Soil Health and Water Storage Assessment in Dry-Farmed Vineyards

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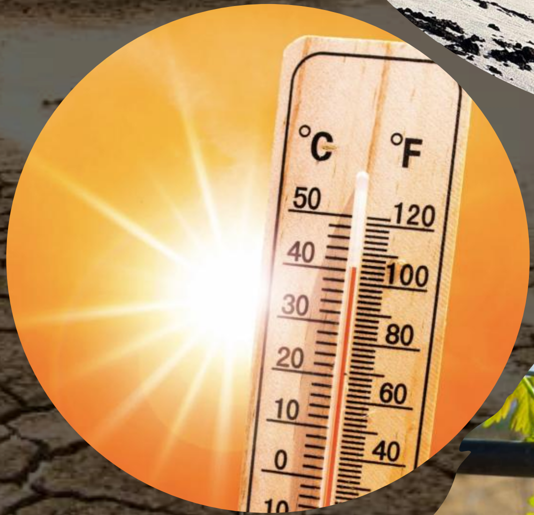
NAPA RCD

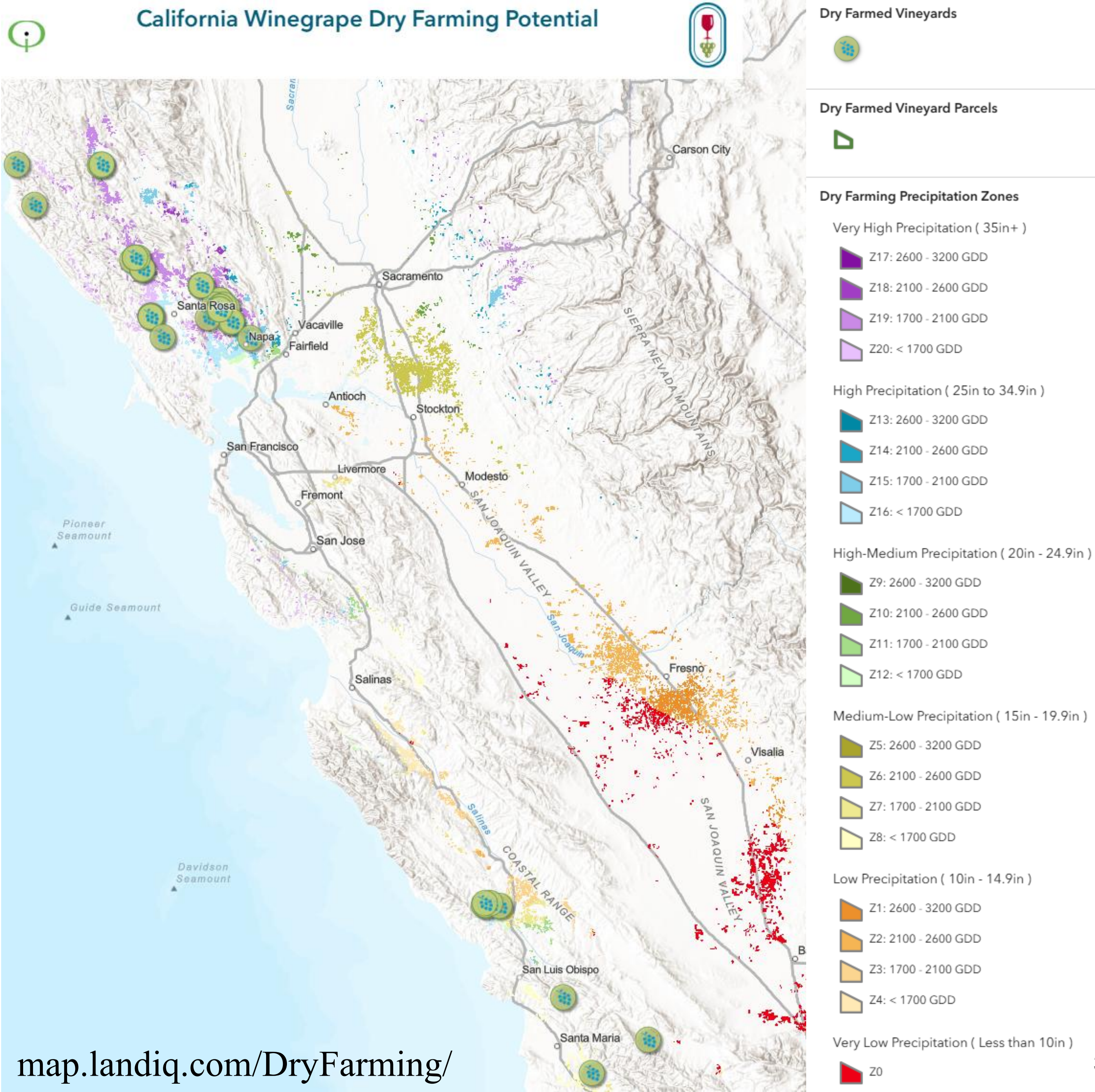
CALIFORNIA SUSTAINABLE WINEGROWING ALLIANCE

Dry farming offers a management strategy that strengthens agricultural resilience in the face of increasing water scarcity and climate uncertainty.



Why Dry Farming Matters Now

- Dry farming has a long historical presence in California agriculture.
- Many vineyards across the state continue to operate successfully without in-season irrigation.
- Climate change is increasing temperature extremes, drought frequency, and variability in water availability across California.
- Growers face increasing uncertainty around irrigation water reliability and long-term water security.
- Dry farming offers a management approach that supports **climate adaptation and system resilience.**
- Reduces dependence on irrigation while encouraging deeper rooting and more self-sufficient vines.



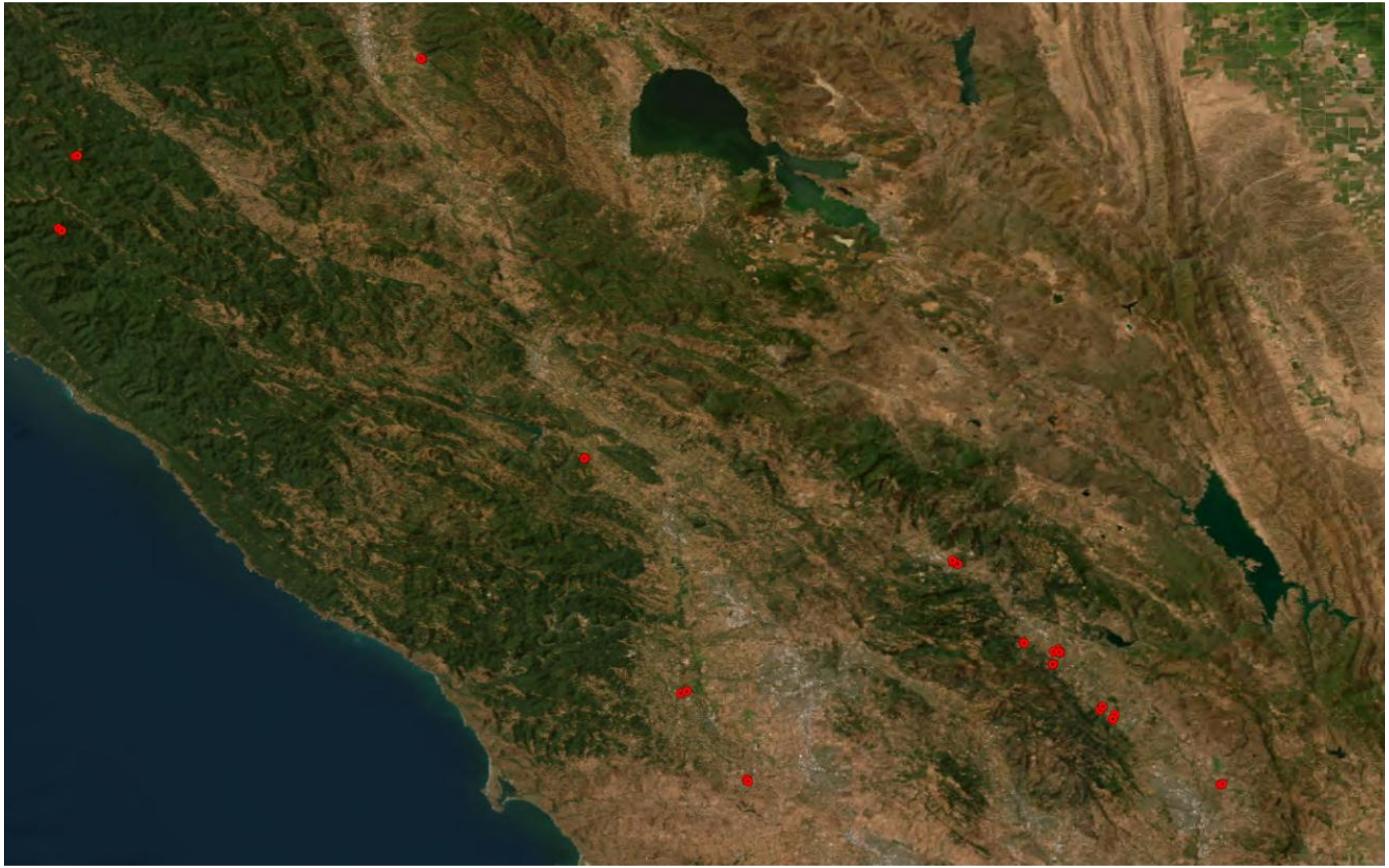
map.landiq.com/DryFarming/

The Knowledge Gap

- There is limited site-specific data on:
  - Soil health in dry-farmed vineyard systems.
  - The soil characteristics that influence how water is stored and mobilized in dry-farmed vineyards.

Project Goals

- Better understand how different dry-farming management approaches influence soil health.
- Evaluate how soil health affects the soil’s ability to:
  - Store and move water efficiently through the soil profile.
- Characterize how soil moisture is:
  - Stored during winter.
  - Depleted and redistributed through the growing season.



- 15 dry-farmed vineyards across Napa, Sonoma, and Mendocino Counties.
- 2 fields per vineyard.

Soil Pit Sampling

- Soil pit sampling was used to evaluate:
  - Soil physical, chemical, and biological properties.
  - Soil moisture levels and changes throughout the season.

- Soil sampling occurred three times during the 2025 growing season:
  - Around budbreak
  - During veraison
  - After harvest

- At each field:
  - Three soil pits were excavated.
  - Pits extended to a depth of five feet.
  - Each pit was sampled in one-foot depth increments.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Soil Management Across Participating Vineyards

•Management spans a wide spectrum from no-till to heavily tilled systems.

•Tillage supports weed control, cover crop incorporation, and moisture management.

•Reduced- or no-till vineyards:

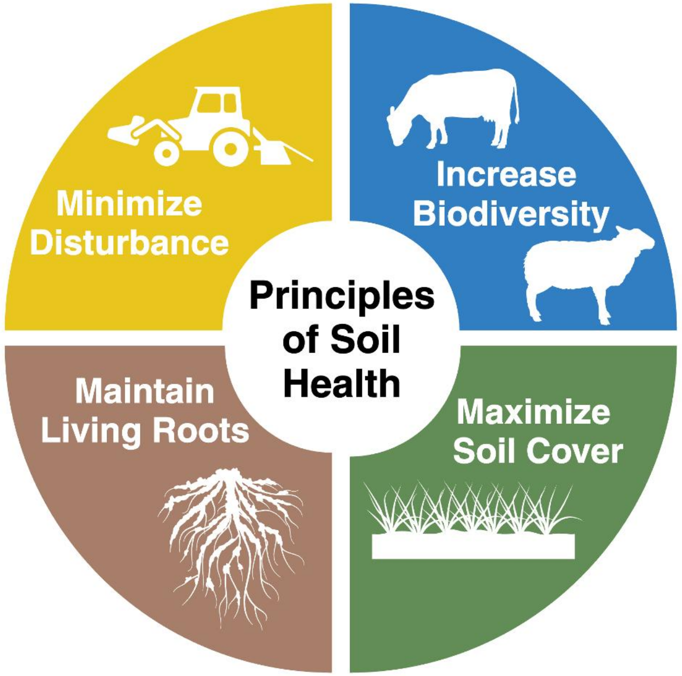
- Leave prunings and cover crop residues on the soil surface.
- Minimize soil disturbance.

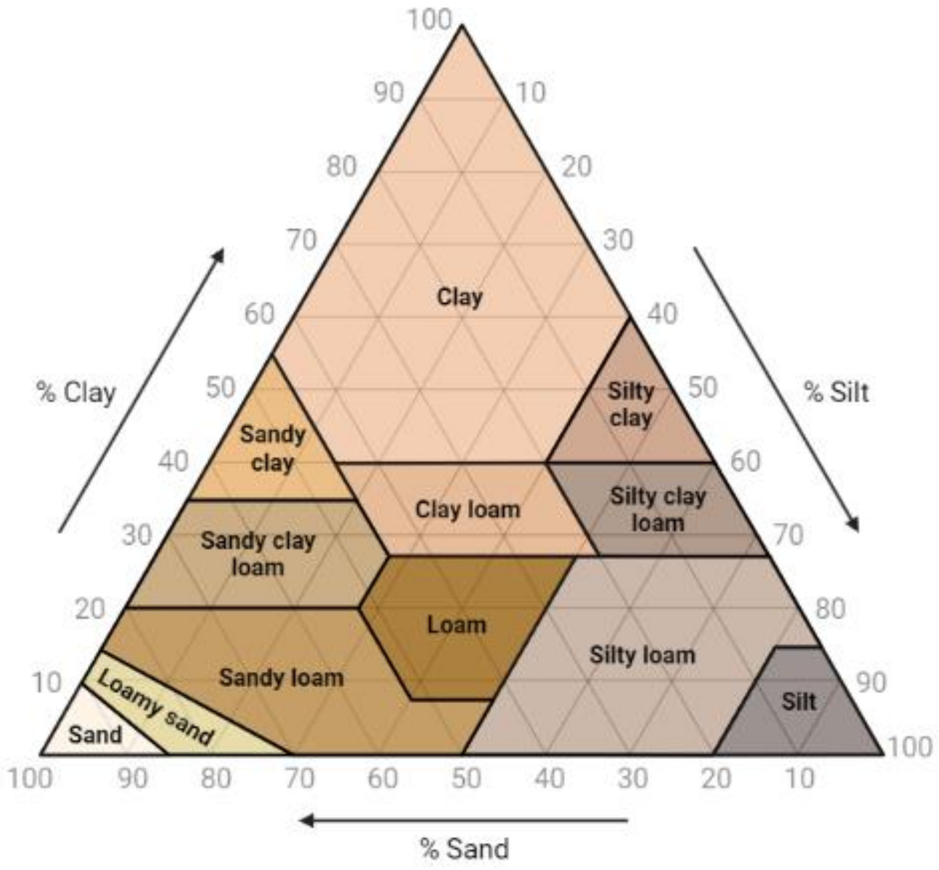
•Compost use differs widely:

- No compost in some vineyards.
- Annual applications of 2 to 3 tons per acre in others.

•This range of practices creates a management gradient that helps evaluate how:

- Disturbance intensity and organic inputs influence soil carbon, biological activity, soil structure, and water storage





Soil texture

- Soil texture: proportions of sand, silt, and clay in a soil.
- Serves as a foundational characteristic shaping nearly all aspects of soil function.
- Soil texture across the vineyards in this project ranges from coarse sandy loam and loamy sand profiles to finer-textured loam, sandy clay loam, clay loam, and occasional sandy clay layers.
- Many vineyards show layered profiles, where coarser surface soils overlie finer-textured subsoils, or vice versa.
- These transitions strongly influence both infiltration and water storage.

Soil health indicators

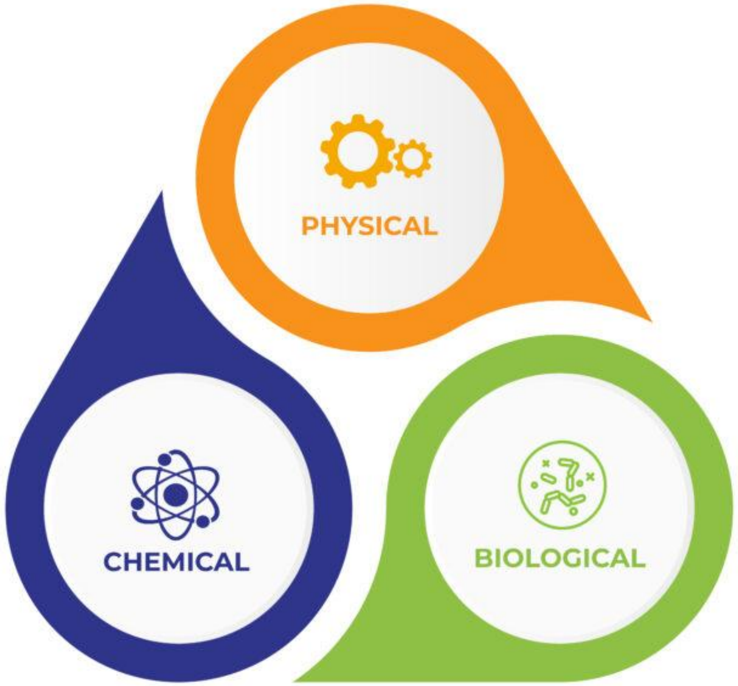
- Organic matter and total carbon: the long-term buildup of plant residues. Influence water-holding capacity, biological activity, aggregation, and overall fertility.

- Active carbon (POX-C), soil respiration and potential mineralizable nitrogen: show how much carbon is available to fuel microbes and how effectively the soil can release nutrients to crops over time.

- Aggregate stability: reflects whether soil particles form strong, stable clumps that resist erosion and improve infiltration.

- Cation exchange capacity (CEC): provides insight into the soil's ability to retain nutrients.

Together, these indicators offer a holistic view of soil function and resilience.



Soil Health Patterns and Role of Management

Soil health indicators in reference to expected values by soil texture or regional averages.			
Soil health indicator	Below	Within	Above
Organic Matter (%)	3	17	10
Total Carbon (%)	4	18	8
POX-C (ppm)	5	11	14
CEC (meq/100g)	9	17	4
Aggregate Stability (%)	4	9	17
Soil Respiration (ppm-C/day)	2	6	22
PMN (mg N/kg soil)	8	10	12

- Most fields scored within or above expected ranges for soil health; only a minority scored lower.

- Two key questions:
  - **Do management practices drive differences in soil health?**
  - **Do lower soil health scores limit water movement and storage?**

- Tillage is a major factor in many lower-scoring fields, but not all tilled fields score poorly.

- Frequent disturbance:
  - Breaks down soil aggregates.
  - Accelerates loss of organic carbon.
  - Reduces long-term organic matter stability.

- Weaker aggregate stability often overlaps with more intensive disturbance.

- However, compost inputs and high cover crop biomass can offset some tillage effects.

Depth (ft)	Available Water (in-H_2O/in-soil)	Expected Available water (in-H_2O/in-soil)	Total Available Water (in-H_2O)	Field Capacity (%)	Moisture at Bloom (%)	Per. Wilting Point (%)	Moisture after harvest (%)
1	0.16	0.10-0.13	1.92	17.6	14.0	5.5	4.9
2	0.14	0.07-0.10	1.69	15.5	17.1	4.8	4.7
3	0.14	0.10-0.13	1.73	18.3	21.2	7.3	11.4
4	0.15	0.10-0.13	1.84	20.1	16.6	8.5	11.3
5	0.16	0.10-0.13	1.93	20.9	21.7	8.7	10.5
Total available water			9.11				

Available water results in reference to expected values by soil texture.			
Soil depth	Below	Within	Above
1 ft	0	8	22
2 ft	0	6	24
3 ft	0	14	16
4 ft	0	14	16
5 ft	0	10	19

Water storage

•All fields show plant-available water within or above expected ranges based on soil texture.

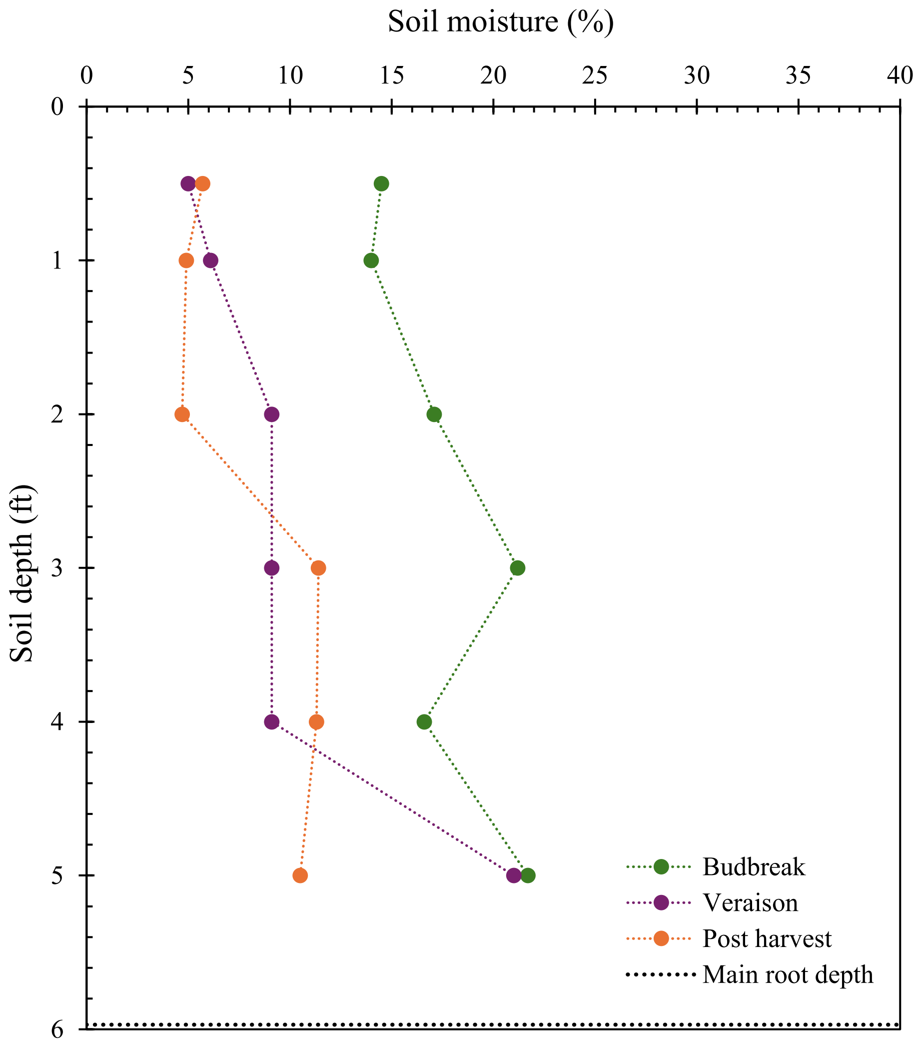
•Soils are functioning at or above their inherent physical potential for water storage.

•Across the five-foot rooting zone, total available water is generally sufficient to support vines through the dry season.

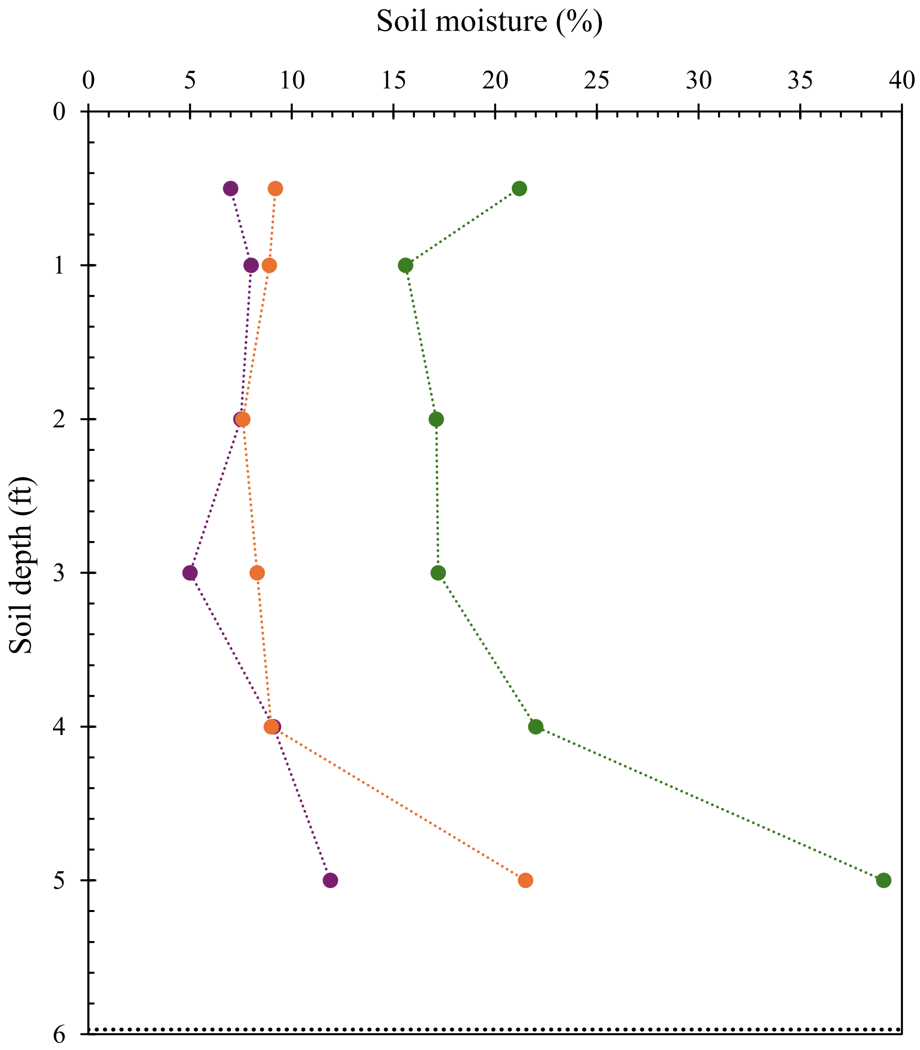
•Winter rainfall does not always fully recharge soils to field capacity.

•Some fields retain residual plant-available moisture after harvest, while others approach lower extraction limits

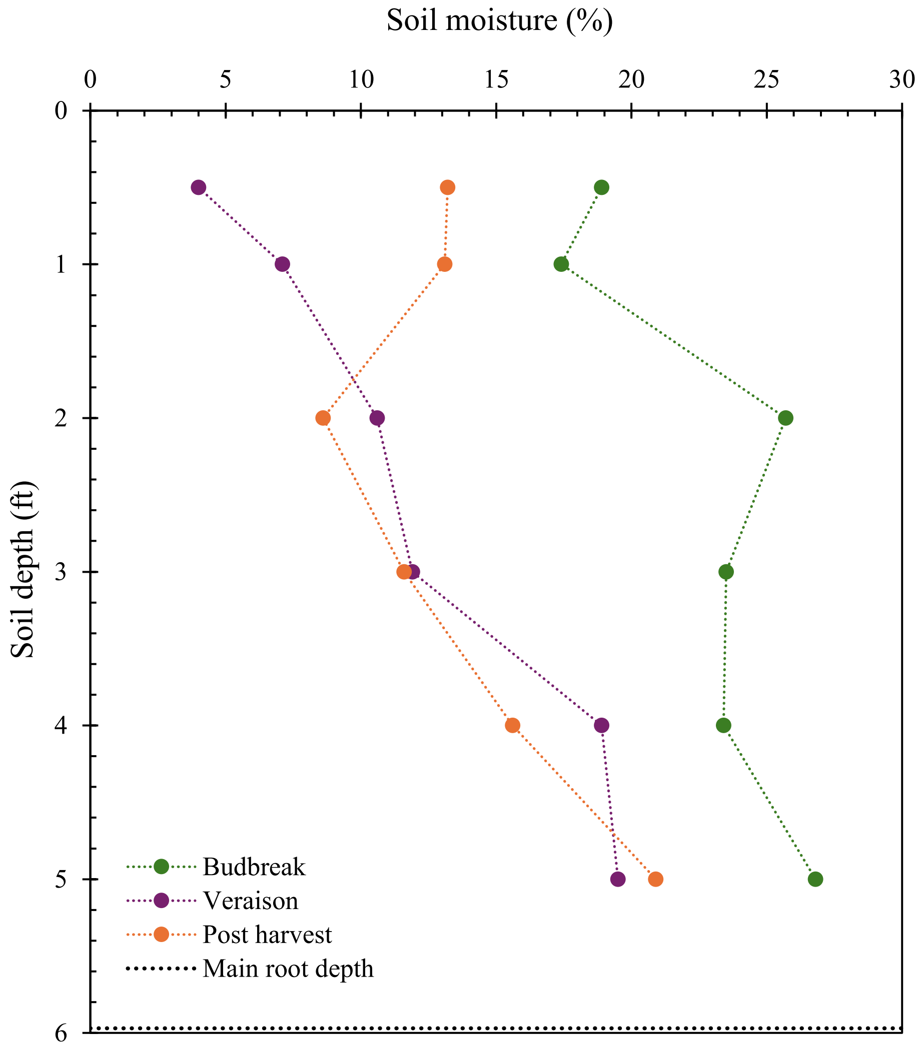
Soil moisture throughout the season



Vineyard 1 Field 1



Vineyard 1 Field 2



Vineyard 2 Field 1

Typical Seasonal Pattern in Dry-Farmed Vineyards

•Clear, repeated pattern across sites:
- Upper horizons dry first as canopy demand increases
- Deeper layers retain moisture longer and act as the late-season reservoir

End-of-Season Moisture Patterns

•Two general patterns by harvest:
- Some fields approach or fall below the permanent wilting point, indicating strong late-season water use and higher stress.
- Other fields retain moisture in deeper layers, providing a late-season buffer.

Water Redistribution Within the Profile

•Some sites show slight internal moisture increases at certain depths late in the season.

•Occurs even with minimal rainfall.

•Likely due to:
- Passive water movement along moisture gradients.
- Hydraulic redistribution by roots.
- Reduced transpiration near senescence.

•Suggests deep water can move upward and remain available in the root zone.

Regional Dry-Farming Soil Assessment Overview

• The majority of fields function within or above expected soil health ranges with stronger biological activity, carbon levels, and aggregation linked to organic inputs and reduced disturbance.

• Soils often began the season below full saturation, highlighting the role of winter rainfall and infiltration.

• Subsoil horizons act as the late-season water reserve.

• Many systems operate near stored water limits by harvest.

• Overall, soils function as effective natural water reservoirs, reinforcing the value of dry farming in aligning production with natural water cycles.

Thanks!

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Soil sampling and picture credits:

Integrated Winegrowing

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