# Understanding Soil Health in California's Annual Rangelands

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# Rangeland Soil Health/Performance Indicators

| Soil Health Indicators | Cause if degraded | Implication |
|---|---|---|
| -Texture | Nature | Everything |
| -Bulk density | Compaction | Degraded root zone |
| -Structure & aggregate stability | Low SOM | Poor surface condition |
| -Soil Organic C | Erosion | Poor fertility & tilth |
| -Infiltration | Many | High runoff & erosion |
| -Plant available water | Erosion & compaction | Reduced productivity |
| -Vegetative cover | Over grazing & climate | Erosion & reduced fertility |

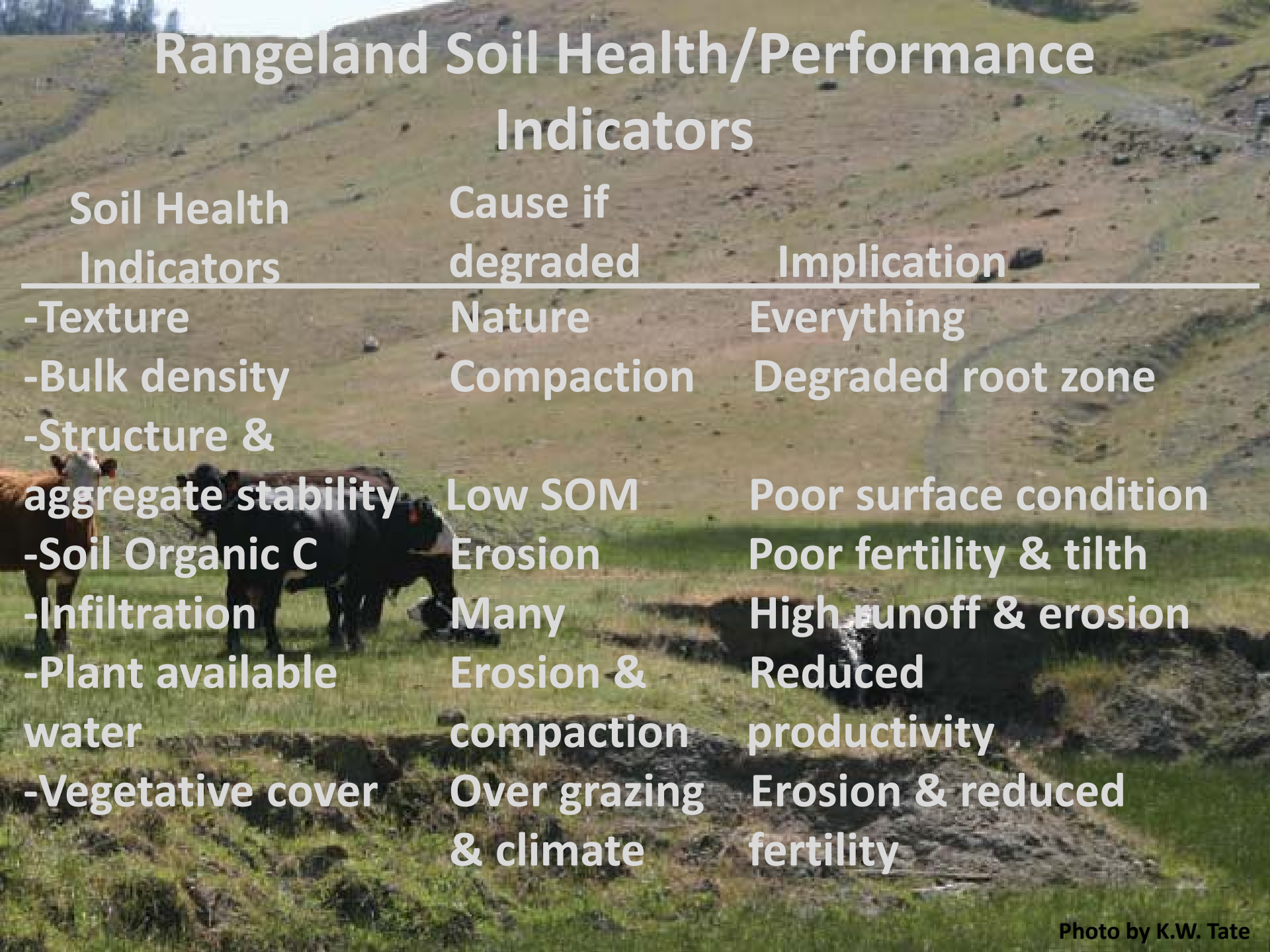
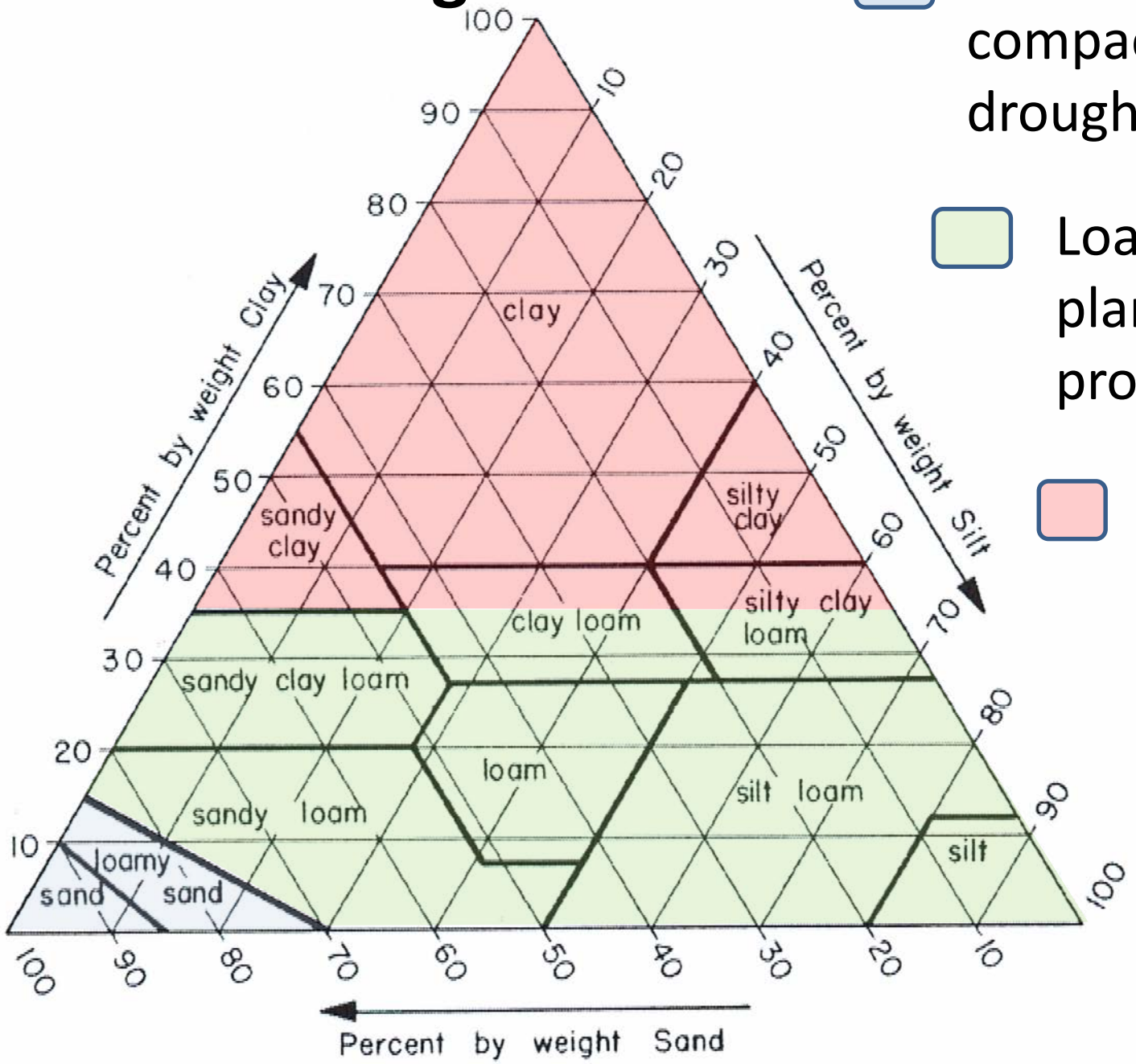


Photo by K.W. Tate

# Textural Triangle



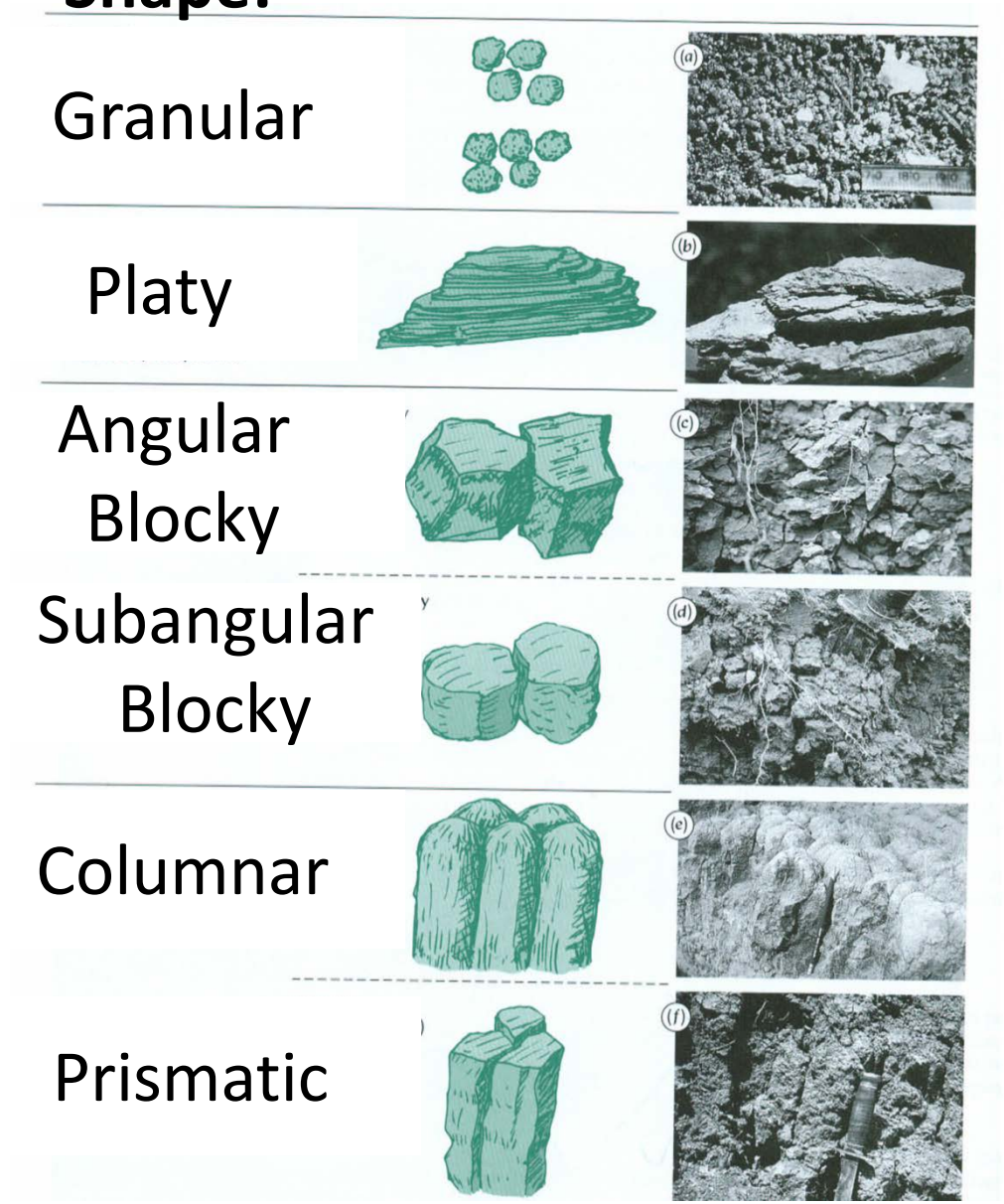

Coarse-resilient to compaction but droughty

Loamy- ideal for plant growth, but prone to erosion

Fine- fertile, but prone to compaction when wet

# Soil Structure

## Shape:




(Brady and Weil, 1999)

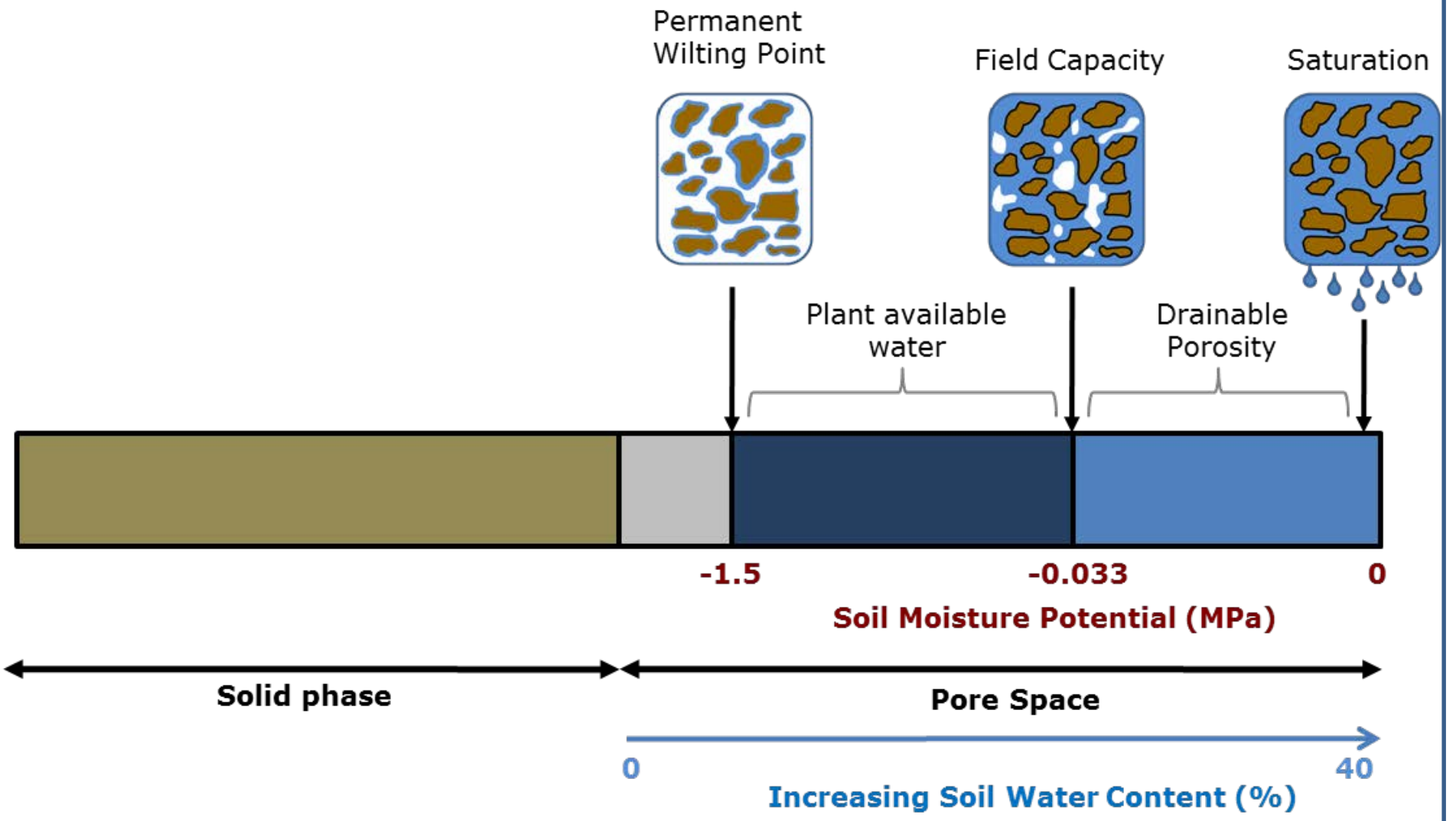
**Soil structure is the aggregation of soil particles into identifiable shapes (aggregates).**

**Grade-degree of aggregation**
**Shape of aggregates**
**Size of aggregates**

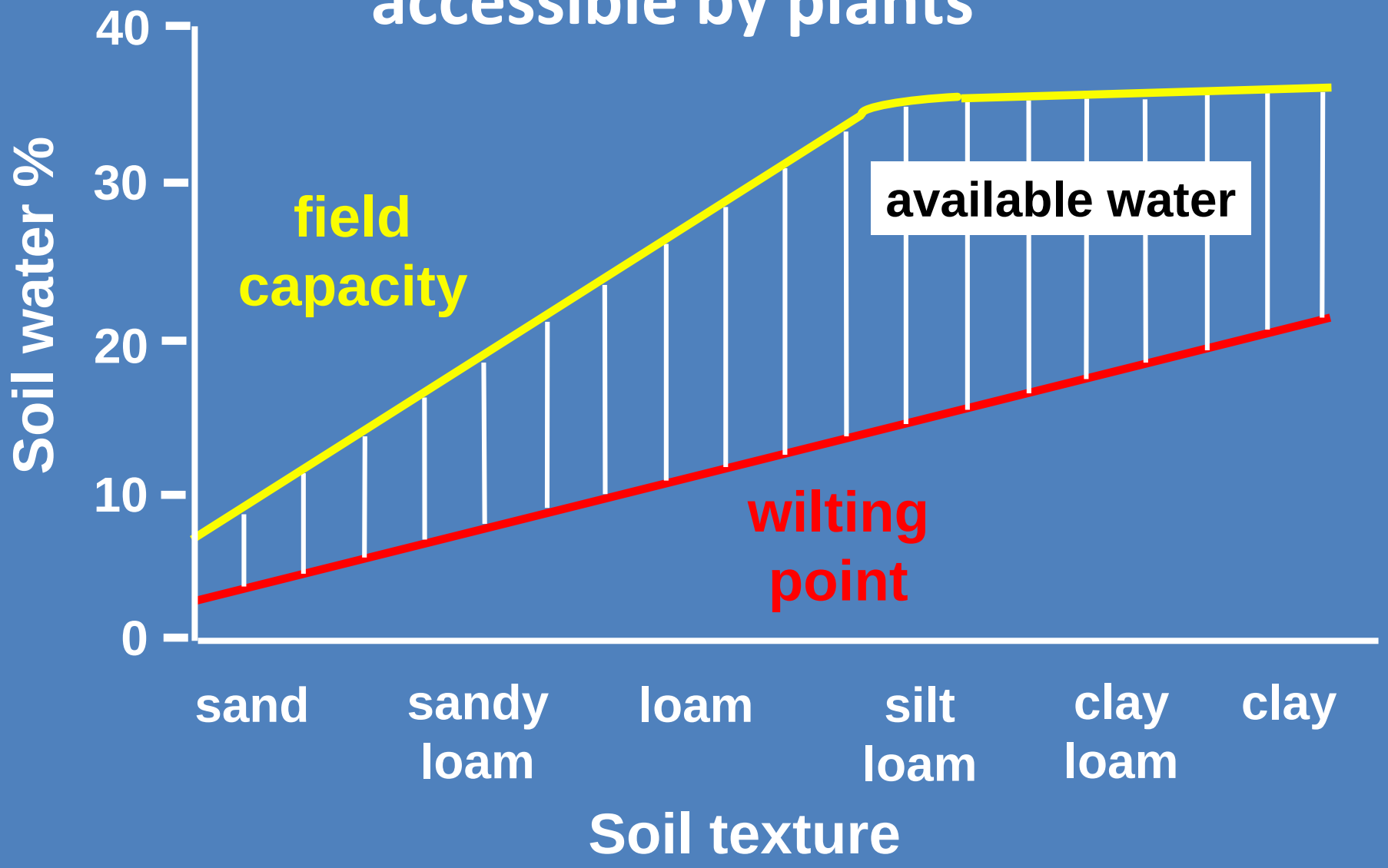
**Consistence- a measure of the ability of soil to resist deformation.** *Which type is best?*

| Moist Consistence | |
|---|---|
| Loose | Soil is non-coherent |
| Very friable | Crushes easily under gentle pressure |
| Friable | Crushes easily under gentle to moderate pressure |
| firm | Crushes under moderate pressure but resistance is noticeable |
| Very firm | Crushes under strong pressure but difficult to crush between thumb and forefinger |
| Extremely firm | Cannot be crushed between thumb and forefingers. |

# Plant Available Water Holding Capacity

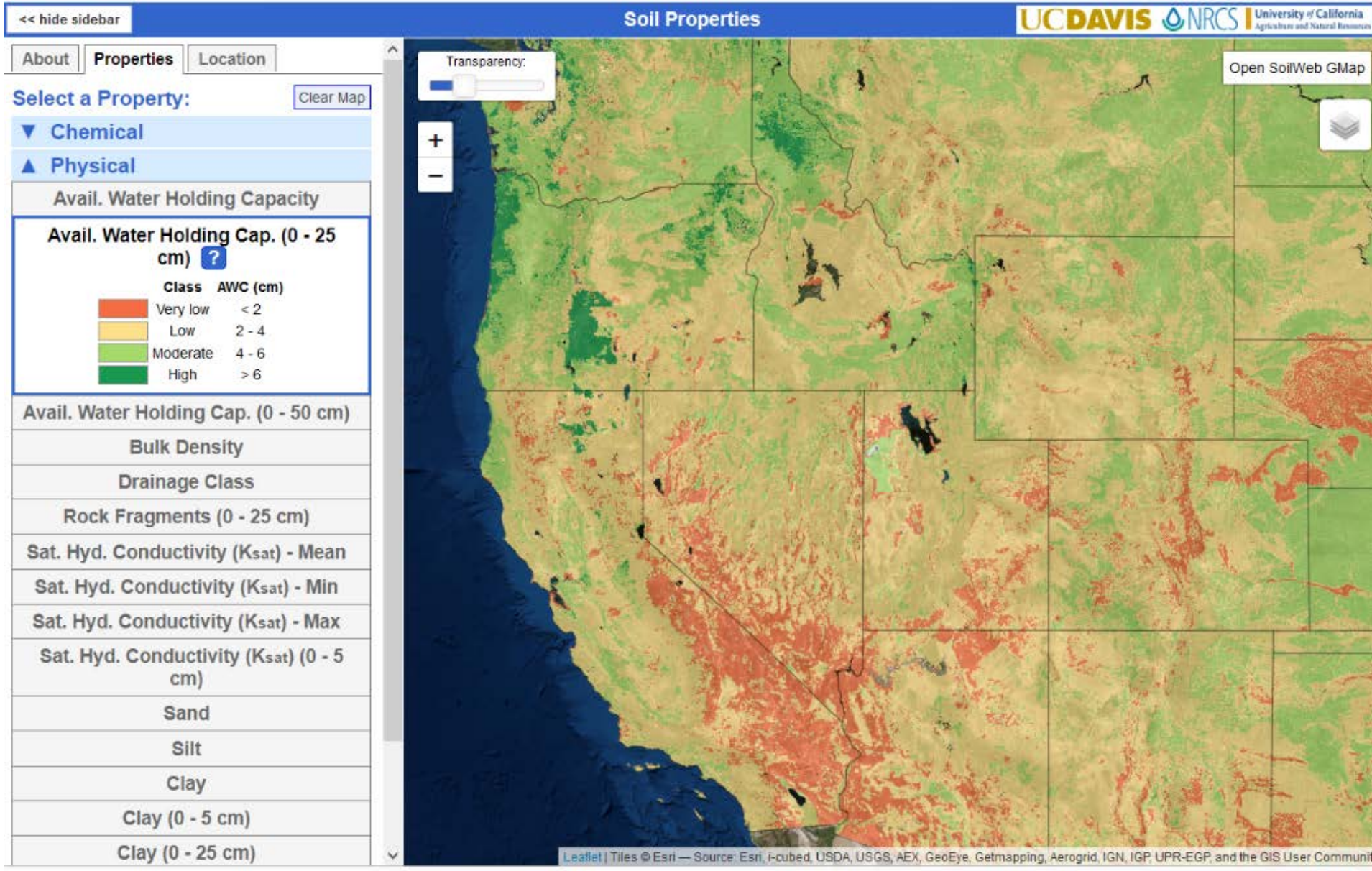


# Plant available water is retained in the soil against the force of gravity yet readily accessible by plants



# Plant available water holding capacity in top 25 cm of soil

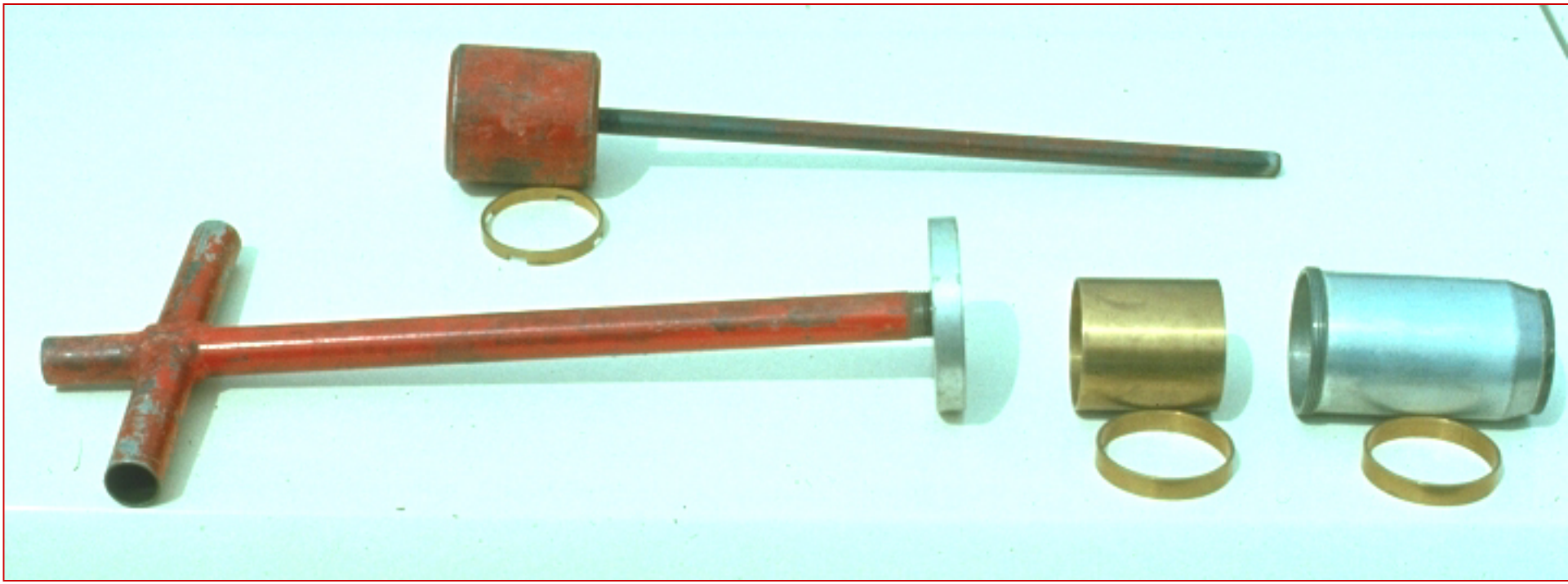
https://casoilresource.lawr.ucdavis.edu/soil-properties/



# Bulk Density

$$\text{Bulk Density (g cm}^{-3}) = \frac{\text{weight of dry soil}}{\text{total volume of core}}$$

Used in mass to volume conversions. Lab analysis units are expressed as a mass. Management uses volumes and area. Also a measure of degree of compaction.



# Interpreting bulk density values

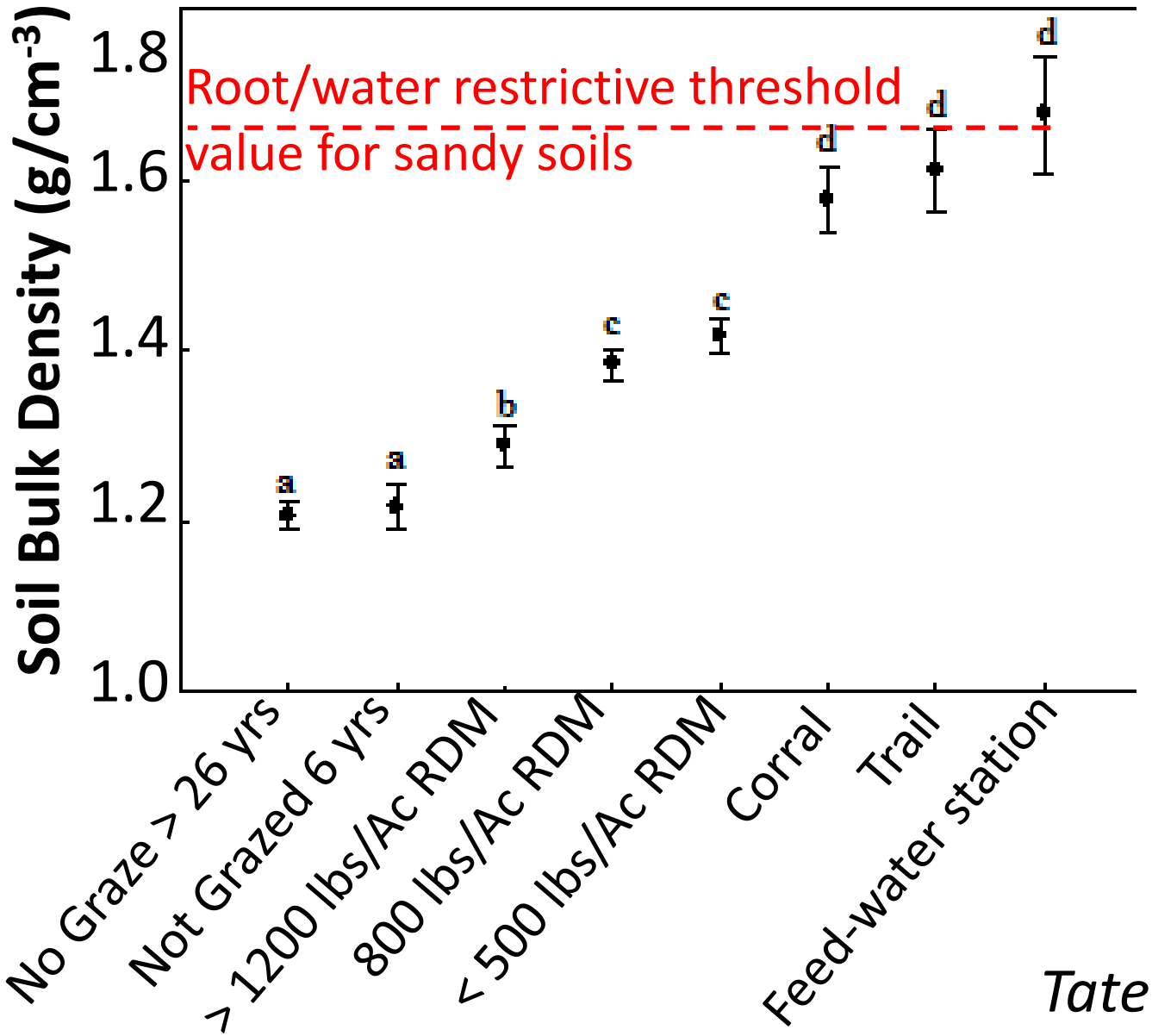
Table 1.—General relationship of soil bulk density to root growth based on soil texture*

| Soil texture | Ideal bulk density for plant growth (grams/cm$^3$) | Bulk density that affects root growth (grams/cm$^3$) | Bulk density that restricts root growth (grams/cm$^3$) |
|---|---|---|---|
| Sand, loamy sand | <1.60 | 1.69 | >1.80 |
| Sandy loam, loam | <1.40 | 1.63 | >1.80 |
| Sandy clay loam, clay loam | <1.40 | 1.60 | >1.75 |
| Silt, silt loam | <1.40 | 1.60 | >1.75 |
| Silt loam, silty clay loam | <1.40 | 1.55 | >1.65 |
| Sandy clay, silty clay, clay loam | <1.10 | 1.49 | >1.58 |
| Clay (>45 percent clay) | <1.10 | 1.39 | >1.47 |

*Does not apply to red clayey soils and volcanic ash soils.

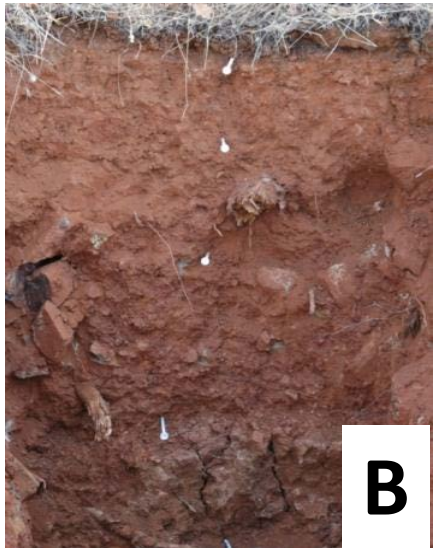
# Effects of grazing on soil compaction

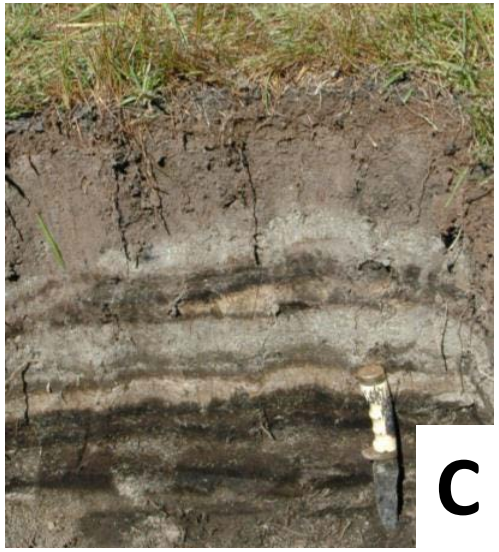
*What is the functional difference?*

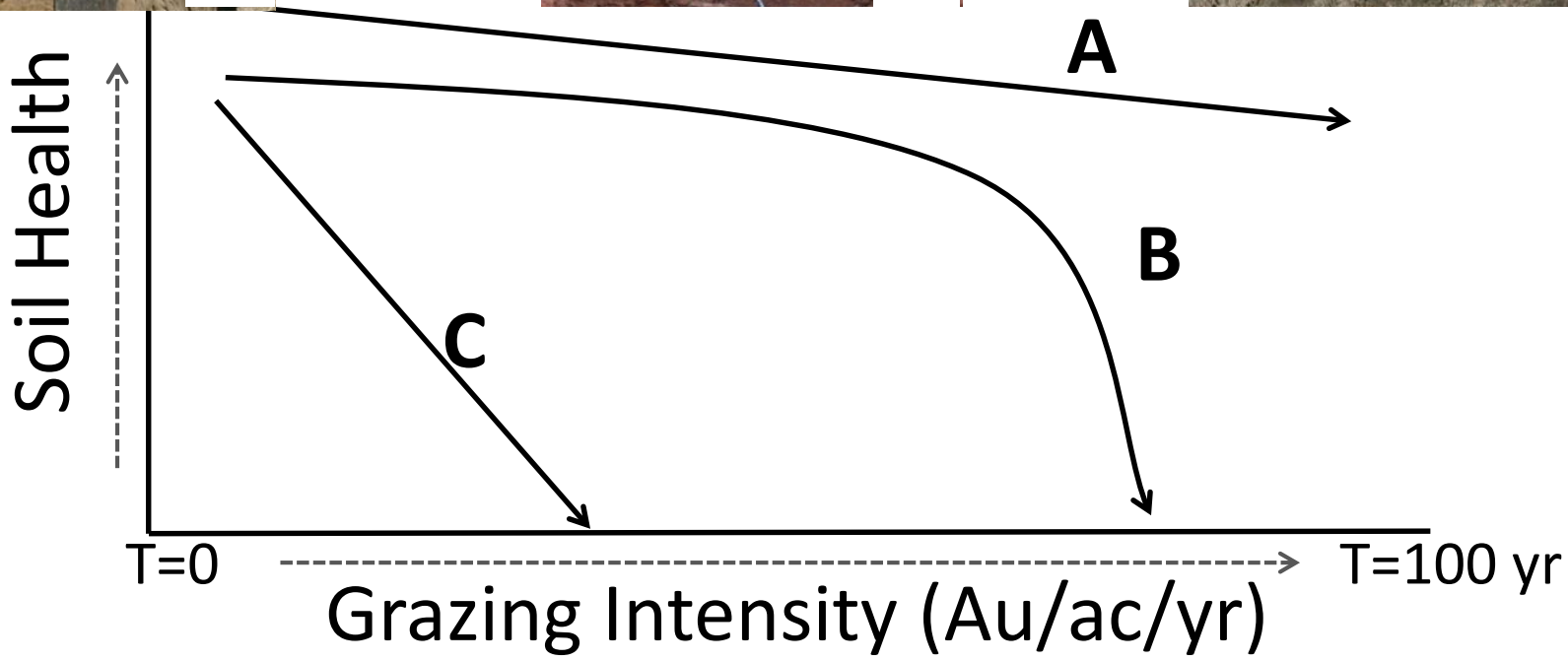



*Tate et al., 2004*

# Need to understand the trajectory of degradation. Not simply a relative change.

# Back-up the indicators with observation

**Rangeland soil with good soil structure $D_b$= 1.4 g $cm^{-3}$**

**Compacted rangeland soil $D_b$= 1.65 g $cm^{-3}$**

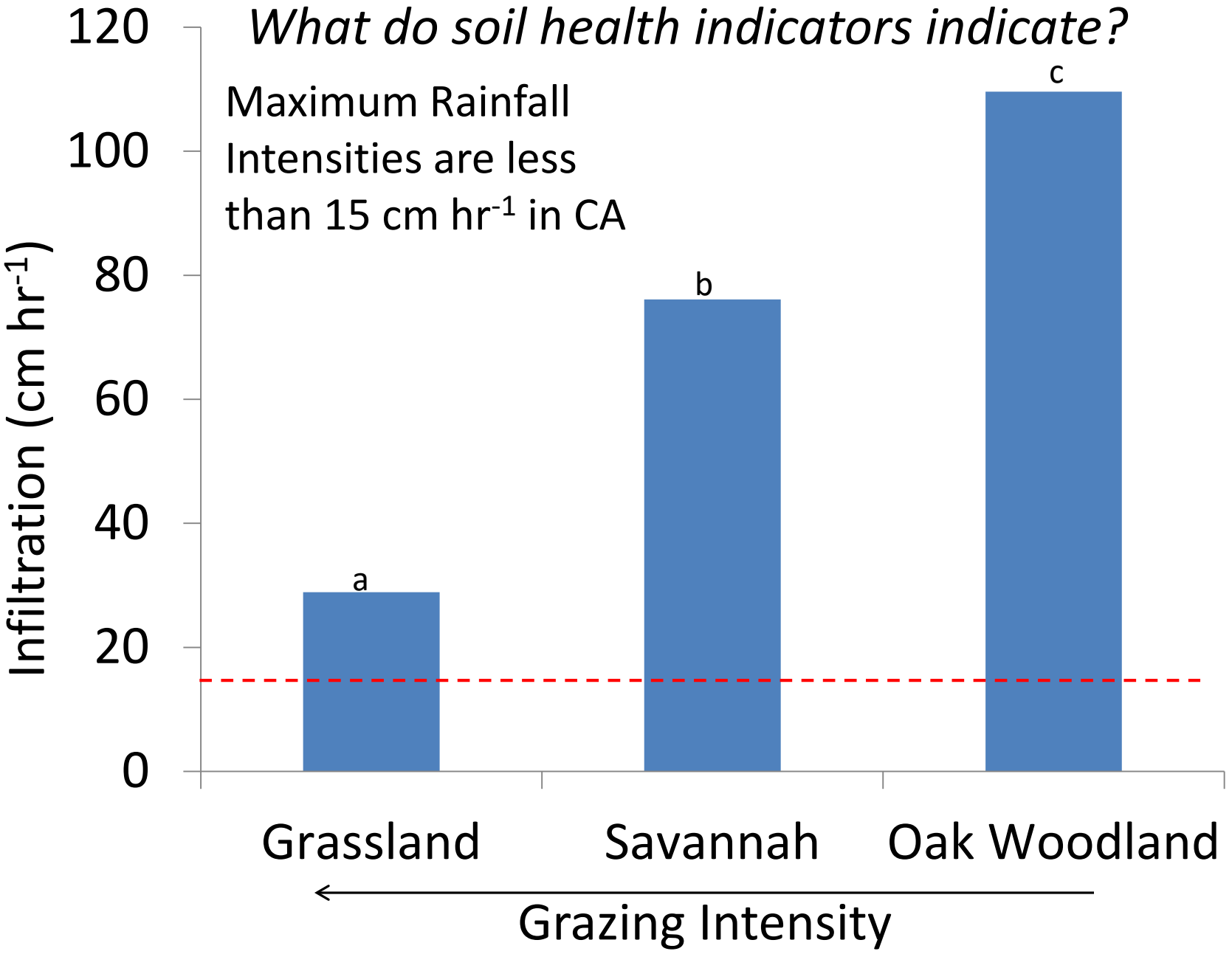
**Link indicators with secondary observations that reflect a condition: diminished structure, abrupt boundary**

# Back-up the indicators

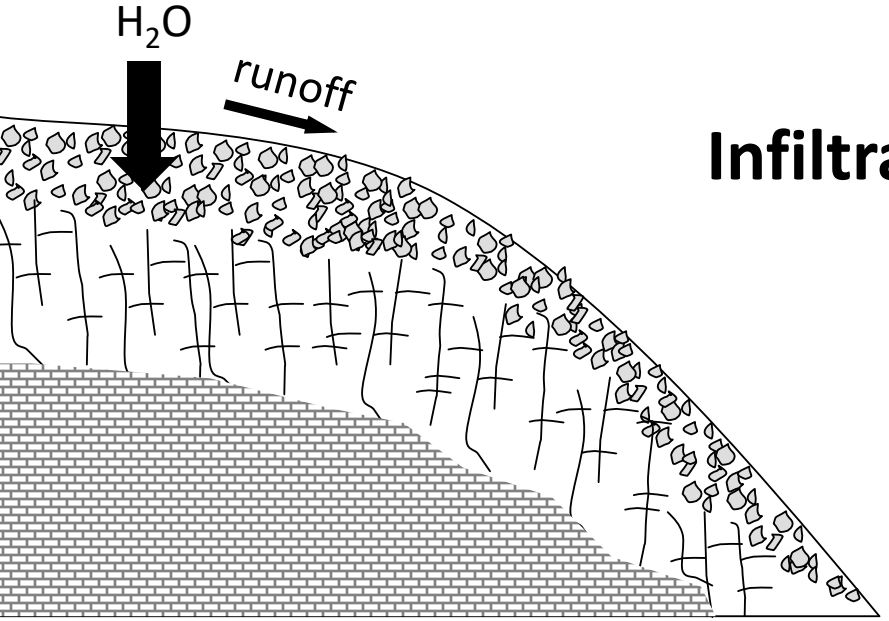
*Redoximorphic features <u>only</u> within the compacted layer*

# Impacts of grazing and oak cover on infiltration

*What do soil health indicators indicate?*



# Runoff Mechanisms: Hortonian overland flow




**Infiltration capacity exceeds rainfall intensity**

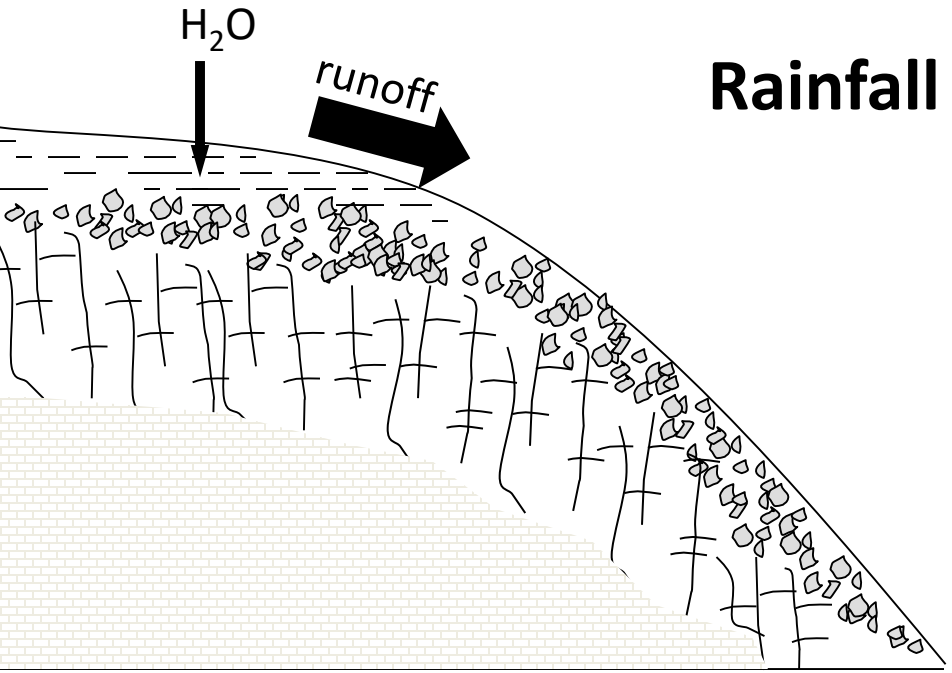
**Low runoff:**

***Good structure***

***Coarse textures***

***High porosity***

***High organic matter***




**Rainfall intensity exceeds infiltration capacity**

**High runoff:**

***Poor structure***

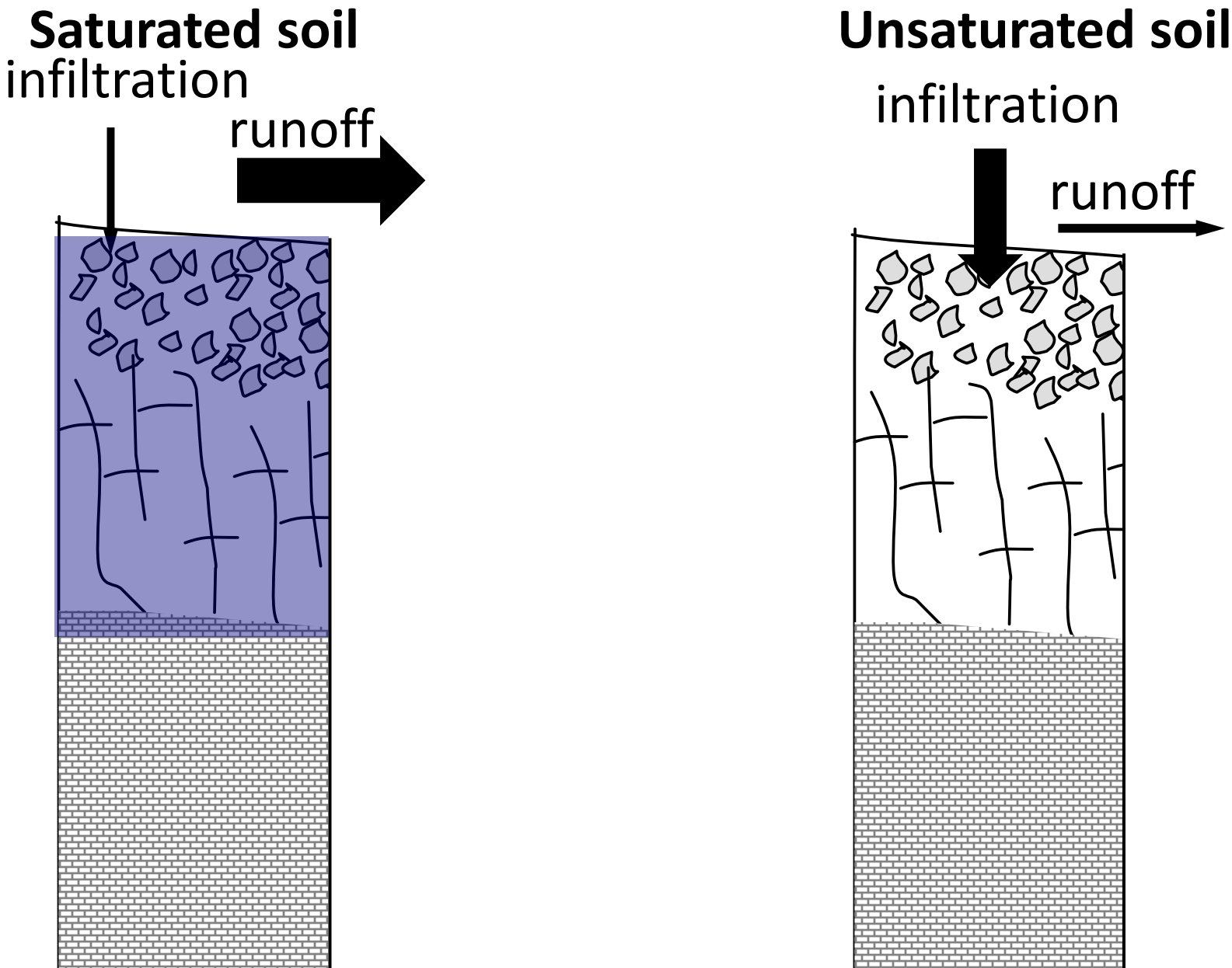
***Compaction***

***Fine textures***

***Low porosity***

***Low organic matter***

# Runoff Mechanisms: Saturated overland flow



# Soil Erosion

Warning signs:

Low cover, low RDM

Evidence of sediment transport: channels, gullies, areas of sediment accumulation on soil surface

Degradation of soil structure, compaction

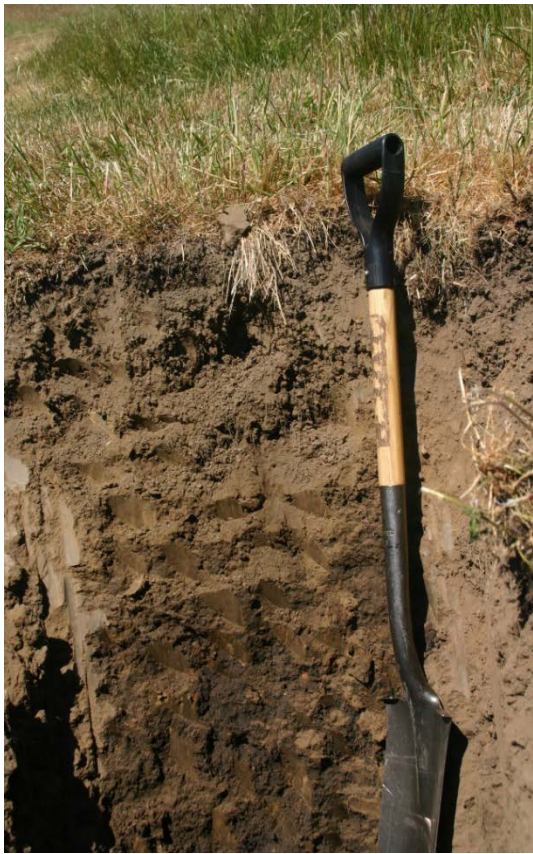
Solutions: maintain RDM recommendations; encourage widespread utilization of ranch area, prescribed grazing

# Soil Organic Matter (SOM)

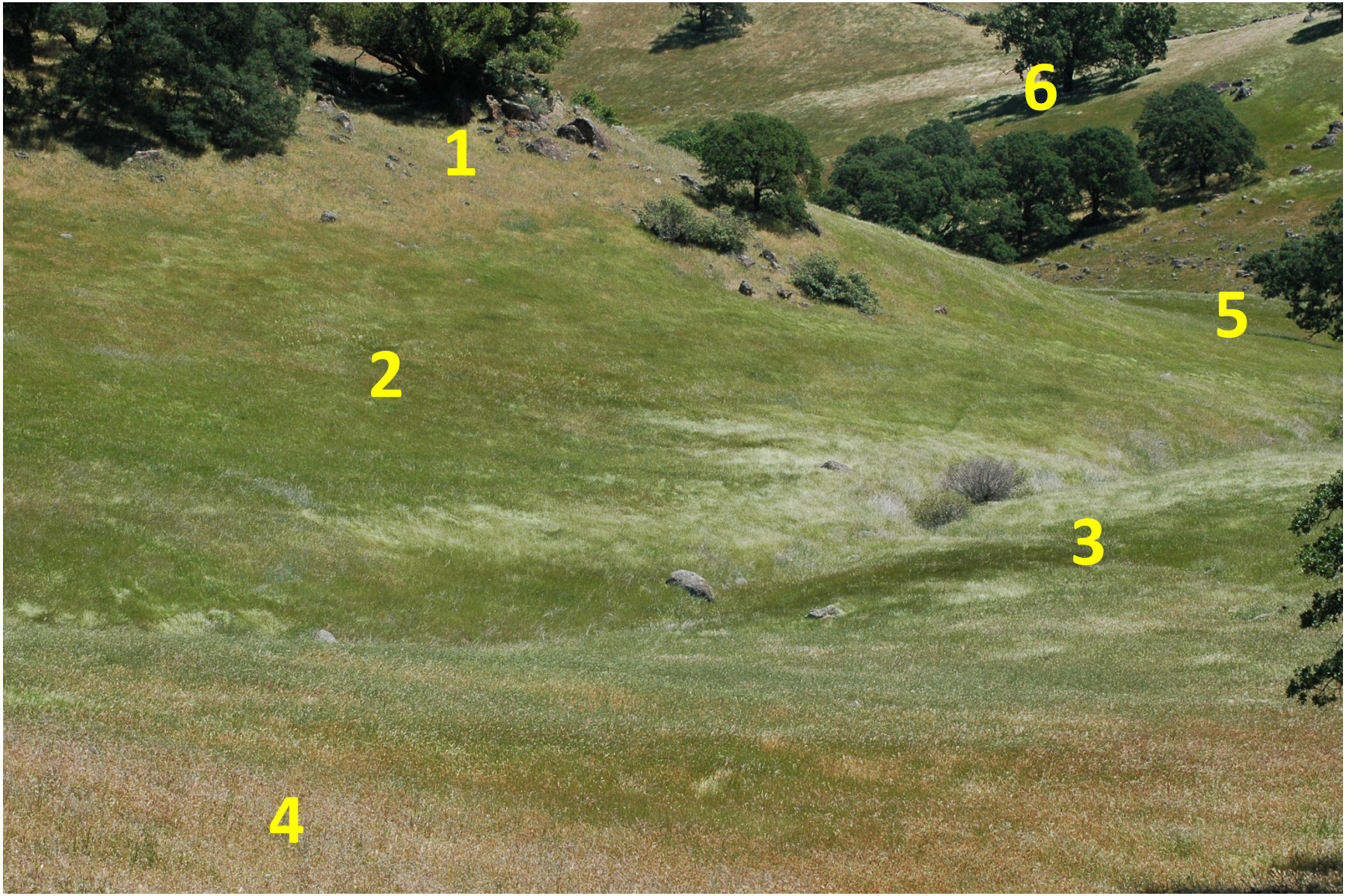
**Depends on climate, topography, and soil texture, drainage**

**Few if any range management tools available to increase SOM**

**Semi-arid & arid climates limit SOM build up, must maintain higher biomass inputs <u>continuously</u> to increase SOM**

# Soil variability in rangelands



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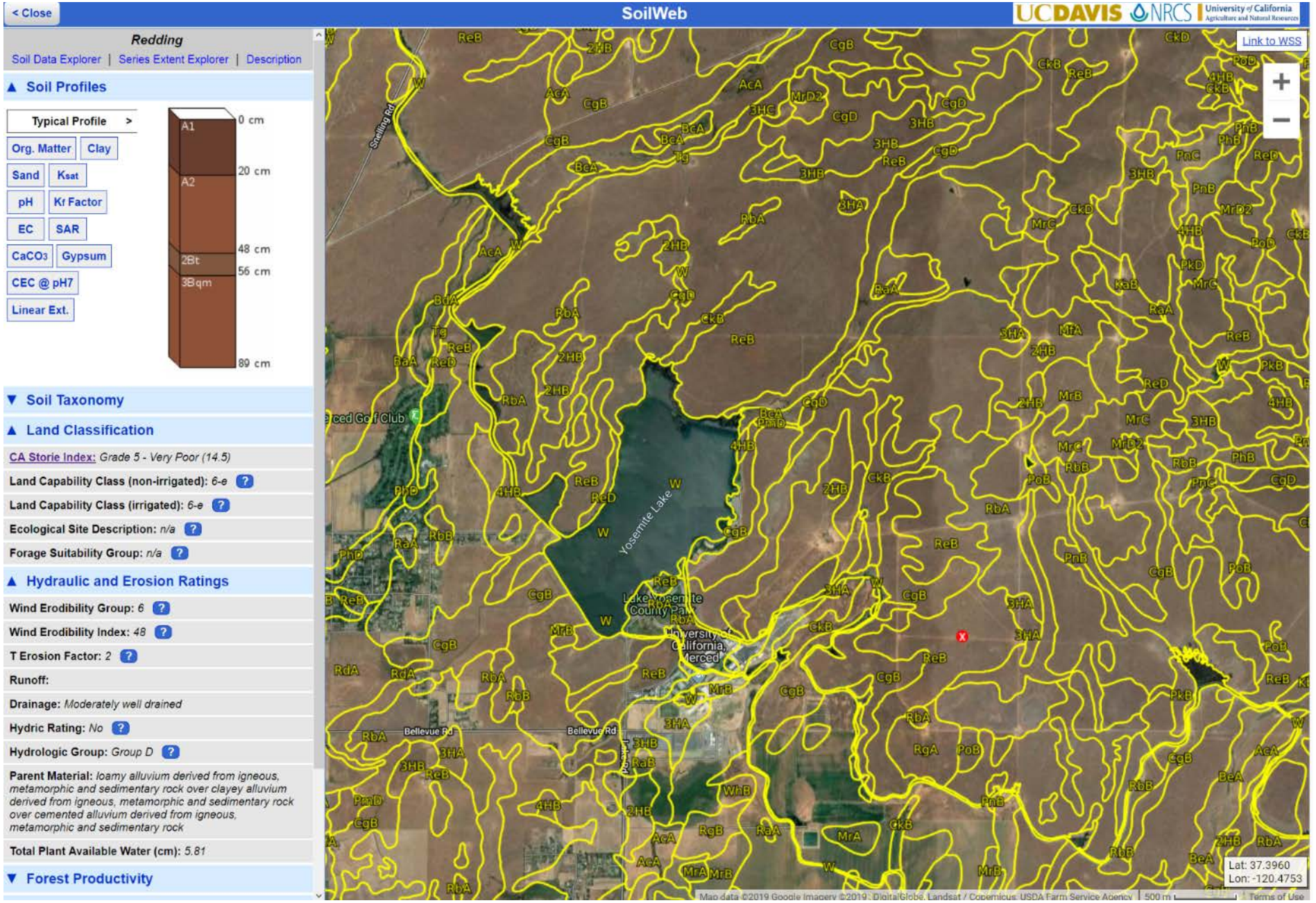
# https://casoilresource.lawr.ucdavis.edu/gmap/



< Close

SoilWeb

UCDAVIS NRCS University of California Agriculture and Natural Resources

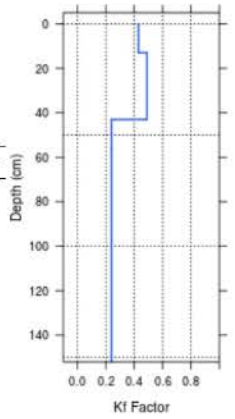
Link to WSS

## Redding

Soil Data Explorer | Series Extent Explorer | Description

### ▲ Soil Profiles

Typical Profile | Org. Matter | Clay | Sand | Ksat | pH | Kf Factor ? > | EC | SAR | CaCO3 | Gypsum | CEC @ pH7 | Linear Ext.




View Source Data


### ▼ Soil Taxonomy

### ▲ Land Classification

CA Storie Index: *Grade 5 - Very Poor (14*

Land Capability Class (non-irrigated): *6*

Land Capability Class (irrigated): *6-e*

Ecological Site Description: *n/a* ?

Forage Suitability Group: *n/a* ?

### ▲ Hydraulic and Erosion Rating

Wind Erodibility Group: *6* ?

Wind Erodibility Index: *48* ?

T Erosion Factor: *2* ?

Runoff:

Drainage: *Moderately well drained*

Hydric Rating: *No* ?

Hydrologic Group: *Group D* ?

Parent Material: *loamy alluvium derived from igneous, metamorphic and sedimentary rock over clayey alluvium derived from igneous, metamorphic and sedimentary rock over cemented alluvium derived from igneous, metamorphic and sedimentary rock*

Total Plant Available Water (cm): *5.81*

| Depth Range (cm) | Horizon Designation | Percent Clay | Percent Sand | Percent Organic Matter | pH by water Extraction | Sat. Hydraulic Conductivity (mm/hr) | EC (dS/m) | SAR (%) | Carbonates (% of < 2 mm) | Gypsum (% of < 20 mm) | CEC at pH 7 (cmol charge / kg soil) | K Factor | LEP | Oven-Dry $D_b$ (g/cm$^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 - 13 | Ap | 14 | 38 | 3.52 | 5.5 | 32.4 | 0.3 | 0 | 0 | 0 | | .43 | 0.5 | 1.2 |
| 13 - 43 | BA | 17 | 36 | 0.93 | 5.8 | 32.4 | 0.3 | 0 | 0 | 0 | 9.1 | .49 | 0.9 | 1.76 |
| 43 - 56 | 2Bt | 50 | 25 | 0.4 | 6.5 | 0.774 | 0.3 | 0 | 0 | 0 | 26.1 | .24 | 5.5 | 1.63 |
| 56 - 152 | 2Btqm | 26 | 60.1 | 0.31 | 5.5 | 0.036 | 0.2 | 0 | 0 | 0 | | .24 | 1.4 | 1.63 |

All Horizon Data

USDA United States Department of Agriculture
Natural Resources Conservation Service

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START WSS

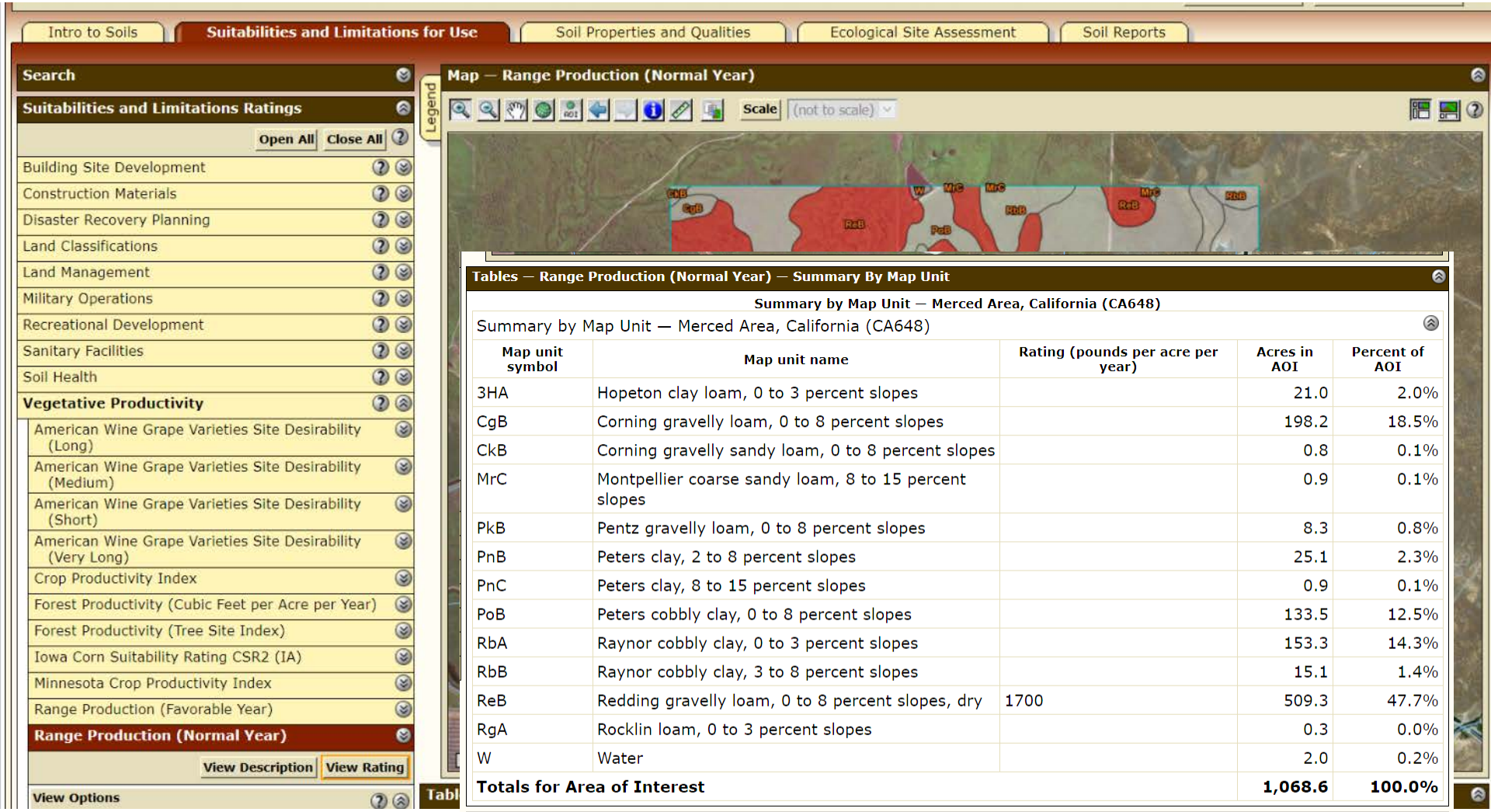
## Welcome to Web Soil Survey (WSS)

Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation's counties and anticipates having 100 percent in the near

**I Want To...**

- **Start Web Soil Survey (WSS)**
- **Know Web Soil Survey Requirements**
- **Know Web Soil Survey operation hours**
- **Find what areas of the U.S. have soil data**
- **Find information by topic**
- **Know how to hyperlink from other documents to Web Soil**

# Range Productivity



# Thank You

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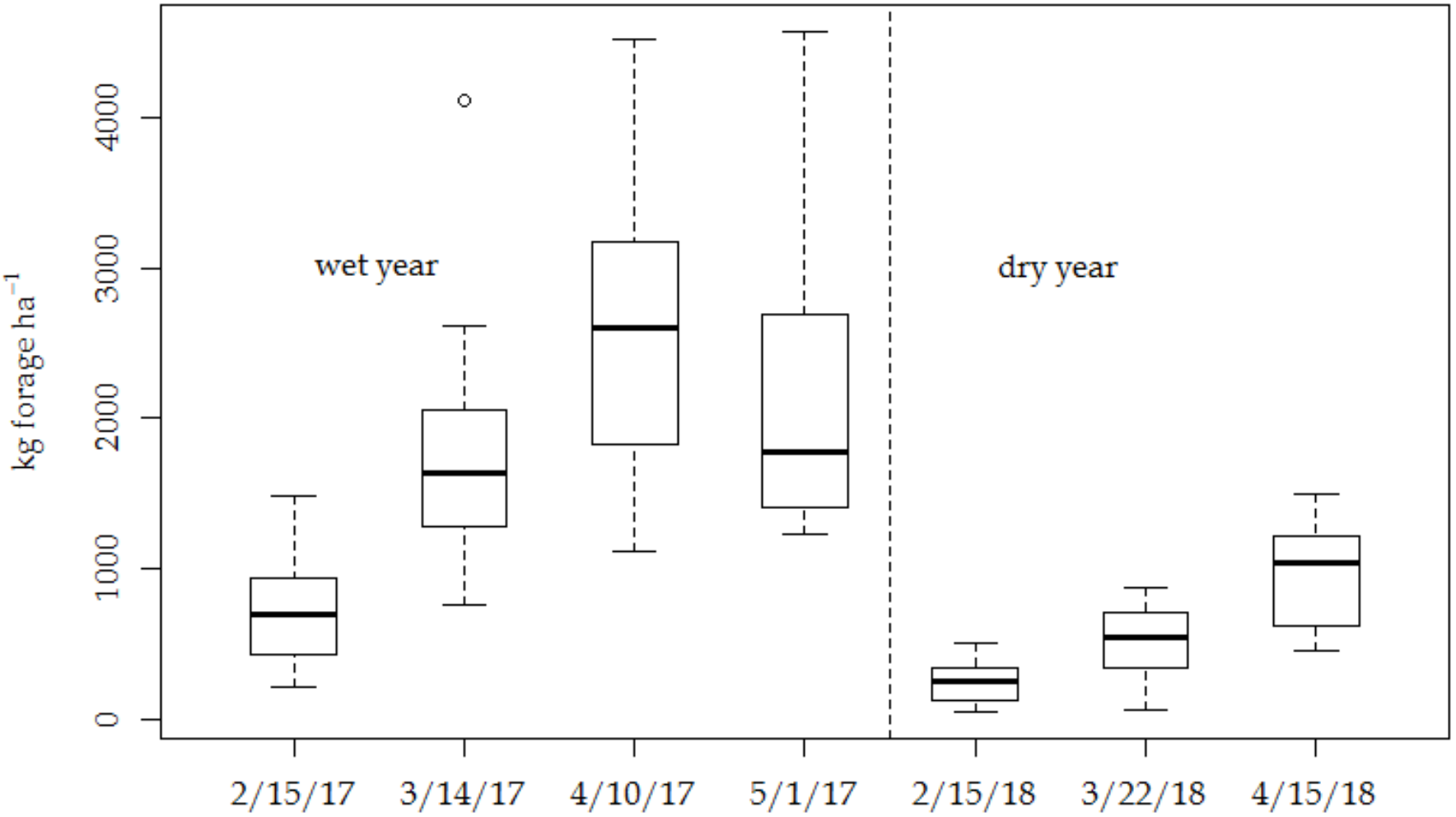
# *Is managing for healthy soils always compatible with other management goals?*

***Do "unhealthy" soils give rise to more landscape scale biodiversity?***

***Do practices that promote soil organic matter correspond with long-term productivity increases?***

***Are healthier soils more or less resilient to weed infestation?***

# Forage productivity at a site in San Luis Obispo County, 2017 & 2018



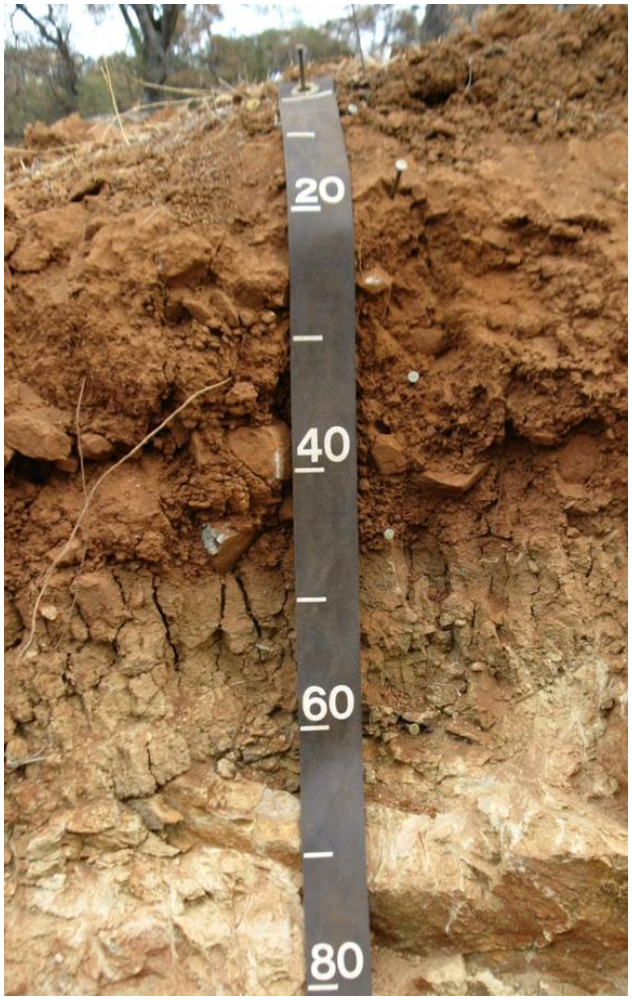
# Southern Sierra Foothills

## Infiltration (cm/hr)

## Aggregate Stability

# Northern Foothill Region

## Plant Available Water



## Plant Available Phosphorus

# Northern Coast Range

Soil Organic Carbon (%)

Foot slope ← Summit

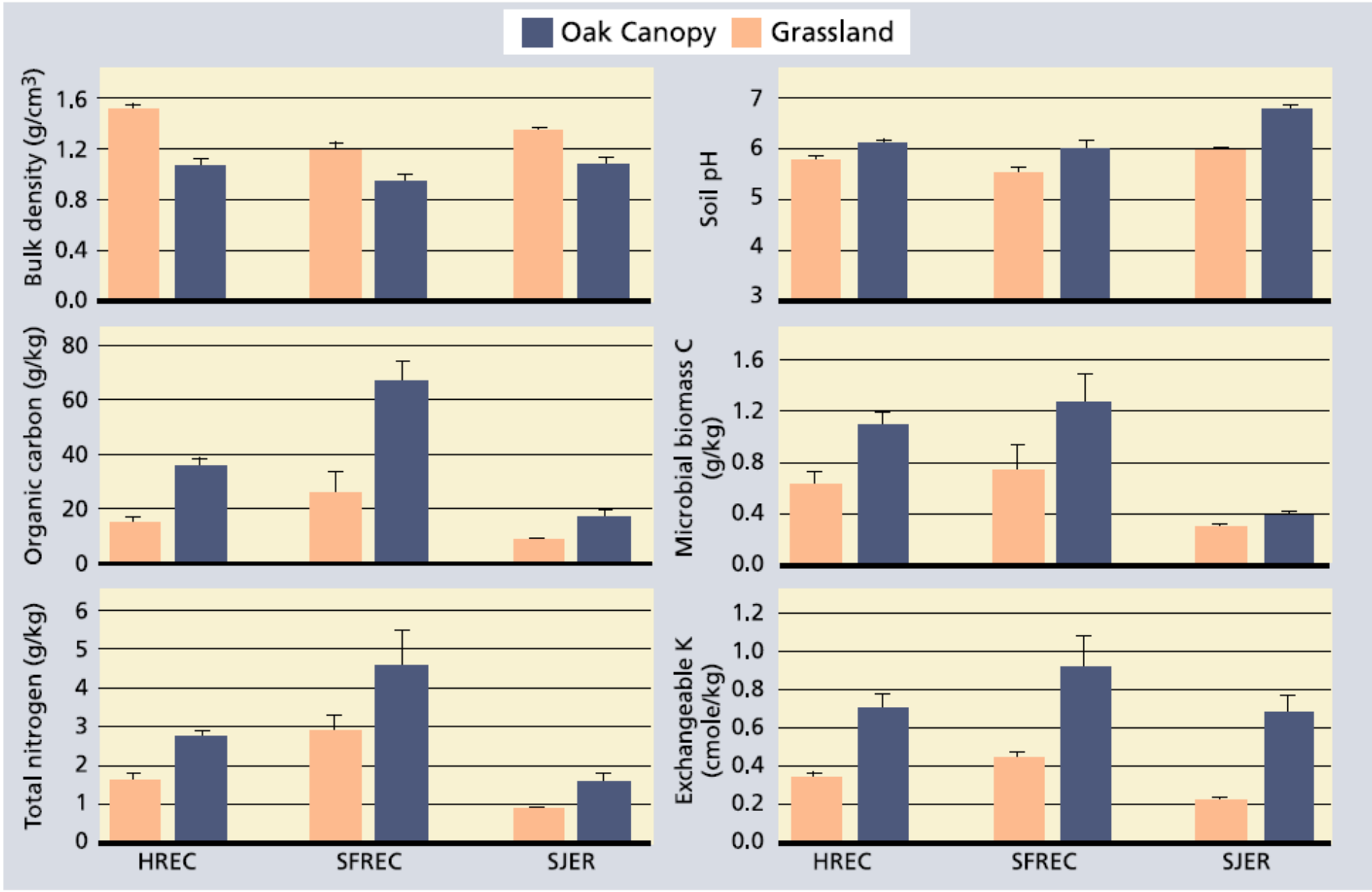
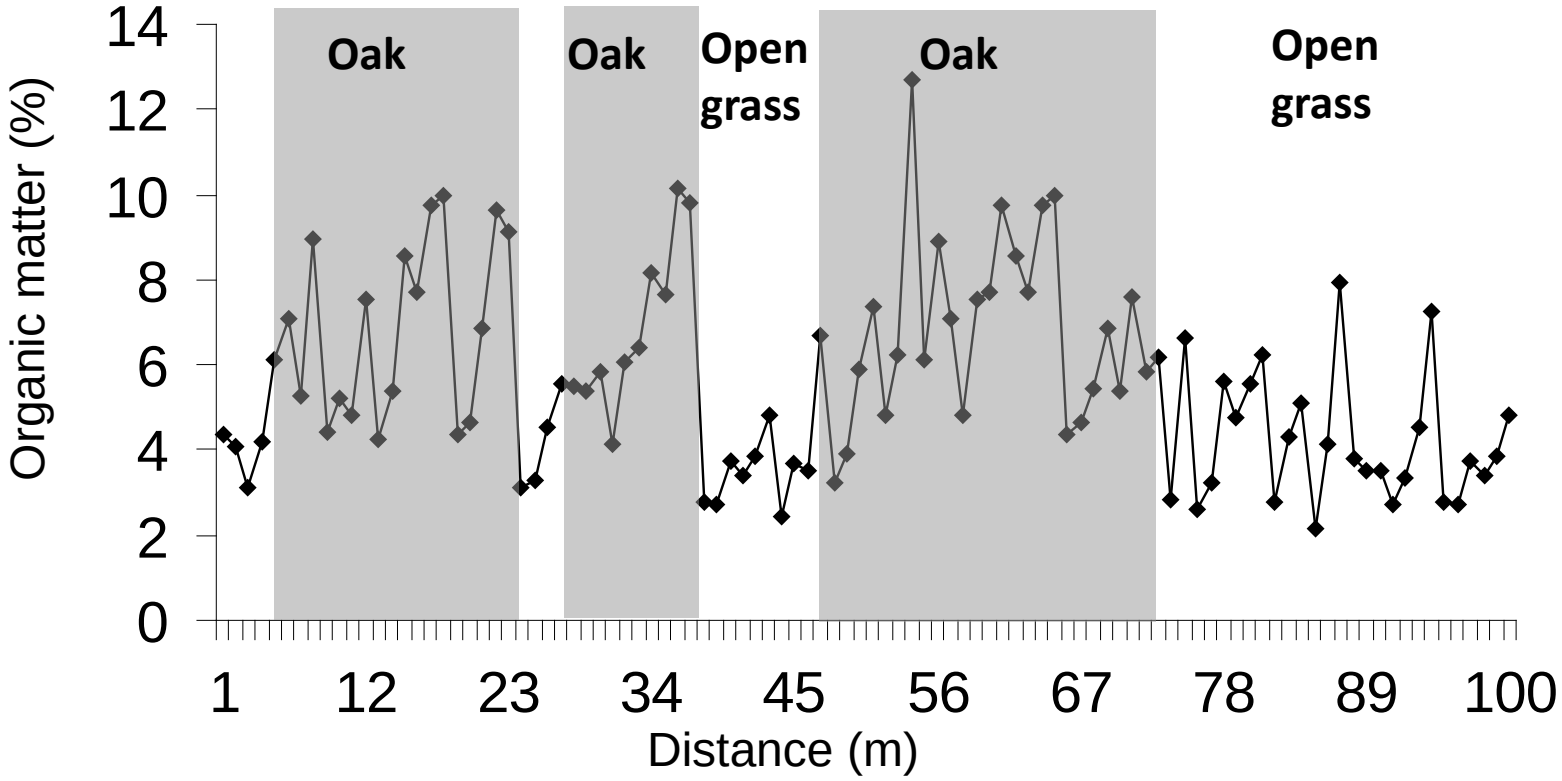



**Fig. 1. Selected soil quality and fertility parameters (mean ± standard error; n = 5) for the 0-to-2-inch- (0-to-5 cm-) depth increment of soils beneath the oak canopy and adjacent**

**Soil organic carbon (top 5 cm) along a 100-m transect of an oak woodland/annual grassland.**

**Grass: 4.0±1.3% OM**

**Oak: 6.9±2.1% OM**




Shaded regions = soils under oak canopy; un-shaded = open grassland