Soil Structure and Compaction

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What is Soil Structure?

Beneficial bacteria produce a glue-like substance that combines bacteria, organic matter, and soil particles (sand, silt, and clay) to create soil **aggregates**.

The arrangement of those soil aggregates into different forms creates a soil's structure.

Why Should You Care About the Structure of Your Soil?

Good soil structure creates spaces for air and water in the soil while allowing roots to grow easily.

Having good soil structures or stable aggregation, opens the soil for water and air movement which are essential for root health and the health of the microbiology in the soil.

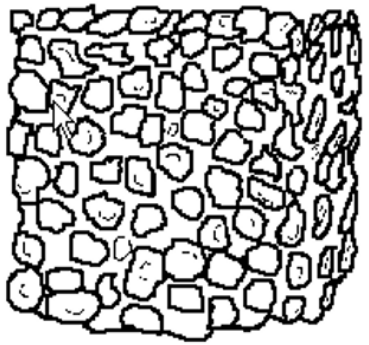
Good Soil Structure increase your soil's water holding capcity and water permeability.

To increase the quality of your soil you first need to have good soil structure. And to improve your soil structure you need to increase your organic matter and microbial community.

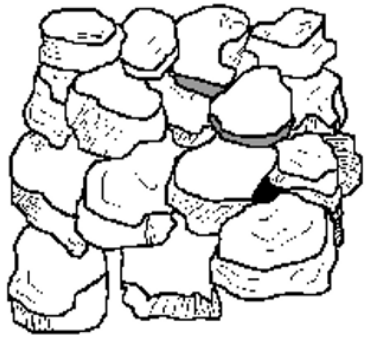
What Does Good Soil Structure Do?

Sources: Utah State University “It’s All About Soil Structure” (2018), UCANR “Building Healthy Soil” (2025)

What Makes up a Soil's Structure?

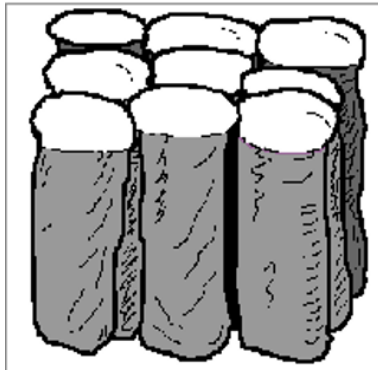


Granular: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.

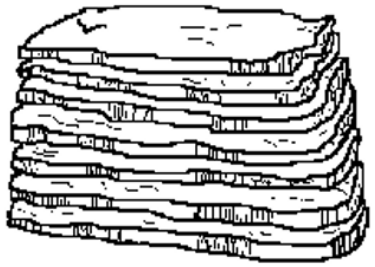


Blocky: Irregular blocks that are usually 1.5 - 5.0 cm in diameter.

Prismatic: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.



Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.



Platy: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.

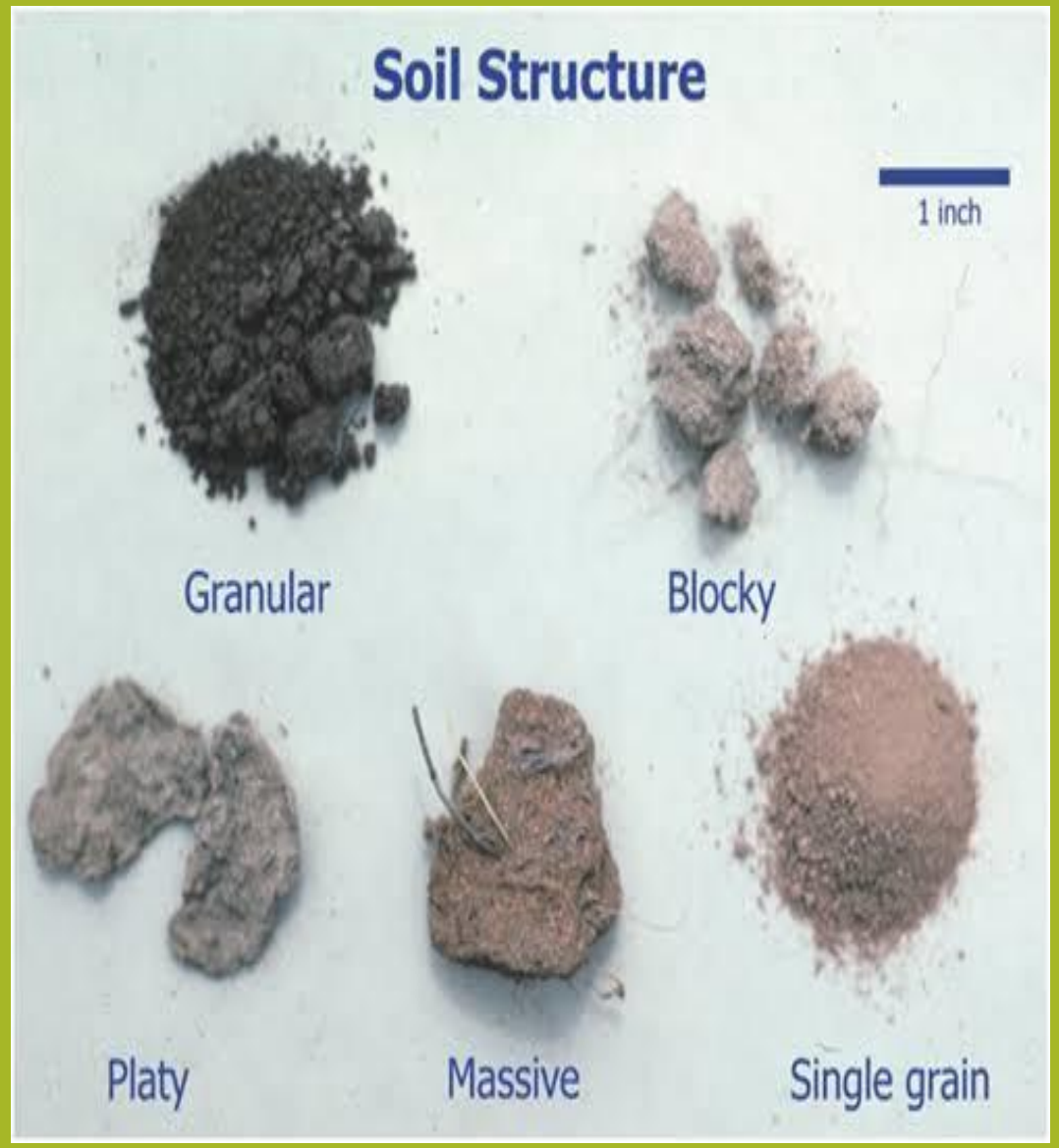
Single Grained: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

Soil Texture: the size and portion of soil particles within a sample

- Organic matter
- Sand
- Silt
- Clay

Soil Structure Types:

- Granular
- Blocky
- Prismatic
- Columnar
- Platy (Compacted)
- Single Grained



Granular – This soul structure has a high permeability with the most pore space

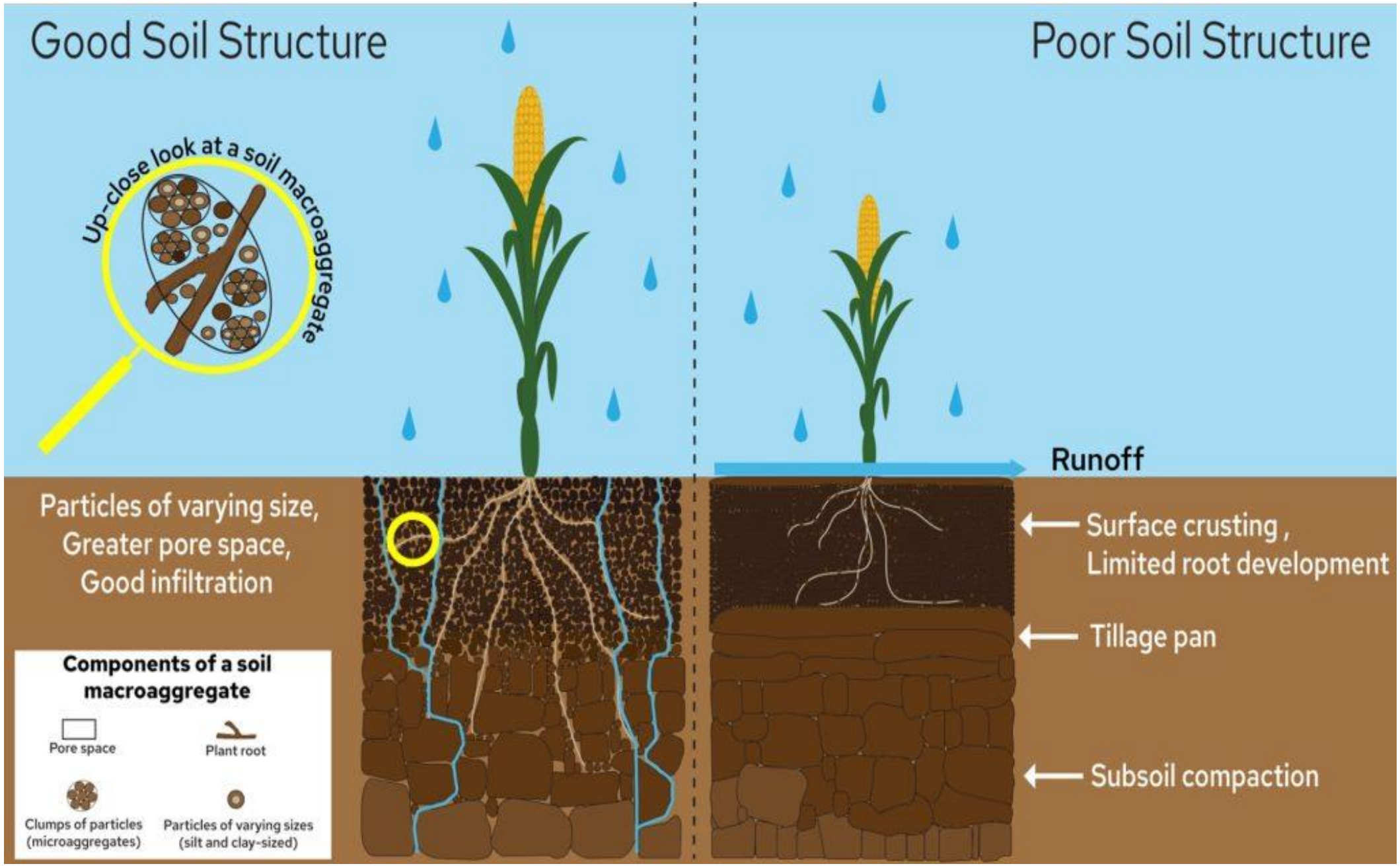
Blocky – This soil structure has medium permeability.

Prismatic or Columnar– This soil structure has a medium permeability, letting water easily slip between the vertical columns.

Platey – This soil structure has low permeability. Platey structures are compacted with plates or sheets of piled horizontally on top of each other.

Massive – This structure type has low permeability because it is practically one giant aggregate with no pore space.

Single grained – This structure type has high permeability but hardly any water retention. There are no aggregates holding the soil together.



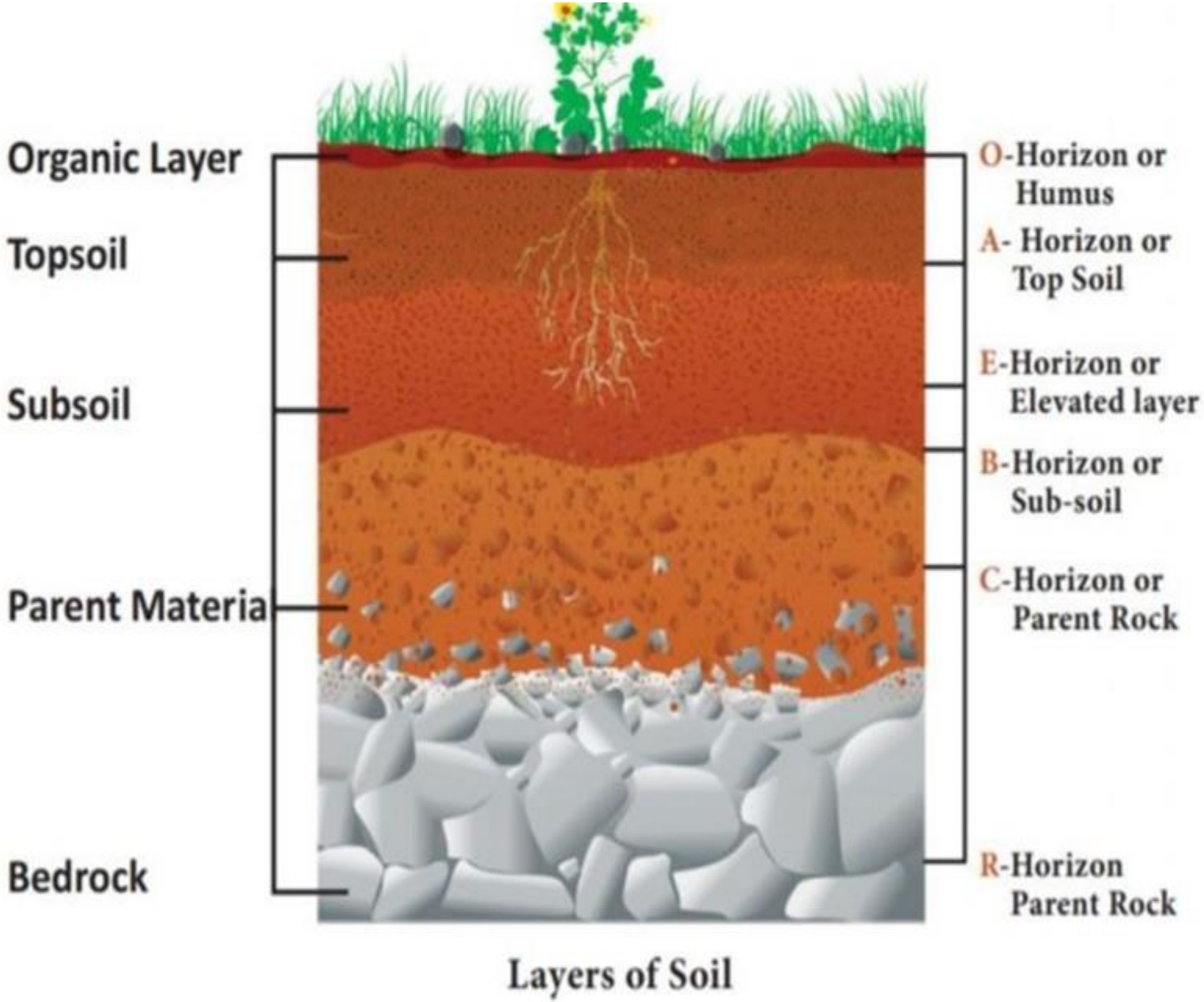
Graphic adapted from Oregon State University Extension and Jastrow and Miller 1998[3].

← Good Soil Structure

Poor Soil Structure ↓

Soil Layers

The average soil depth in Fallbrook and surrounding areas is 40-60 inches deep over weathered bedrock.
Bonsall: 50-90 inches



Layers of Soil

Soil Structure vs. Soil Texture

A Soils' **Texture** refers to the proportions or percentages of sand, silt, and clay. These proportions are what determines a soil's class or type. (i.e. sandy loam, loamy clay, etc.)

Vs.

A Soils' **Structure** refers to the formation of the soil particles (sand, silt, and clay) and organic matter combined together.

Types of Soil in Fallbrook and Temecula Area

Vista Course Sandy Loam

- Medium fertility
- Moderate-rapid permeability
- Available water holding capacity of 4 – 6 inches
- Rooting depth is 27 to 47 inches

Fallbrook Sandy Loam

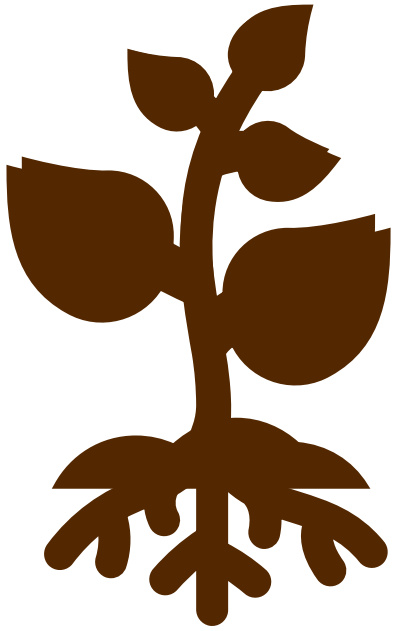
- Medium fertility
- Moderate permeability
- Available water holding capacity is 4.5 - 8inches
- Rooting depth of 28 to 60 inches.

Temecula: Greenfield Sandy Loam

- Medium fertility
- Moderate-rapid permeability
- Available water holding capacity is between 5.5 - 7.5 inches
- Rooting depth is more than 60 inches

Improving a Soil's Structure Through Biology

What creates and supports a soil's structure is the microbiology and organic matter within the soil.



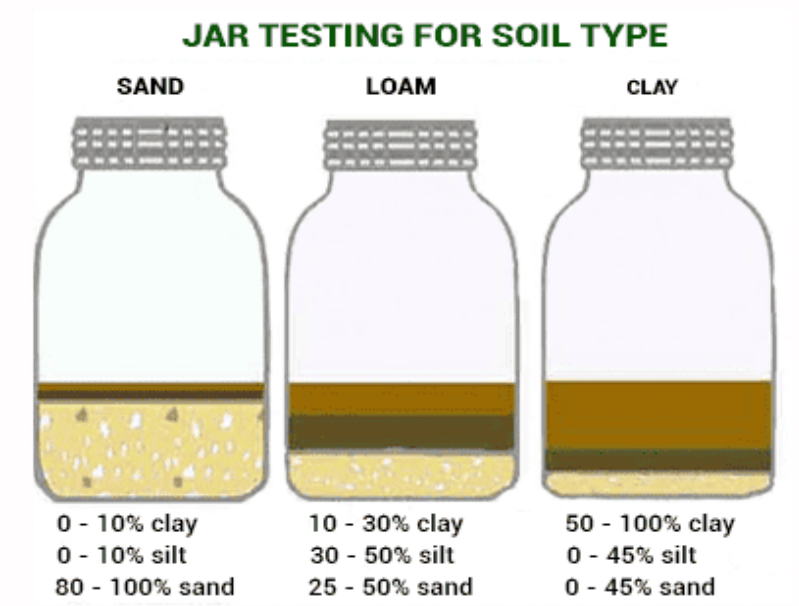
Ways to increase your soil's biology:

- Compost
- Compost and/or worm Teas
- Worm castings
- Beneficial nematodes

Easy Soil Tests

Jar Test – SOIL TEXTURE

- **What you'll need**: Mason Jar, soil, water, 1tsp of dish soap or water softener
- **What to do**: Fill 1/3 of the jar with soil, add 1sp of dish soap, and fill the rest with water till almost full. Shake the jar for 1 min straight. Let the soil settle for 24hours.



Shovel Test – soil structure

- Perform the test when the soil is moist
- Dig a 8-12in depth cube of soil and place on a flat surface or tray
- What to look for: break the soil sample in your hands and look for roots, soil clumps, earthworms. If the soil has a plate-like structure running horizontally, it is likely compacted soil.

Damages to Soil Structure

There are several ways Soil Structures can become damaged.

- Working soil when it is too wet
- Excessive tillage
- Bare soil and erosion
- Heavy axel loads and repeated traffic
- Loss of organic matter

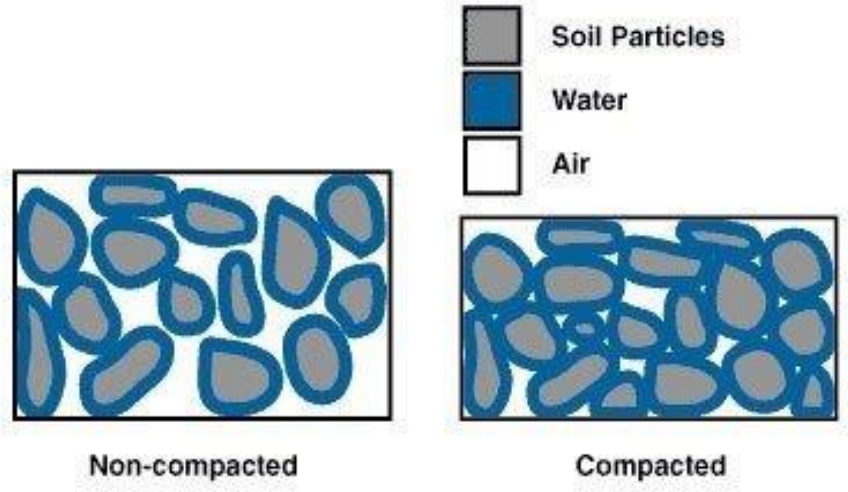
Soil Compaction

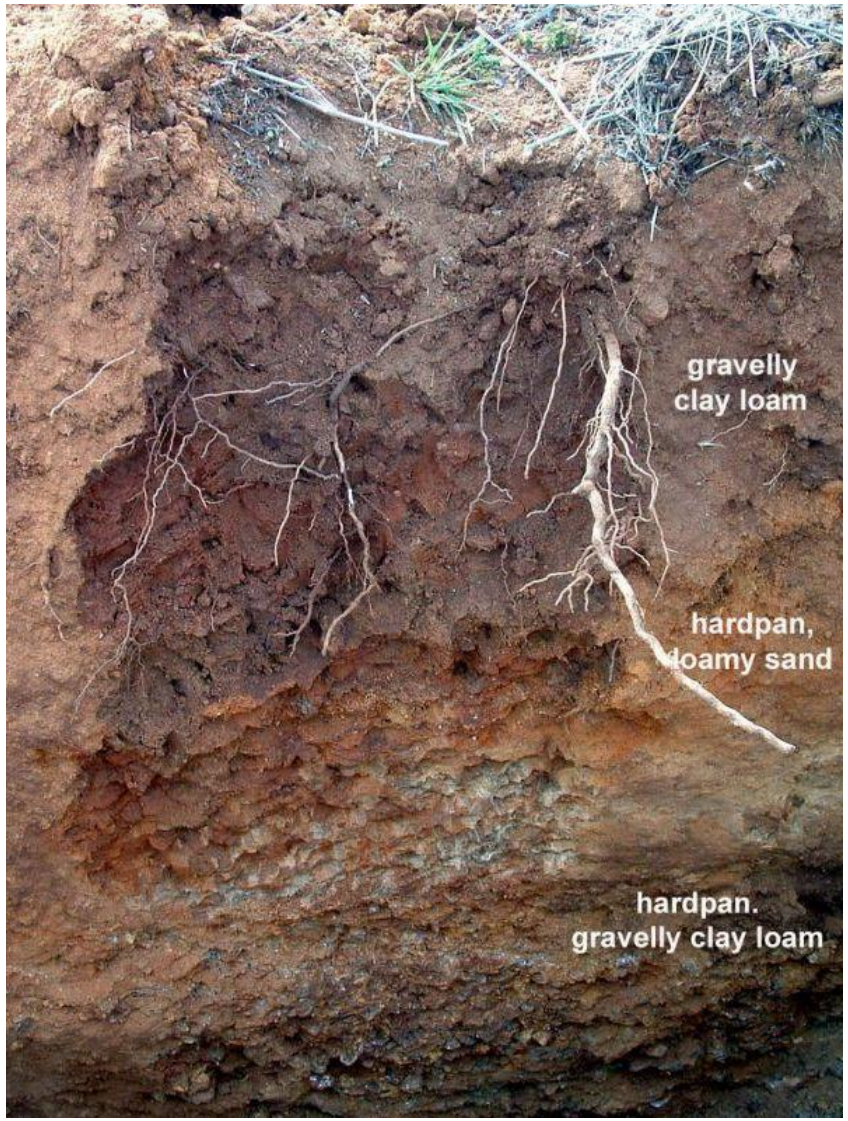
- Soil compaction occurs when soil particles are pressed closer together, reducing pore space.
- Less air for roots
- Slower water movement
- Restricted root growth

Why Pore Space Matters

Pores = pathways for air + water + roots

Compaction → fewer & smaller pores





What Crops Are Most Sensitive to Compaction?

No single crop is most sensitive.
Impacts depend on soil, moisture, roots, and traffic.

Examples:

Tomatoes — restricted roots & growth

Alfalfa — highly sensitive to repeated traffic

Tree & vine crops — deep compaction can restrict rooting

Restricted roots = reduced access to water & nutrients

Causes

Heavy equipment and repeated wheel traffic

Working or driving on wet soil

Repeated tillage at the same depth

Foot traffic and livestock pressure

Construction, grading, or other heavy loads

Wet Soil = Higher Risk

Less resistance to pressure

→ Deeper, longer-lasting compaction

Two Forms

Surface: crusting & sealing

Subsoil: hardpans & deep compaction

How Much Does a Tractor's Total Weight Matter?

What Matters Most?

Total weight matters — but **axle load** is more useful for assessing compaction risk at depth.

Tire size & pressure determine how that load is distributed at the surface.

Wet soil is more vulnerable to compaction, especially under heavier loads.

Think About the Whole System

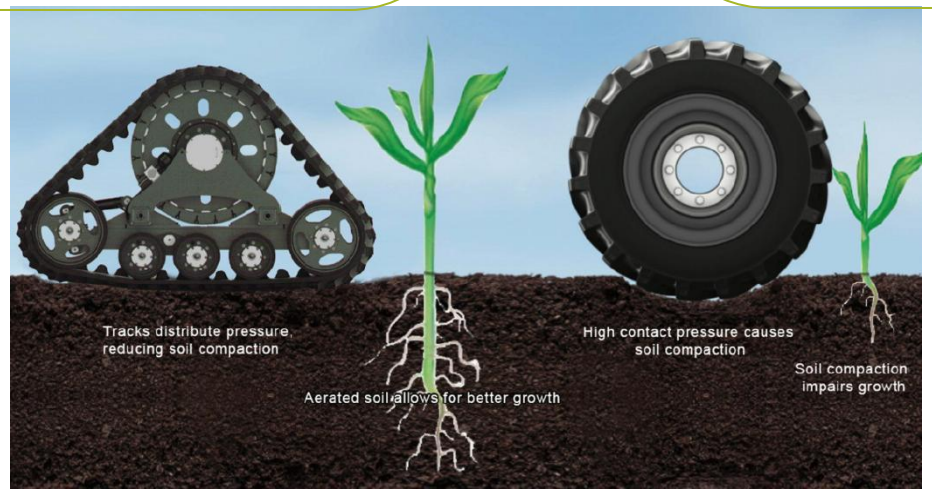
Tractor + implement weight

Load per axle/tire

Tire size & inflation pressure

Number of passes & traffic pattern

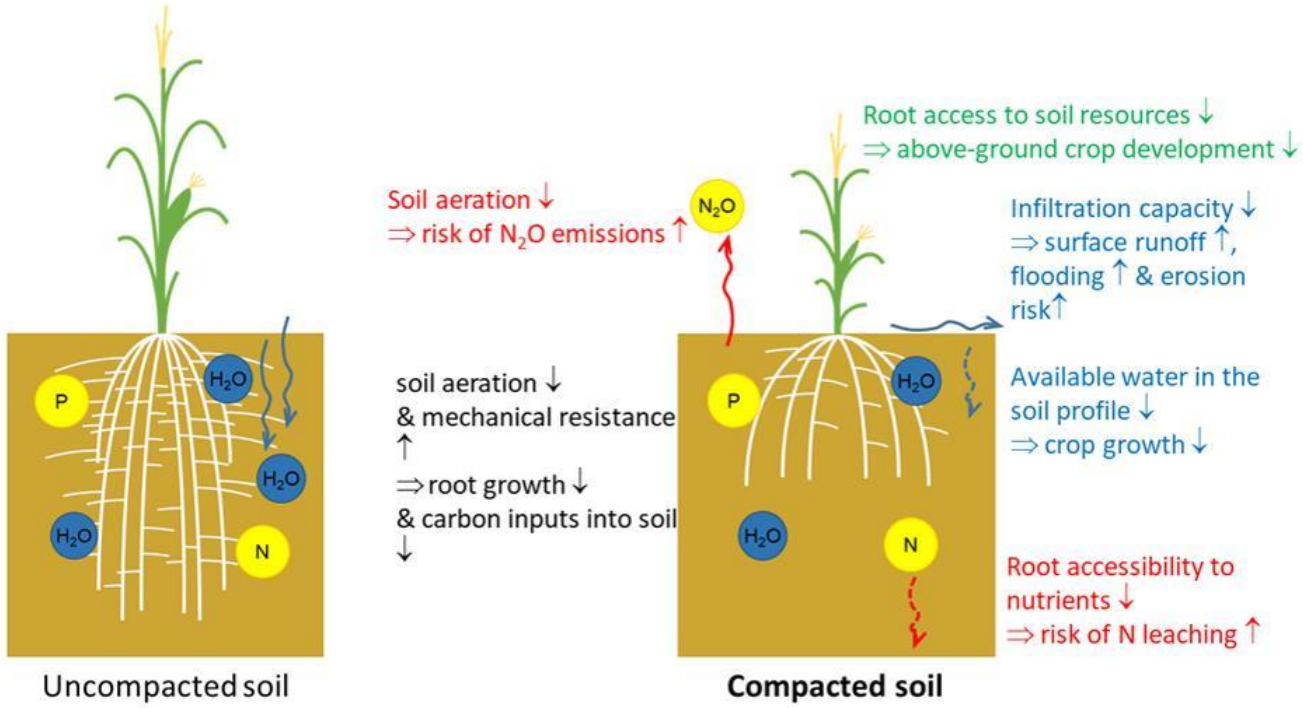
Soil moisture & texture



California yield example

UC IPM reports that two wheel-traffic passes reduced alfalfa yield by an average of 25% in UC Davis studies; impacts were greater when traffic occurred on wet soil.

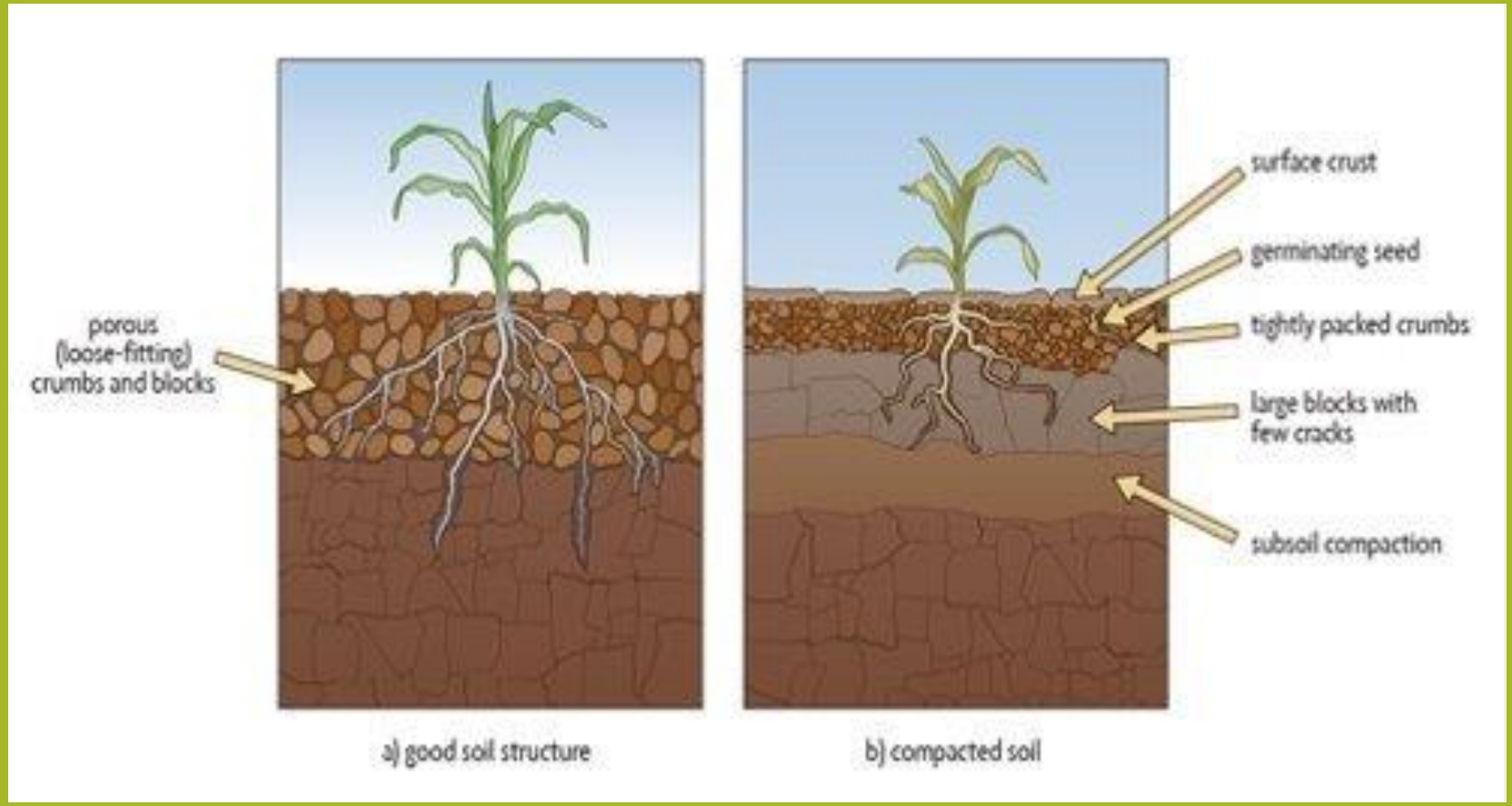
Why Are Compacted Layers a Problem?



- Restrict root growth
- Limit water movement
- Reduce soil oxygen
- Can cause poor drainage & runoff
- Difficult to correct at depth

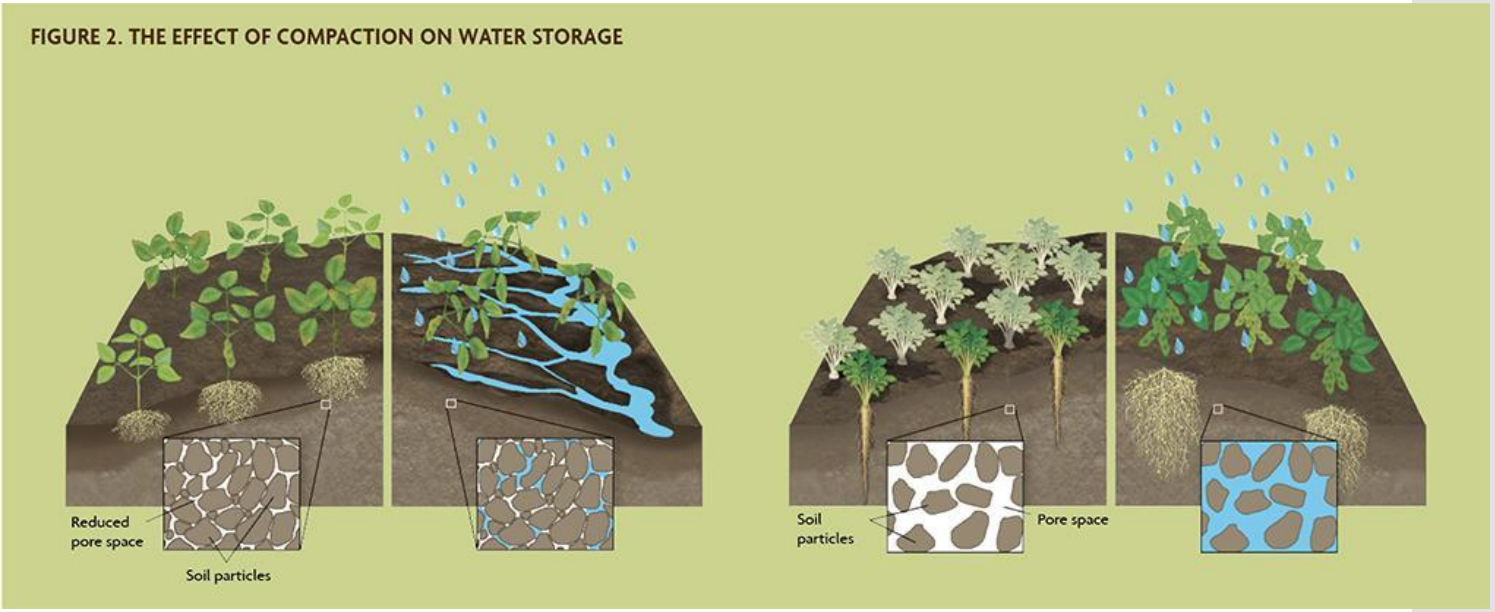
Issues

- Restricted root growth
- Less water infiltration
- Poor drainage & aeration
- Reduced nutrient uptake
- Lower growth & yields



Compaction → Less pore space → Less access to air & water

How Does Compaction Affect Infiltration?



Healthy soil

Connected pores allow water to move into the soil

Larger pores improve water movement

Compacted soil

Less pore space → slower infiltration

Water can perch above a compacted layer

More ponding, runoff & erosion

Irrigation becomes less efficient

Compaction → Less pore space → Less water movement

Economic Impact

- Lower yields or uneven crop growth
- Less efficient use of irrigation water
- More runoff/erosion and potential loss of inputs
- Extra labor, fuel, and equipment passes to correct the problem
- Mechanical remediation can be costly and may not restore soil structure long-term

How Can a Grower Tell if Soil Is Compacted?

Look for signs

Ponding or slow infiltration

Wheel ruts

Uneven crop growth

Shallow or restricted roots

Dig & compare

Use a shovel to compare compacted and undisturbed areas.

Look for:
Dense layers • Poor structure • Restricted roots

Confirm

Use a **soil probe or penetrometer** to test resistance.

What Is a Compaction Assessment?

A simple field check to locate and confirm compacted soil.

1. **Observe**

Ponding • Wheel tracks • Poor crop growth

2. **Dig**

Examine the soil profile for **dense layers & restricted roots**

3. **Test**

Compare soil resistance with an **unaffected area**

4. **Record**

Note **depth, moisture & location**

Techniques to Fix Compaction

Diagnose → Correct → Prevent

1. Diagnose First

Identify **depth & severity**

Don’t automatically rip the whole field

2. Address the Layer

Surface: Light treatment + protect with residue/cover

Subsurface: Rip or chisel **when soil is dry**

Never rip wet soil

3. Prevent It From Returning

Reduce traffic & unnecessary passes

Vary tillage depth

Keep soil covered

Build organic matter with **compost, residues & cover crops**

Diagnose Compaction With Equipment

Have a Penetrometer?

- Measure resistance **by depth**
- Take **multiple readings**
- Compare with an unaffected area

Simple Field Checks

- **Dig:** Look for dense layers & restricted roots
- **Push:** Compare resistance with a rod or probe
- **Infiltrate:** Check how quickly water enters the soil

Solutions and Prevention

Avoid field traffic and tillage when soil is wet

Designate permanent traffic lanes/paths

Reduce unnecessary trips

Use appropriate tire pressure and distribute equipment weight

Keep soil covered with residue, mulch, or living cover crops

Build soil organic matter with compost and crop residues

San Diego County example

San Diego UCCE's Healthy Soils demonstration at Valdivia Farm in Carlsbad is testing compost and cover crops in tomatoes. The project identifies reduced soil compaction as one benefit of cover cropping.

Soil Resources

- UCANR Soil Resources

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

- WETA Irrigation Evaluation Program

cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

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Area of Interest

Import AOI

Address

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Address: 2648 N Stage Coach Ln, Fallbrook, CA 92028

Show location marker

View

State and County

Soil Survey Area

Latitude and Longitude or Current Location

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Department of Defense

Forest Service

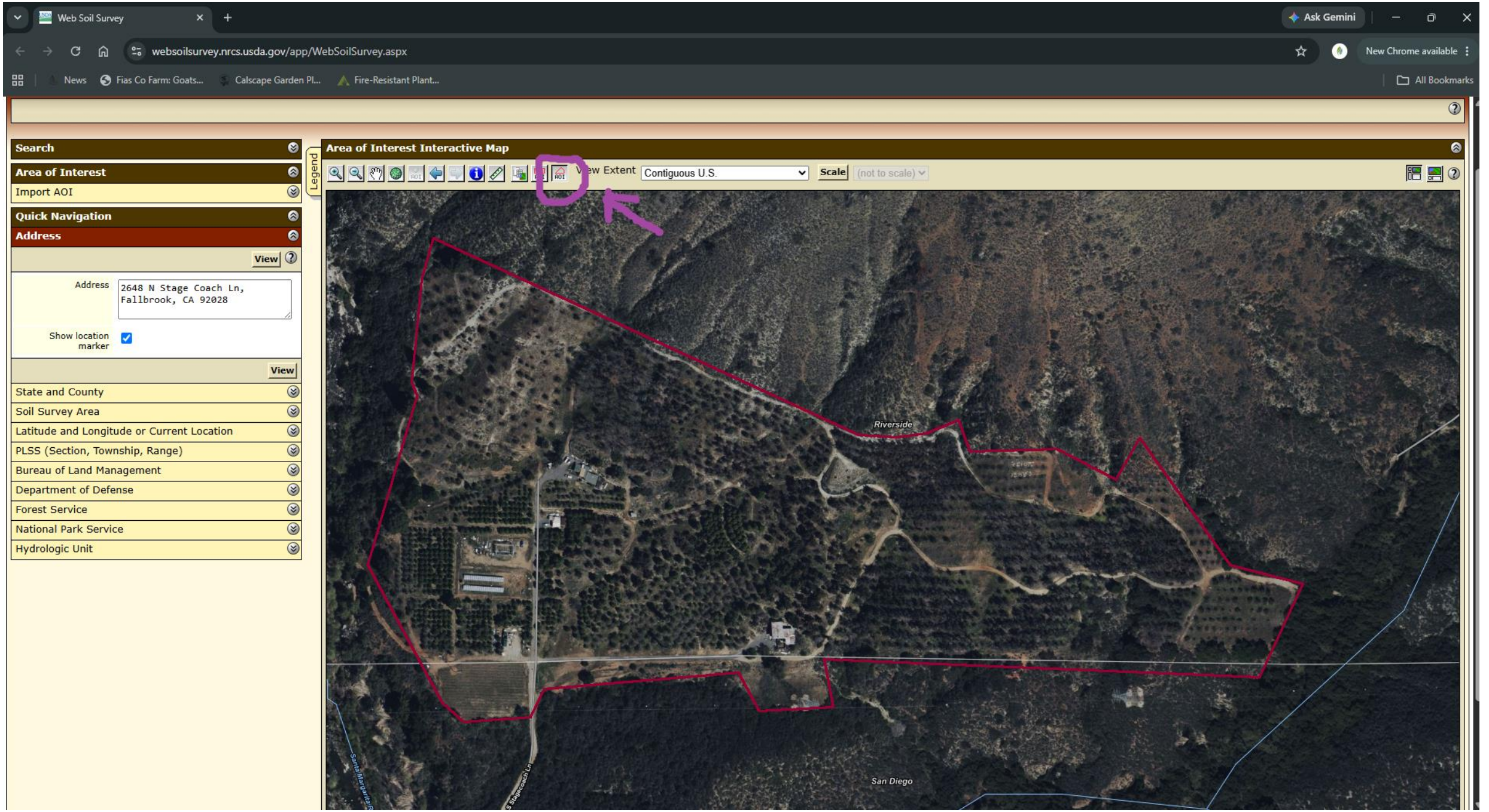
National Park Service

Hydrologic Unit

Legend

Area of Interest Interactive Map

View Extent: Contiguous U.S. | Scale: (not to scale)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Map Unit Legend

San Diego County Area, California (CA638)
Western Riverside Area, California (CA679)

San Diego County Area, California (CA638)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
LpC2	Las Posas fine sandy loam, 5 to 9 percent slopes, eroded	0.7	1.5%
LpD2	Las Posas fine sandy loam, 9 to 15 percent slopes, eroded	0.5	1.2%
LrE2	Las Posas stony fine sandy loam, 9 to 30 percent slopes, eroded	0.3	0.7%
LrG	Las Posas loam, 30 to 65 percent slopes, stony	1.5	3.4%
Subtotals for Soil Survey Area		**3.0**	**6.8%**

Western Riverside Area, California

Legend

Soil Map

Scale (not to scale)

Custom Soil Resource Report
Soil Map

Map Scale: 1:4,270 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 50 100 200 300

Feet
0 200 400 800 1200

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
LpC2	Las Posas fine sandy loam, 5 to 9 percent slopes, eroded	0.7	1.6%
LpD2	Las Posas fine sandy loam, 9 to 15 percent slopes, eroded	0.5	1.3%
LrG	Las Posas loam, 30 to 65 percent slopes, stony	0.4	1.0%
Subtotals for Soil Survey Area		**1.6**	**3.8%**
Totals for Area of Interest		**41.9**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
LaC	Las Posas loam, 2 to 8 percent slopes	8.2	19.5%
LaE3	Las Posas loam, 8 to 25 percent slopes, severely eroded	7.3	17.3%
LkF3	Las Posas rocky loam, 15 to 50 percent slopes, severely eroded	24.8	59.3%
Subtotals for Soil Survey Area		**40.3**	**96.2%**
Totals for Area of Interest		**41.9**	**100.0%**

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