Modernizing and Understanding Fertilizer Recommdations

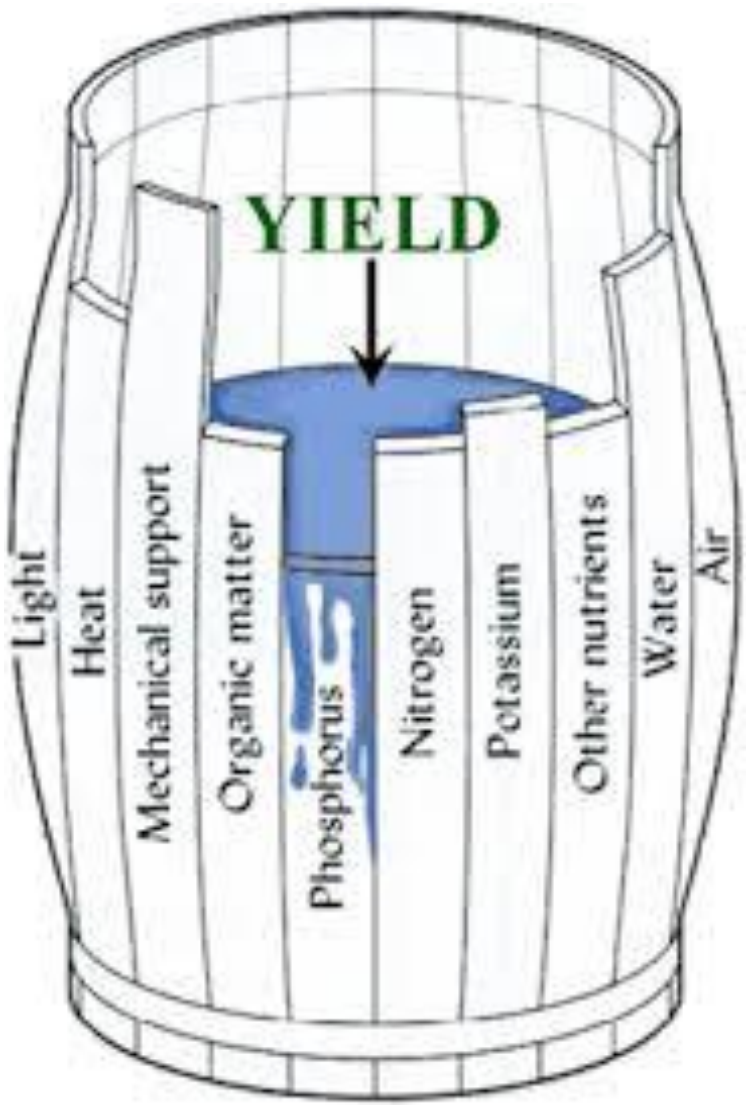
Vaughn Reed

MSU Row Crop Short Course

Dec 11, 2024

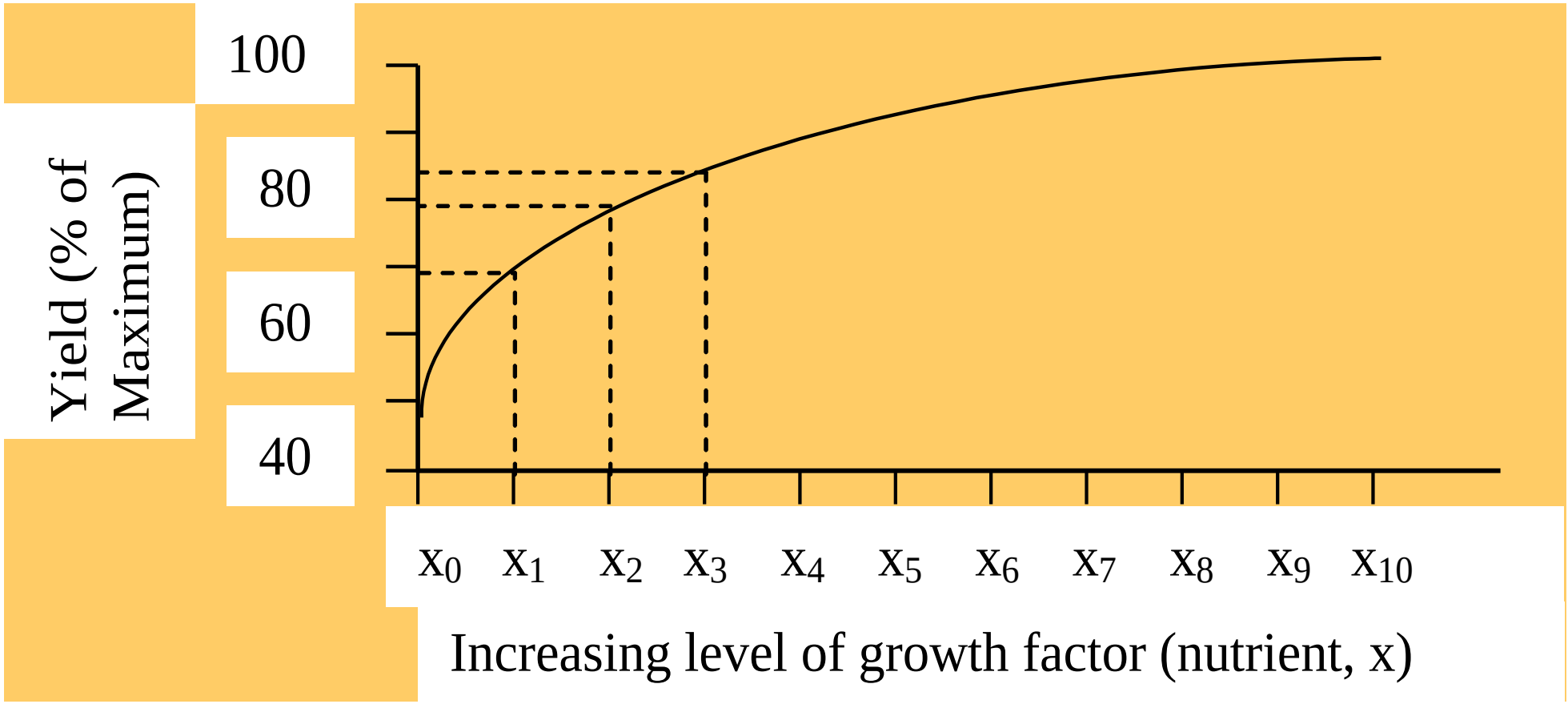
In the beginning…

von Liebig Law of the Minimum

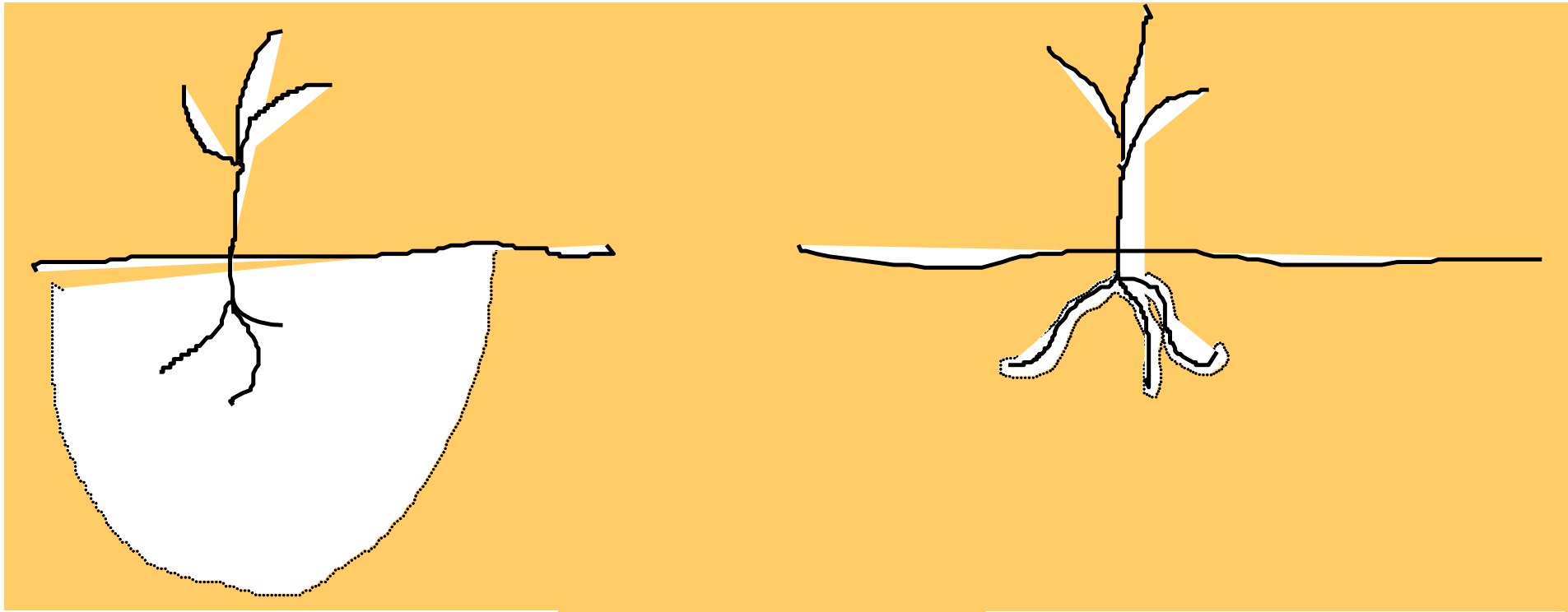


- Yield will be limited by lowest available growth factor

Mitscherlich Law of Diminishing Returns



Bray Nutrient Mobility Concept



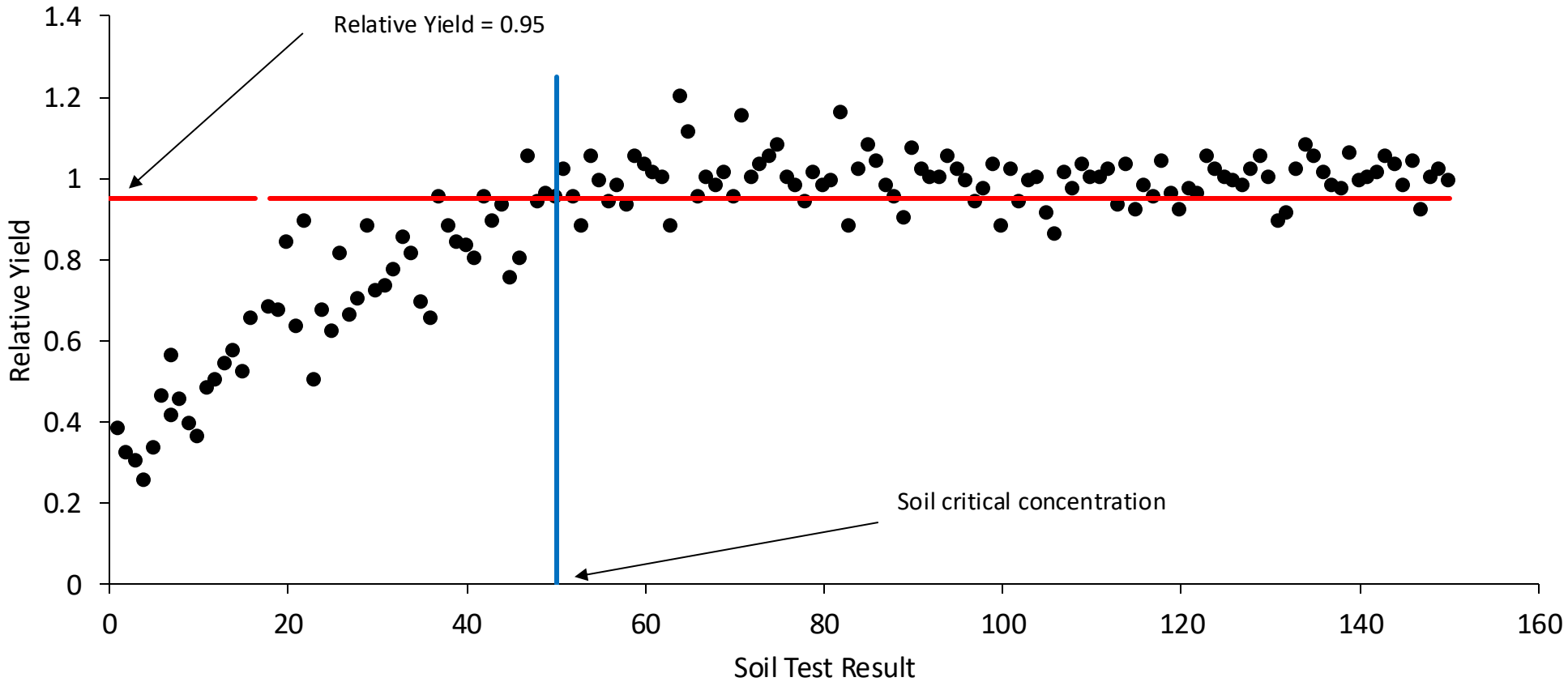
Mobile Nutrient
(root system sorption

Immobile Nutrient
(root surface sorption

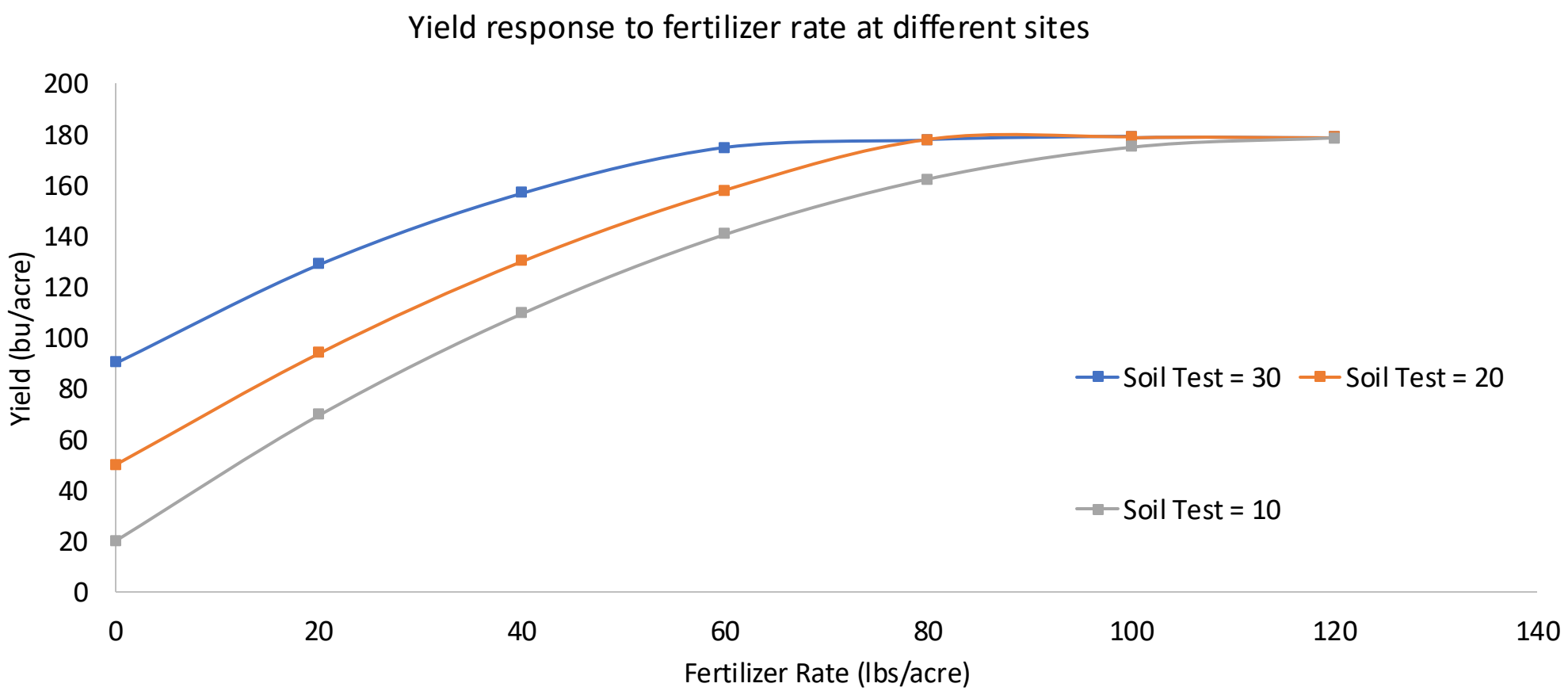
Soil Extractor

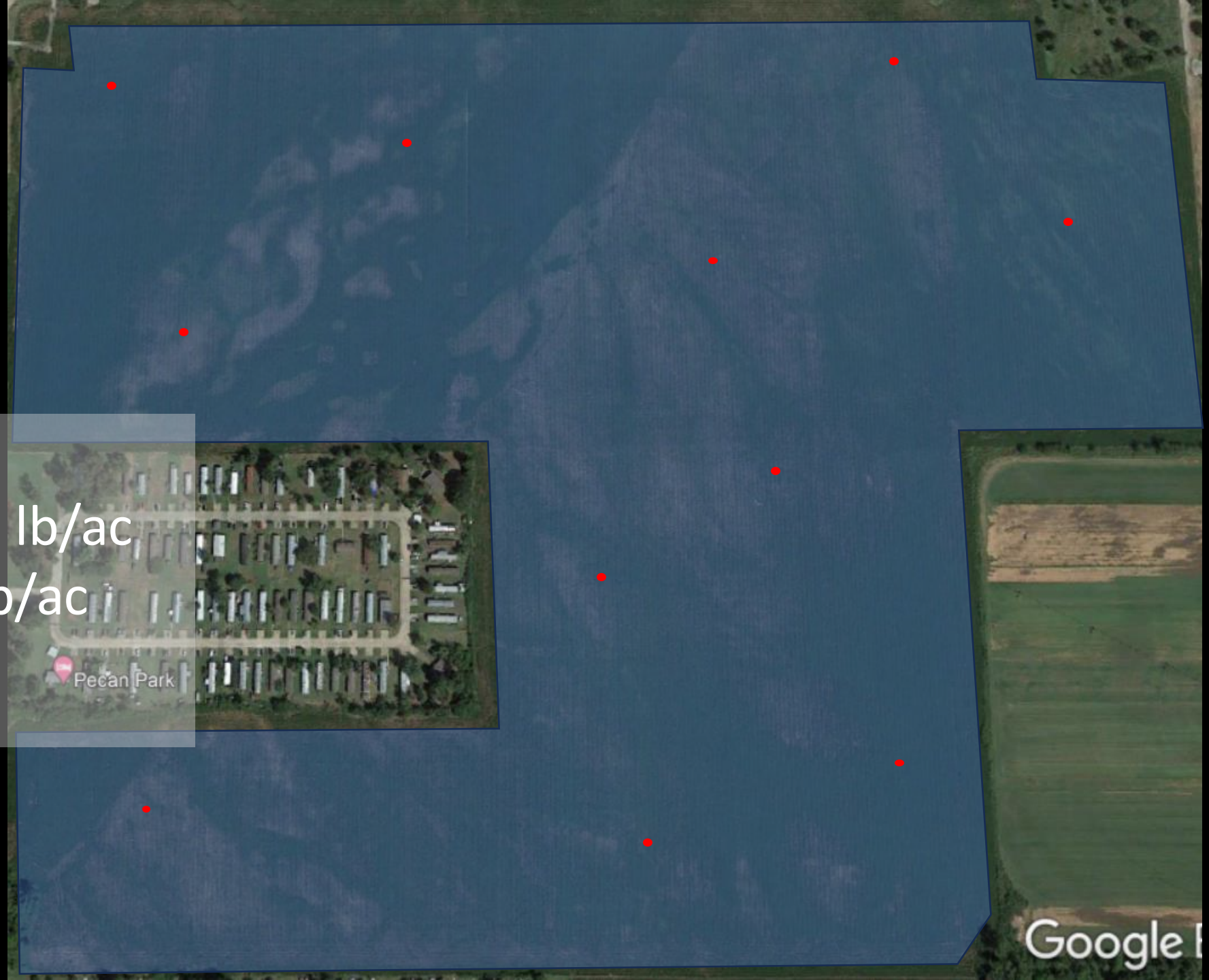
- Bray (1945)
- Olsen (1954)
- Mehlich 1 (1953)
- Lancaster (1970)
- Mehlich 3 (1984)

Correlation



Calibration




pH: 6.0
P: 12.0 lb/ac
K: 91 lb/ac
CEC: 7.7
Pecan Park
Google


Pecan Park
Google


1
2
3
4
5
6
7
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9
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48
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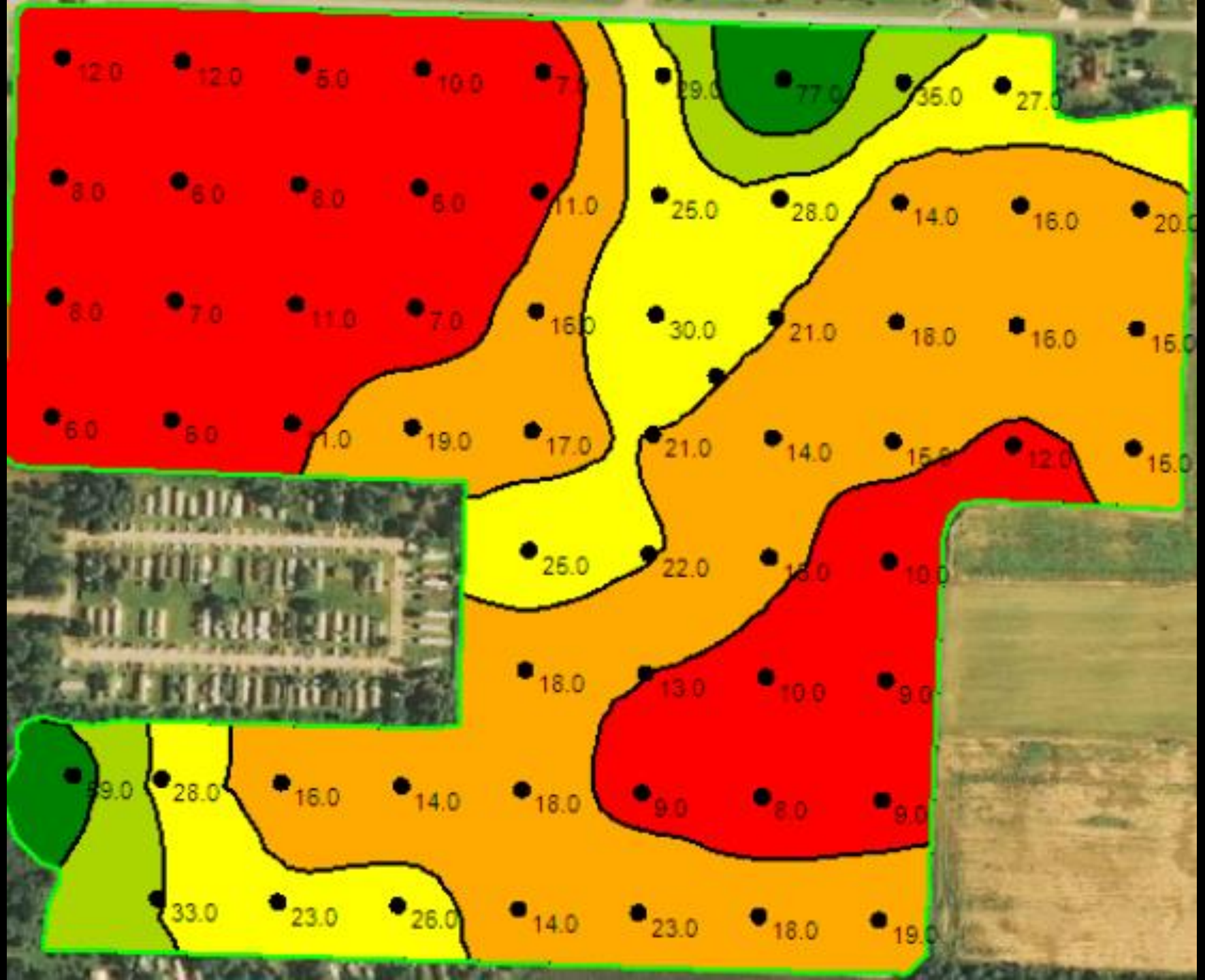
57
58
59
60
61
62

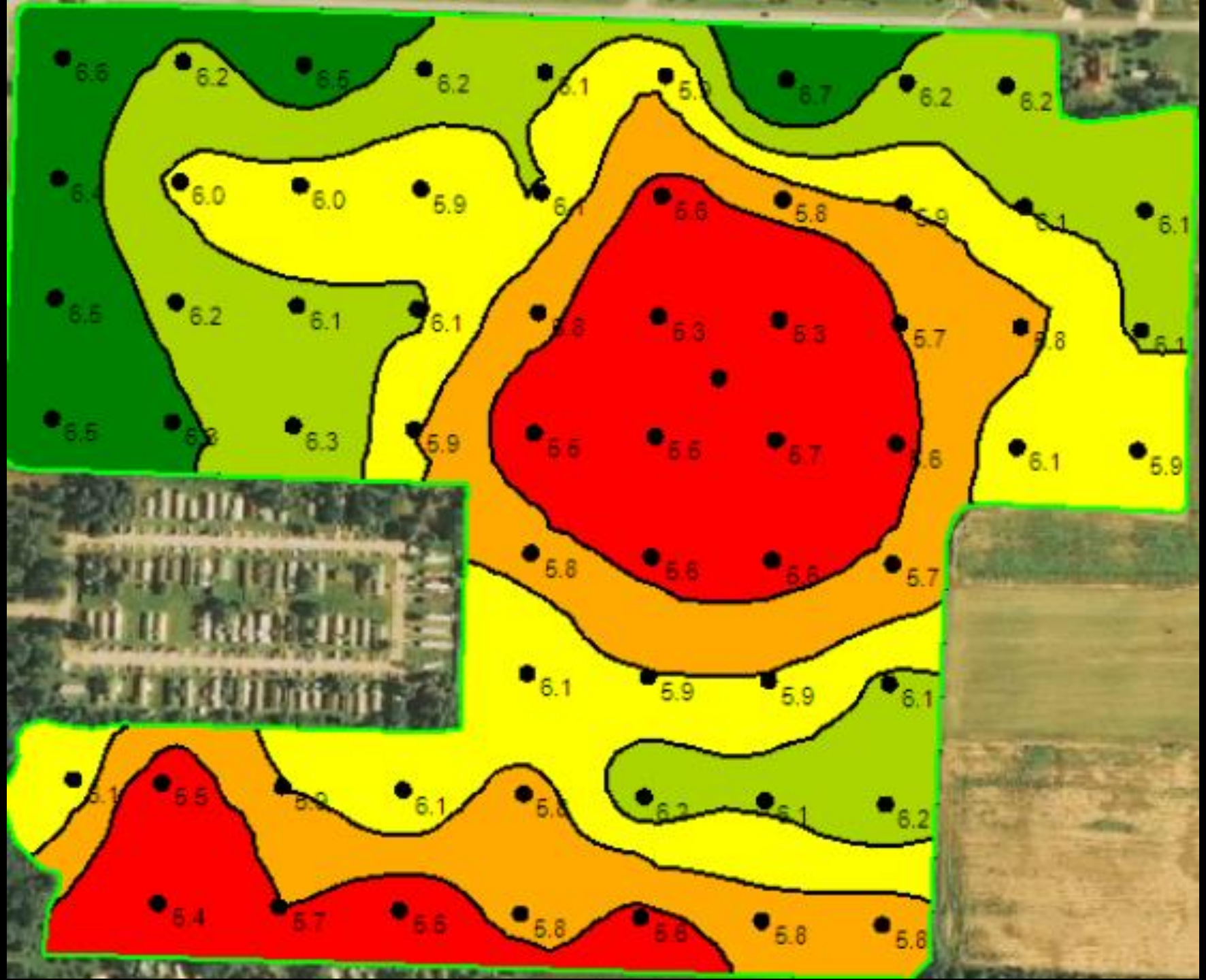
STK


75
86
86
72
175
110
89
99
107
69
91
72
92
99
112
128
125
76
62
67
95
70
64
74
66
81
81
63
79
62
76
103
63
67
61
64
88
102
66
88
73
79
64
78

STP


12.0
12.0
5.0
10.0
8.0
6.0
8.0
6.0
11.0
6.0
7.0
11.0
7.0
16.0
6.0
6.0
1.0
19.0
17.0
29.0
77.0
35.0
27.0
25.0
28.0
14.0
16.0
30.0
21.0
18.0
16.0
21.0
14.0
12.0
25.0
22.0
18.0
10.0
18.0
13.0
10.0
9.0
9.0
28.0
16.0
14.0
18.0
9.0
8.0
9.0
33.0
23.0
26.0
14.0
23.0
18.0
19.0

pH


6.6
6.2
6.5
6.2
6.1
6.7
6.2
6.2
6.0
6.0
5.9
6.6
6.6
6.1
6.1
6.5
6.2
6.1
6.1
6.3
6.3
6.7
6.1
6.1
6.5
6.3
5.9
6.6
6.6
6.7
6.1
5.9
6.8
6.6
6.6
6.7
6.1
5.9
6.1
5.9
6.1
6.5
6.1
6.4
6.7
6.6
6.8
6.8
6.8
6.8

Fertilizer Recommendations

- Use of correlation/calibration to make fertilizer recommendations

Table 4.3. Primary nutrient soil test calibration tables for small grains and row crops.

NITROGEN REQUIREMENTS

SMALL GRAIN Yield Goal (bu/A)			N (lbs/A)	GRAIN SORGHUM Yield Goal (lbs/A)	N (lbs/A)	CORN Yield Goal (bu/A)	N (lbs/A)	COTTON Yield Goal (bales/A)	N (lbs/A)	CANOLA Yield Goal	N (lbs/A)
Wheat	Barley	Oats									
15	20	25	**30**	2000	**30**	40	**40**	1.0	**50**	1000	**50**
20	25	35	**40**	2500	**40**	50	**50**	1.5	**75**	1500	**75**
30	35	55	**60**	3000	**50**	60	**60**	2.0	**100**	2000	**100**
40	50	70	**80**	4000	**70**	85	**85**	2.5	**125**	2500	**125**
50	60	90	**100**	4500	**85**	100	**110**	3.0	**150**	3000	**150**
60	75	105	**125**	5000	**100**	120	**130**	3.5	**175**	3500	**175**
70	90	125	**155**	7000	**160**	160	**190**	>3.5	**175**		
80	100	140	**185**	8000	**195**	180	**215**				
100	125	175	**240**	9000	**230**	200	**240**				

PHOSPHORUS REQUIREMENTS

P SOIL TEST INDEX	SMALL GRAINS Percent Sufficiency	SMALL GRAINS P_2O_5 (lbs/A)	GRAIN SORGHUM Percent Sufficiency	GRAIN SORGHUM P_2O_5 (lbs/A)	CORN Percent Sufficiency	CORN P_2O_5 (lbs/A)	COTTON Percent Sufficiency	COTTON P_2O_5 (lbs/A)	CANOLA Percent Sufficiency	CANOLA P_2O_5 (lbs/A)
0	25	80	40	60	30	80	55	75	25	80
10	45	60	60	50	60	60	70	60	45	60
20	80	40	80	40	80	40	85	45	80	40
40	90	20	95	20	95	20	95	30	90	20
65+	100	0	100	0	100	0	100	0	100	0

POTASSIUM REQUIREMENTS

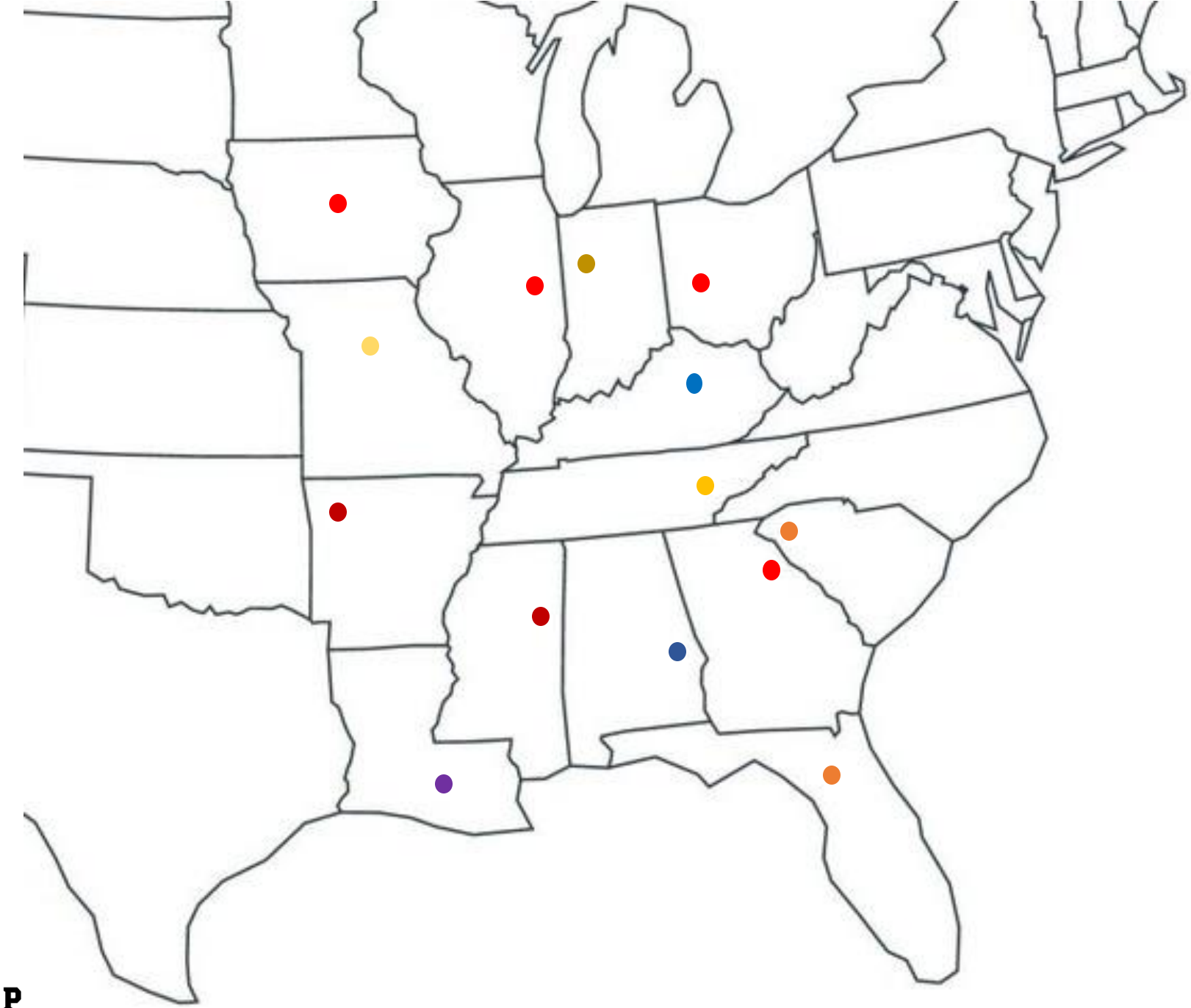
K SOIL TEST INDEX	SMALL GRAINS Percent Sufficiency	SMALL GRAINS K_2O (lbs/A)	GRAIN SORGHUM Percent Sufficiency	GRAIN SORGHUM K_2O (lbs/A)	CORN Percent Sufficiency	CORN K_2O (lbs/A)	COTTON Percent Sufficiency	COTTON K_2O (lbs/A)	CANOLA Percent Sufficiency	CANOLA K_2O (lbs/A)
0	50	60	40	100	40	120	40	110	50	60
75	70	50	65	75	60	80	60	80	70	50
125	80	40	80	50	75	60	75	60	80	40
200	95	20	95	30	90	40	90	40	95	20
250+	100	0	100	0	100	0	100	0	100	0

Fertilizer Application

- Fall vs. Spring Application
- Dry vs. Liquid
- Placement
- Product
- Rates

- Repeat Every year, or do once, and repeat same for a few years, then restart

Where does it go wrong?



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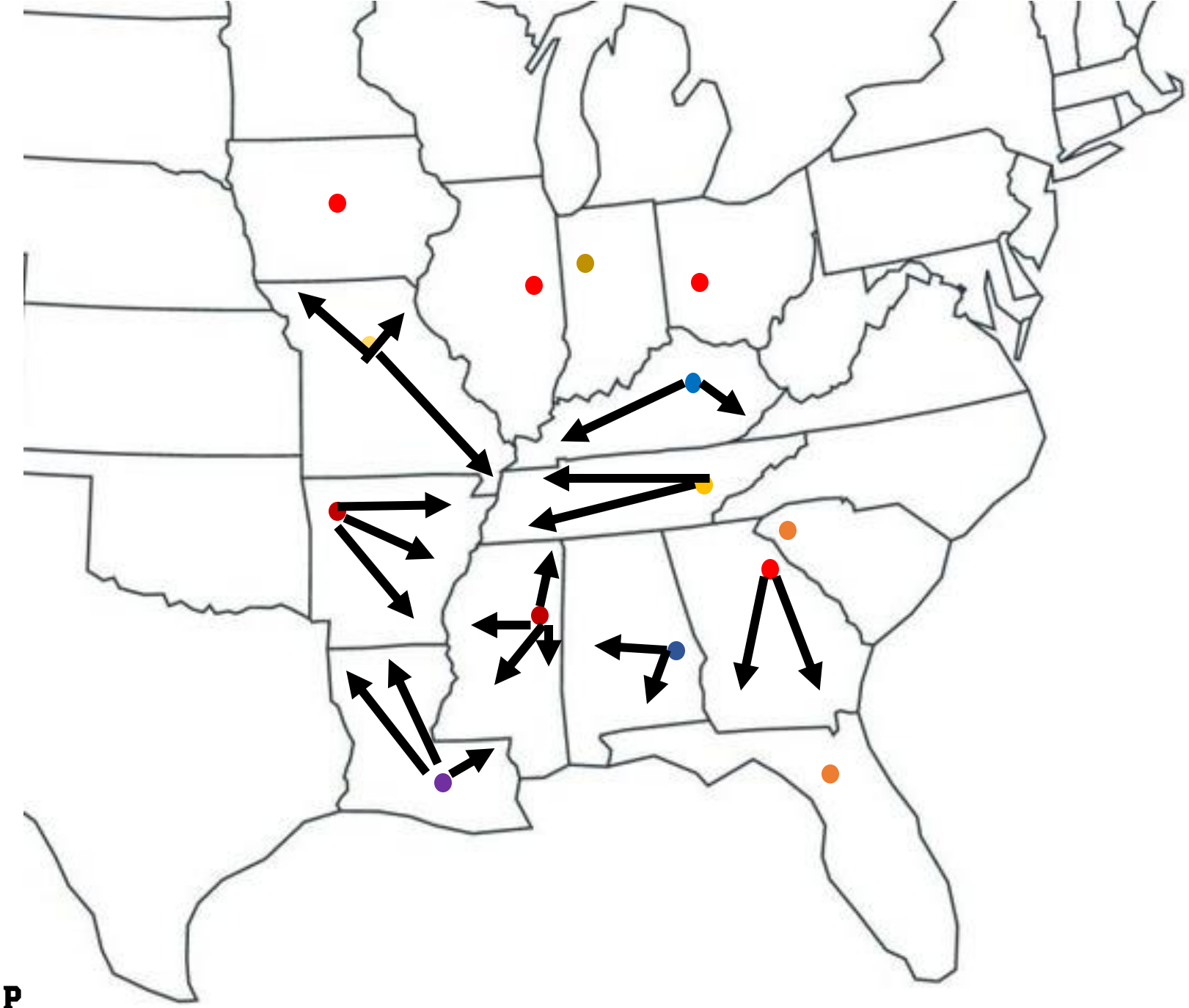

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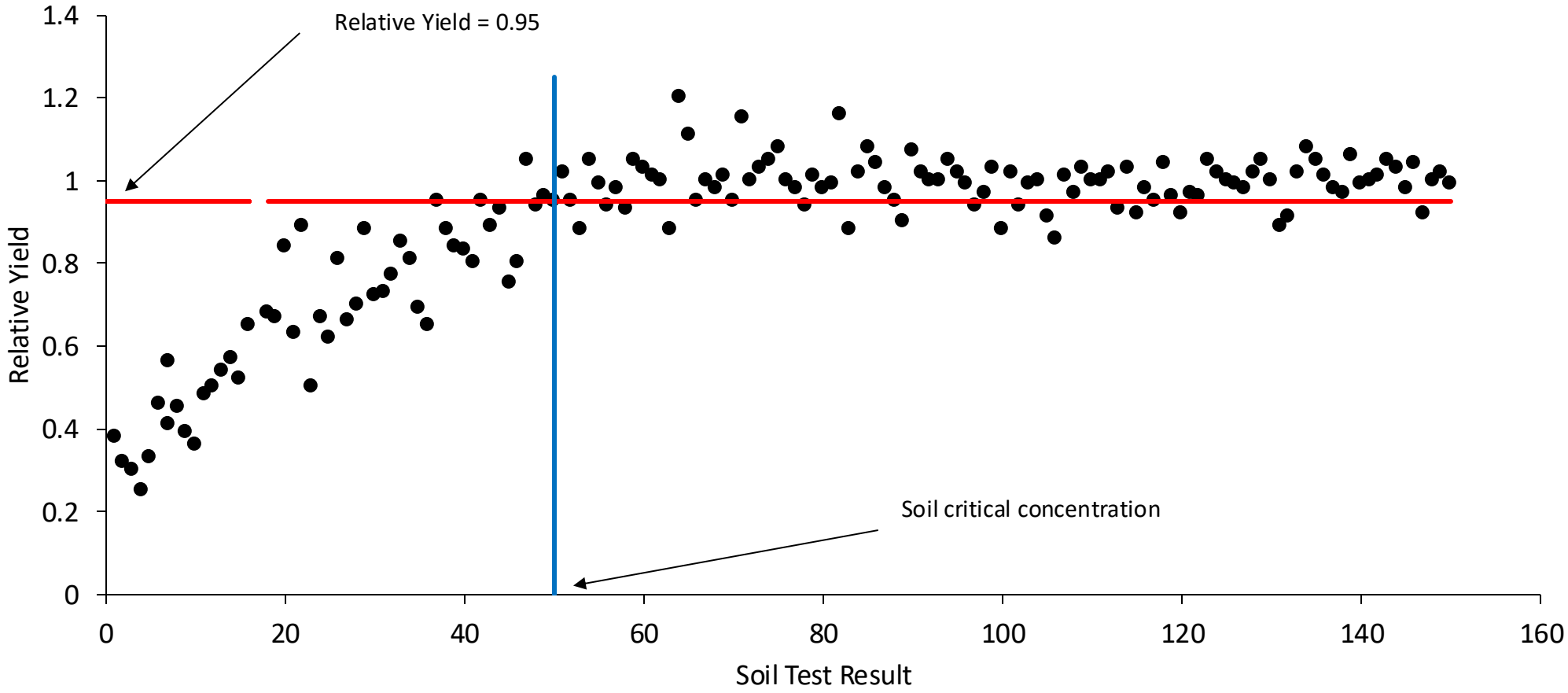
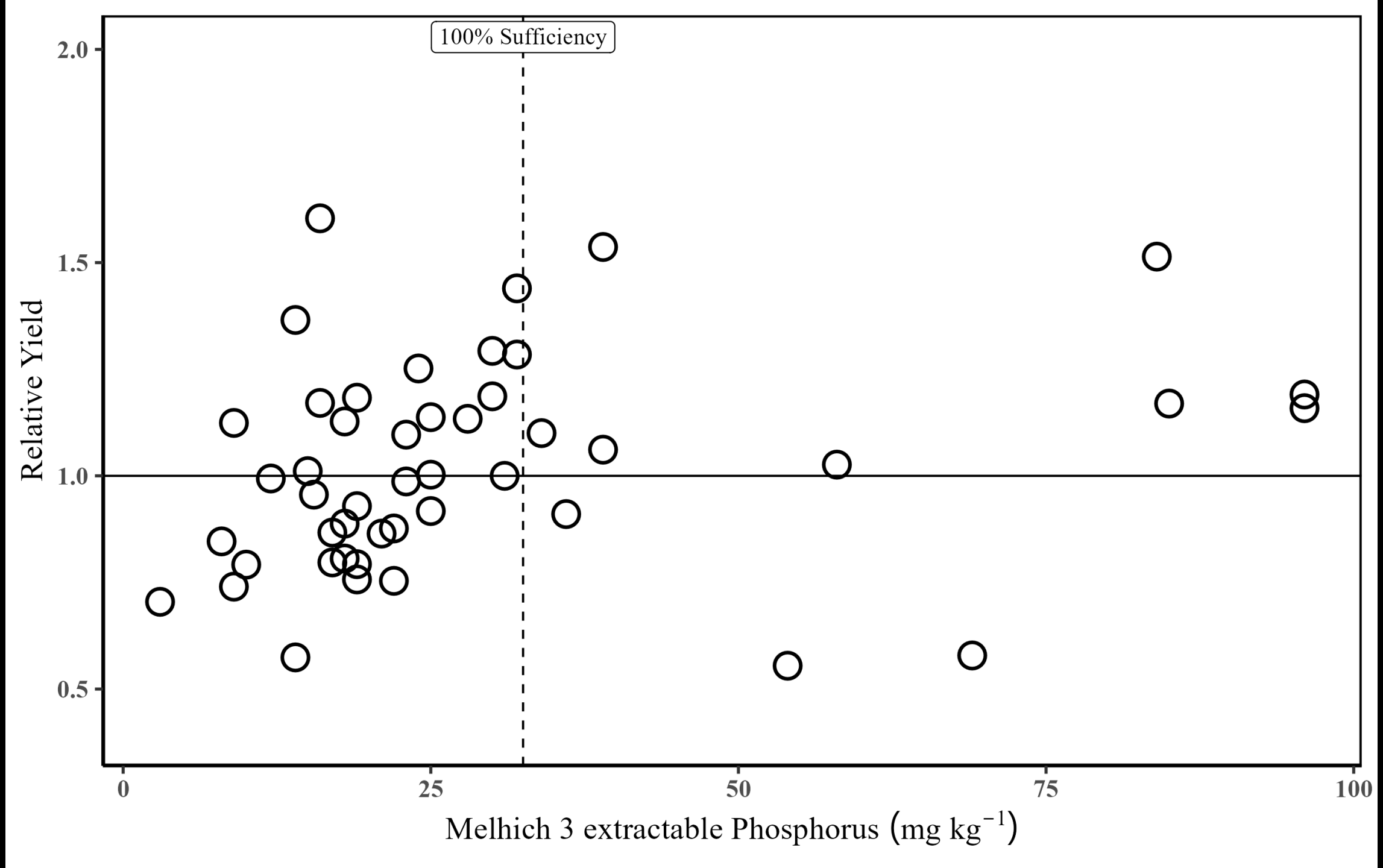
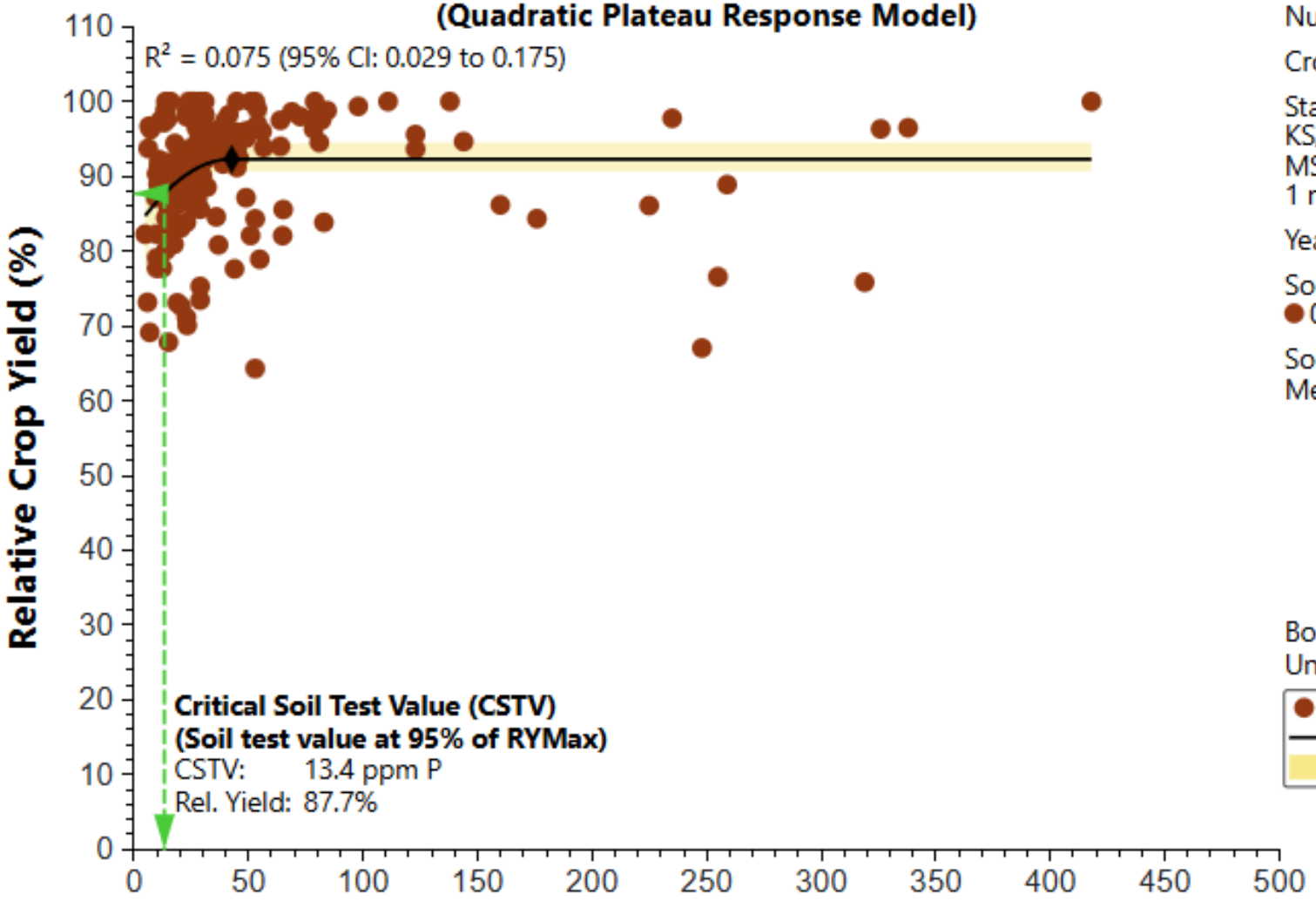
Correlation




100% Sufficiency
2.0
1.5
1.0
0.5
Relative Yield
0
25
50
75
100
Melhich 3 extractable Phosphorus (mg kg^{-1})

P Soil Test Correlation

(Quadratic Plateau Response Model)



Nutrient: P

Crop: Corn

States: AR, DE, IA, IL, KS, LA, MA, MD, ME, MN, MS, NJ, PA, RI, SC, TN, 1 more state

Years: 1955 to 2023

Soil Sample Depths:
● 0 to 6 in. (n=177)

Soil Test Method:
Mehlich-3

Bootstrap Samples: 1000
Unusable Samples: 113

● Site Year
— Fitted Model
Model 95% CI R. Yield

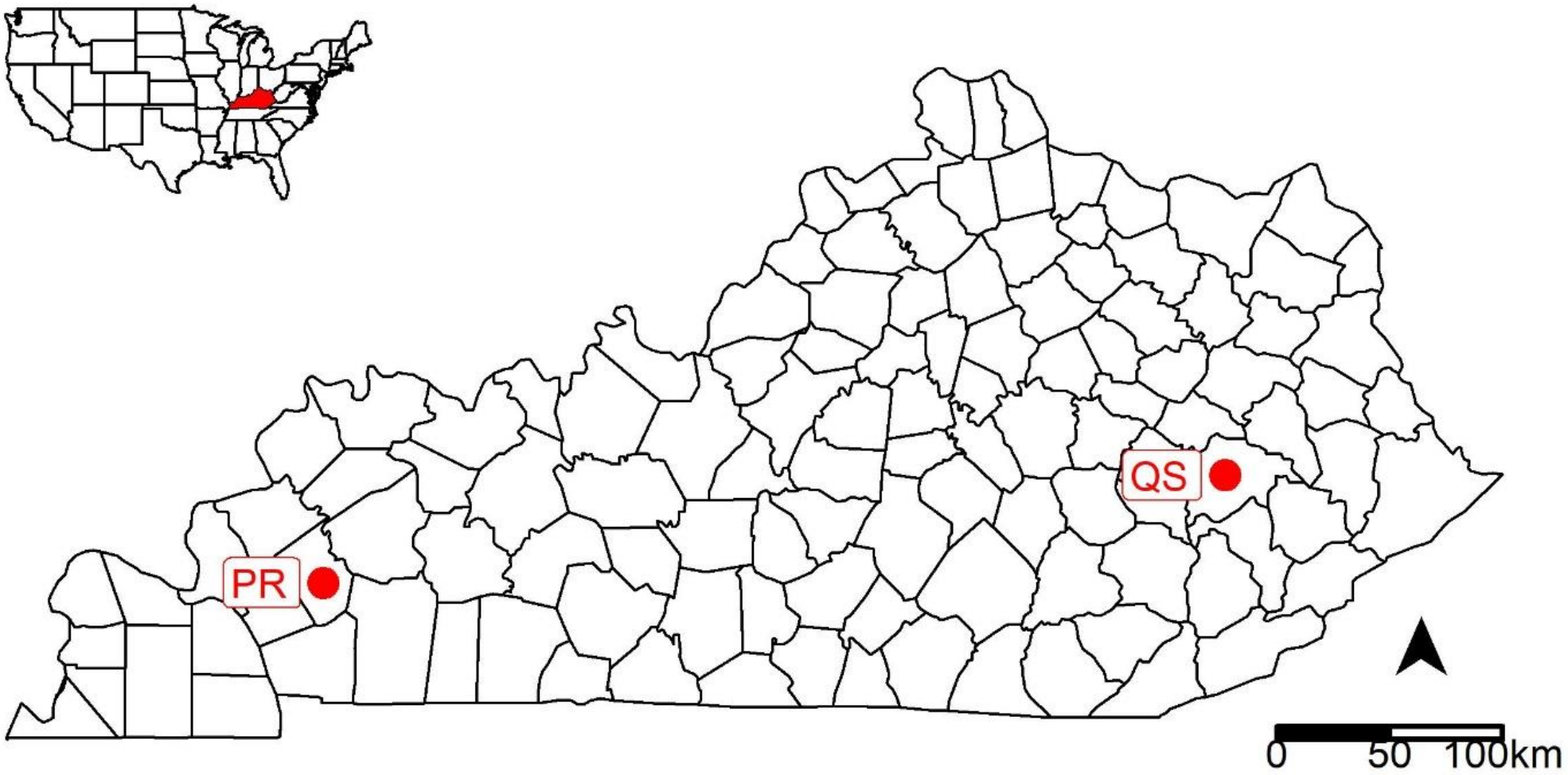
Estimated Model Parameters Using Bootstrapping

Parameter	Value	Description
STVJP(♦)	42.8	Nutrient soil test value (ppm) where relative crop yield is constant. (Join Point)
RYMax(♦)	92.3	Relative crop yield (%) maximum value. (Plateau relative crop yield)
Int	82.5	Relative crop yield (%) at nutrient soil test value of 0

FRST

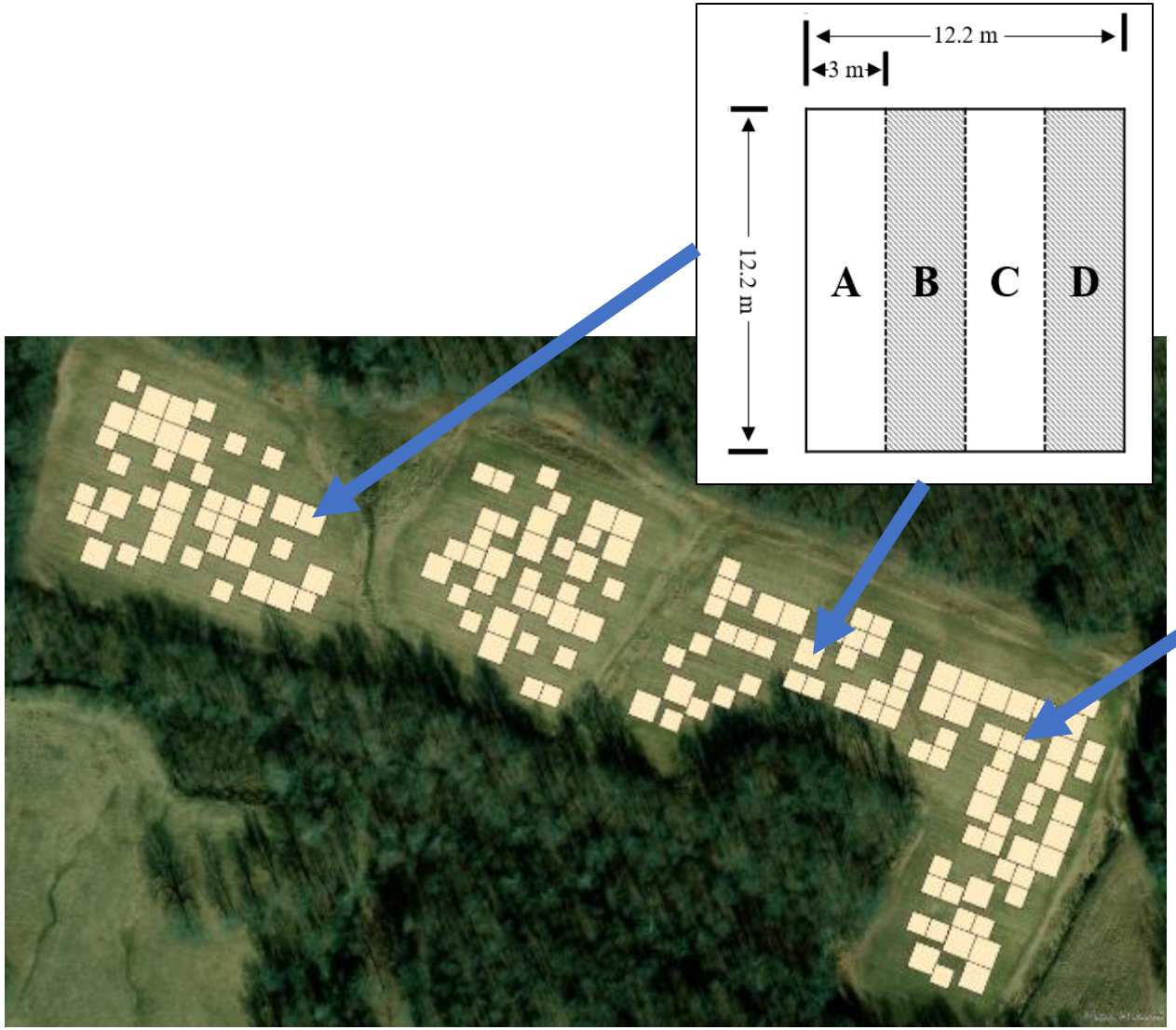
11-06-2024

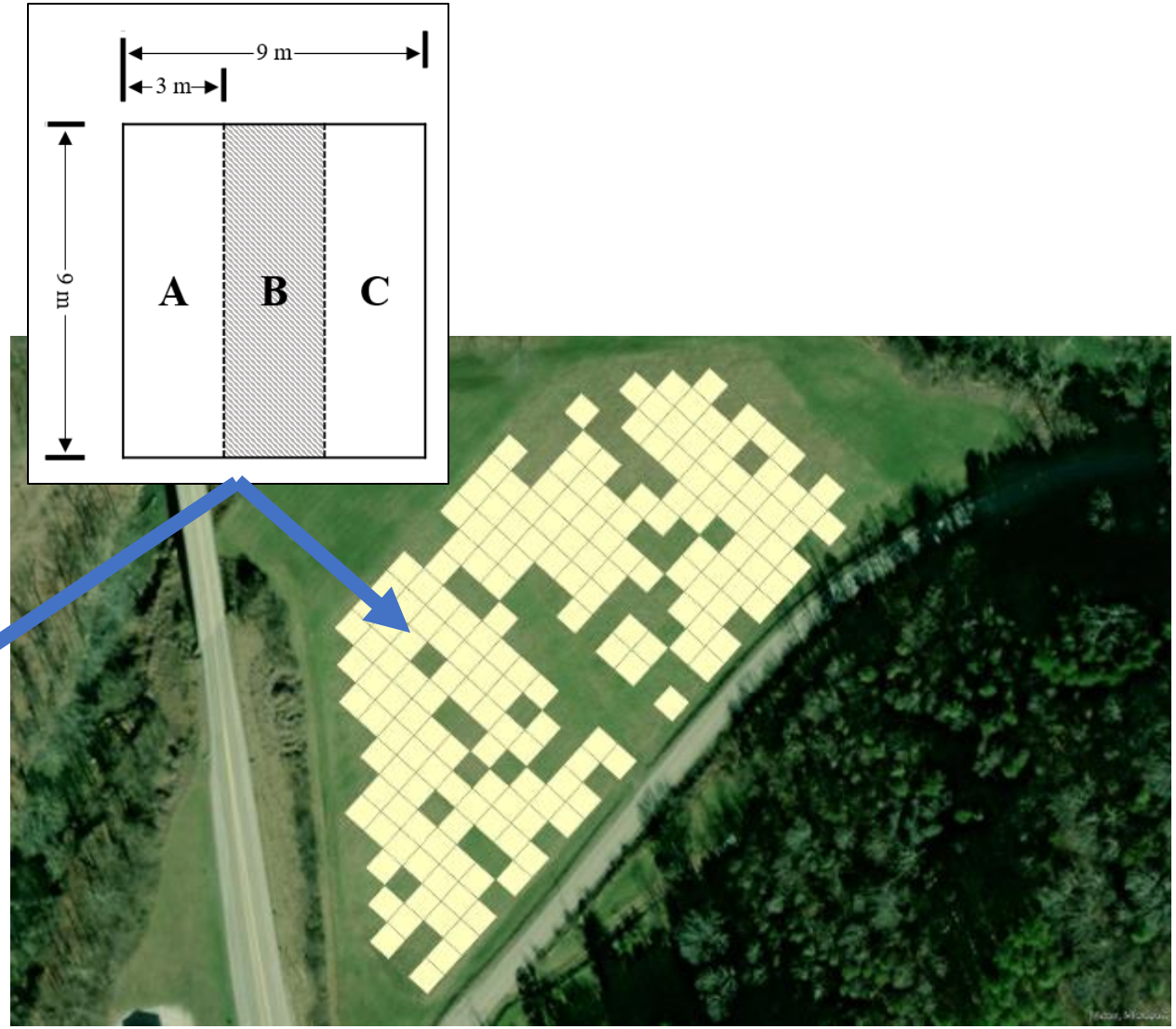
Okay, so we can’t make ONE recommendation across a state, what about a recommendation for a field or a region?


PR
QS
0
50
100km

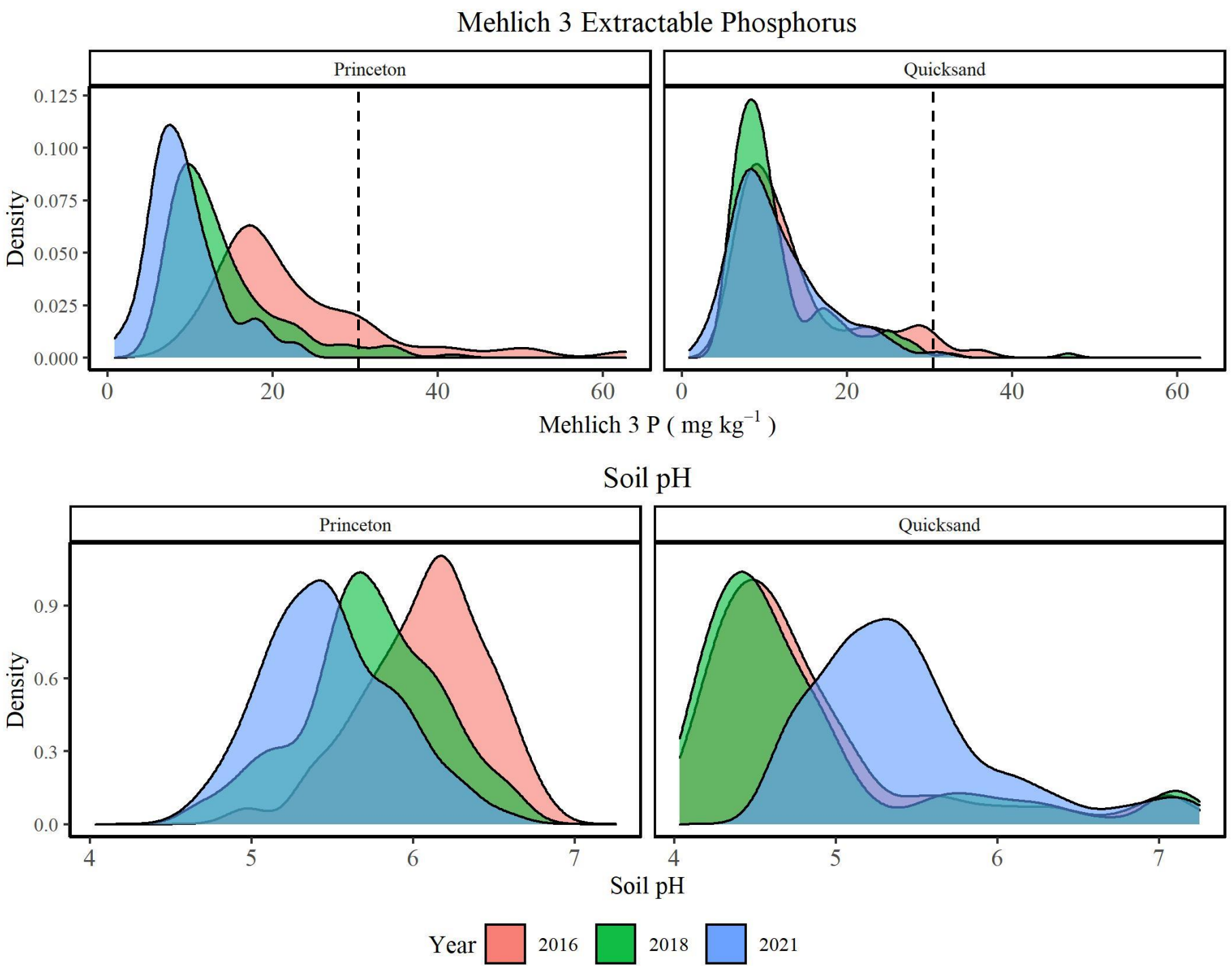
12 ac

6 ac





900 sq ft, 0.02 ac


Mehlich 3 Extractable Phosphorus
Princeton
Quicksand
Density
0.125
0.100
0.075
0.050
0.025
0.000
0
20
40
60
Mehlich 3 P (mg kg^{-1})
Soil pH
Princeton
Quicksand
Density
0.9
0.6
0.3
0.0
4
5
6
7
Soil pH
Year
2016
2018
2021

How accurate were recommendations

Year	STP (UK 100%: 30 ppm)	Recommendations	Yield w/o P fertilizer	Yield with P Fertilizer
2016	12 ppm	80 lb P_2O_5 ac^{-1}	176 bu ac^{-1}	186 bu ac^{-1}
2018	11 ppm	90 lb P_2O_5 ac^{-1}	233 bu ac^{-1}	243 bu ac^{-1}
2020	11 ppm	80 lb P_2O_5 ac^{-1}	158 bu ac^{-1}	171 bu ac^{-1}
2021	12 ppm	80 lb P_2O_5 ac^{-1}	128 bu ac^{-1}	141 bu ac^{-1}

Accurate = ✓

Precise = ???

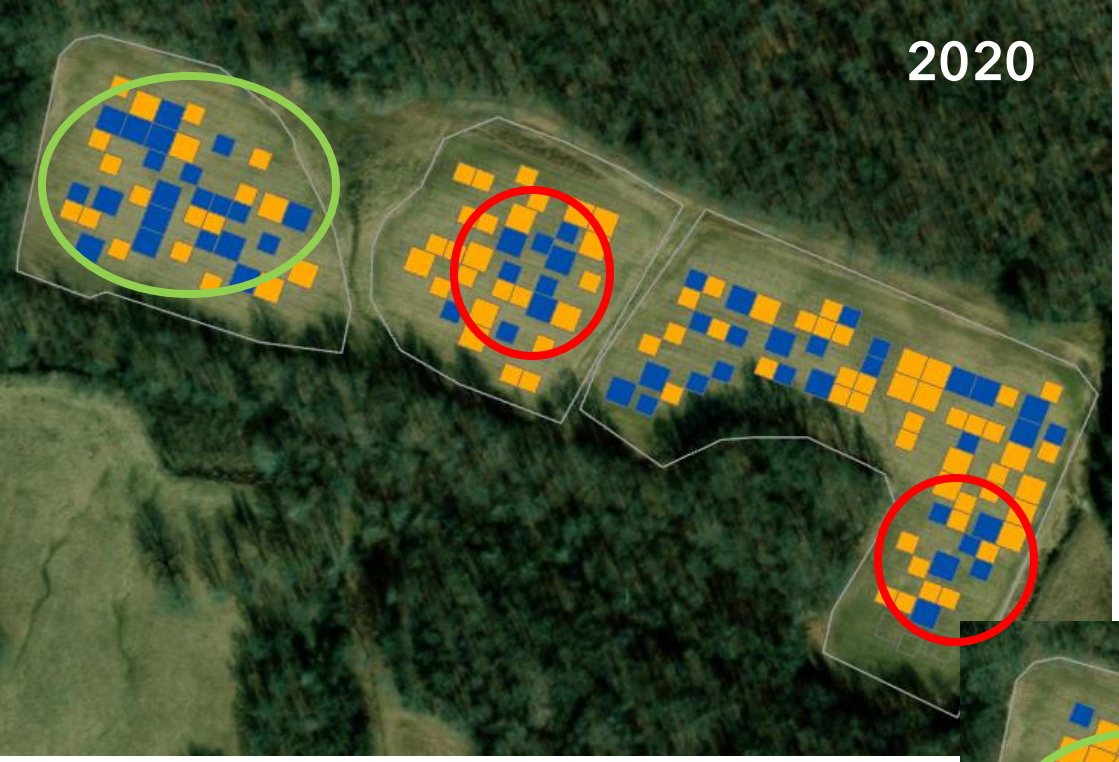
Relative Yield

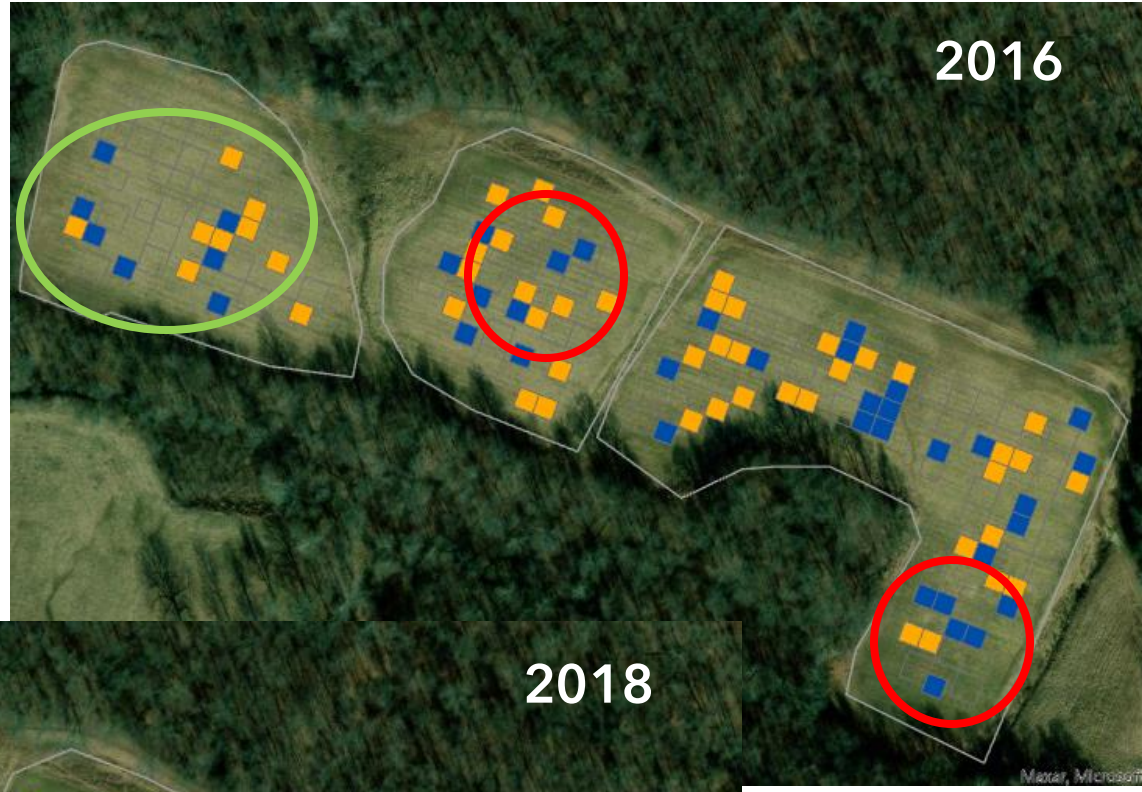
Check/Yield

<1 = Yield > Check

Responsive

Relative Yield < 0.95





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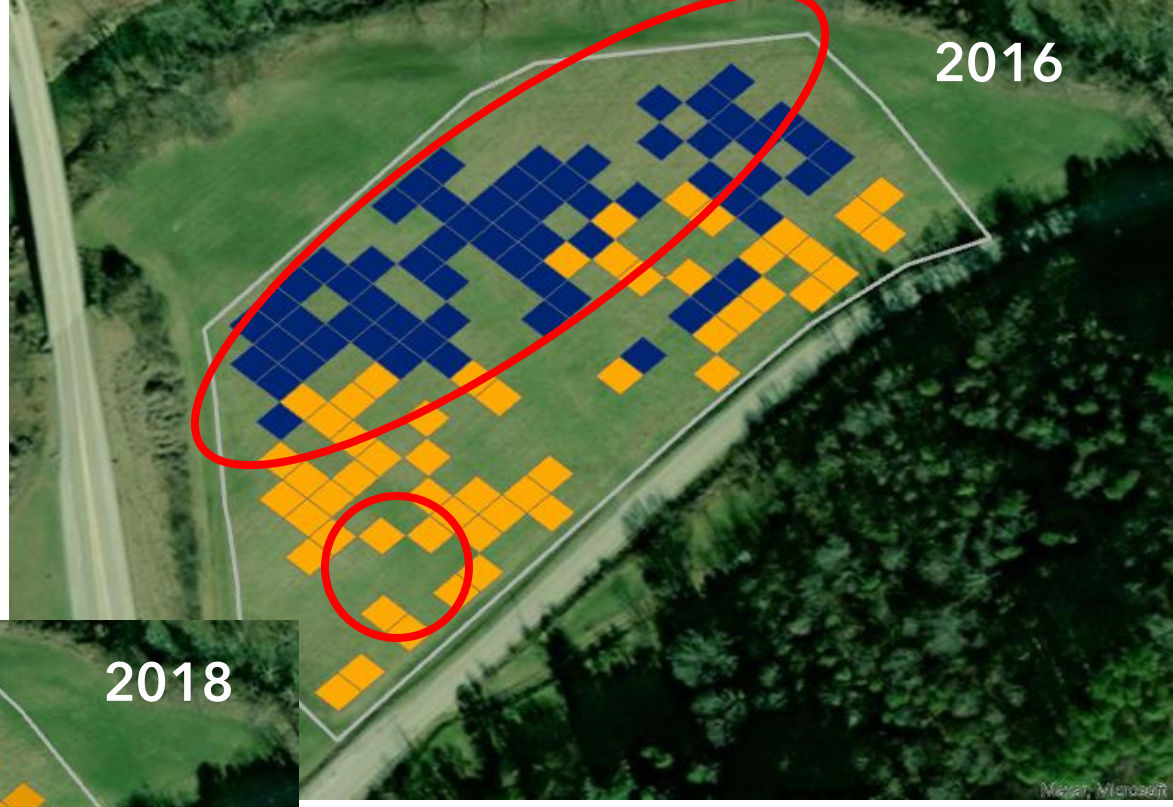
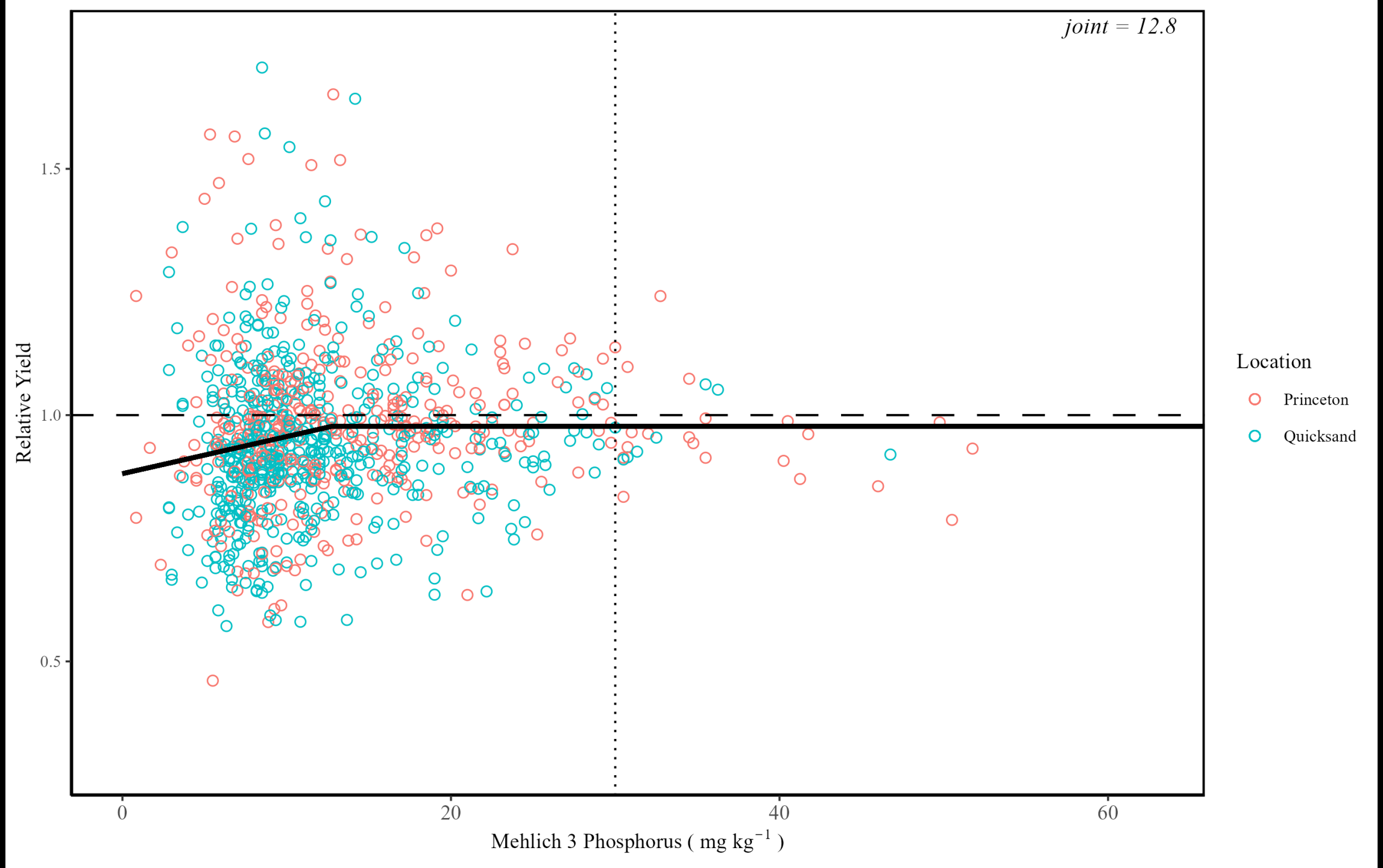
2020


2016

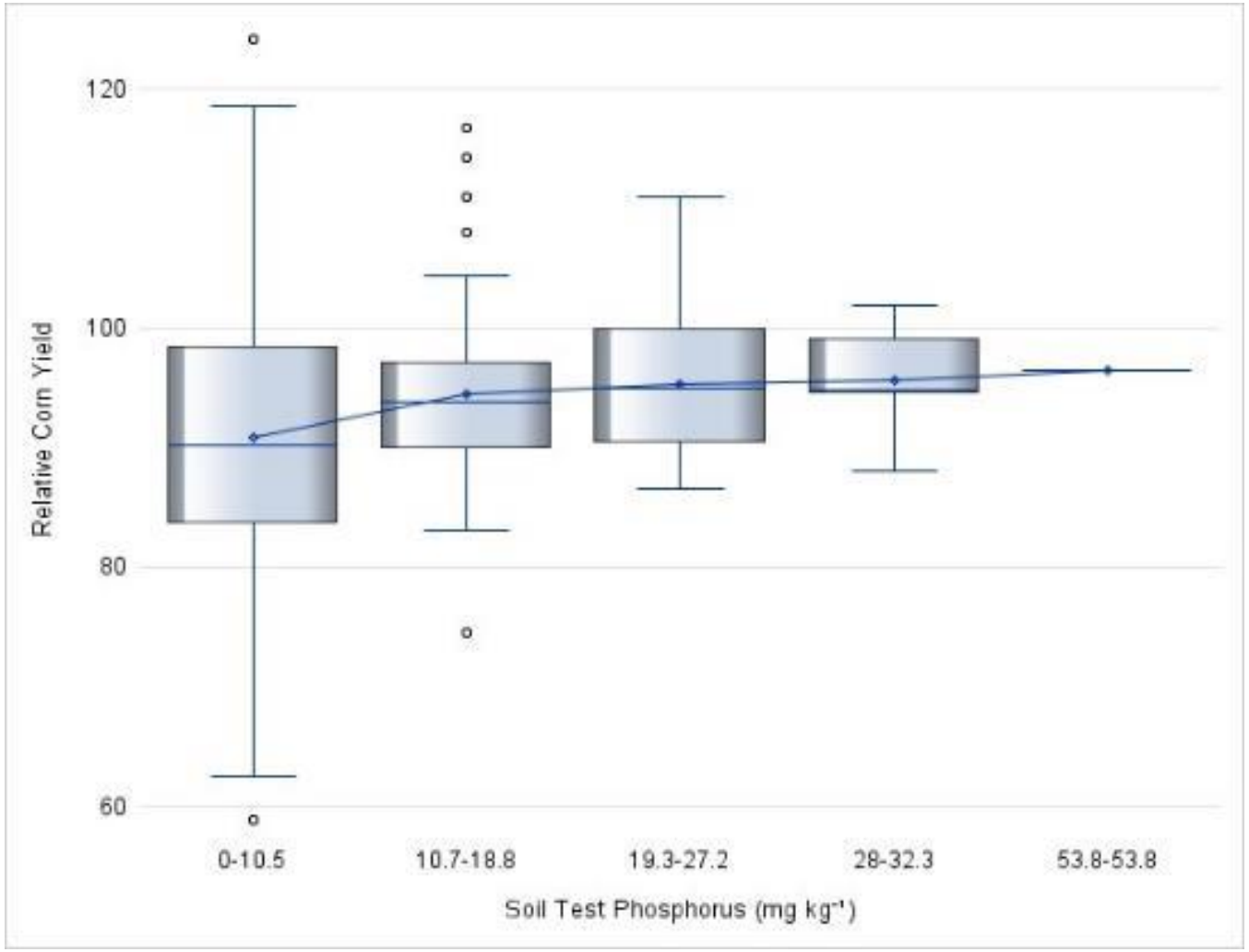

2018

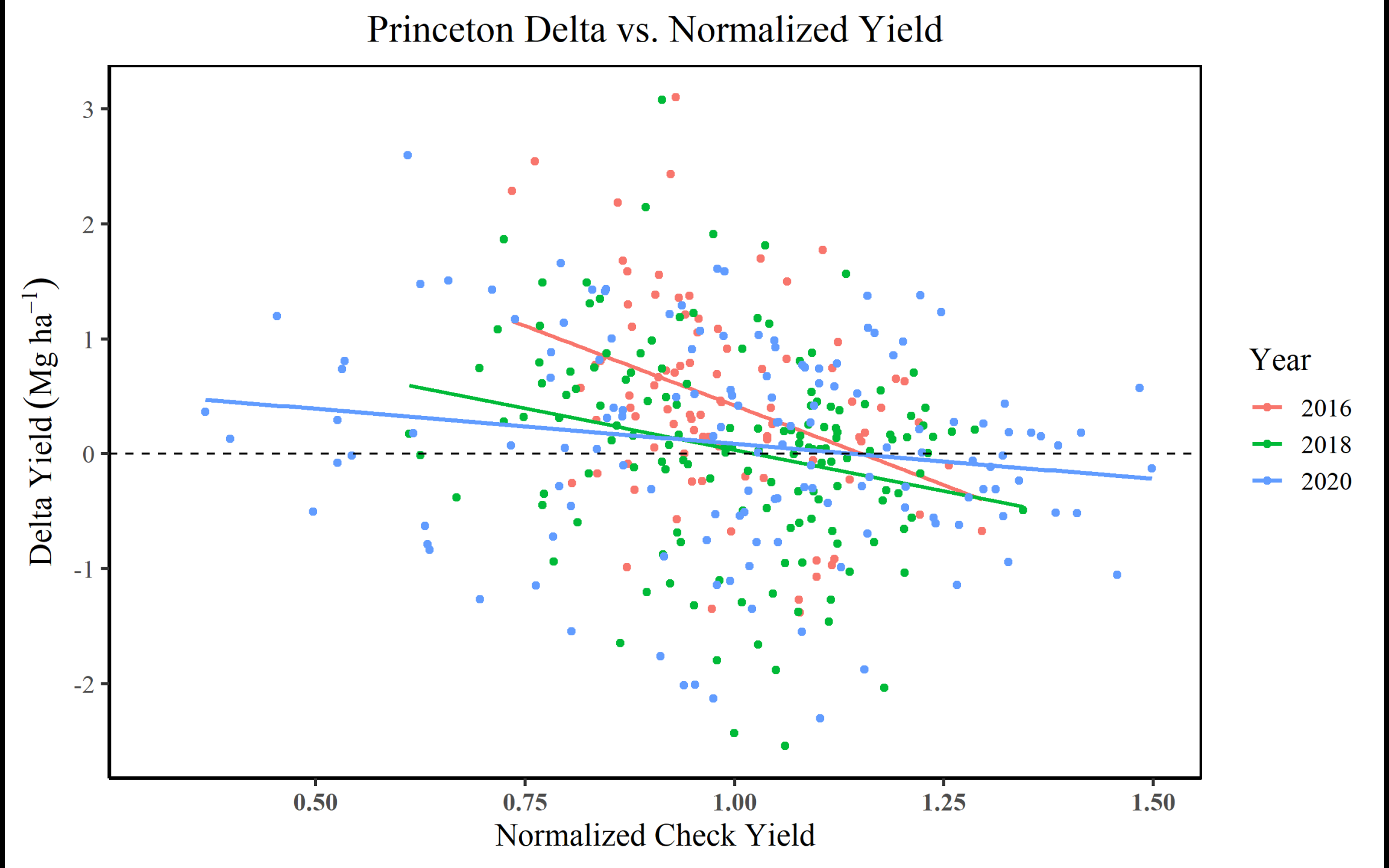

joint = 12.8
1.5
1.0
0.5
Relative Yield
0
20
40
60
Mehlich 3 Phosphorus (mg kg^{-1})
Location
Princeton
Quicksand

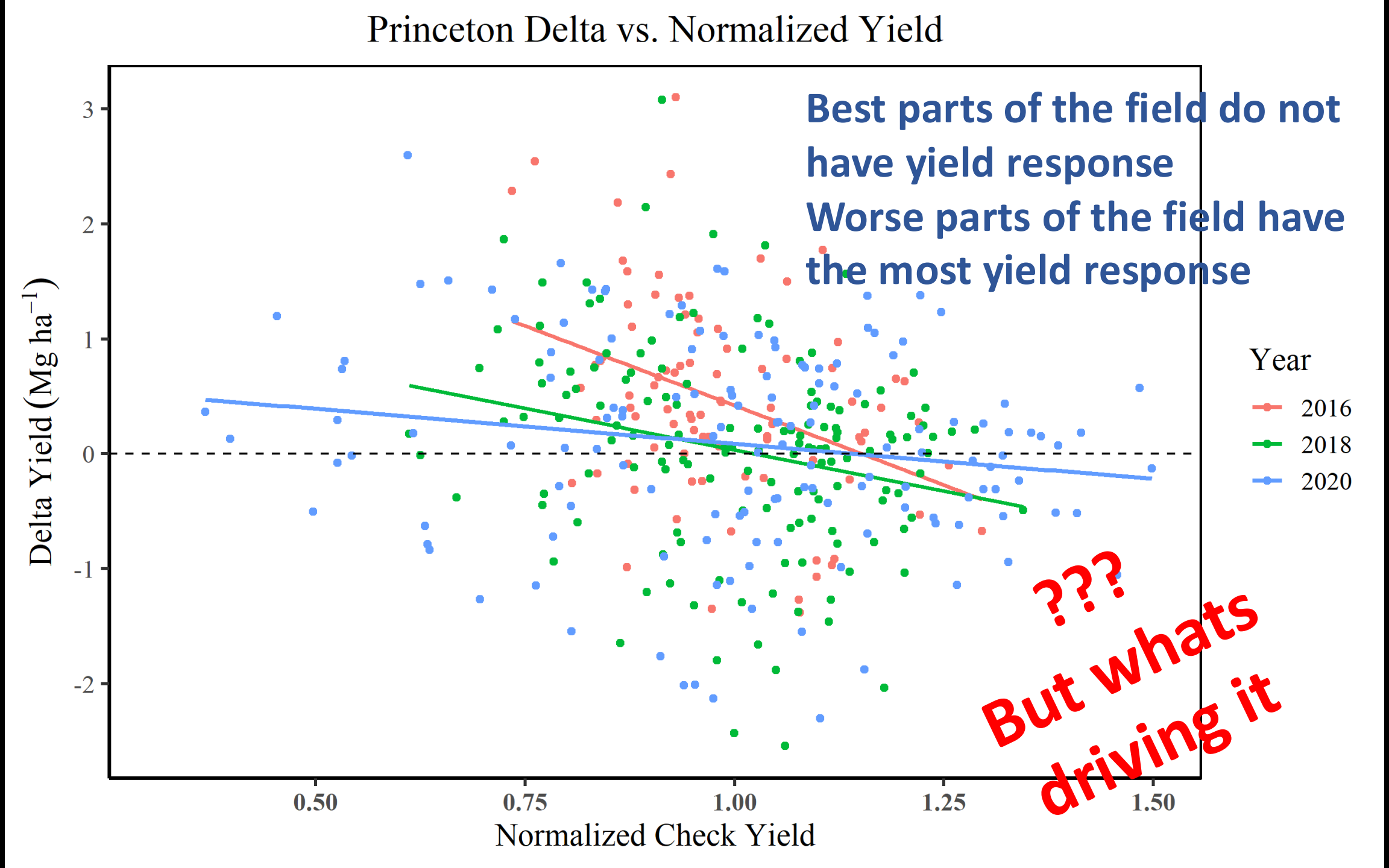
Variance decreases as soil P increases

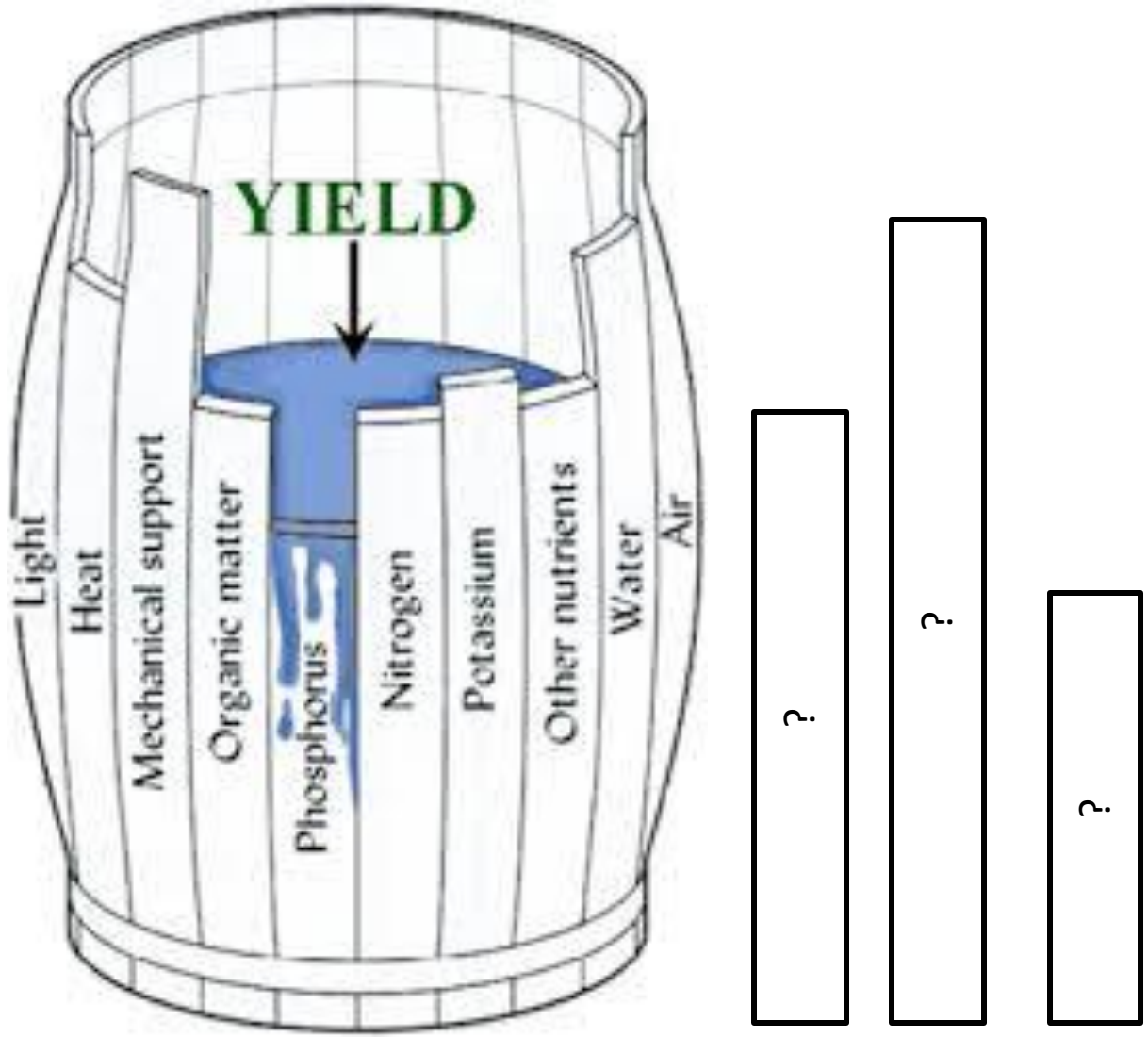
Above threshold doesn't mean no response…

Just less chance of it occurring




Princeton Delta vs. Normalized Yield
Delta Yield (Mg ha^{-1})
3
2
1
0
-1
-2
0.50
0.75
1.00
1.25
1.50
Normalized Check Yield
Year
2016
2018
2020


Princeton Delta vs. Normalized Yield
Best parts of the field do not have yield response
Worse parts of the field have the most yield response
???
But whats driving it
Delta Yield (Mg ha^{-1})
Normalized Check Yield
Year
2016
2018
2020
3
2
1
0
-1
-2
0.50
0.75
1.00
1.25
1.50

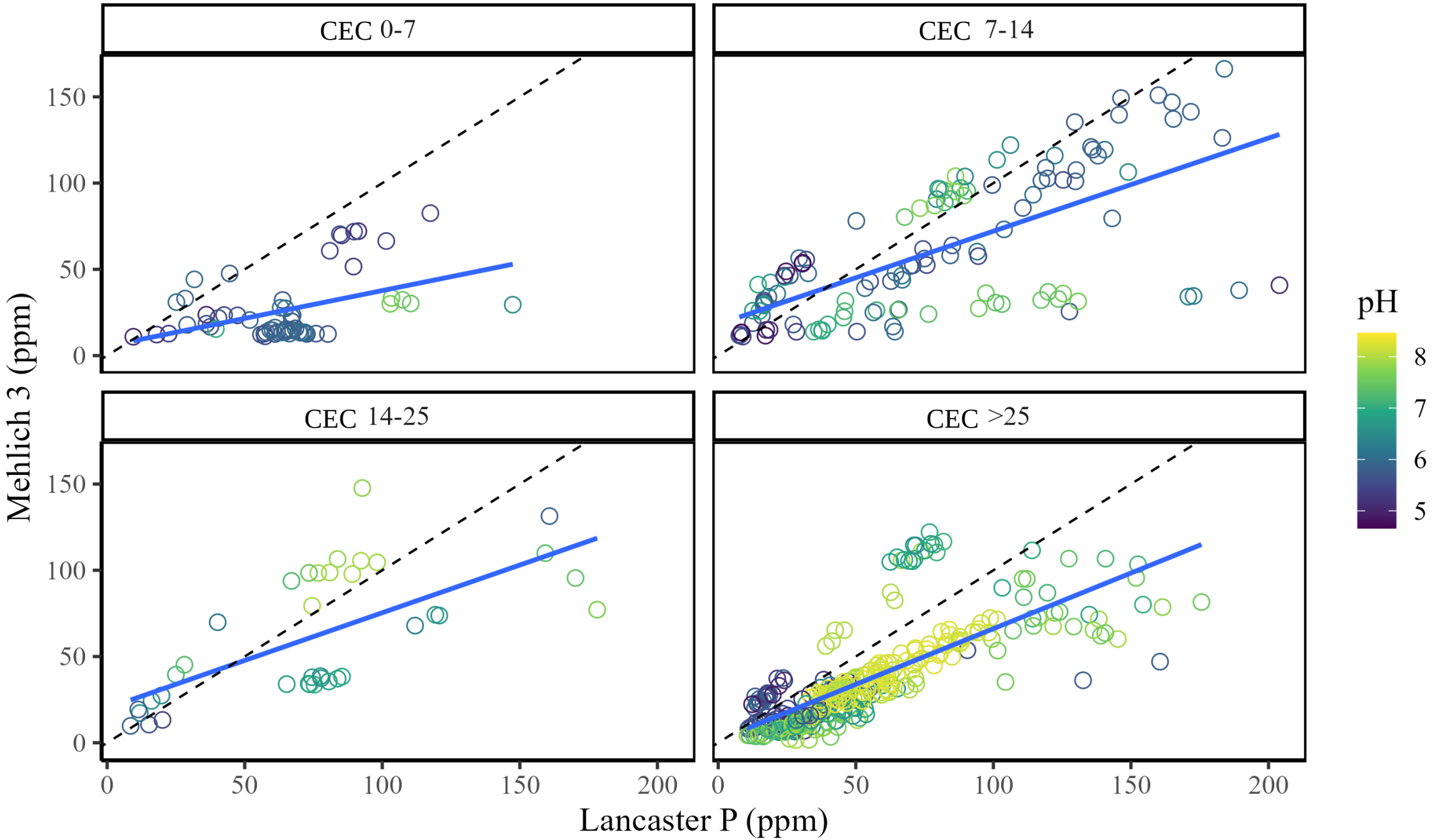

YIELD
Light
Heat
Mechanical support
Organic matter
Phosphorus
Nitrogen
Potassium
Other nutrients
Water
Air
?
?
?

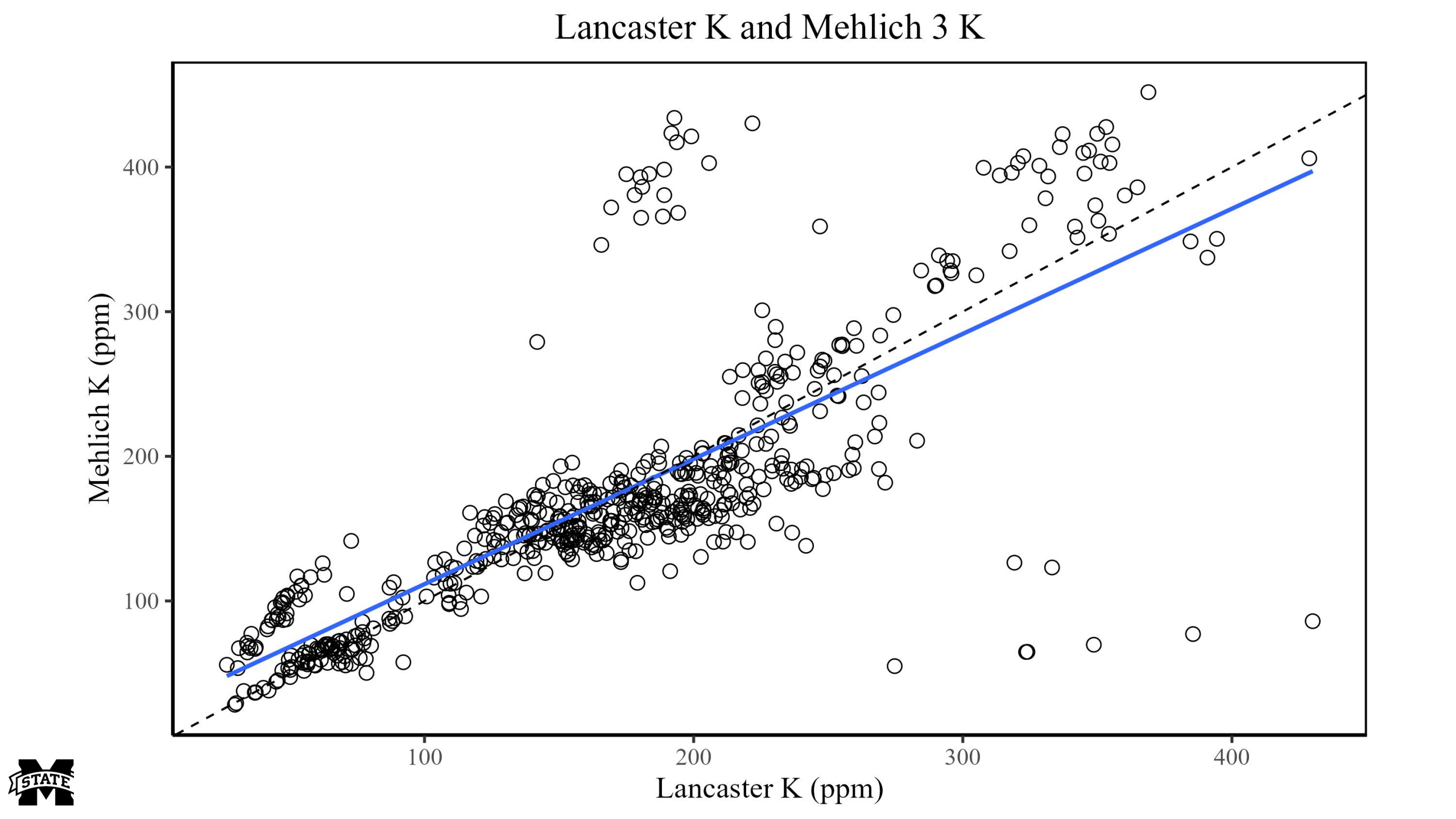
What are we doing about it?

Spatial Drivers of Yield Response

- Field long strips, looking for variance in nutrient response
- Soil sensors (Veris EC/OM, Geoprospector)
- Soil data every 30 ft
- Deep core soil sampling, based on depth, and stratification

Lancaster P and Mehlich 3 P




Lancaster K and Mehlich 3 K
Mehlich K (ppm)
400
300
200
100
100
200
300
400
Lancaster K (ppm)

FRST Decision Aid - Tool

frst.scinet.usda.gov/tool

Fertilizer Recommendation Support Tool

Home Tool Manual Feedback Funding Privacy Register Log

Soil Nutrient

Crop

States/Territories

Mapped Soil Series

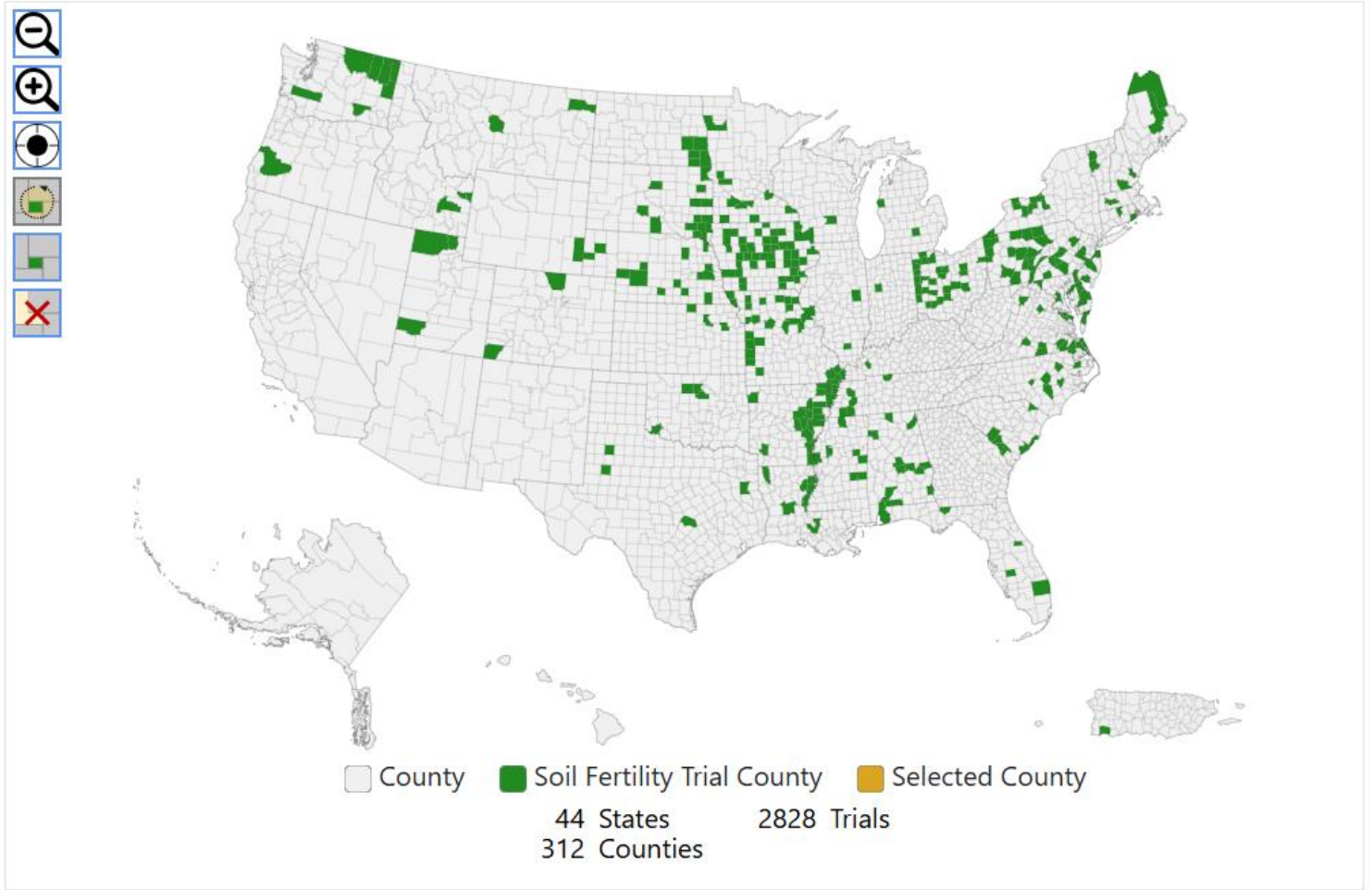
Years

From 1949 to 2023

Soil Sample Depths (in.)

Soil Test Method

Run Correlation



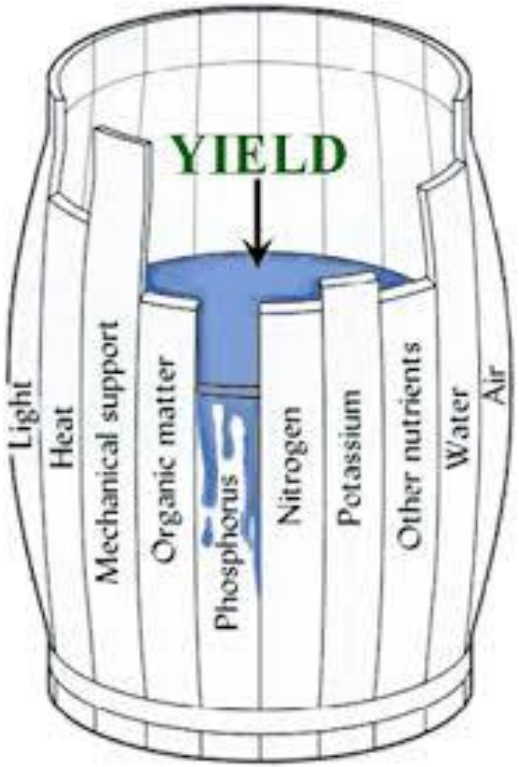
Frst.scinet.usda.gov/tool

Soil Fertility Team





What can YOU do?



Secondary/
Micronutrients

Nitrogen

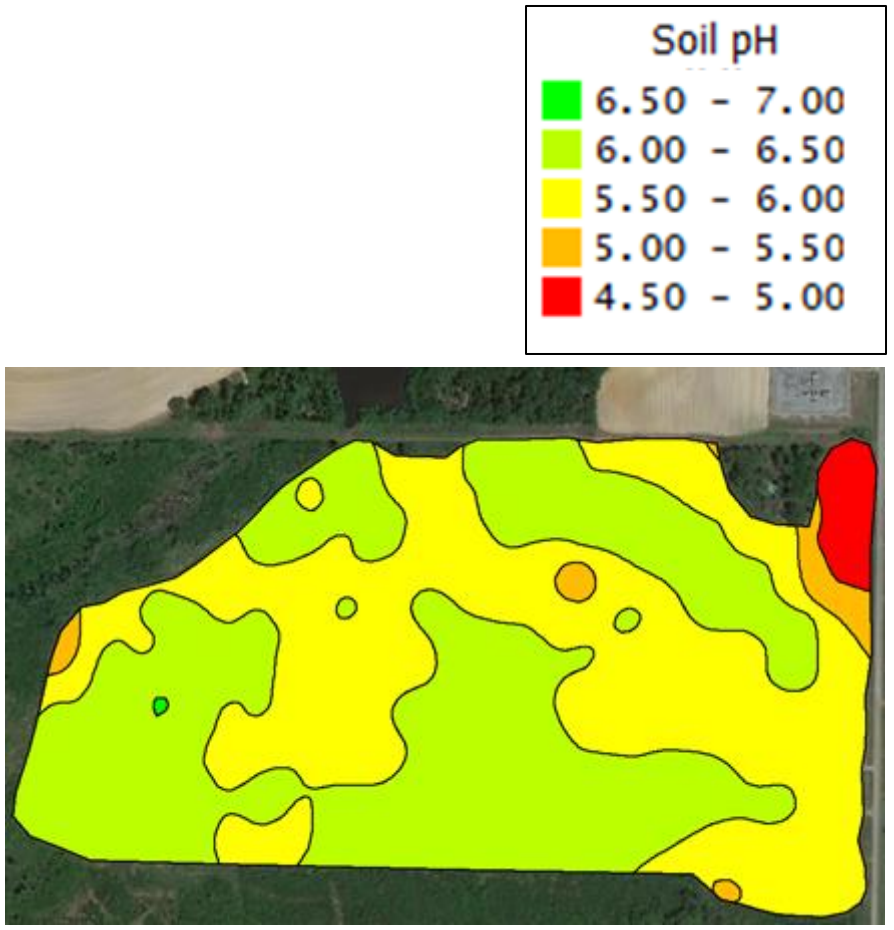
P & K

Soil pH

Soil Test

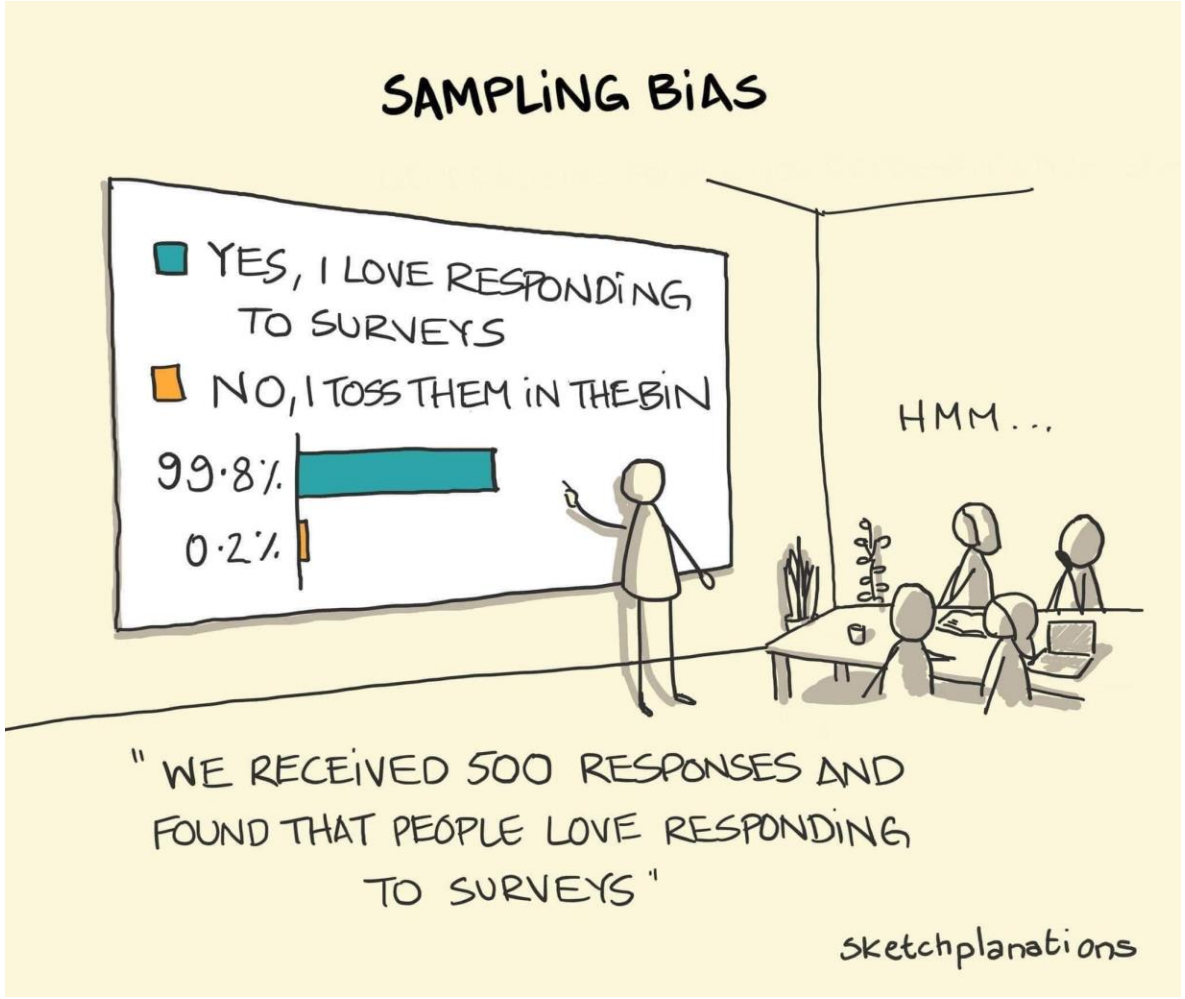
Data Compilation

- Looking for Grid Soil Sample Data
- I want as much as you are willing to share
  - Grid Size
  - Soil test values
  - County
- Shape Files!
- Send to vr401@msstate.edu
- Will NOT be added to national database!



What soil data will provide

- Survey of current status of regions soils
- Spatial Variability of Soils
- Impact of repeat applications
- Variance in sampling timings



Take Home

- Current recommendations are not perfect, but work
- We are working on it, making it better, and devising new ways to make recommendations, not only in Mississippi, but a NATIONAL effort
- Beware of silver bullets…

Questions?

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https://breakingdownsoilfertilitywithvaughnreed.wordpress.com/

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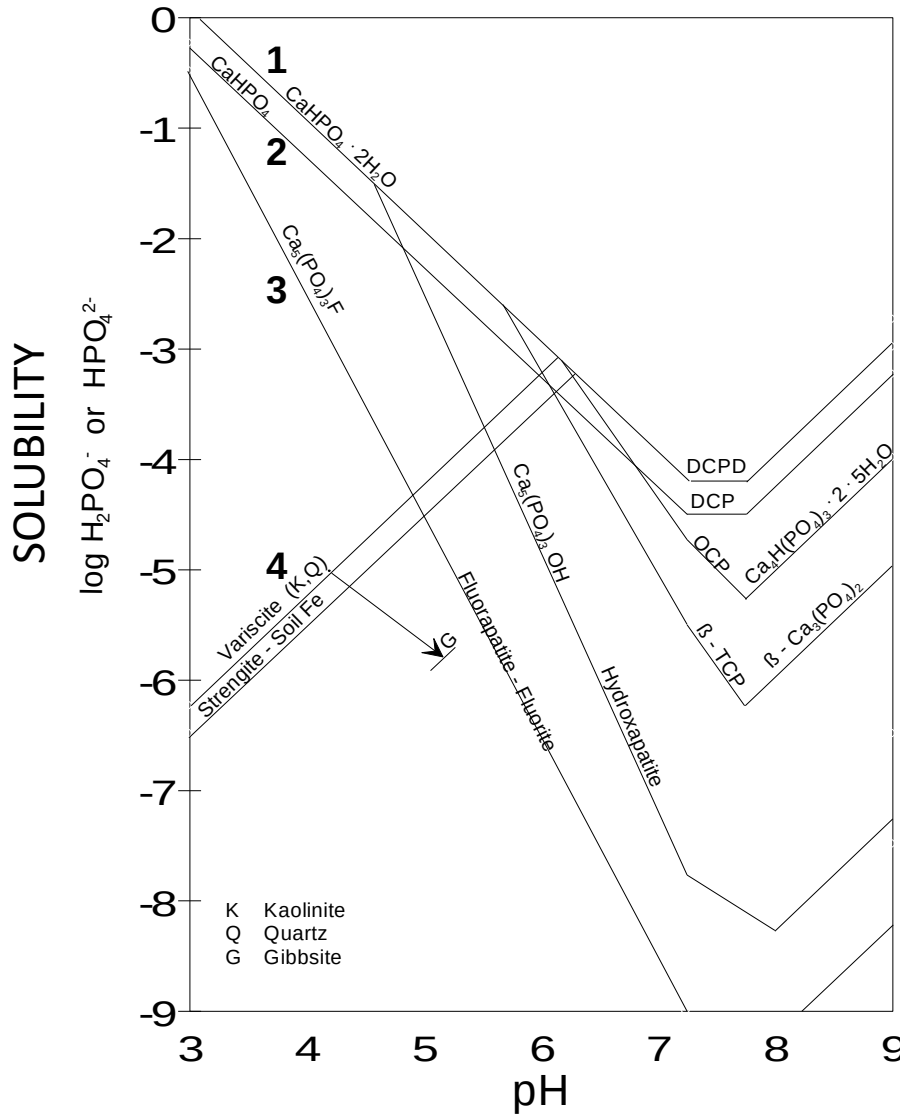
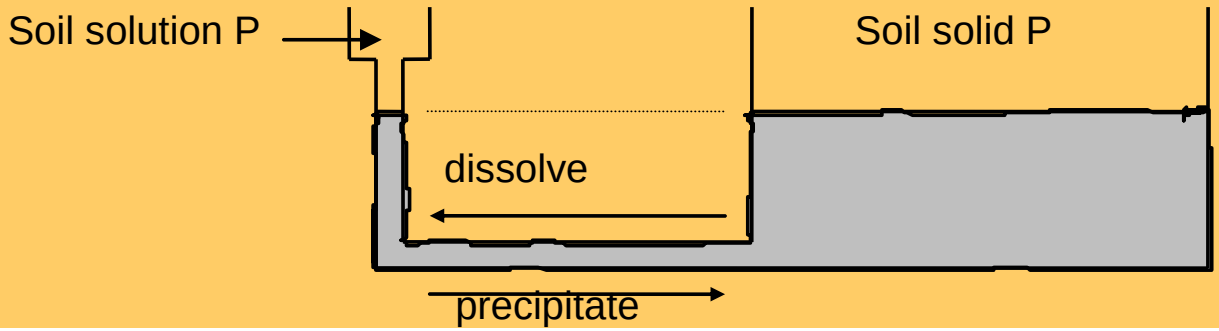
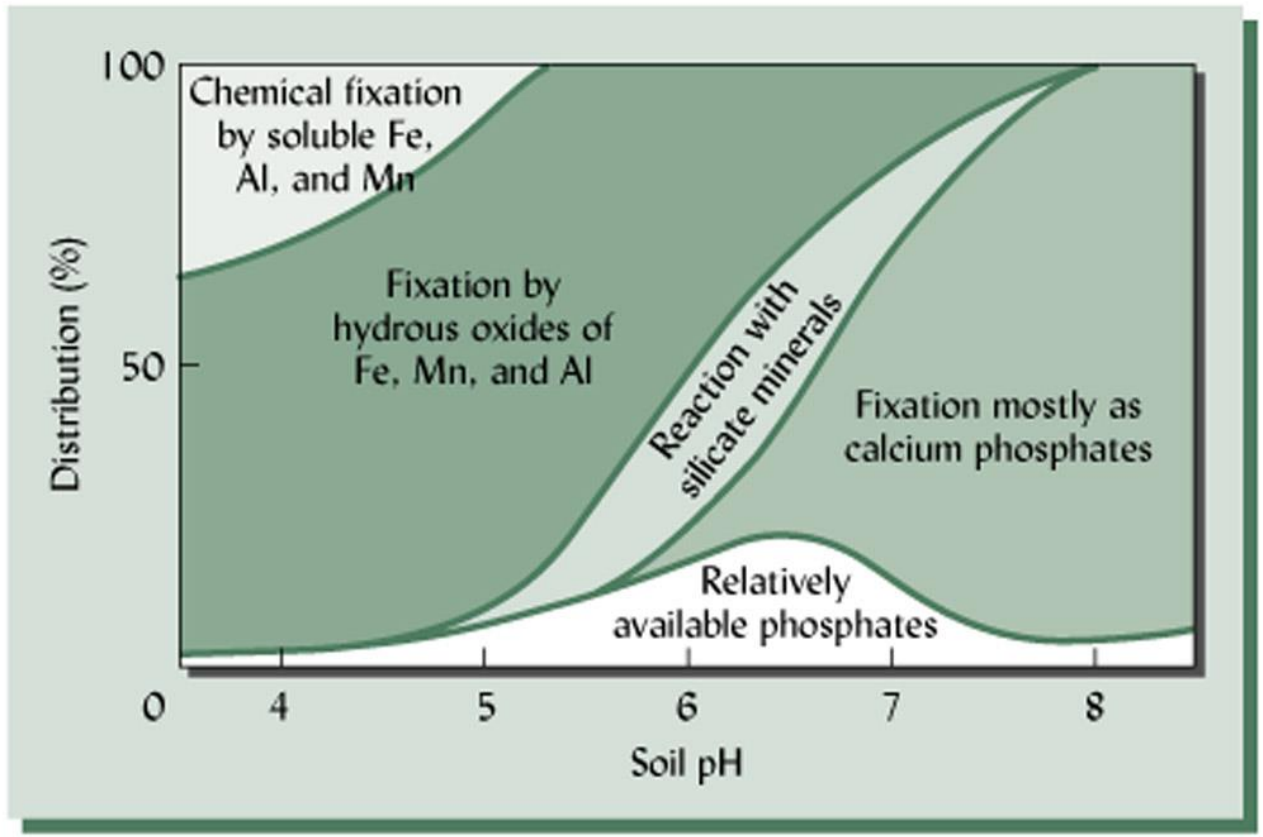
MS AGRICULTURAL AND FORESTRY EXPERIMENT STATION



Soil solution P ←==→ labile P ←==→ non - labile P

[intensity factor] [--------capacity factor ----------]




100
50
0
Distribution (%)
Chemical fixation by soluble Fe, Al, and Mn
Fixation by hydrous oxides of Fe, Mn, and Al
Reaction with silicate minerals
Fixation mostly as calcium phosphates
Relatively available phosphates
4
5
6
7
8
Soil pH