



# Understanding and managing soil health of citrus

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# What is soil health?



USDA Natural Resource Conservation Service (NRCS) definition:

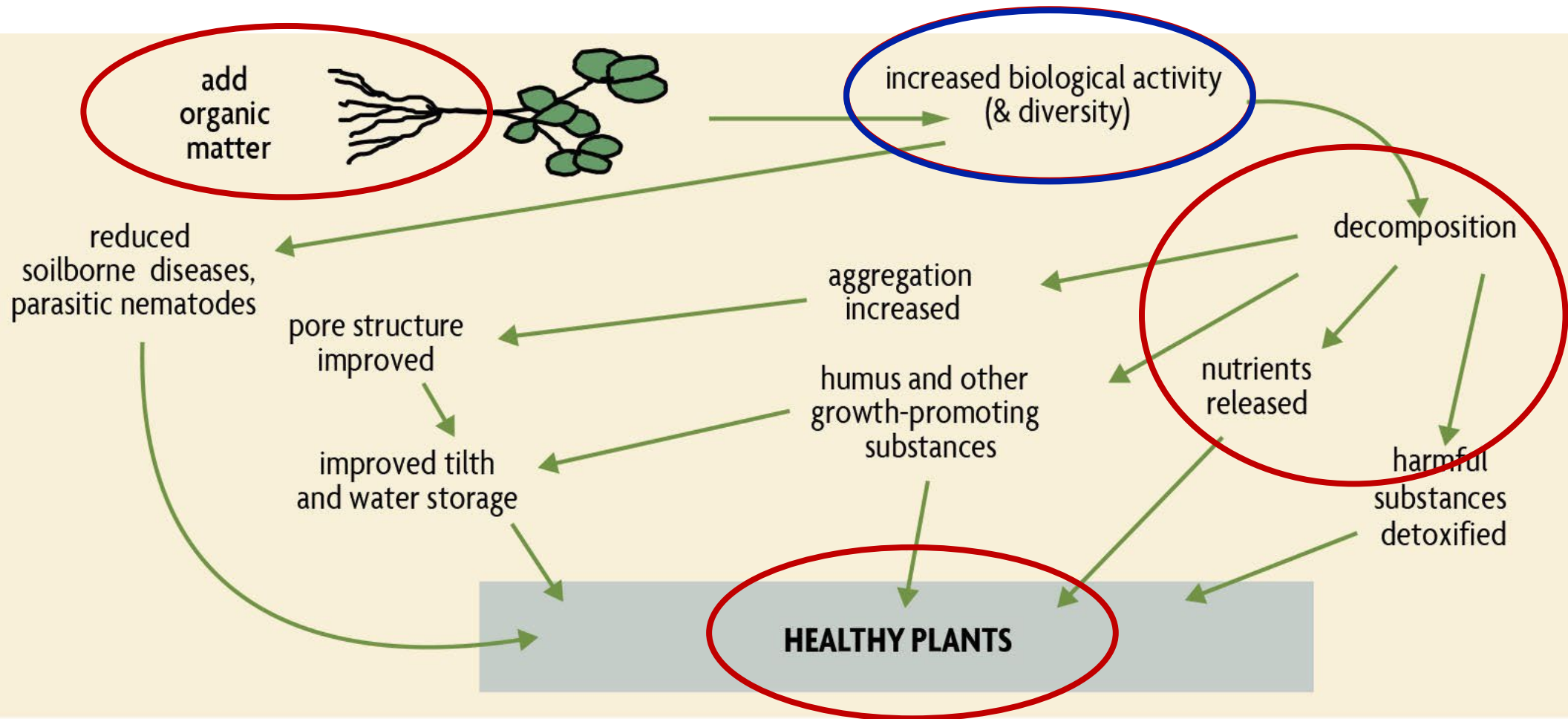
”....the continued capacity of a soil to function as a vital living ecosystem that sustains plants, animals, and humans”

Soil quality = soil fertility = soil health?



**“Soil health” includes soil biota (and microbes!)**

# Why is soil health important?



# What can you do to improve your soil health?



Cover Crops

Compost



Humic and fulvic acids

# Field trials: cover crops

Locations and trees:

- Southwest Florida region
- Trees are 'Valencia' on Swingle
- Cover crops planted twice per year (May and November)



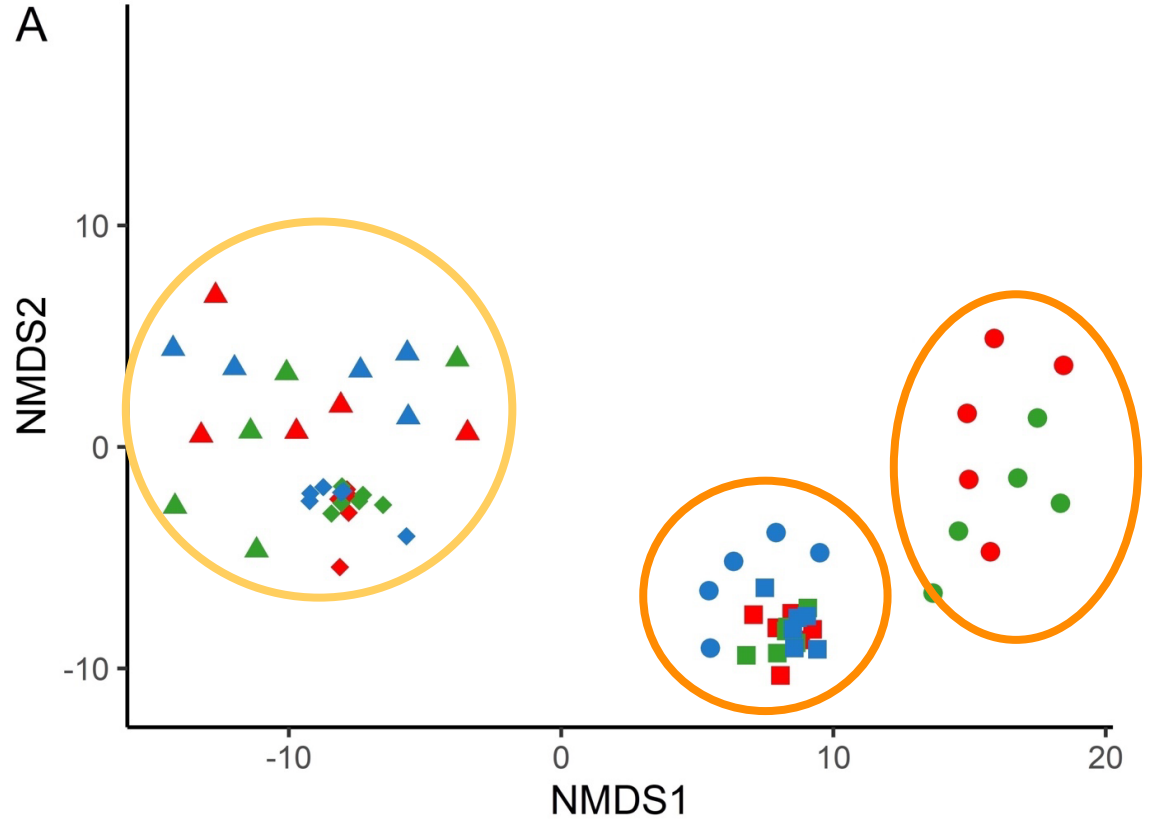
# Cover crop treatments



	Summer	Winter
<b>Legumes (LG)</b>	Sunnhemp	Sunnhemp
	Cowpea	Cowpea
<b>Non-legumes (NL)</b>		White clover and/or Crimson clover
	Buckwheat	Buckwheat
	Brown top millet and/or Dove millet	Daikon radish
	Egyptian wheat or Sorghum sudangrass	Oats
		Rye

# Cover crop mixtures CAN impact soil microbes

## Bacteria

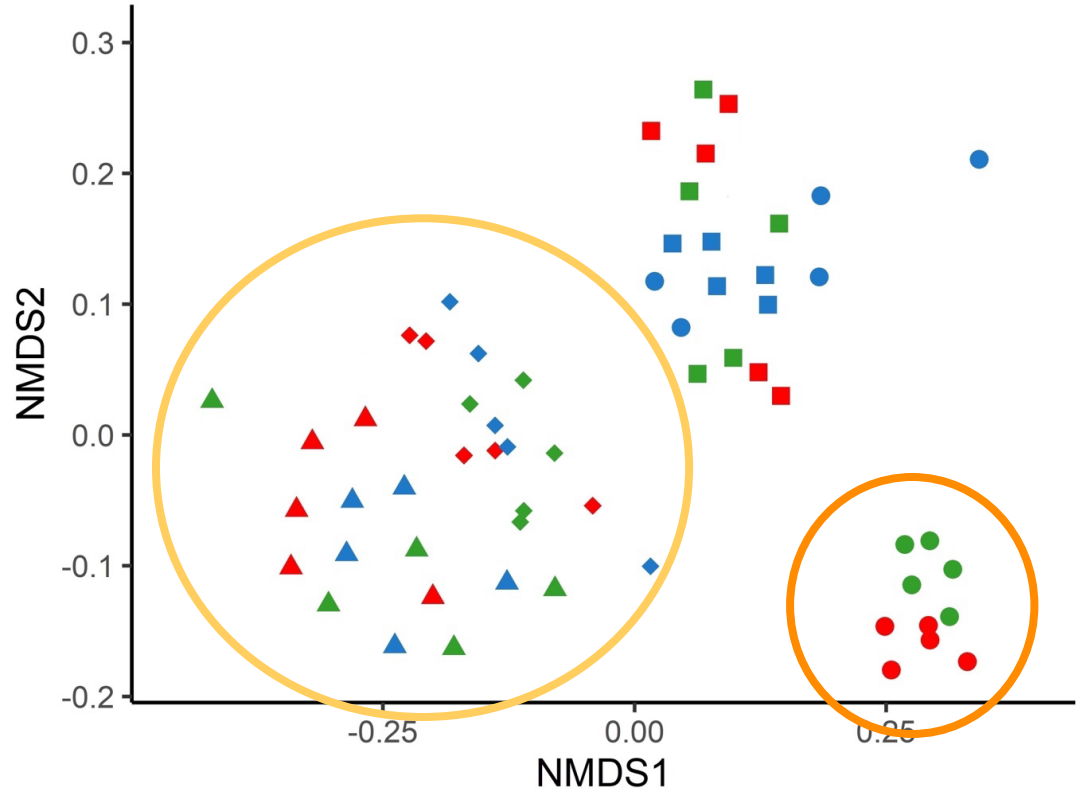


COA : PERMANOVA: Treatment:  $p < 0.001$ ; Time point:  $p < 0.001$   
 COB : PERMANOVA: Treatment:  $p > 0.05$ ; Time point:  $p > 0.05$

### Time point

- COA - Start
- COA - End
- ◆ COB - Start
- ▲ COB - End

## Fungi



COA : PERMANOVA: Treatment:  $p < 0.001$ ; Time point:  $p < 0.001$   
 COB : PERMANOVA: Treatment:  $p > 0.05$ ; Time point:  $p > 0.05$

### Treatment

- LG + NL
- NL
- GSC

# Take home:

Cover crops can change soil microbiome composition and functions

Magnitude of changes depends on cover crop mix and time

....but we still have questions

Long-term impacts on trees

Nutrient release/availability

Carbon sequestration





# What can you do to improve your soil health?



Cover Crops

Compost



Humic and fulvic acids

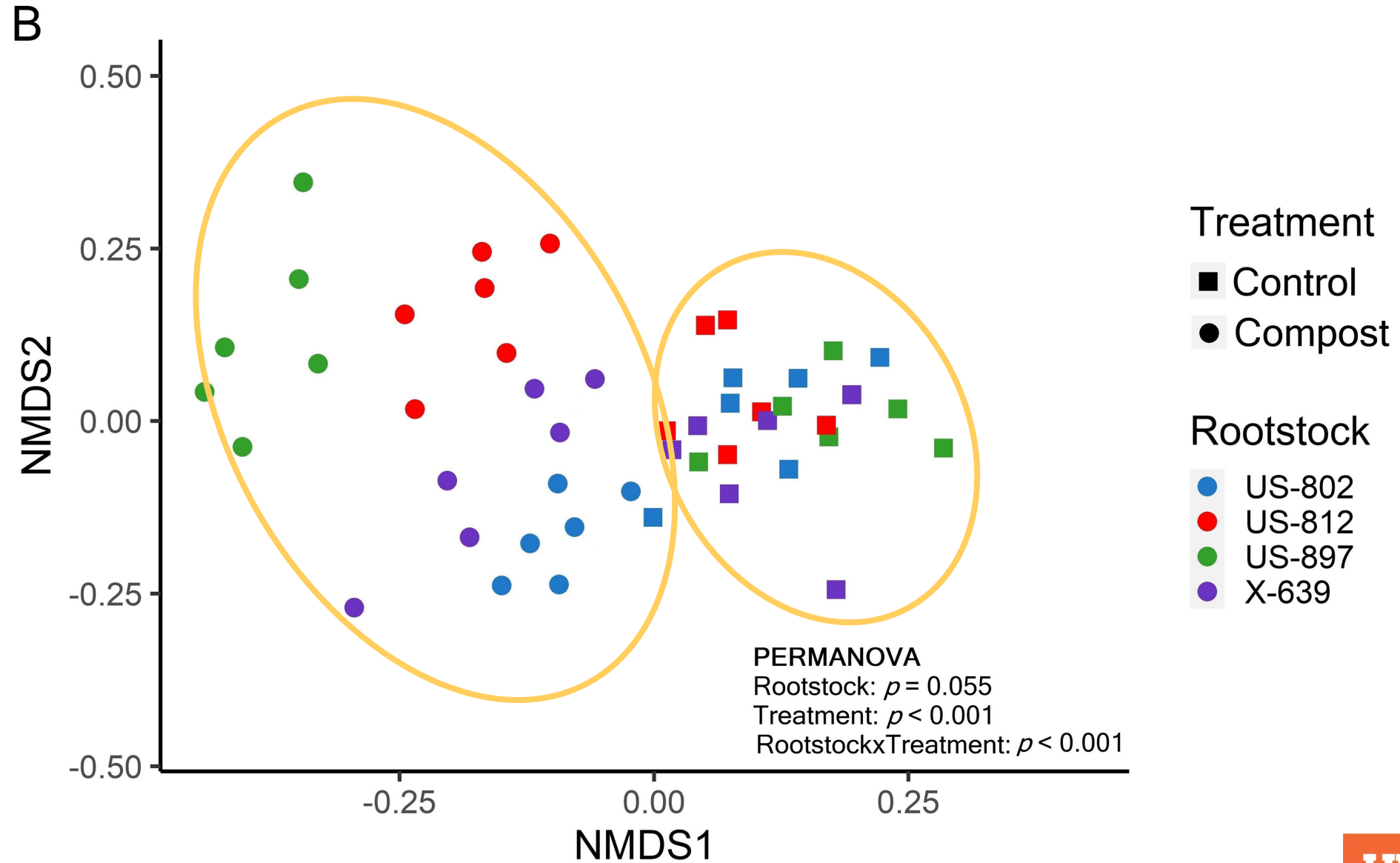


# Field trials: compost application

- Commercial field trial with 4 rootstocks  
X-639, US-802, US-812, US-897
- Plant-based compost and no-compost treatments  
Compost applied 2x year at 12.4 tons/ha



# Rootstock-specific interactions with compost



# Take home:

Compost impacts on rhizosphere differ based on rootstock

Compost can change rhizosphere microbes related to specific root nutrients

....but we still have questions

Long-term impacts on trees

Nutrient release/availability

Differences in compost types and application rates



# Field trials: combining treatments

- Compost + cover crops on young trees
  - Valencia on US-942 planted in April
  - All trees have IPCs
- Compost and cover crops to be applied twice/year



# What do you measure to determine soil health?

# Measuring soil health in Florida citrus

Assessments of indicators in commercial citrus groves using cover crops (i.e. “healthy” soils):

Old grove: 35+ year old trees and cover crops for 4+ years

Young grove: 10 year old trees and cover crops for 2+ years



# Indicators to be tested

## “Short-term” indicators (3 times/year) at one soil depth:

- Soil chemical indicators:
  - POXC
  - C mineralization
  - N mineralization
  - ACE protein content
  - Extractable P
- Soil microbial/chemical indicators:
  - Microbial biomass P
  - Enzyme activities (C, N, and P cycling enzymes)

## Cover crop and production data:

- Cover crop C and N inputs
- Tree yield
- Leaf N concentration
- Tree growth

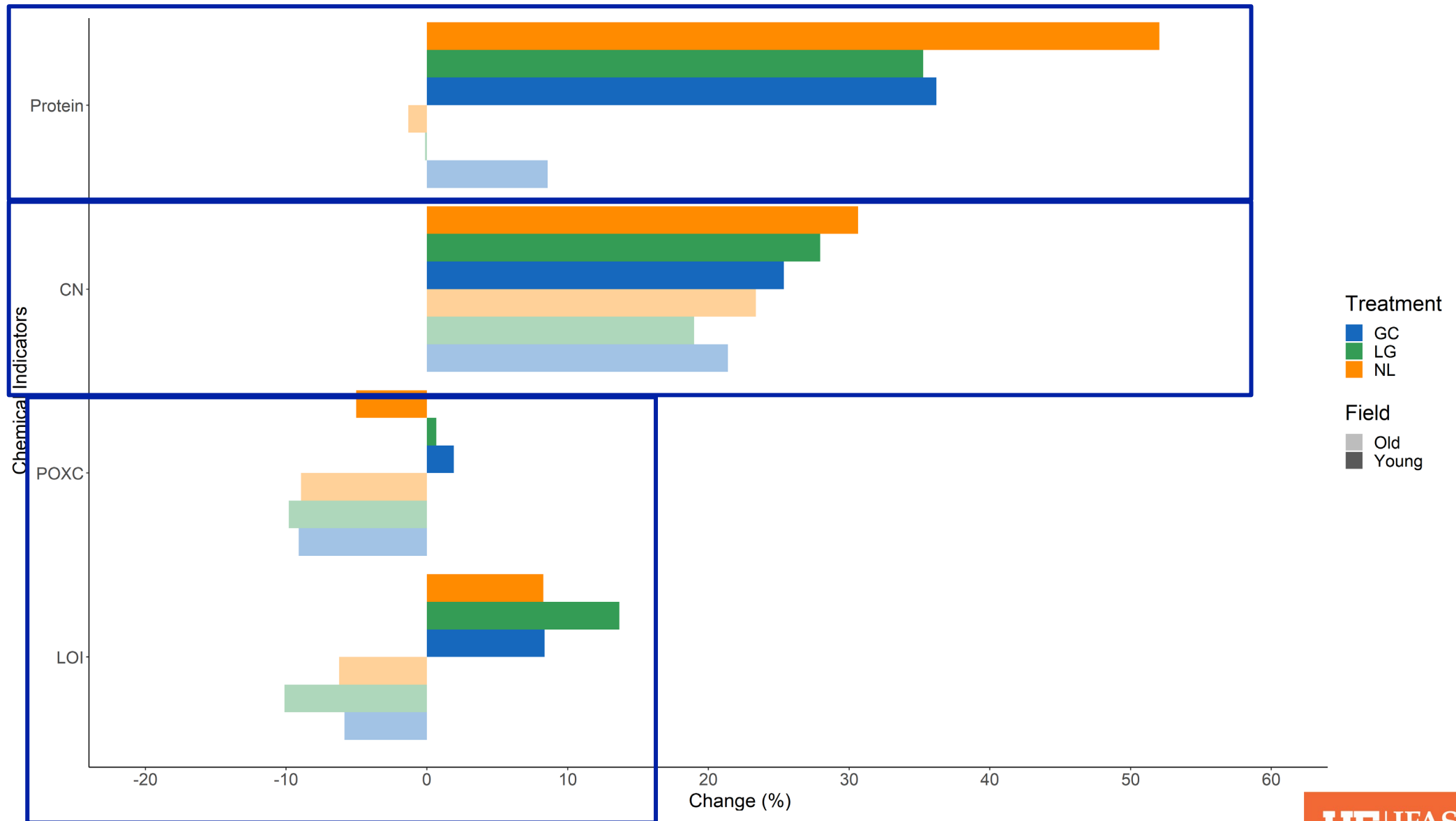
## “Long-term” indicators (once/year) at 3 soil depths:

- Soil physical indicators:
  - Aggregate characterization
  - Water content
  - Infiltration
  - Bulk density
- Soil chemical indicators:
  - CEC
  - pH
  - Inorganic N (nitrate and ammonium)
  - Total C
  - Total N
  - SOM
- Soil microbial indicators:
  - Abundance of N and P cycling genes
  - Plant growth promoting bacteria abundances and activity

Comparison with commercial soil health tests

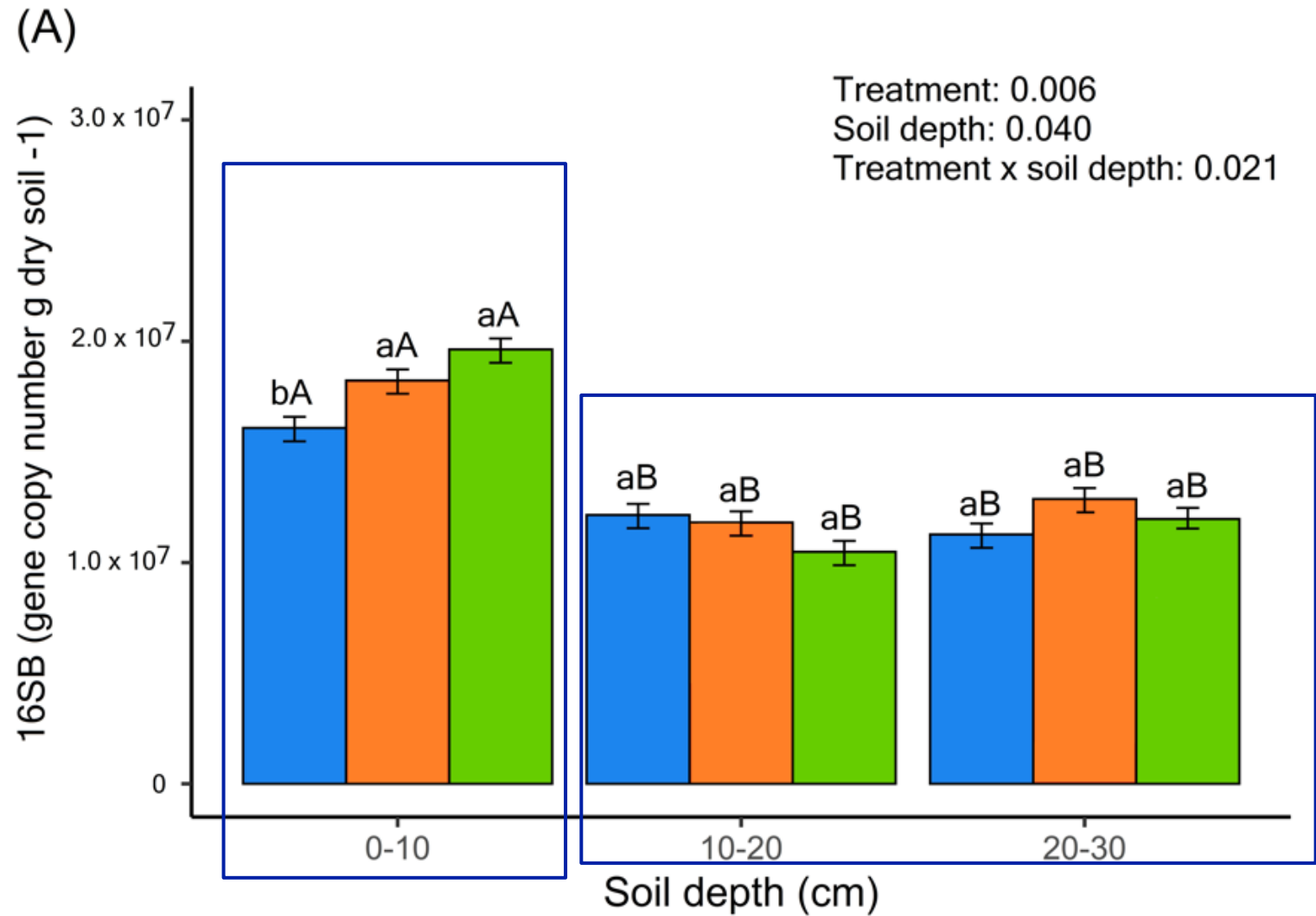


# Soil health indicators after 1 year



-Gonzales, Bacon, Strauss, and Maltais-Landry in preparation

# Indicators can vary by depth



....project in  
progress!

Determine which indicators  
are best at different time  
scales and depths

Best methods to monitor  
changes in soil health



# Summary

- Soil health is an analogy to help us think about ecosystem functions
- Cover crops and compost can impact soil microbes in citrus groves, but *changes to trees could take time*
- Most soil health indicators have not been evaluated in subtropical crops, and soil depth could be important to consider when looking at results



## Collaborators

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*Icons by Flaticon*



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