

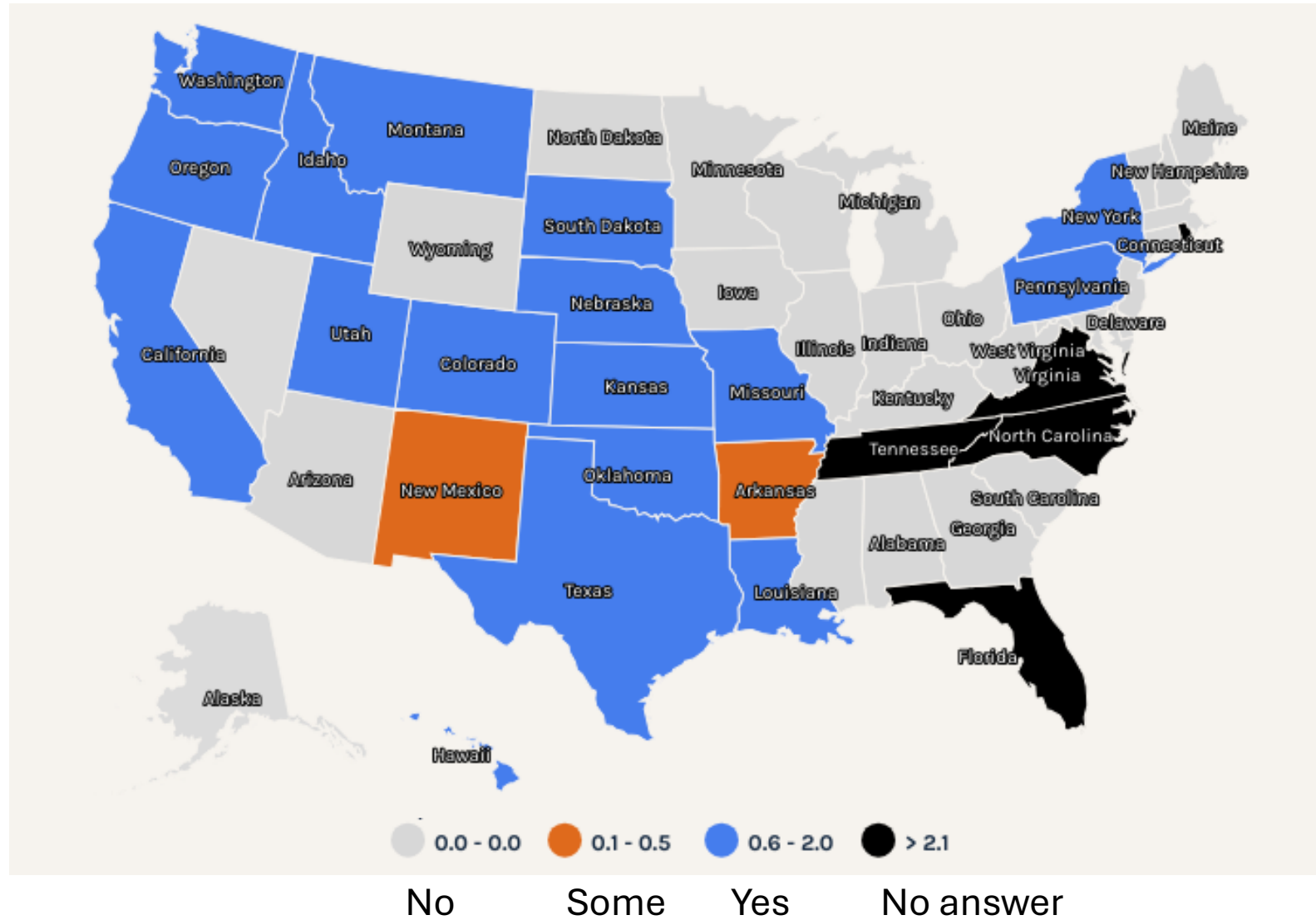
# **Sulfur FRST Committee Updates**

# Committee Members

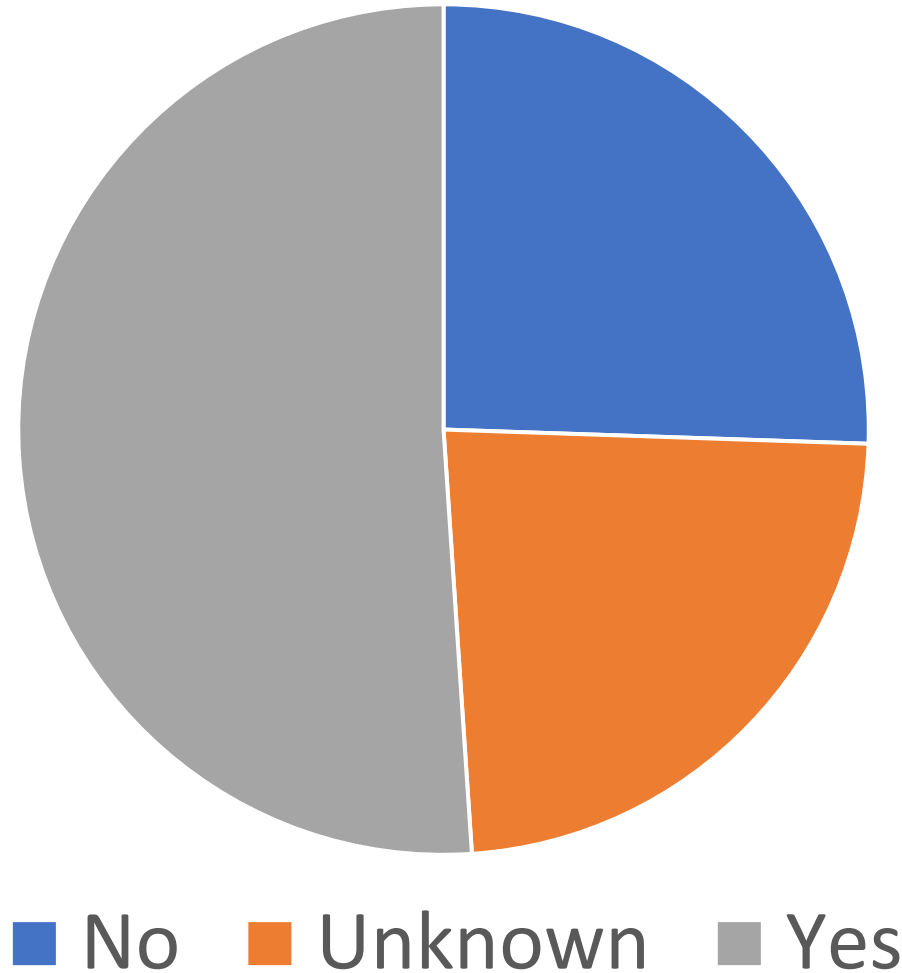
Region	Name
West	Matt Yost
	Clain Jones
	Jared Spackman
Midwest	Daniel Kaiser
	Jeff Volenec
	Brian Arnall
	Dorivar Ruiz Diaz
Northeast	Renuka Mathur
	John Spargo
	Deanna Osmond
Southeast	Nathan Slaton
	Gerson Drescher
Industry	Ron Olsen



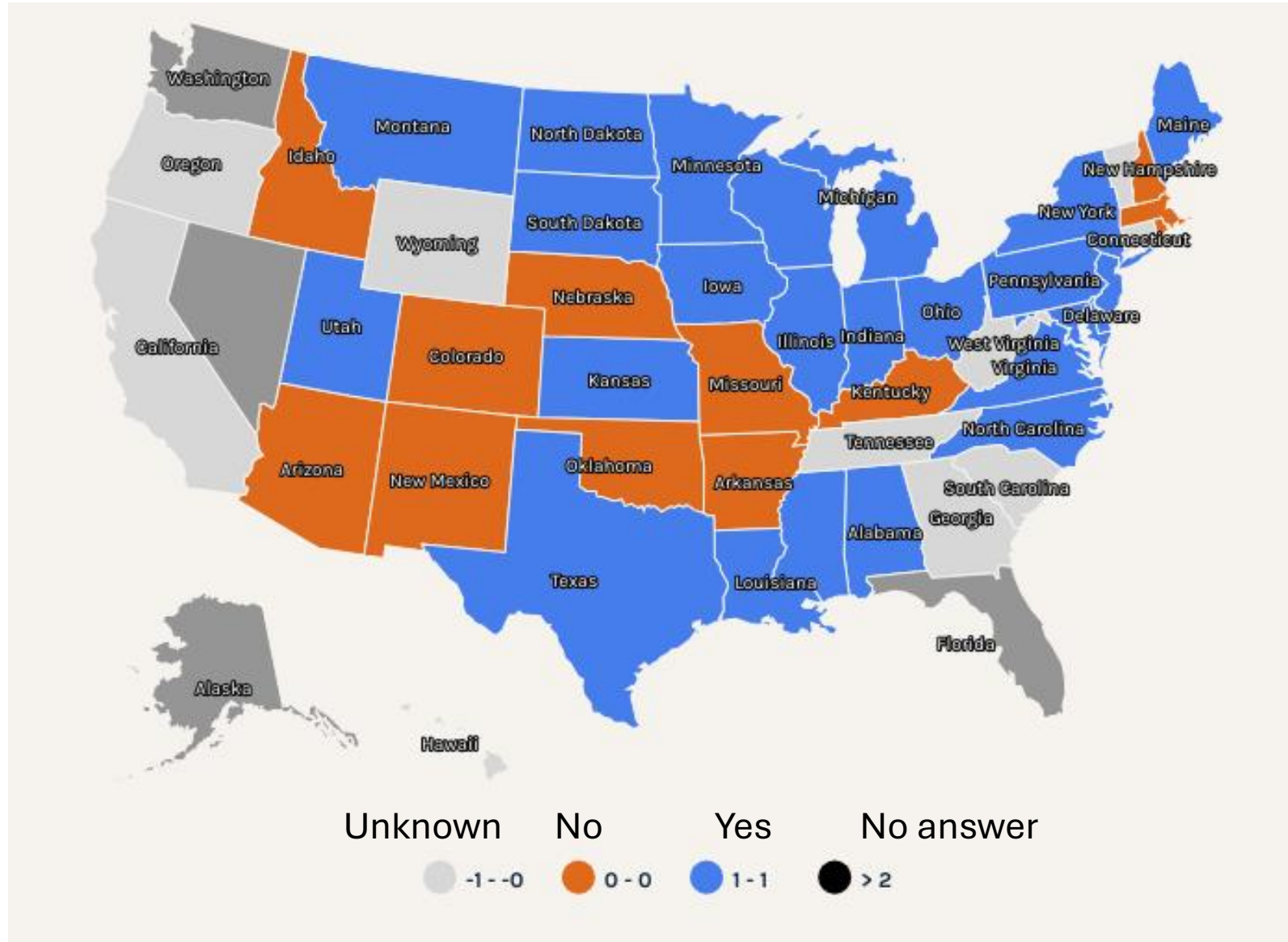
# Do you use soil test S in recommendations?



Has sulfur deficiency become more common in your state over the last ten years?



# Has sulfur deficiency become more common in your state over the last ten years?



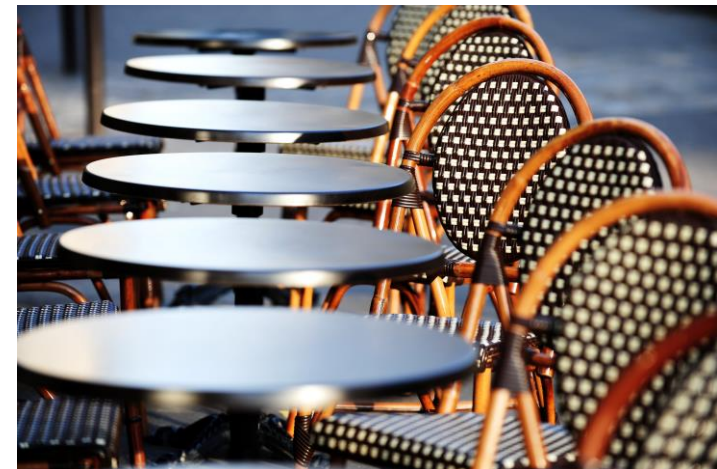
State	Extractant	Depth (inches)	CSTV
California	Hot Water		
Colorado		4	10
Hawaii	AB-DTPA	6	
Idaho	Hot Water	12	10
Kansas	Ca(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>	24	
Louisiana	Mehlich-3		12
Minnesota	Ca(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>		
Missouri			6
Montana			
Nebraska			9
New Mexico		12	
New York	CaCl <sub>2</sub> (or SrCl <sub>2</sub> )		
North Carolina	Mehlich-3		12
Oklahoma			1/10 of N - soil sulfate
Oregon	Ca(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>	6	
Pennsylvania	Mehlich-3		15
South Carolina		6-8	10
South Dakota	Ca(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>	24	
Texas	Mehlich-3	6	
Utah	Ca(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>	12	8
Washington	Saturated paste		

# Extractants

- $\text{NH}_4\text{OAc}$
- $\text{KH}_2\text{PO}_4$
- $\text{Ca}(\text{H}_2\text{PO}_4)_2$
- $\text{CaCl}_2$
- Morgan
- Mehlich-3
- Hot water
- Saturated paste

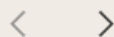
# Measurements

- ICP-AES  
(organic and inorganic S)
- Turbimetric  
Spectrophotometer at 420 nm  
(inorganic S)



# Task 1: MDS approval

	A	B	C
1	FRST Data Submission Template Version 3.30.21		
2	Contact: Deanna Osmond dosmond@ncsu.edu		
3	<b>Instructions</b>		
4	All value units are indicated in the column headings. All are in SI units.		
5	Only one study per Data Submission Template. One study may have multiple individual trials.		
6	P and K trials must be entered separately. If a trial has both P and K treatment rates, enter them as two separate trials with unique trial IDs. Each must contain a control (0 kg/ha) rate.		
7	If a single-year trial has multiple crops, enter each crop as a separate trial with a unique trial ID. Multi-year rotation studies with multiple crops may have the same trial ID for different years.		
8	If you have treatments in addition to the nutrient of interest (for example, different tillage practices at each nutrient rate), enter each additional treatment as a separate trial with a unique trial ID		
9	If multiple soil depths, soil analyses, plant tissues, or plant component yields were measured for a single trial, enter in separate rows with the same trial ID		
10	For multi-year trials, use one trial ID for each trial with separate rows for each year on all tabs except for the User & Publication Information tab. Each year of the study must have it's own row.		
11	Required fields are highlighted in yellow		
12	Items with drop-down options are shaded	Please contact us if you have suggested additions to drop-down lists.	
13	<i>Items that still need attention have notes in red</i>		
14			
15	<b>Data Dictionary</b>		
16		<i>Required or Recommended by FRST Minimum Dataset</i>	<i>Description</i>
17	<b>User &amp; Publication Information</b>		
18	Last Name	Required	Last name of corresponding author or main point of contact
19	First Name	Required	First name of corresponding author or main point of contact
20	Middle Name	Recommended	Middle name of corresponding author or main point of contact
21	Role in Study	Required	Role in Study of main point of contact
22	Organization	Required	Organization of corresponding author or main point of contact
23	Department	Recommended	Department of corresponding author or main point of contact
24	Entered by (if different from A)	Recommended	Person who entered the data into the FRST database if different from column A
25	Contact Email	Required	Email of corresponding author or main point of contact
26	Year Published (YYYY)	Required (if published)	The year of the publication (if published)
27	Publication DOI	Required (if published)	DOI of publication (if published and available)
28	Full Citation	Required (if published)	Full citation of publication/study (if published)
29			
30	<b>Trial Information</b>		
31	Trial ID	Required	ID given to the individual trial by the researcher. This could be any value to identify an individual trial within a study.
32	Nutrient of Interest	Required	The nutrient of interest. Either P or K.
33	Country	Required	Country where the trial took place (ISO country code)
34	State	Required	The state in which the trial took place
35	Nearest City	Recommended	The nearest city to where the trial took place.
36	County	Required	The county in which the trial took place.
37	Latitude (decimal degrees)	Recommended	Latitude of the trial location
38	Longitude (decimal degrees)	Recommended	Longitude of the trial location
39	Nearest NOAA Weather Station ID	Required	NameID for the closest National Weather Service station. Please visit <a href="https://www.weather.gov/NWR/station_listing">https://www.weather.gov/NWR/station_listing</a> to view stations by state.
40	Weather Station Latitude (decimal degrees)	Recommended	Latitude of weather station, decimal degrees



Instructions & Data Dictionary

User & Publication Information

Trial ... + :



# Task 1: MDS approval

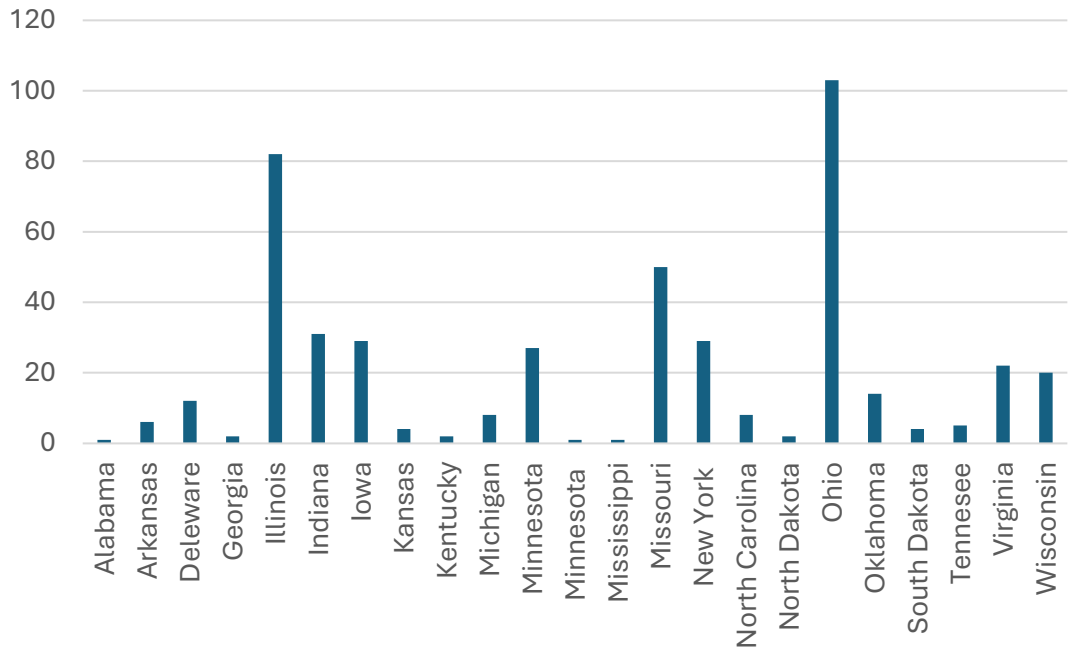
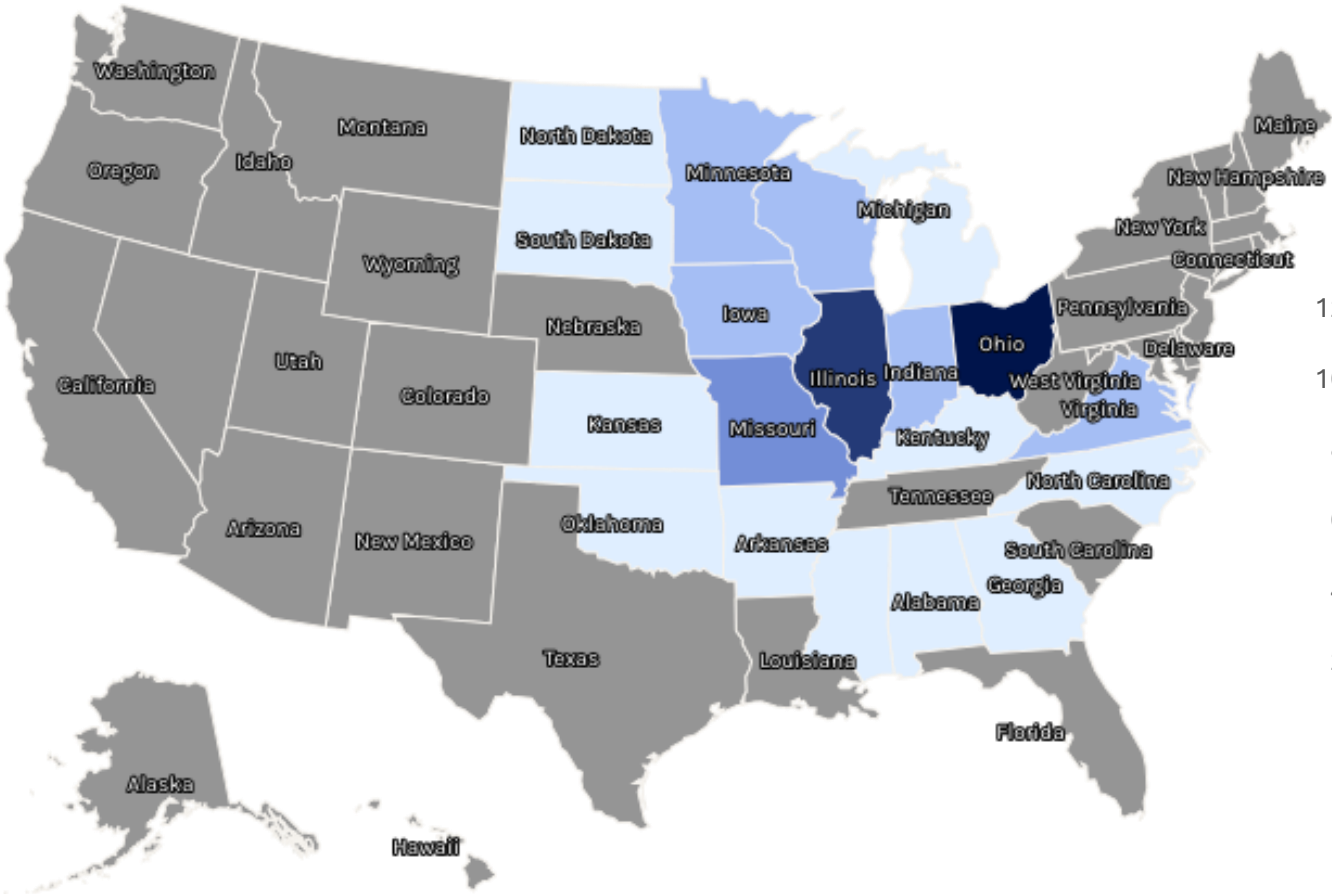
- **Fertilizer source**
- Sulfur incorporation depth
- **S concentrations in irrigation water**
- Soil series or GPS coordinates
  - **Soil texture** (measured or from NRCS)

# Task 2: Build database & assess utility

- 505 site-years to date
- Need to finalize MDS and then update collection

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	Authors	Year	Site Name	City	State	GPS	Crop	Previous Crop	crop rotation	Irrigated	Reps	conc. (mg kg <sup>-1</sup> )	Timing	Depth (cm)	ry method	Extraction	extraction citatic	OM (g kg <sup>-1</sup> )	Soil Series	Soil texture	Sanc	Silt	Clay
2	Kaur et al., 2019	2016	Absaraka			46 58'42.6" N 97 25'20.3" W	Corn	Soybean	C-S	No	4	16	Preplant	15	40C	Ca(H2PO4)2 + BaCl7	<a href="#">Combs et al., 1998</a>	49	Glyndon	Silt loam	52	38	10
3	Kaur et al., 2019	2016	Adal			47 18'53.8" N 96 24'31.8" W	Corn	Wheat	C-W	No	4	18	Preplant	15	40C	Ca(H2PO4)2 + BaCl6	<a href="#">Combs et al., 1998</a>	31	Wheatville	Loam	61	31	8.6
4	Kaur et al., 2019	2016	Downer I			46 48'06.2" N 96 32'52.1" W	Corn	Soybean	C-S	No	4	19	Preplant	15	40C	Ca(H2PO4)2 + BaCl5	<a href="#">Combs et al., 1998</a>	38	Elmville	Sandy loam	60	22	18
5	Kaur et al., 2019	2016	Gardner			47 09'55.3" N 97 03'14.9" W	Corn	Soybean	C-S	No	4	11	Preplant	15	40C	Ca(H2PO4)2 + BaCl4	<a href="#">Combs et al., 1998</a>	46	Fargo	Silty clay loam	29	42	30
6	Kaur et al., 2019	2016	Walcott I			46 31'45.2" N 96 54'14.3" W	Corn	Soybean	C-S	No	4	14	Preplant	15	40C	Ca(H2PO4)2 + BaCl3	<a href="#">Combs et al., 1998</a>	42	Fargo	Silty clay	16	44	40
7	Kaur et al., 2019	2017	Adal II			47 21'20.5" N 96 25'43.0" W	Corn	Soybean	C-S	No	4	16	Preplant	15	40C	Ca(H2PO4)2 + BaCl2	<a href="#">Combs et al., 1998</a>	31	Augsburg	Loam	59	23	18
8	Kaur et al., 2019	2017	Amenia			46 59'05.5" N 97 14'26.4" W	Corn	Soybean	C-S	No	4	10	Preplant	15	40C	Ca(H2PO4)2 + BaCl1	<a href="#">Combs et al., 1998</a>	36	Glyndon-Tiffany	Silt loam	29	59	12
9	Kaur et al., 2019	2017	Casselton			46 56'53.8" N 97 12'10.5" W	Corn	Soybean	C-S	No	4	7	Preplant	15	40C	Ca(H2PO4)2 + BaCl0	<a href="#">Combs et al., 1998</a>	46	Bearden	Silty clay loam	25	43	33
10	Kaur et al., 2019	2017	Downer II			46 51'55.8" N 96 30'55.0" W	Corn	Soybean	C-S	No	4	15	Preplant	15	40C	Ca(H2PO4)2 + BaCl1	<a href="#">Combs et al., 1998</a>	33	Lamoure	Silt loam	27	58	16
11	Kaur et al., 2019	2017	Walcott II			46 31'05.5" N 96 52'24.1" W	Corn	Soybean	C-S	No	4	13	Preplant	15	40C	Ca(H2PO4)2 + BaCl2	<a href="#">Combs et al., 1998</a>	46	Wheatville	Silt loam	31	56	13
12	Canon et al., 2021	2015		Milan	TN	35.9198° N, 88.7589° W	Corn	Soybean	C-S	No	6	3.3 ppm	Preplant	15		Mehlich-3 extraction	Mehlich, A. (1984), Mehlich 3 so		Collins	Silt Loam			
13	Canon et al., 2021	2015		Milan	TN	35.9198° N, 88.7589° W	Soybean	Corn	C-S	No	6	4.5 ppm	Preplant	15		Mehlich-3 extraction	Mehlich, A. (1984), Mehlich 3 so		Collins	Silt Loam			
14	Canon et al., 2021	2016		Milan	TN	35.9198° N, 88.7589° W	Corn	Soybean	C-S	No	6	10 ppm	Preplant	61		Mehlich-3 extraction	Mehlich, A. (1984), Mehlich 3 so		Collins	Silt Loam			
15	Canon et al., 2021	2016		Milan	TN	35.9198° N, 88.7589° W	Soybean	Corn	C-S	No	6	8.5 ppm	Preplant	61		Mehlich-3 extraction	Mehlich, A. (1984), Mehlich 3 so		Collins	Silt Loam			
16	Boubakry et al., 2023	2020-2022		Milan	TN	35 56 06.8" N, 88 45 13.2" W	Corn			No	4	3.2	Preplant	15				5.24	Loring	Silt loam	230	500	210
17	Boubakry et al., 2023	2020-2022		Barton	AL	34 44 35.2" N, 87 54 02.4" W	Corn			No	4	2.2	Preplant	15				7.34	Rhodic Paleudult	Silt loam	310	500	190
18	Stecker et al., 1995	1991	B53		MO		Corn			Yes	6	7	Preplant	15		Ca(H2PO4)2 + BaCl2	<a href="#">Brown and Bodrig</a>	8		fine sandy loam			
19	Stecker et al., 1995	1991	B54		MO		Corn			No	6	9.3	Preplant	15		Ca(H2PO4)2 + BaCl3	<a href="#">Brown and Bodrig</a>	24		sandy loam			
20	Stecker et al., 1995	1991	B55		MO		Corn			Yes	6	0.8	Preplant	15		Ca(H2PO4)2 + BaCl4	<a href="#">Brown and Bodrig</a>	16		Silt loam			
21	Stecker et al., 1995	1991	B56		MO		Corn			Yes	6	6.3	Preplant	15		Ca(H2PO4)2 + BaCl5	<a href="#">Brown and Bodrig</a>	16		Silt loam			
22	Stecker et al., 1995	1991	C33		MO		Corn			Yes	6	5.3	Preplant	15		Ca(H2PO4)2 + BaCl6	<a href="#">Brown and Bodrig</a>	22		Silt loam			
23	Stecker et al., 1995	1991	C34		MO		Corn			No	6	5.8	Preplant	15		Ca(H2PO4)2 + BaCl7	<a href="#">Brown and Bodrig</a>	17		Silt loam			
24	Stecker et al., 1995	1991	C33		MO		Corn			Yes	6	4.2	Preplant	15		Ca(H2PO4)2 + BaCl8	<a href="#">Brown and Bodrig</a>	18		Silt loam			
25	Stecker et al., 1995	1991	C40		MO		Corn			No	6	5.8	Preplant	15		Ca(H2PO4)2 + BaCl9	<a href="#">Brown and Bodrig</a>	24		Silt loam			
26	Stecker et al., 1995	1991	C41		MO		Corn			No	6	2.1	Preplant	15		Ca(H2PO4)2 + BaCl10	<a href="#">Brown and Bodrig</a>	17		Silt loam			
27	Stecker et al., 1995	1991	C42		MO		Corn			No	6	2.5	Preplant	15		Ca(H2PO4)2 + BaCl11	<a href="#">Brown and Bodrig</a>	23		clay loam			
28	Stecker et al., 1995	1991	C43		MO		Corn			Yes	6	4.1	Preplant	15		Ca(H2PO4)2 + BaCl12	<a href="#">Brown and Bodrig</a>	18		Silt loam			
29	Stecker et al., 1995	1991	E35		MO		Corn			No	6	6	Preplant	15		Ca(H2PO4)2 + BaCl13	<a href="#">Brown and Bodrig</a>	18		1			
30	Stecker et al., 1995	1991	E36		MO		Corn			No	6	6	Preplant	15		Ca(H2PO4)2 + BaCl14	<a href="#">Brown and Bodrig</a>	39		silty clay loam			
31	Stecker et al., 1995	1991	E50		MO		Corn			No	6	5.3	Preplant	15		Ca(H2PO4)2 + BaCl15	<a href="#">Brown and Bodrig</a>	23		silt loam			
32	Stecker et al., 1995	1991	E51		MO		Corn			No	6	6.5	Preplant	15		Ca(H2PO4)2 + BaCl16	<a href="#">Brown and Bodrig</a>	25		silt loam			
33	Stecker et al., 1995	1991	N45		MO		Corn			No	6	5.6	Preplant	15		Ca(H2PO4)2 + BaCl17	<a href="#">Brown and Bodrig</a>	9		silt loam			
34	Stecker et al., 1995	1991	N57		MO		Corn			No	6		Preplant	15		Ca(H2PO4)2 + BaCl18	<a href="#">Brown and Bodrig</a>	0		silt loam			

# Task 2: Expand geographic coverage



● < 17  
 ● 18 - 34  
 ● 35 - 51  
 ● 52 - 68  
 ● 69 - 85  
 ● > 86

# Task 2: Large datasets

Site-Yrs	Crop	Authors	Year	State(s)
16	Alfalfa	Ketterings et al., 2012	2008	NY
28	Corn	Camberato et al., 2023	2017	IN
49	Corn	Fleuridor et al., 2023	2013	OH
50	Corn	Stecker et al., 1995	1991	MO
82	Corn	Hoefl et al., 1995	1977	IL
27	Soybean	Almeida et al., 2023	2021	AK, IA, IN, KS, MI, MN, NC, ND, OH, SD, VA, WI
34	Soybean	Fleuridor et al., 2023	2013	OH
51	Soybean	Brooks et al., 2022	2019	AK, KT, MI, MN, MI, NC, OH, SD, VA, WI
12	Wheat	Fleuridor et al., 2023	2014	OH
14	Wheat	K. Girma et al. 2005	1996	OK

# Task 2: Outputs

**Manuscript 1** – Evaluate the extraction/analysis methods and STS vs. Yield response to determine validity and site specificity of using STS.

**Manuscript 2** – How does STS approach (CSTV) compare to other approaches:

- Yield-goal based like N
- Soil texture/OM categories
- Hybrid approach

# Task 2.5

Start incorporating S into FRST database using the literature review database to ingest a large chunk of legacy data.

# Task 3: Survey of national S levels

Survey of STS levels across the country. Request soil S tests from major labs and assess whether soil S is declining over time and how it varies spatially.

## SUMMARY UPDATE

### *Soil Test Levels in North America*

By P.E. Fixen

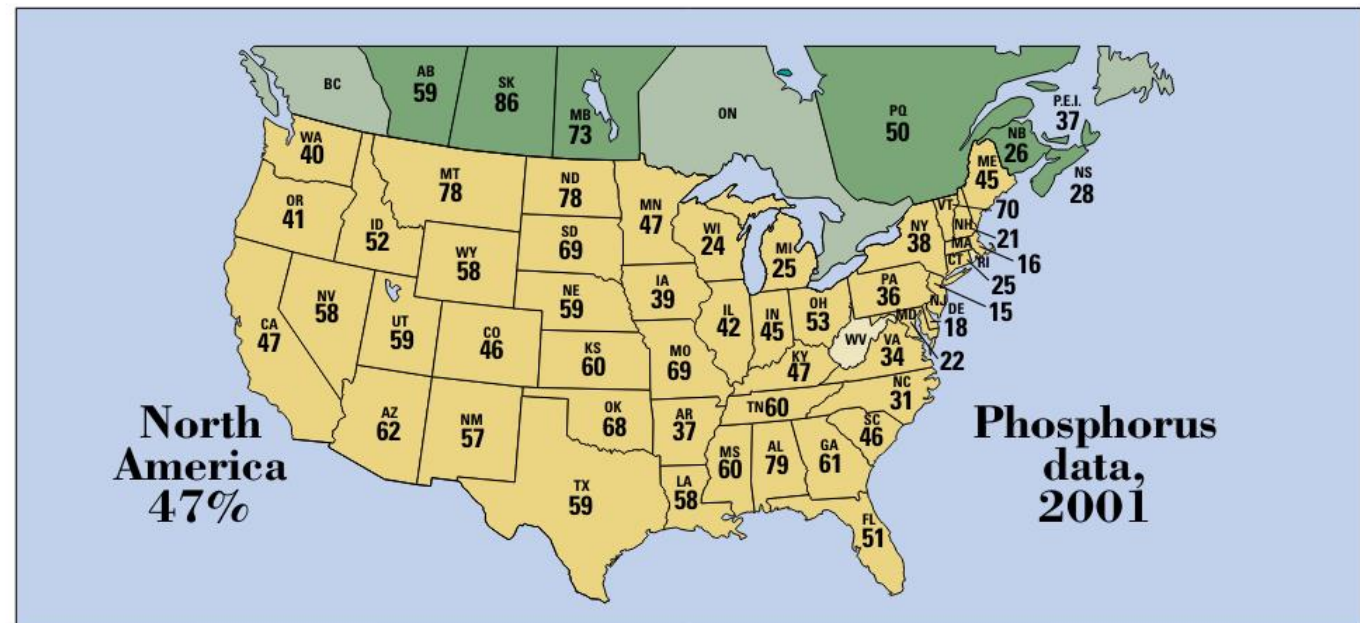


Figure 1. Percent of soils testing medium or lower in P.

# Task 4: Soil depth study

Soil depth impacts on S levels (Culman's data; Mehlich-3 with ICP).

\*First need to evaluate whether Mehlich-3 works well in predicting yield response from Task 2.