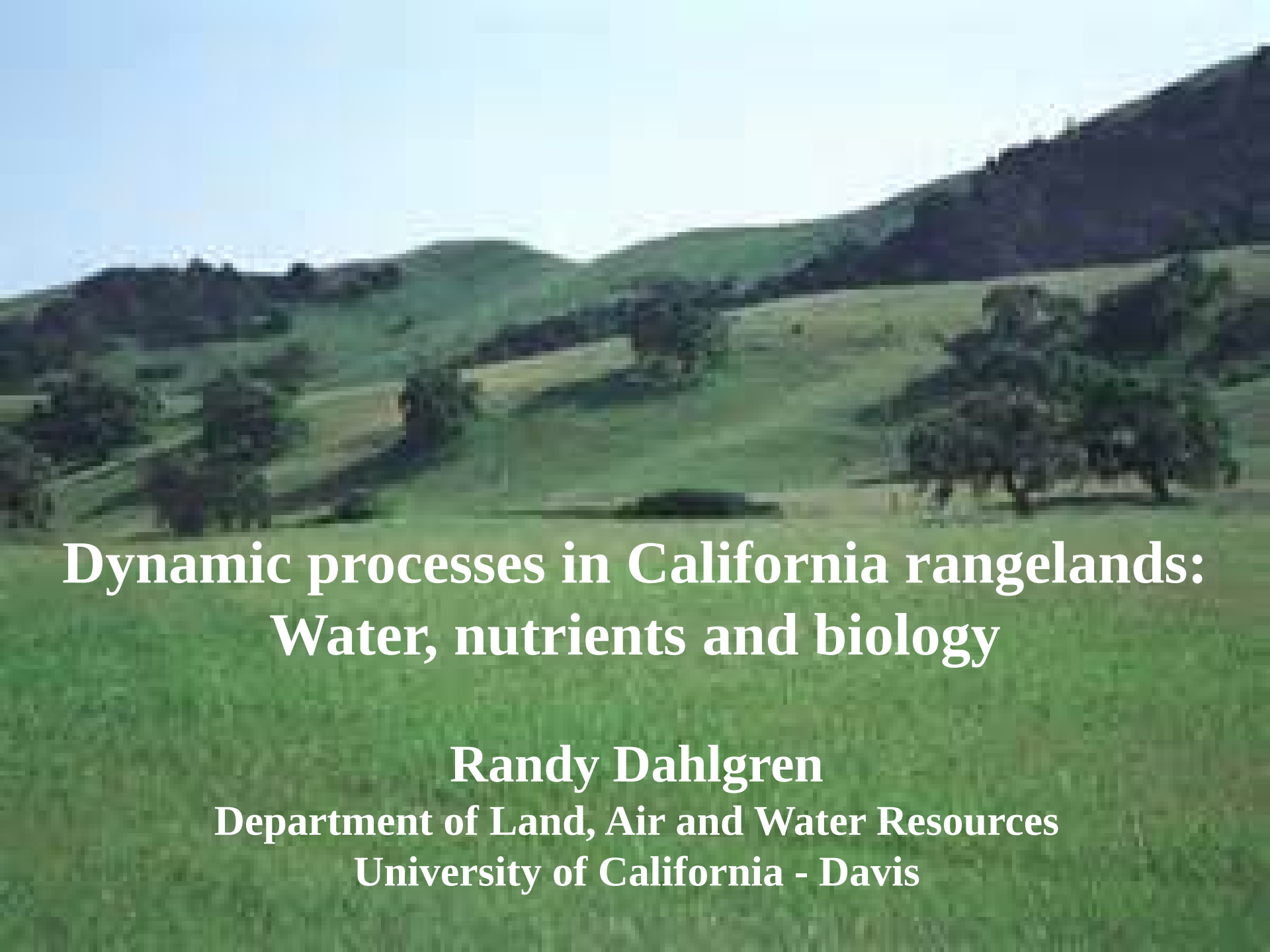
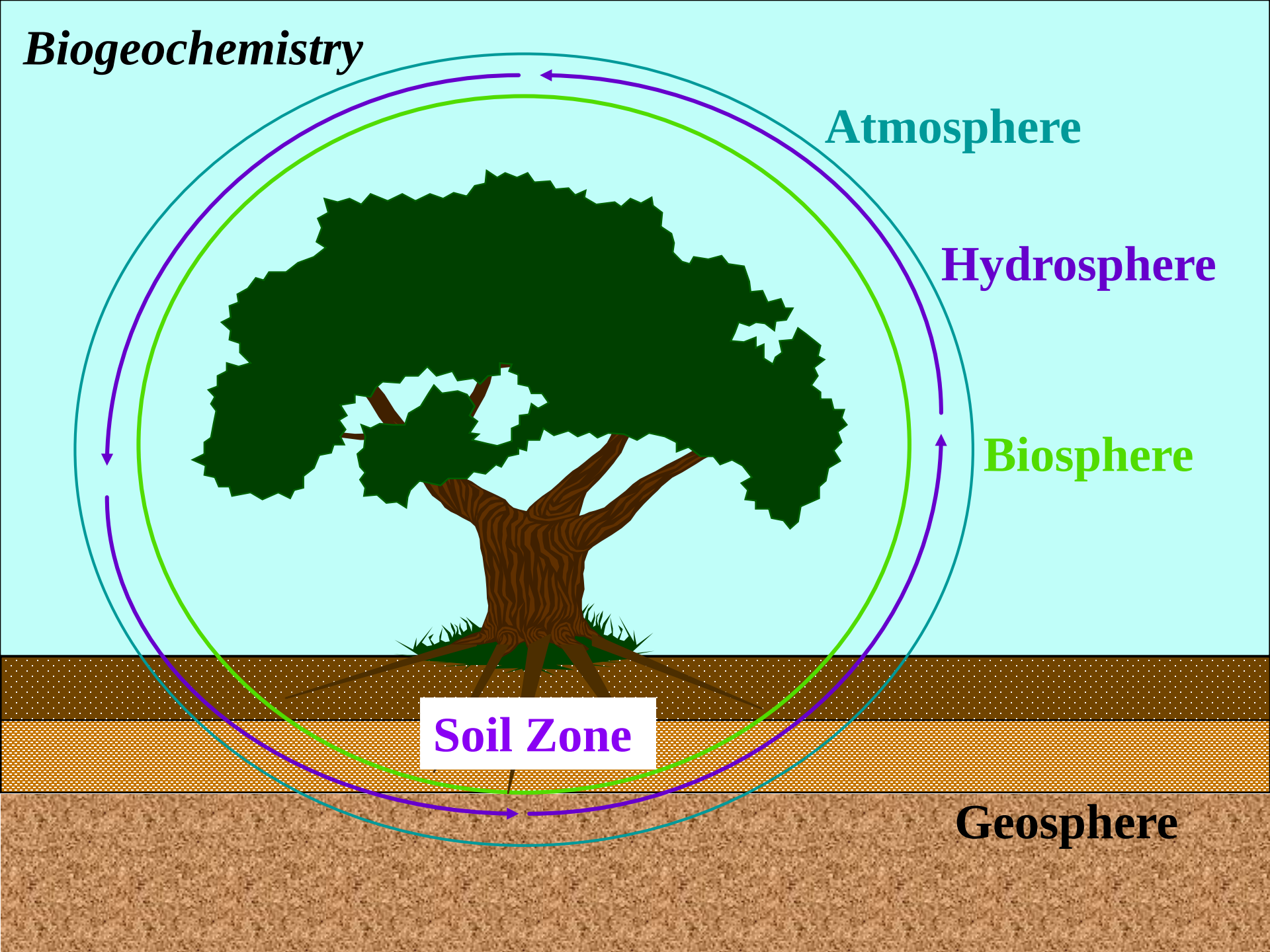
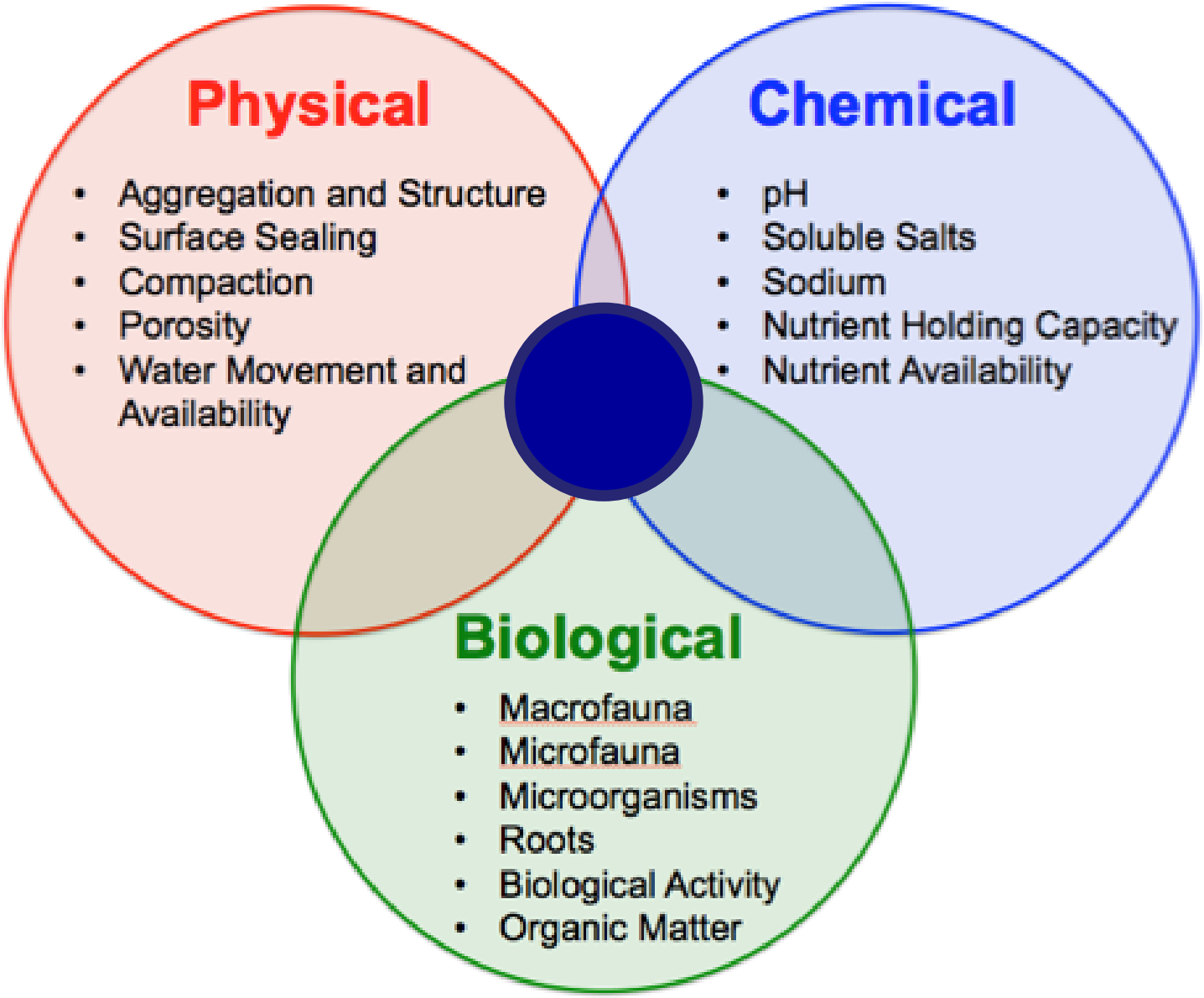


Dynamic processes in California rangelands: Water, nutrients and biology

Randy Dahlgren
Department of Land, Air and Water Resources
University of California - Davis


Biogeochemistry
Atmosphere
Hydrosphere
Biosphere
Soil Zone
Geosphere



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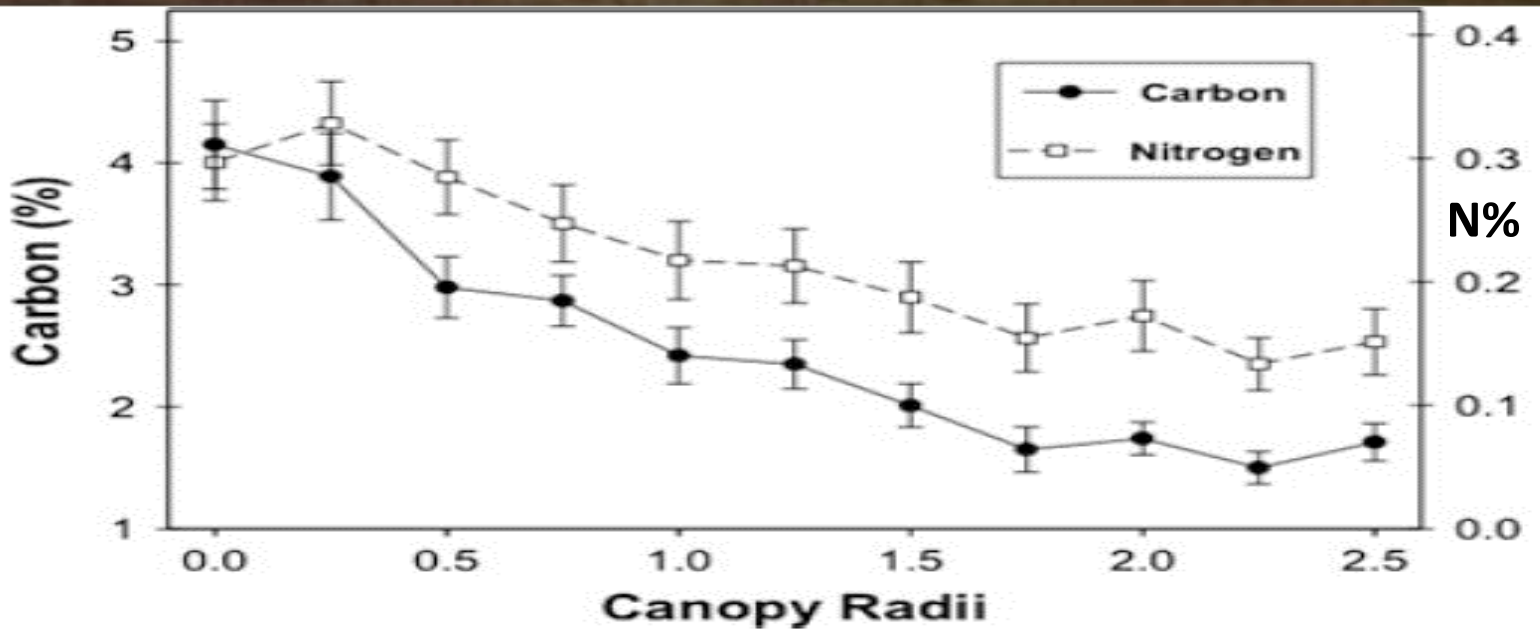
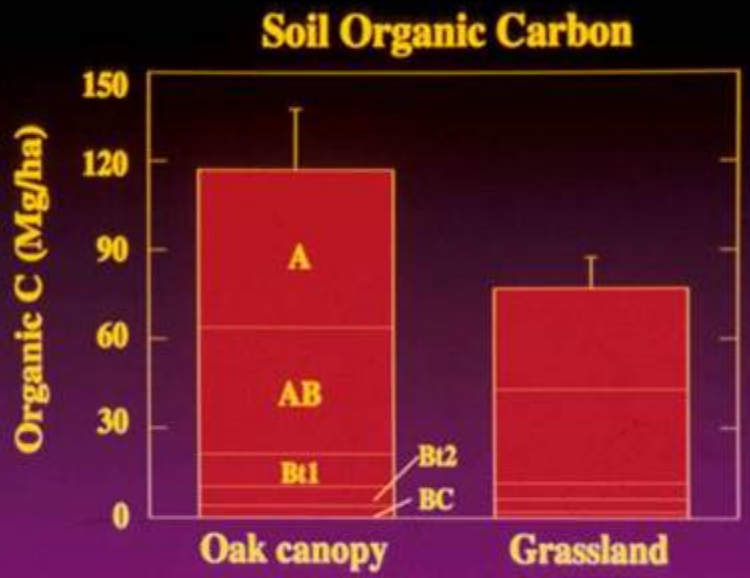
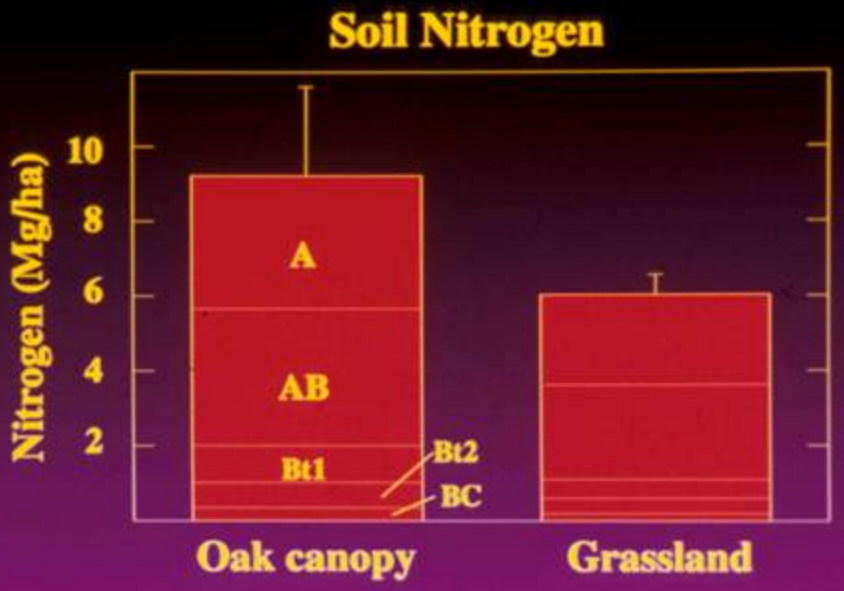
Oak trees create "Islands of Soil Fertility"


Carbon
Nitrogen
Carbon (%)
N%
Canopy Radii
5
4
3
2
1
0.4
0.3
0.2
0.1
0.0
0.0
0.5
1.0
1.5
2.0
2.5



Organic Matter & Nutrient Enrichment Occurs beneath Oak Canopy

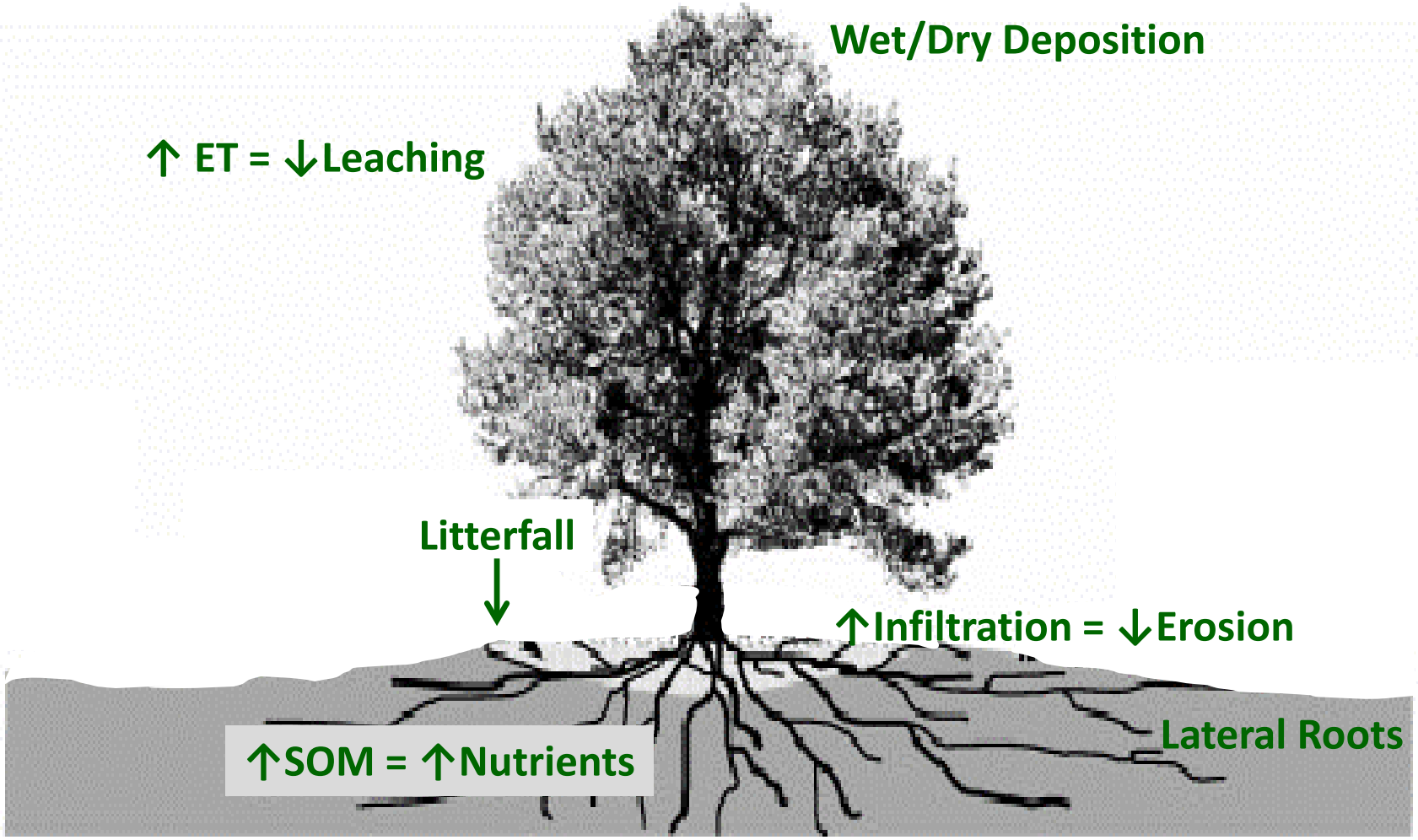


Blue Oak Canopy vs Grassland Soil Properties

Table 4.3 Mean (±standard deviation) for selected soil properties for non-grazed soils beneath the oak canopy compared to soils in open grasslands on basic metavolcanic (greenstone) bedrock in the Sierra Nevada foothills of northern California (Dahlgren et al. 1997)

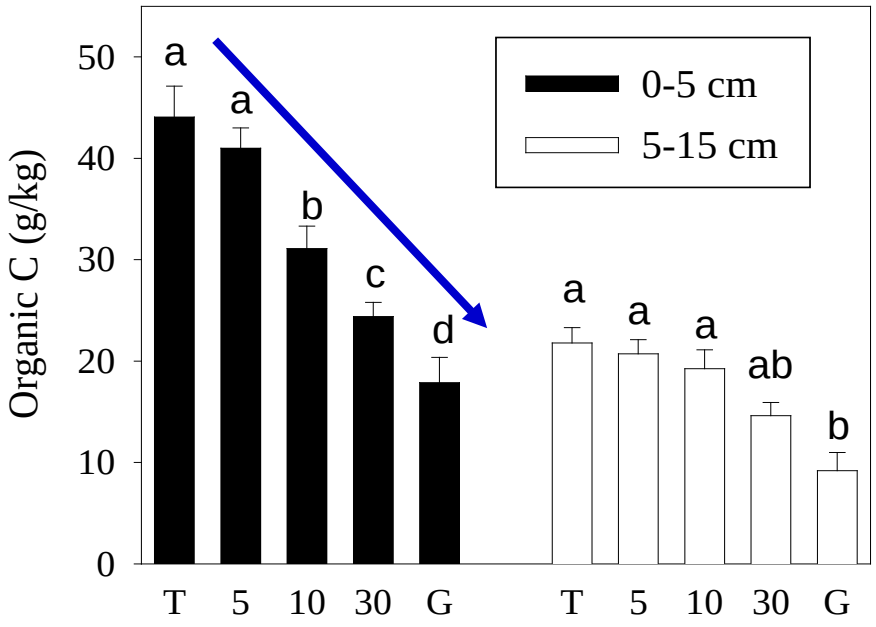
Soil property	Oak canopy soil	Grassland soil
A horizon thickness (cm)	12.1 (2.4)	8.4 (2.1)
Bulk density (g cm^{-3})	0.92 (0.08)	1.12 (0.04)
Infiltration rate (cm hr^{-1})	10.4 (2.9)	6.9 (1.2)
pH (H_2O)	7.16 (0.15)	6.44 (0.15)
Organic C (g kg^{-1})	66.0 (8.3)	40.9 (4.1)
Total N (g kg^{-1})	4.44 (0.88)	2.98 (0.45)
C/N ratio (atomic)	17.5 (1.3)	16.2 (1.6)
Microbial biomass C (g kg^{-1})	1.25 (0.21)	0.78 (0.26)
TP (mg kg^{-1})	718 (204)	406 (71)
Available P (Bray—mg kg^{-1})	39.8 (14.1)	11.8 (3.0)
Exchangeable Ca ($cmol_c kg^{-1}$)	16.8 (1.9)	7.9 (1.0)
Exchangeable Mg ($cmol_c kg^{-1}$)	3.0 (0.3)	2.1 (0.5)
Exchangeable K ($cmol_c kg^{-1}$)	0.91 (0.39)	0.44 (0.07)
Base saturation (%)	71.8 (8.4)	50.9 (9.2)

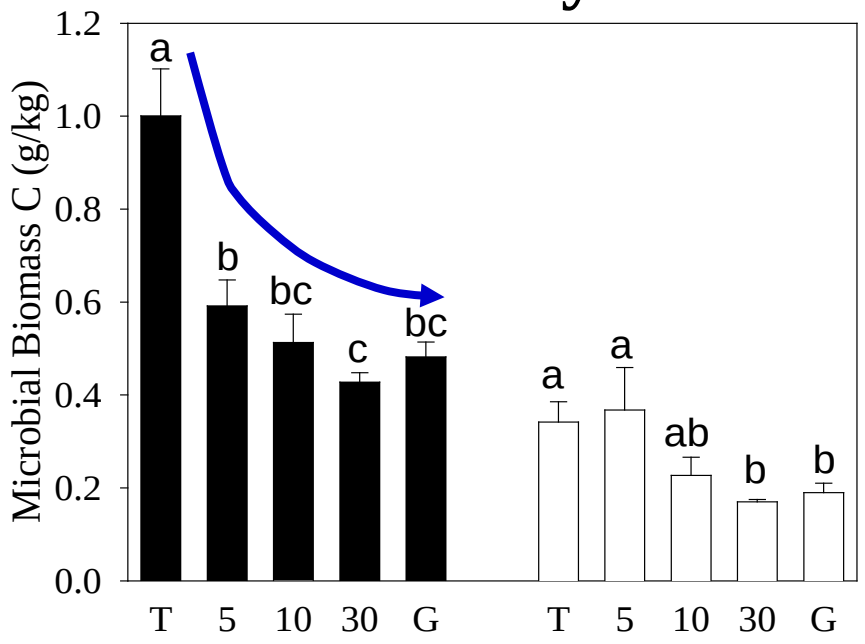
Blue Oak – Ecological Engineers

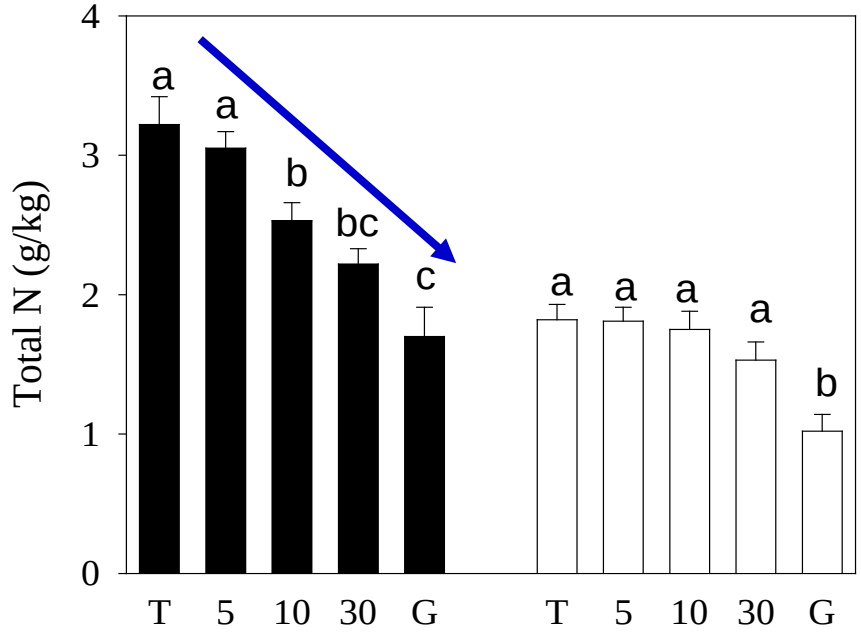


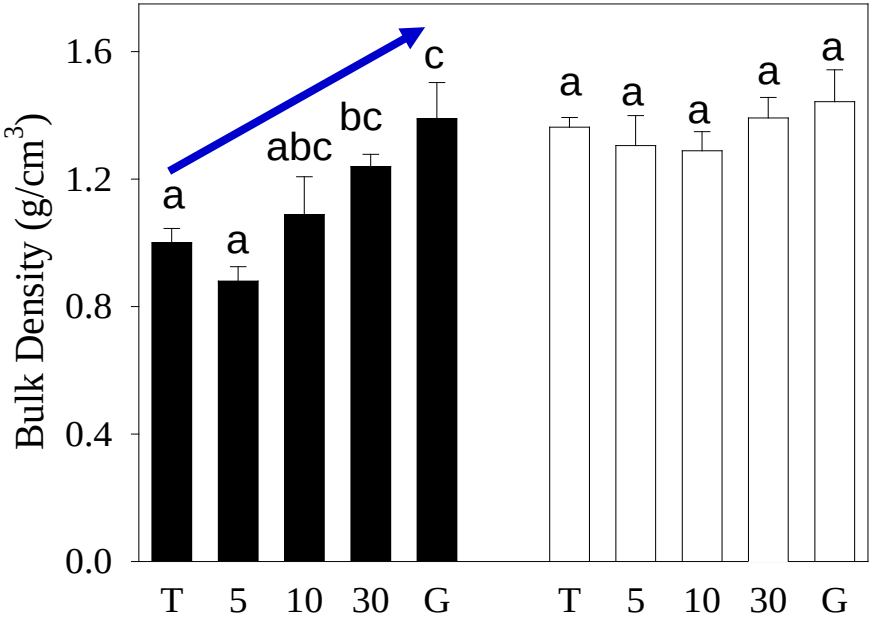
What happens when blue oak are removed?

Effects of Oak Tree Removal on Soil Fertility Islands

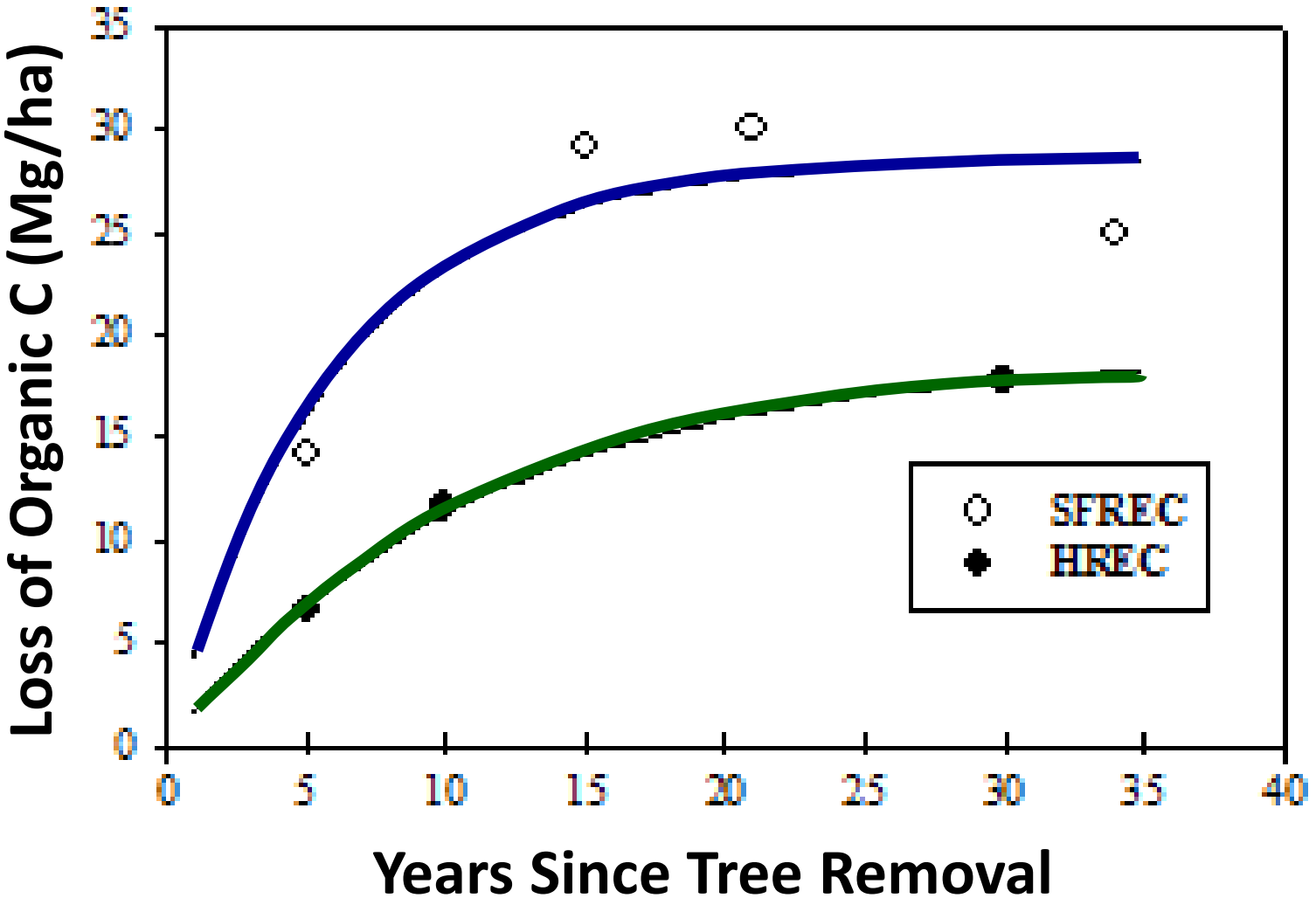








Loss of organic carbon following oak tree removal



Organic Matter Decomposition & Stabilization Model

Grassland

Oak Canopy

Consolidated view

Soil continuum model

Formation

Destruction

Plant, animal residues

Carbohydrate, protein, lignin, lipid, pyrogenic

Adsorption

Desorption

Aggregates

Large biopolymers

Not assimilable (>600 Da)

Assimilable (<600 Da)

Small biopolymers

onomers

Mineral surfaces

CO_2

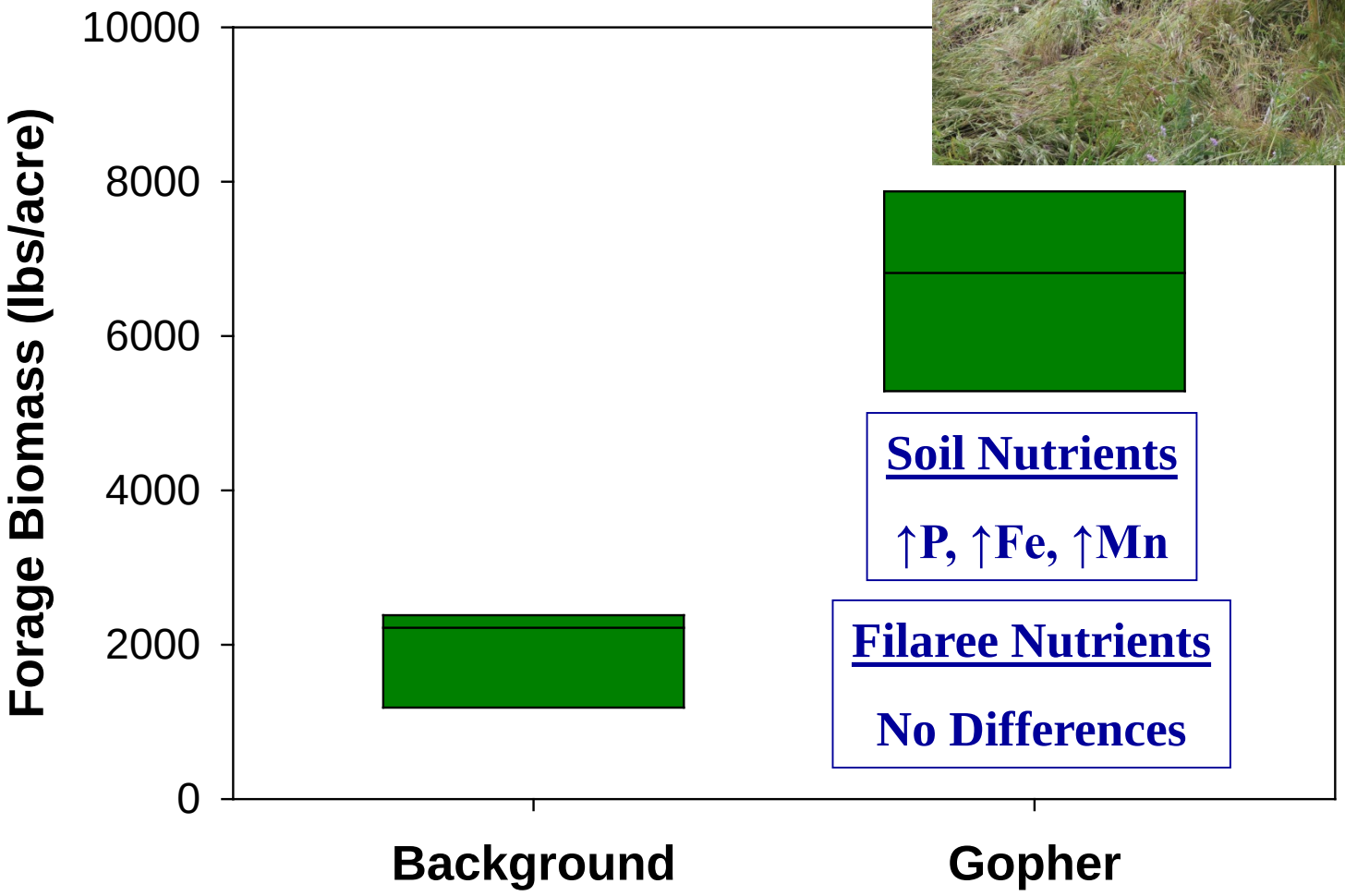
Turnover time

Lehmann & Markus Kleber


Central Coast Rangeland
Soil Pit
Gopher Mounds

Forage Biomass

Gophers vs Background



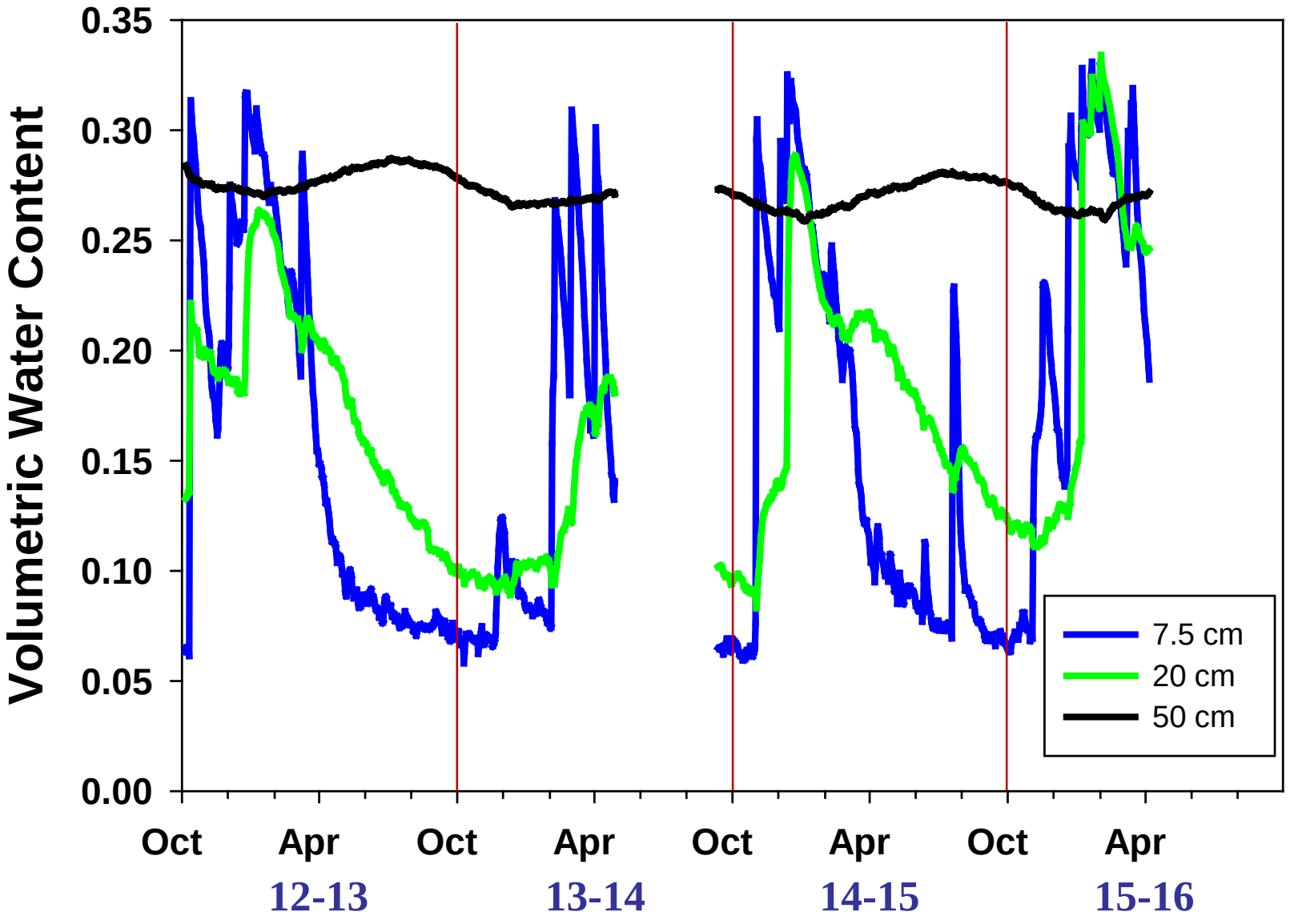
Soil Nutrients

↑P, ↑Fe, ↑Mn

Filaree Nutrients

No Differences

Soil Moisture Content – Central Coast

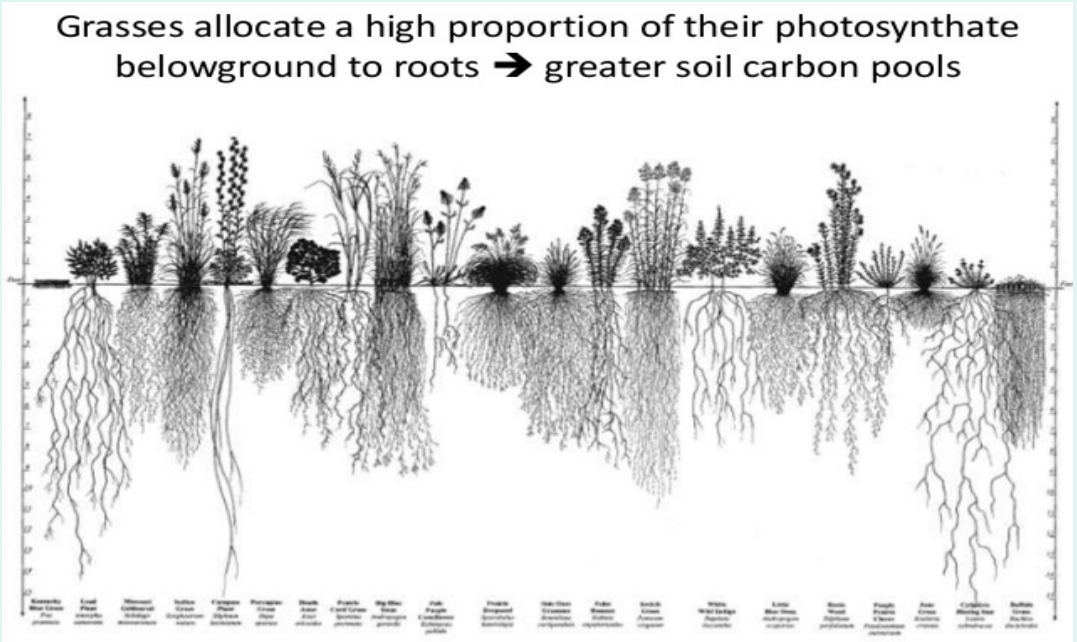


Courtesy Royce Larsen

Grassland SOM Distribution

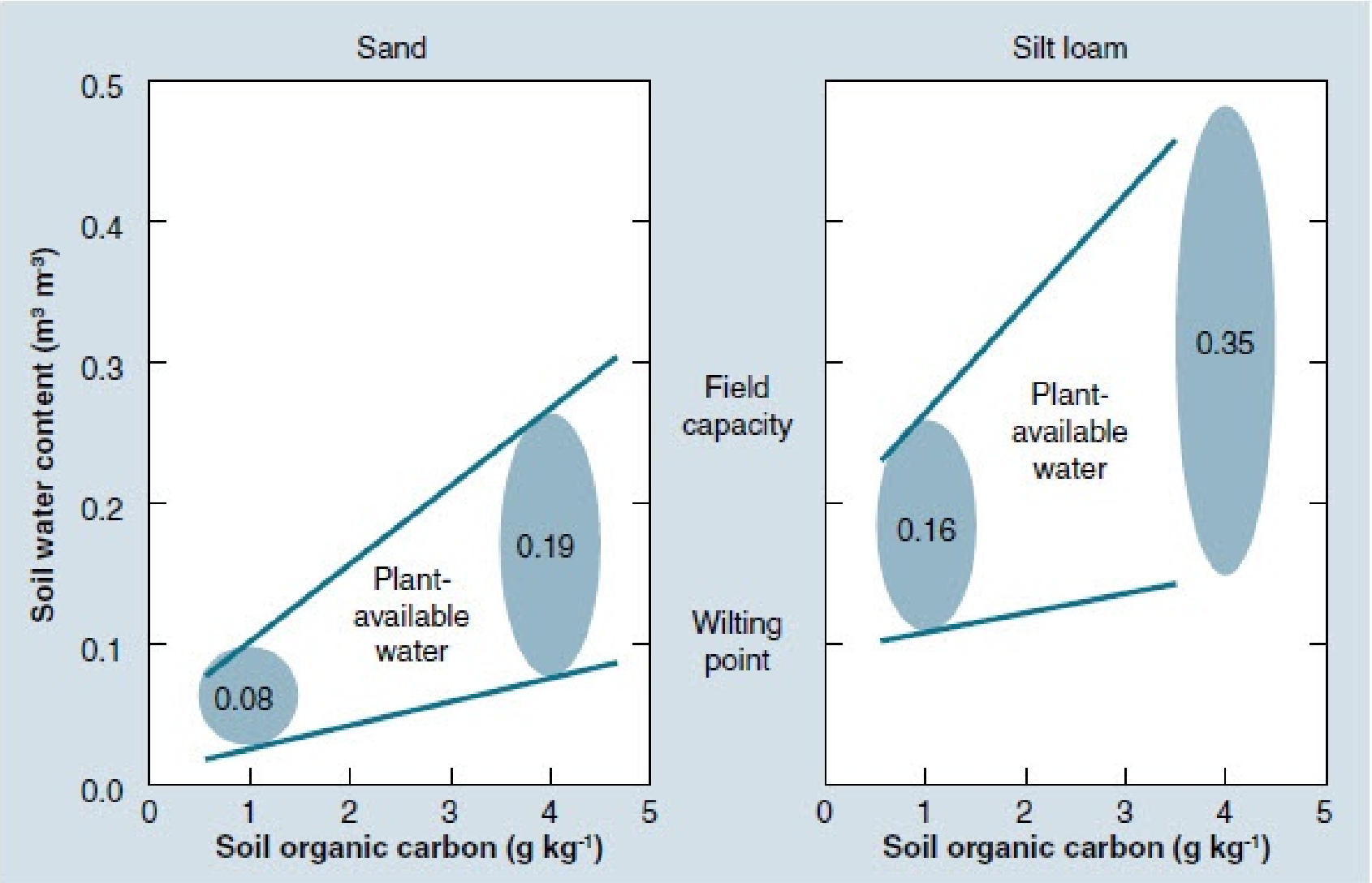
Kernza

Winter wheat



Global average Root:Shoot ratio of 3.7 for grasslands

Organic Matter Increases Plant-Available Water Holding Capacity



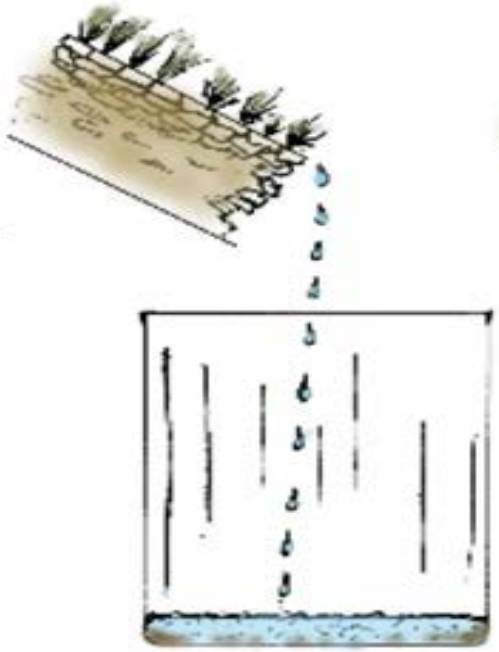
Yeomans Plow to Promote Infiltration and Deeper Root Growth?

Importance of Soil Cover

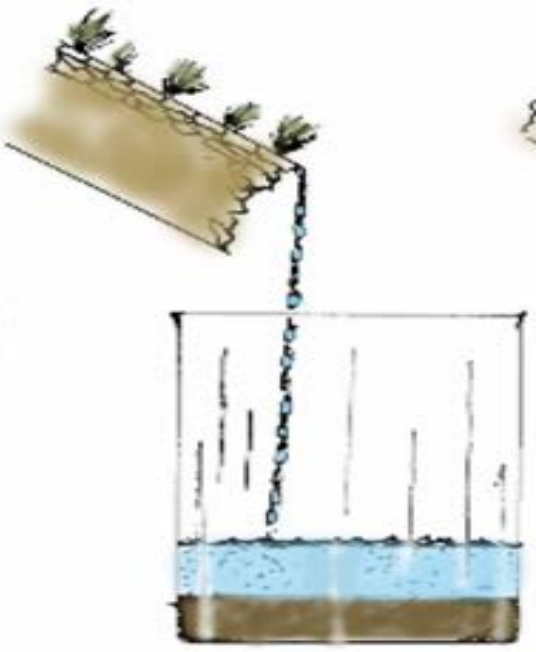
Good
ground cover
60 -75% of ground covered with plants and litter

Fair
ground cover
37 % of ground covered with plants and litter

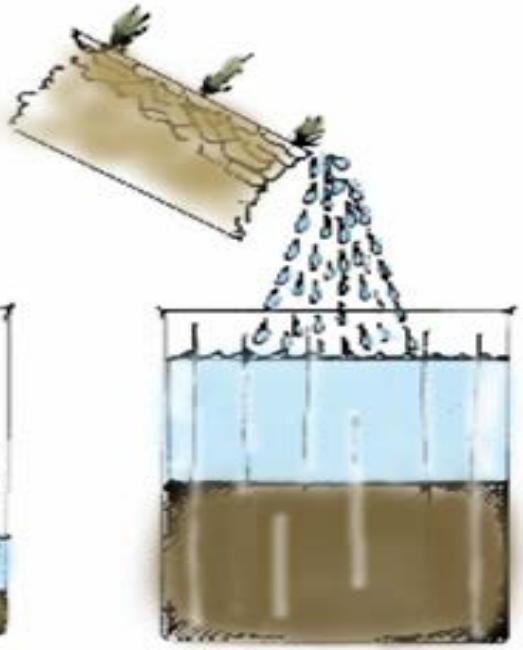
Poor
ground cover
10 % of ground covered with plants and litter



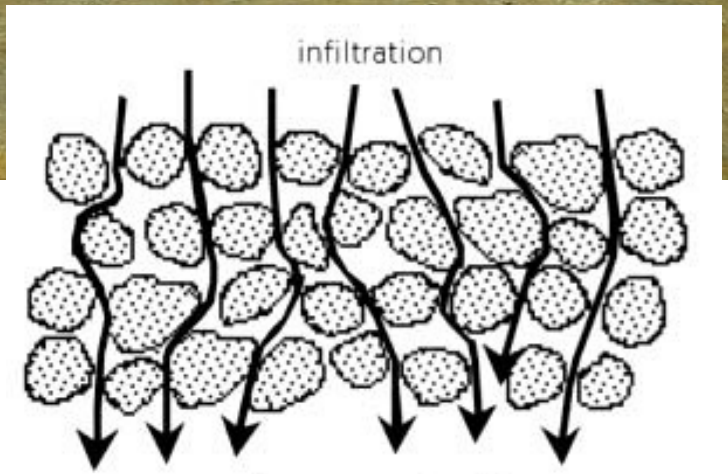
Surface runoff
2 % of rainfall
Soil Loss 0.05 tons/ acre

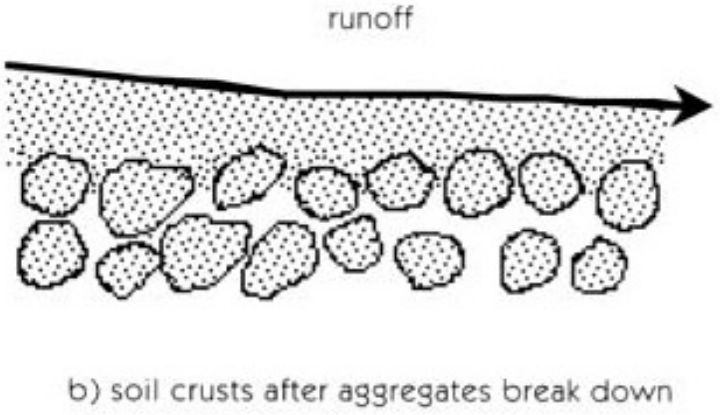


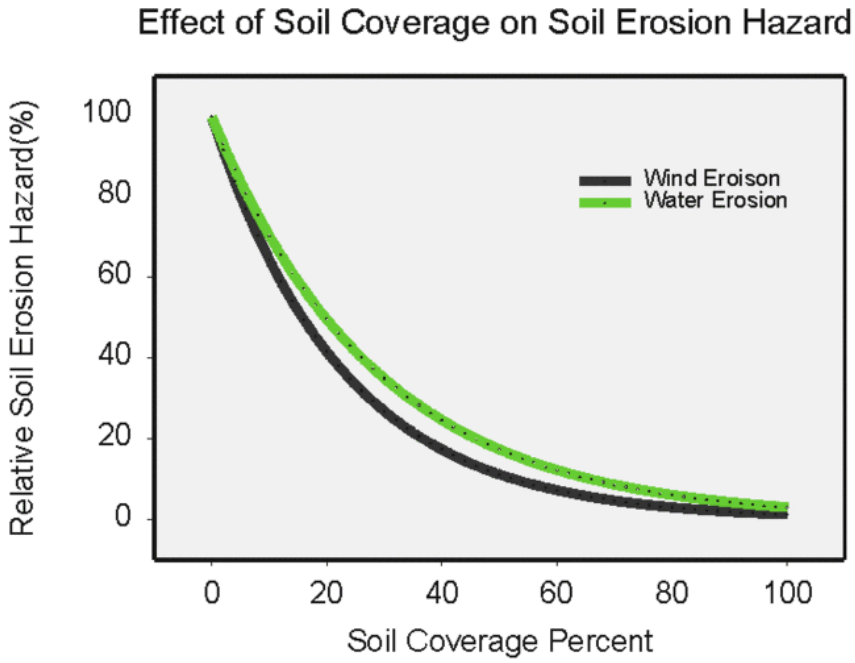
Surface runoff
14 % of rainfall
Soil Loss 0.5 tons/ acre



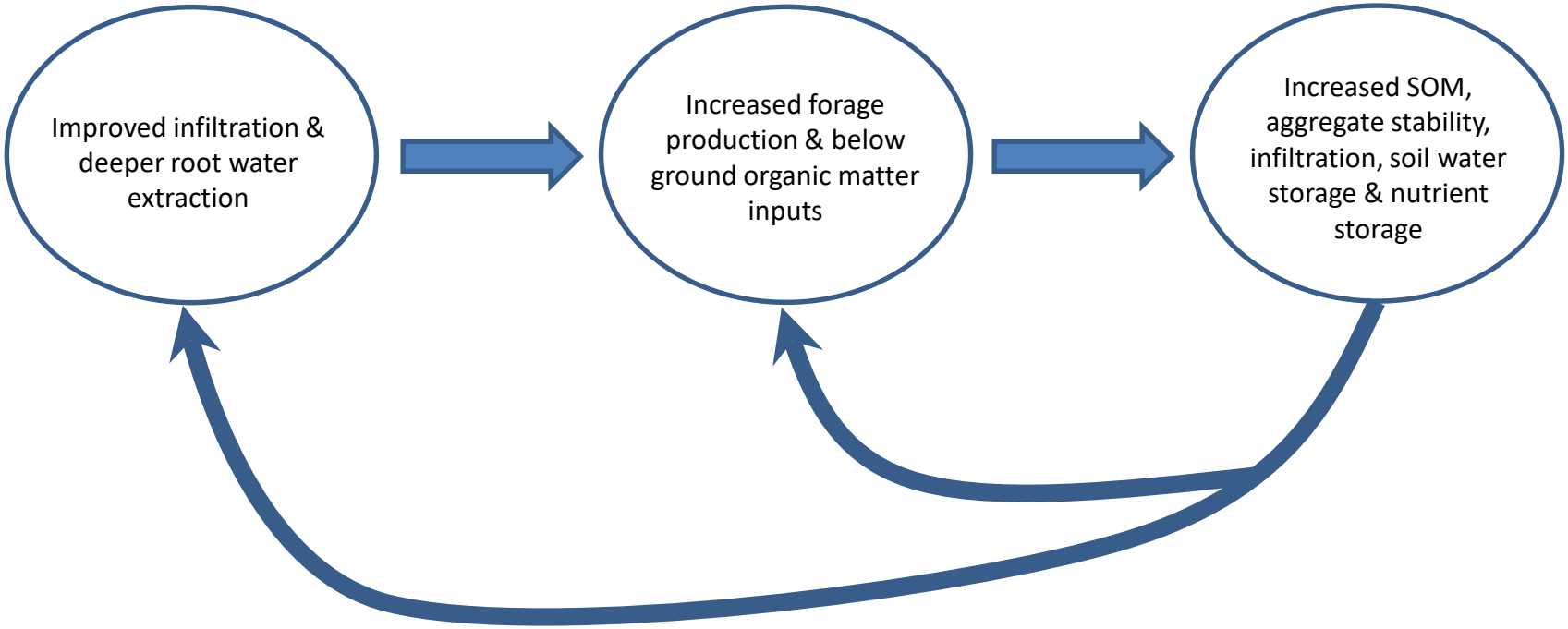
Surface runoff
73 % of rainfall
Soil Loss 5.55 tons/ acre


infiltration
a) aggregated soil

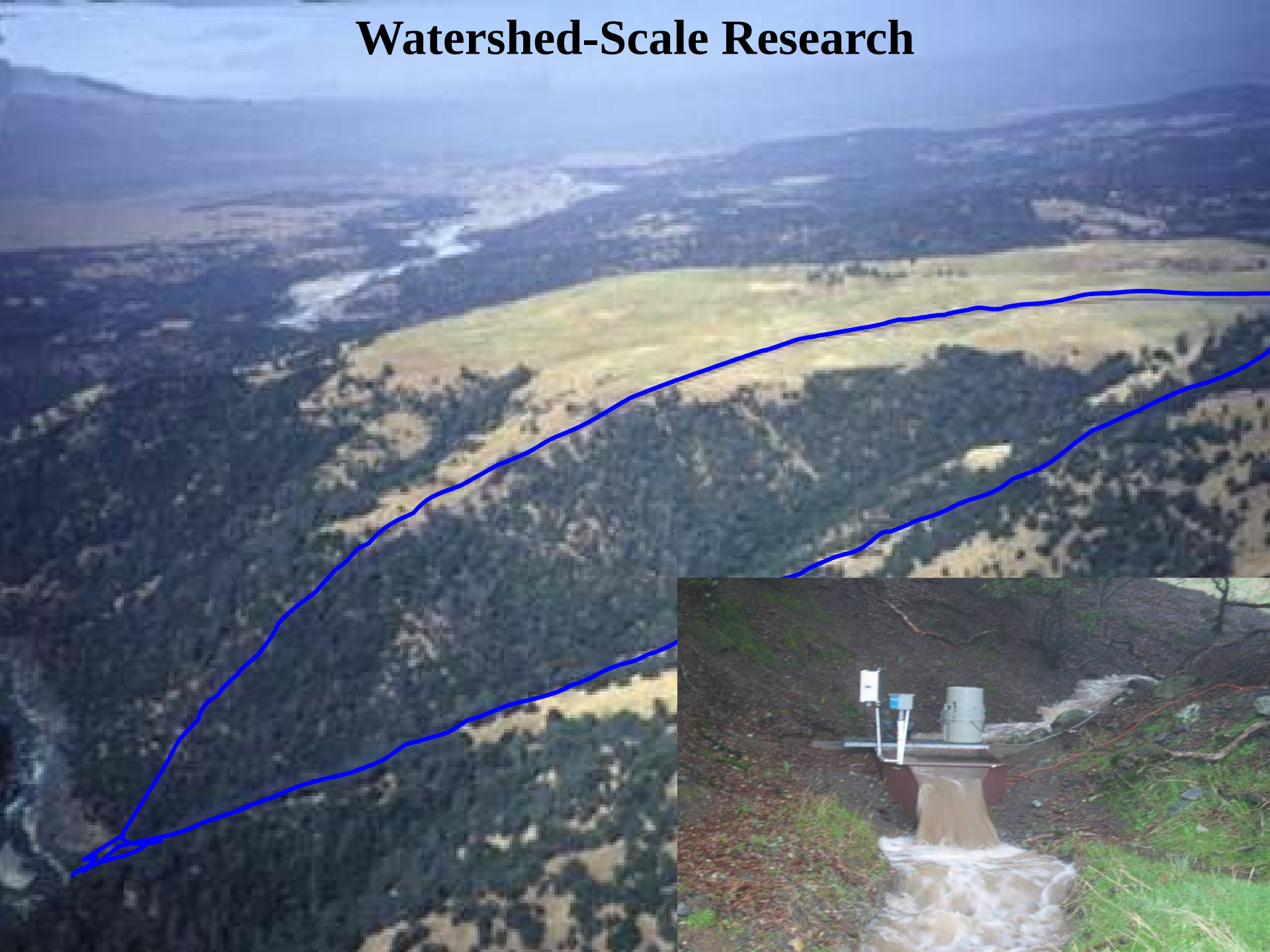

runoff
b) soil crusts after aggregates break down


Effect of Soil Coverage on Soil Erosion Hazard
Relative Soil Erosion Hazard(%)
100
80
60
40
20
0
0
20
40
60
80
100
Soil Coverage Percent
Wind Eroison
Water Erosion

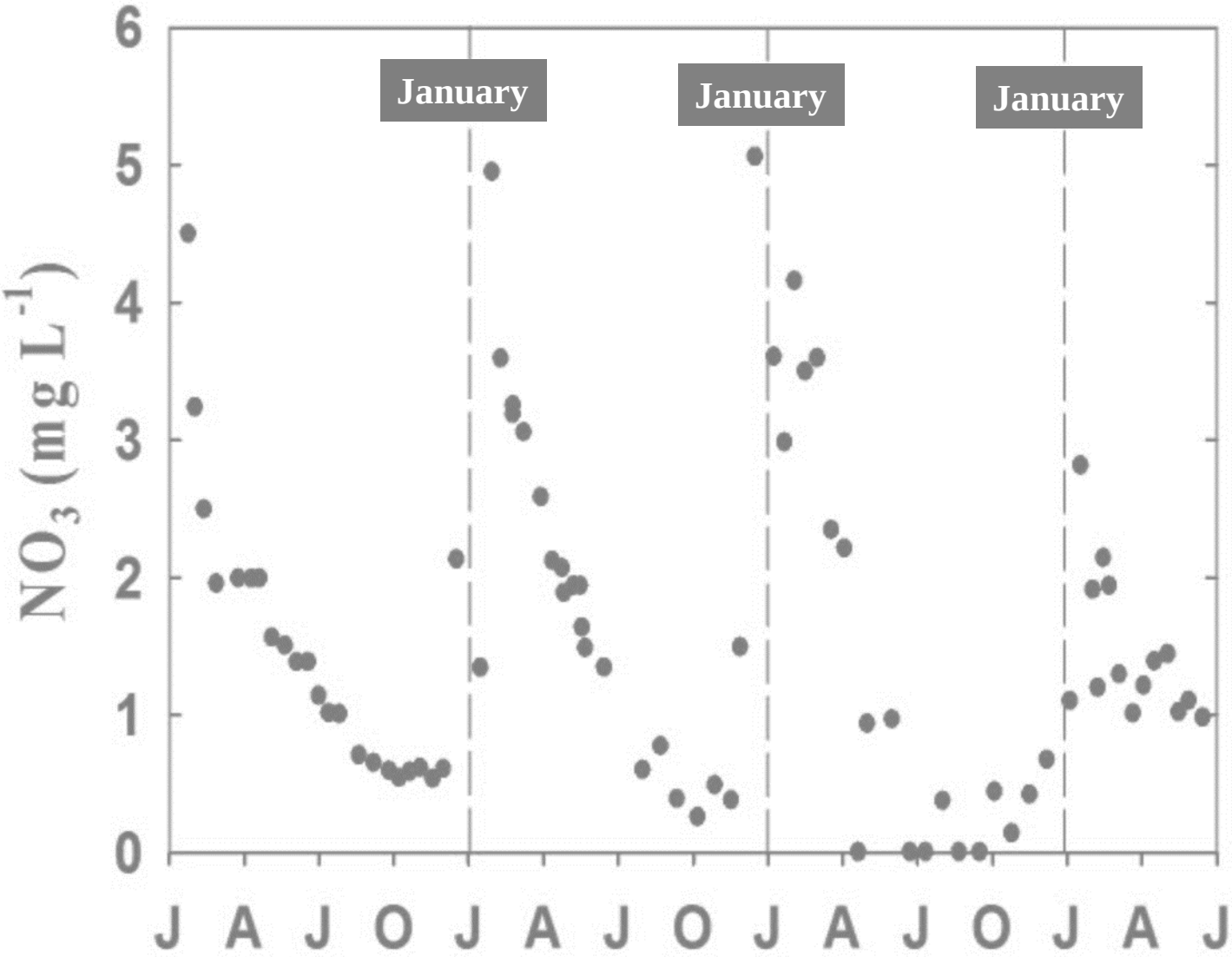
Enhanced Water Utilization in Rangelands



Watershed-Scale Research

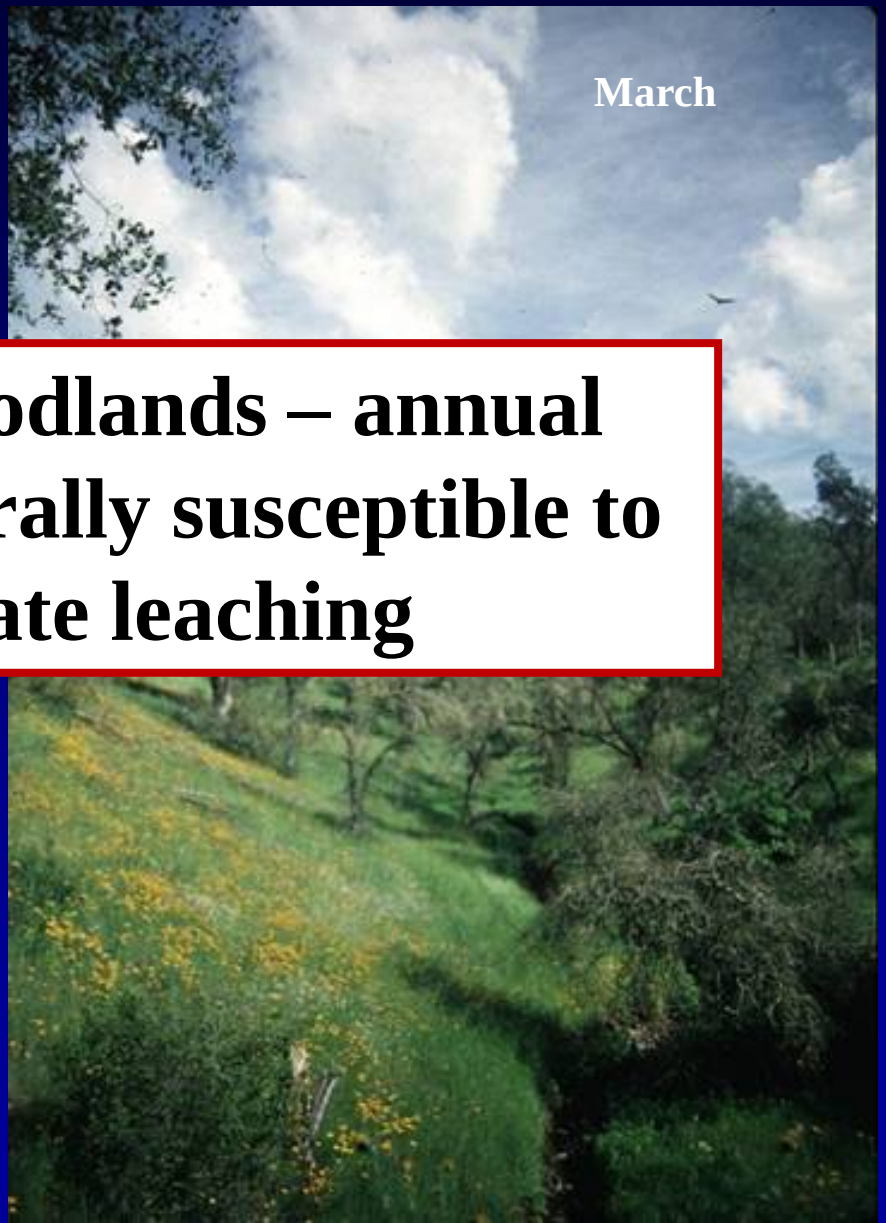


Seasonal Pattern in Streamwater Nitrate



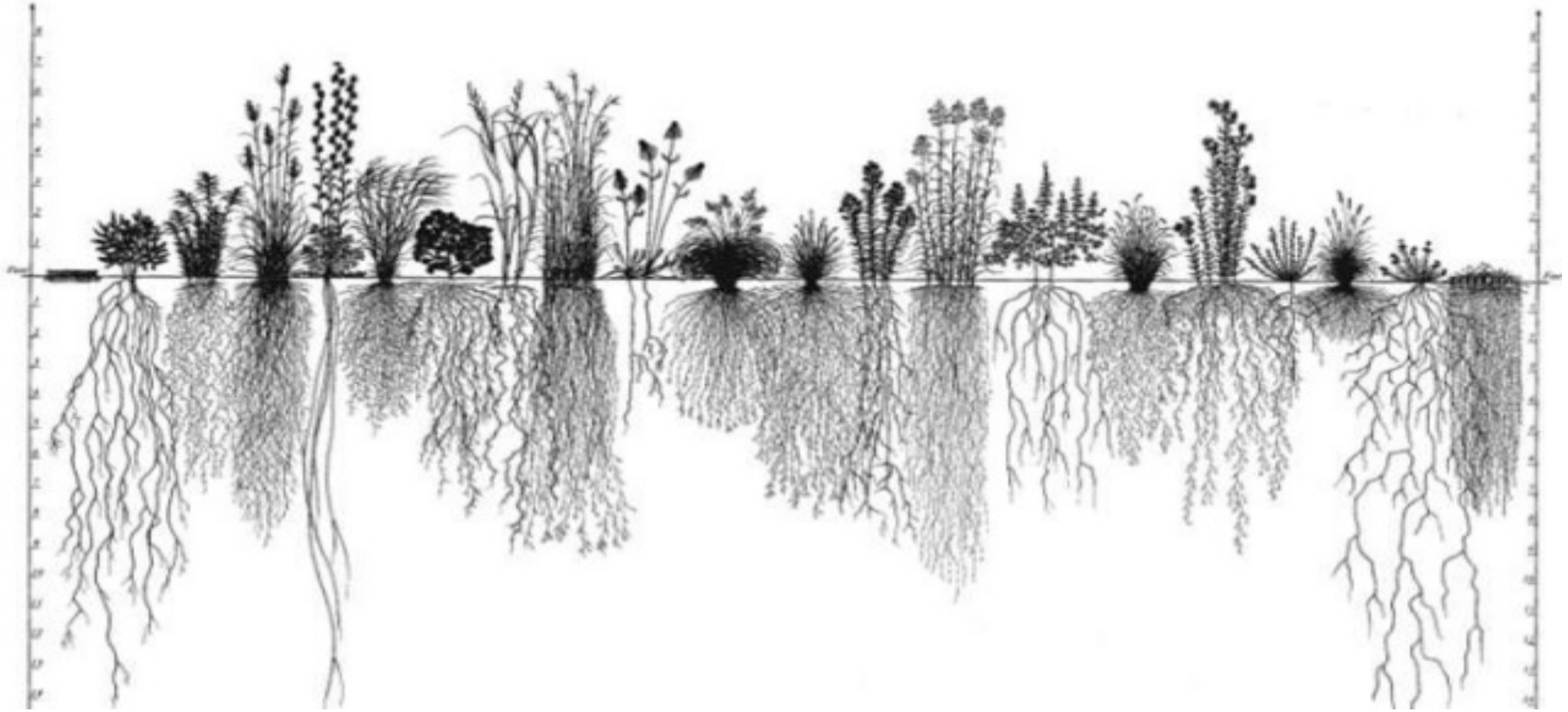
Low Nutrient Demand

High Nutrient Demand



California oak woodlands – annual grasslands are naturally susceptible to seasonal nitrate leaching

Deeper root structure, especially perennials, would capture nutrients more efficiently

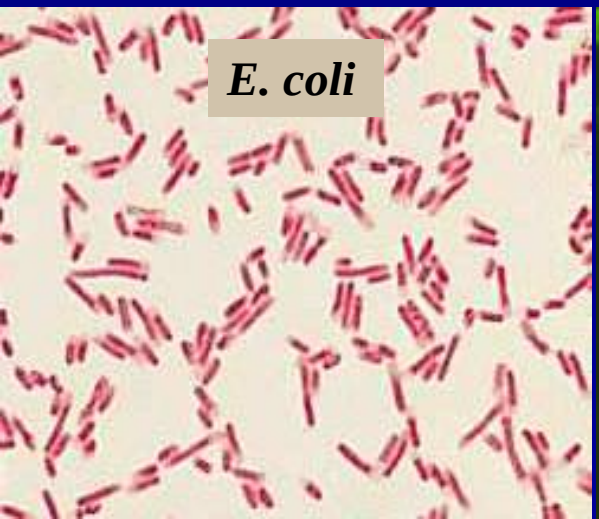


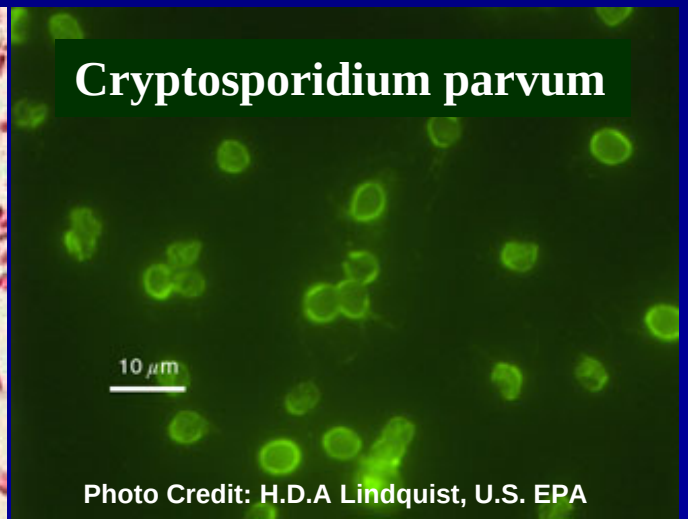
Annual grass typically <30 cm rooting depth

Nonpoint Source Pollutants on CA Rangelands

Nutrients (N/P)

Pathogens



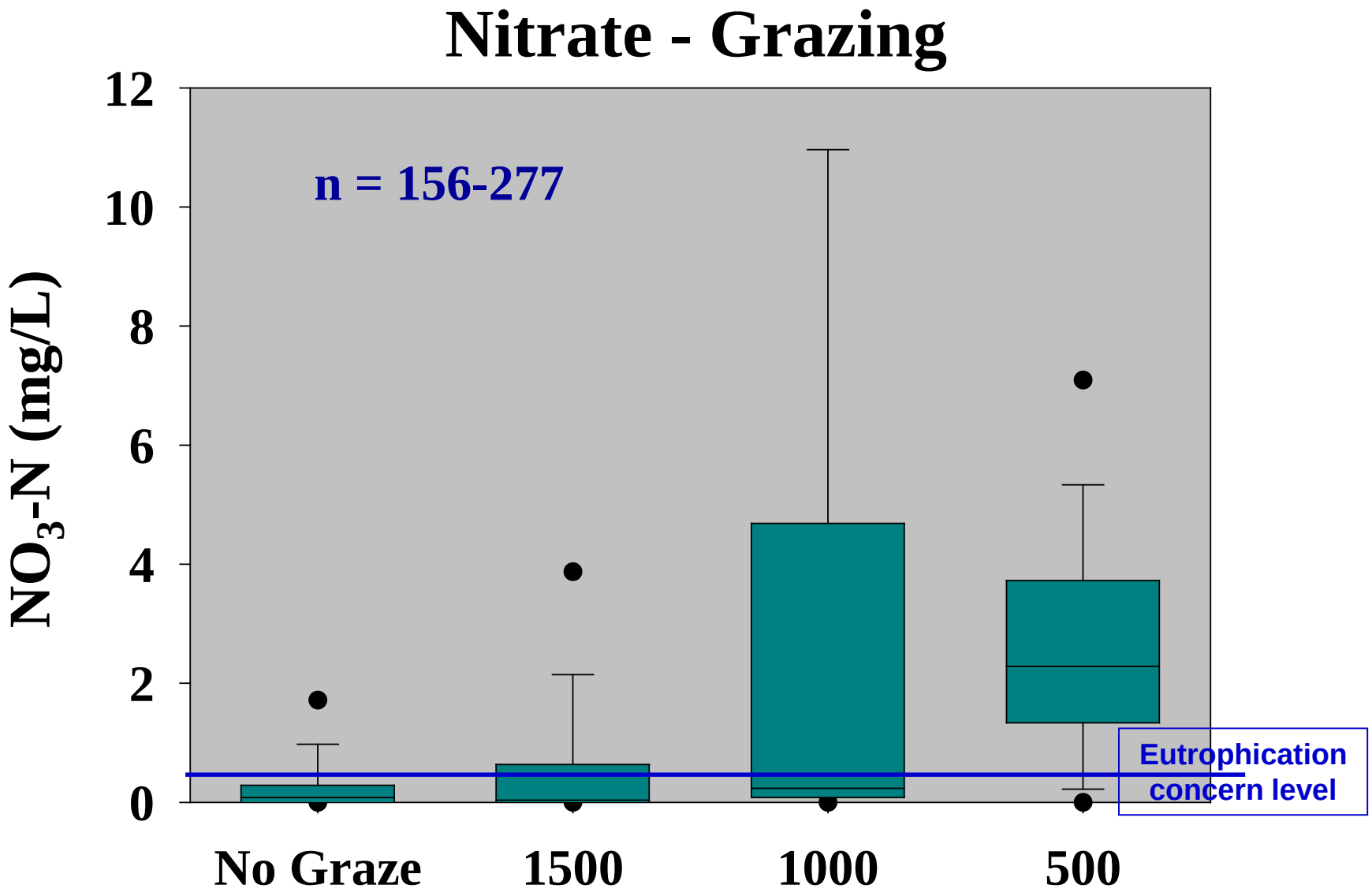


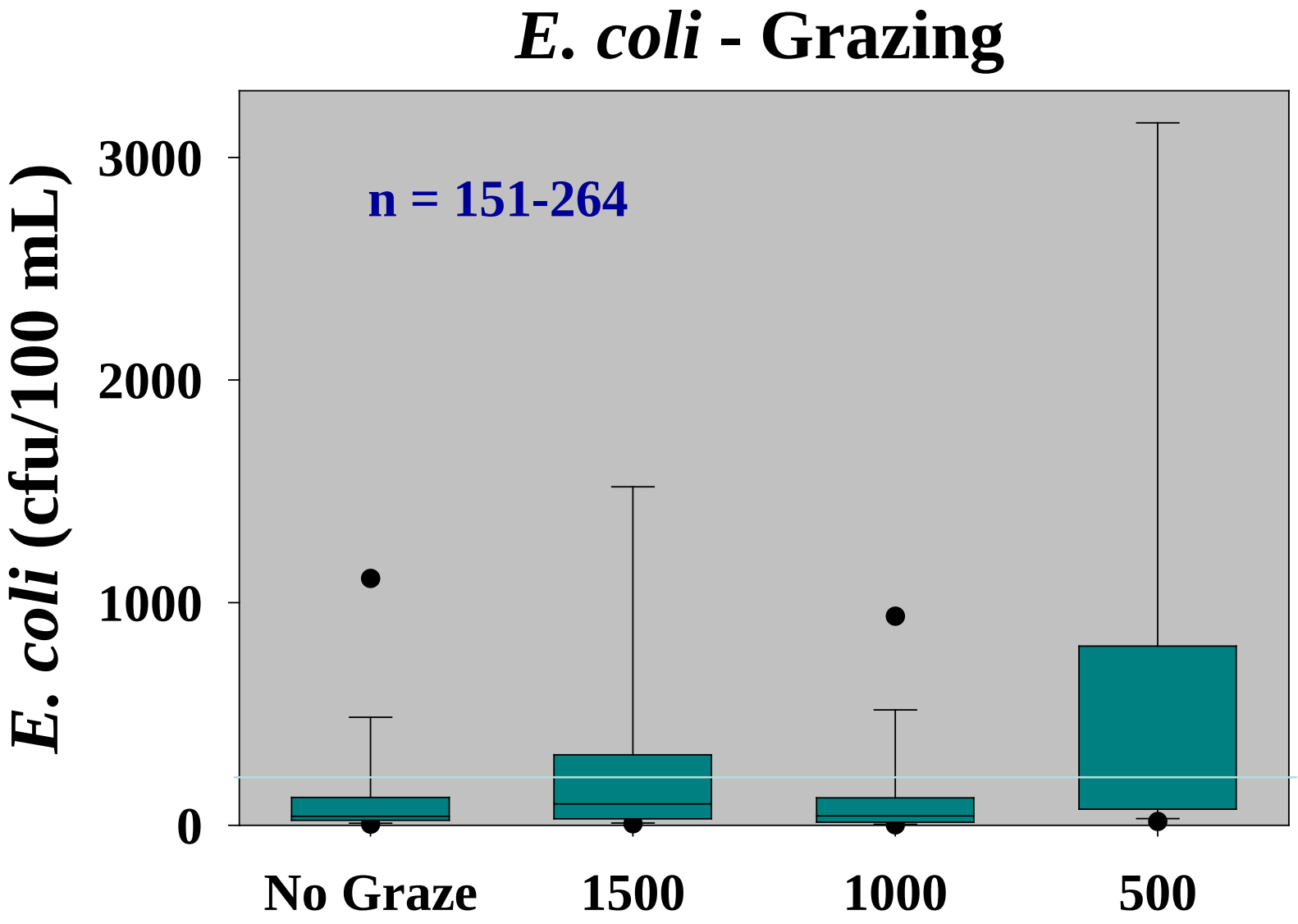
Sediments

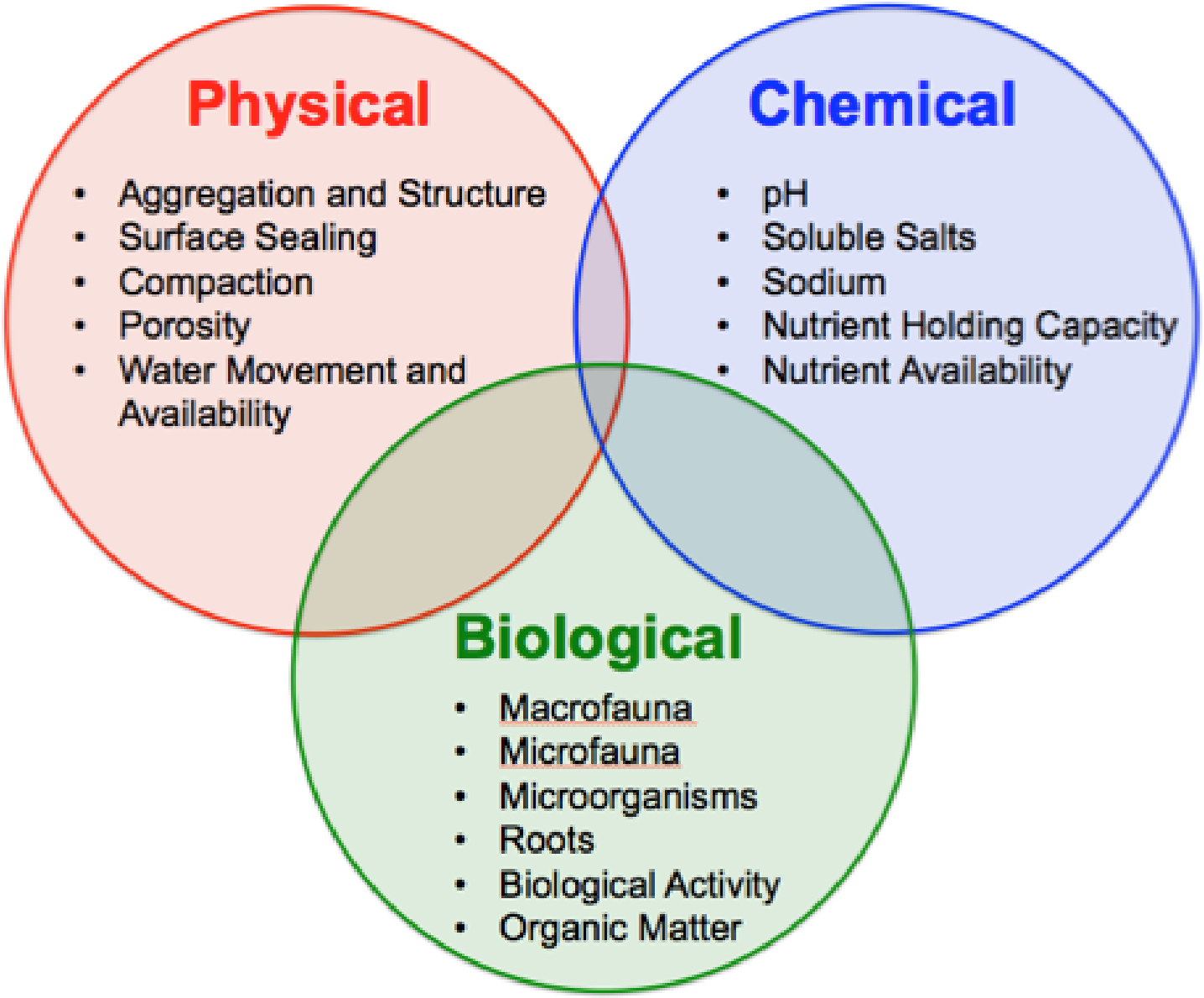
Grazing Treatments

- No grazing
- 1500 kg/ha RDM
- 1000 kg/ha RDM
- 500 kg/ha RDM

RDM = residual dry matter


Nitrate - Grazing
n = 156-277
NO_3-N (mg/L)
12
10
8
6
4
2
0
No Graze
1500
1000
500
Eutrophication concern level


E. coli - Grazing
n = 151-264
E. coli (cfu/100 mL)
3000
2000
1000
0
No Graze
1500
1000
500



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Questions/Comments?

Importance of Soil Organic Matter