

HOW MUCH FERTILIZER DO WE REALLY NEED?

GLIMPSEING THE TIP OF THE ICEBERG WITH NUTRIENT RESULTS



What I'd Like to Discuss

- Our story, our data
- Stepping back (with trepidation) – conceptual models of soil
 - Which models do a better job of explaining our data ?

CIG: 5 fields, 50 acres, 3 counties, 13 sample zones

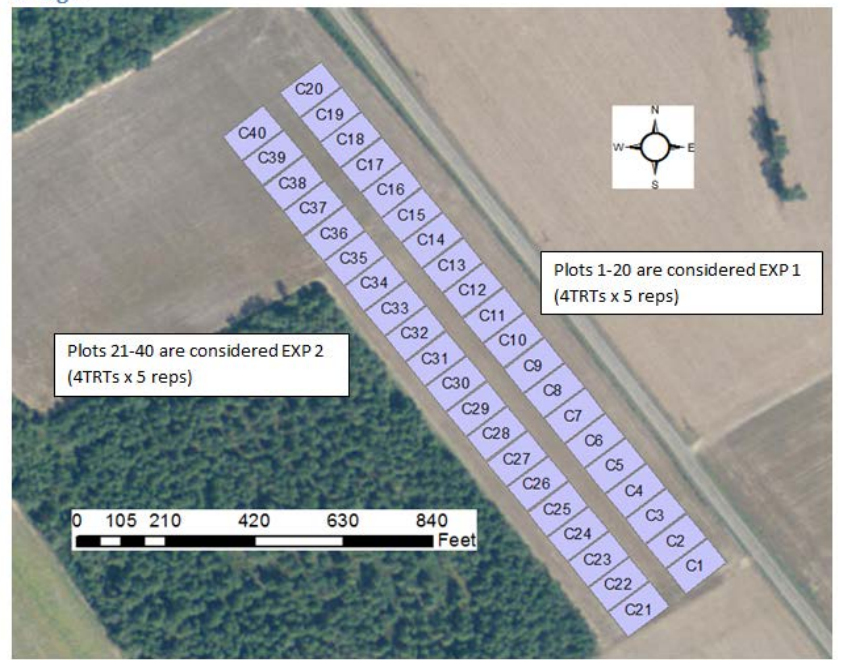
All 13 Mgmt Units

	Nov-13	Nov-17	%Ch
SoilpH	5.9	5.8	-2%
P	101	107	6%
K	141	123	-13%
Mn	12.2	18.5	52%
OM	1.2	1.7	47%

4 Mgmt Units Zero Manure

	Nov-13	Nov-17	%Ch
SoilpH	5.9	6.0	0%
P	120	107	-11%
K	190	196	3%
Mn	15.8	20.8	32%
OM	1.7	2.4	38%

No lime, or synthetic fertilizers for 4 years



Fertilizer Plots

STK average 108

= CU “Medium” Soil Test Rating

Soil Series: Orangeburg loamy sand

Treatment	Yield (Total bu) 2015-2017 ¹
No K ₂ O	351 bu ²
Rx K ₂ O	349 bu ³

1. Average of 10 plots for each treatment
2. 51, 41, 147, 48 bu, 64 bu wheat ('15), beans ('15), corn ('16), wheat ('17), beans ('17)
3. 50, 41, 144, 51 bu, 64 wheat ('15), beans ('15), corn ('16), wheat ('17), beans ('17)

P and K Grain Removal (5 crops¹, 36 Months)

Average of 10 plots where Rx N was added but no P₂O₅ or K₂O

	Begin 6" Soil Test Value ²	Grain Removal (lb/ac)	End 6" Soil Test Value ³	Actual Change "lb/ac"
Phosphorus (P)	114	-79	83	-31
Potassium (K)	102	-206	108	+6

1. Wheat, beans, corn, wheat, beans

2. December 2014

3. November 2017

STK Changes in 36 Months¹

	Begin 6” STK ²	K added (lb/ac)	End 6” STK ³	STK Change “lb/ac”	
No Potash Added⁴	102	0	108	+6	+4%
Rx Potash Added⁵	113	214 ⁶	106	-7	-6%

1. Crops were wheat, beans, corn, wheat, beans – est. grain removal was 199 lb for both sets
2. December 2014
3. Nov 2017
4. Average of 10 plots
5. Average of 10 plots
6. 408 lbs of 0-0-60 (~ 214 lb K, = 258 lb K₂O)

Other Stories

- Plant Tissue P – 279 tests¹ 3 years, 2 deficient in P (0.7% of samples)
- Coleman check plots¹ (Corn 2016):
 - average yield 95 bu (64-124 bu range)



1. Wheat, Corn, Cotton no manure or P₂O₅ fertilizer
2. 0-0-0 added to 21 check plots

Soils At Depth

Average of 33 samples Statewide 2015-2016	STP “lb/ac”	STK “lb/ac”
0-6”	121	118
6-12”	61	117
12-24”	22	150

Average of 12 samples Fert Plots 2107	STP “lb/ac”	STK “lb/ac”	%OM
0-6”	116	112	1.9
6-12”	81	126	1.3
12-24”	9	206	1.6

Regenerating

Degraded

% OM
Nov 2013 – 1.2%
Nov 2017 – 1.9%

~15 species
cash and
cover

~3 species

Rx fertilizer &
Lime

Extractive

No P, K
fertilizer &
Lime

Regenerative



Summarizing Our Data

- 2013 CIG
 - pH, P, K micronutrients steady or up – no fertilizer (4 years)
- Fertilizer Plots
 - Same yields for “medium” soil K rating – no K_2O vs Rx K_2O over 5 crops
 - Soil test P – dropping at 1/3 of the rate of calc P removal
 - Soil test K – sandy soils – higher after 3 crops and 0 K_2O added

Fert Rx Example

Mehlich 1	lb/ac
STP	73
STK	165

Soil Groups for P:

Grp 3 – Coastal Plain

Grp 4 - Piedmont

Range in Extractable Phosphorus, Potassium, Calcium, and Magnesium Represented by the Soil Test Ratings of the Clemson University Agricultural Service Laboratory

Soil Test Rating	P		K	Ca	Mg	
	Soil Groups 1,2,3&6	Soil Groups 4&5	All Soil Groups	All Soil Groups	Soil Groups 1,2,3&5	Soil Groups 4&6
	<i>lbs/acre</i>					
Low	<31	<21	<71	<401	<33	<47
Medium	31 – 60	21 – 40	71 – 156	401 – 800	33 – 60	47 – 100
Sufficient	61 – 80	41 – 54	157 – 182	801 – 1600	>60	>100
High	81 – 120	55 – 80	183 – 235	1601 – 2000		
Excessive	>120	>80	>235	>2000		

Sufficient for P

Sufficient for K

Crop Code No. 029

Small Grain

Soil Groups 1, 2, 3, 4 or 6	Desired pH 6.0-6.5				
	Phosphorus	Potassium			
	Low	Medium	Sufficient	High	Excessive
	<i>pounds of N-P₂O₅-K₂O per acre</i>				
Low	90-80-80	90-80-60	90-80-40	90-80-0	90-80-0
Medium	90-40-80	90-40-60	90-40-40	90-40-0	90-40-0
Sufficient	90-20-80	90-20-60	90-20-40	90-20-0	90-20-0
High	90- 0-80	90- 0-60	90- 0-40	90- 0-0	90- 0-0
Excessive	90- 0-80	90- 0-60	90- 0-40	90- 0-0	90- 0-0

Commercial Lab Rx?

Dr. Brad Joern YouTube

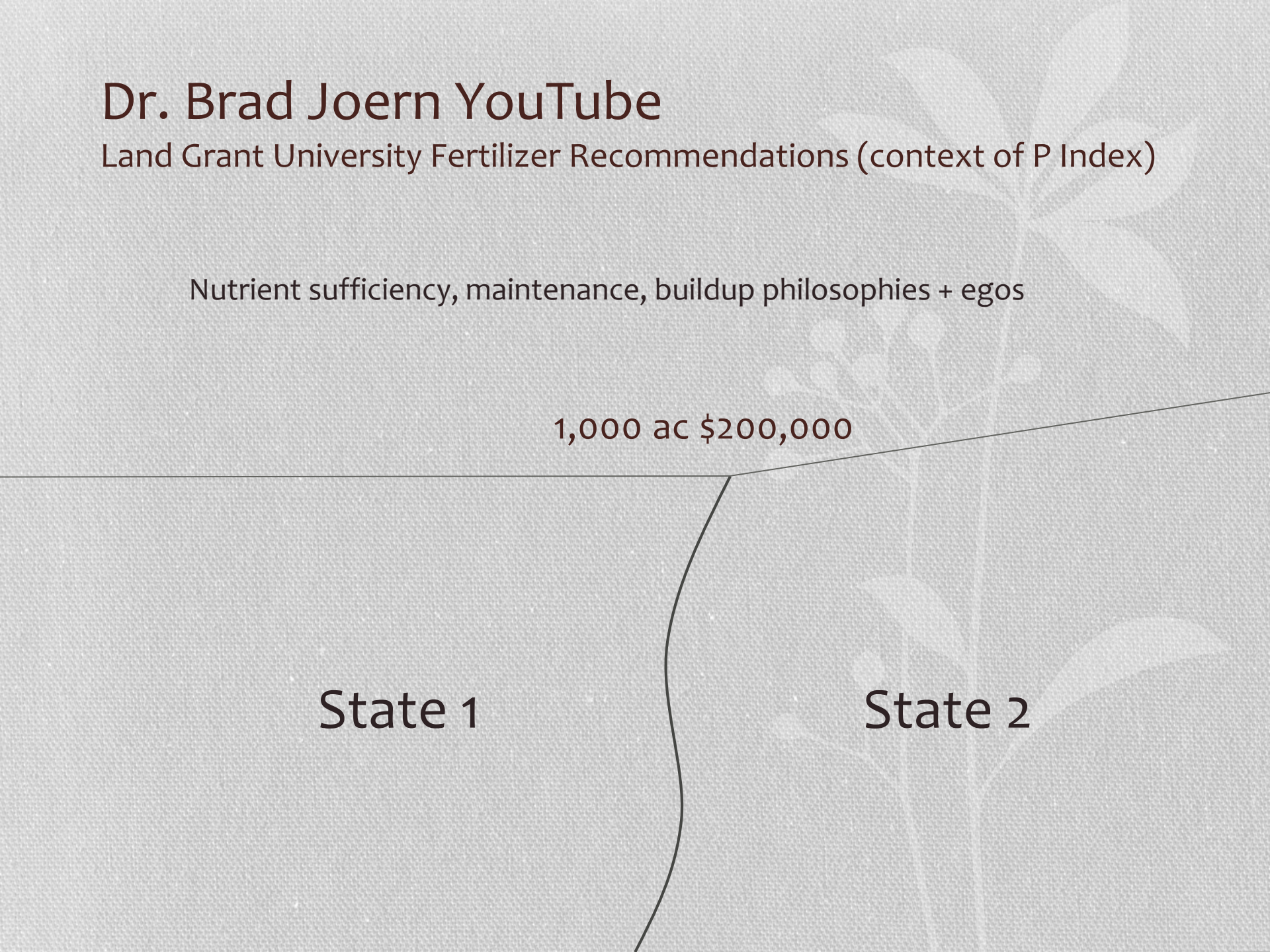
Land Grant University Fertilizer Recommendations (context of P Index)

Nutrient sufficiency, maintenance, buildup philosophies + egos

1,000 ac \$200,000

State 1

State 2



Deconstruction - Assumptions of the Rx

(From my own reading/experience ~ 2004)

- Lab extracted nutrient \equiv plant availability
- Lab extracted nutrient in top 6" – that's all there is
- Soils are leaky – they don't hold fertilizer well
- In the real world fertility programs, biology can usually be ignored*
- Base on science, precise soil test measurement \equiv precise recommendation

After all, these are the LAW

My LGU Experience – doubtful that this is unique

* Typically we see credits for a crop like corn behind soybeans.

Thomas Khun - helpful

“Structure of Scientific Revolution”

Set of assumptions \equiv Paradigm
“worldview”
“shared experience of reality”

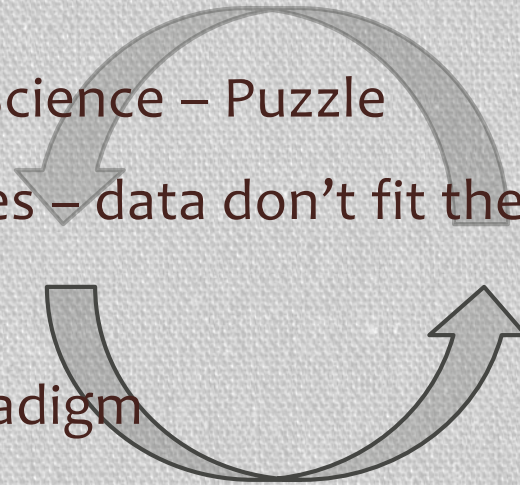
Determine what questions
need to be asked

Normal Science – Puzzle

Anomalies – data don't fit the paradigm

Crisis

New Paradigm



Anomalies and Crisis

(My experience)

- Ray Steyer (NC)
- Gabe Brown, Menoken Farms (ND)
- Dave Brandt (OH)
- Marion Calmer (IL) - See “Marion Calmer on Applying Dry P&K Fertilizer” on YouTube
- Bryan Jorgensen (SD)
- Potassium paradox 2014 (Khan, Mulvaney & Ellsworth)
- Our fertilizer plots – farms of Coleman, Price, Gaddy, Carter, McInnis (SC) and then some.

Investigate or Dismiss?

The Stories we Hear

To the Farmer

- You don't understand
- You'll get away with first crop, but the next will tell on you
- Mining your soils
- Mining your subsoils

To the Researcher

- We tried that 30 years ago
- Unscientific
- Dangerous and irresponsible
- Your research is a special case
- Wrong

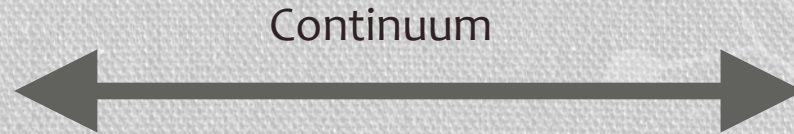
These are good, respected, smart people..
How do we explain the stories?

Janice Snow

“Misunderstanding of Soil Ecosystems”

Paradigms or Conceptual Models of Soil

Medium to
Grow Plants
MTGP



Living,
Dynamic
Mutualistic
Ecosystem
LDME

Snow, J.S. 2009. *Misunderstanding Soil Ecosystems. How flawed conceptions of soil have lead to flawed U. S. land, water and climate policies.* MA thesis, Tufts University, Boston, MA.

Christine Jones (Amazing Carbon)

(ACRES March 14, Vol 45 #3)

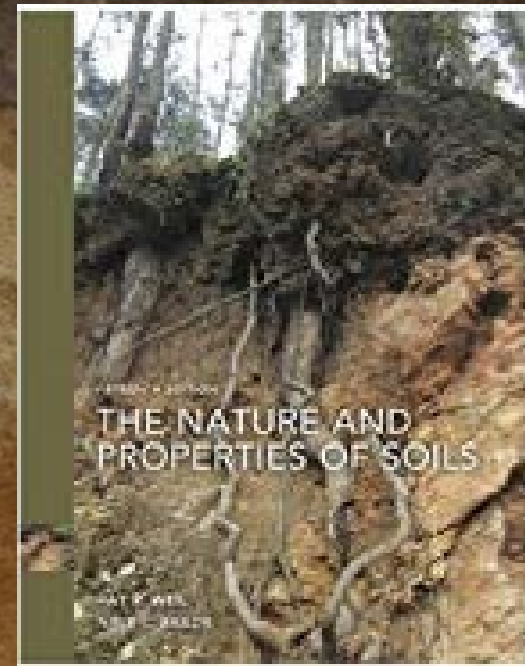


“Much of the agricultural research undertaken in pots in glass houses is fundamentally flawed. Soil is homogenized to remove background noise, that is, to make the soil in all the pots similar at the outset. The blending process breaks up the hyphae of mycorrhizal fungi....”

“Similarly with field trials, if the soil has been cultivated or bare fallowed, mycorrhizal fungi will not be there in sufficient quantities for effective carbon flow and nutrient acquisition. In healthy, biologically active soils, we do not see a response to synthetic nitrogen or phosphorus fertilizers. If anything, the use of these is counterproductive.”

Table 1.3
QUANTITIES OF SIX ESSENTIAL ELEMENTS FOUND IN UPPER 15 CM OF REPRESENTATIVE SOILS
IN TEMPERATE REGIONS

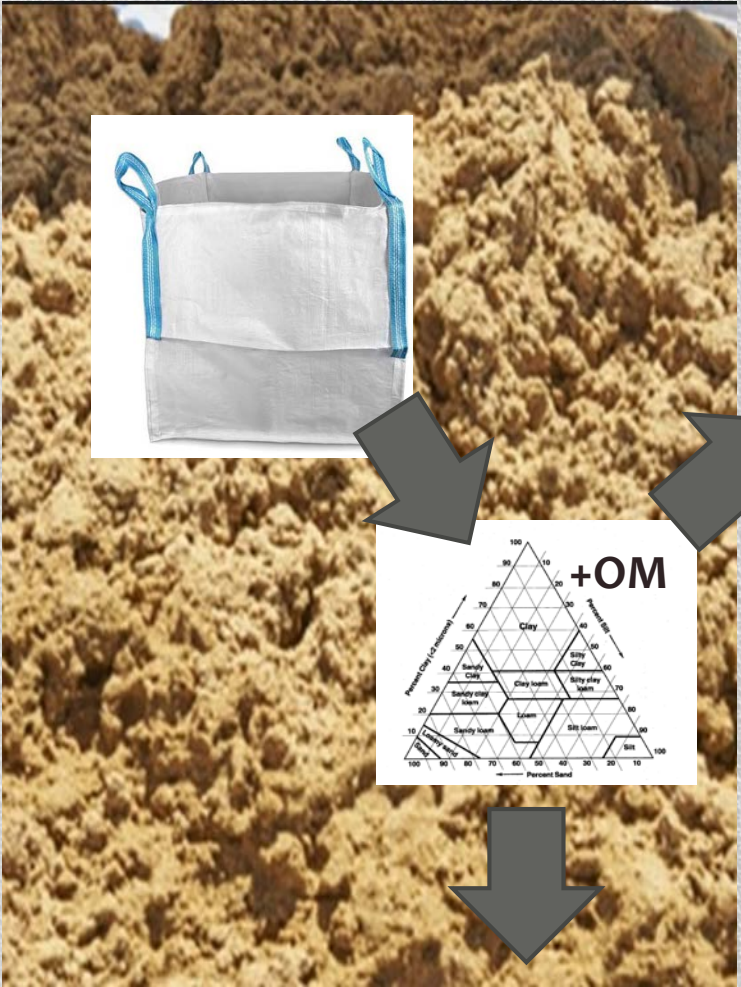
Essential element	Humid Region Soil			Arid Region Soil		
	In solid framework, kg/ha	Exchangeable, kg/ha	In soil solution, kg/ha	In solid framework, kg/ha	Exchangeable, kg/ha	In soil solution, kg/ha
Ca	8,000	2,250	60–120	20,000	5,625	140–280
Mg	6,000	450	10–20	14,000	900	25–40
K	38,000	190	10–30	45,000	250	15–40
P	900	—	0.05–0.15	1,600	—	0.1–0.2
S	700	—	2–10	1,800	—	6–30
N	3,500	—	7–25	2,500	—	5–20



Well and Brady, Nature and Properties of

Maybe?

MTGP



Efficiency – reduce losses
Dividing the pie

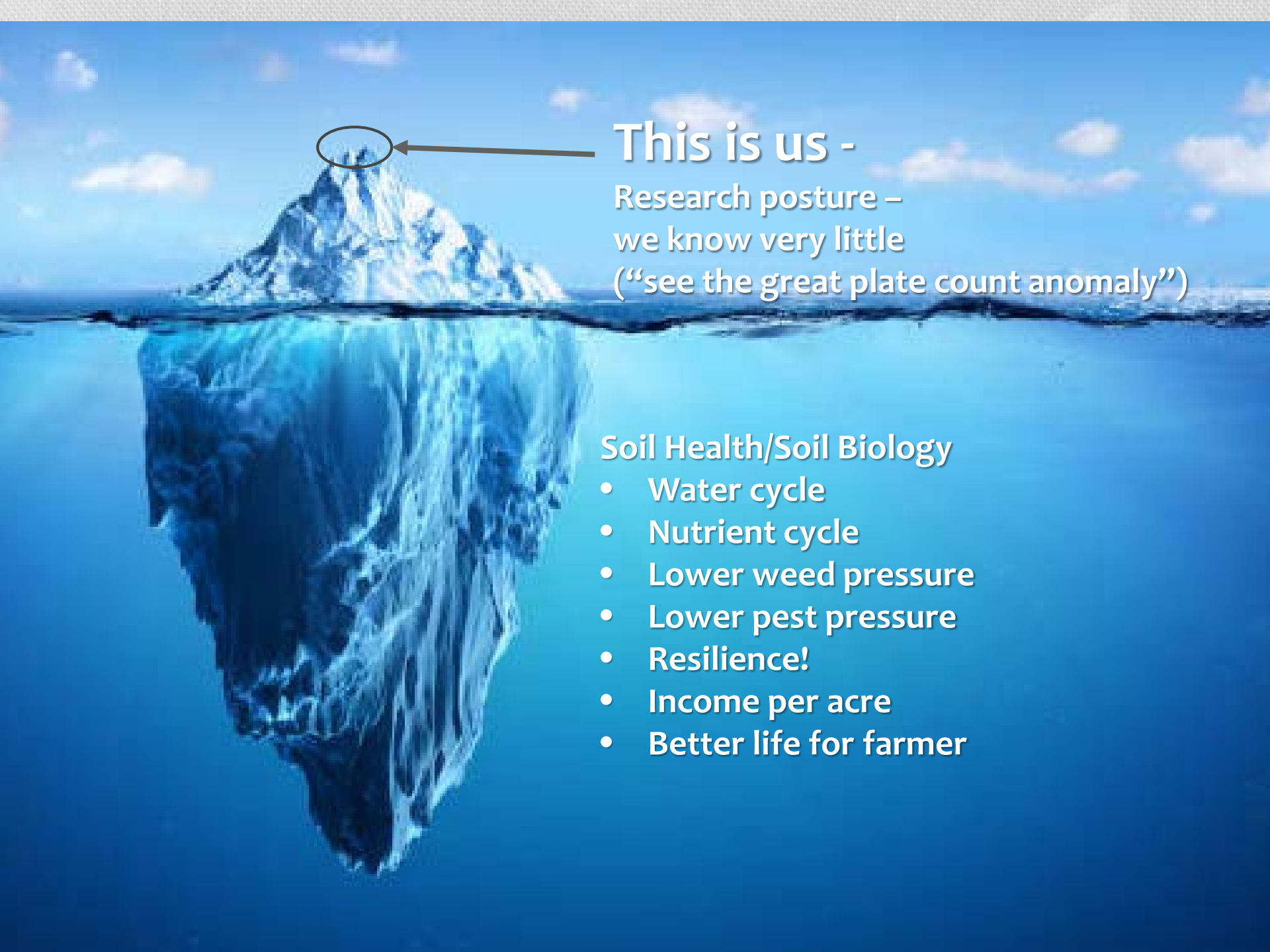
LDME



Making more pie available
through biology

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This is us -

Research posture –
we know very little
 (“see the great plate count anomaly”)

Soil Health/Soil Biology

- Water cycle
- Nutrient cycle
- Lower weed pressure
- Lower pest pressure
- Resilience!
- Income per acre
- Better life for farmer

Biology

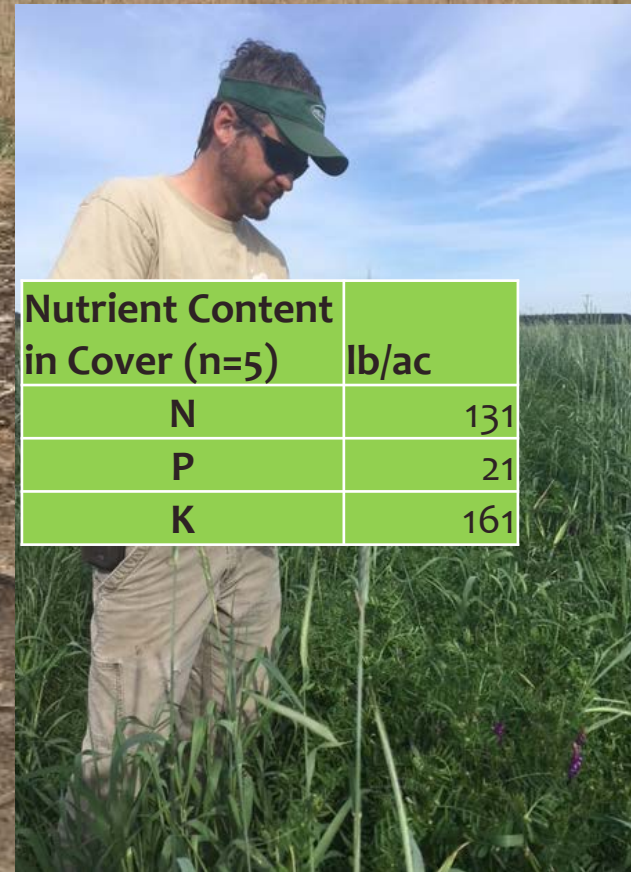
Relevant or not?

Carter Farms 5 NT vs CC Plots 2018

Clemson	Cover	No Cover	Stat Diffs?
pH	6.8	6.6	x
P	164	174	x
K	270	268	x
Mn	26.8	22.8	x
%OM	2.28	2.36	x

Haney	Cover	No Cover	Stat Diffs?
CO ₂ -C	26	28	x
H ₂ O Organic N	14	15	x
H ₃ A Nitrate	4.3	14.9	√
H ₂ O Total Organic C	160	138	√

Ward Labs PLFA	Cover	No Cover	Stat Diffs?
Total Biomass	3902	2822	√
Total Bacteria Biomass	1839	1336	√
Total Fungi Biomass	402	184	√



Nutrient Content in Cover (n=5)	lb/ac
N	131
P	21
K	161



Are we measuring the right things?

**Soils below 6"
Biology?**

Inorganic Chem?