soil type and how it affects water movement
- You can always dig down to see how far the water infiltrated into the soil

(Kai et al. 2015)



Apple Tree Water Needs

(Hale's Apple Orchard)

- Rapid cell division happens in fruit during the month after full bloom: receiving enough water at this time is important for fruit size and quality
  - Maybe there's enough water in the soil, or maybe it would help to irrigate
  - Likely depends on total winter rainfall stored in soil
- Bear in mind that your goals for fruit size, quality, flavor profile, etc. likely differ depending on your end use - fresh vs. cider apples

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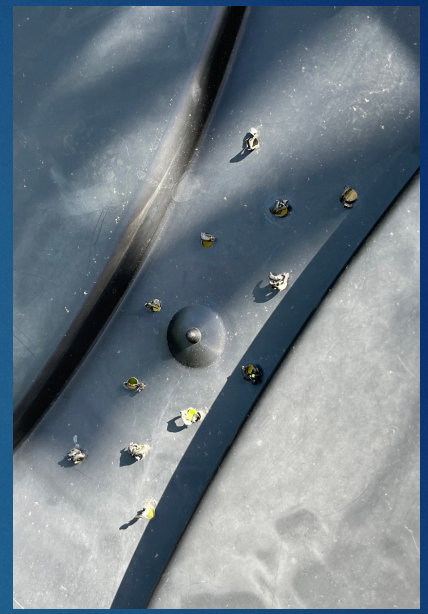
Apple Tree Water Needs



Mini rainwater catchment approach for young replants in a small dry farmed apple orchard with Laura (Laura's Apples)

- Nonbearing trees should not be stressed when they are young

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Apple Tree Water Needs

- Water stress can lead to more sunburn on fruit because of higher fruit temperatures

Sunburn damage (Washington State University)

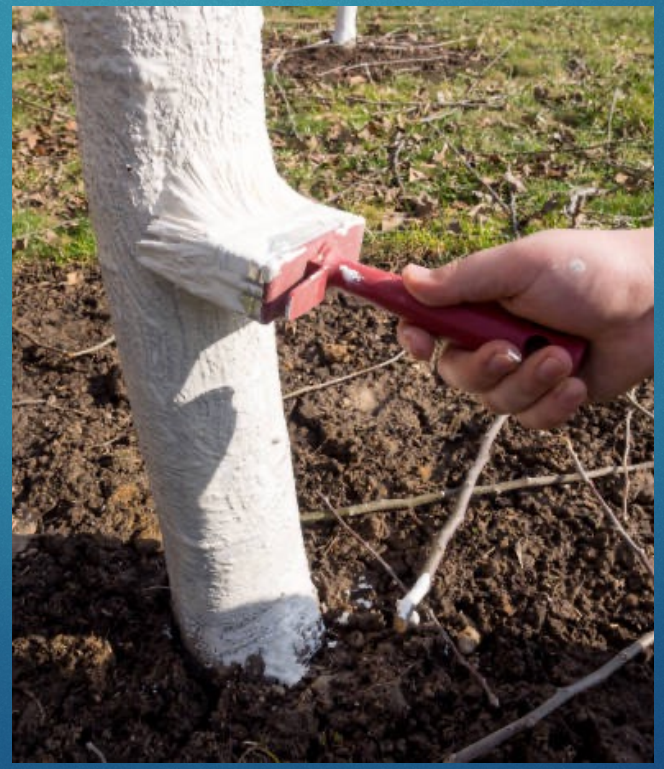
Apple Tree Water Needs

- Drought stress can increase susceptibility to sunburn on branches & trunks as well

(UC IPM)

Apple Tree Water Needs

- White wash can help reduce sun damage particularly under drought conditions
- Trunk guards can provide protection
- Make sure you're irrigating enough during high ET periods



(UC IPM)

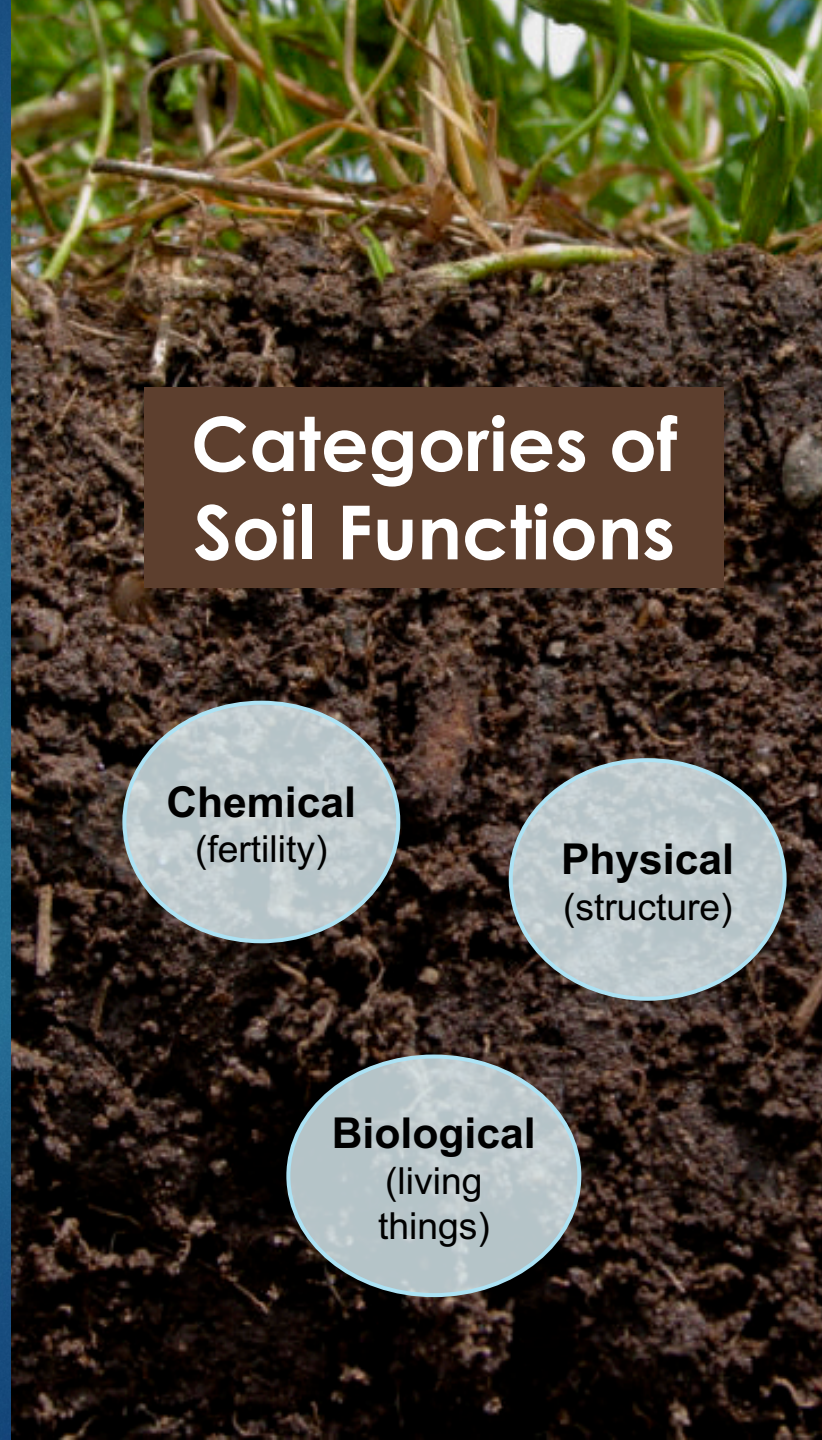
(Devoto Orchards)

Soil Health & Water

- What is soil health?

Soil Health & Water

- What is soil health?
  - The ability of the soil to function and sustain life
  - Revolves around sustainability, vitality, resilience, biology
  - Context-dependent ...what are your specific goals?



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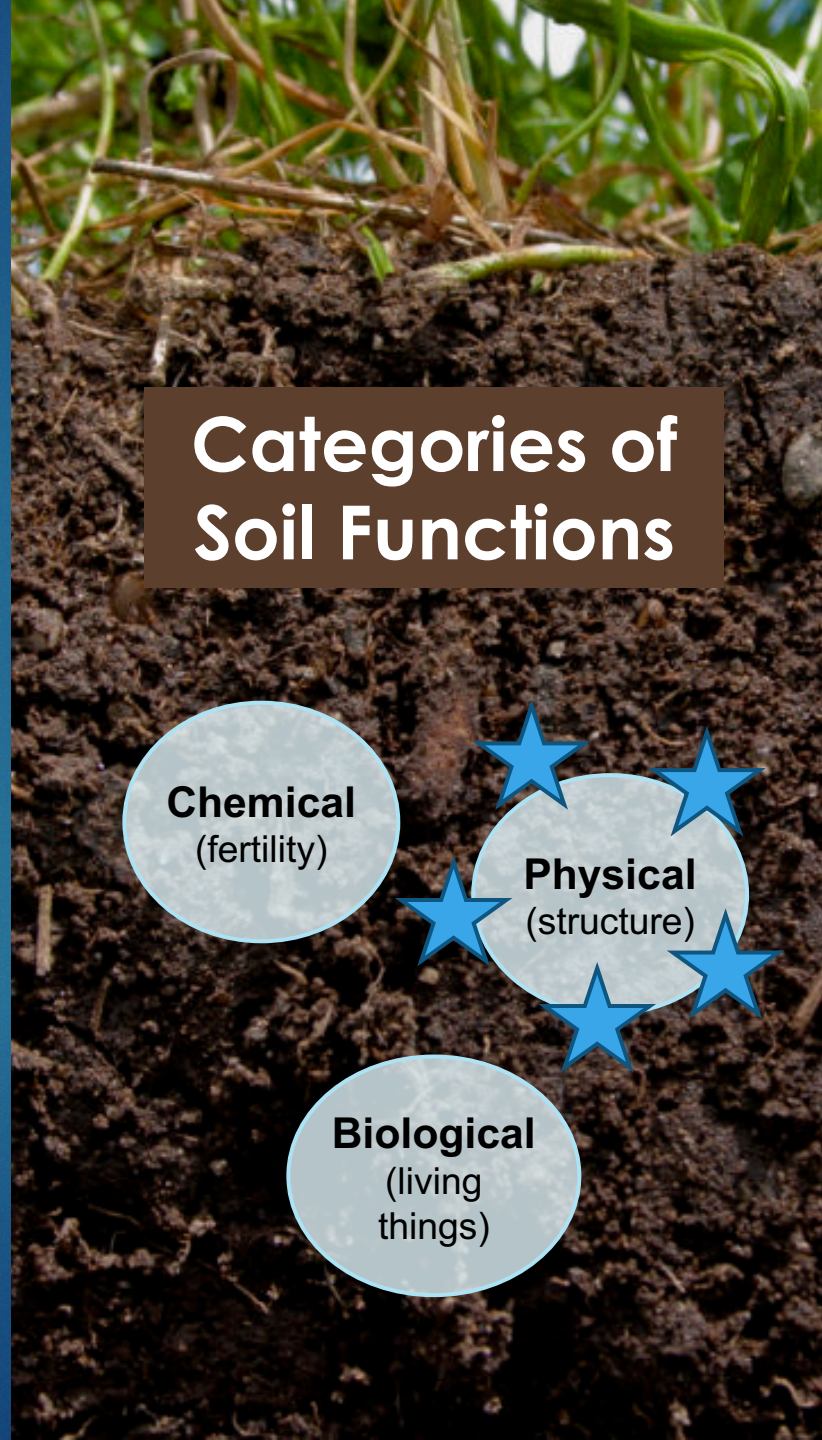
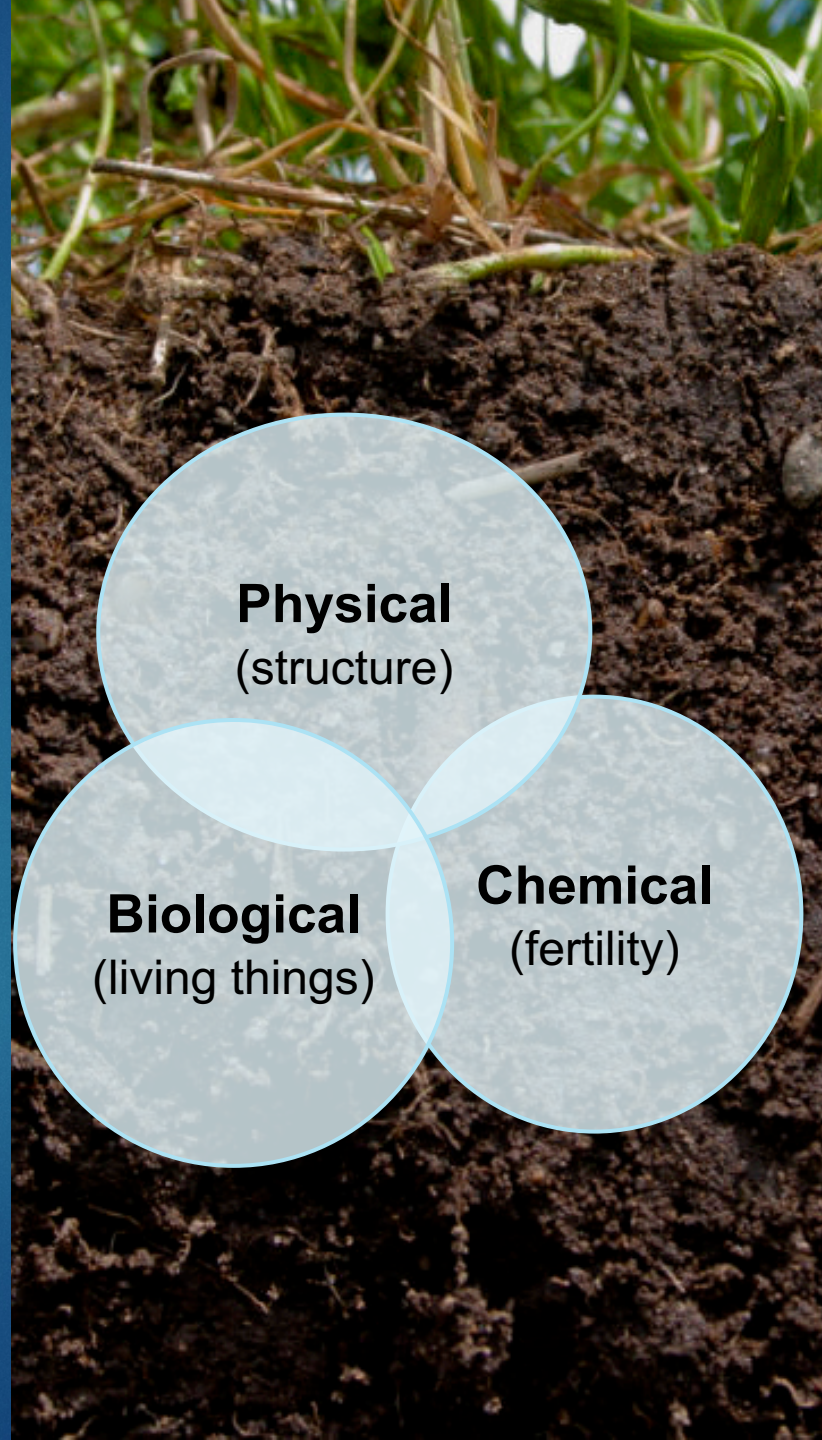
Soil Health & Water

- Physical indicators of soil structure (architecture) tell us about water dynamics
  - Water infiltration rate: how quickly does water move into the soil?
  - Soil compaction via bulk density, penetration resistance: how compacted is my soil?
  - Soil aggregate stability is related to the soil's resistance to erosion: how stable is my soil?



Soil Health

- Just remember, in real life, they're all connected & influence each other



Soil Health Practices

- How can we improve soil health & associated water dynamics?
  - Living roots in the soil (such as cover crops)
  - Cover on the soil (mulches, residues, etc.)
  - Minimal soil disturbance or tillage
  - Livestock integration

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Soil Health Practices

- How can we improve soil health & associated water dynamics?
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  - Cover on the soil (mulches, residues, etc.)
  - Minimal soil disturbance or tillage
  - Livestock integration

Stacked practices: *consider integrating multiple soil health practices together with other water conservation practices!*

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Cover Crops & Water

- Cover crops: any non-cash crop grown in addition to the primary cash crop
- Cover crops can help:
  - Improve water infiltration into the soil
  - Reduce runoff
  - Break up compacted soil
  - Increase SOM over time thru biomass & root exudates

(Cover Crops)

SOM & Water

Compost pile and small compost spreader at Laura's Apples orchard

- Soil Organic Matter (SOM): the component of the soil that comes from living things
- Build & maintain SOM with cover crops, compost, mulch, minimal tillage
- Increasing SOM can help improve water dynamics

Mulch & Water

- Benefits of mulch:
  - Provides a physical barrier on the soil surface
  - Improves water infiltration rate
  - Reduces evaporative losses
  - Improves soil surface's energy balance & sensible heat flux
  - Keeps more water in the rootzone
  - Suppresses weeds, less competition for water

Mulch in a cherry orchard
(TJ Mullinax, Good Fruit Grower)

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Mulch & Water

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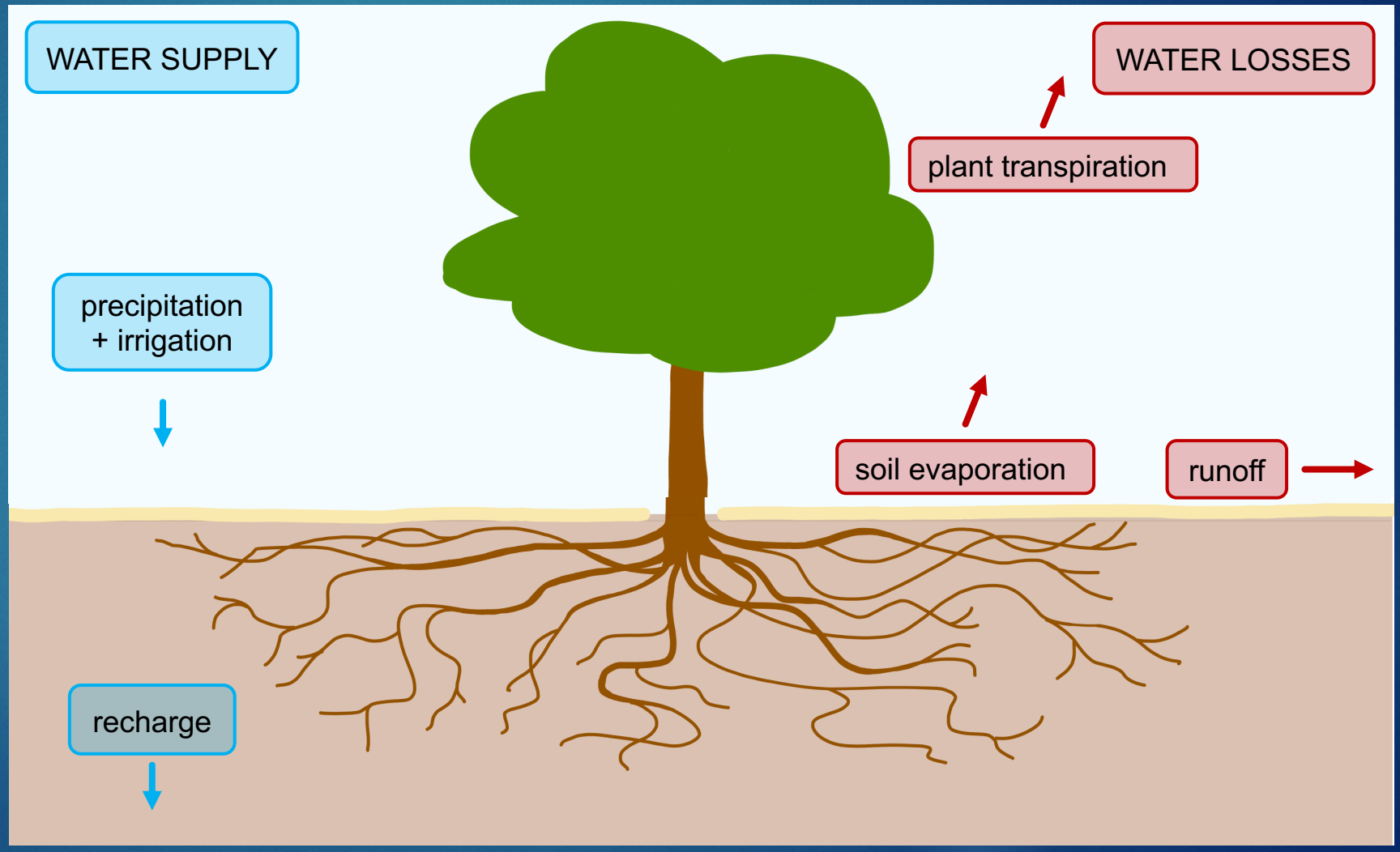
  - Keeps more water in the rootzone
  - Suppresses weeds, less competition for water

- Limitations of mulch:
  - It can be a fire hazard
  - It can be expensive

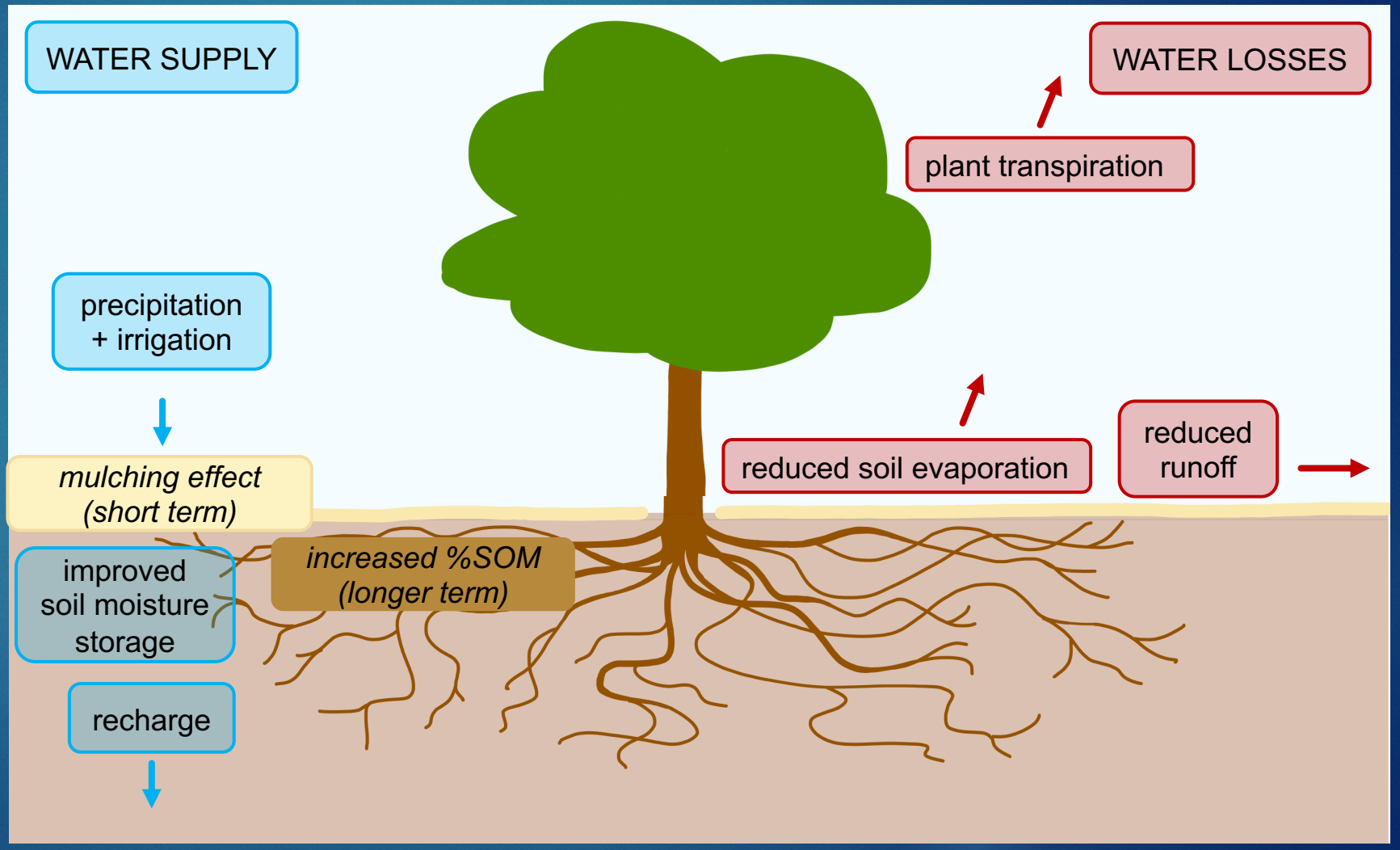
Mulch in a cherry orchard
(TJ Mullinax, Good Fruit Grower)

UC CE

Mulch & Water

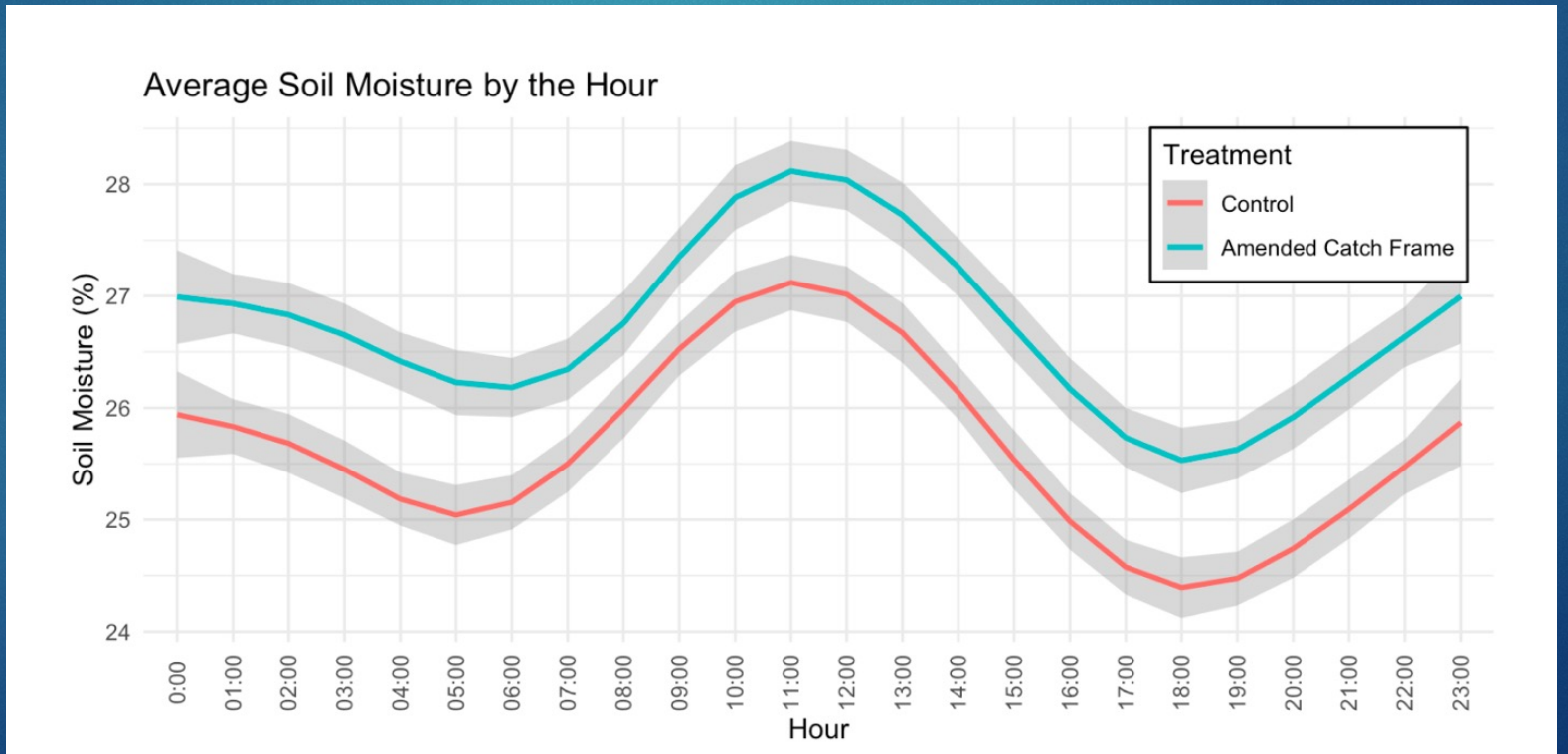

WATER SUPPLY
WATER LOSSES
plant transpiration
precipitation
+ irrigation
soil evaporation
runoff
recharge

Mulch & Water


WATER SUPPLY
WATER LOSSES
plant transpiration
precipitation
+ irrigation
reduced soil evaporation
reduced
runoff
mulching effect
(short term)
increased %SOM
(longer term)
improved
soil moisture
storage
recharge

Mulch & Water

- Example: surface-applied almond hulls & shells as a mulch maintained higher average soil moisture



(Andrews et al. unpublished data)

Mulch, Roots, & Water

- Mulch can create a better environment for root growth near the soil surface, which can promote water uptake

(Photo by Ellie Andrews)

Assessing Your Context

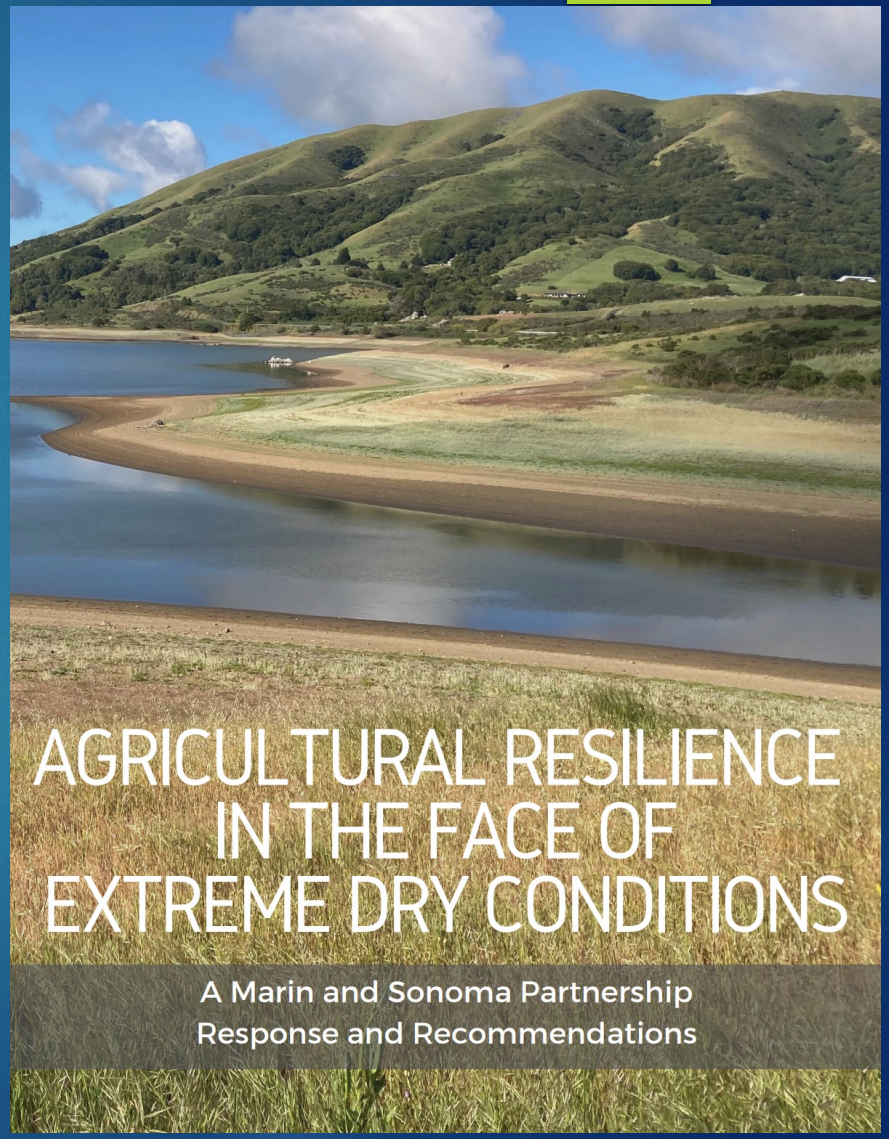
Assessing Your Context

- Extreme Climate Events
- Site Assessment Tools
- Water Monitoring Tools
- Irrigation and Water Management Cost Estimates

Our Shared Context

- Climate scientists are projecting there will be at least a 25% increase in extreme precipitation events by the end of the 21st century

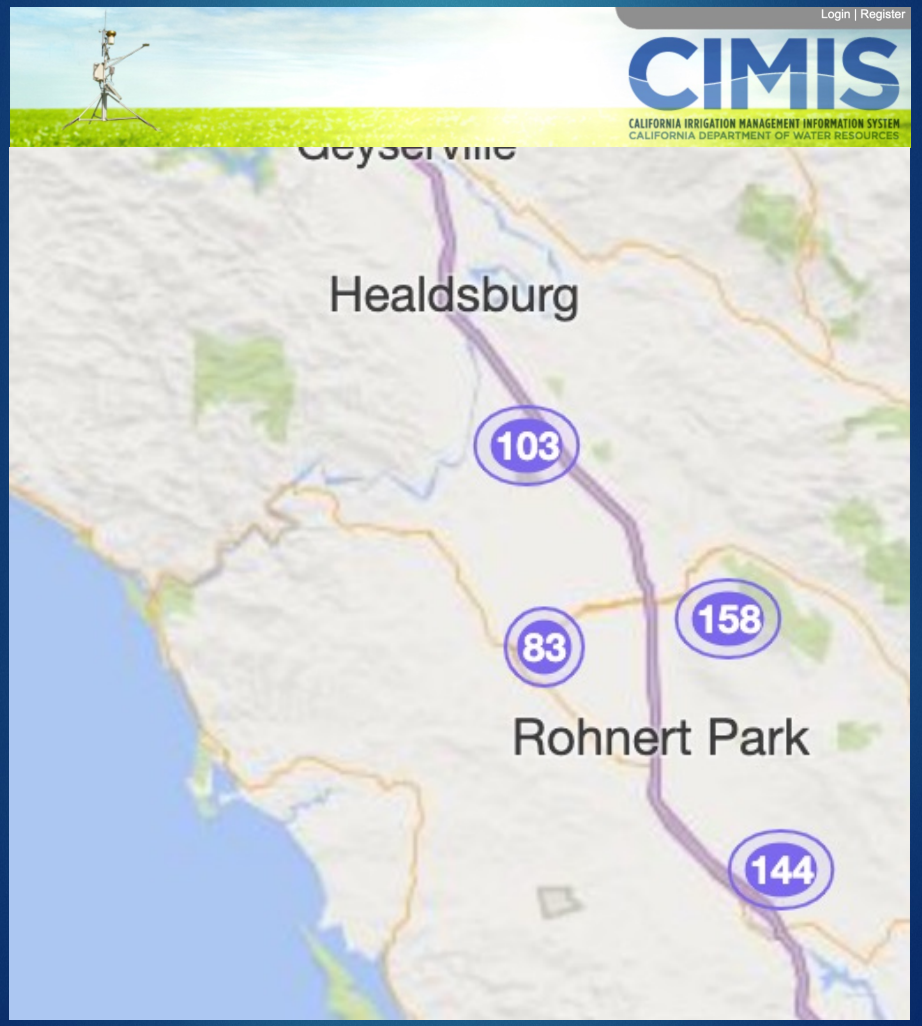
- We need to plan accordingly and build water resilience into our orchard systems



Site Assessment

- Consider Climate
  - Average annual rainfall
  - Average summer temperatures
  - Humidity & sun exposure
  - Does your site ever flood?

Site Assessment



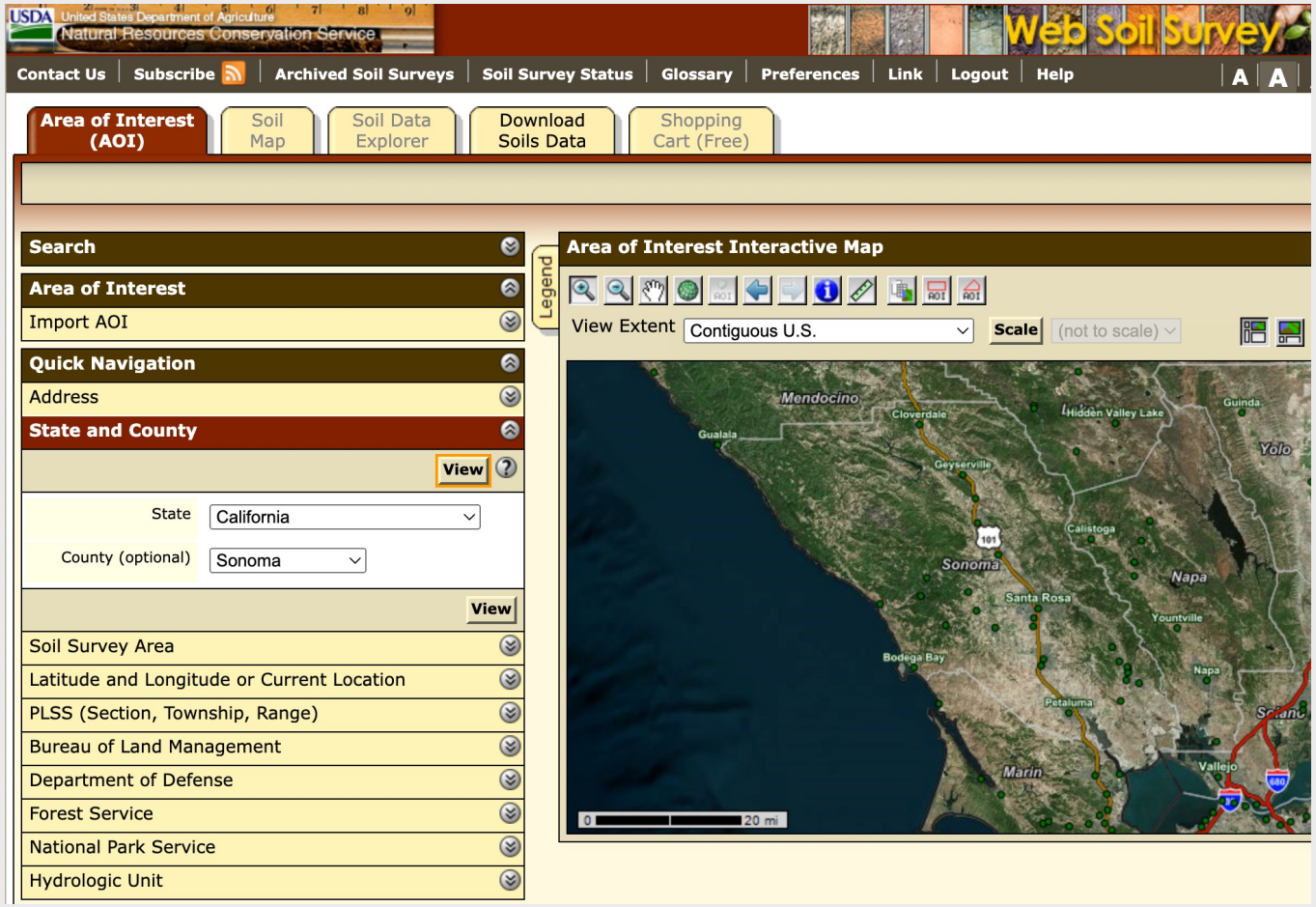
- Consider Climate
  - See nearby CIMIS stations
  - Can use weather stations or data loggers at your site

Site Assessment

- Inherent Site Characteristics
  - Soil type & water holding capacity
  - Soil depth & subsoil constraints
  - Slope & wind

Site Assessment

- Inherent Site Characteristics
  - Reference the NRCS Web Soil Survey



Site Assessment

- Inherent Site Characteristics
  - Reference the NRCS Web Soil Survey

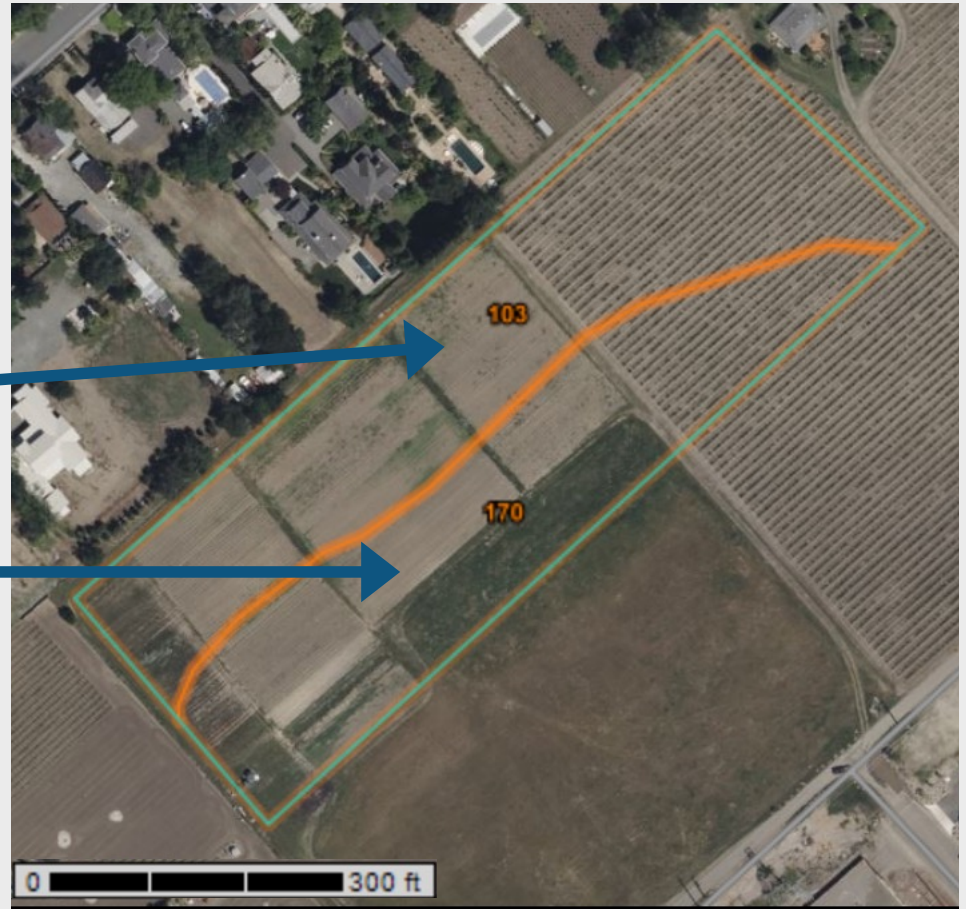
Map Unit Legend

Napa County, California (CA055)

Napa County, California (CA055)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
103	Bale loam, 0 to 2 percent slopes	3.4	55.7%
170	Pleasanton loam, 0 to 2 percent slopes, MLRA 14	2.7	44.3%
Totals for Area of Interest		**6.1**	**100.0%**

(Example)



Soil Structure

- Aggregate Stability:
  - How easily soil aggregates break down
  - Indicates the soil's resistance to erosion from water & wind
  - Soil aggregates are soil particles that are bound together by Soil Organic Matter

Well-aggregated soil
(DeJong-Hughes, University of Minnesota Extension)

Soil Structure

- Testing Aggregate Stability:
  - Lab Analysis
    - More expensive
    - More precise
  - In the Field via Slake Test
    - Less expensive
    - Less precise
    - A great educational activity

Well-aggregated soil
(DeJong-Hughes, University of Minnesota Extension)

Testing Soil Physical Structure

- Aggregate Stability in the Field via Slake Test

Insert wire mesh into top of jars. Fill jars with water.

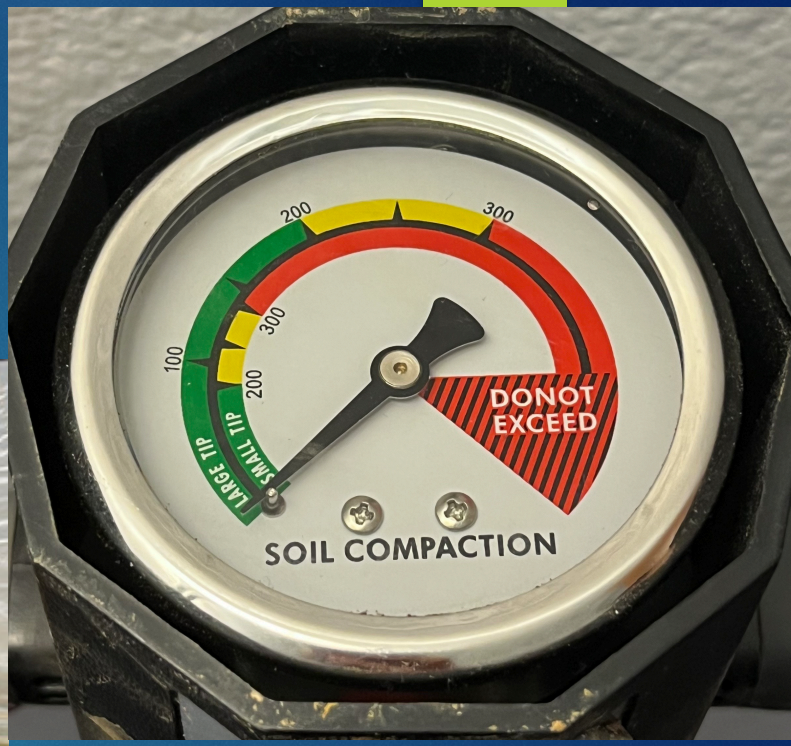
Place each soil sample into mesh holder in separate jars.

Photo credit:
Soul Fire Farm's "How Alive is My Soil?"

See which soil holds together for the longest (is the most stable). You can estimate the % of each soil remaining after 1 minute.

Testing Soil Physical Structure

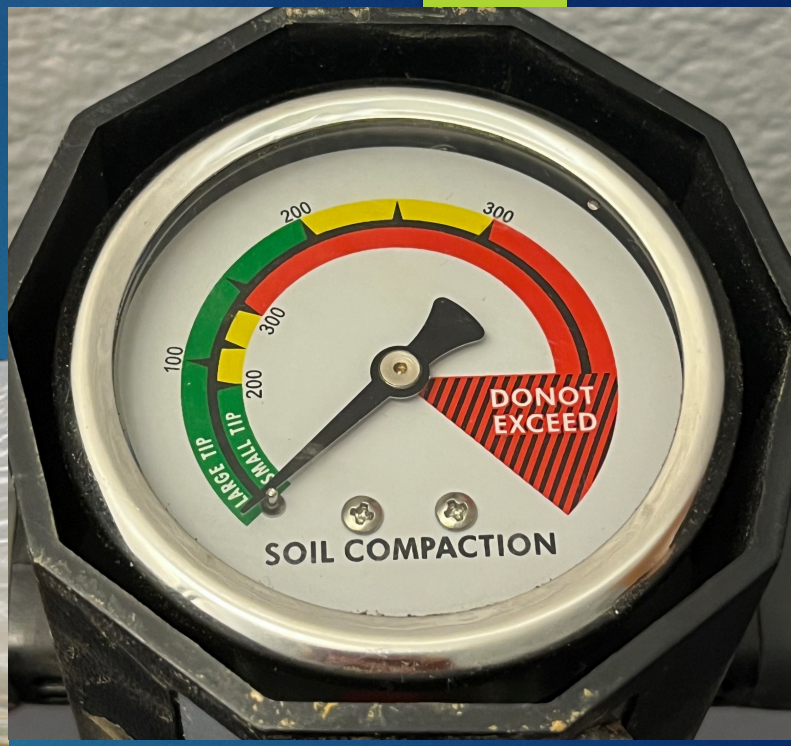
- Penetration Resistance:
  - A penetrometer measures compaction in terms of pressure (PSI)
  - Helps you understand the amount of force plant roots would require to grow in a given soil
  - Measure ~24 hours after irrigation/rain



Penetrometer
(Farmer & Educator Jen Aron, Growing for Market)

Testing Soil Physical Structure

- Penetrometer: ($100-400)
  - A faster and more grower-friendly way to assess soil compaction than soil bulk density
  - Less precise
  - Can be useful for quickly comparing different beds/fields



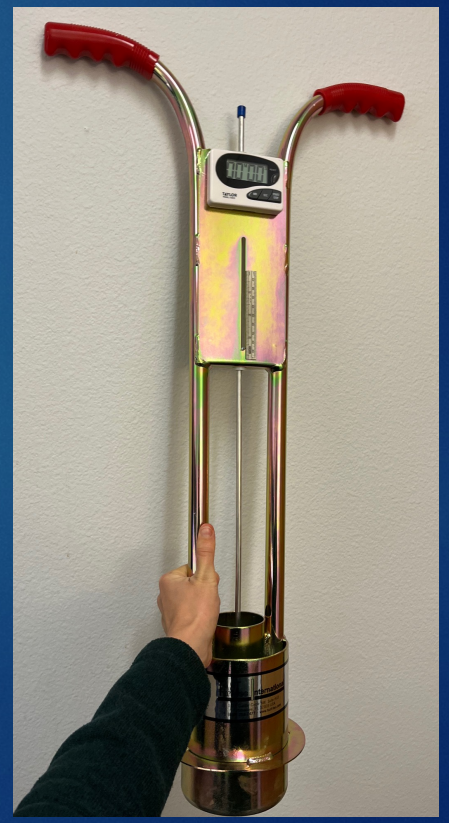
Penetrometer
(Farmer & Educator Jen Aron, Growing for Market)

Testing Soil Physical Structure

- Water Infiltration Rate:
  - Metal ring or aluminum coffee can with a hammer ($10-20)
    - Cheaper
    - Allows you to compare infiltration rate in terms of seconds

    (or)

  - Infiltrometer ($200+)
    - More expensive
    - Allows you to compare infiltration rate in inches of water per hour



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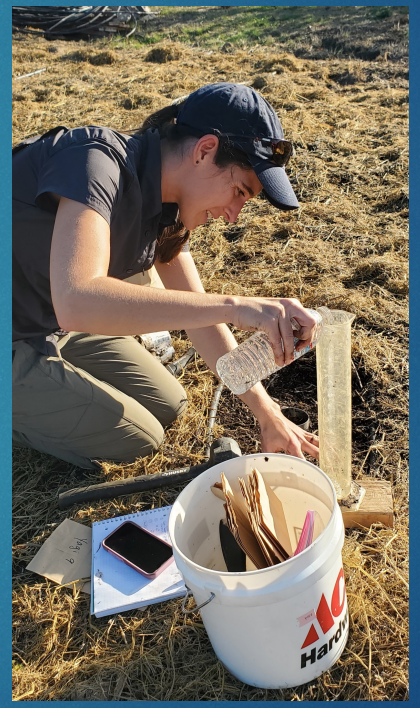
Testing Soil Physical Structure

- Water Infiltration Rate with Metal Ring

Brush away debris from soil surface. Install metal ring evenly, halfway into the soil. Pour water in & around ring to wet the soil.



Measure out a known volume of water.

Testing Soil Physical Structure

- Water Infiltration Rate with Metal Ring

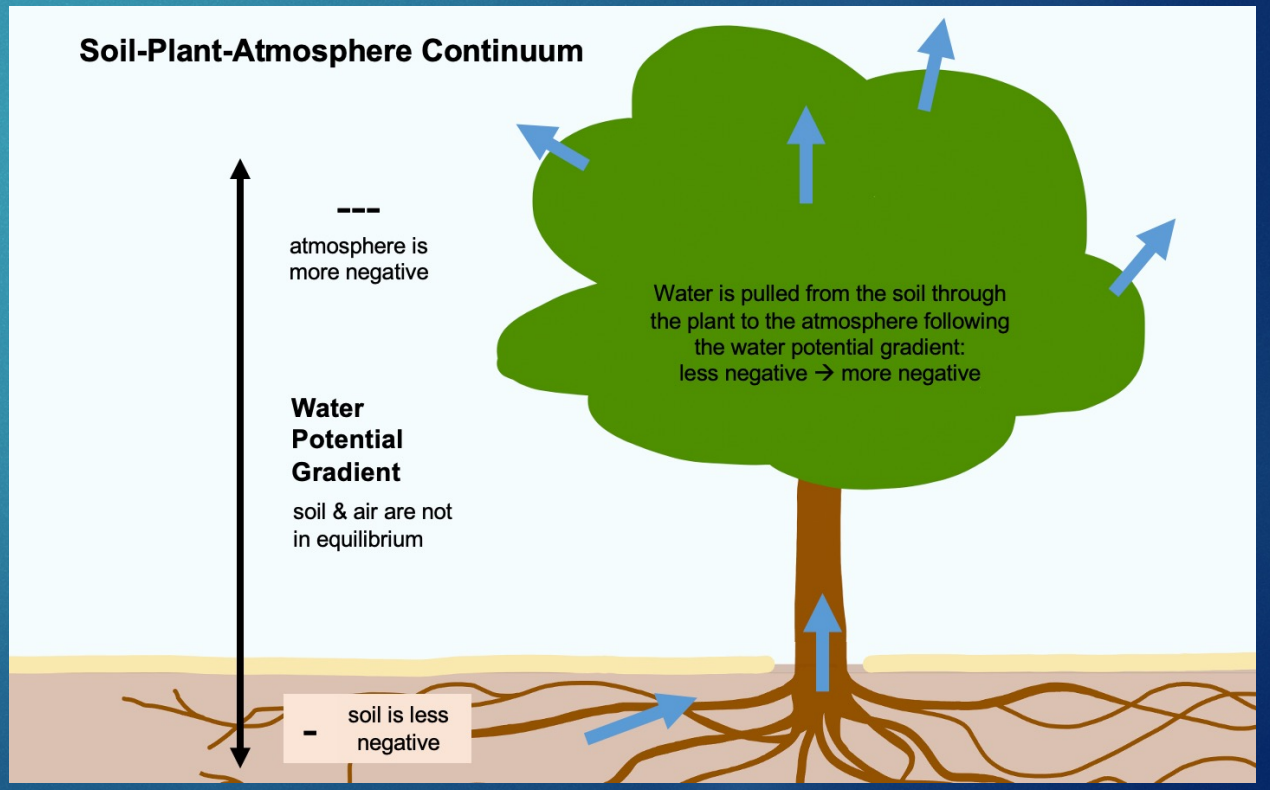
Pour known volume of water into ring, time how long it takes to infiltrate.

Write down total seconds, compare between locations.

Water Assessment Tools

- How can we assess water status?

- Measure the:
  - Soil
  - Plant
  - Atmosphere
  - Or a combo of these



Soil Moisture Monitoring Tools

- Soil Water Content: the current status of the amount of water in the soil
- There are many different soil moisture probe options

Water Mark Sensor	Sensor Reader
(~$45)	(~$250)
	

Tensiometers

(~$100)

Products are mentioned as examples, not endorsements.

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Soil Moisture Monitoring Tools

- Soil Water Content: the current status of the amount of water in the soil
- There are many different soil moisture probe options

Cloud-based Systems

(~$1100)

Products are mentioned as examples, not endorsements.

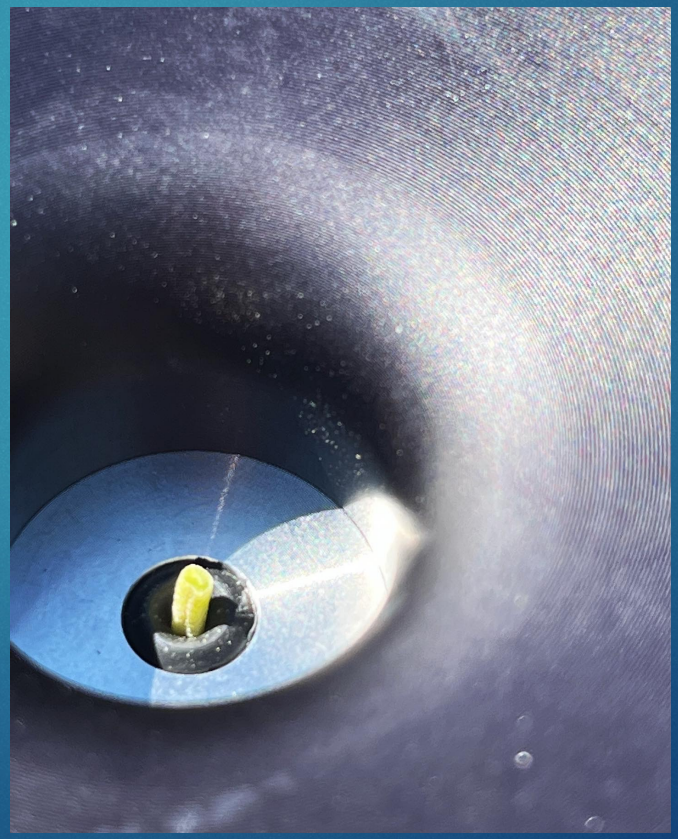
Stem Water Potential

- The most direct way to measure plant water stress

(Photos by Ellie Andrews)

Stem Water Potential

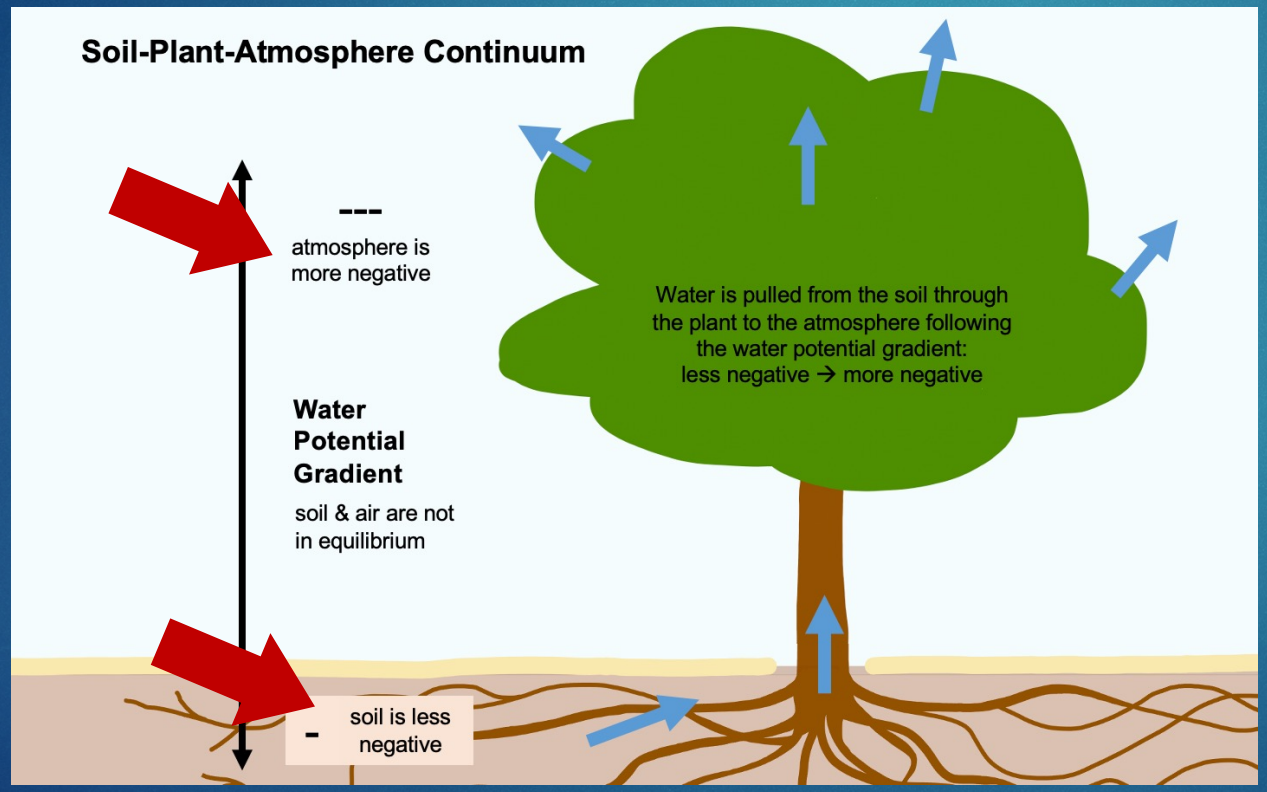
- The most direct way to measure plant water stress



(Photos by Ellie Andrews)

Stem Water Potential

- Record values as negative bars of pressure (keep a notebook log)
- Collect data at midday or early afternoon



(Photos by Ellie Andrews)

Stem Water Potential

- Then compare -bars to established ranges for apples
  - Above -7 bars is considered over-watered
    - Can stimulate excessive vegetative growth

(Photos by Ellie Andrews)

Stem Water Potential

- Then compare -bars to established ranges for apples
  - Below (more negative than) -25 bars is considered low
    - Water cannot freely flow throughout the tree
    - Processes like transpiration, photosynthesis, fruit growth decrease
  - Below -40 bars is very low
    - This can cause structural damage to the tree
    - Can limit yield this year and next year

(Photos by Ellie Andrews)

Microtensiometers & Dendrometers

- Sensors embedded into trunk of tree that continuously measure tree water tension
- More tension means more water stress

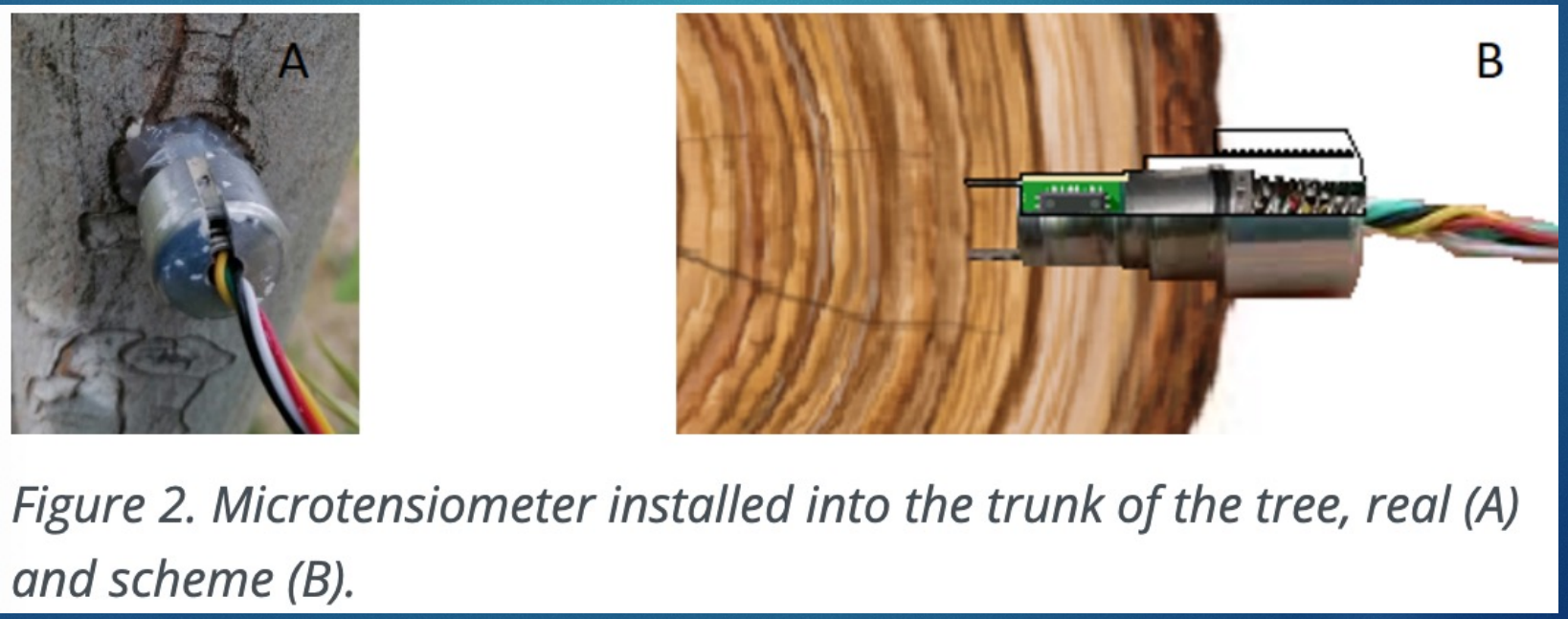


Figure 2. Microtensiometer installed into the trunk of the tree, real (A) and scheme (B).

(Blanco et al. 2022 WSU Tree Fruit)

Microtensiometers & Dendrometers

- Convenient & automated: sends continuous data to phone or computer

(Blanco et al. 2022 WSU Tree Fruit, Flora Pulse)

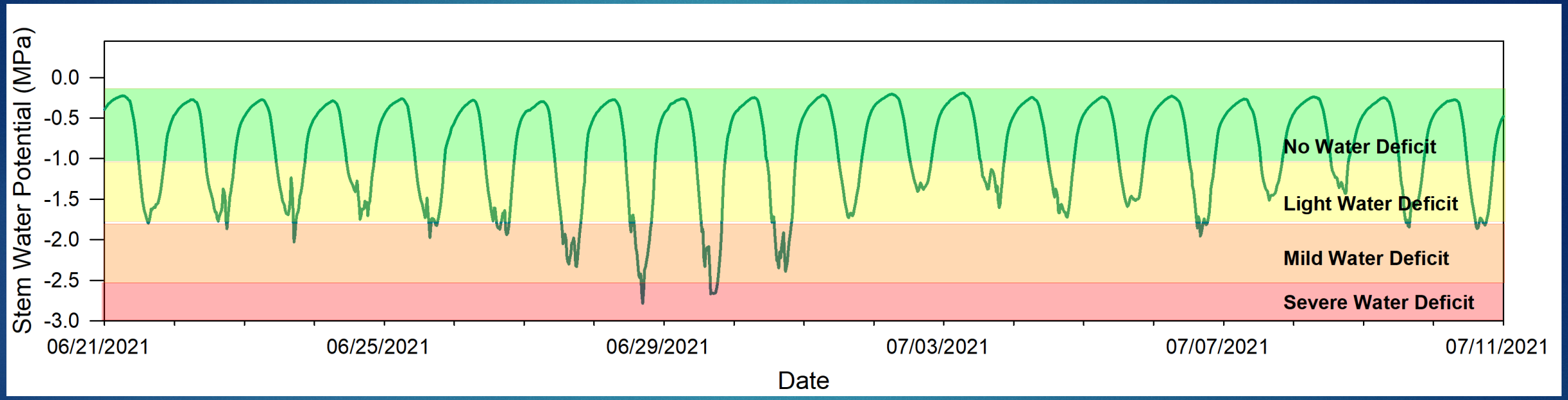
UC CE

Microtensiometers & Dendrometers

- Less time intensive than stem water potential via pressure chamber, but likely more expensive
- Representative: can place multiple sensors throughout orchard

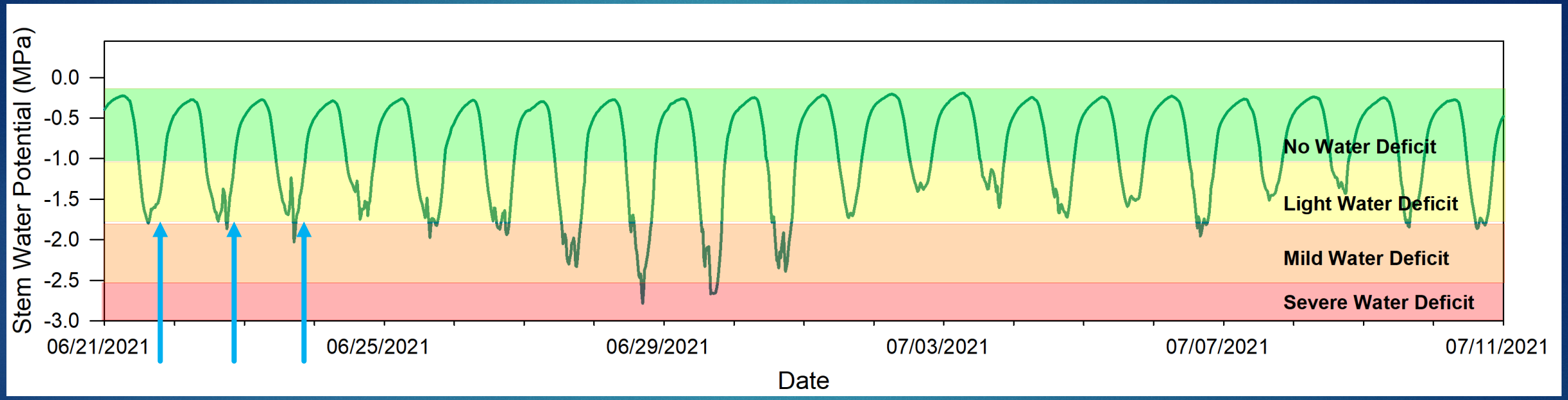
(Blanco et al. 2022 WSU Tree Fruit)

Microtensiometers & Dendrometers



Water deficit ranges and evolution of SWP values measured by microtensiometers in an apple orchard irrigated according to growers' goals (Blanco et al. 2022 WSU Tree Fruit)

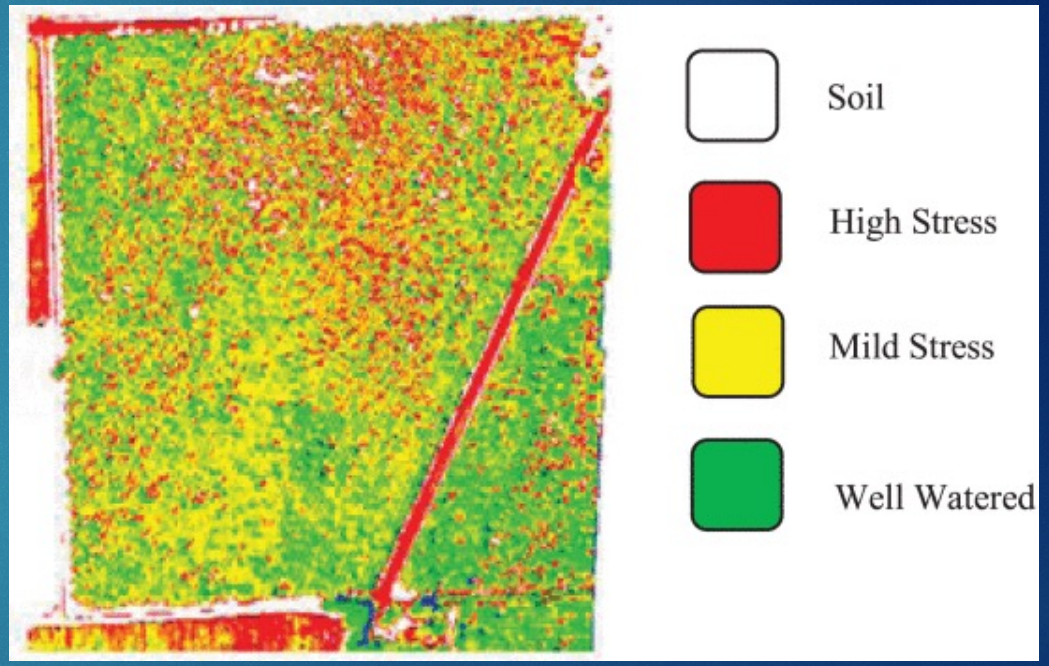
Microtensiometers & Dendrometers



Water deficit ranges and evolution of SWP values measured by microtensiometers in an apple orchard irrigated according to growers' goals (Blanco et al. 2022 WSU Tree Fruit)

Deficit Irrigation Tools

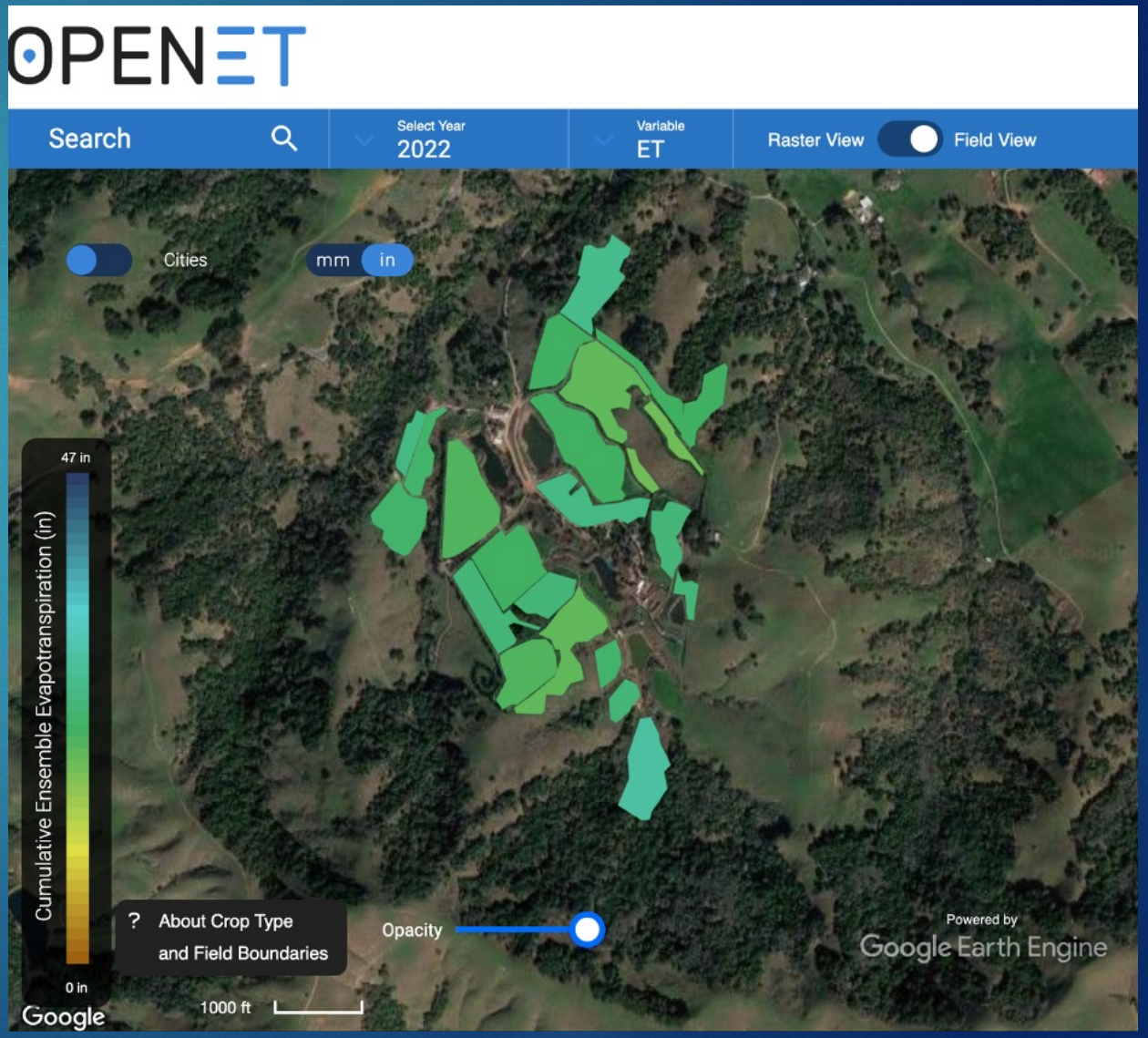
- NDVI
  - Normalized Difference Vegetation Index
  - Helps map tree health across an orchard
  - Helps growers visualize and assess field heterogeneity and problem spots



NDVI Water Stress Map in a walnut orchard (Ayaz et al. 2019)

Deficit Irrigation Tools

- Open ET
  - A modeling tool that provides a general estimate of whole field water use
  - Helps compare sites
  - A big-picture look at water use over a large area
  - Caveat: designed for use in grapes so interpret with a grain of salt



Apple Orchard Irrigation Costs

- UC Davis Cost Study – Central Coast
  - Worked closely with apple growers to estimate production & harvest costs
  - Cost of water was estimated to be ~$280 per acre foot or $23.50 per acre-inch
  - Authors acknowledged costs vary a lot depending on water district/agency, delivery, fees, taxes, pumping variables

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SAMPLE COSTS TO PRODUCE AND HARVEST

APPLES FOR PROCESSING

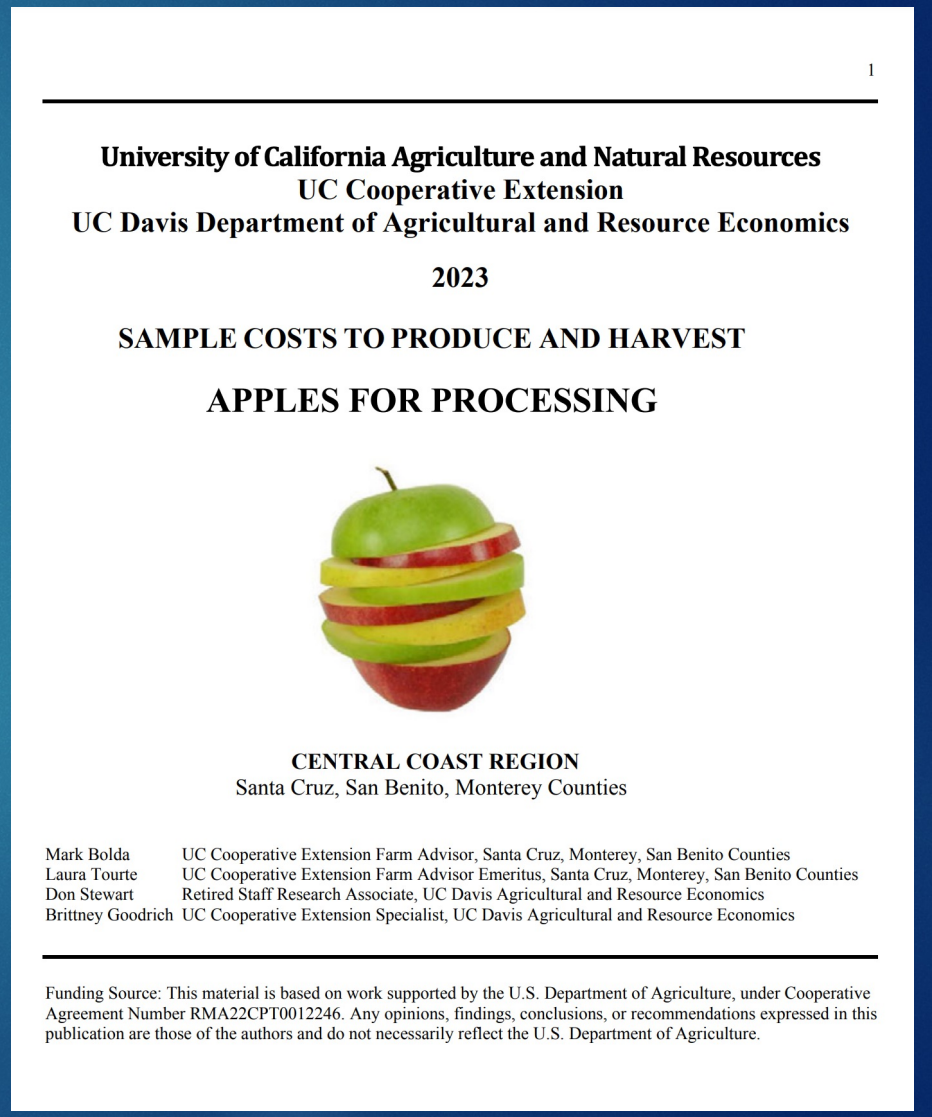
CENTRAL COAST REGION
Santa Cruz, San Benito, Monterey Counties

Mark Bolda	UC Cooperative Extension Farm Advisor, Santa Cruz, Monterey, San Benito Counties
Laura Tourte	UC Cooperative Extension Farm Advisor Emeritus, Santa Cruz, Monterey, San Benito Counties
Don Stewart	Retired Staff Research Associate, UC Davis Agricultural and Resource Economics
Brittney Goodrich	UC Cooperative Extension Specialist, UC Davis Agricultural and Resource Economics

Funding Source: This material is based on work supported by the U.S. Department of Agriculture, under Cooperative Agreement Number RMA22CPT0012246. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the U.S. Department of Agriculture.

Apple Orchard Irrigation Costs

- UC Davis Cost Study – Central Coast
  - Spring rainfall & wet foggy conditions reduce the need for orchard irrigation early in the growing season
  - Growers in this region typically irrigate 2 times in July/August using 3 acre-inches of water each time to help with fruit size
  - Orchard soil is disced and smoothed after each irrigation event



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Apple Orchard Irrigation Costs

- Irrigation system consists of:
  - Pump
  - Metering system
  - Main lines
  - Filtration station
  - Micro sprinkler or drip system

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Apple Orchard Irrigation Costs

- Annual costs (after setting up your system)

Cost	Value or Cost/Acre
Water costs (6 acre-inches split into 2 irrigation events)	$141
Labor & material costs related to irrigation	$188
Irrigation System parts	$28
Irrigation System maintenance (cash & labor)	$64
Total:	$421

Apple Orchard Irrigation Costs

- UC Davis Cost Study – Central Coast
- How does this compare with our region?

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Climate-Resilient Irrigation Practices

Climate-Resilient Irrigation Practices

- Diverse Sources of Irrigation Water
- Exploring Types of Irrigation Systems
- Irrigation Duration & Frequency
- Phenology-Based Deficit Irrigation
- Dry Farming

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Diverse Sources of Irrigation

- The ability to access more than one water source for irrigation can help promote climate resiliency
- Water resource planning can include water access from some combination of the following:
  - Irrigation ponds
  - Wells
  - Access to river water and groundwater
  - Storage infrastructure
  - Recycled water
  - Roof capture

(Photo from *Agricultural Resilience in the Face of Extreme Dry Conditions*, 2021)

Diverse Sources of Irrigation

- Having more than one option

Dry water storage pond in August 2021 (photo from the County of Marin)

Types of Irrigation Systems

- Micro sprinkler
- Drip
- Flood (not used in our region)

Micro sprinkler irrigation (Jack Kelley Clark, UC IPM)

Drip irrigation lines

Types of Irrigation Systems

- If you irrigate your orchard, consider that most roots are usually concentrated in the upper ~2-3 ft of soil

- Drip is more efficient than micro sprinklers
  - Less water loss to evaporation
  - Provide only what the tree needs

Drip irrigation lines: raised (top) or on the soil surface (bottom)

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Irrigation System Maintenance

- Flush irrigation system, flush screens and filters
- Plan routine inspections to look for leaks or clogged emitters (clear or replace them)

(Devoto Orchards)

Irrigation Duration & Frequency

- Once your irrigation system is set up, consider your site characteristics to determine duration & frequency

- Examples of approaches
  - Pulse irrigation: high frequency, short duration events
  - Less frequent deep soaking events

(Devoto Orchards)

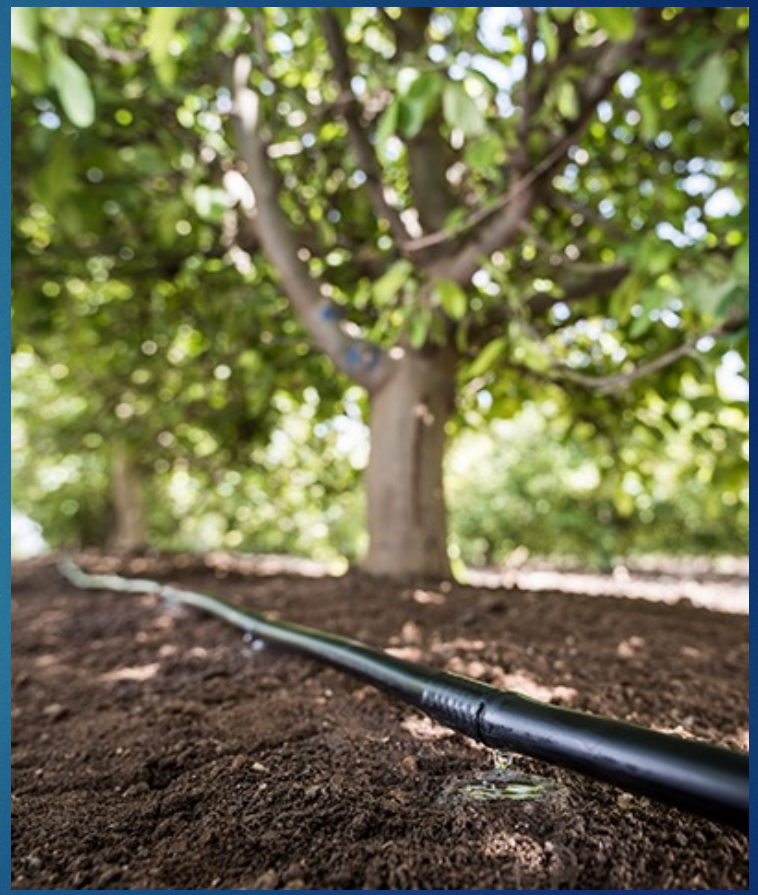
Thinning

- Can help reduce overall tree water demand
- Helps ensure fruit reaches full size
- Growers typically thin to ~1 fruit per 6 inches

(Devoto Orchards)

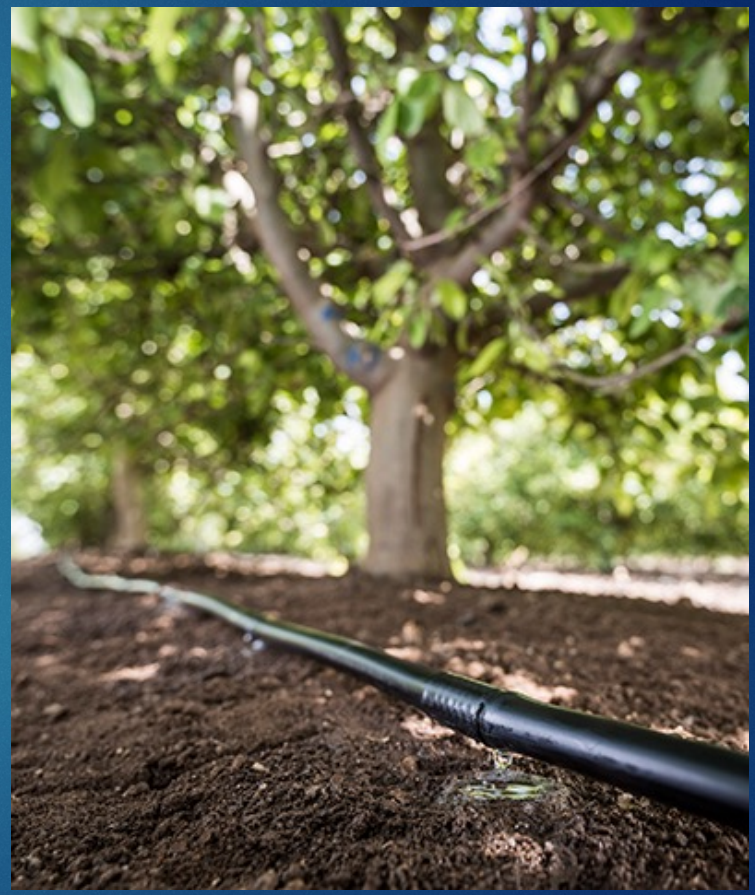
What is Deficit Irrigation?

- Irrigating below maximum water demand (ET)
- An approach to improve irrigation precision



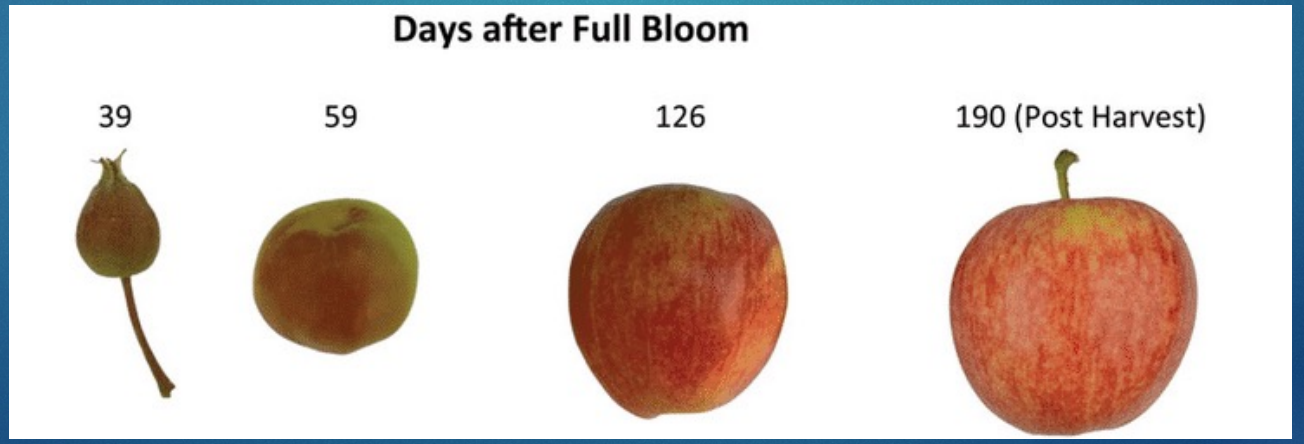
Phenology-Based Deficit Irrigation

- Goal: match the timing of water deficit with the appropriate timing of crop water stress tolerance
  - Apply water during periods of critical plant growth and development, but not during water stress sensitive stages
  - Reduce water use during periods of plant growth when crops have lower sensitivity to water stress



Phenology-Based Deficit Irrigation

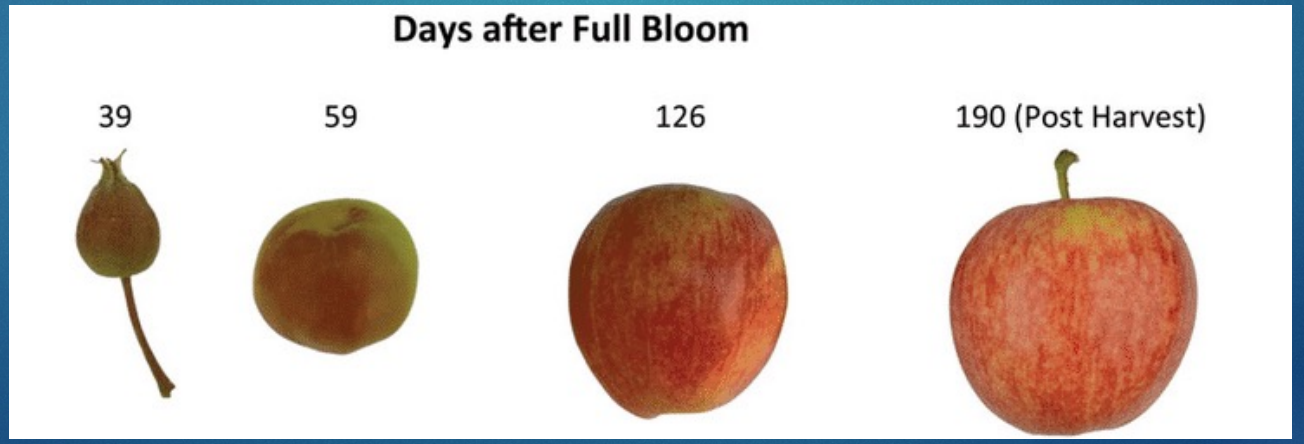
- Generally, bearing trees can tolerate some moderate water stress until the fruit is ~1/2 grown
- Then irrigation can help increase fruit size



(Henry-Kirk et al. 2018)

Phenology-Based Deficit Irrigation

- Light water stress after fruit expansion can ensure fruit weight and improve quality



(Henry-Kirk et al. 2018)

- Some water stress during later fruit development can increase fruit quality (Wang et al. 2019)
  - Fructose, glucose, sorbitol content

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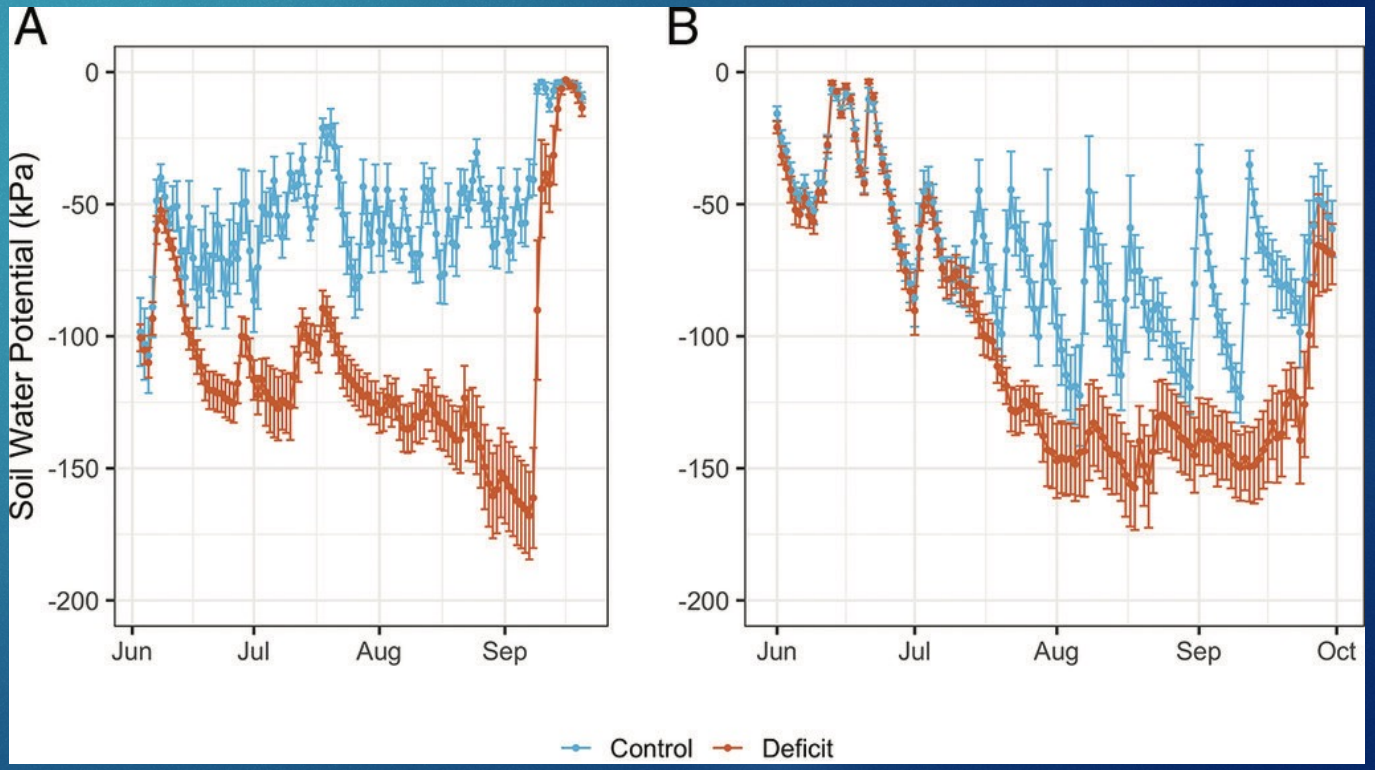
Phenology-Based Deficit Irrigation

- Fruit quality: regulated deficit irrigation can reduce fruit size & increase fruit polyphenolic compounds, total soluble solids, firmness, and titratable acidity (Kendall et al. 2021)
- Neutral or positive impacts for cider quality



What is Dry Farming?

- Unirrigated crop production *during the dry season*
- Usually in regions receiving 20+ inches of annual rainfall
- Soil moisture from the rainy season is stored in the soil and used by crops during the dry season
- Warm summer Mediterranean climate: cool season precipitation, warm season drought

(Hale's Apple Orchard)

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What is Dry Farming?

Dr. Michael Kotutwa Johnson presents on Hopi Dry Farming: 2000 Years of Resiliency

Dry Farming Collaborative
798 subscribers
Subscribe
88
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- A traditional approach used for millennia in the American West & throughout the world
- Working within means of the environment, rather than focusing on manipulating environment to fit crops; using what the environment gives us. -Michael Kotutwa Johnson (PhD) Hopi Tribe of Arizona

What is Dry Farming NOT?

- It is typically not a yield maximization strategy
- It does not involve growing crops during the winter/rainy season
- It is not a one-size-fits-all approach

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Key Goals of Dry Farming

- Farming without irrigation during dry season
- Capturing water during rainy season
- Creating conditions that make it easier for crops to use that water in the summer

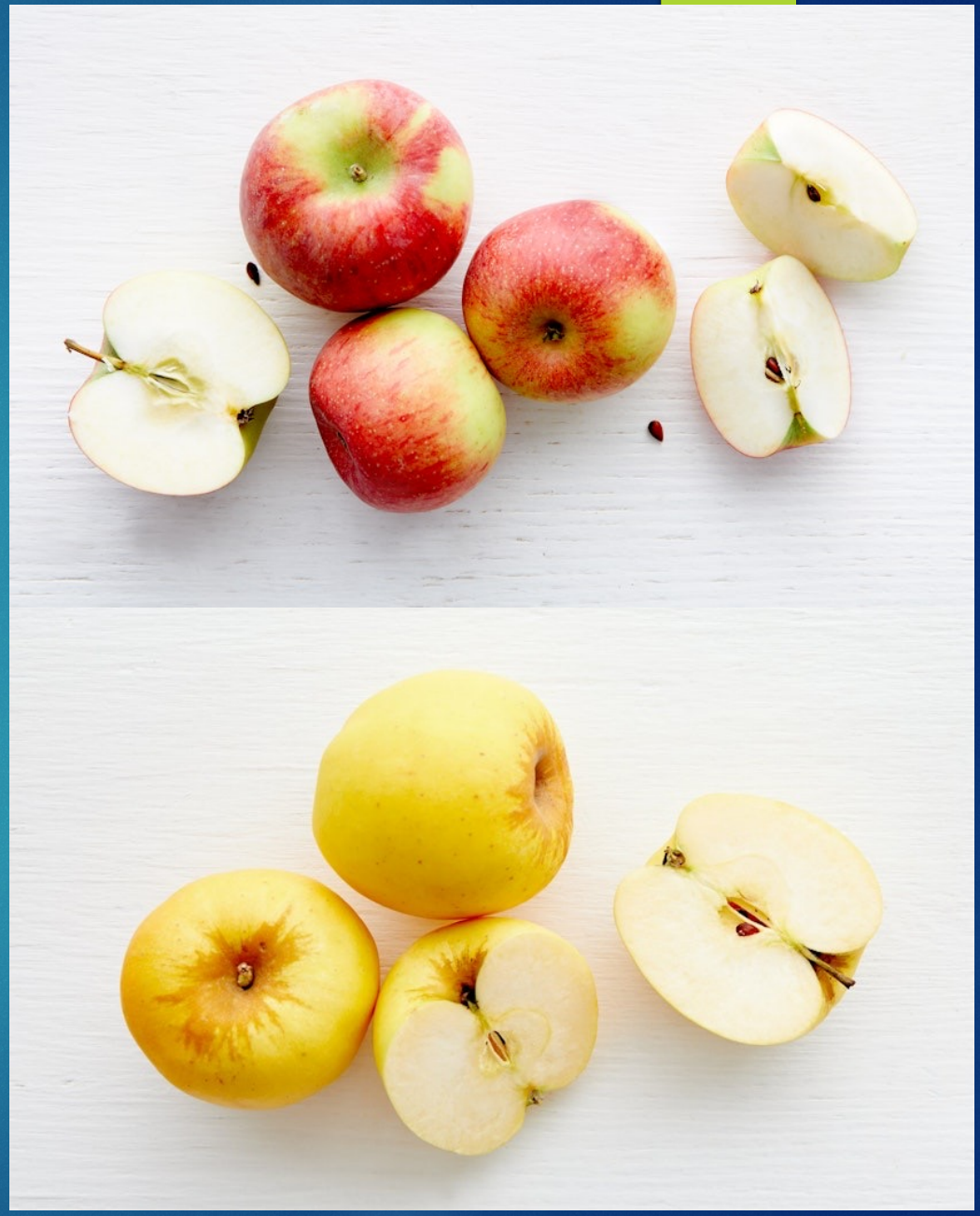
Benefits of Dry Farming

- Water savings: reduced irrigation use & associated costs
- Mitigating risks related to drought
- Improved weed control
- Increased productivity on land with low/no water availability

(Hale's Apple Orchard)

Benefits of Dry Farming

- Improved yield quality
- New marketing potential due to quality improvements & water conservation
- Can offer crop security during times of uncertain water supply



(goodeggs.com/devoto)

Limitations of Dry Farming

- Yield quantity tends to be lower than irrigated agriculture
  - Important to set realistic yield expectations
- May require wider plant spacing
- Some winters, it might not rain at all → more severe water stress the following season

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Dry Farming – It's not All-or-Nothing

(Hale's Apple Orchard)

- Consider trying it out first on a small area and hone your approach before scaling up
- Some areas of your orchard may be better suited than others
- You can consider irrigating crops at planting to help them get established
- You can irrigate crops at key times throughout the dry season if needed especially when you're beginning to experiment with dry farming

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Dry Farming – It's not All-or-Nothing

- Bear in mind, some years it may not rain at all in the winter
- Having irrigation set up and some amount of available water access is a good safety net

(Devoto Orchards)

Dry Farming Considerations & Strategies

Climate
- average annual rainfall
- average summer temperature
- humidity, wind, & sun exposure

Inherent Site Characteristics
- soil type & water holding capacity
- soil depth & subsoil constraints
- slope, backup water access

Soil Fertility
- fertility tests across depths
- available nutrients
- addressing pH, deficiencies

Soil Structure
- compaction & infiltration
- raised or leveled beds
- dust mulching & erosion

Soil Organic Matter
- building & maintaining SOM
- cover crops, compost, mulch
- tillage, reduced-till, or no-till

Crop Selection
- low-water use crops
- drought-tolerant varieties
- deep rooted

Planting & Competition
- early planting & root development
- transplants & spacing
- weed control strategies

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Dry Farming Strategies

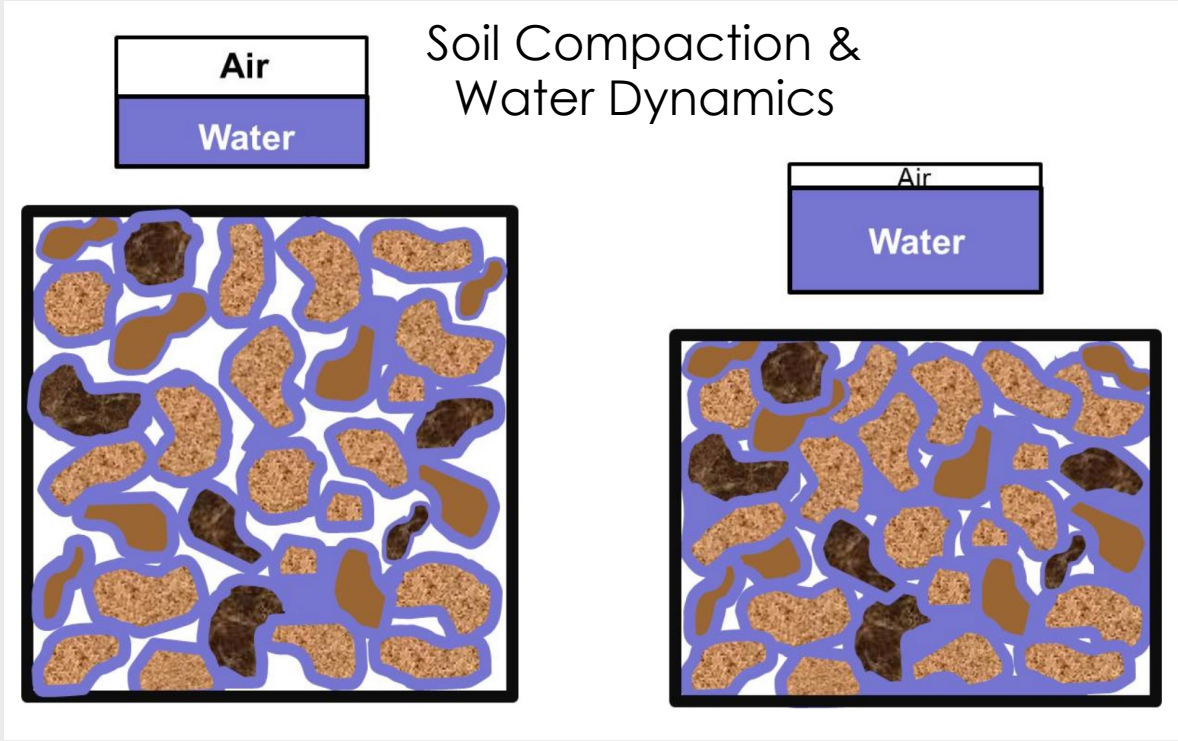
- Thoughtfully choose & combine practices to maximize success

Genetics for Dry Farming

- Rootstock & Scion Selection
  - Water-efficient & drought tolerant
  - Early maturing varieties
  - Deep root system architecture
  - Could try a small variety trial – maybe several options would do well at your site

Dry Farming Strategies

- Soil Structure
  - Compaction & infiltration
  - Raised or leveled beds
  - Dust mulching traps moisture



(UMN Extension)

Dry Farming Strategies

- Dust mulching, tillage, soil disturbance
  - Some growers use tillage to seal in soil moisture by breaking capillary action
  - Benefits: moisture retention deeper in the soil
  - Tradeoffs: erosion risk, over time can reduce SOM
  - Maybe more suitable in some situations than others

(Hale's Apple Orchard)

Dry Farming Strategies

- Planting & Competition
  - Some orchard and grape growers deep-irrigate plants in the first year or two to help them get established, while other growers do not
  - Consider having backup water available
  - Consider weed control

Dry Farming Strategies

- Adapt tree spacing to maximize water use by each tree: consider spacing them farther apart than in irrigated systems
- Time of year of planting matters

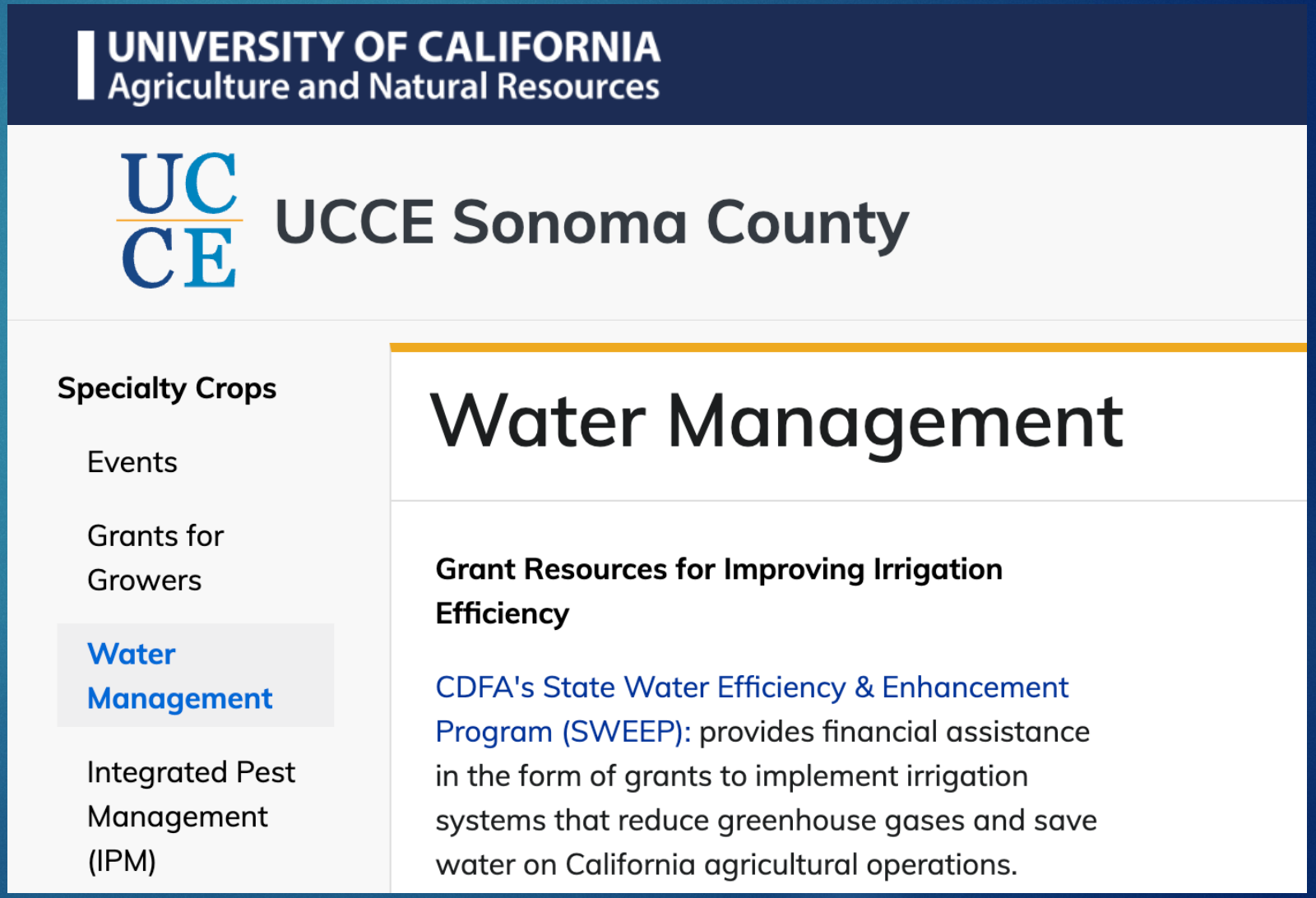
(…)

Resources & Information

Resources & Information

- Science-based Resources & Information
- Funding Options for Water Conservation & Drought Resilience

More Resources



More Resources

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More Resources

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

UC SAREP

California Cover Crops Resources

Cover Crops for California Farms

A cover crop can be any non-cash crop grown in addition to the primary cash crop. Cover crops offer many potential benefits. There are also management implications to consider when deciding whether to use cover crops, and identifying which crop or mixture of crops to plant. Impact of cover crops on yield depends on many factors, including water availability, initial soil quality, cover crop type or mixture, and timing of cover crop operations.

Learn more about incorporating cover crops into your farming operations using the resources on this website.

How to Manage Cover Crops

Cover Crop Selection

Resources

Resources

UC SAREP Cover Crop Database

Expert Grower Database: Cover Cropping Practices in Orchards and Vineyards

Challenges: Expert Grower Perspectives

Farmer Profiles: On-Farm Practices

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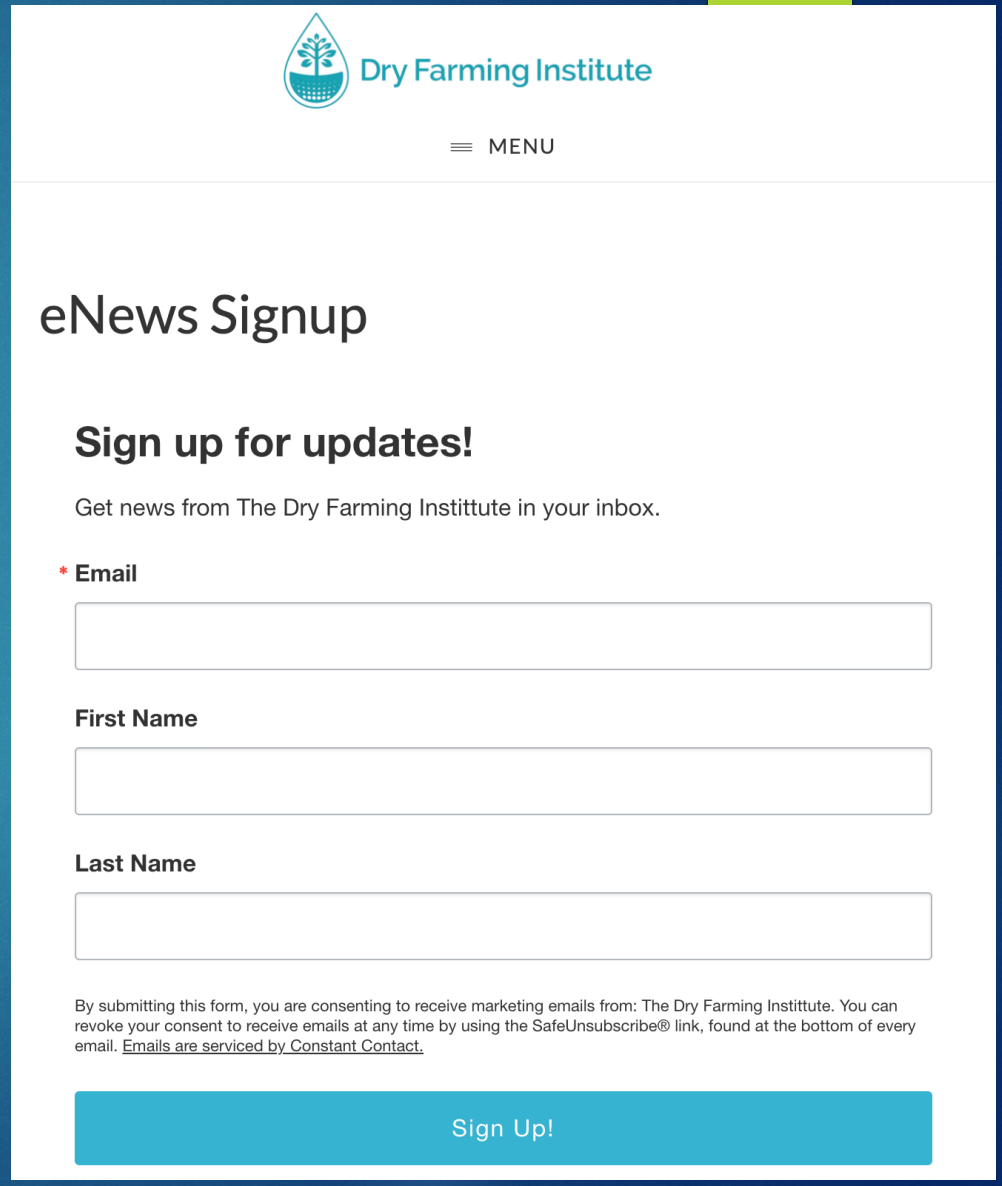
How to Learn More

- OSU Dry Farming Institute
- OSU Dry Farming Accelerator Program: a self-paced course

How to Learn More

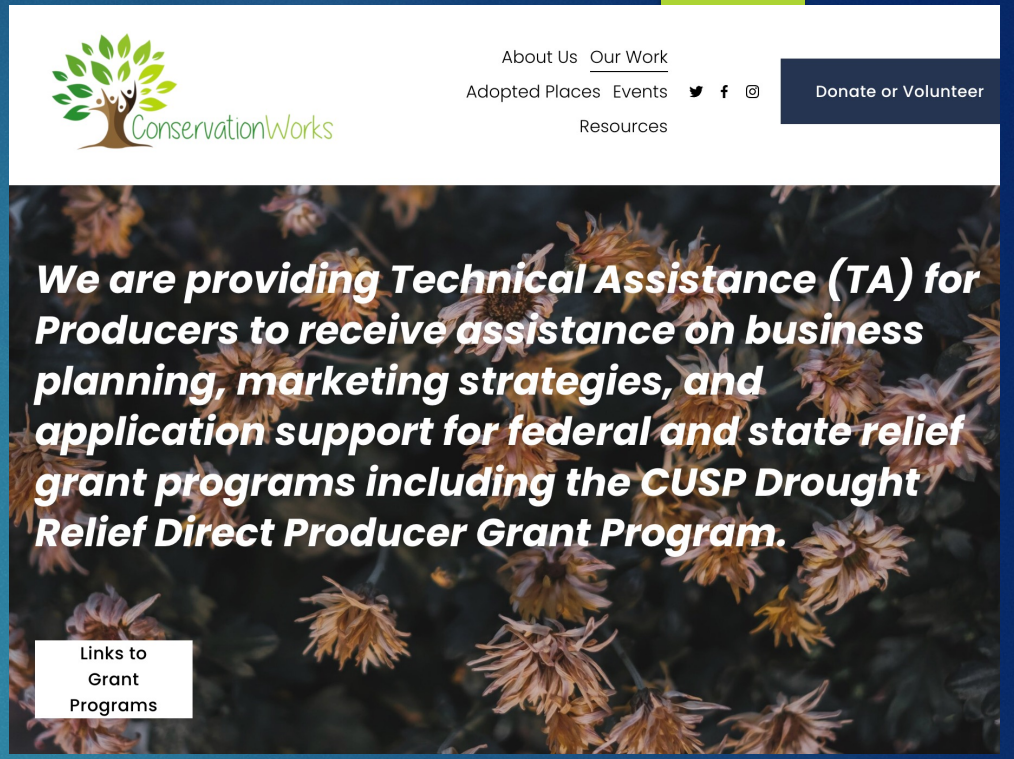
- Dry Farming Institute
  - Newsletter
  - Host an annual virtual convening on dry farming in February, recordings of all past events are on their website
  - Instagram



Funding Opportunities

- Conservation Works: CUSP Drought Relief Direct Producer Grant Program
  - Compensates growers who experienced yield losses due to drought

- NRCS
  - EQIP On-Farm Energy Initiative: can fund energy efficiency improvements including irrigation pumps
  - Conservation Stewardship Program helps build on existing conservation efforts
  - Emergency Watershed Program



Funding Opportunities

- California Small Agricultural Business Drought & Flood Relief Grant Program

- CDFA's State Water Efficiency & Enhancement Program (SWEEP)
  - provides financial assistance to implement irrigation systems that reduce greenhouse gases and save water in agricultural operations
  - Examples: soil moisture monitoring, drip systems, switching to low pressure irrigation pumps, retrofits, etc.
  - Reach out to Amanda Charles in our office to learn more!

Funding Opportunities

- Noninsured Crop Disaster Assistance Program (NAP)
  - A modified form of crop insurance
  - Provides financial assistance to producers of noninsurable crops when low yield, loss of inventory, or prevented planting occur due to natural disasters

USDA Farm Service Agency
U.S. DEPARTMENT OF AGRICULTURE

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Local RCDs

- Check out their website!

SONOMA
RESOURCE CONSERVATION DISTRICT

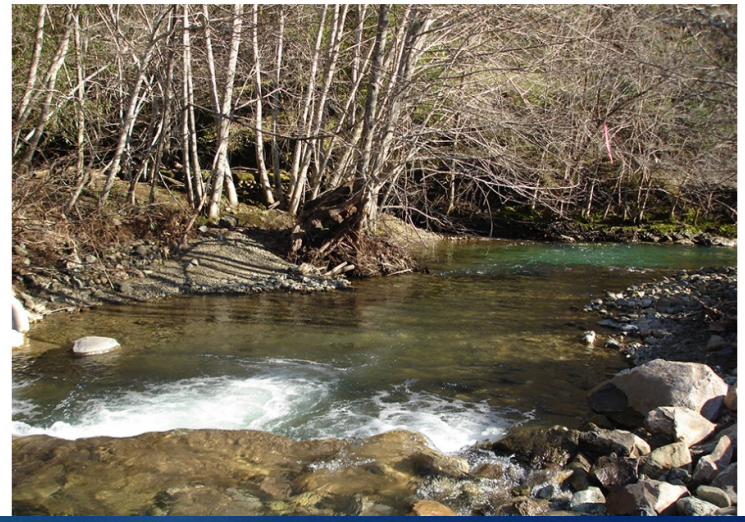
ABOUT US | WHAT WE DO | PROGRAMS | GET INVOLVED | RESOURCES

ALTERNATIVE WATER SUPPLY DEVELOPMENT VINEYARD IRRIGATION EVALUATIONS GROUNDWATER MANAGEMENT

LandSmart Water Resources® provides landowners and managers with tools to achieve their water management and conservation goals. Through this program the RCD assists landowners in assessing their water resources and needs and developing conservation projects that provide multiple benefits to their operations and their natural resources.

Water Resources Programming includes:

- Water management and conservation technical assistance
- Vineyard irrigation system evaluations
- Alternative water supply development
- Groundwater well monitoring



Local RCDs

- Check out their website!

GOLD RIDGE
RESOURCE CONSERVATION DISTRICT

ABOUT US | OUR WORK | GET INVOLVED | R

Water

Water

Gold Ridge RCD works with local, regional and state partners to improve the quality of our watersheds. The RCD helps landowners to manage their sediment and nutrient contributions to waterways, improve flow within our streams by developing alternatives to groundwater and surface water diversions, enhance the wildlife habitat within and near waterways, and more. Below are descriptions of our work in improving overall watershed health, the quality of water in our district, and the opportunities landowners and residents have to conserve water.

Frequently served: Farmers, ranchers, rural landowners

Thank you!

(Devoto Orchards)

Relevant Grants & Funding

- https://www.conservationworksnc.org/drought-relief-ta-for-producers
- https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives
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References & Resources

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