Compost for soil improvement in alfalfa

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The Soil Ecosystem – what is it and why do we care about keeping soil healthy?

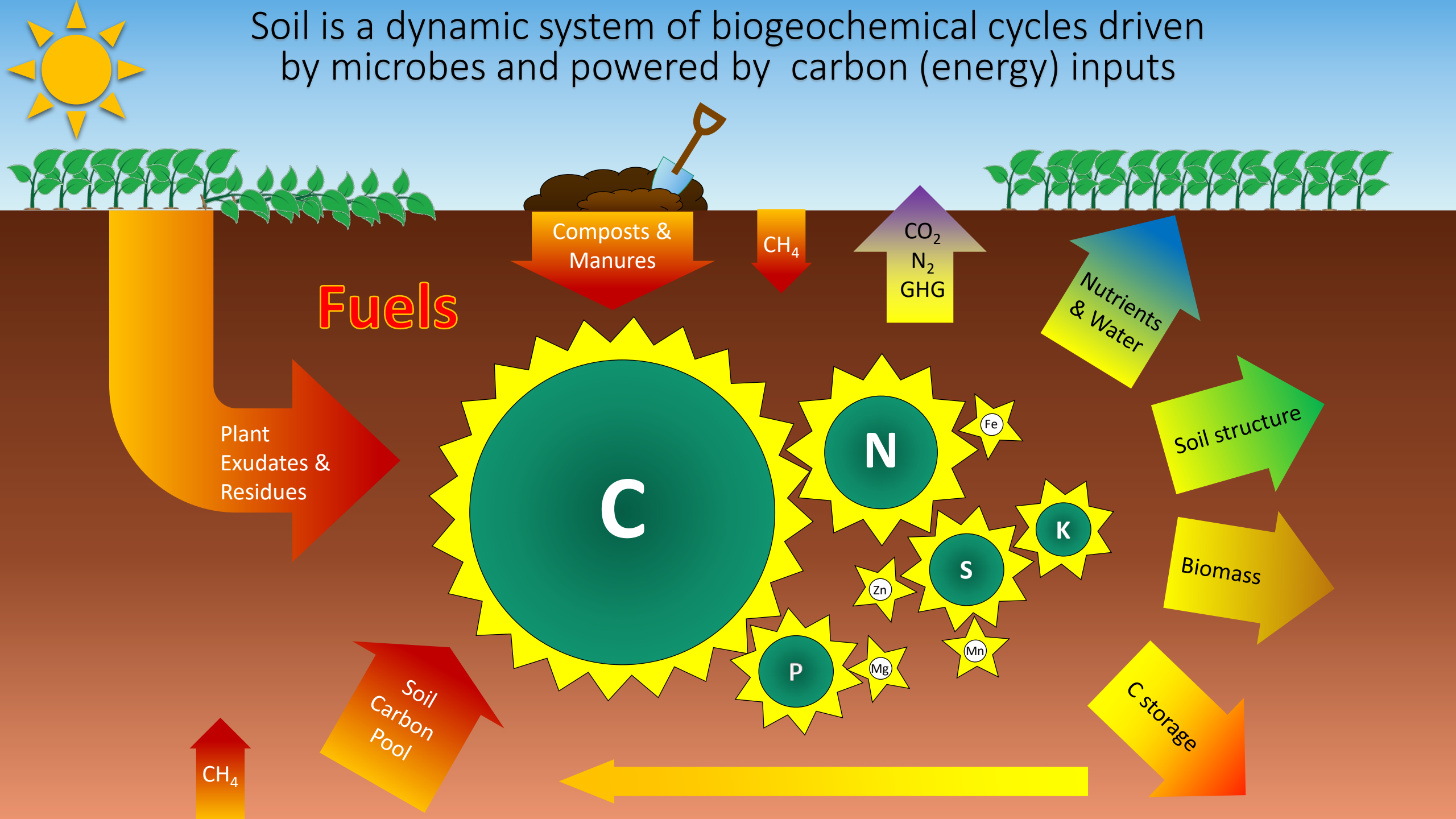
Soil is a vital living entity that sustains plants, animals,

humans and microbes!

Healthy soil provides:

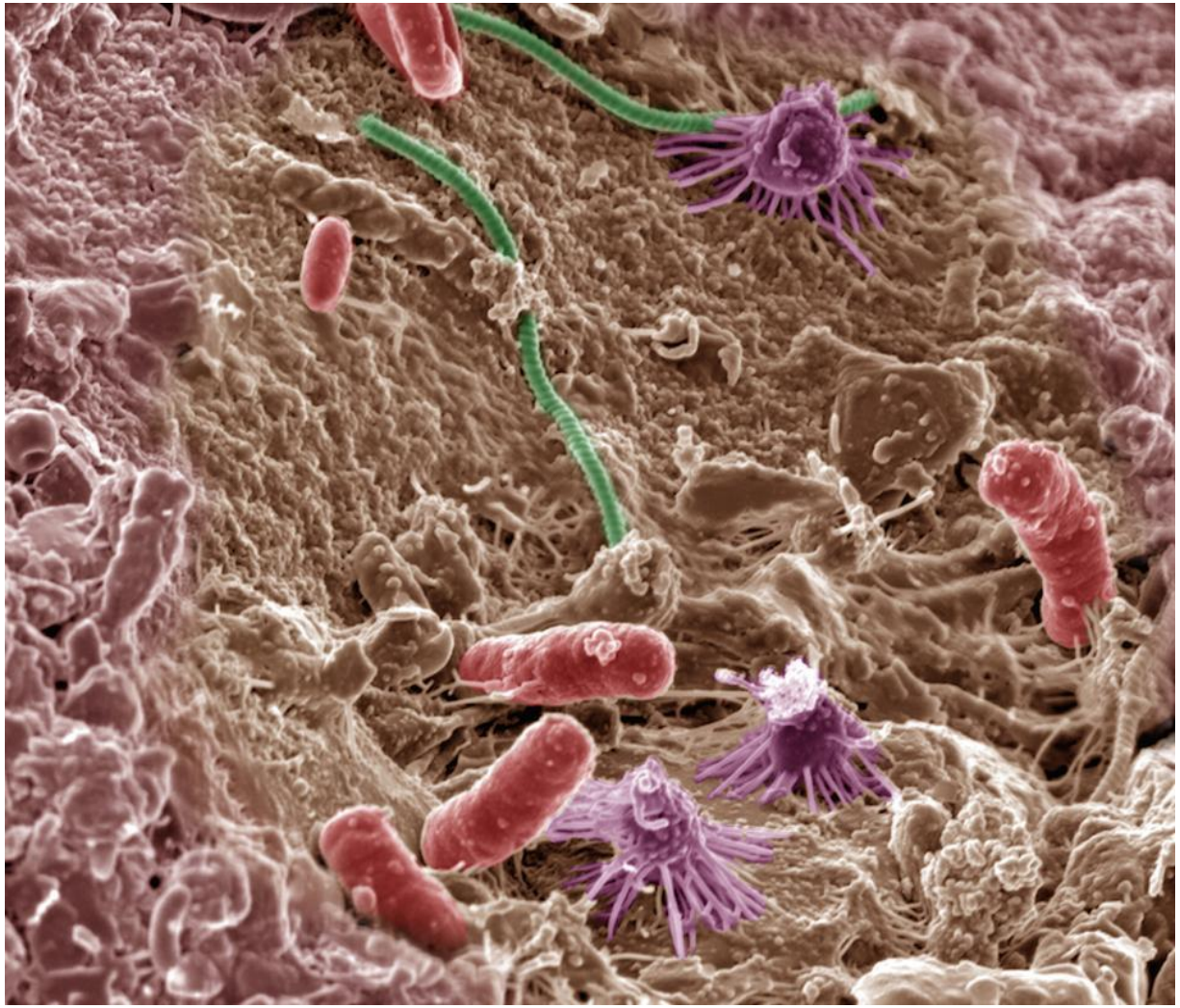
- Physical stability and support
- Water (infiltration and availability)
- Filtering and buffering
- Nutrient cycling
- Habitat for biodiversity
- Carbon storage

Soil is a dynamic system of biogeochemical cycles driven by microbes and powered by carbon (energy) inputs



Soil microbes

- Scale
- Diversity
- Behavior



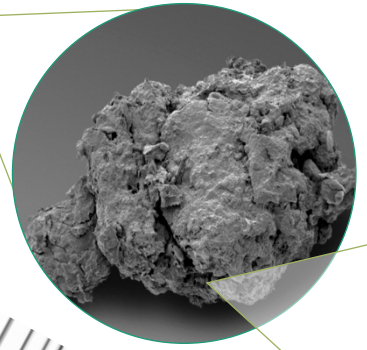
Scale

The Southwest

Russel Ranch

Us

Microaggregates



Microbes

1000 km

1 km

1 m

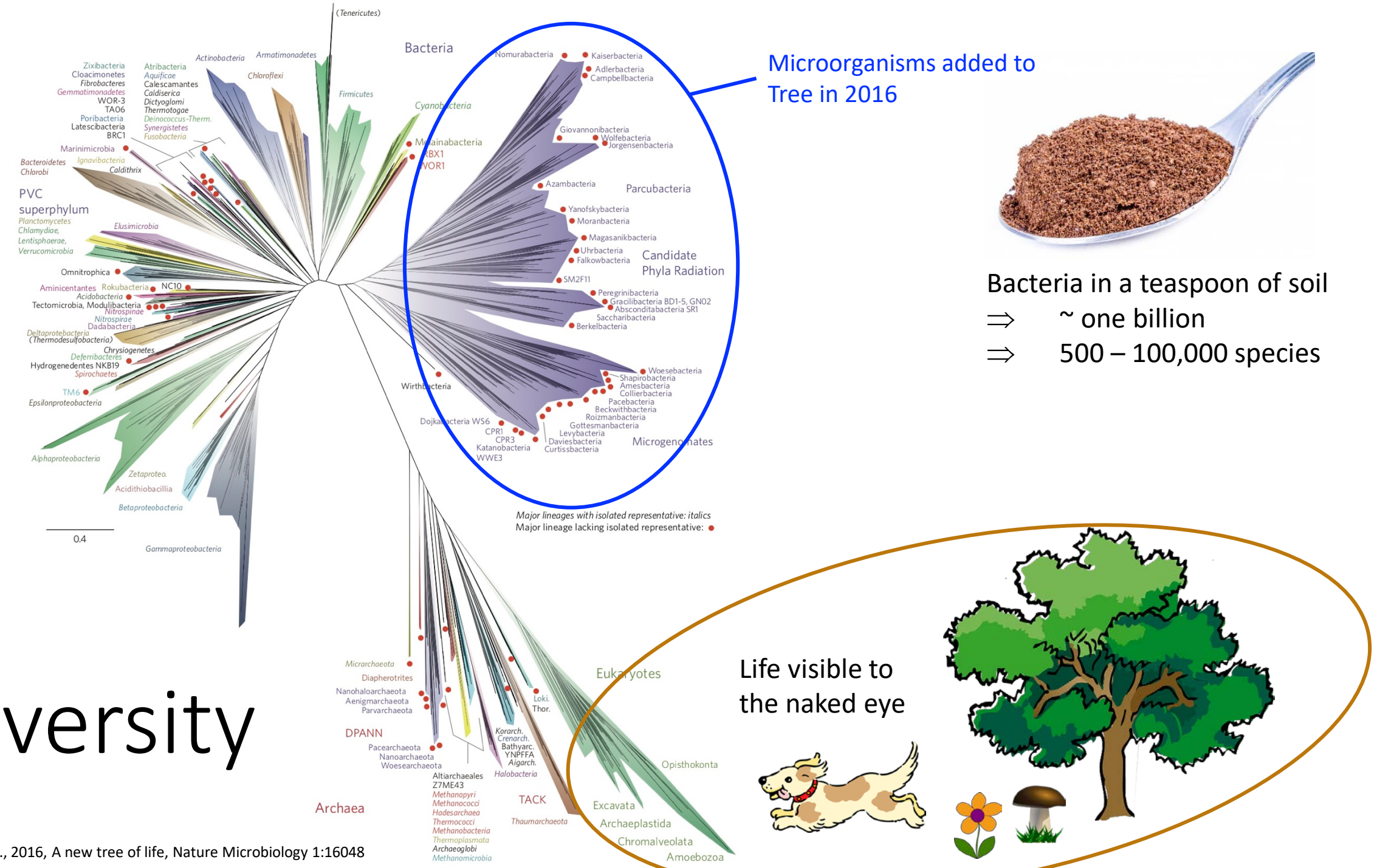
1 mm

1 µm

Distinct soil environments only micrometers apart can differ considerably in abiotic characteristics, microbial abundance, rates of activity and community composition.

Fierer 2017 Nature Reviews:Microbiology, 15:579-590

Diversity



Hug et al., 2016, A new tree of life, Nature Microbiology 1:16048

Microorganisms added to Tree in 2016

Bacteria in a teaspoon of soil

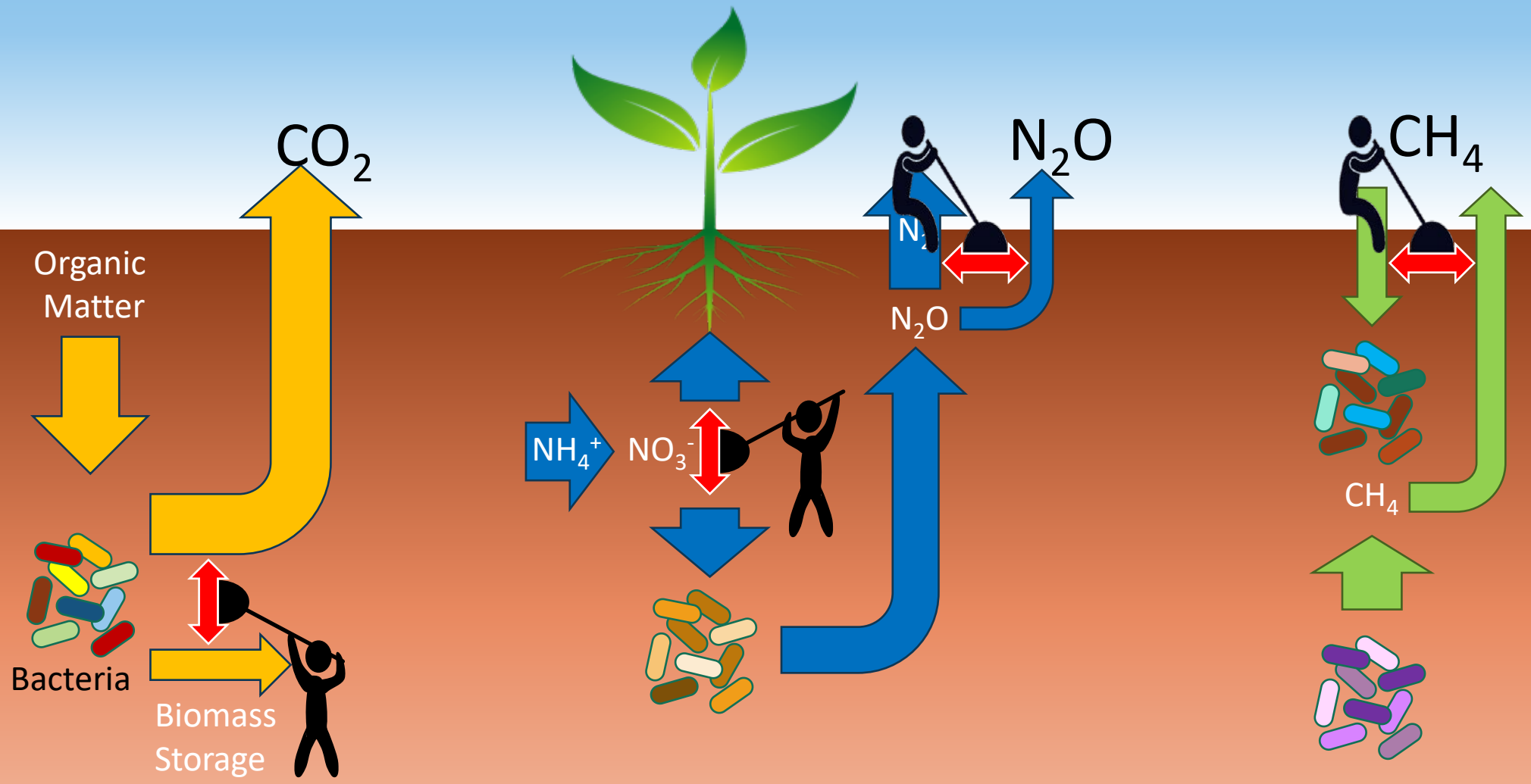
⇒ ~ one billion

⇒ 500 – 100,000 species

Life visible to the naked eye

Behavior

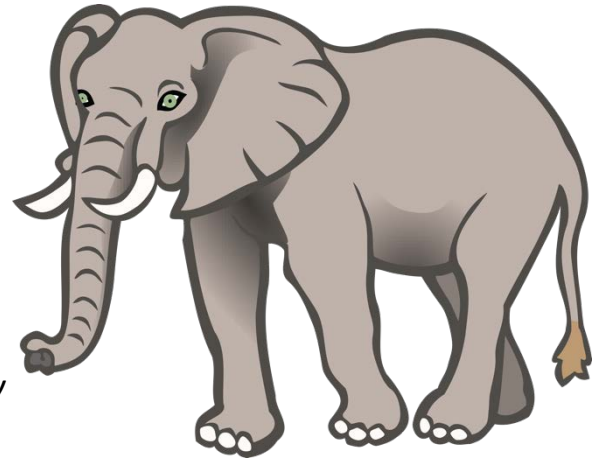
How do we move the microbe levers to change soil nutrient cycles ?



Microbial Life Strategies

Competitors

- Larger genomes
- Antibiotic production
- Filamentous growth
- High catabolic diversity
- Siderophore production



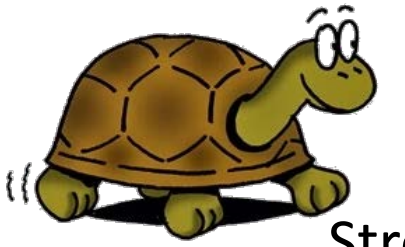
Low *Low*

Stress

- *limited labile carbon*
- *low pH*
- *moisture stress*
- *high/low temperatures*
- *low nutrients*

Disturbance

- *drying-rewetting*
- *fire*
- *aggregate instability*
- *change in redox status*
- *predation*



High *High*

Stress tolerators

- Slow growth
- auxotrophs
- few rRNA operon copies
- high substrate affinity
- EPS production

High *Low*

Stability

- *nutrient supply stability*
- *niche diversity*
- *carbon use efficiency*

Ruderals

- Rapid growth
- Multiple rRNA operon copies
- Low catabolic diversity
- Spore formation
- Low C:N and low C:P ratios
- high codon usage bias

Grime's competitor-stress tolerator-ruderal framework applied to soil bacterial heterotrophs.

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How do we move the microbe levers to change soil nutrient cycles ?

Life strategies

CO_2

Organic Matter

Bacteria

Biomass Storage

NH_4^+

NO_3^-

N_2O

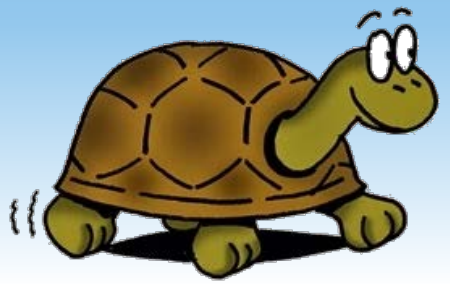
N_2

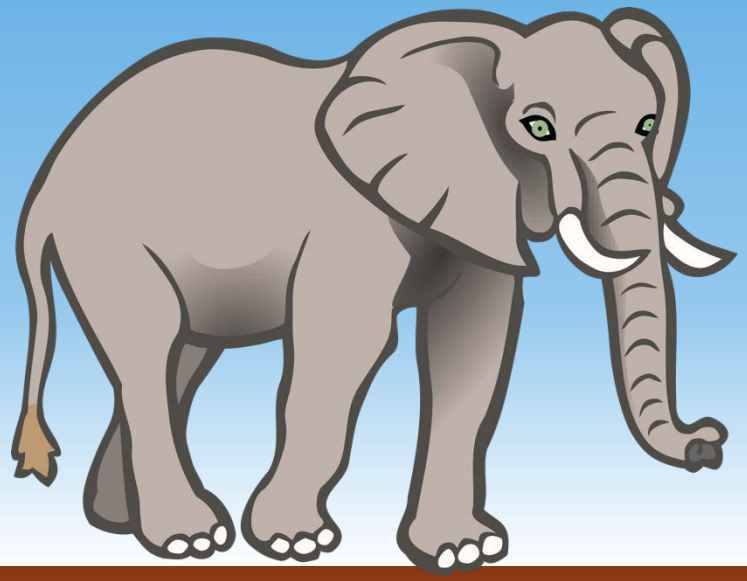
N_2O

CH_4

CH_4

Managing soil, managing microbes





“Hare” microbes do fine with:

- Simple nutrients
  - mineral fertilizers
- Fallow periods
  - no food source for microbes
- Tillage
  - food access

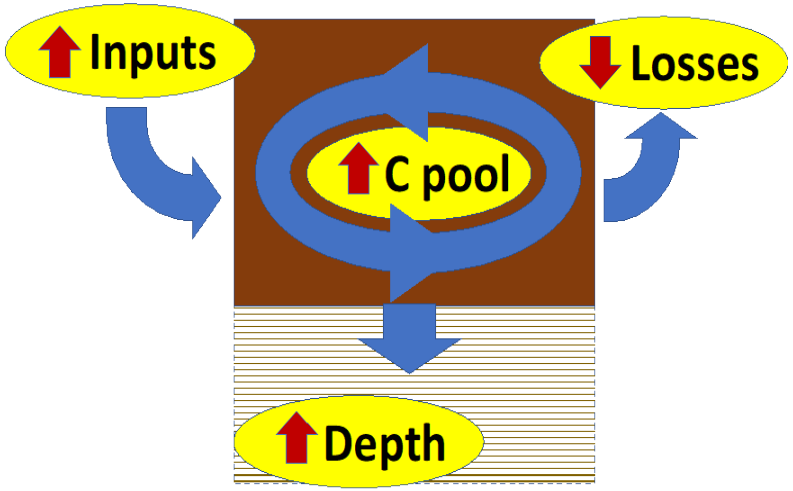
“Tortoise” and “Elephant” microbes do better with:

- Complex nutrients
  - composts and manures
- Cover crops
  - food
  - variety
- Reduced tillage
  - niche preservation

Alfalfa compost trial

Compost as a soil amendment

- Increases soil carbon
  - Slow release of nutrients
    - steady food supply for microbes
  - Organic compound supply
    - promotes metabolic diversity
    - feeds range of soil cycles
- Improves soil structure and water infiltration
- Compost nutrient content is important
  - It's possible to manipulate nutrients for desired effects
- There is a threshold minimum application rate (~3 ton/acre)
- Greenhouse gas emissions - reduced in many systems, details under study

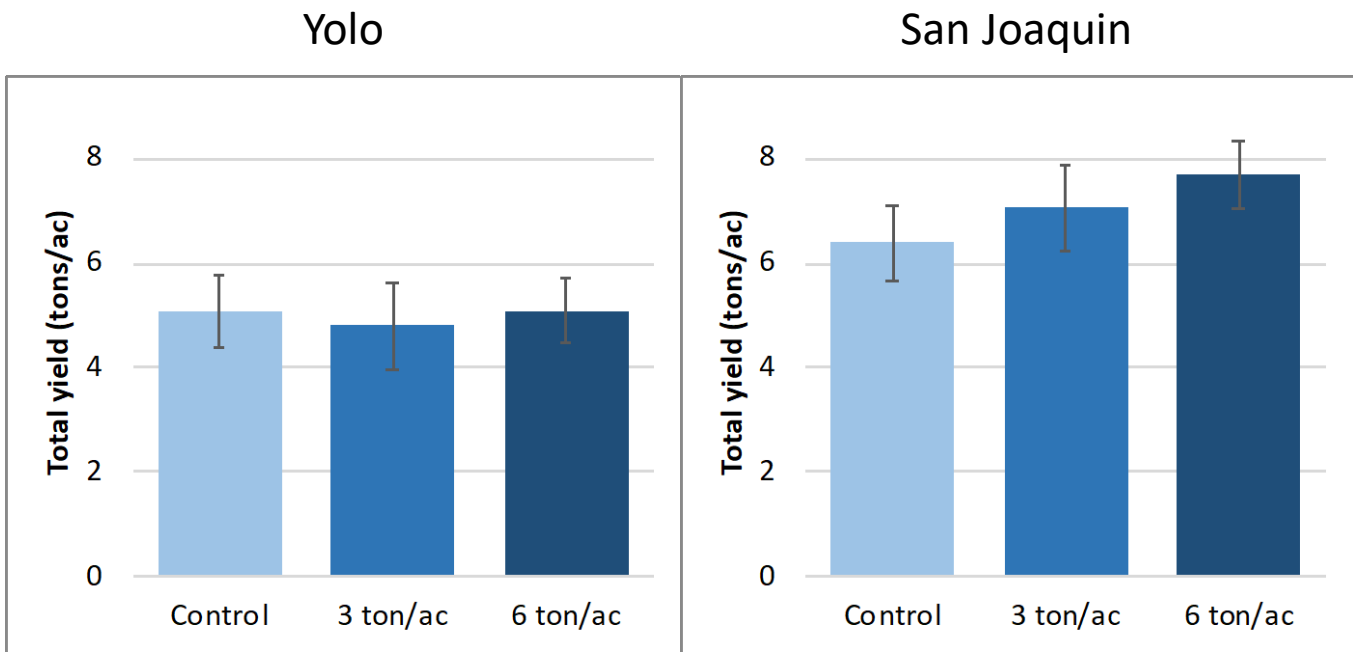


Increasing soil carbon

Alfalfa compost trial

Yield

- Green waste compost application at two rates - 3 or 6 tons/acre
- Two field sites - San Joaquin and Yolo county
- Compost was applied in fall
- Alfalfa flood irrigated
- Compost treatments had similar yields to no compost controls during first season
- Increased yield with compost at San Joaquin site in second season

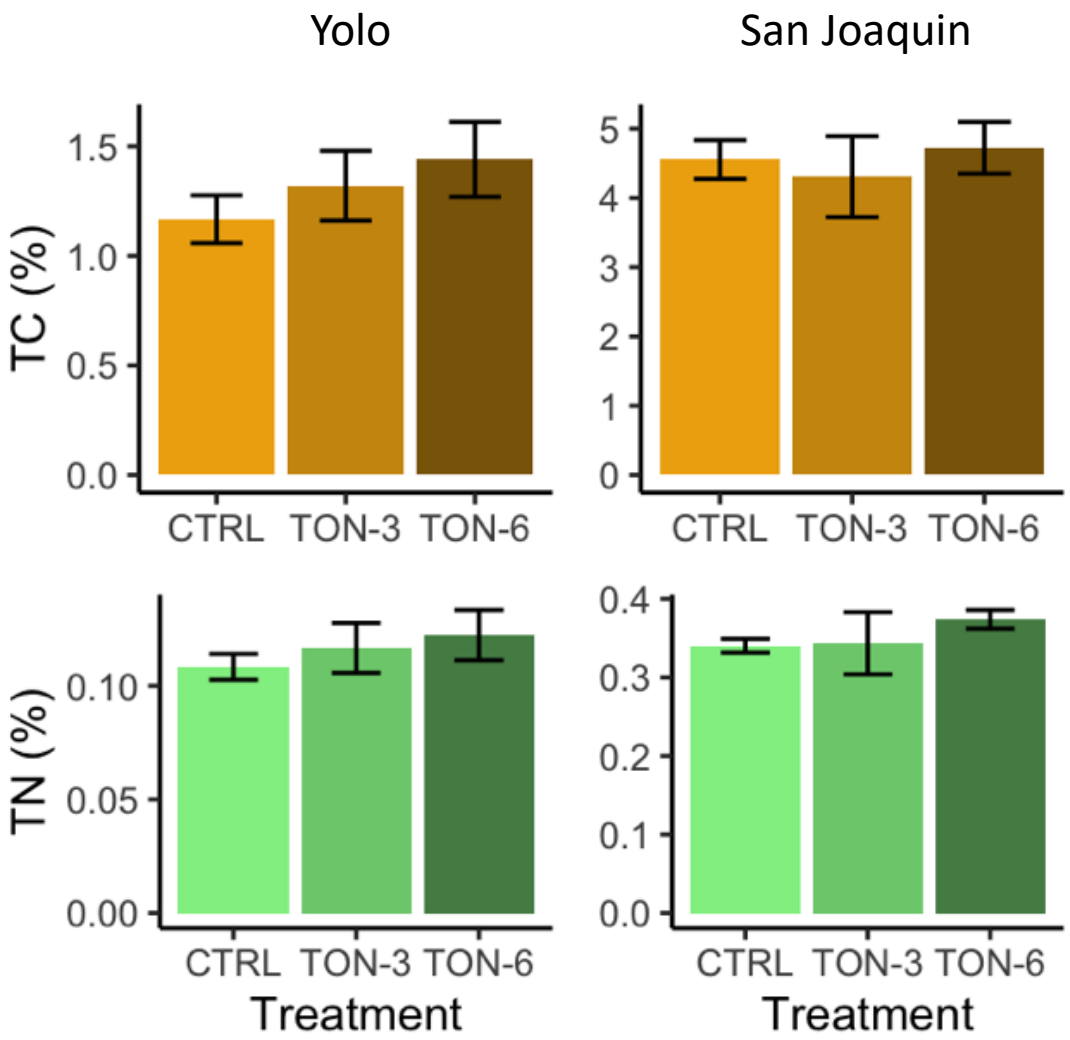


Total yield 2022

Alfalfa compost trial

Nutrients

- Green waste compost application at two rates - 3 or 6 tons/acre
- Two field sites - San Joaquin and Yolo county
- Compost was applied in fall
- Alfalfa flood irrigated
- Compost treatments had similar yields to no compost controls during first season
- Increased yield with compost at San Joaquin site in second season
- Nutrients - increasing trends in low OM soil, limited changes in high OM soil

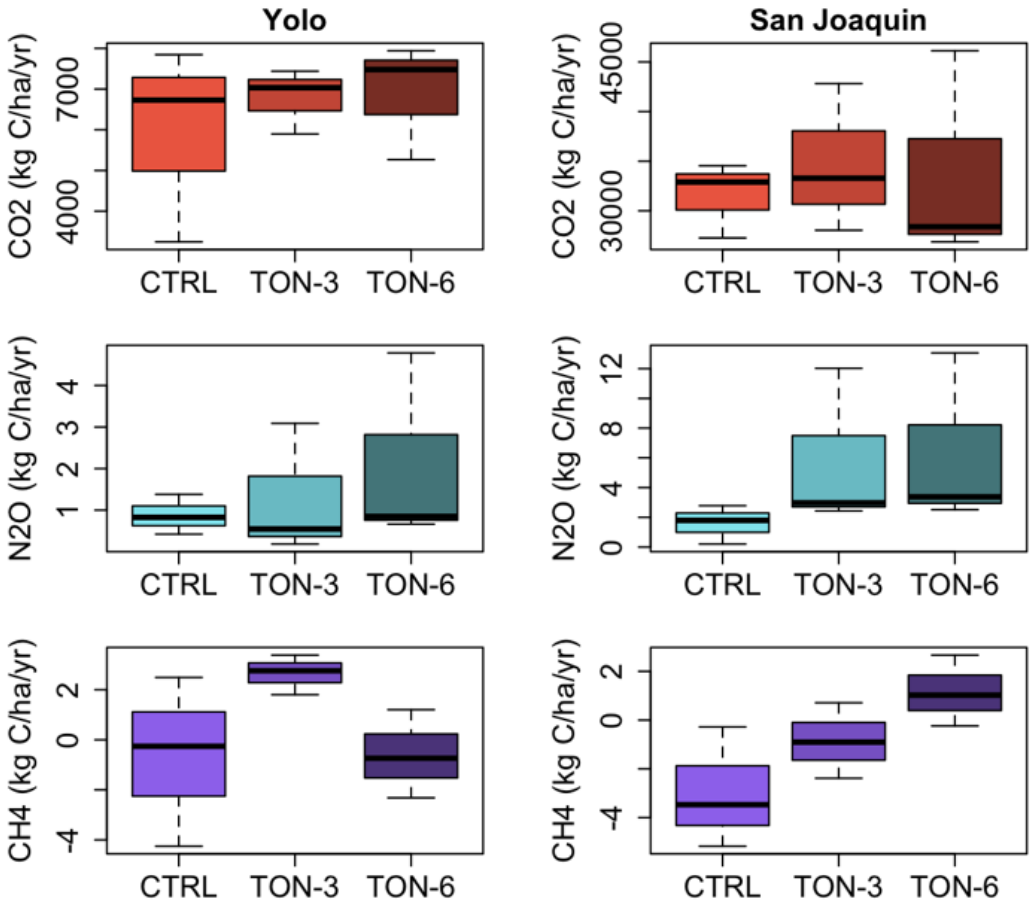


Total soil carbon and nitrogen

Alfalfa compost trial

Greenhouse gas fluxes

- Carbon dioxide (CO_2)
  - Year 1 - higher efflux with compost
  - Year 2 - similar CO_2 efflux to control
- Nitrous oxide (N_2O)
  - Similar efflux between control and compost additions
- Methane (CH_4)
  - Negative flux - soils act as methane sink - in high OM soils
  - Higher efflux at 3 tons/ac compost in Yolo



Year 2 efflux for Yolo and San Joaquin sites

Alfalfa compost trial

Conclusions

- Compost application leads to improved nutrient content in poorer soils
- Similar yields in the short term, higher trends with compost
- Similar GHG fluxes with compost (particularly CO_2), consistent with more carbon stored in soil

Healthy Soils Program
CDFA OFFICE OF ENVIRONMENTAL FARMING & INNOVATION

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Questions?

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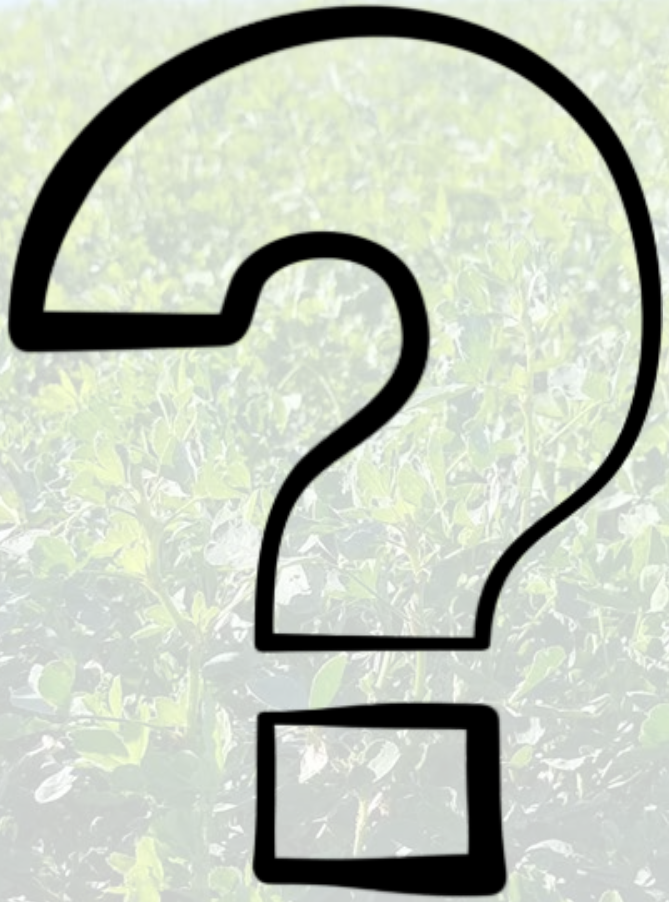

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