BEAM

Biologically
Enhanced
Agricultural
Management

Regenerating the Diversity of Life in Soils-
Hope for: Farming, Ranching, Environment and Climate!

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Biologically Enhanced Agricultural Management

The **BEAM** approach views soils from a

"Systems Perspective"

and includes all practices that enhance or improve populations of beneficial microbes in the soil microbiome!

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Biologically Enhanced Agricultural Management

BEAM practices include:

- **NO, or Reduced Chemical inputs or disturbance from tillage**
- **Year-round Living Roots from Full Time Ground Cover** of Cover Crops and/or Commodity Crops
- **Implementation of livestock** using Adaptive Multipaddock Grazing methods for range management. (carboncowboys.org)

or….

- **Inoculation with Beneficial Microbes** (i.e. from a Johnson Su Composting Bioreactor; https://youtu.be/DxUGk161Ly8)

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Microorganisms have shaped almost every facet of development on this living planet for the last 4.2 billion years…

They have accomplished this by:

Increasing System Biodiversity

and

Improving the Efficiency of the Capture, Storage and Utilization of Energy

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Land Plants & Glomeromycota
~400 to 500 MYA

Multi-cellular Photosynthesizing Organisms
~700 MYA

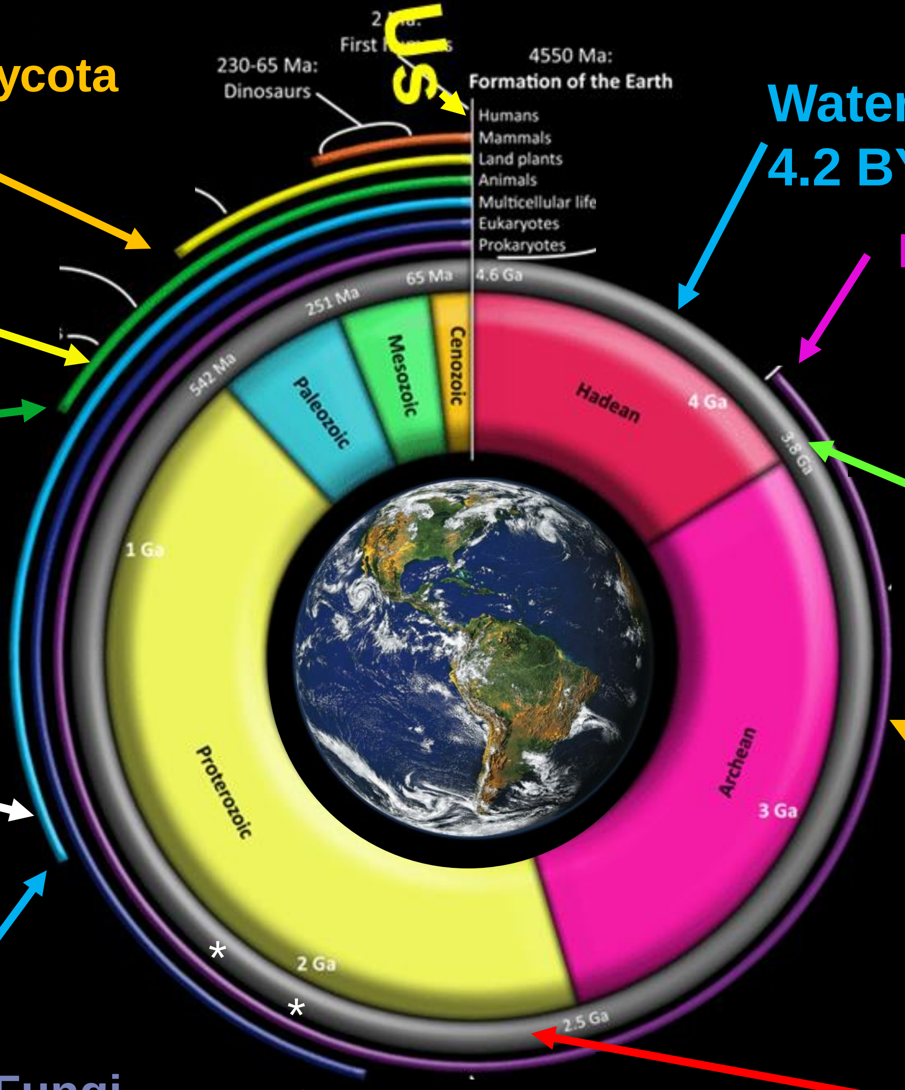
First Single Cell Animals
~750 MYA

Aerobic Respiration 18-times increase in Energy Use Efficiency

Mitochondria Evolved
~1.45 bya

Ozone Layer
Multicellular Life
~1.6 bya

Fungi
~2.2 BYA



Water
4.2 BYA

Bacteria
~4 BYA

Cyanobacteria Anoxygenic Photosynthesis
~3.8 BYA

Nitrogen Fixation
~3.2 BYA

Oxygenic Photosynthesis
Oxygen Rich Atmosphere
~2.4 BYA

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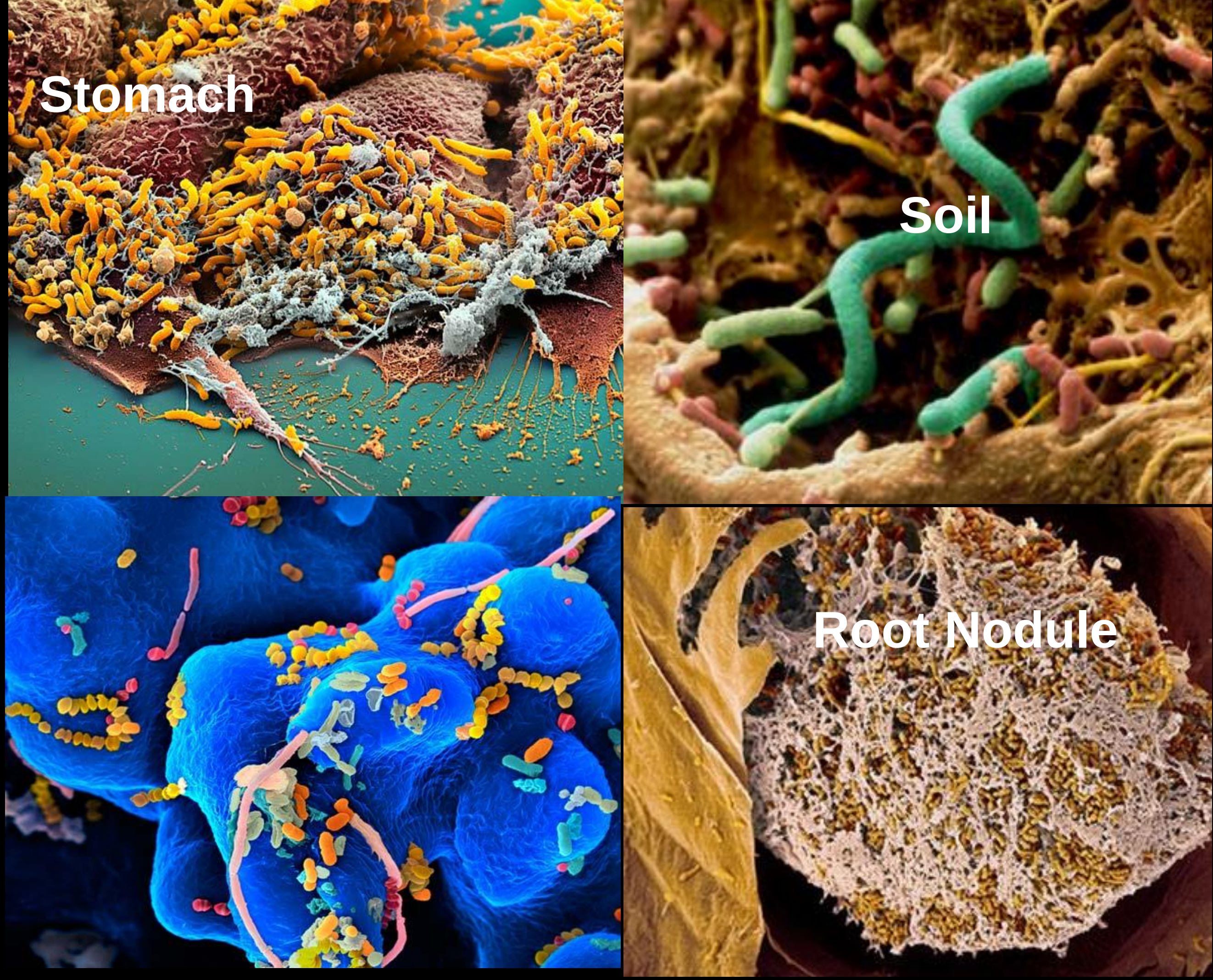
Microbes are the Foundation of Every Organism and Ecosystem on this “Living Planet”.



http://ngm.nationalgeographic.com/2013/01/125-microbes/oeggerli-photography

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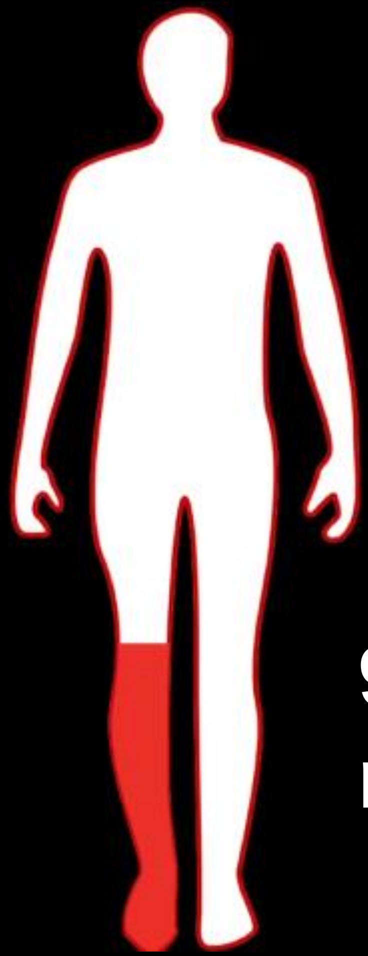
1 Quadrillion Resident Viruses

Cell Count Comparison

The human microbiome is comprised of all the:

- bacteria,
- fungi,
- protozoa and
- viruses

in our bodies



10 trillion human cells

90 trillion microbial cells

https://www.youtube.com/watch?v=i-icXZ2tMRM

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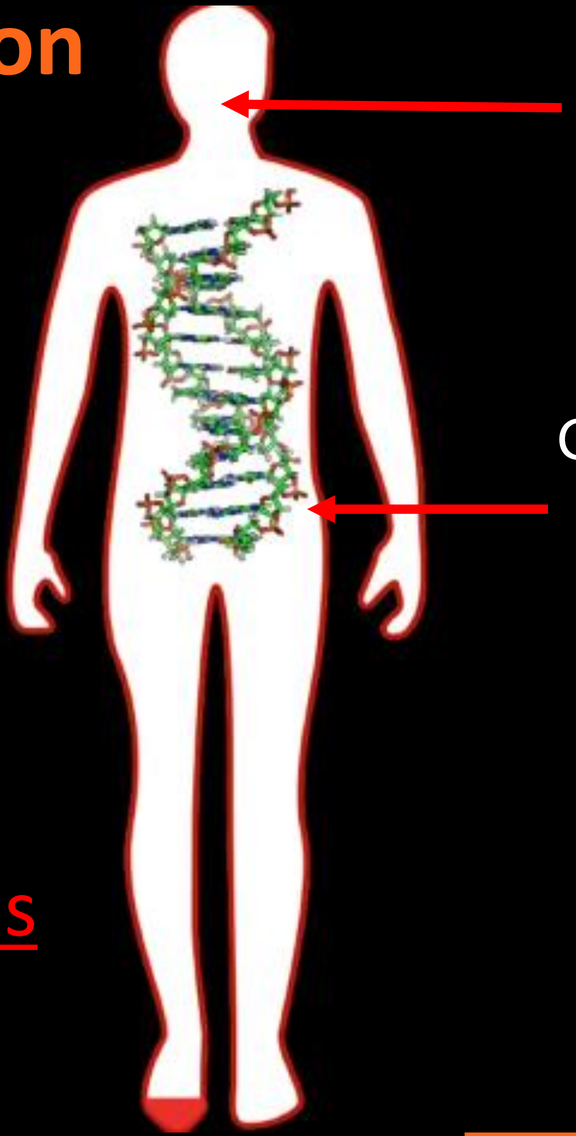
Gene Count Comparison



Oral Microbial Genome
24 million genes

Gut Microbial Genome
22 million genes

23,000
human genes

https://www.youtube.com/watch?v=i-icXZ2tMRM
https://www.sciencedaily.com/releases/2019/08/190814113936.htm

Food Digestion

Cell Renewal

Comprises >~~60~~ 80% of Immune System

Nutrient Generation

Controls Appetites and Cravings

Vitamin Synthesis

Detoxify Carcinogens

Turn off and on our genes that regulate brain development, anxiety, depression, autism, arthritis and emotional behavior

Prevents Allergies, Skin Diseases and Asthma

https://thesocietypages.org/socimages/2014/11/07/visualizing-the-fetus/

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What Happens When These Microbial Communities Are Disrupted Through

- Administration of Antibiotics
- Exposure to Chemicals
- Diet Related Issues

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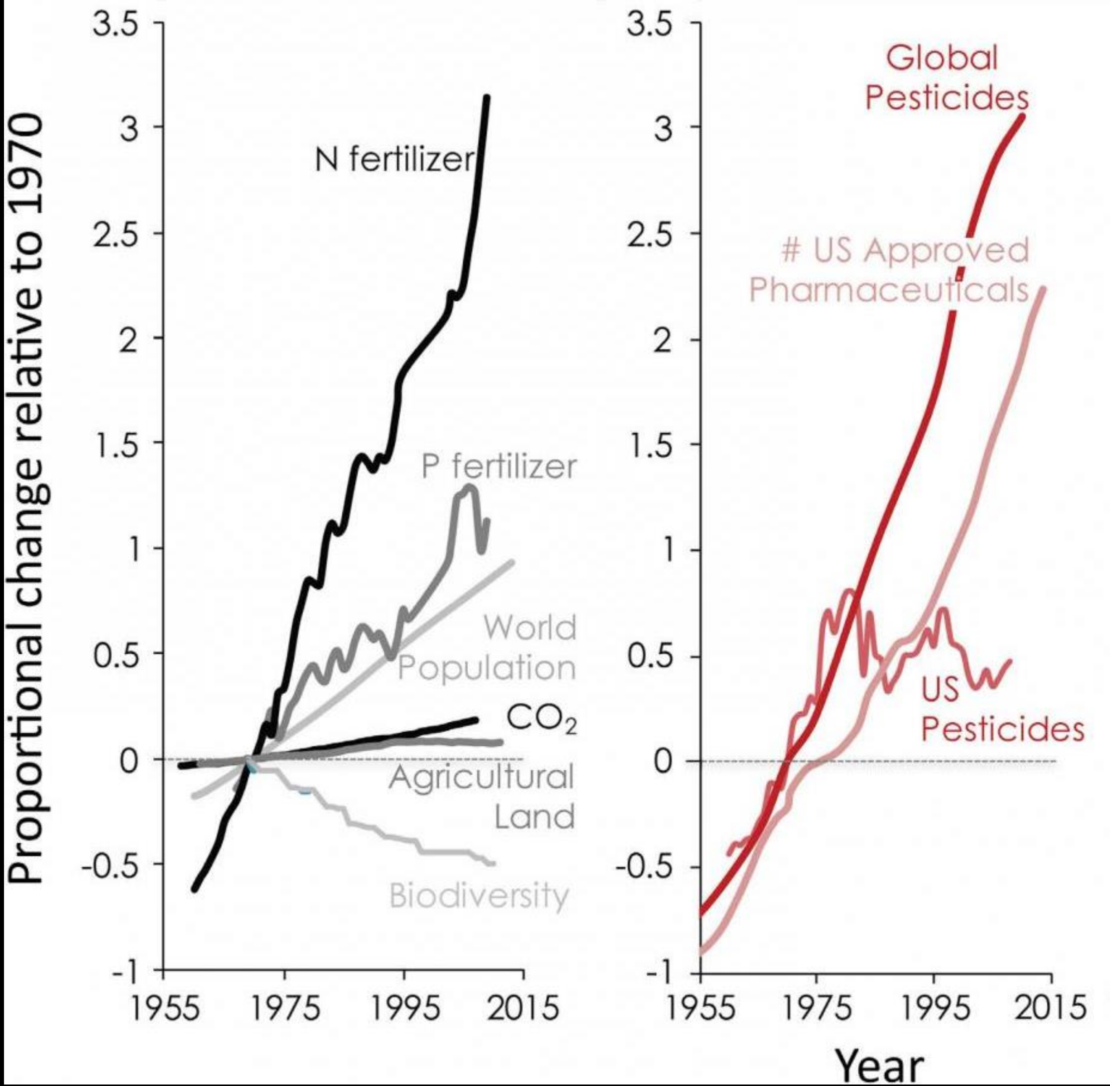
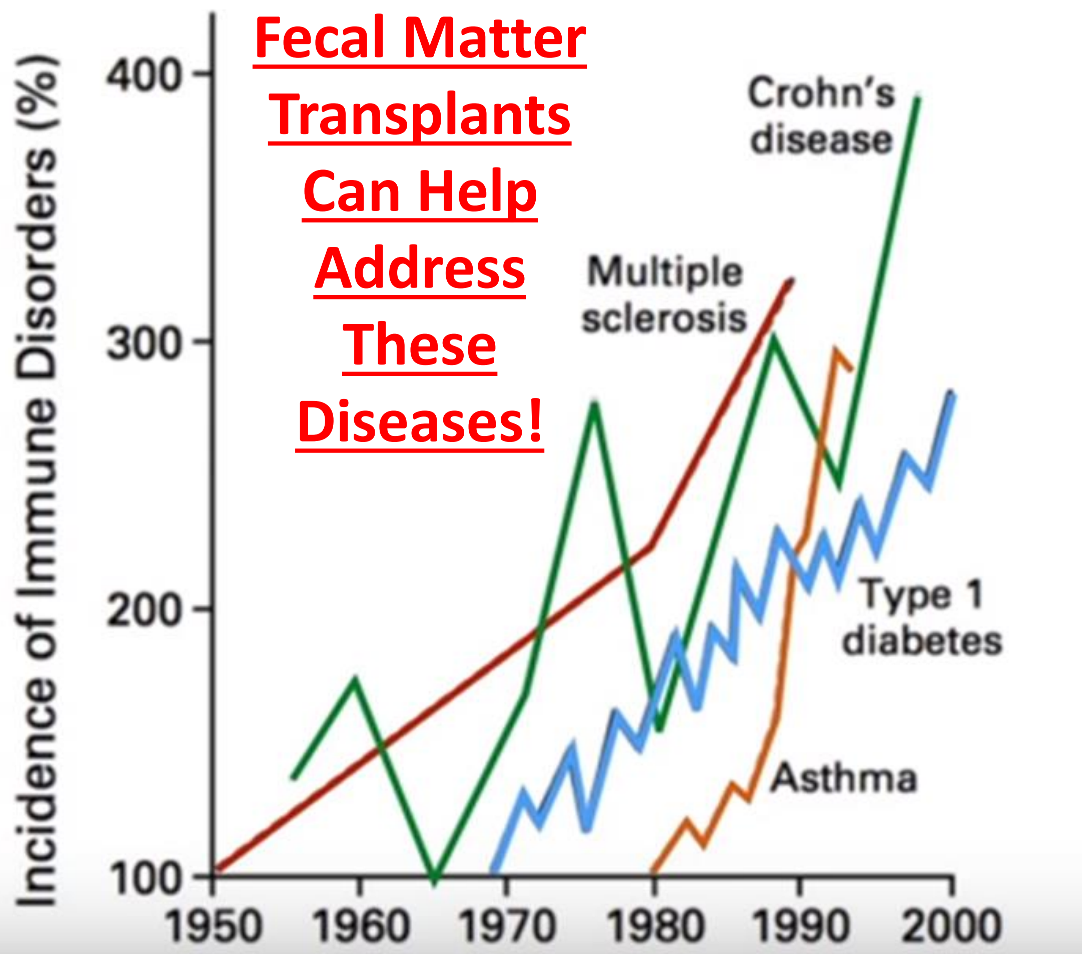


https://desdaughter.com/2017/02/08/production-of-synthetic-chemical/

Increased Incidence of Auto Immune Diseases



https://www.youtube.com/watch?v=47csmddyZMM Bach (2002) N Engl J Med. Vol. 347, 911-920 Med

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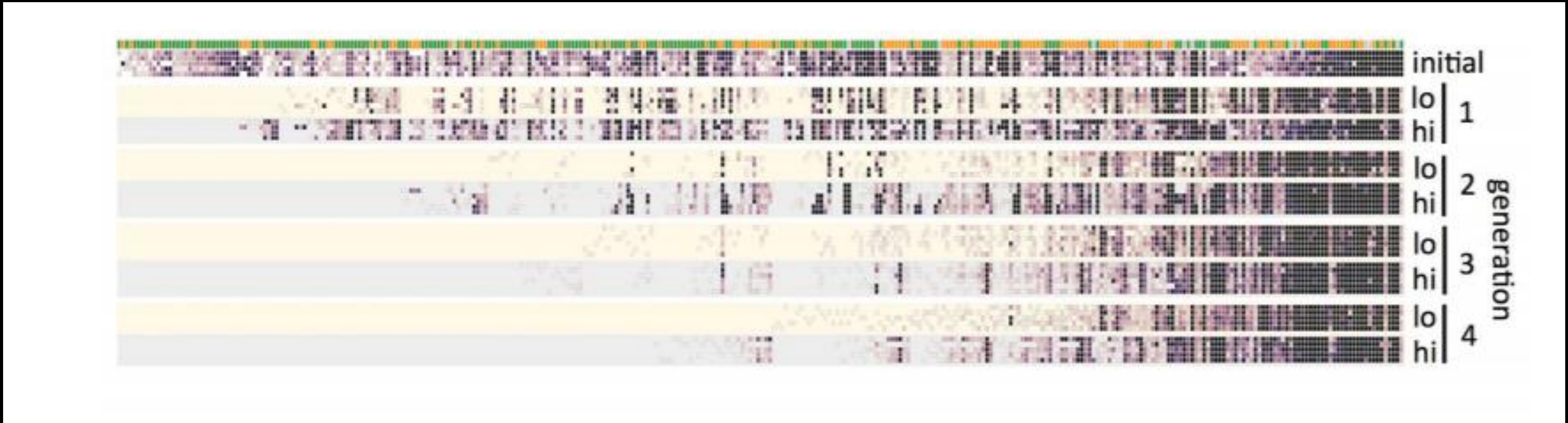
Diet Induced Extinction of Microbiota

Microbiota-accessible Carbohydrates (MAC) FIBER

Low Fiber Diet



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4850918/pdf/nihms742543.pdf

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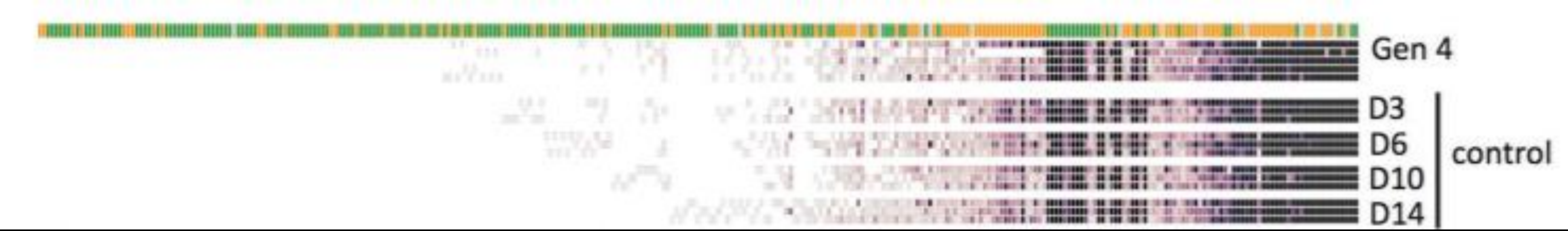
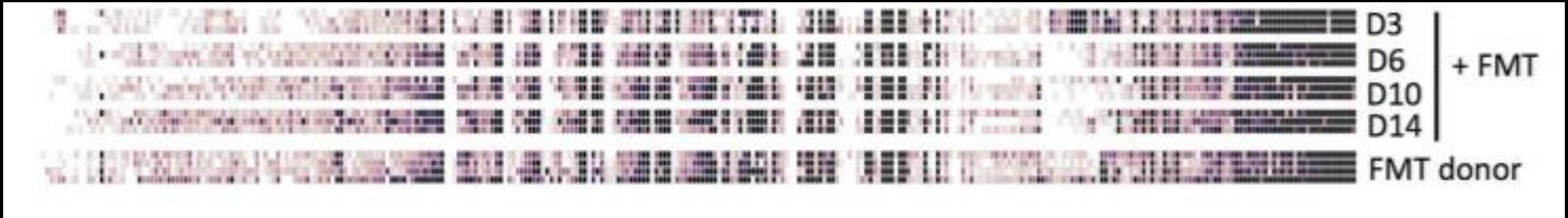
Re-establishment of Gut Microbiome

Re-introduce Fiber into the Diet



Increased Fiber Diets + **Fecal Matter Transfers**



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4850918/pdf/nihms742543.pdf

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Two Things have Happened Over the Last 120 years as a Result of our Farming management:

- We have significantly altered the soil microbiome with our agricultural management practices.
- Soil microbial biomass has changed from fungal dominant to bacterial dominant.

These have created a soil that has lost its biological functionality…… decreasing the ability for the soil microbiome to supply necessary elemental nutrients to plants from the soil parent material and our atmosphere.

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If Microbiota Transfers Work in the Human Microbiome.....

Can a simple inoculation of beneficial microbes help restore microbiome structure and function in agricultural soils?

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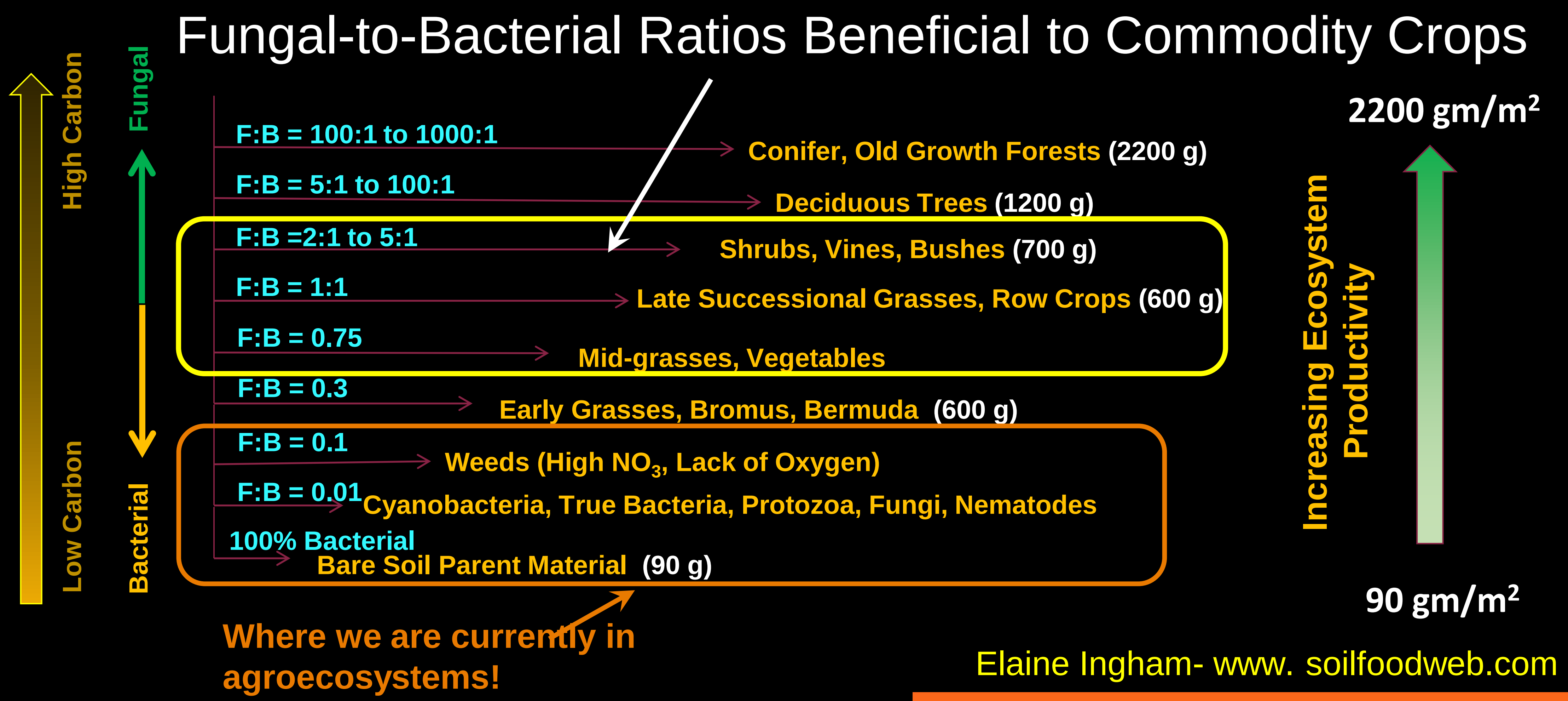
Plant Succession Ladder as a Function of Fungal:Bacterial Ratio (F:B)



Elaine Ingham- www. soilfoodweb.com

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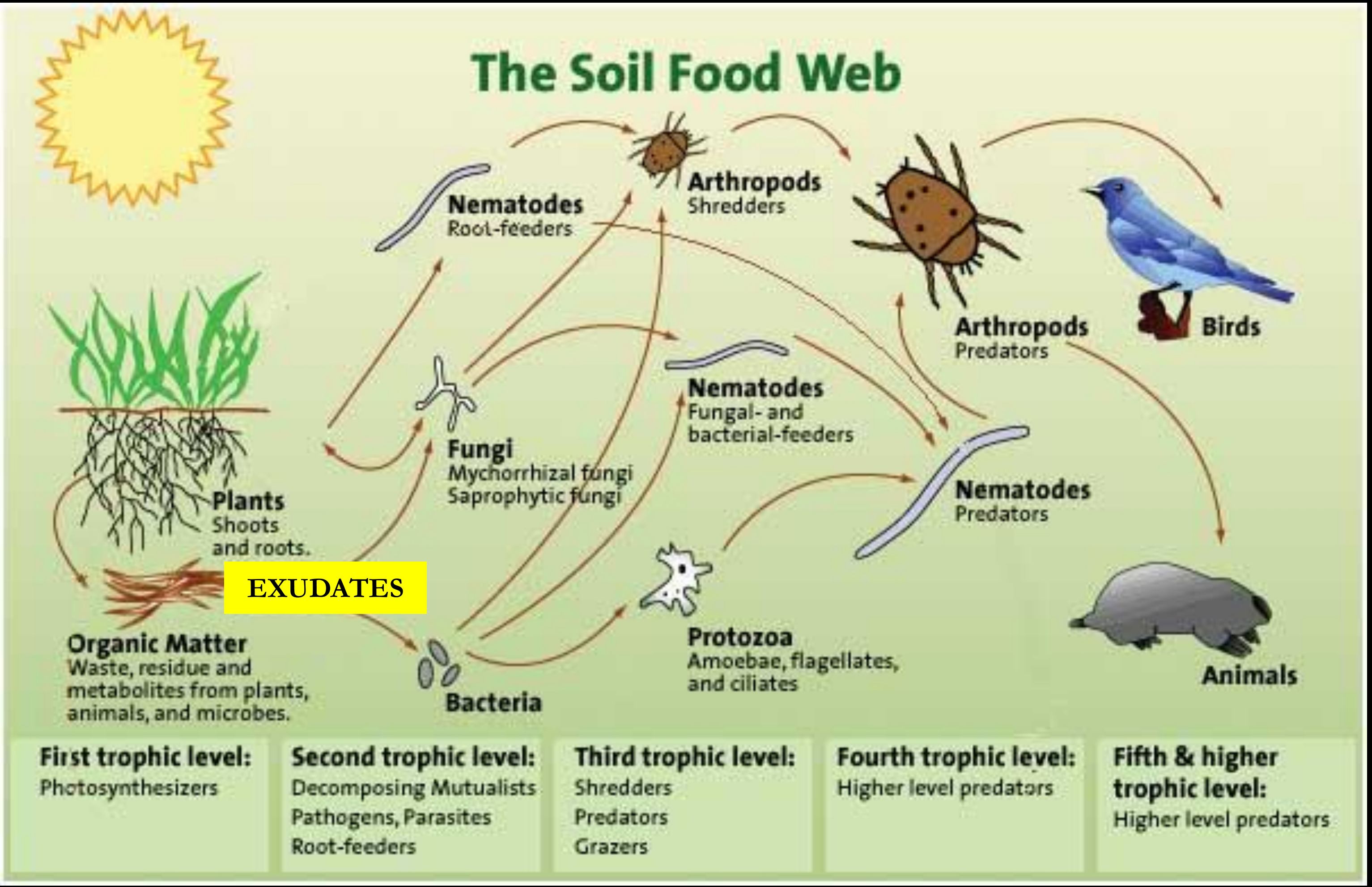

Living Organisms

$C_{18\%}H_{10\%}O_{65\%}N_{3\%}Ca_{1.4\%}P_{1\%}\ X_{4.9\%}$

Respiration

$CO_2 + H_20$
$+ NH_3$

C:N Ratio **4-5:1** **15:1** **20:1**

$3\ NH_4^+$ $4\ NH_4^+$

https://www.britannica.com/science/cellular-respiration
https://www.soilfoodweb.com.au/about-our-organisation/benefits-of-a-healthy-soil-food-web

Nature’s System of Soil Building

https://www.smithsonianmag.com/science-nature/these-non-lethal-methods-encouraged-science-can-keep-wolves-killing-livestock-180976505/
https://www.nationalgeographic.com/animals/article/150418-insects-dung-beetles-animal-behavior-navigation
https://www.panna.org/blog/got-worms-why-healthy-soil-matters

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Johnson-Su Bioreactor







https://youtu.be/DxUGk161Ly8

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Johnson/Su

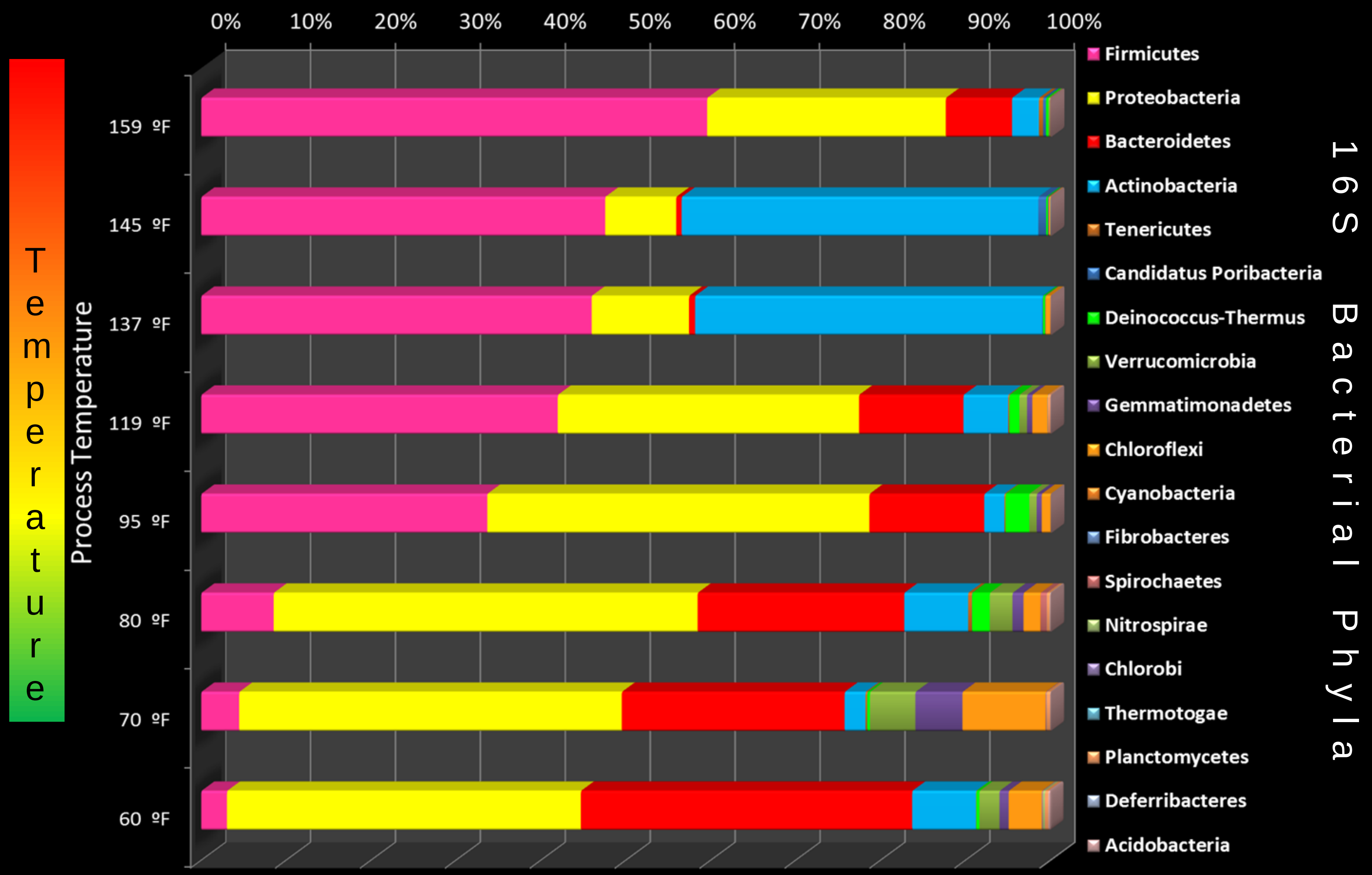
Static Composting Technology

- ~70% moisture content !
- No-Turning !
- Aerobic (6 air columns up through the pile)
- <u>Do Not Let It Freeze or Dry Out !!!!!</u>
- Worms added after temperature goes below 80˚ F (27˚ C)
- One year to reach maturity
- Follow the instructions closely on the first try…no short cuts, please !

https://youtu.be/DxUGk161Ly8

60°C

15°C



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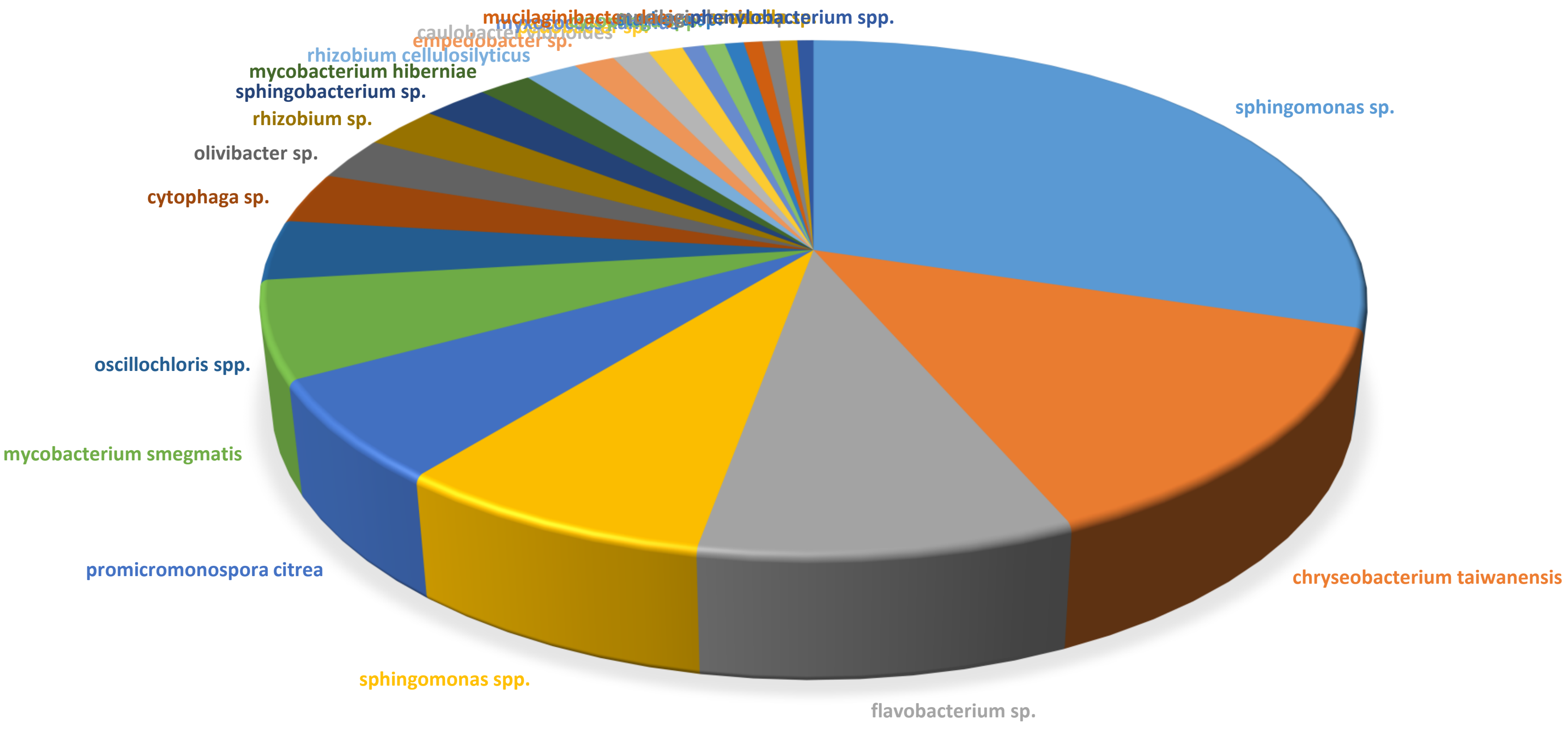
4 WEEK (316 of 740 species)
Top 80% has 23 species



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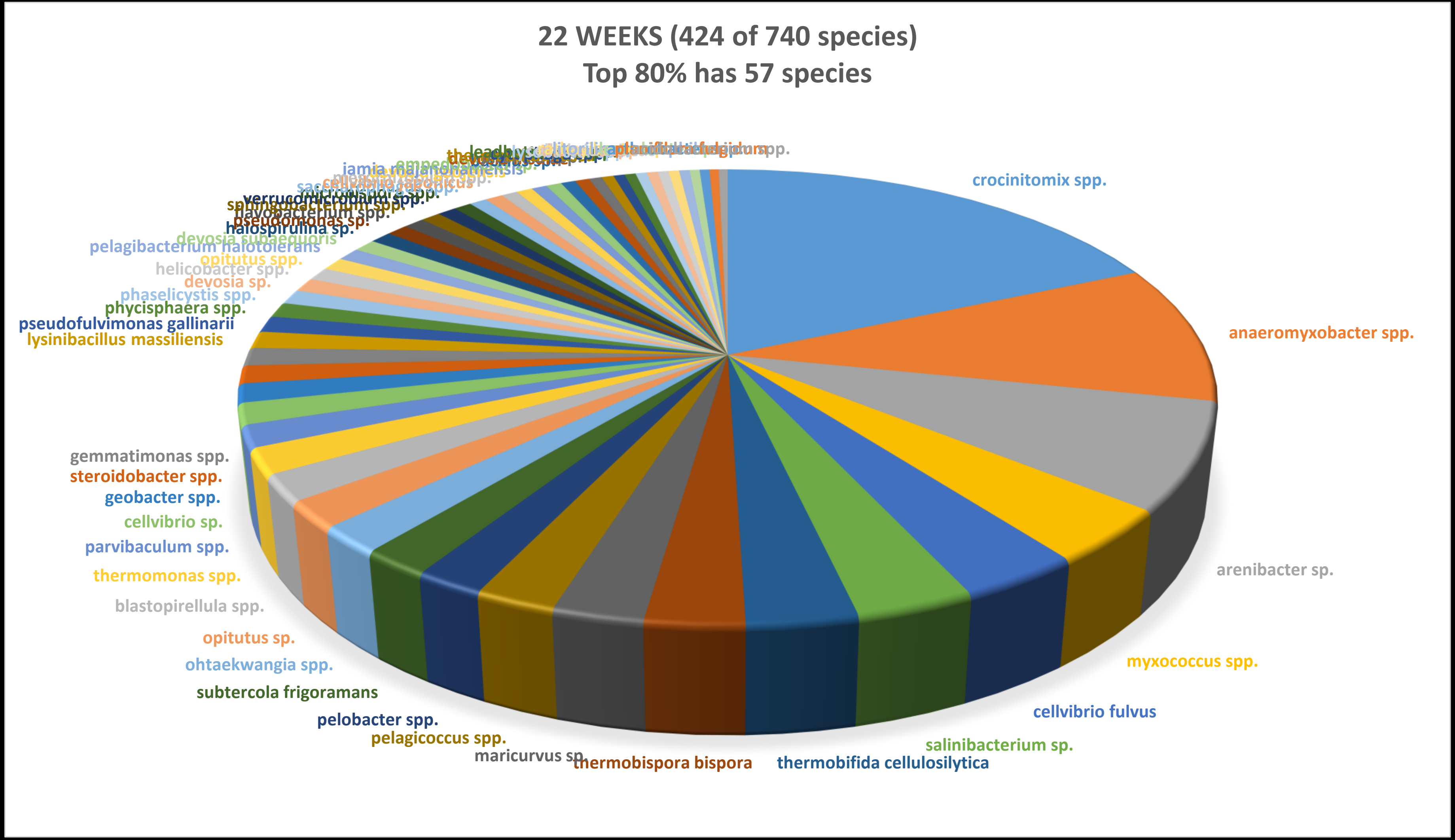

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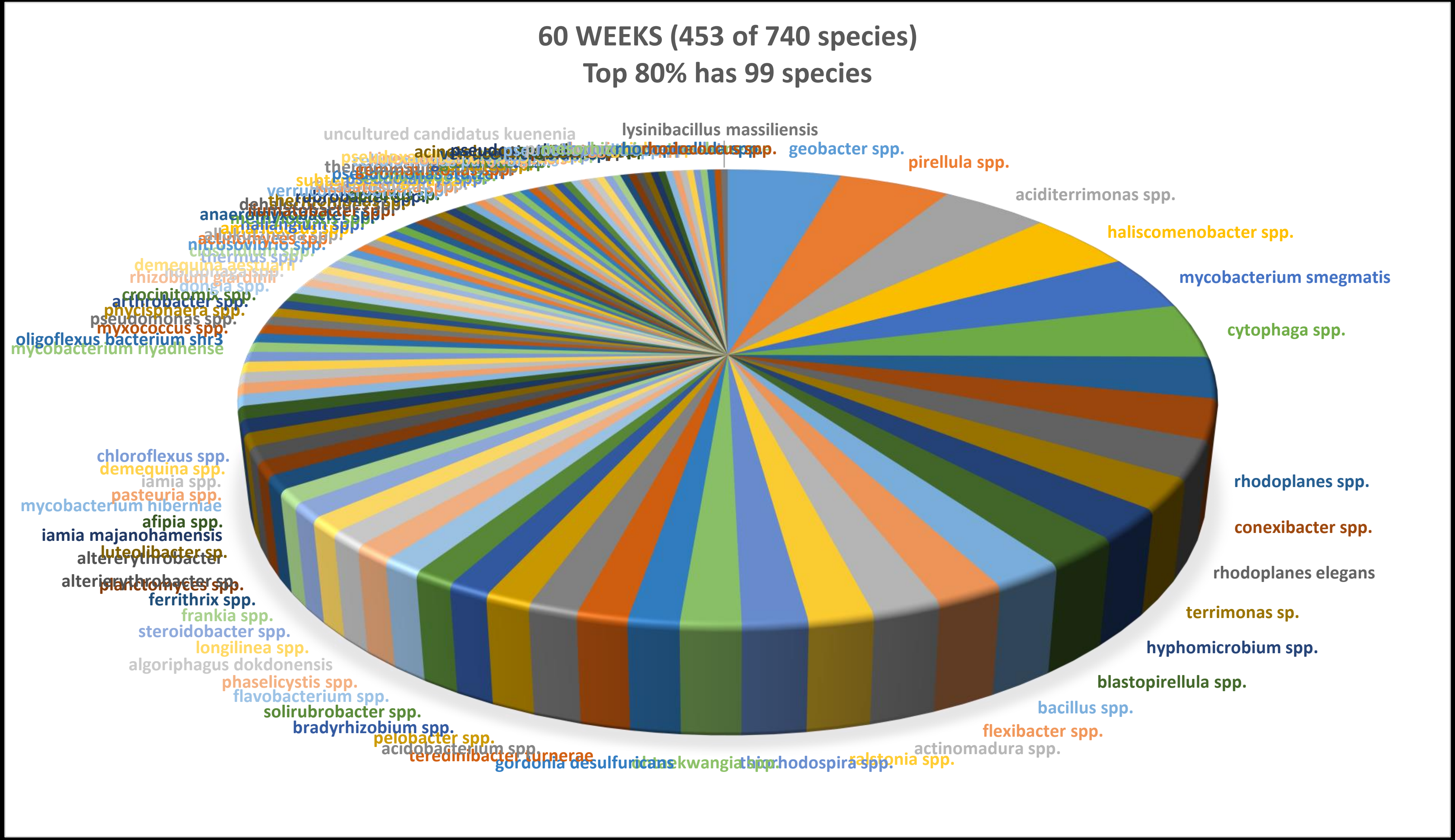

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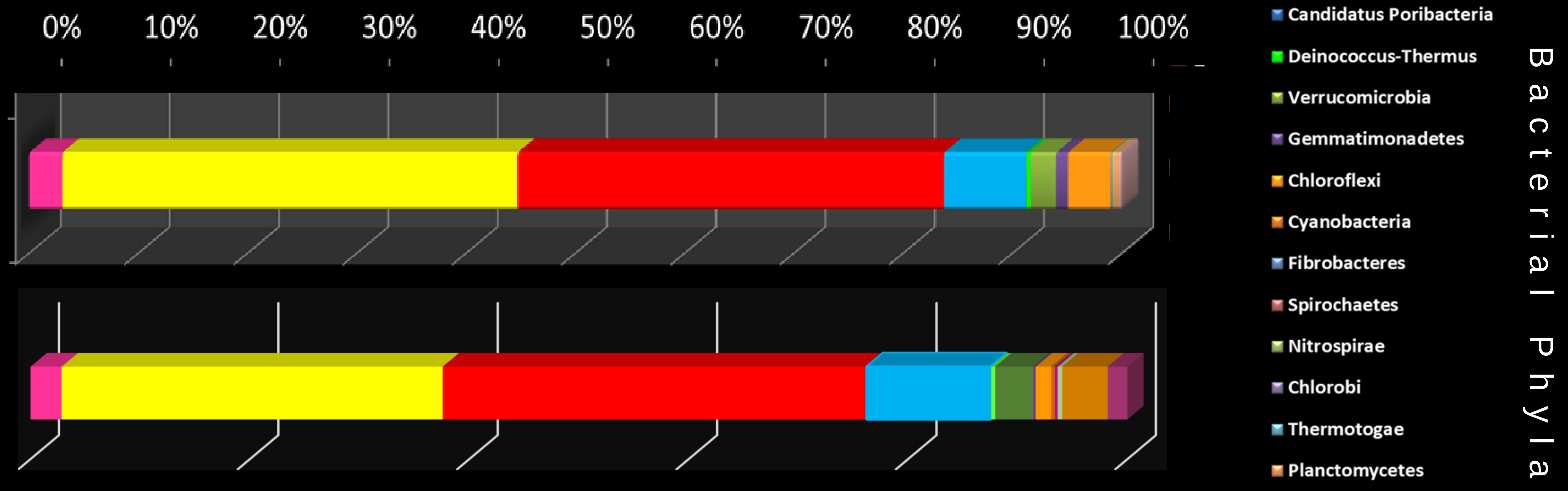
Two Compost Samples
Ten Years Apart with Different Materials



16S Bacterial Diversity Assay

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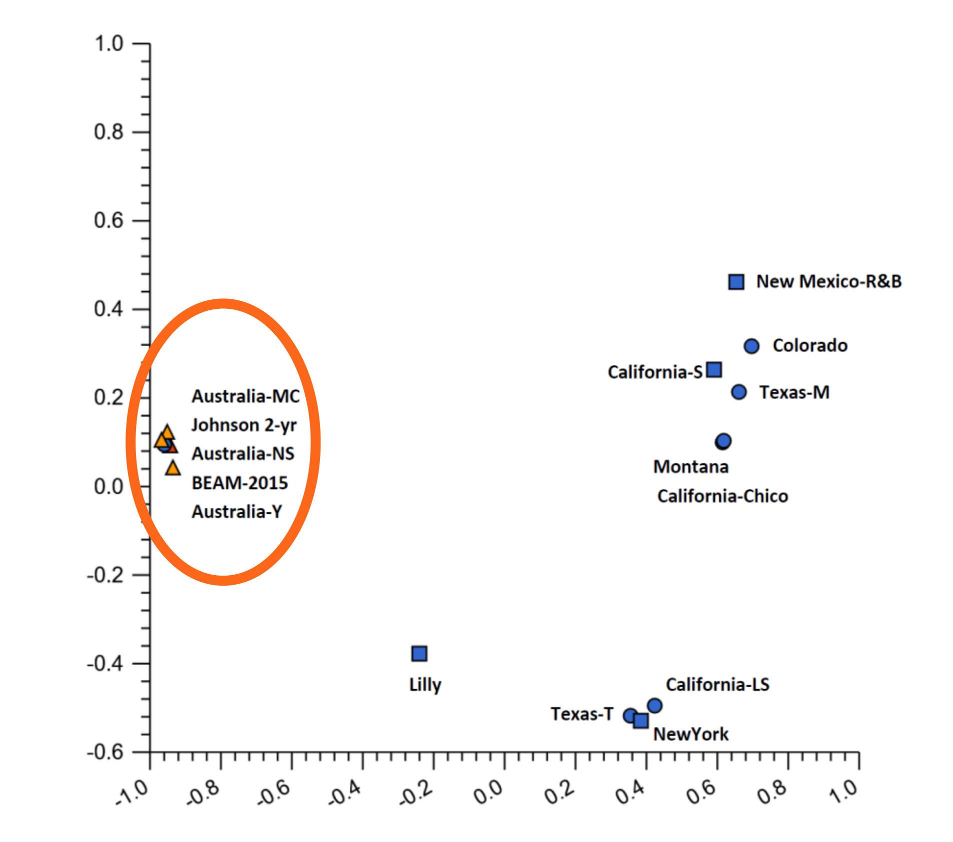
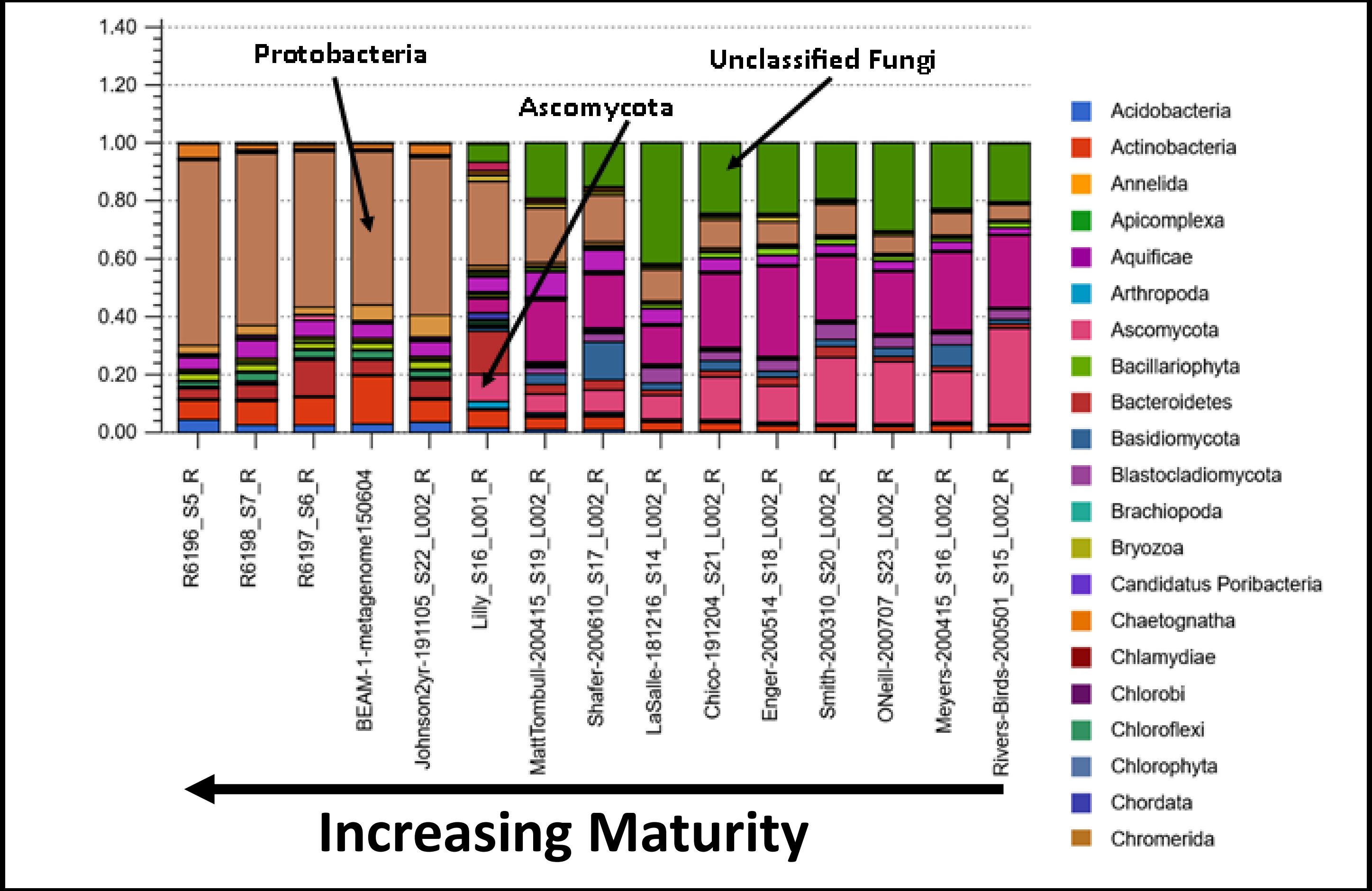
Principal Component Analysis: Euclidean Distance Method, Genus Level, w/Normalization



Metagenome Analyses (phyla level)



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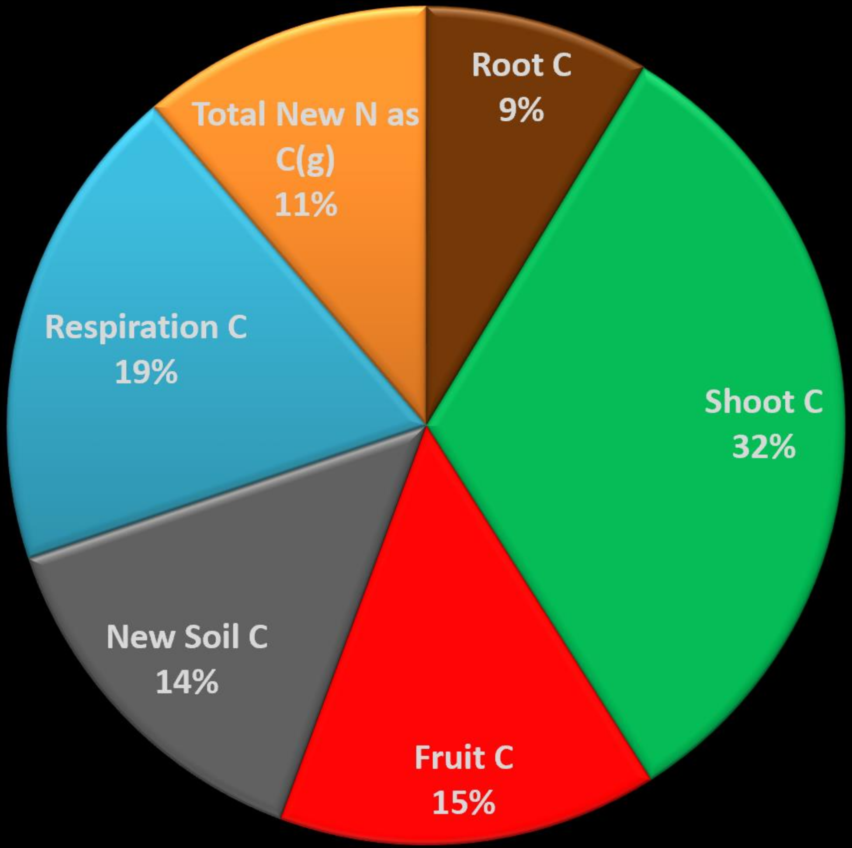
Greenhouse Trials with Green Chile Assessing the Influence of F:B On C & N Partitioning



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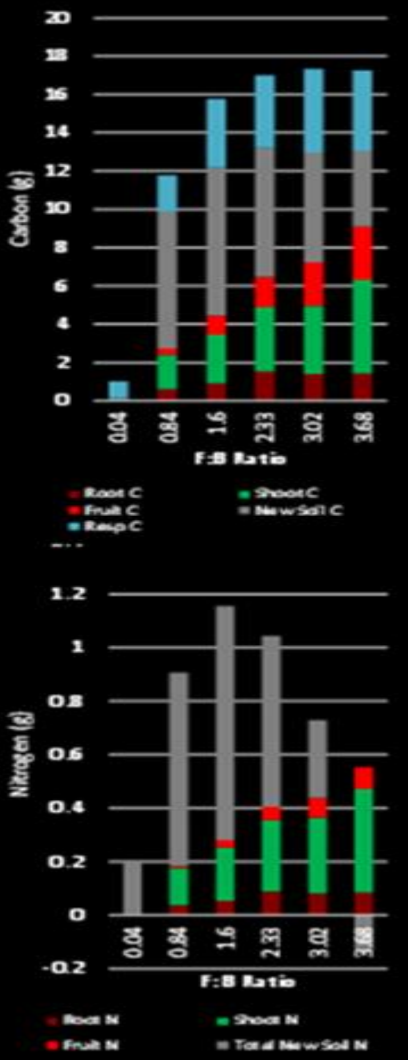
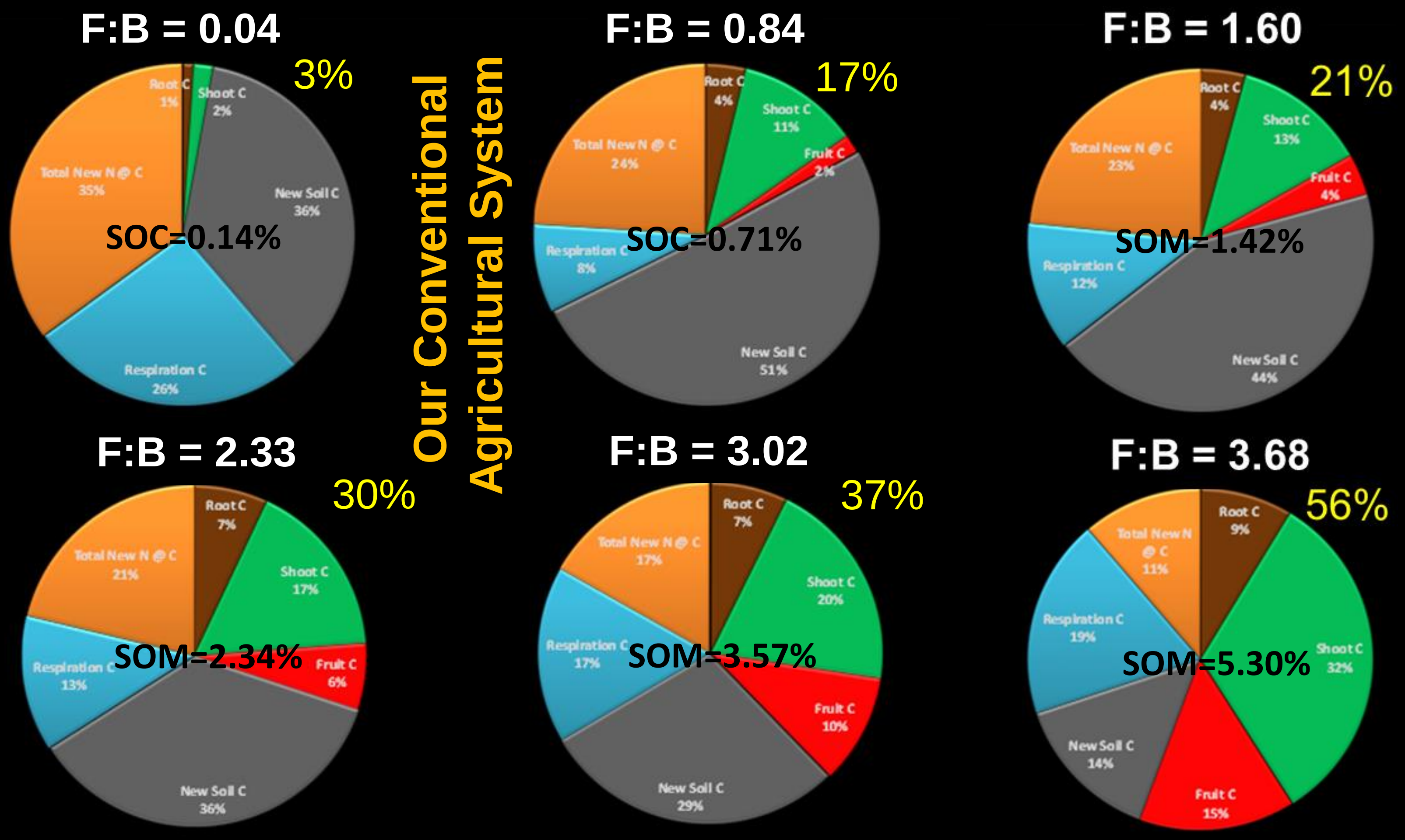
Efficiency of Carbon Flow into Plant Biomass





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Second Winter Cover

1,608 grams dry biomass/m^2

540 kg N/ha (486# of N/acre)

2015 Desert Sandy Soil Trial

One Time Compost Application Rate

504 kg/ha (450 lbs/ac)

12 inches (30 cm)

12 inches (30 cm)

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2016 Desert Sandy Soil Trial

Third Winter Cover

2,190 grams dry biomass/m^2 21.9 tons Dry Biomass/ha

654 kg N/ hectare (588# N/acre)

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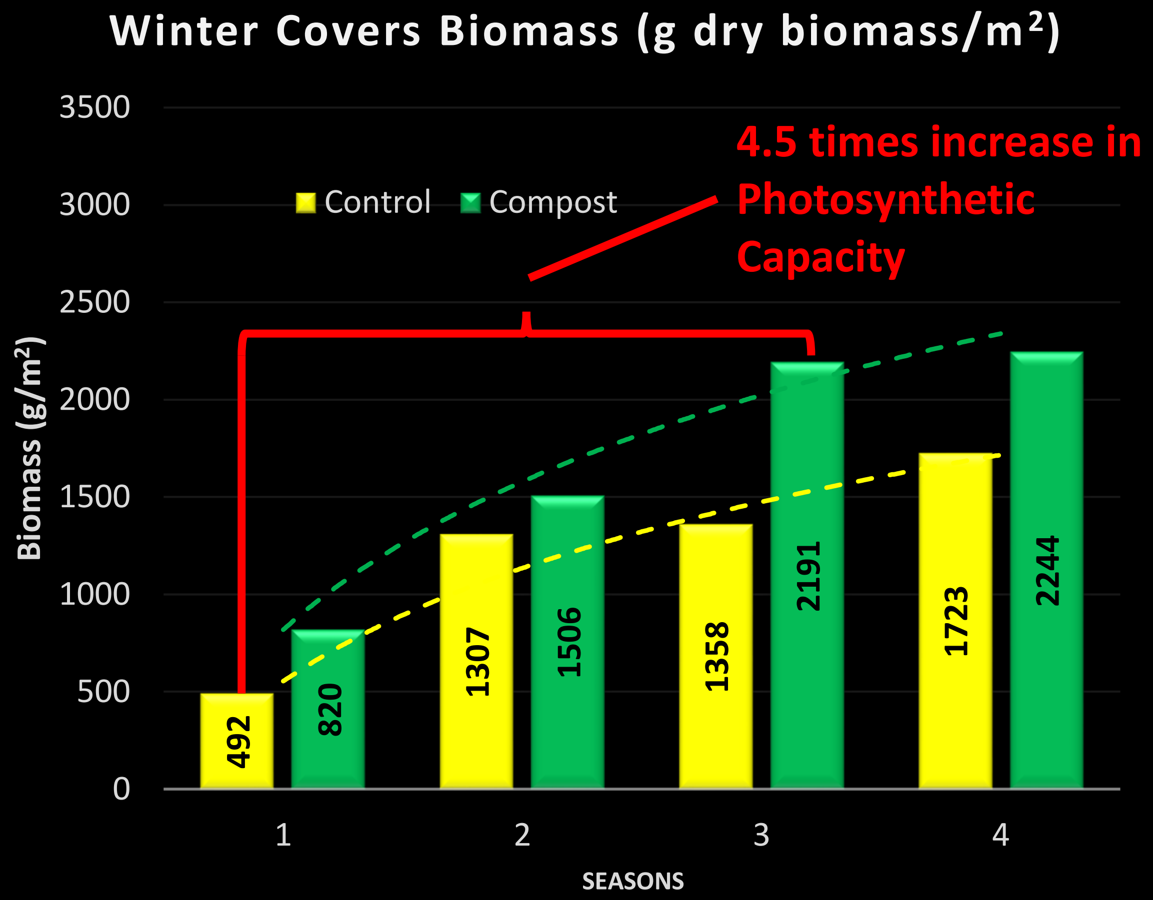

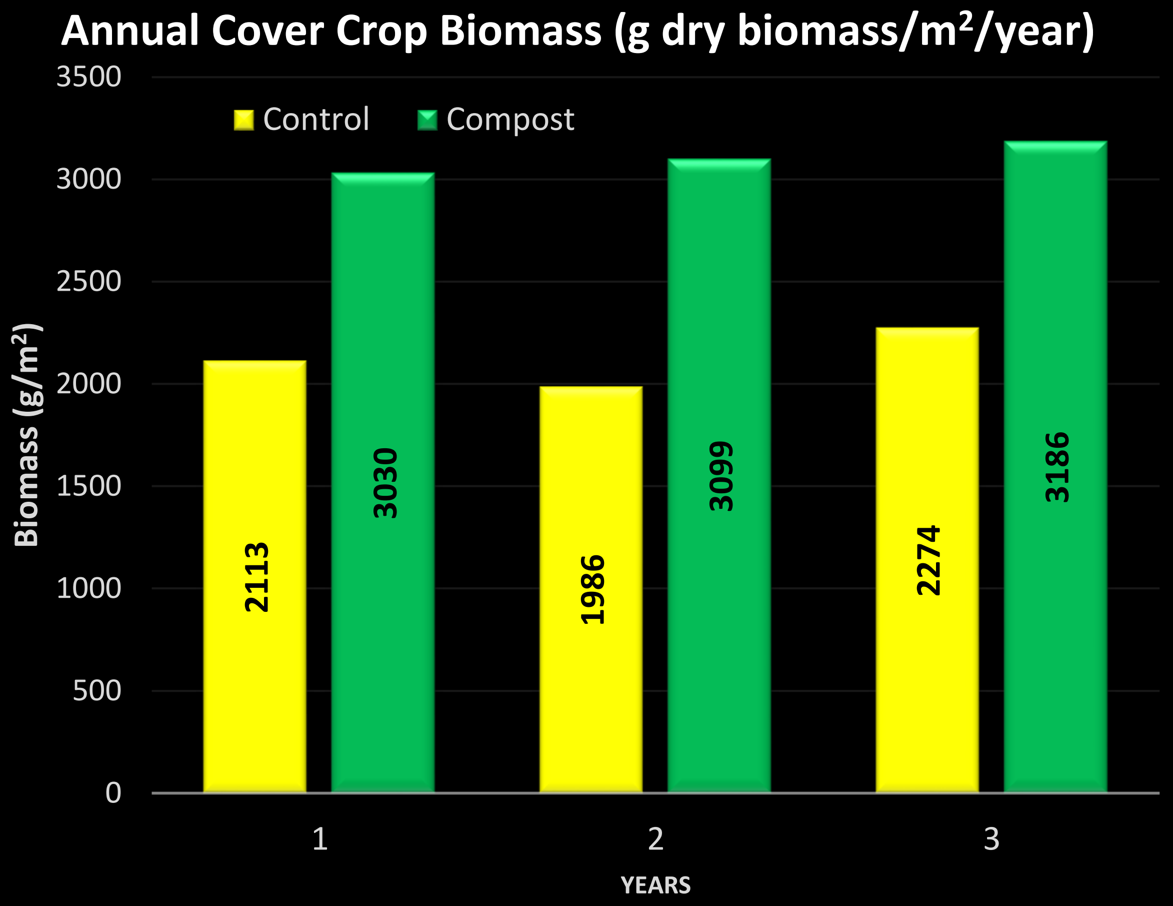

3,186 grams of dry biomass/m^2/year (31.86 tons dry biomass/ha/year)

14.19 tons dry biomass/acre

872 kg N/ hectare/ year (777 lbs N/acre/year)

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Metagenome Analysis

Domain	★	Phyla	Compost Treated Soil	Control	Desert
Archaea	★	Crenarchaeota	0.0025296	0.00044	5.5E-05
Archaea	★	Euryarchaeota	0.000739	0.00055	0
Archaea		Korarchaeota	0.0033539	0.00399	0.09006
Archaea		Thaumarchaeota	0.173095	0.15609	0.63556
Archaea		unclassified	0	2.6E-05	0
Bacteria	★	Acidobacteria	0.0046045	0.0024	0.0008
Bacteria		Actinobacteria	0.0474377	0.02007	0.0724
Bacteria	★	Aquificae	0.0013927	0.0006	2.2E-05
Bacteria	★	Bacteroidetes	0.1310008	0.05387	0.00084
Bacteria		Chlamydiae	0.0014496	0.0017	0
Bacteria	★	Chlorobi	0.0001705	0	0
Bacteria	★	Chloroflexi	0.005173	0.00245	0.00097
Bacteria		Cyanobacteria	0.0006537	0.0006	0.00082
Bacteria	★	Deferribacteres	5.685E-05	2.6E-05	1.1E-05
Bacteria	★	Deinococcus-Thermus	0.0006253	2.6E-05	1.1E-05
Bacteria	★	Dictyoglomi	0.0001421	5.2E-05	1.1E-05
Bacteria		Elusimicrobia	0	2.6E-05	0
Bacteria	★	Fibrobacteres	2.842E-05	2.6E-05	0
Bacteria		Firmicutes	0.0156325	0.01302	0.11783
Bacteria	★	Fusobacteria	0.0003127	0.0001	9.9E-05
Bacteria		Gemmatimonadetes	0.0009095	0.00115	0
Bacteria		Nitrospirae	0.0021886	0.00365	0
Bacteria	★	Planctomycetes	0.0388256	0.02307	0.00034
Bacteria		Proteobacteria	0.1308302	0.05497	0.02271
Bacteria		Spirochaetes	0.0009664	0.00123	8.8E-05
Bacteria	★	Synergistetes	2.842E-05	0	0
Bacteria		Tenericutes	0.0004832	0.00078	2.2E-05
Bacteria	★	Thermodesulfobacteria	0.0003695	0.00021	0
Bacteria	★	Thermotogae	0.0006253	0.00029	0
Bacteria	★	Verrucomicrobia	0.0208623	0.01086	0.00209
Bacteria		unclassified	0.4059915	0.64178	0.04112
Eukaryota		Ascomycota	0.0015064	0.00157	0.0143
Eukaryota		Bacillariophyta	5.685E-05	0.00112	0
Eukaryota	★	Basidiomycota	0.0001421	2.6E-05	0
Eukaryota	★	Chlorophyta	8.527E-05	7.8E-05	0
Eukaryota	★	Streptophyta	0.000938	0.00057	0.00013
Eukaryota	★	unclassified	0.0004832	0.00044	1.1E-05

Diversity is the currency of survival....

William Knauss

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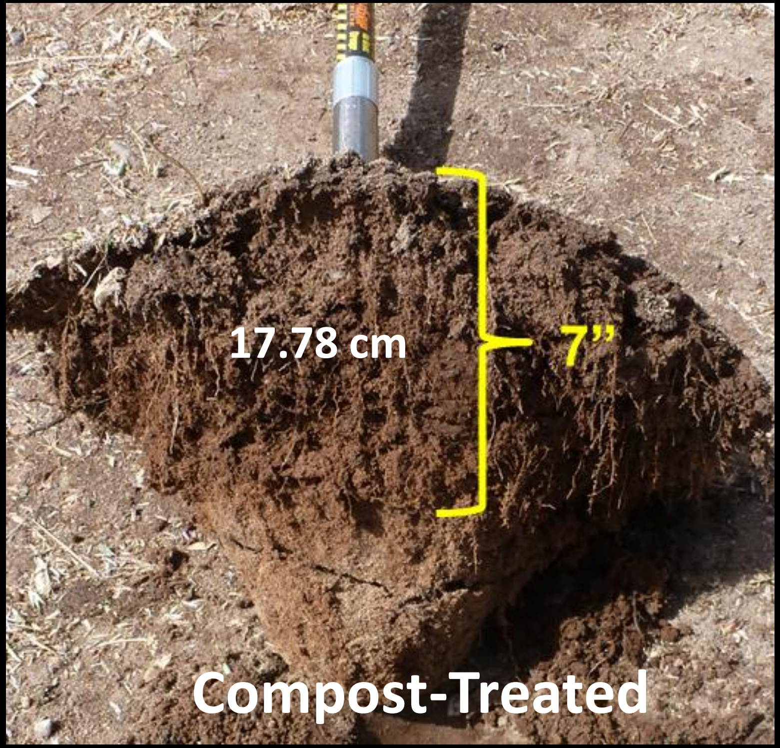
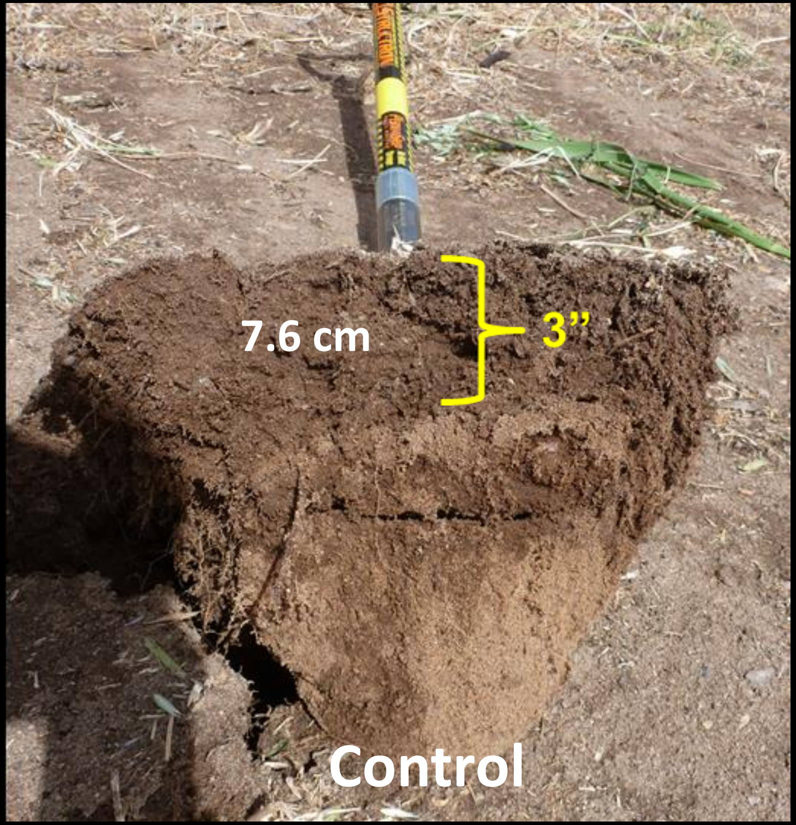
3.5 year Small Plot Study





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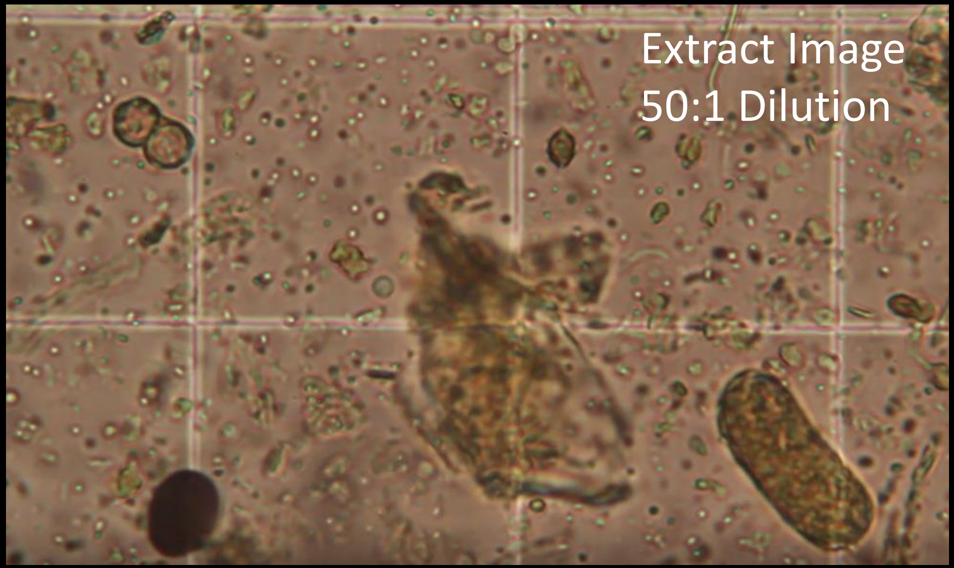

~ 50 bacteria/0.25nl and ~2-3 fungal spores/0.25 nl

Applied 2 Kg compost/hectare in 180 liters water
No Brewing!

~ 900 million bacteria/m^2
~18-54 million fungal spores/m^2

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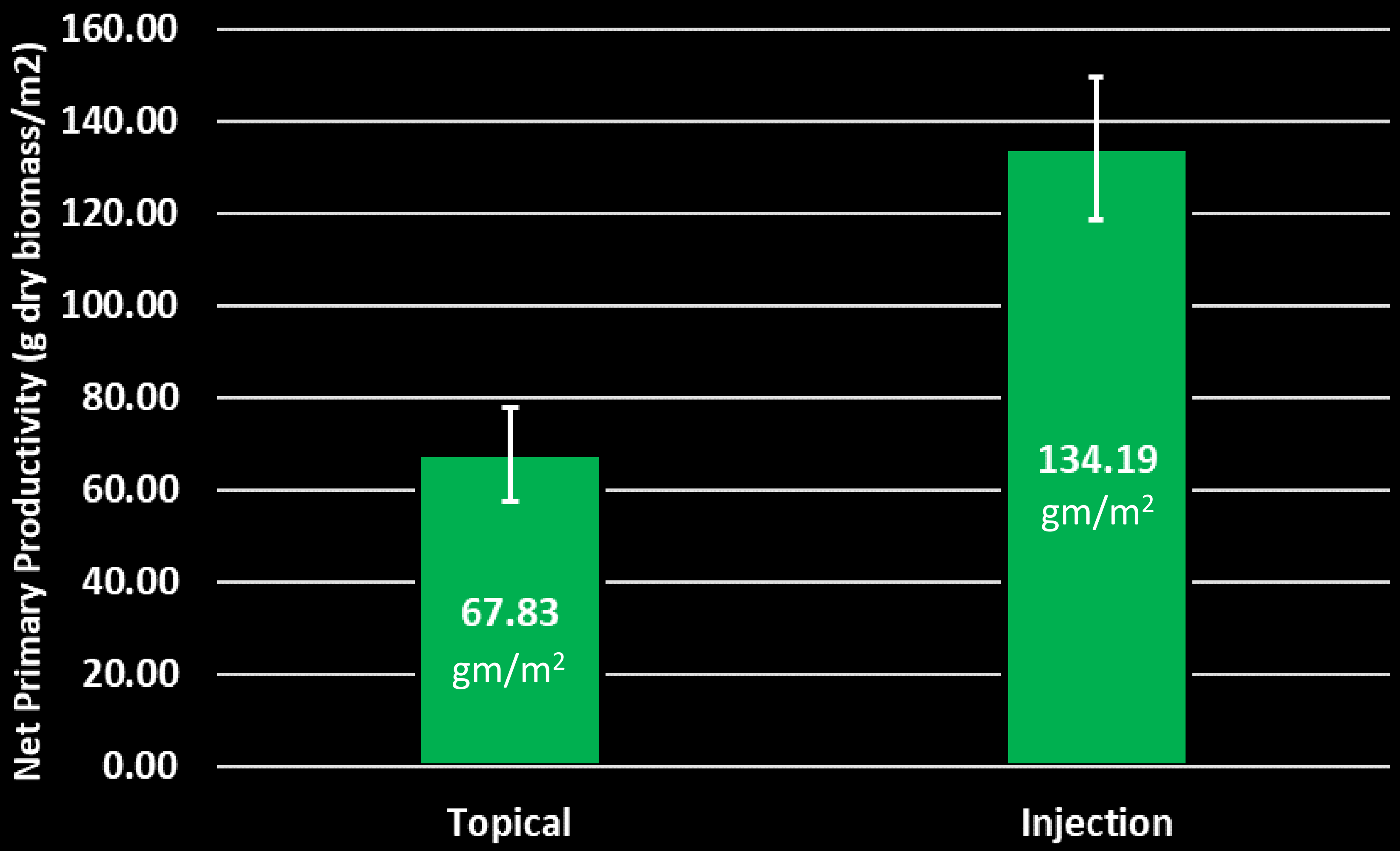
Topical vs. In-Furrow Injection



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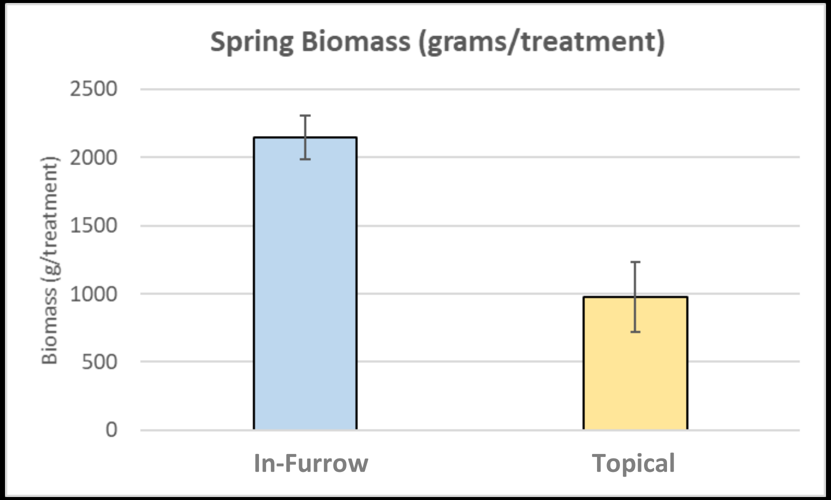
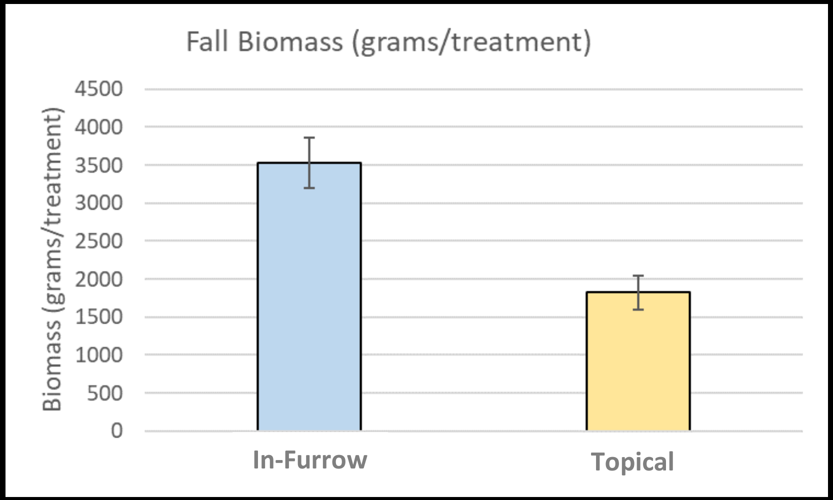
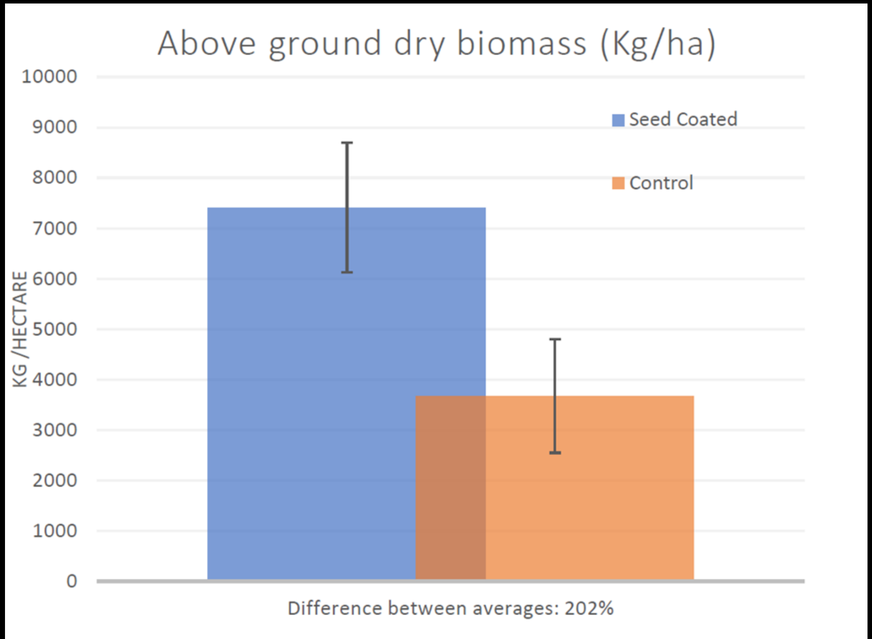

Spring Biomass (grams/treatment)
Biomass (g/treatment)
2500
2000
1500
1000
500
0
In-Furrow
Topical

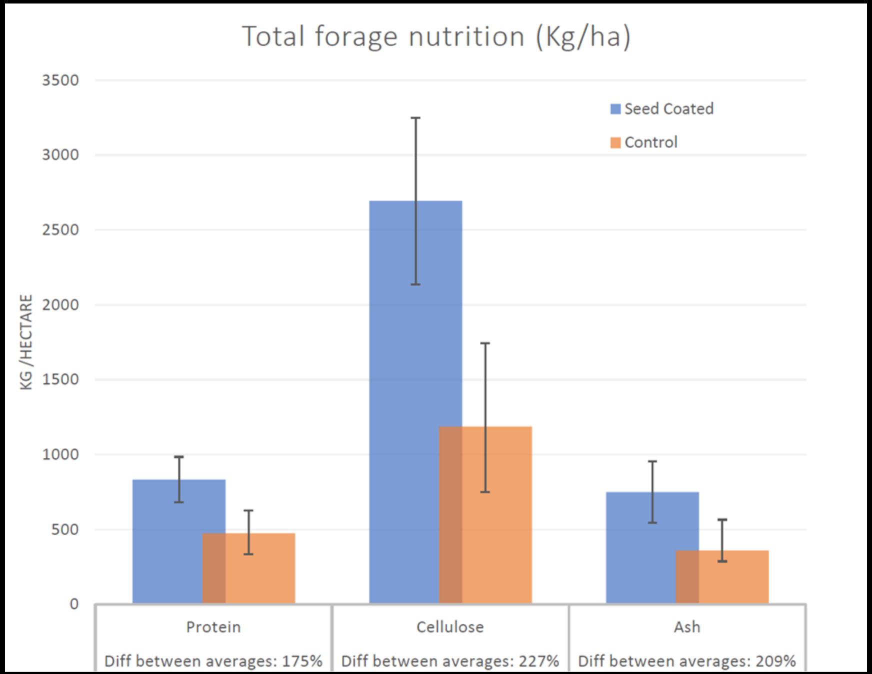

Fall Biomass (grams/treatment)
Biomass (grams/treatment)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
In-Furrow
Topical


In-Furrow
Topical



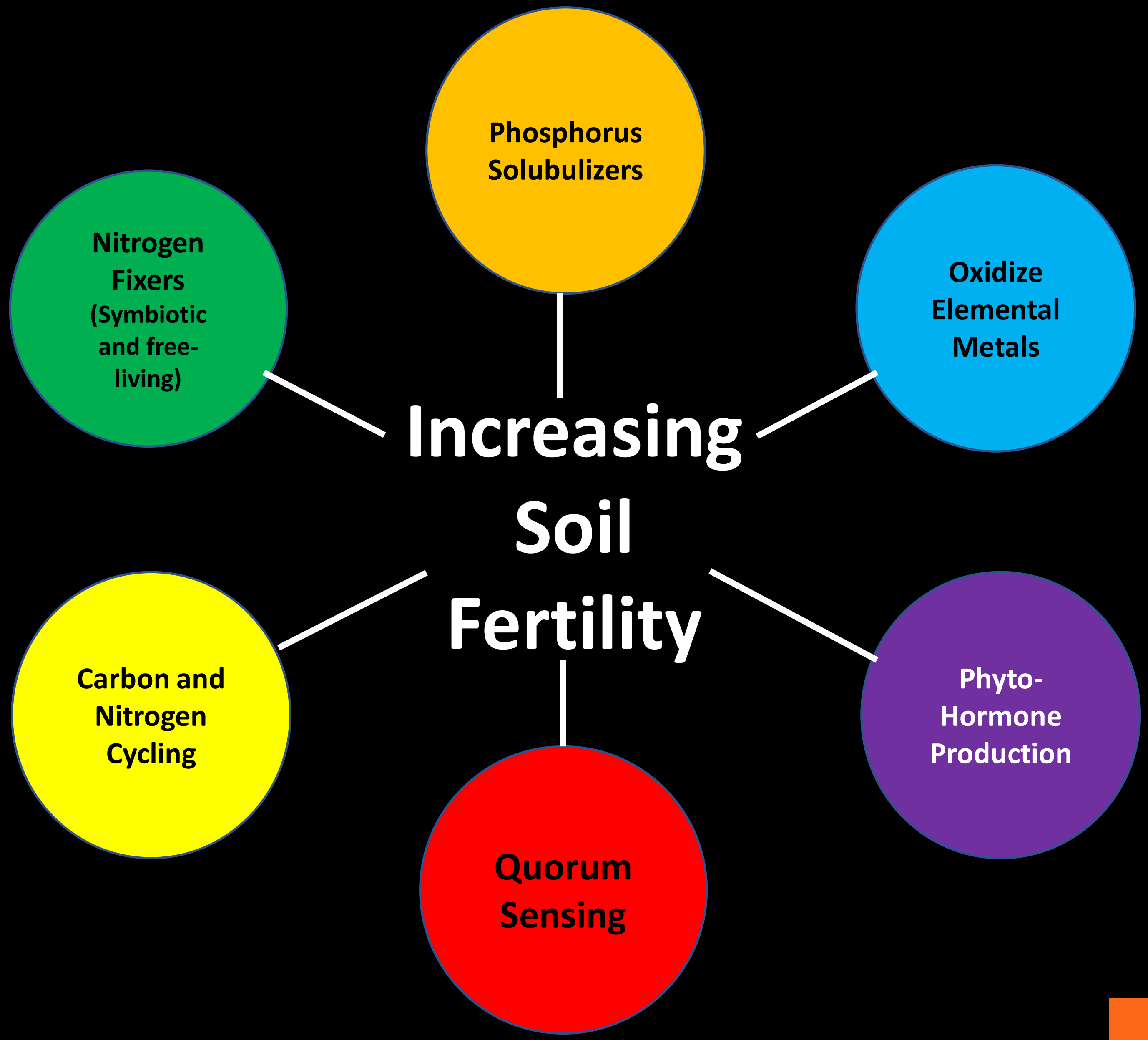
Information

- Farmer: Géraud Dumont de Chassart
- Location: Ferme de la Sarte, Longueville, Belgium
- Seed coating: Juan de la Serna
- Data collection : David Verstraete
- Data Treatment : Juan de la Serna



Seeding

- Crops: Radish, field peas, moha, sorghum, alfalfa.
- Experimental area: 1ha with coated seeds, 1ha as control.
- Seeding rate : 90kg/ha.
- Seeding date : 9/05/2020.
- Clay-loam soil.
- No fertilizer or amendments.
- Seed coating: Dr. David Johnson recipe.



What do these Microbes do for your Soils and your Crops?

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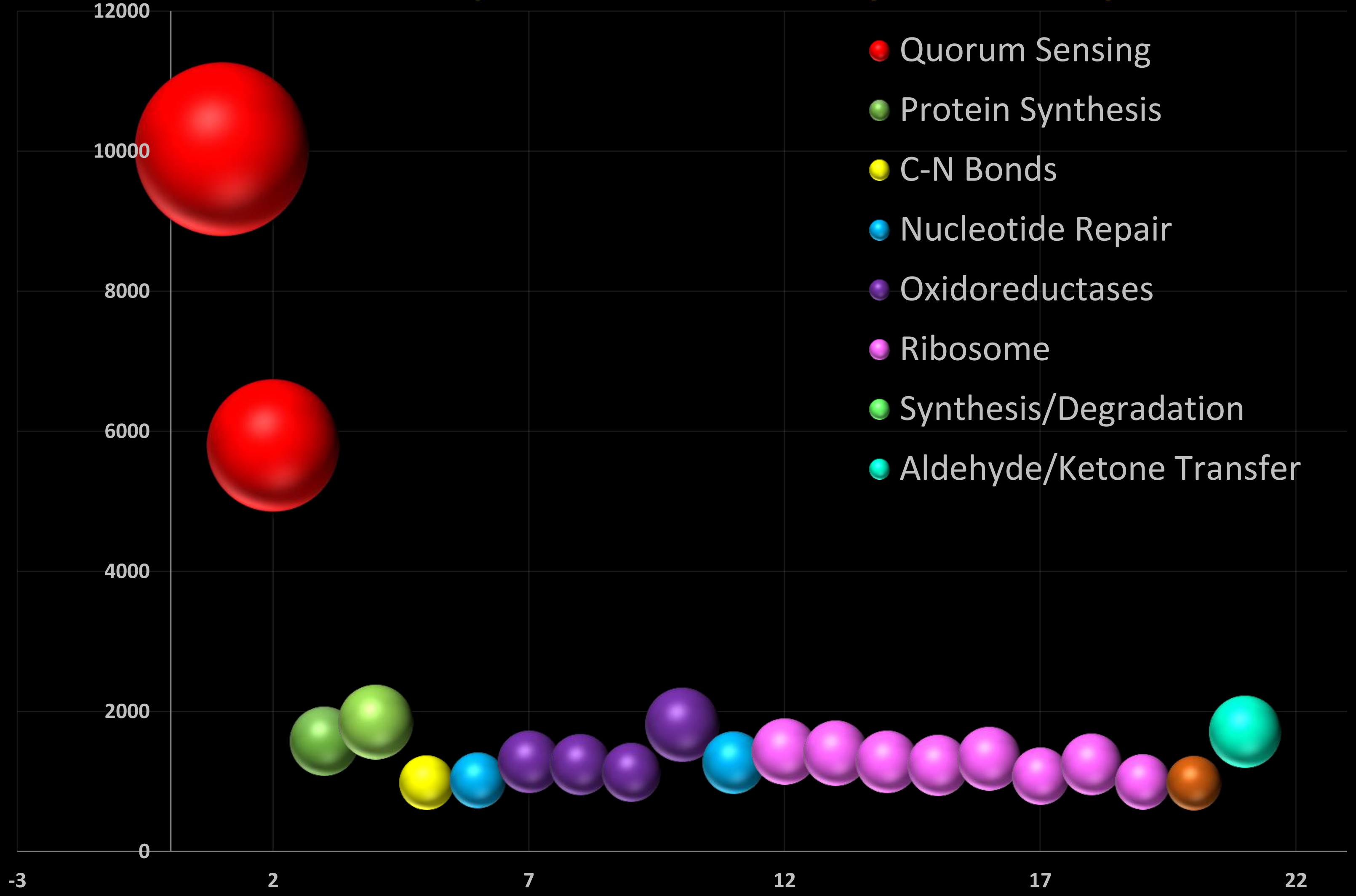
Metatranscriptome Analysis: Top 21 mRNA



4,687 mRNA, Average= 62

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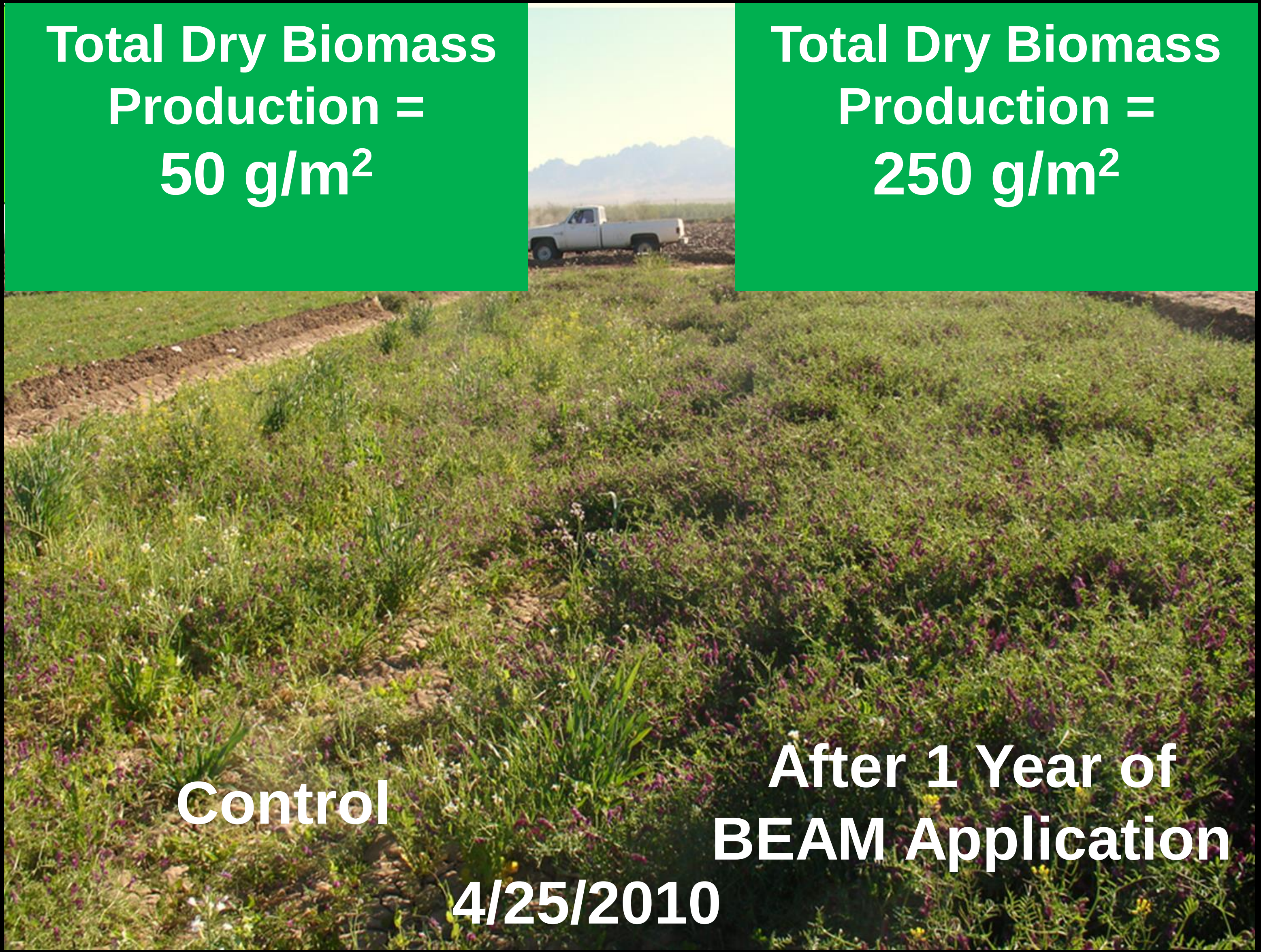

Small Field Trials

No Nitrogen or Fertilizers Added

4.5-times Increase in Photosynthetic Capacity over the Seven Year Trial

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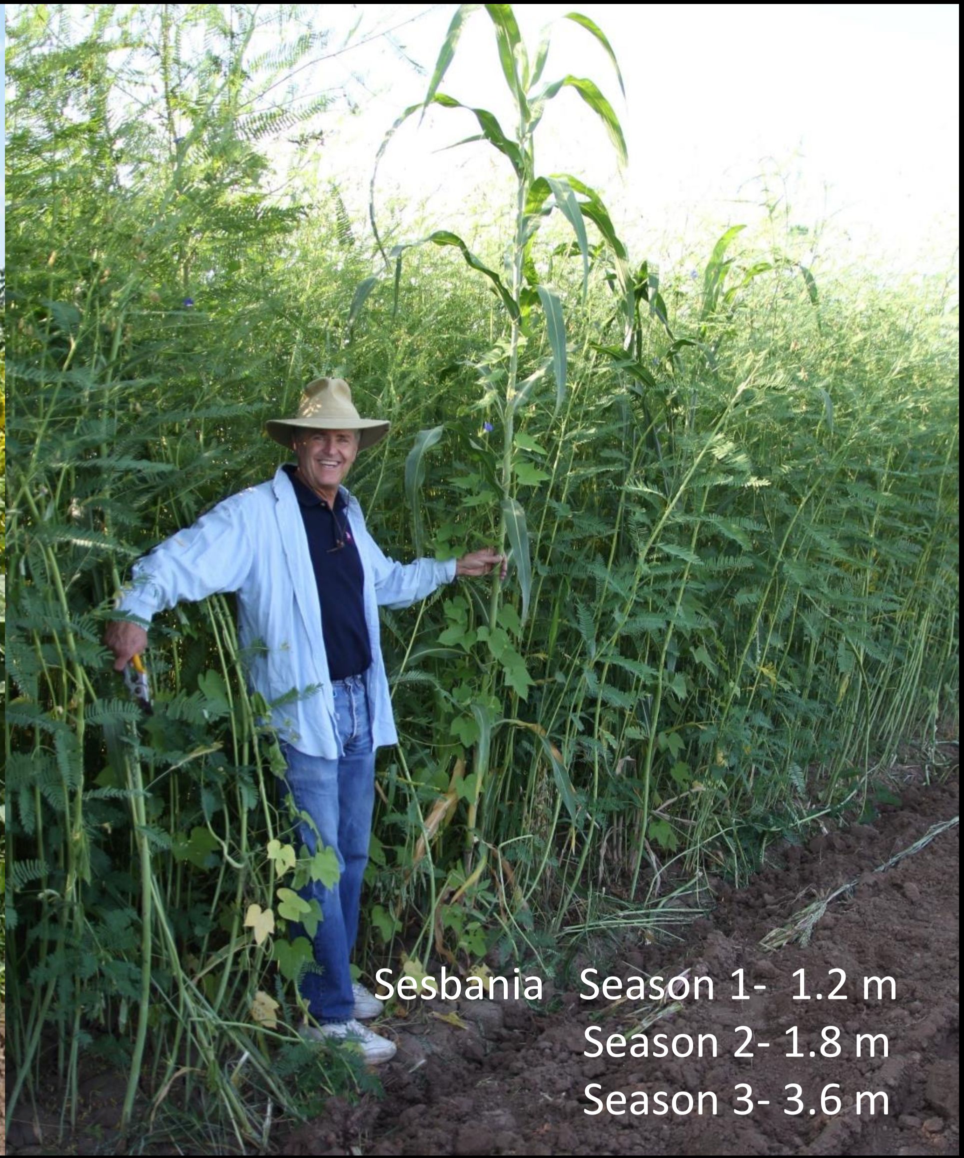

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Cotton 2,769 kg lint/ha (5 bales/acre)
3,764 kg seed/ha

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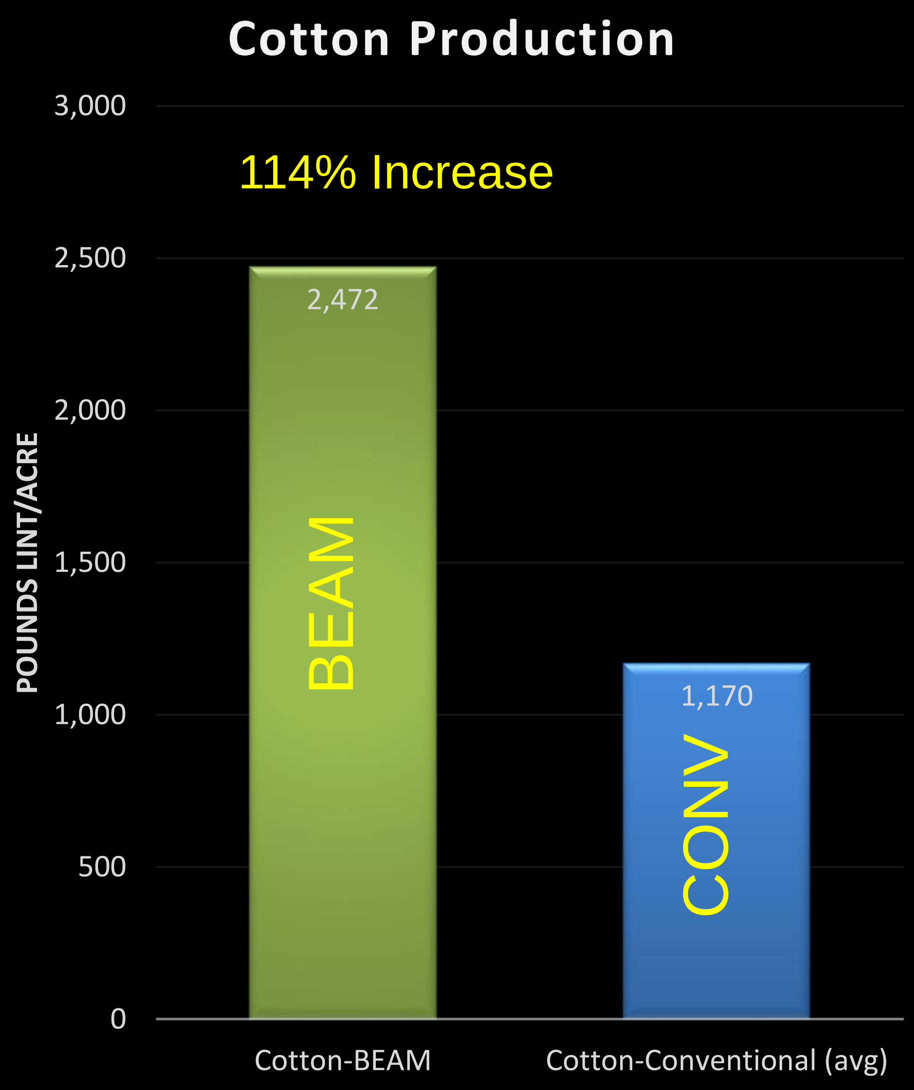

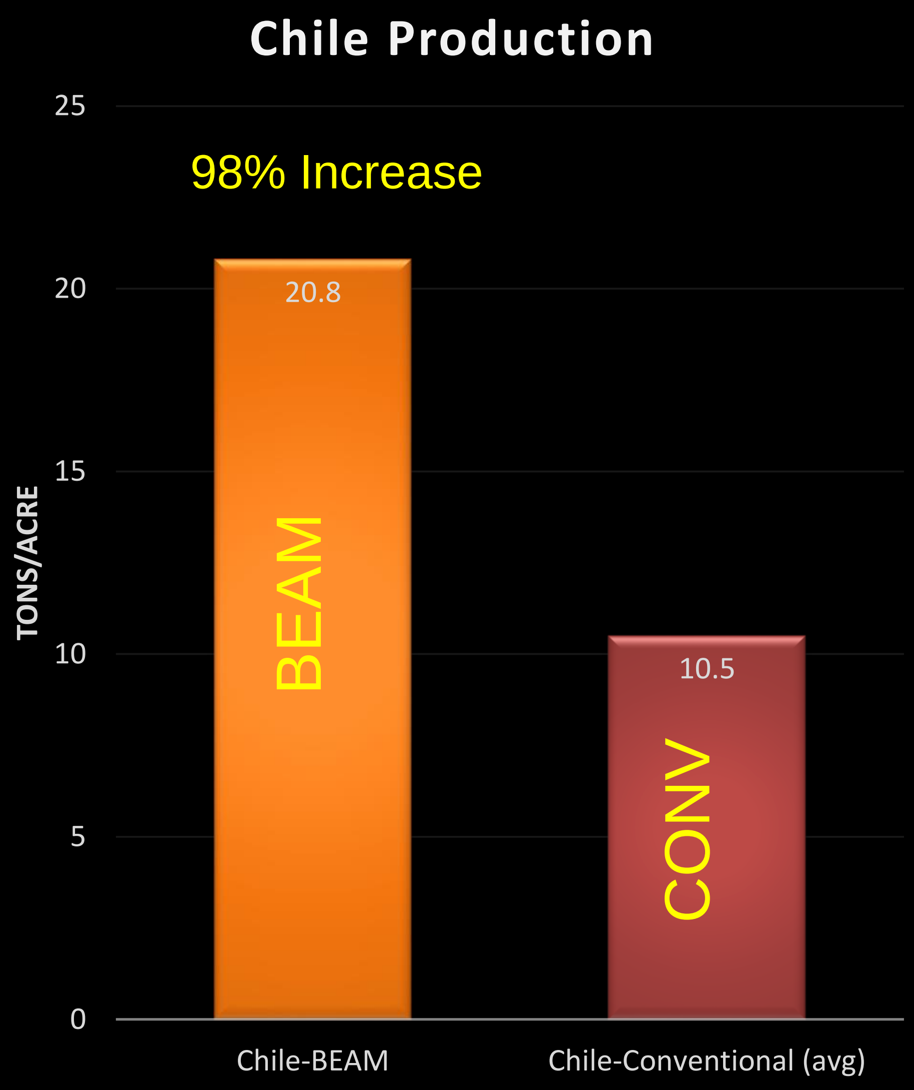

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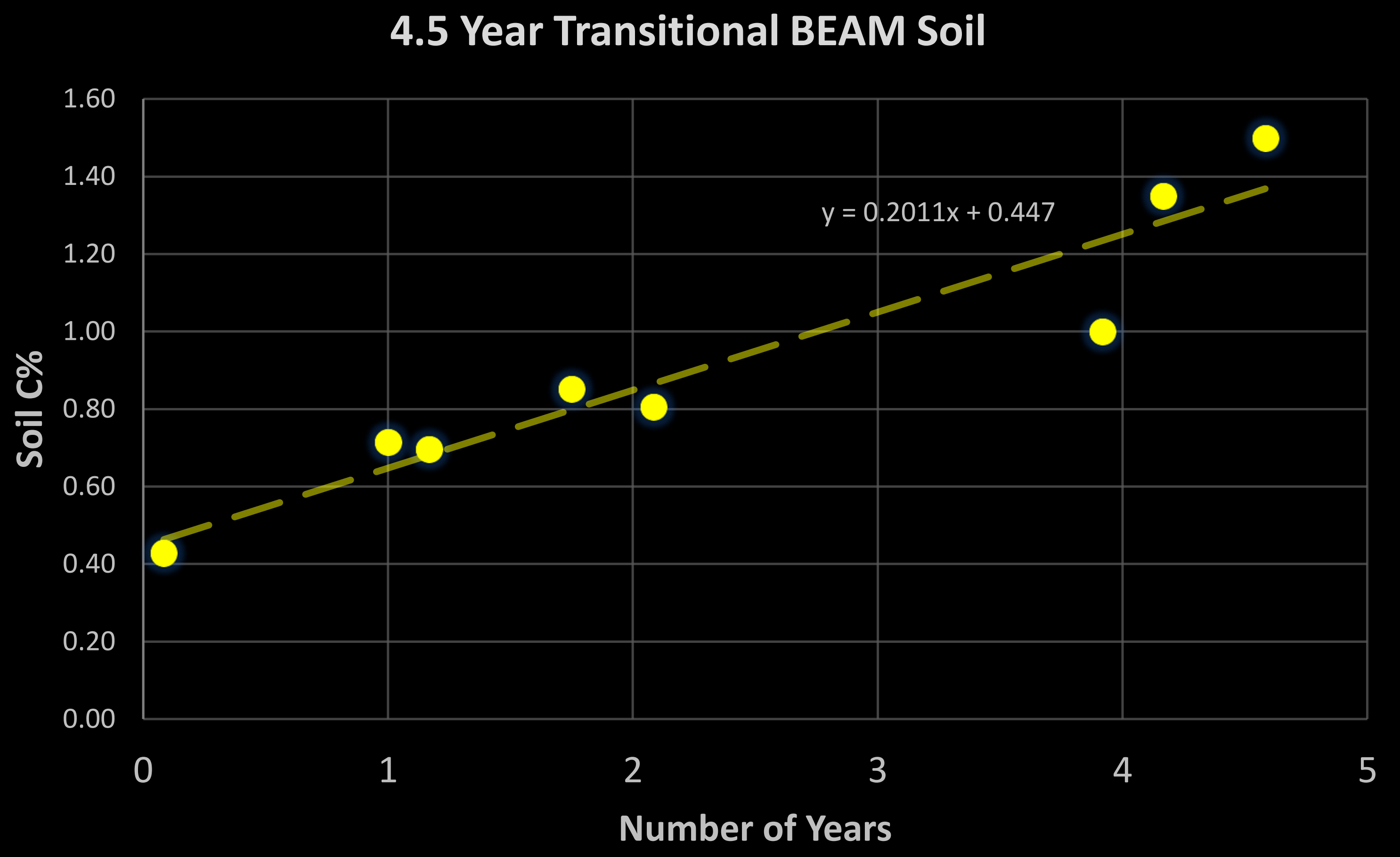
Soil Carbon Increase



NMSU Leyendecker Plant Science Research Center; Las Cruces NM

Annual 0.24% C increase in the top 30 cm

<u>~10.7 metric</u> tons C/hectare/year or <u>37 metric tons</u> CO_2/hectare/year captured

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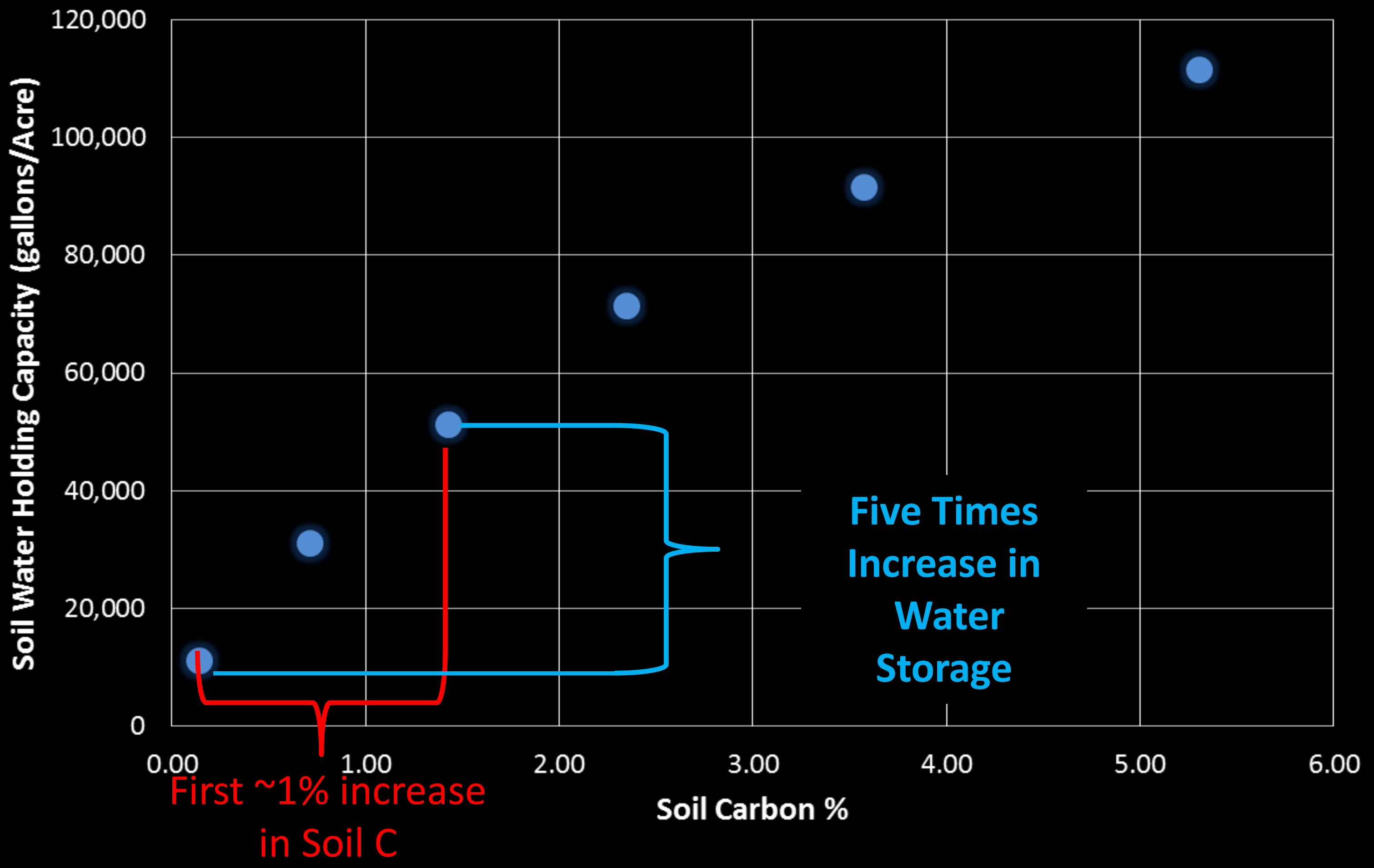
Increases Storage and Availability Water



First 1% increase in Soil Organic Carbon Increases Soil Water Holding Capacity from 90,000 liters/ha

450,000 liters/ha

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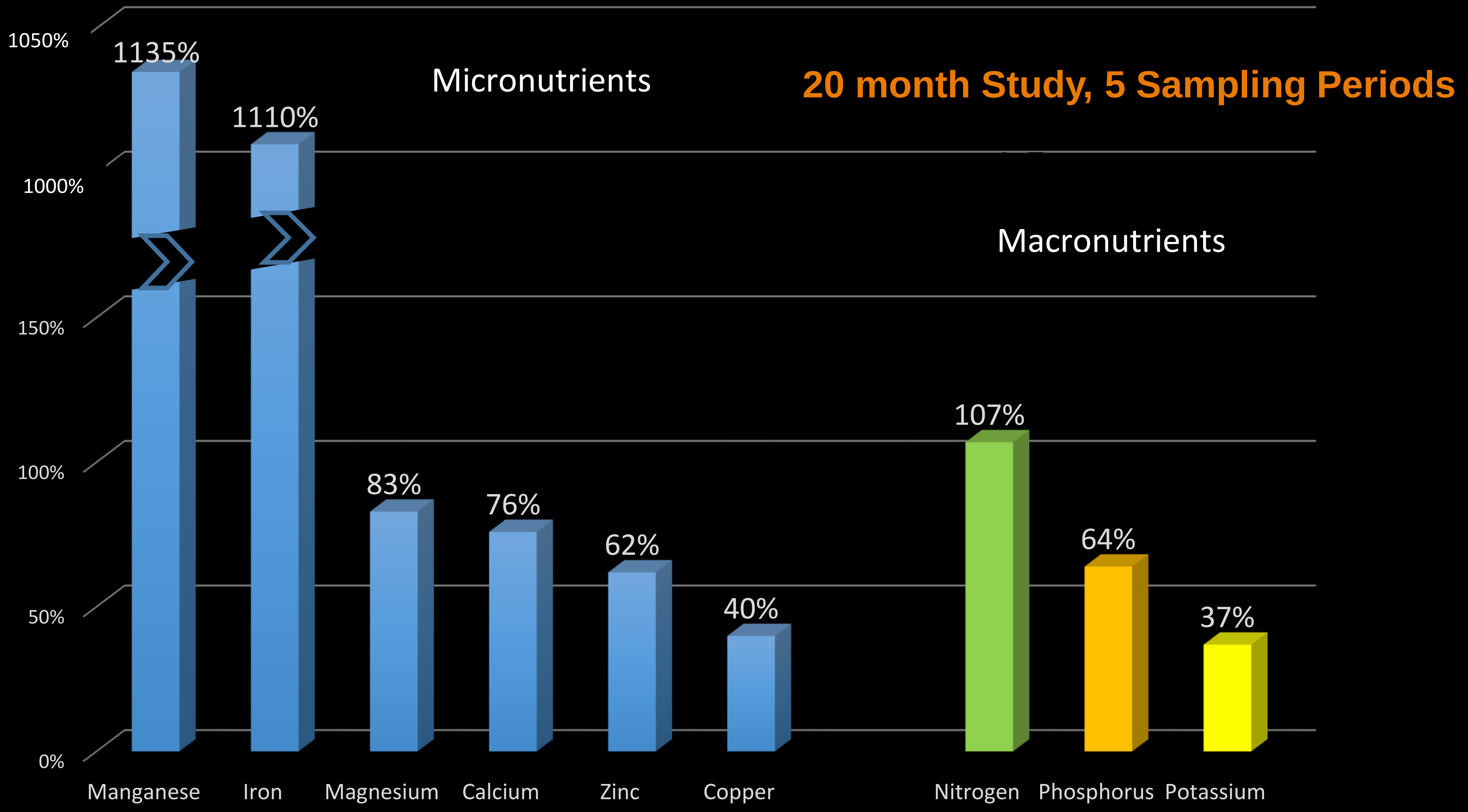

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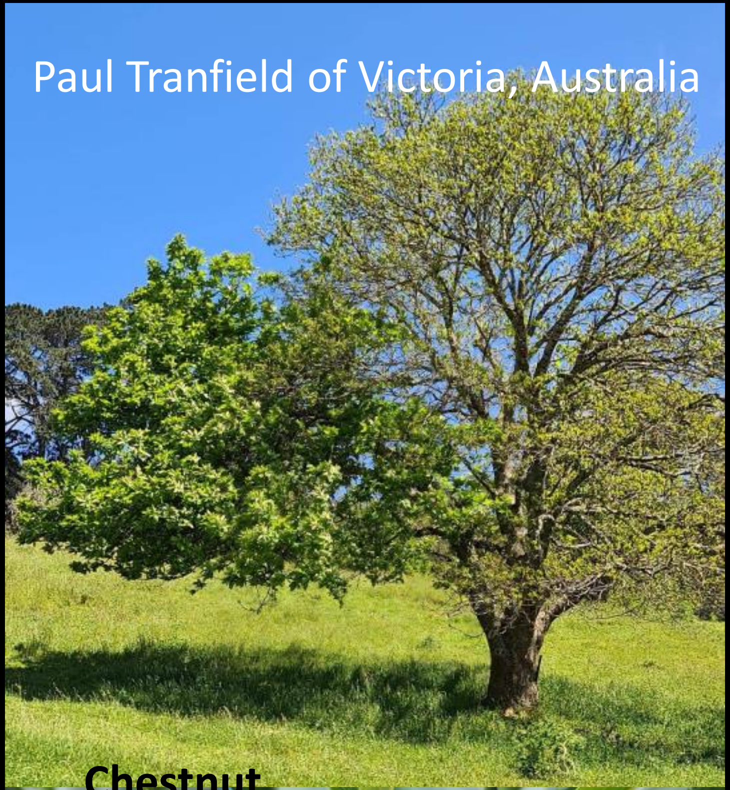
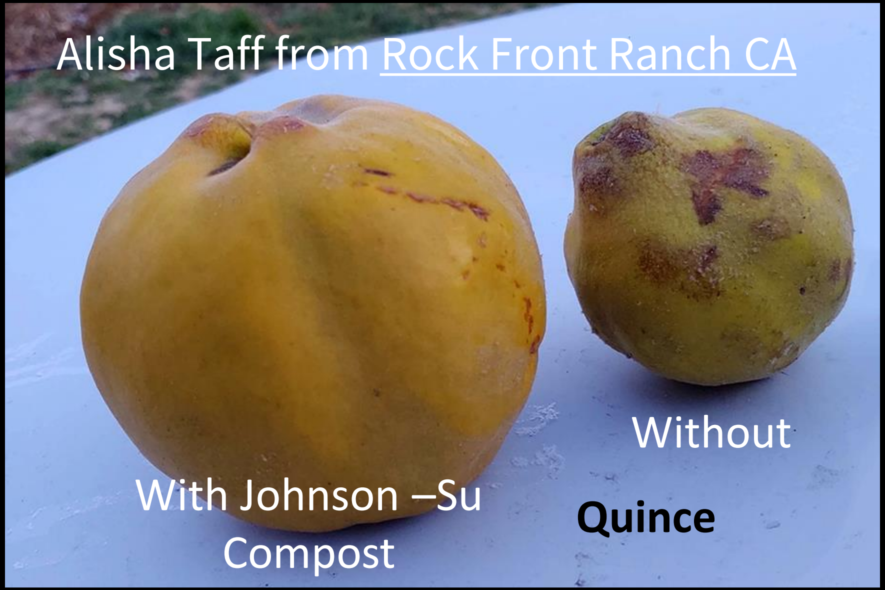
User Observations





https://www.csuchico.edu/regenerativeagriculture/bioreactor/citizen-science/index.shtml

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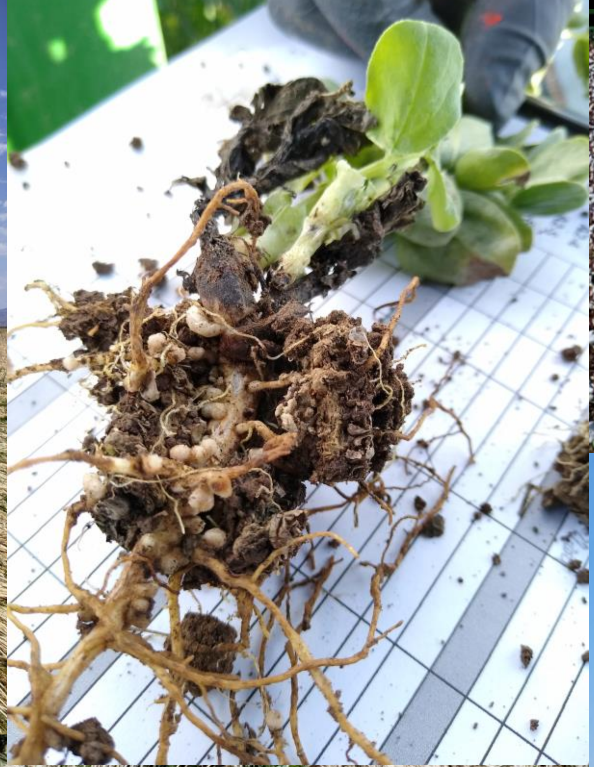
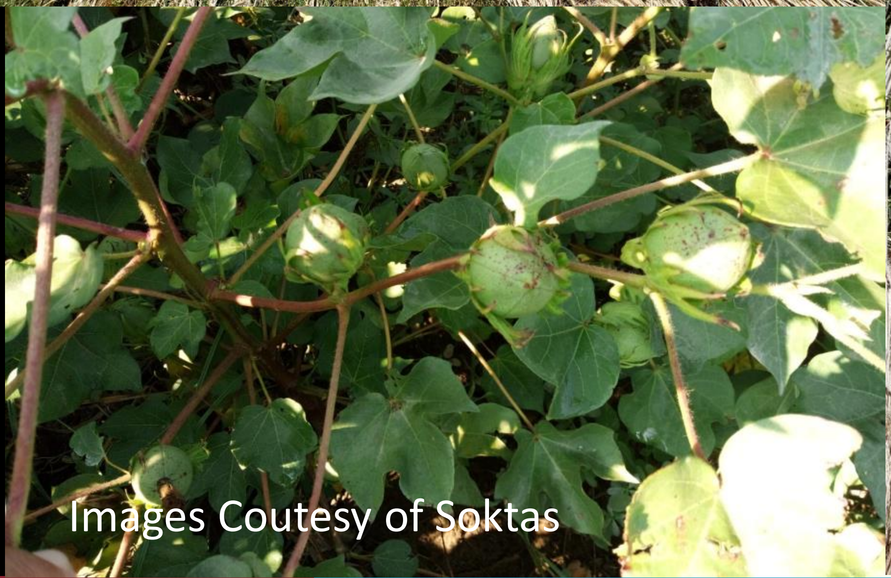
Stella McCartney Cotton Project in Turkey
Soktas





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nr	application	Terms of appl.	explanation	input	amount
1	Deep cultivator	april		-	-
2	fertilizer	april	npk	15-15-15 fert	350 kg/ha
3	fertilizer	april		urea % 46 azot	100 kg/ha
4	discharrow	april	mixing fert. With soil	-	-
5	Cultivator with roller	april		-	-
6	Harrow	april		-	-
7	Herbicide	end of apr-beg may	before seeding	stomp extra	3 kg/ha
8	Seed drill	end of apr-beg may	Seed type : Bayer Gloria	bayer Gloria	40/kgha
9	Herbicide	3-4 leaves	Syngenta Envoke 75		150 gr/ha
10	Pesticide	3-4 leaves	Abamectin	Abamectin	400 gr/ha
11	Insecticide	3-4 leaves	DİMETHOATE	DİMETHOATE	600 gr/ha
12	Insecticide	3-4 leaves		IMIDACLOPRİD +BETA CYFLUTHRİN	200 gr/ha
13	Insecticide	4-6 leaves		EMEMACTİN BENZOATE	400 gr/ha
14	fertilizer	before 1. irrigation		Amonium sulfate	250 kg/ha
15	fertilizer	before 1. irrigation		Amonium nitrate	250 kg/ha
16	Foliar nutrition		spray	amino acid	1000 gr/ha
17	Foliar nutrition		spray	zinc	1200 gr/ha
18	Herbicide		spray	Clethodim	750 gr/ha
19	Irrigation	40-45 days after germination			
20	Foliar nutrition	after 1. irrigation	spray	NPK content	1250 gr/ha
21	Irrigation	15-25 days after 1. irrigation			
22	Foliar nutrition		spray	K content	1000 gr/ha
23	Irrigation	15-25 days after 2. irrigation			
24	Defoliation	End of sep-mid of oct	Depending on wheather	Bayer Finish + Dropp Ult	600 gr+2500 gr/ha
25	Harvest				
26	Mulching	After harvest	Mulcher		

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Observations of the Farmers from Turkey:

- 85% less fertilizer used with no yield impact. Yields were better than cotton fields that received 100% fertilizer application = HUGE COST SAVINGS
- Yields were 4.2 metric tons cotton/ha (3,748 lb/acre)
- Crops did well despite government restricted irrigation and low rainfall (two irrigation events)
- No herbicides were used due to good weed suppression from the cover crop (100% displacement!)
- Observed biodiversity in their soil that they had not seen since their childhood!
- Have now taken this method to Romania for grain and oil seed crop production.

Images Coutesy of Soktas

Field Research on Corn

Corn production has the highest land area devoted to crop production in the US at 37 million hectaress,

Uses 43% of total N applied in the US,

Uses three times more synthetic-N than any other crop by mass

(USDA-EMIS, 2019)

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Regenerative Practices Using Cover Crops Promotes:

1. Soil Surface Protection and Lower Soil Temperature
2. Reduced Evaporation and More Efficient Use of Water
3. Soil Carbon Increase as Forage for Soil Microbes and Beneficial Insect Communities
4. Increases Cycling and Availability of Nutrients for Commodity Crops
5. Higher Profits and Fewer Inputs
6. A Major Shift from Bacterial Dominance to Fungal Dominance

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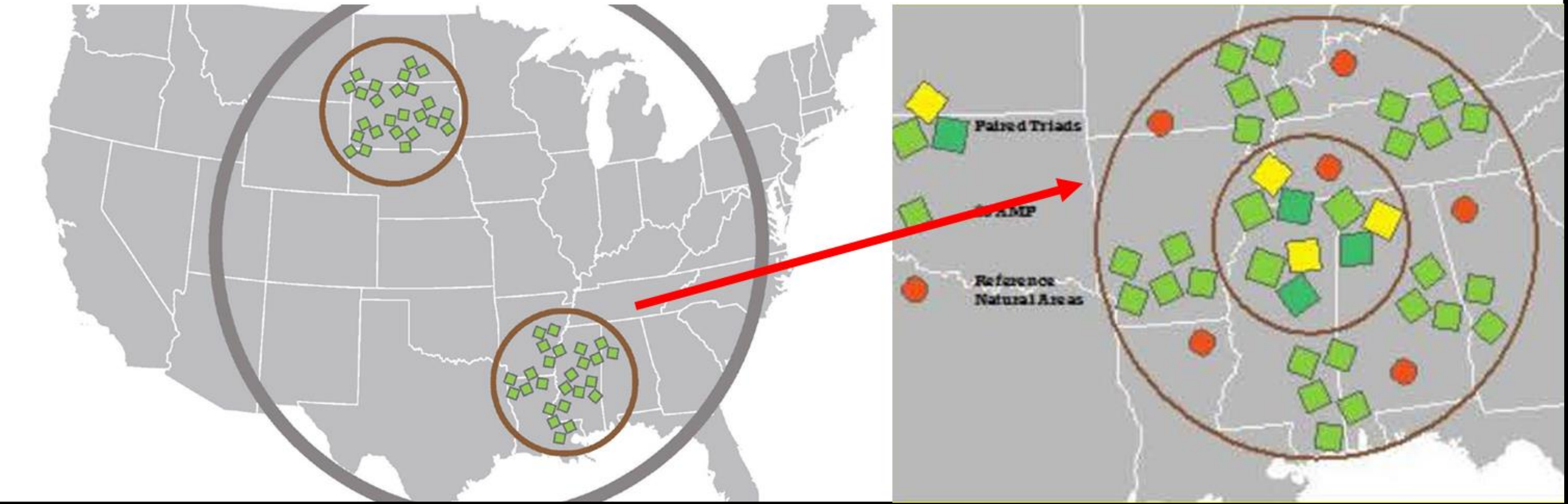
Adaptive Multi-Paddock Grazing (AMP) vs. Continuous Grazing (CG)



https://peerj.com/articles/13750

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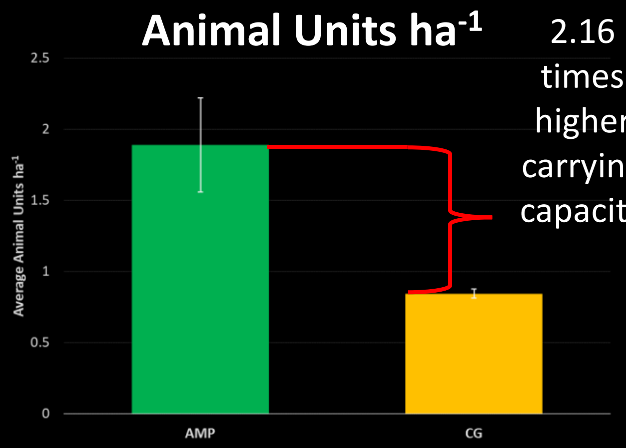
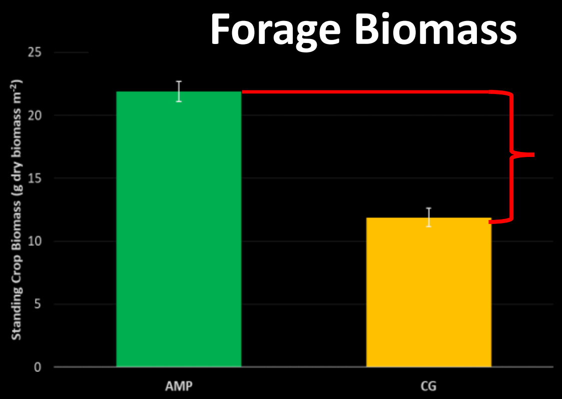
AMP Grazing Systems Promoted:

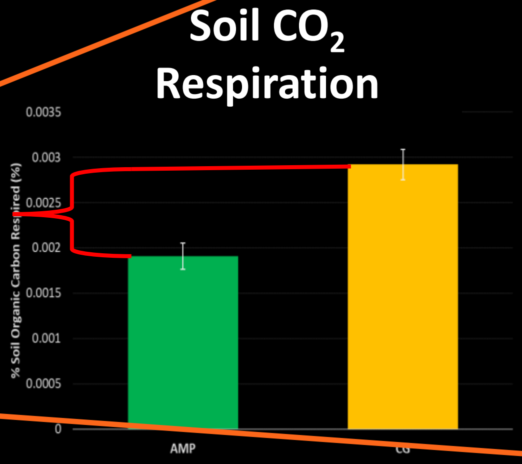


2.16 times higher carrying capacity

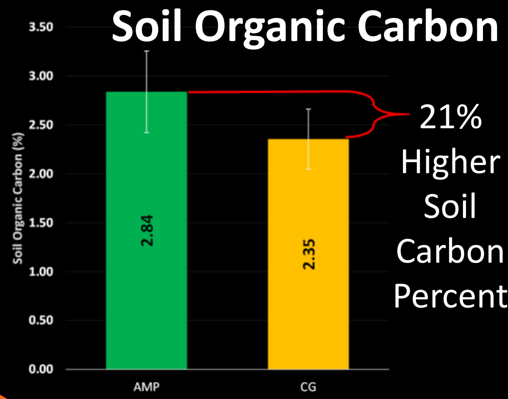


46% Forage Biomass Increase

9.82 Billion Tons CO_2/year



18% Lower Respiration



21% Higher Soil Carbon Percent

1.25 billion hectares of savannahs and grasslands

6.66 Billion Tons CO_2/year

2.34 Billion Tons CO_2/year

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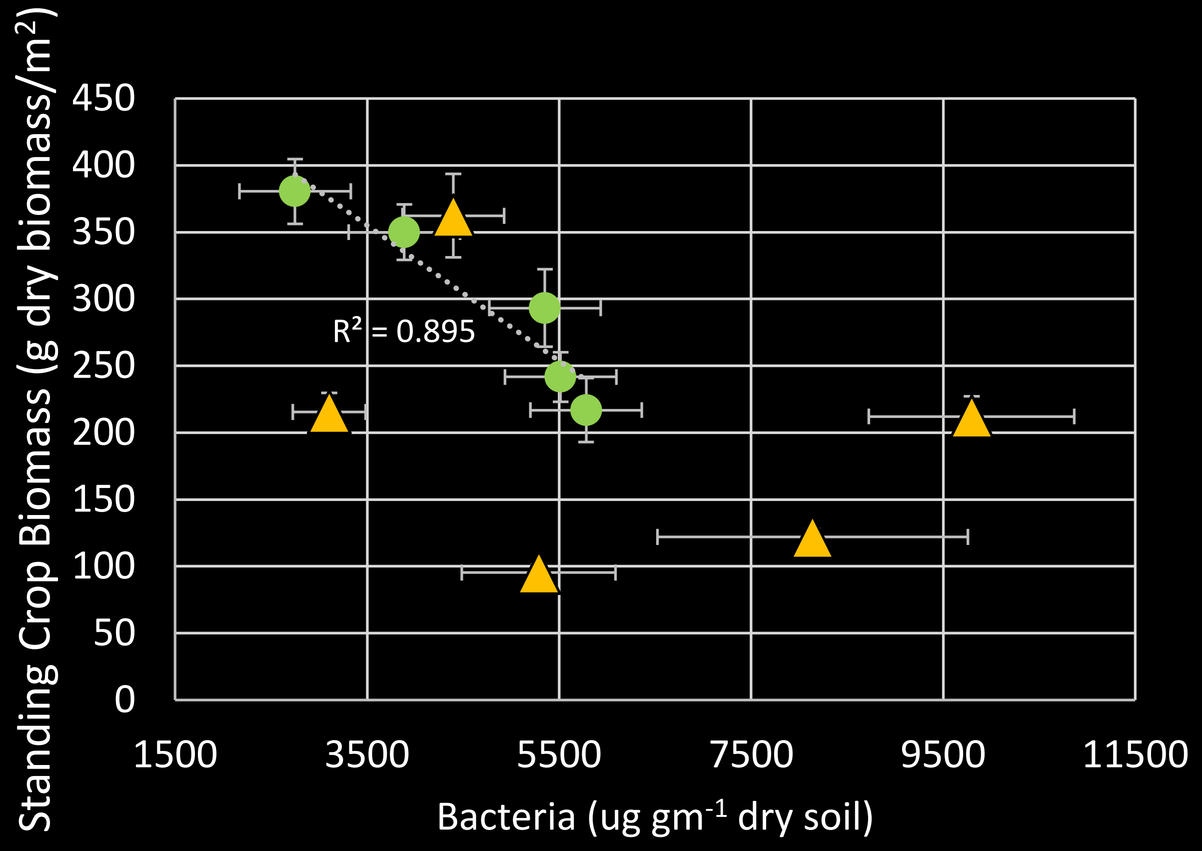
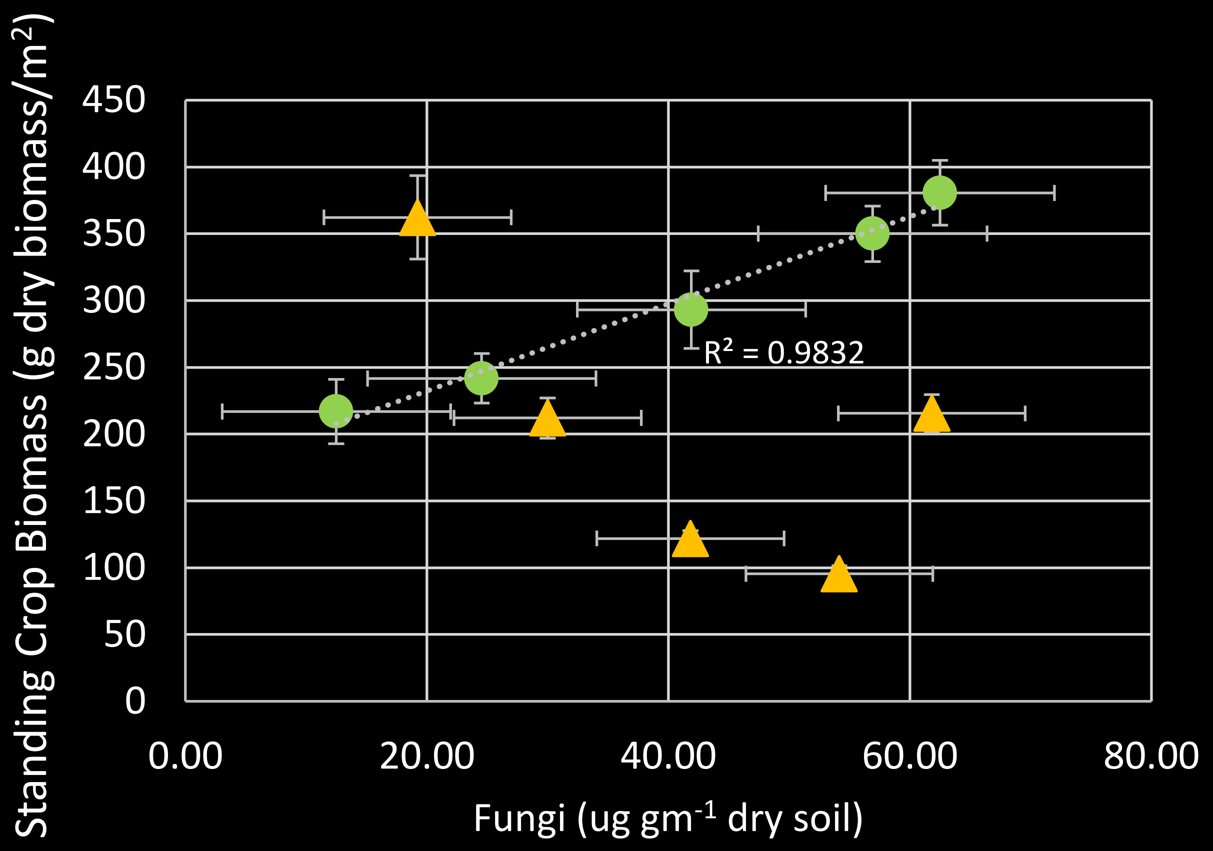
Soil Foodweb Analyses





AMP- ●

CG- ▲

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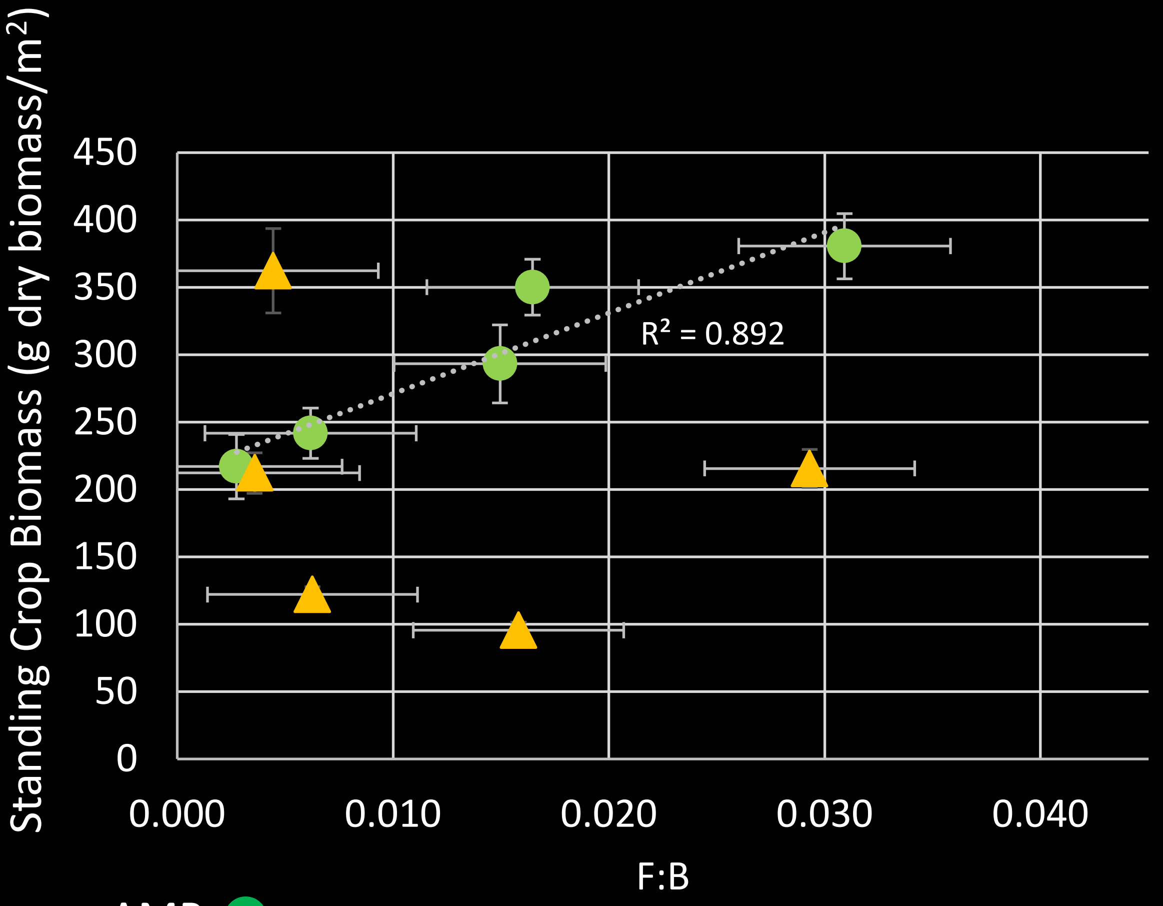
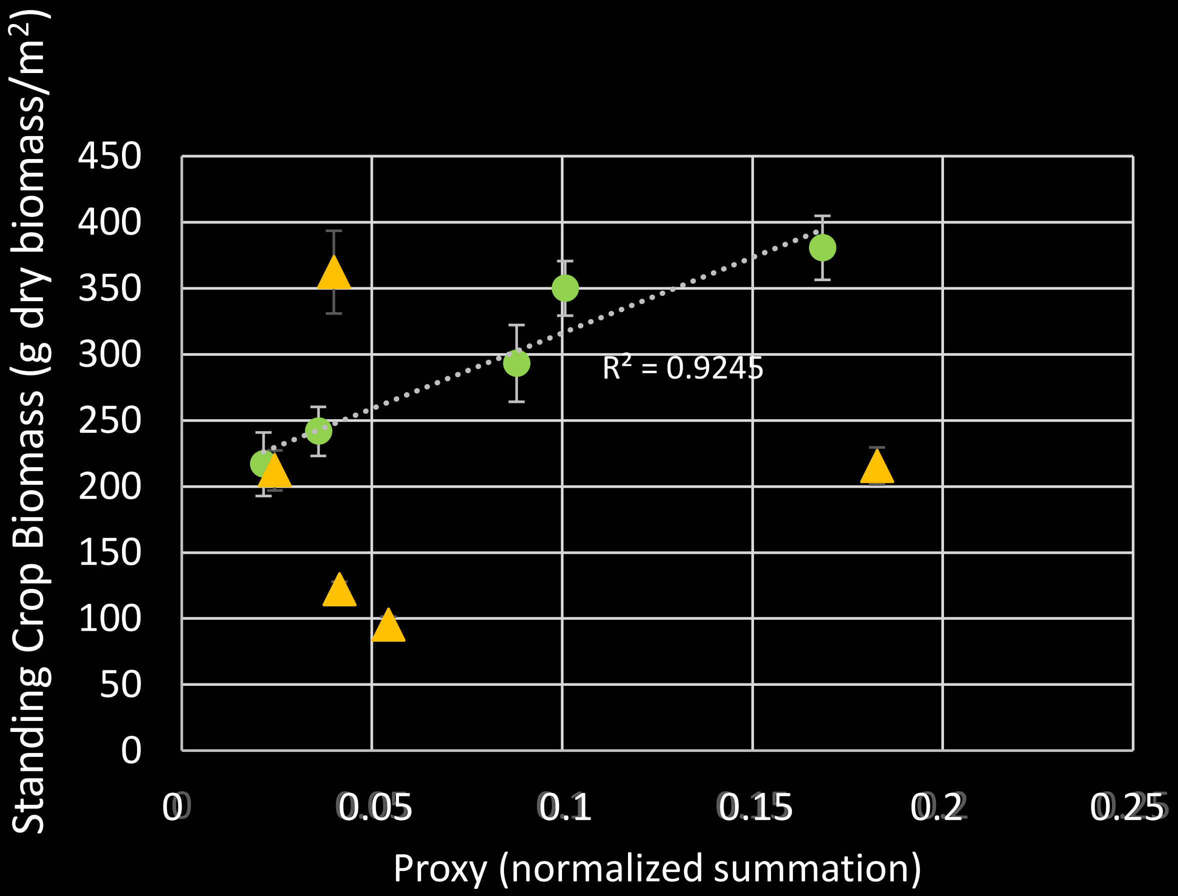
Soil Foodweb Analyses





AMP- ●

CG- ▲

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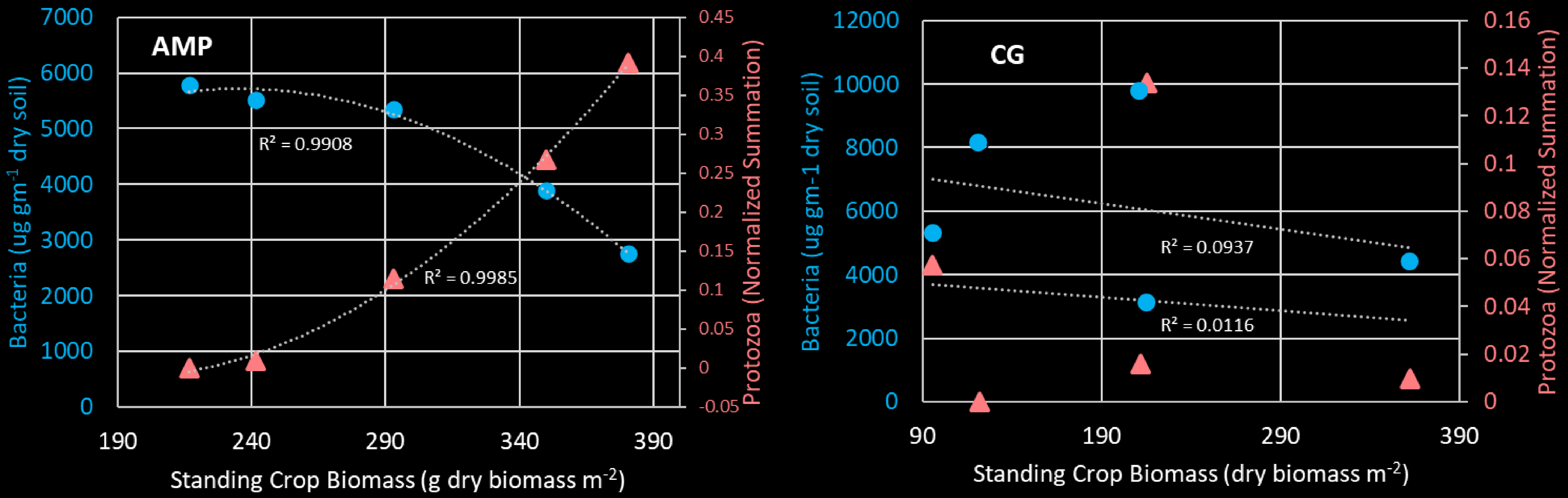
Predator Prey Relationships



https://peerj.com/articles/13750

Against all odds: turning sand into profit

PROSPECT PASTORAL COMPANY

Farm Facts

Wyalkatchem, Dowerin, Cunderdin and Meckering districts, around 190 km north east of Perth, WA Central Wheatbelt

Enterprise: Crops. Sheep.
Cereal grains and cereal hay crops; specially-bred sheep for wool and premium grade fat lambs

Property Size: 8000 hectares

Average Annual Rainfall: 200-300 mm (home farm)

Elevation: 320 m (home farm)

Ian & Diane Haggerty

20,000 Hectares

https://soilsforlife.org.au/prospect-pastoral-company-against-all-odds-turning-sand-into-profit/

Ian & Di Haggerty's Field

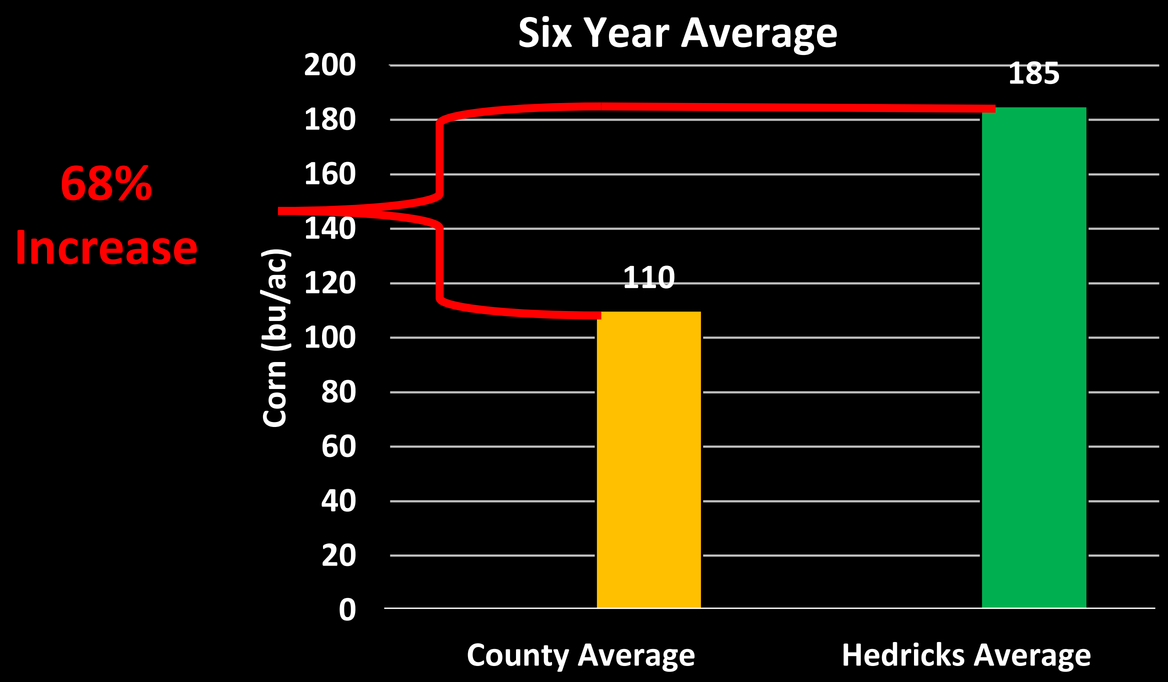
http://www.futuredirections.org.au/wp-content/uploads/2017/08/FDI-Feature-Interview-Ian-and-Di-Haggerty.pdf

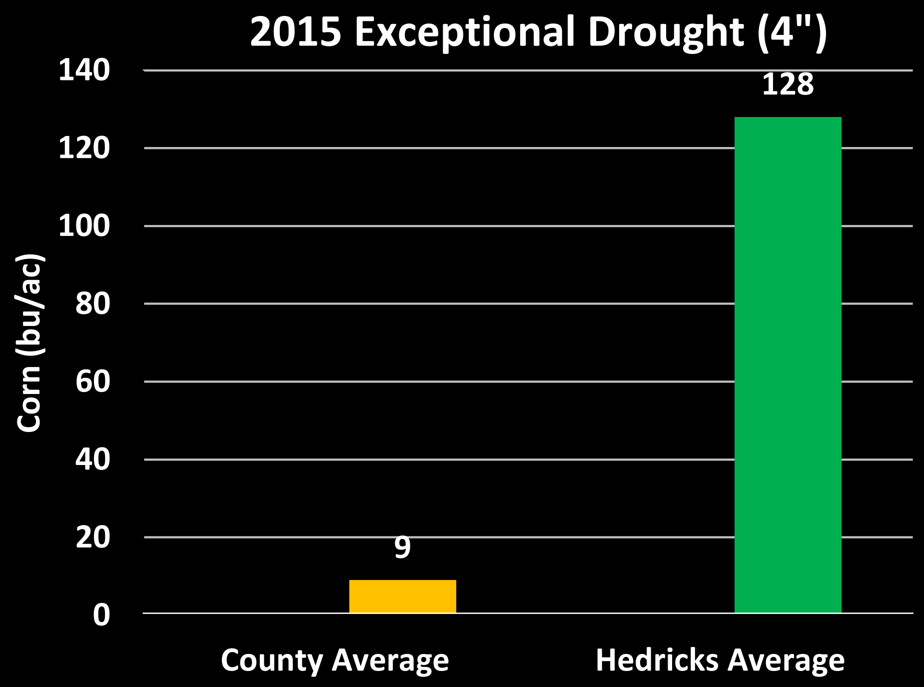
Russell Hedrick (JRH Grain Farms)

Hickory, North Carolina

- Full-time Cover or Commodity Cropping
- Introduced Cows, Sheep & Pigs
- 80% reduction in fertilizer application
- No Fungicides or Pesticides in the last six years

Corn Production





https://regenfarming.news/articles/454-us-farmer-interview-russell-hedrick

Alejandro Carrillo

Images by Allen R Williams, Ph.D.

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Adaptive MultiPaddock Grazing

Images by Allen R Williams, Ph.D.

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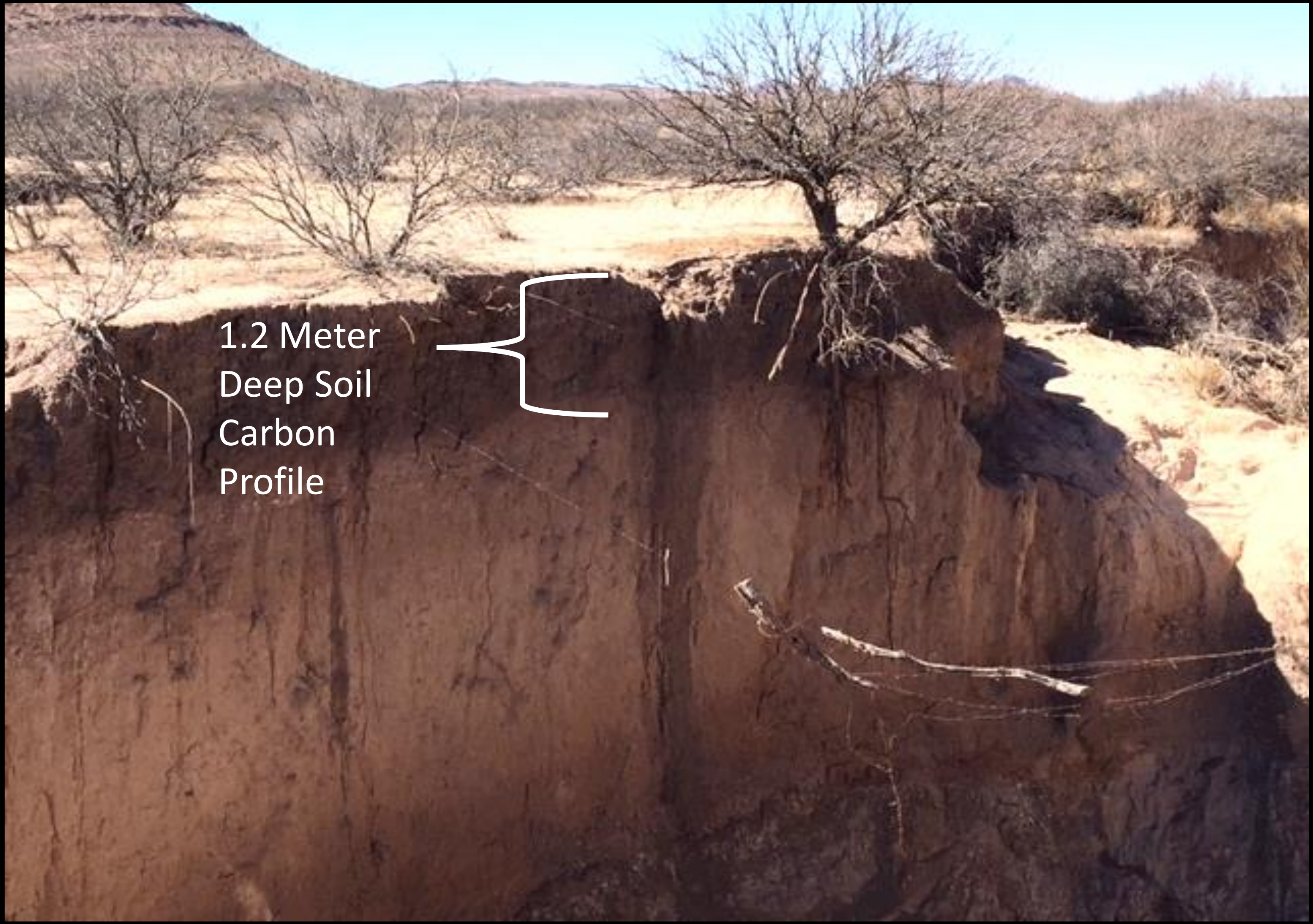

Image by Allen R Williams, Ph.D.

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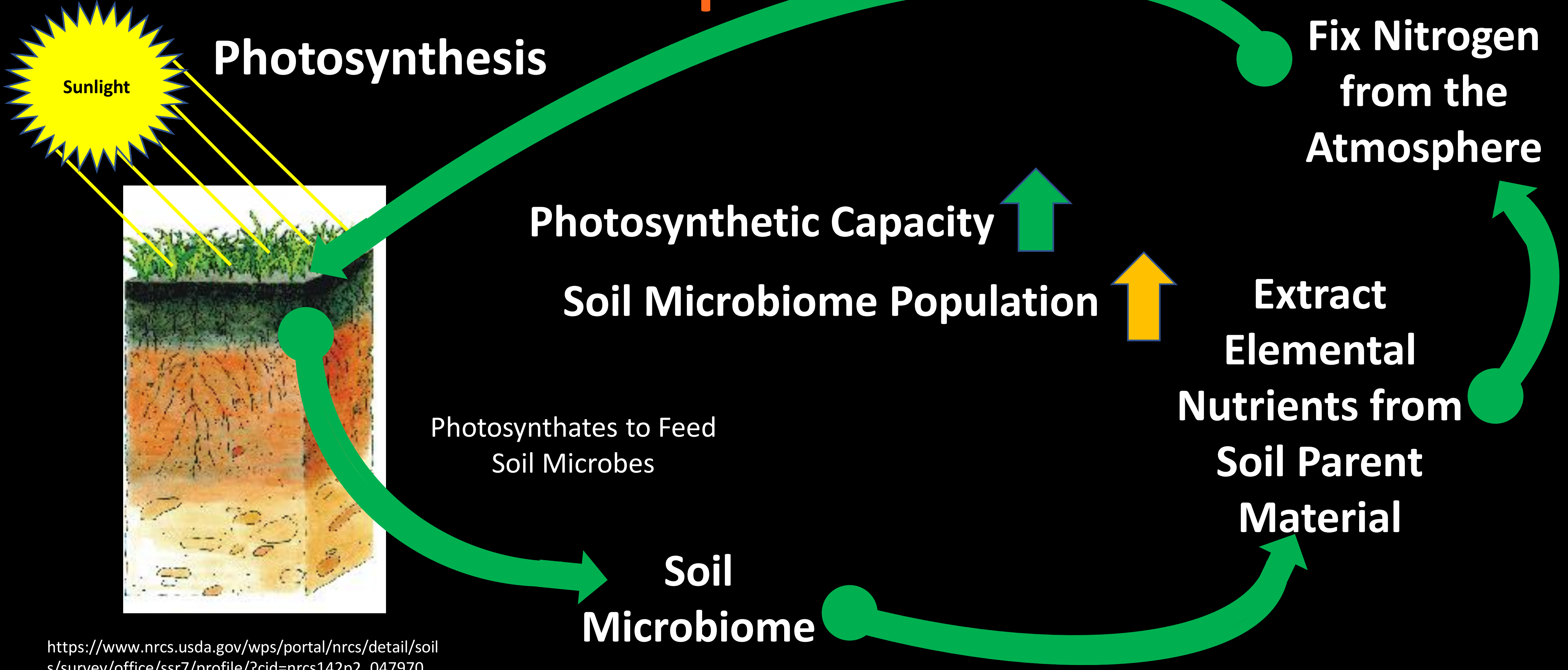
Positive Feedback Loop



https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/office/ssr7/profile/?cid=nrcs142p2_047970

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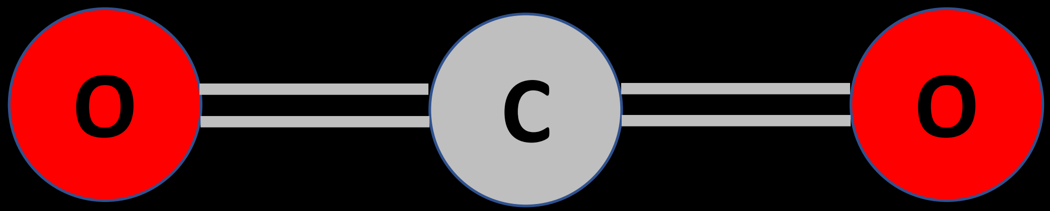
6

C

Carbon

12.011



Carbon Dioxide

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Potential CO_2 Offsets

1.25 billion HECTARES Temperate Grasslands

AMP System Annual CO_2 Offsets

Extra Forage Production	9.82	gigatons CO_2
Reduced Soil CO_2 Respiration	6.66	gigatons CO_2
Increased Soil Carbon	2.34	gigatons CO_2
Total	18.82	gigatons CO_2

1.36 Billion Hectares Farmland

BEAM System Annual CO_2 Offsets

Extra Forage Production	5.8	gigatons CO_2
Reduced Soil CO_2 Respiration	7.9	gigatons CO_2
Increased Soil Carbon	43.9	gigatons CO_2
Total	57.6	gigatons CO_2

Current Anthropogenic CO_2 Emissions

36.8 gigatons CO_2 year $^{-1}$

Total Potential- 76.4 gigatons CO_2 year $^{-1}$

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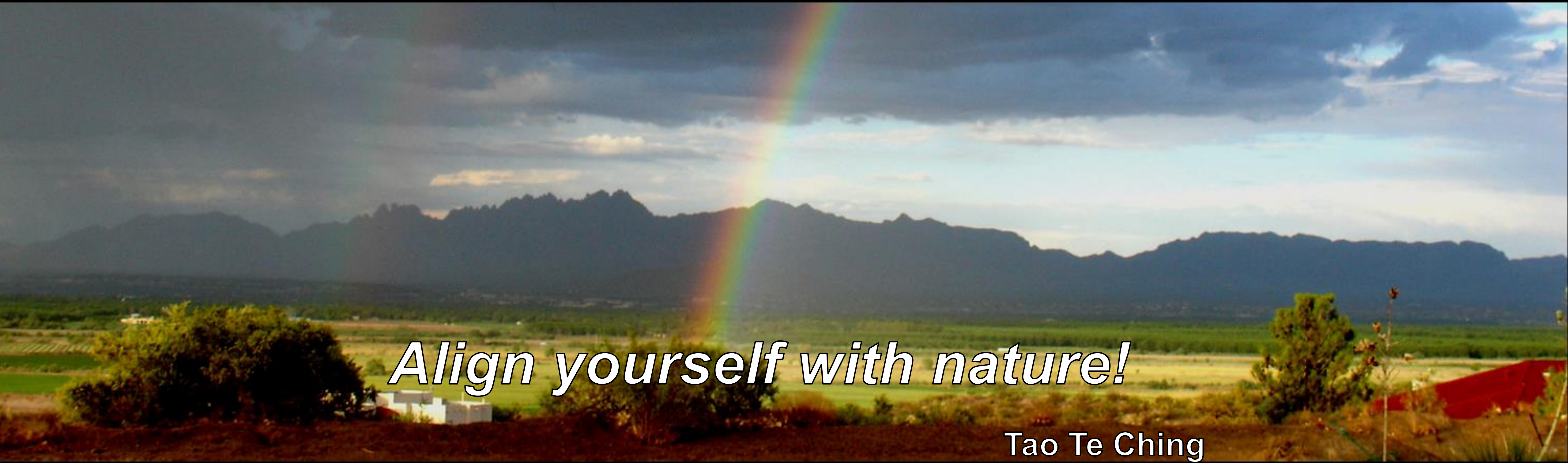

GLOBETROTTER FOUNDATION

#NOREGRETS Initiative

LAIRD NORTON FAMILY FOUNDATION

Thornburg Foundation

https://www.youtube.com/channel/UCVSSTOJVSSuRcCu68IMcsEA

MIGHTY ARROW FAMILY FOUNDATION

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