Interpreting Soil Test Report

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AGVISE Laboratories

Established 1976

Northwood, ND & Benson, MN

AGVISE Northwood Laboratory
40,000 sq. feet - New in 2007

Agenda

1. Interpreting a soil test report
    - What is tested on the topsoil and subsoil
    - How test data is reported
    - How fertilizer guidelines are calculated
    - How AGVISOR is used to make changes in soil report
    - Regional trends in nutrients and soil properties

2. Your Questions are the most important thing!

What do we test and what depths?

Topsoil, 0-6" (mobile and immobile)

N, P, K, S, Cl, B, Zn, Fe, Mn, Cu, Mg, Ca, Na, CEC, organic matter, salts, pH, buffer pH, soil texture, water holding capacity

Subsoil, 6-24" (mobile only)

N, S, Cl, salts pH, soil texture, water holding capacity

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Nutrient value in the soil (ppm vs. lb/acre)

Nutrient reporting units
lb/acre = mobile, moves with water
ppm = immobile, does not move with water

NUTRIENT IN THE SOIL			INTERPRETATION VLow	Low	Med	High
Nitrate	0-6"	16 lb/ac	****	*		
	6-24"	24 lb/ac				
	0-24"	40 lb/ac				
	24-48"	88 lb/ac				
Olsen Phosphorus		9 ppm	****	****	**	
Potassium		300 ppm	****			
Chloride						
Sulfur	0-6"	10 lb/ac	****			
	6-24"	36 lb/ac	****			
Boron						
Zinc		0.69 ppm	****	****	**	
Iron						
Manganese						
Copper						
Magnesium						
Calcium						
Sodium						
Org.Matter		2.8 %	****	****		
Carbonate(CCE)						
Sol. Salts	0-6"	0.37 mmho/cm	****	**		
	6-24"	0.35 mmho/cm	****	**		

	1ST CROP CHOICE		2ND CROP CHOICE		3RD CROP CHOICE	
Crop	Wheat-Winter		Wheat-Spring		Wheat-Spring	
YIELD GOAL	30	BU	40	BU	50	BU
SUGGESTED GUIDELINES	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION
N	34		68		95	
B						
Zn	0		0		0	
Fe						
Mn						
Cu						
Mg						
Lime						

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range) % Ca	% Mg	% K	% Na	% H
6.9							

NUTRIENT IN THE SOIL		INTERPRETATION VLow	Low	Med	High
Nitrate 0-6" 6-24" 0-24" 24-48"	16 lb/ac 24 lb/ac 40 lb/ac 88 lb/ac	****	*		
Olsen Phosphorus	9 ppm	****	****	**	
Potassium	300 ppm	****	****	****	****
Chloride					
Sulfur 0-6" 6-24"	10 lb/ac 36 lb/ac	**** ****	** ***		
Boron					
Zinc	0.69 ppm	****	****	**	
Iron					
Manganese					
Copper					
Magnesium					
Calcium					
Sodium					
Org.Matter	2.8 %	****	****		
Carbonate(CCE)					
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1ST CROP CHOICE			2ND CROP CHOICE			3RD CROP CHOICE		
Wheat-Winter			Wheat-Spring			Wheat-Spring		
YIELD GOAL			YIELD GOAL			YIELD GOAL		
30	BU		40	BU		50	BU	
SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
Band			Band			Band		
	LB/ACRE	APPLICATION		LB/ACRE	APPLICATION		LB/ACRE	APPLICATION
N	34		N	68		N	95	
P_2O_5	16	Band *	P_2O_5	22	Band *	P_2O_5	27	Band *
K_2O	10	Band(Starter)*	K_2O	10	Band(Starter)*	K_2O	10	Band(Starter)*
Cl								
S								)
B								
Zn								
Fe			Fe			Fe		
Mn			Mn			Mn		
Cu			Cu			Cu		
Mg			Mg			Mg		
Lime			Lime			Lime		

Relative nutrient level (helps explain)

Low – High probability of yield response

Med – Medium prob. of yield response

High – Low prob. of yield response

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range) % Ca	% Mg	% K	% Na	% H
6.9							

NUTRIENT IN THE SOIL		INTERPRETATION			
		VLow	Low	Med	High
Nitrate 0-6" / 6-24" / 0-24" / 24-48"	16 lb/ac / 24 lb/ac / 40 lb/ac / 88 lb/ac	****	*		
Olsen Phosphorus	9 ppm	****	****	**	
Potassium	300 ppm	****	****	****	****
Chloride					
Sulfur 0-6" / 6-24"	10 lb/ac / 36 lb/ac	**** / ****	** / ***		
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Sodium					
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YIELD GOAL	30	BU	40	BU	50	BU
SUGGESTED GUIDELINES	Band		Band		Band	
	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION
N	34		68		95	
P_2O_5	16	Band *	22	Band *	27	Band *
Mg						
Lime						

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
6.9							

<u>Don’t forget about soil properties!!!</u>
<u>(May be yield limiting factor!!)</u>

<u>Soil properties (%OM, pH, salts, texture)</u>

%OM - Low is bad
Salts – High is bad
pH – very low is bad

Why do soil test levels change from year to year?

Mobile nutrients move with water (nitrate, chloride, sulfate, salts)

- More rainfall can leach nutrients downward (deeper than 24” sampling depth)
- High water table can bring salts upward (chloride, sulfate)
- Drought conditions limits crop yield (high soil N)
- Was topsoil bone-dry, preventing plant root uptake of applied fertilizer? (stranded N fertilizer in 0-6”?)
- Were plant roots obtaining nutrients from below soil sampling depth? (going below 24” for N and water)

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Why do soil test levels change from year to year?

<u>Immobile nutrients do not move with water (P, K, micronutrients, pH, organic matter)</u>

- Sampling depth important; too deep (0-8”) or too shallow (0-4”) can cause values to increase or decrease
- Deep tillage dilutes nutrient concentrations
- Erosion loses topsoil and nutrients
- Is GPS perfect? Did you hit fertilizer bands?
- Applying high fertilizer rates will increase soil test
- Applying low rates decrease soil test level (P, K etc.)

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Soil organic matter, 0-6” topsoil

Relative level	Soil organic matter (%)
Very low	0-1.5
Low	1.6-2.5
Medium	2.6-5.0
High	5.1-10.0
Very high (muck)	10.1-15.0
Peat	>15.0

- General indicator of soil productivity (N mineralization, water holding capacity, water infiltration)
- Herbicide binding potential (less weed control)
- Baseline determined by climate, natural vegetation, soil texture, topography

How can soil organic matter change from year to year?

- Soil sample depth changes
  - Shallow sample (0-4 inch) = higher OM
  - Deep sample (0-8 inch) = lower OM
  - No-till and reduced till systems – depth is critical
- Excessive crop residue in soil sample
  - Test method measures weight loss when carbon is burned away (360 °C, loss-on-ignition method)
  - Weight loss is inflated when crop residue is included
- Tillage improves consistency because of mixing

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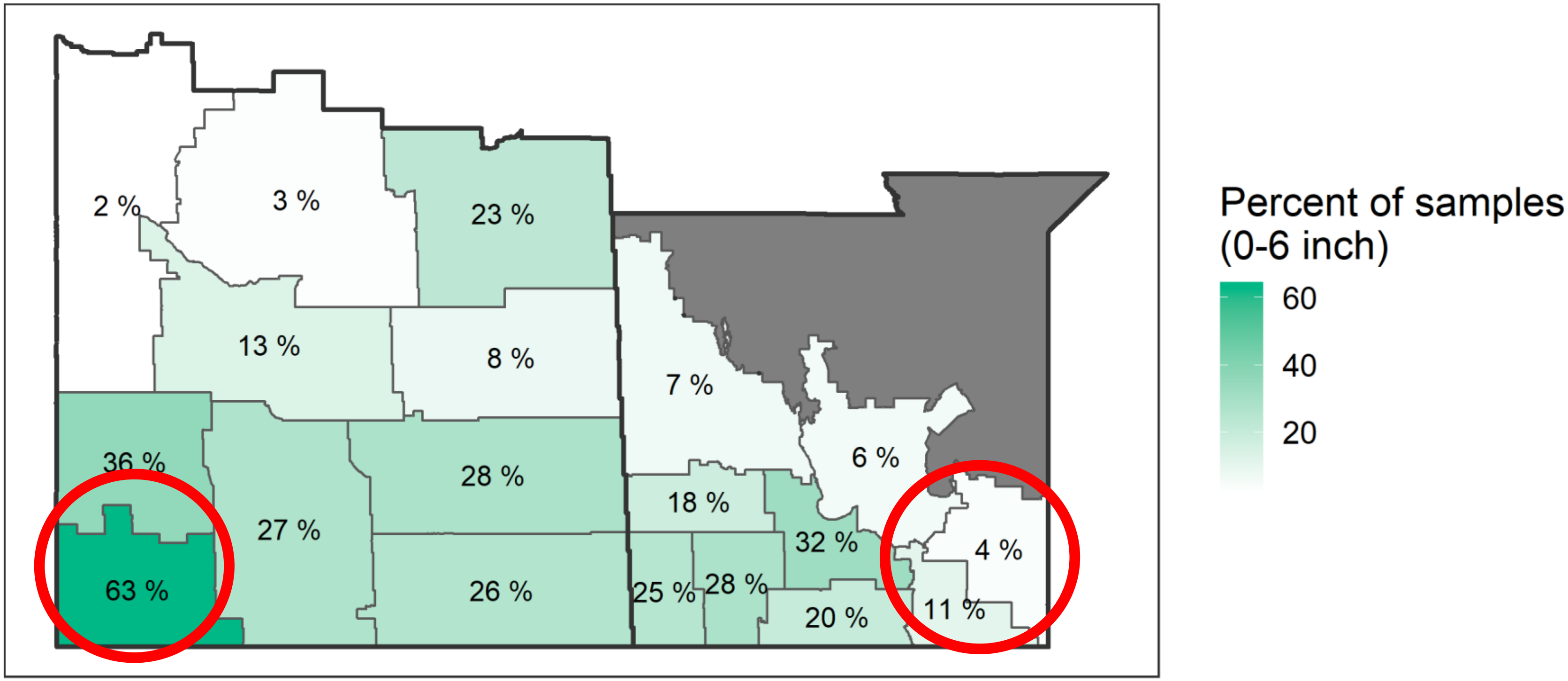
Soil samples with soil organic matter below 3% in 2019



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Soil pH, 0-6” topsoil

Relative level	pH (1:1 method)	Interpretation
Very acidic	<5.5	Aluminum toxicity, liming important
Acidic	5.5-6.5	Liming may be necessary, crop choice
Neutral	6.5-7.5	
Alkaline	**7.5-8.5**	**Band P fertilizer, maybe Zn?**
Very alkaline	>8.5	Possible sodium problem, gypsum may be required

- Herbicide breakdown affected in low or high pH soils
- pH > 7.3 indicates calcium carbonate (CCE) present

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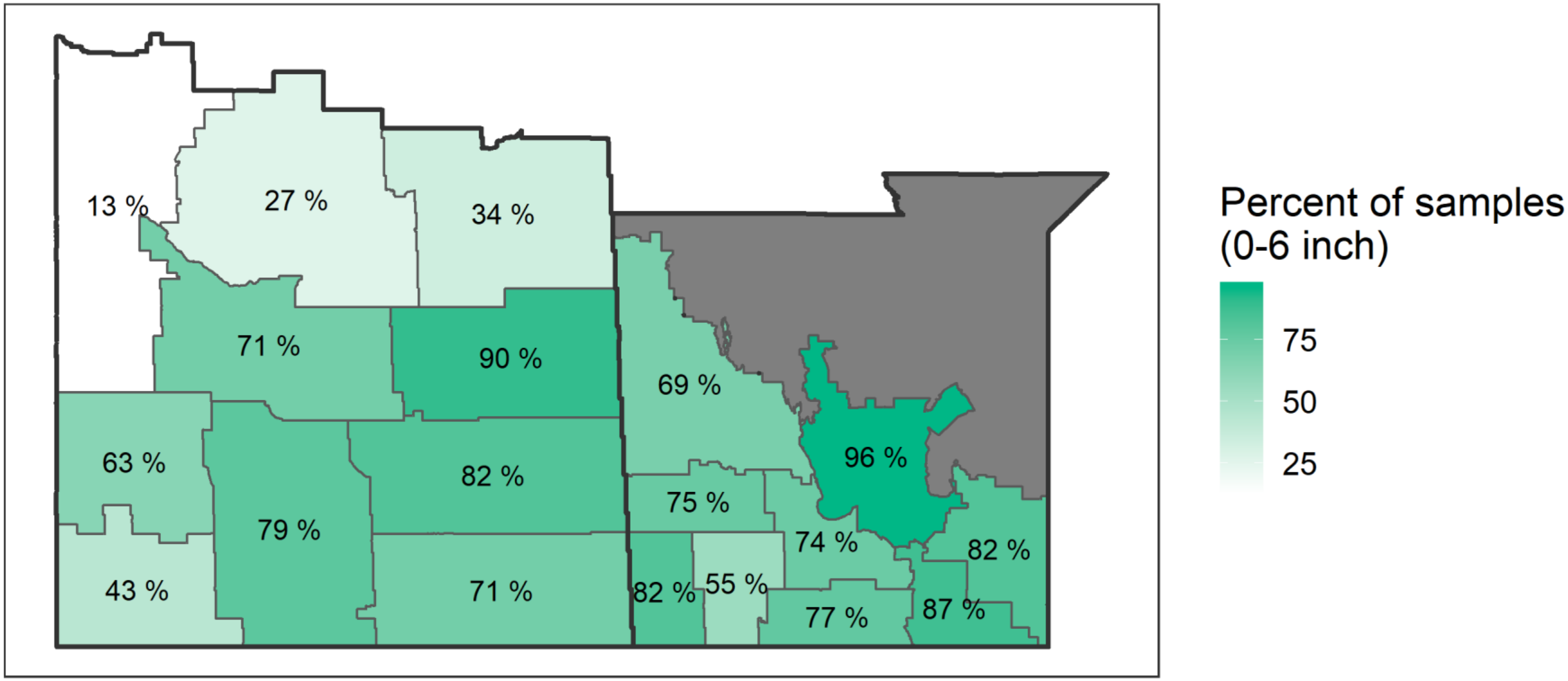
Soil samples with soil pH above 7.3 in 2019



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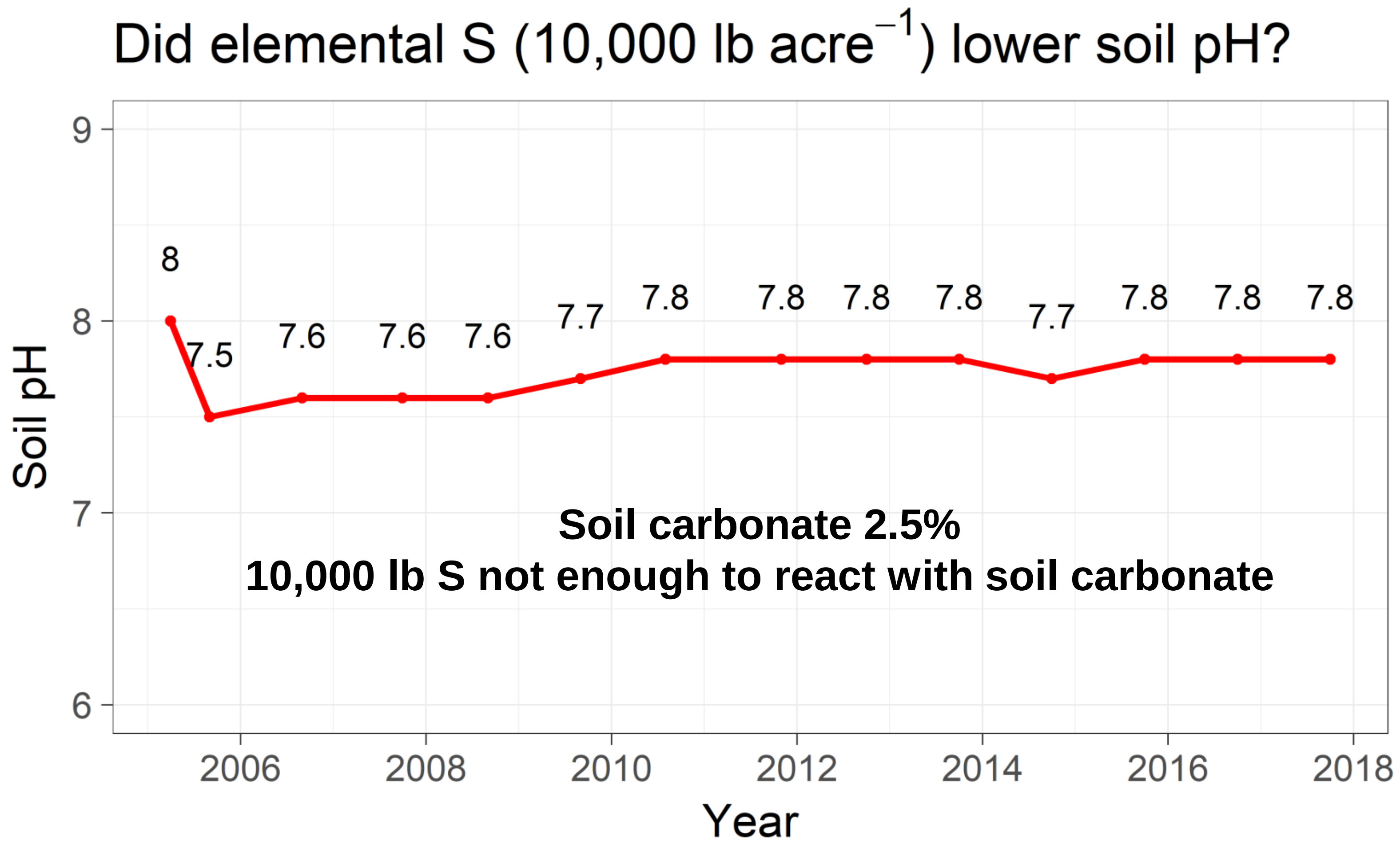
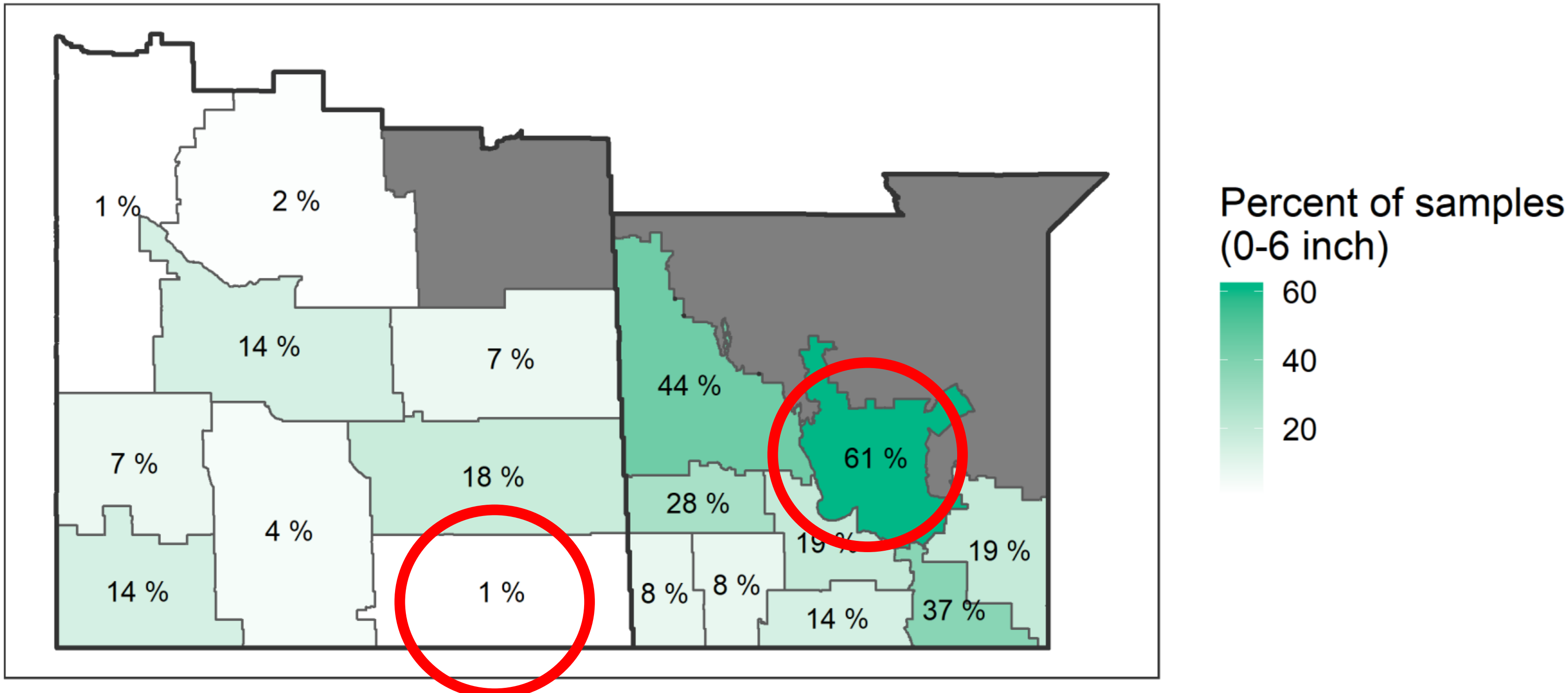
AGVISE Demonstration Project



Apparently, 10,000 lb/acre elemental S was not enough.

Soil samples with soil carbonate (CCE) above 5.0% in 2019



Data not shown where n< 50
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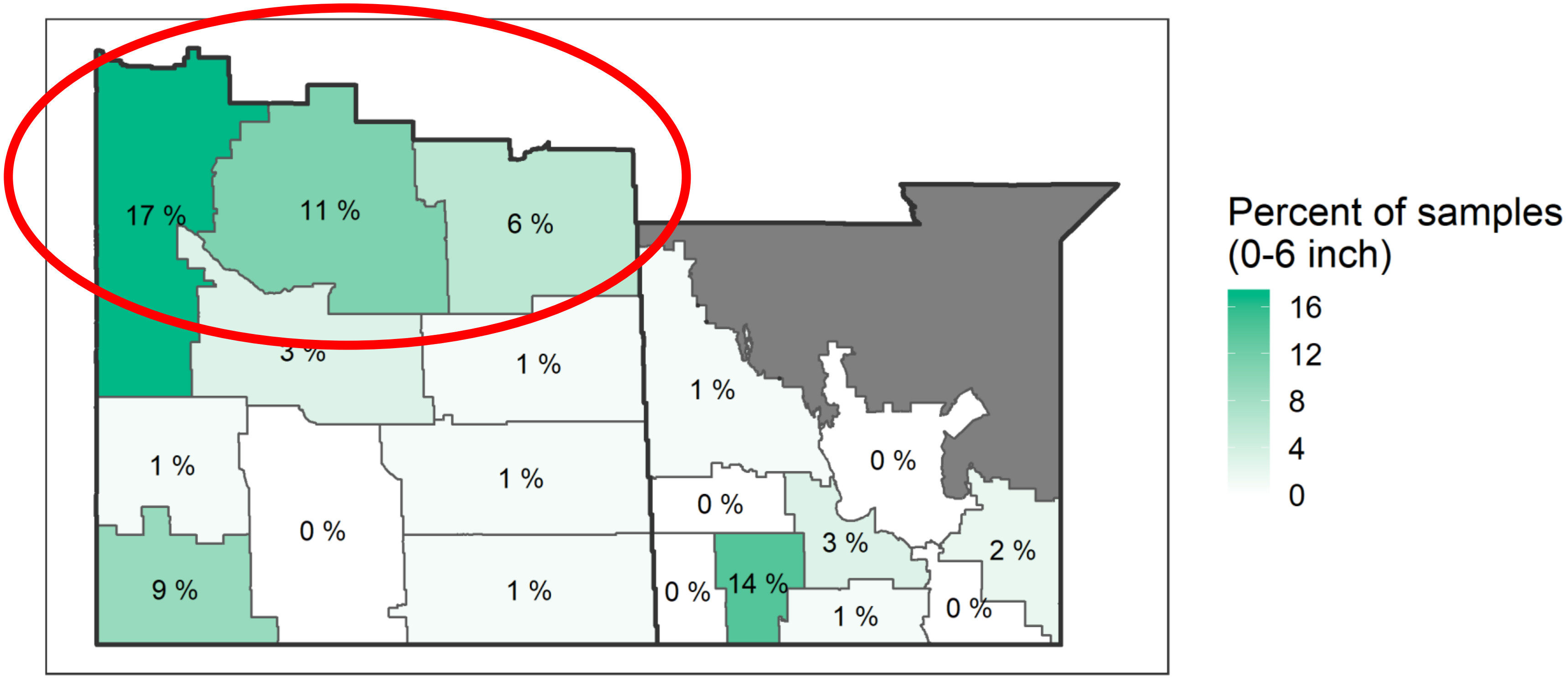
Soil pH increasing? Stop soil erosion!

Photo from Bohn, M., D. Hopkins, C. Gasch, D. Steele, and S. Tuscherer. 2018. Predicting soil health and function using remote-sensed evapotranspiration and terrain attributes for a benchmark soil. In: Franzen, D.W., chair, 2018 NDSU Soil and Soil Water Workshop, Fargo, ND. 17 Jan. 2018. North Dakota State Univ., Fargo, ND.

Where are the low pH soils?

Soil samples with soil pH below 6.0 in 2019



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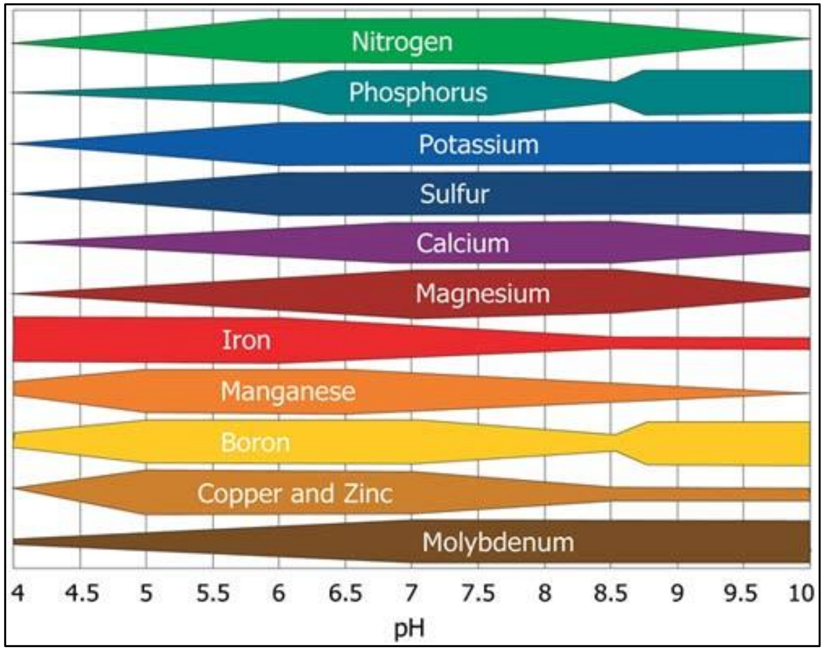
Why are acid soils problematic?

Reduced nutrient availability



Aluminum toxicity

Photo: Gene Hettel/CIMMYT. https://flic.kr/p/8Ke1Jr

Aluminum toxicity on wheat seedlings

High Al^{3+}

No Al^{3+}

Photo: S. Carr. https://www.agric.wa.gov.au/soil-acidity/effects-soil-acidity

HRSW variety evaluation for acidity tolerance (Dickinson, ND 2018)

More tolerant variety (right) has larger root system and plant growth

Photo: J.S. Breker, June 2018.

Salinity Testing
0-6" and 6-24" depths

- High water table brings salts to surface
- Saline seeps along sidehill coal/gravel veins
- High salts = high nitrate and sulfur test level
- High salts = high risk of IDC (soybean, flax)

- Saline soils are usually white with good tilth
- Some crops can tolerate high salts
  - e.g., barley, sugar beet, salt-tolerant grasses

Salinity (soluble salts, electrical conductivity), 0-6" and 6-24" depths

Relative level	EC (1:1 method, mmhos/cm or dS/m)
Very low	<0.25
Low	0.26-0.50
Medium	0.51-0.75
High	0.76-2.0
Very high	>2.0

1.0 dS/m stresses sensitive crops, e.g., soybean, dry bean

High salinity prevents plants from taking in water normally. Plants in very saline soils will die from limited water intake.

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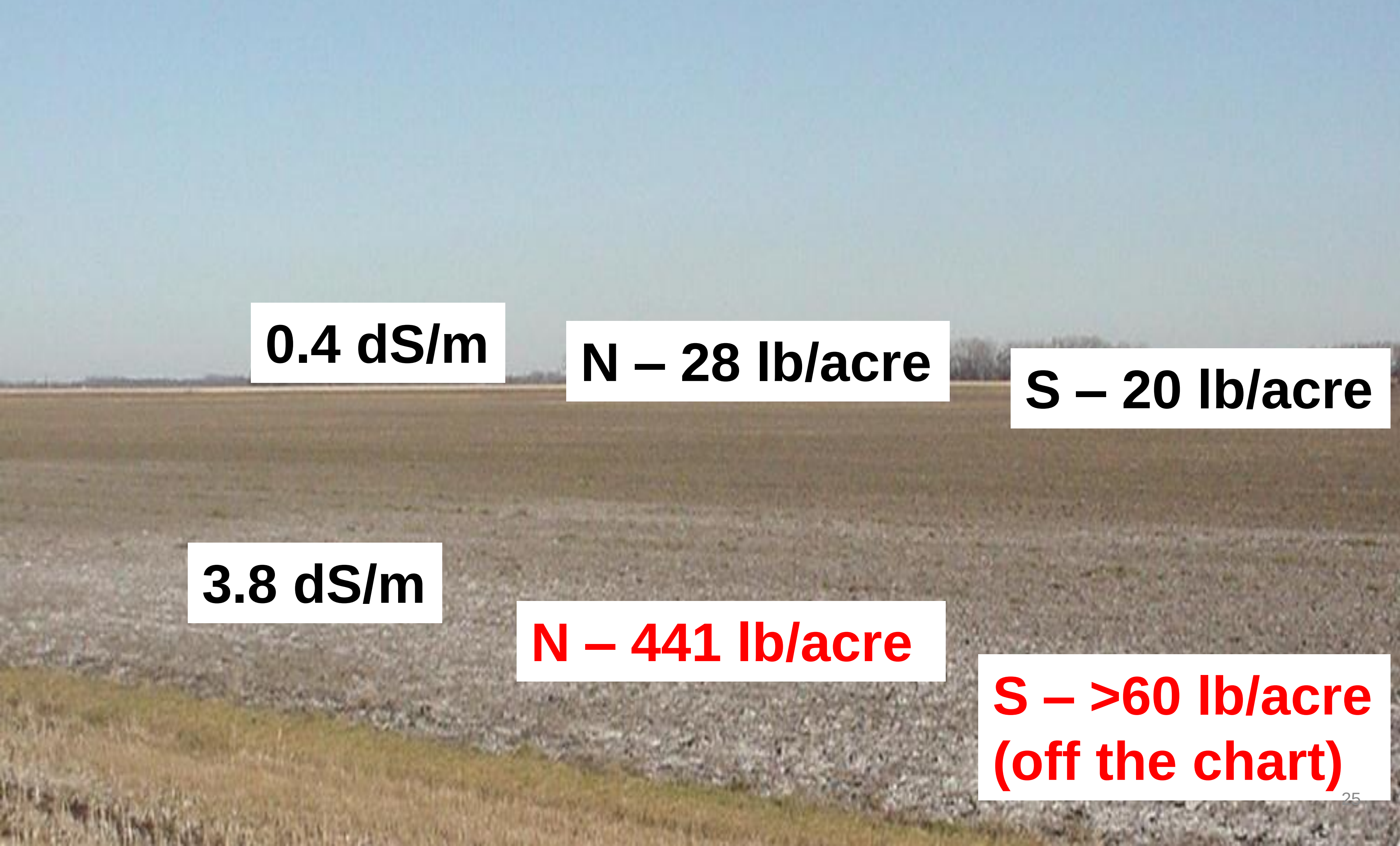
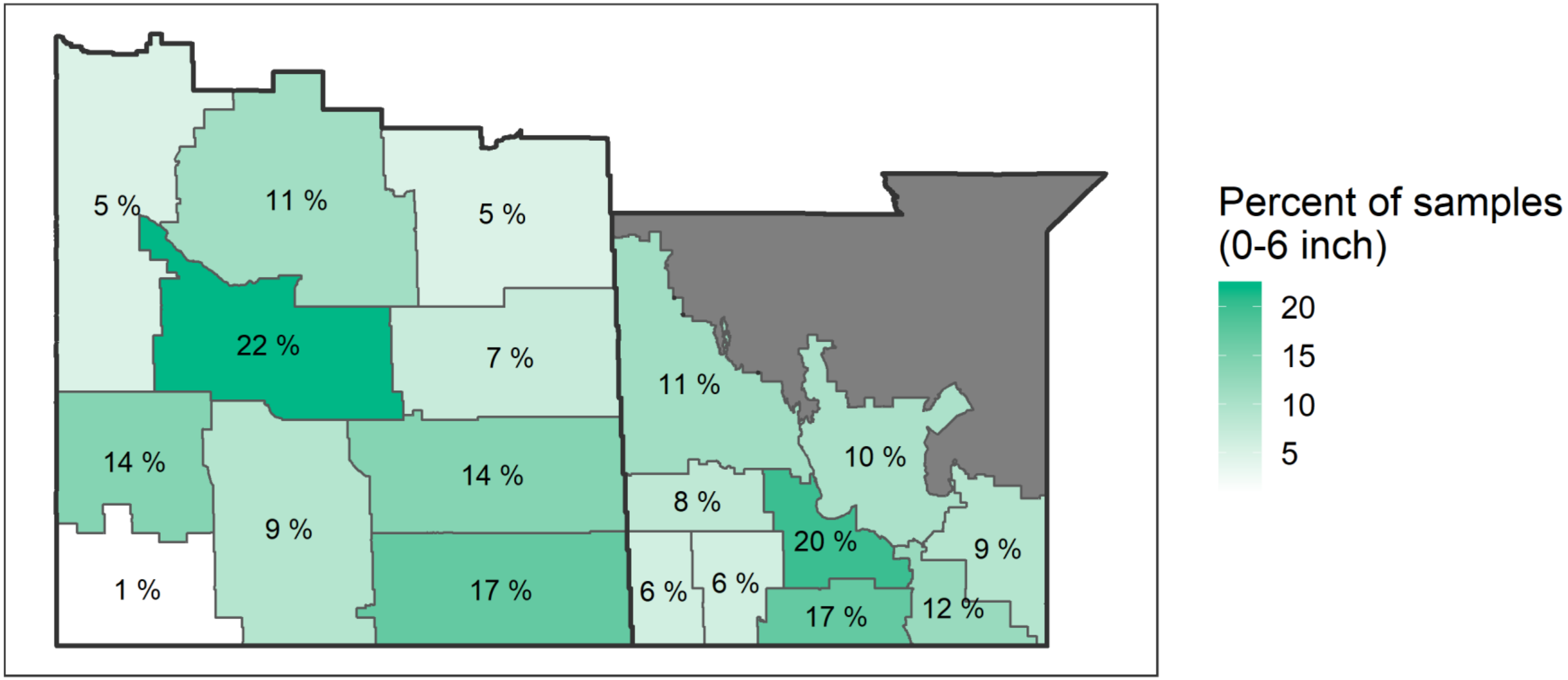
Salinity – soluble salts, electrical conductivity



Soil samples with soil salinity above 1.0 dS/m (1:1) in 2019



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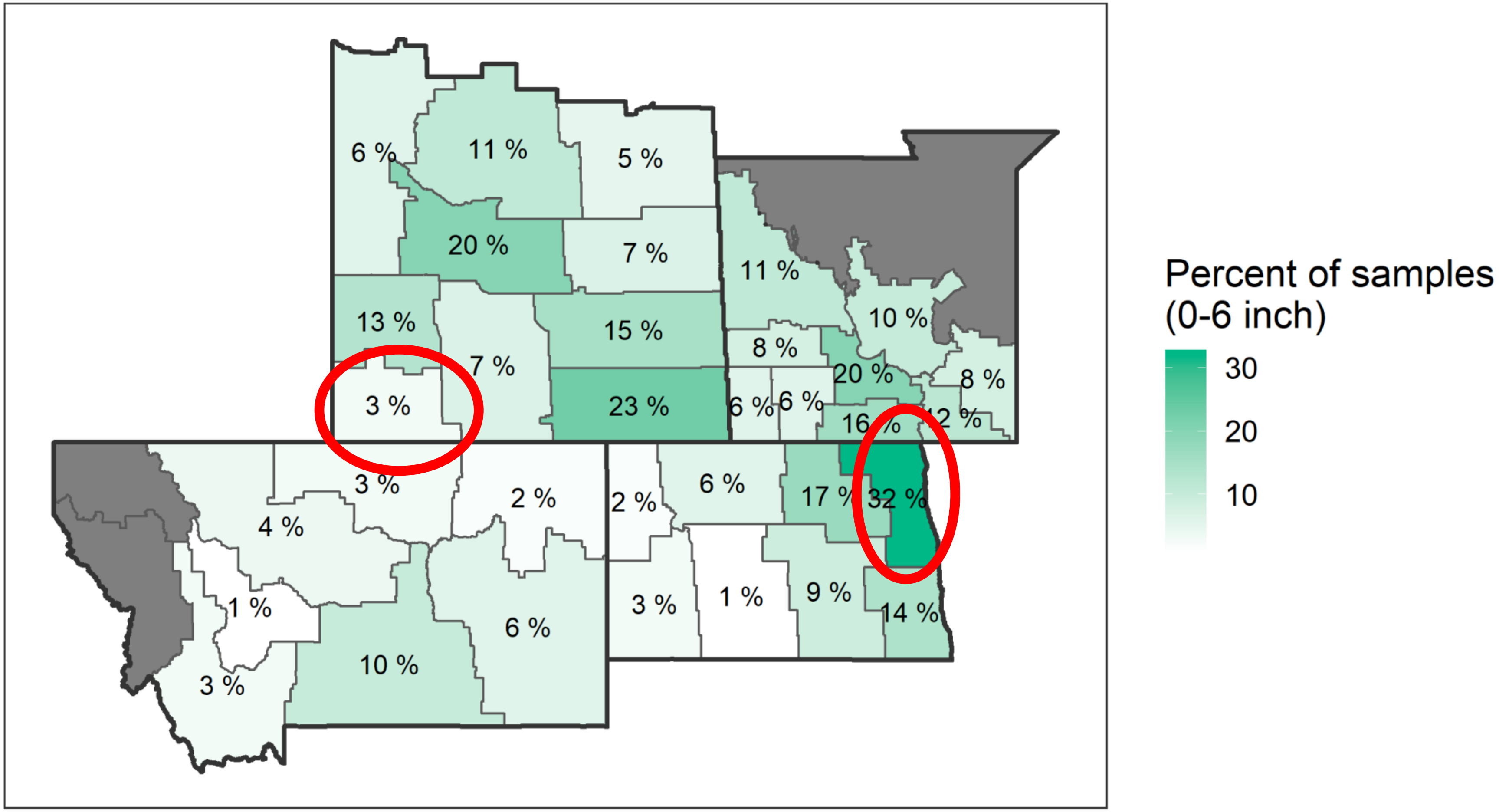

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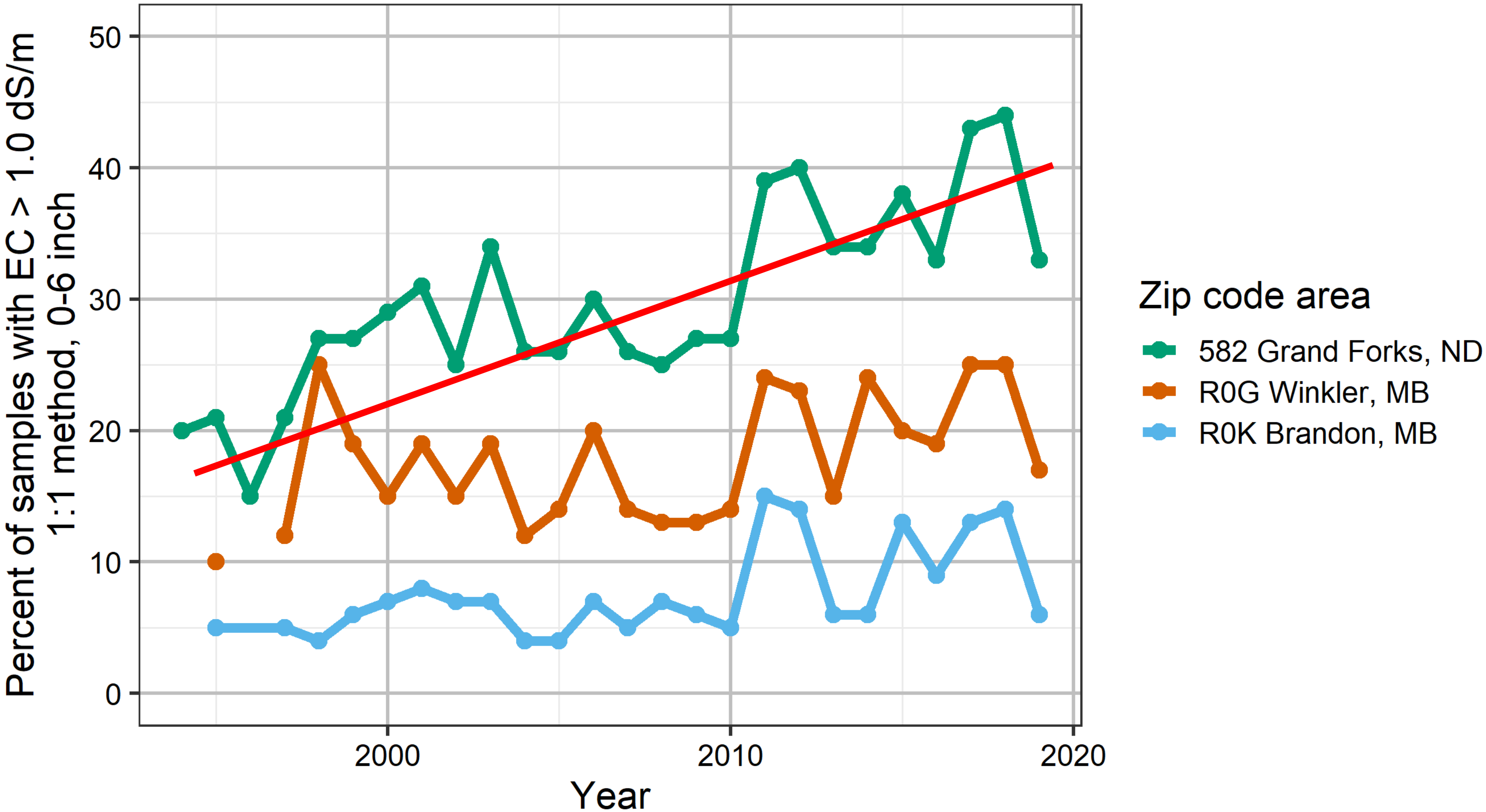
Soil salinity trend (>1.0 dS/m) across southern MB & northeast ND



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Saline soil management is about water management

- Subdivide field for saline and non-saline areas
- Select salt-tolerant crops
- Plant salt-tolerant grasses, cut for hay or graze
- Install tile drainage (higher rainfall needed)
- Let the kochia grow, cut for silage (poor man's alfalfa)

- Stop tillage, only evaporating more groundwater
- Do not apply gypsum or manure, you cannot remove salts by adding more salts
  - Sodic soils are special cases where amendments may be necessary

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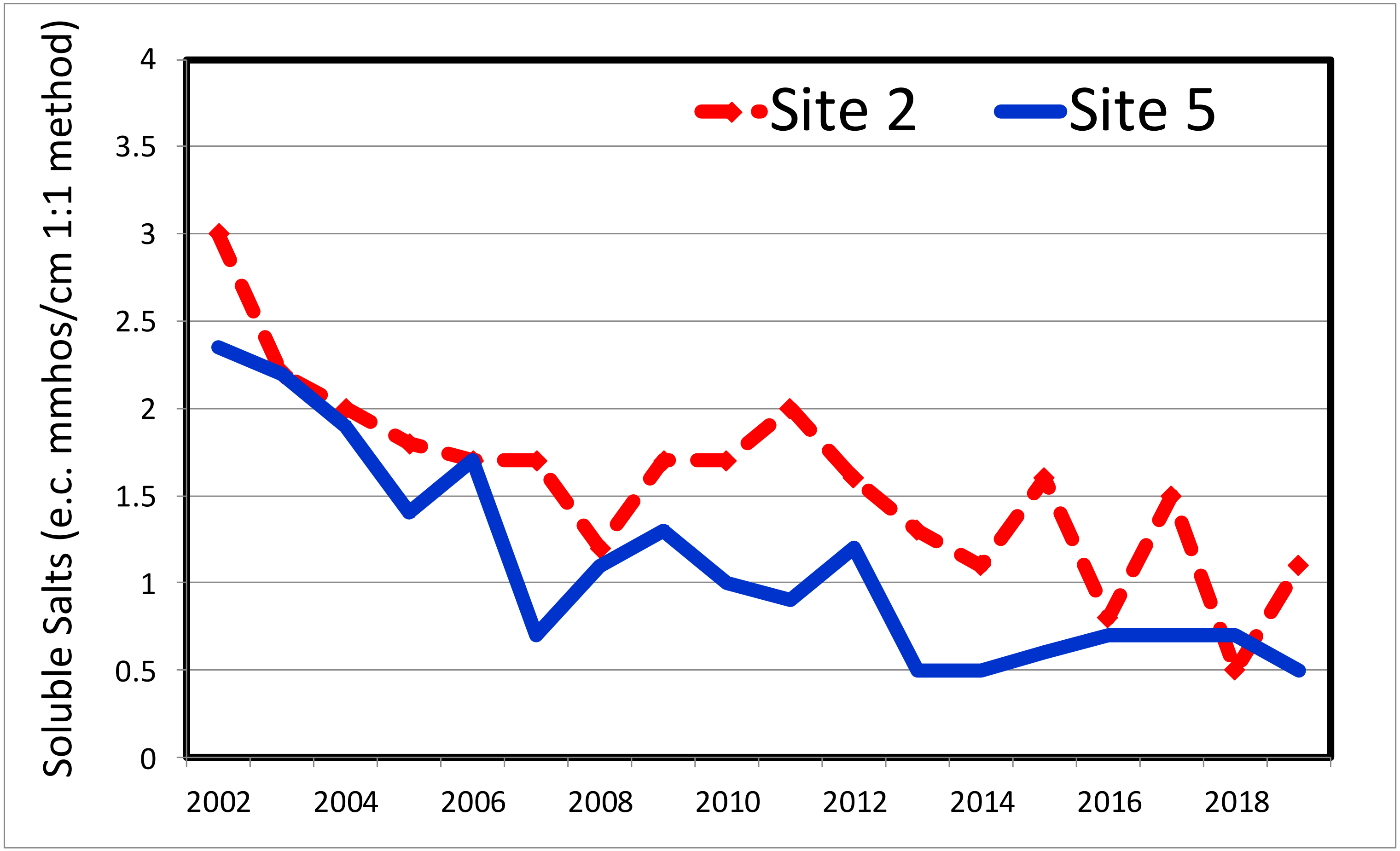
Salinity trend on sandy loam – Northwood ND
Tile Drained Feld (2002 – 2019)
Topsoil



Nitrogen (N) fertilizer guideline calculation

Topsoil and subsoil (0-24”) nitrate-N

- Crop requirement (yield x N factor)
- Soil nitrate level (0-24”)
- Previous crop N credit (legumes)

Crop requirement – (0-24” Soil Nitrate) – legume credit = N guideline

Topsoil (0-6”) nitrate-N only

Crop requirement – (0-24” estimated Soil N) – legume credit = N guideline

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Crop nitrogen factors ranges

Crop	Soil + fertilizer N requirement lb N/bushel
Corn	1.0-1.2 (AGVISOR 1.2)
Spring wheat	2.5-3.0 (AGVISOR 2.7)
Canola	3.0-3.5 (AGVISOR 3.5)
Soybean	0

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Why is 0-24 inch sample needed for best nitrogen fertilizer guideline?

- Strongest relationship with nitrogen uptake
- Frigid, semi-arid environment (lucky us!)
  - Frozen soil does not leach nitrate or allow N mineralization
  - Limited water to leach nitrate below root zone between fall and spring

Sampling depth (inch)	Plant N uptake explained by soil nitrate-N (r^2)
0-6	32%
0-12	64%
0-24	**84%**
0-36	82%
0-48	78%

Soper, R.J., G.J. Racz, and P.I. Fehr. 1971. Nitrate nitrogen in the soil as a means of predicting the fertilizer nitrogen requirements of barley. Can. J. Soil Sci. 51(1):45–49.

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Is soil organic matter factored in when you use the 24” Nitrate test to make guidelines?

Soil test method	Barley yield response to fertilizer N explained by soil test N (r^2)
Soil nitrate-N (0-48”)	**95%**

YES
Average N mineralization contribution from all sites is included.
Researchers apply wide range of N rates to determine correct rate
(N mineralized from organic matter is where portion of N came from)

Nitrogen mineralization from soil organic matter is difficult to predict and environment dependent from year to year

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Soper, R.J., and P.M. Huang. 1963. The effect of nitrate nitrogen in the soil profile on the response of barley to fertilizer nitrogen. Can. J. Soil Sci. 43(2):350–358.

Previous crop (Legume) nitrogen credits reduce N fertilizer rate requirement

Previous crop	AGIVSE N credit lb N/acre		University N credit lb N/acre
	Long-season crop e.g., corn, sunflower	Short-season crop e.g., wheat	All crops
Alfalfa	50	25	50
Soybean	30	15	40
Dry bean	30	15	40
Field pea	30	15	40
Faba bean	30	15	40
Lentil, chickpea	20	10	40

Why is my nitrate-N so low?

Production (crop N use)

- Yield goal was set too low (all fertilizer N used)
- Crop yield more than expected

Environmental

- Wet conditions = leaching and denitrification
- Cool temperatures during the summer
  - Less N mineralization than usual from soil organic matter
- Low soil organic matter (less potential N mineralization)

Why is my nitrate-N so high?

Production (crop N use)

- Yield goal was set too high
- Crop yield less than expected
- Previous crop N credits were not included

Environmental

- Drought conditions (less crop use, fertilizer N positionally unavailable)
- Warmer temperatures during the summer
  - More N mineralization than usual from soil organic matter
- High soil organic matter (more potential N mineralization)

Bad sample

- Saline area included in sample
- Incorrect soil sample depth recorded

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What is the sweet spot for residual nitrate-N?

<30 lb/acre nitrate-N consistently(0-24”)

- Yield likely lost
- Quality was likely impaired (e.g., wheat protein)

>60 lb/acre nitrate-N consistently(0-24”)

- Highest yield attained
- High amount of nitrate-N in soil profile subject to loss
- Bought your N a year earlier than needed

30-60 lb/acre nitrate-N consistently ☺ (0-24”)

- Enough N was supplied to meet yield and quality without excessive N remaining in soil profile

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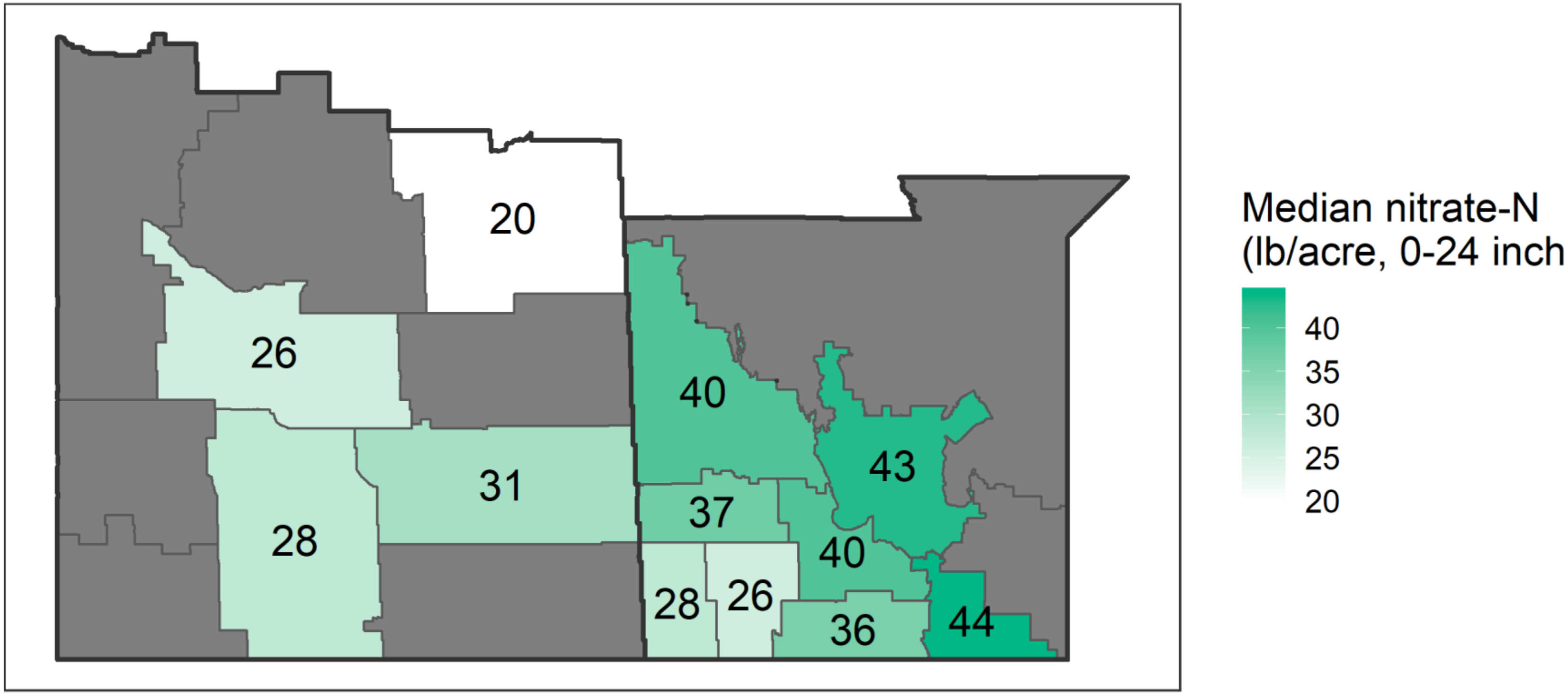
Residual nitrate following wheat in 2019



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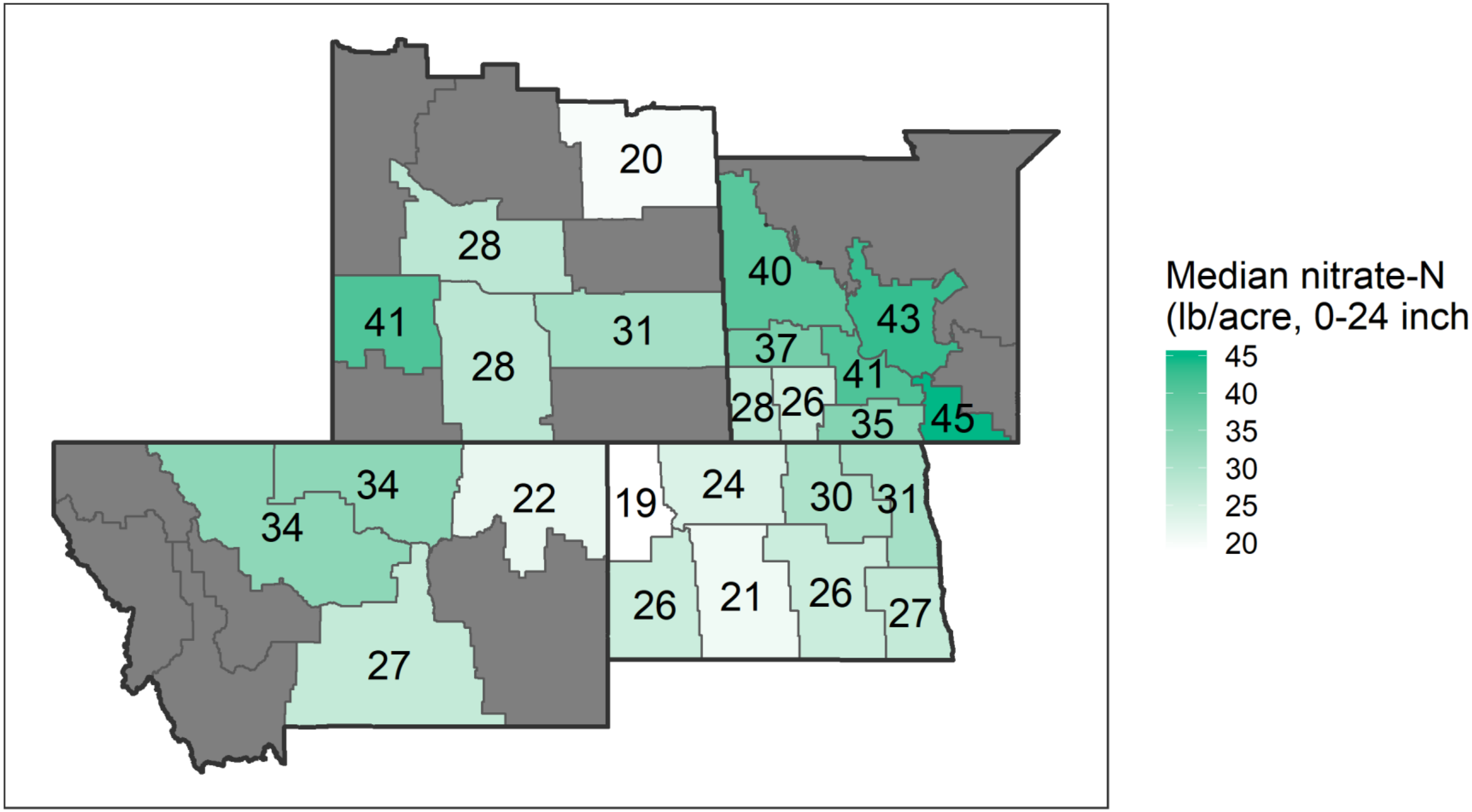
Residual nitrate following wheat in 2019



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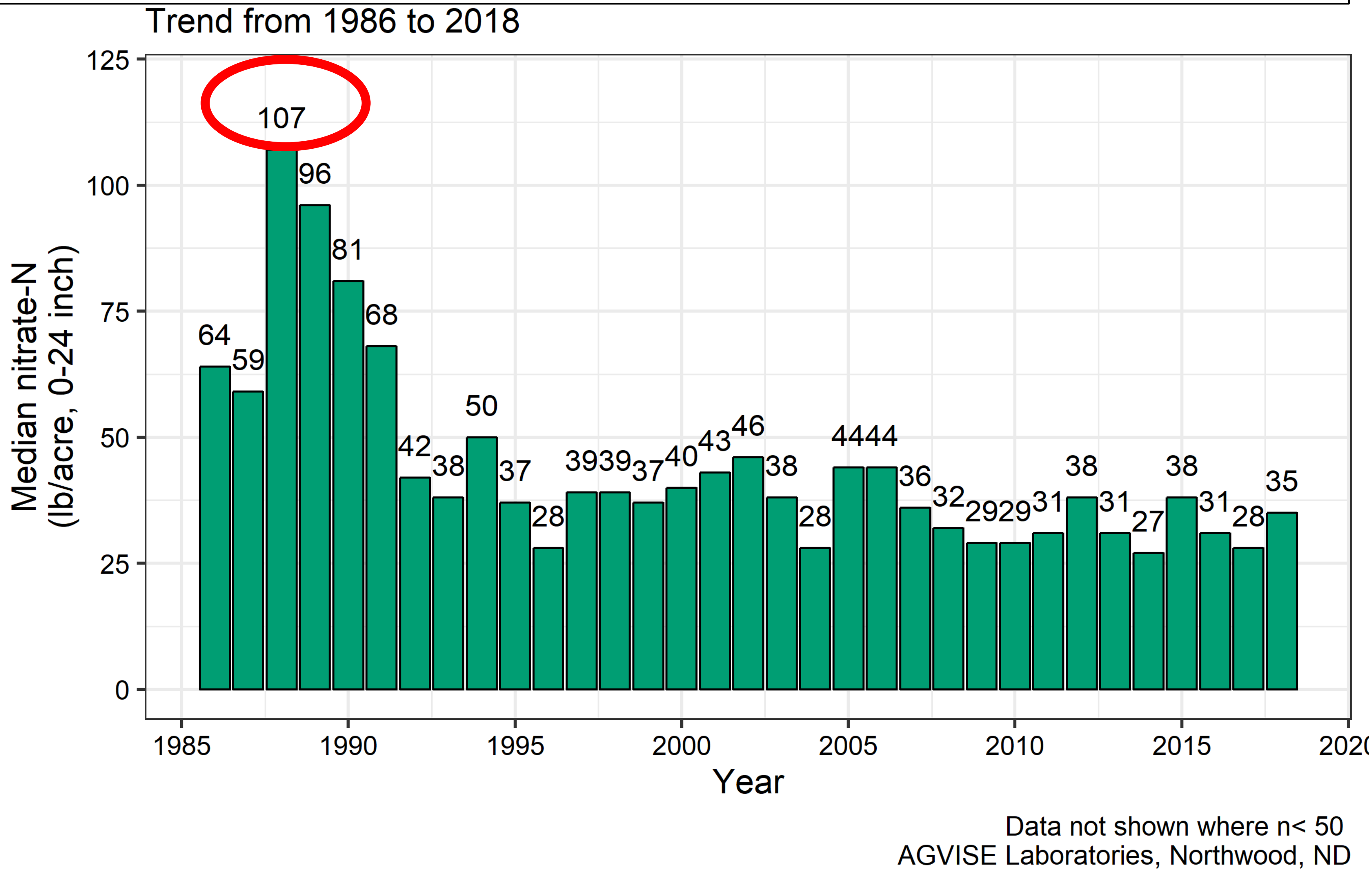
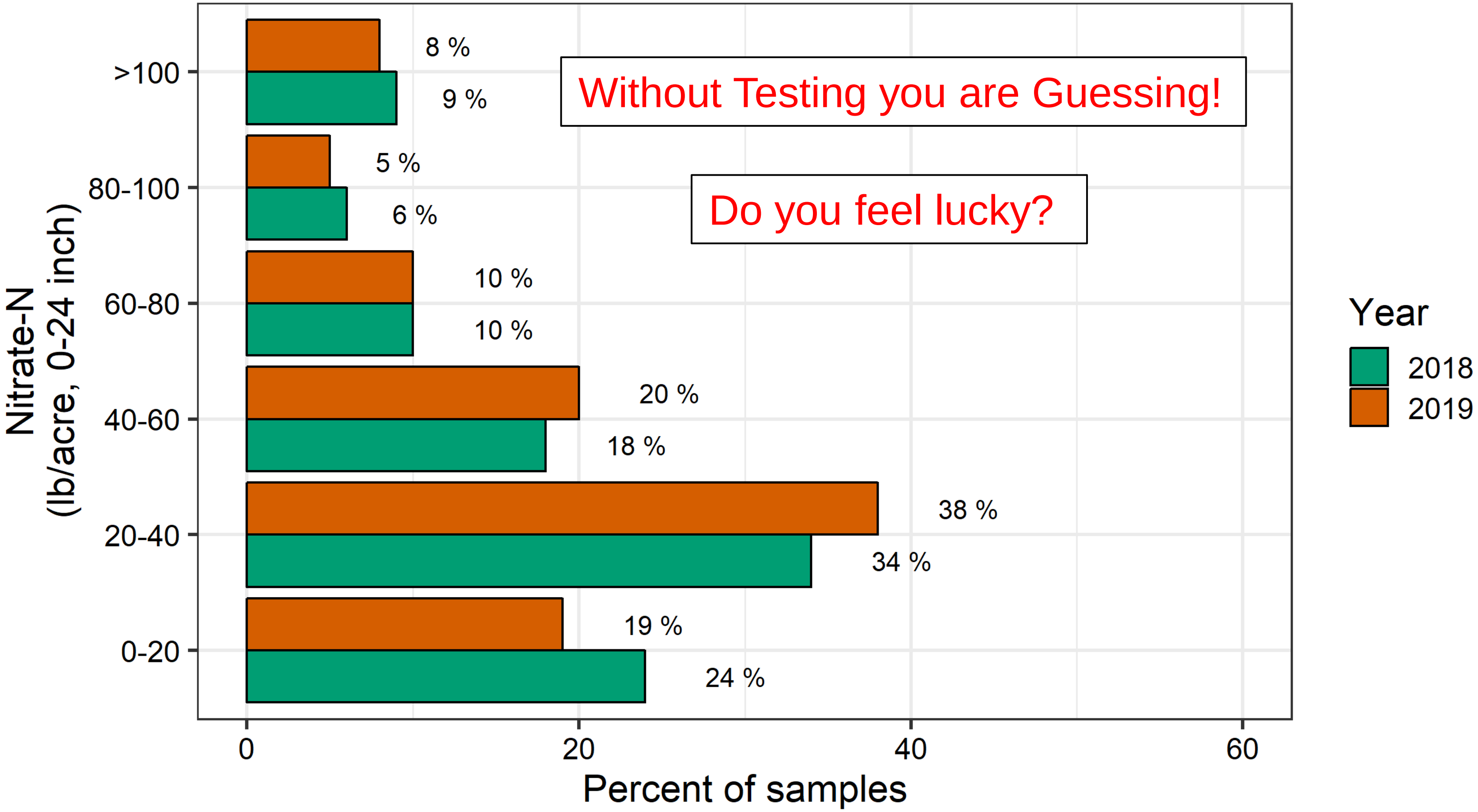
Regional Residual Nitrate (0-24”) Following Wheat



Variability in residual nitrate following wheat in 2018 & 2019



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Recap on soil testing for nitrate-N

- 0-24 inch soil sample provides best information
- Environment is dominant factor in year-to-year variation (dry or wet years)
- Residual nitrate-N after any crop varies regionally and locally, field-to-field and within-field variability (zone sampling trend)
- Soil testing can be used predictively (for next year) or retrospectively (look back on the year)

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P and K Testing

- P & K are not mobile in soil
- Reported in parts per million (ppm) because they are only an index (low, medium, or high chance of response to fertilizer)
- All soil test methods measure only the plant-available portion of P or K in soil. Each test correlated to crop response by field research in this region.
- A low test level for P or K means there is a high probability of yield response to applied fertilizer.

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Phosphorus (P), 0-6” topsoil

Method	Soil test category				
	Very low	Low	Medium	High	Very high
Olsen P pH 5.5-8.5	0-3	4-7	8-11	12-15	>15
Bray-1 P pH <7.3	0-5	6-10	11-15	16-20	>20

Olsen test useful on both high and low pH soils.
Bray and Mehlich methods fail on soils with high pH (carbonates)

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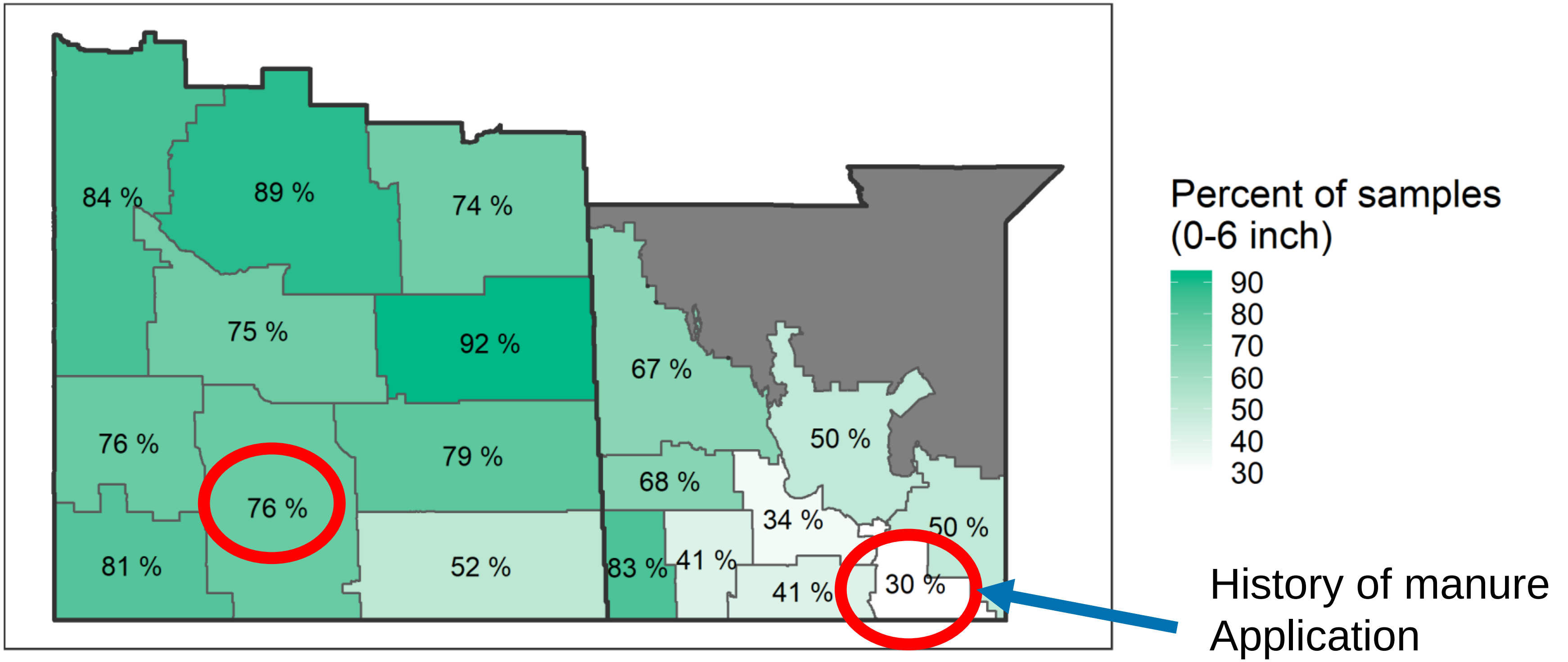
Soil samples with soil test phosphorus below 15 ppm (Olsen P) in 2019



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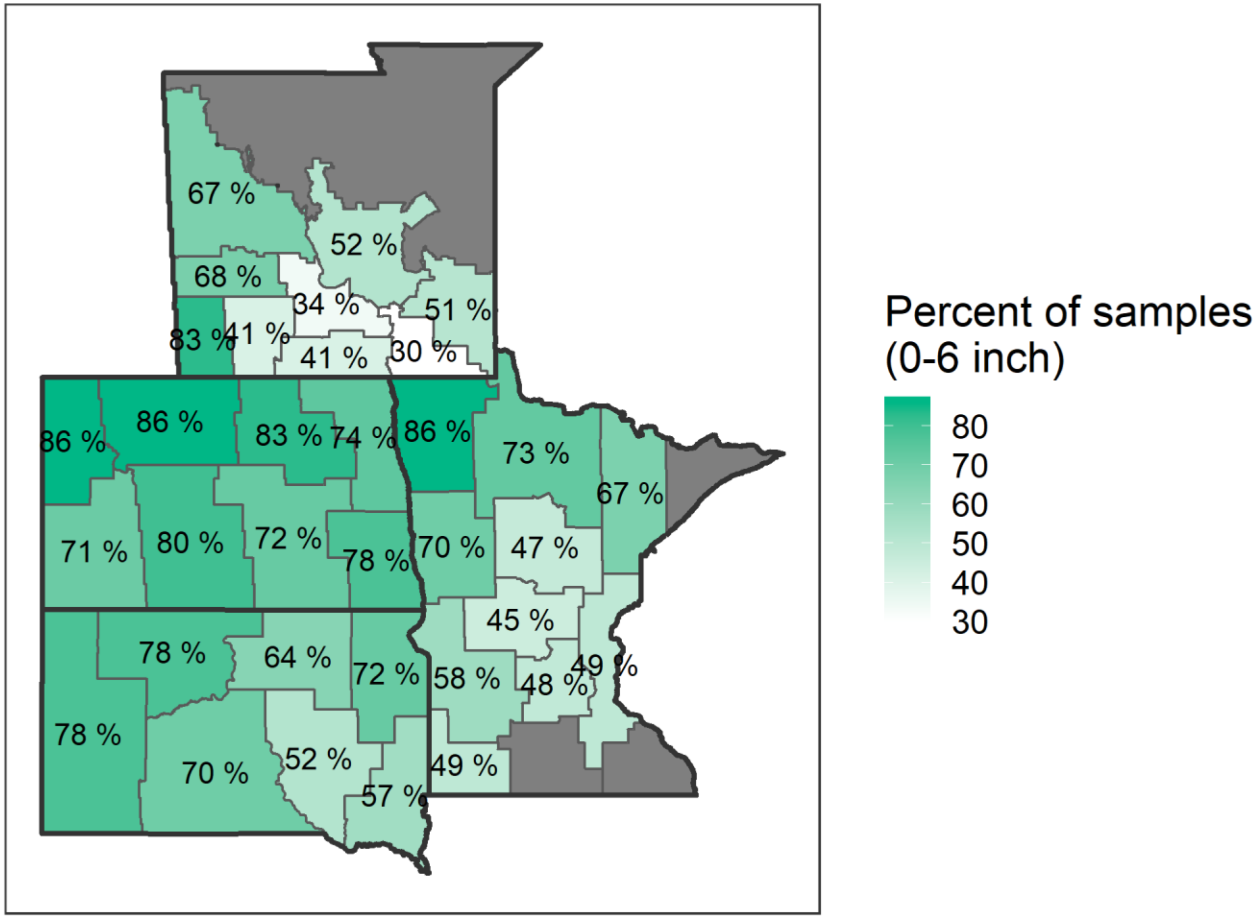
Soil samples with soil test phosphorus below 15 ppm (Olsen P) in 2019



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Potassium (K), 0-6" topsoil

Soil test category	Ammonium acetate K (ppm)
Very low	<40
Low	41-80
Medium	81-120
High	121-160
Very high	>160 (critical level)

Most soils with a loam soil texture or heavier have high soil test K. Sandy soils Usually test low in K and are prone to leaching (difficult to build soil test K on sandy soil).

Potassium deficiency can develop on high testing soils if soil is compacted or if soil contains high proportion of smectitic clays.

Potassium deficiency is one of the first nutrient problems to show up when water is limiting. Tissue analysis is helpful.

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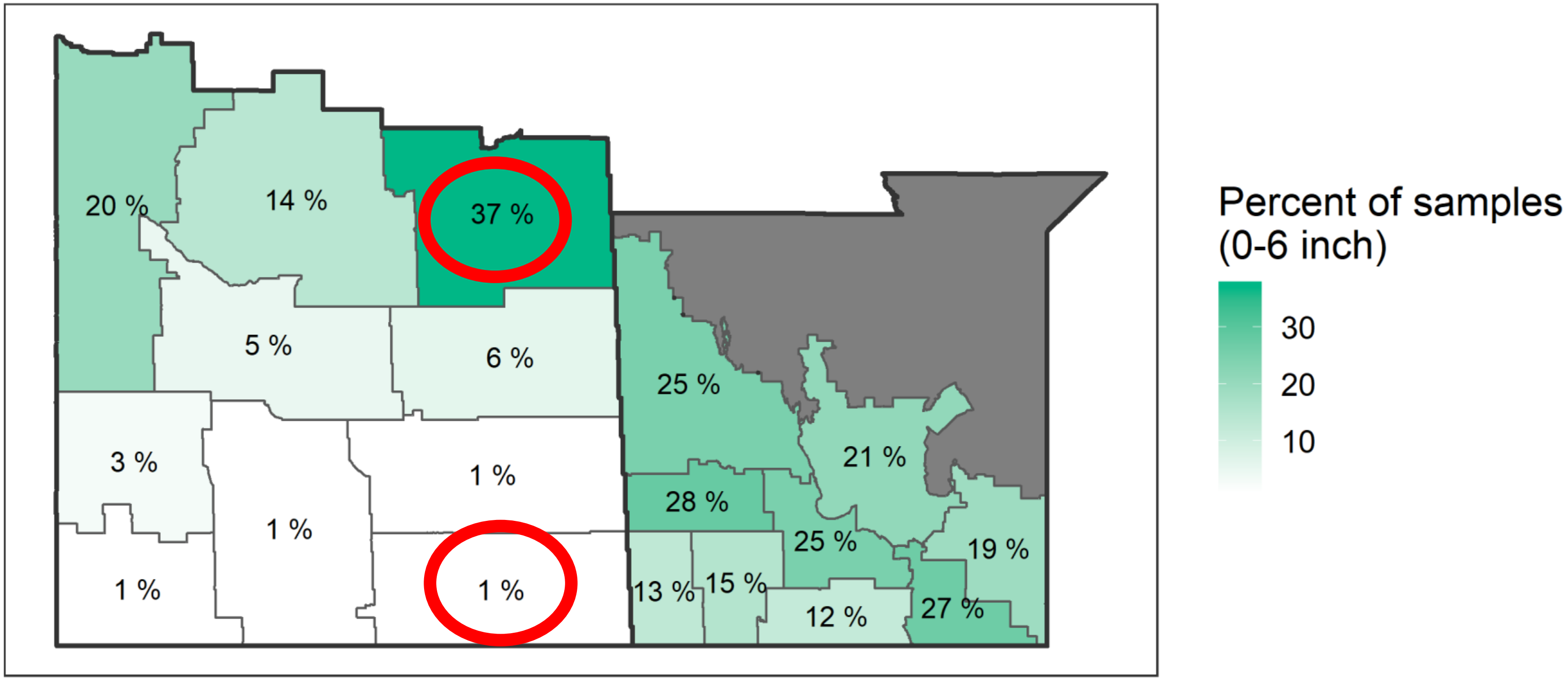
Soil samples with soil test potassium below 150 ppm in 2019



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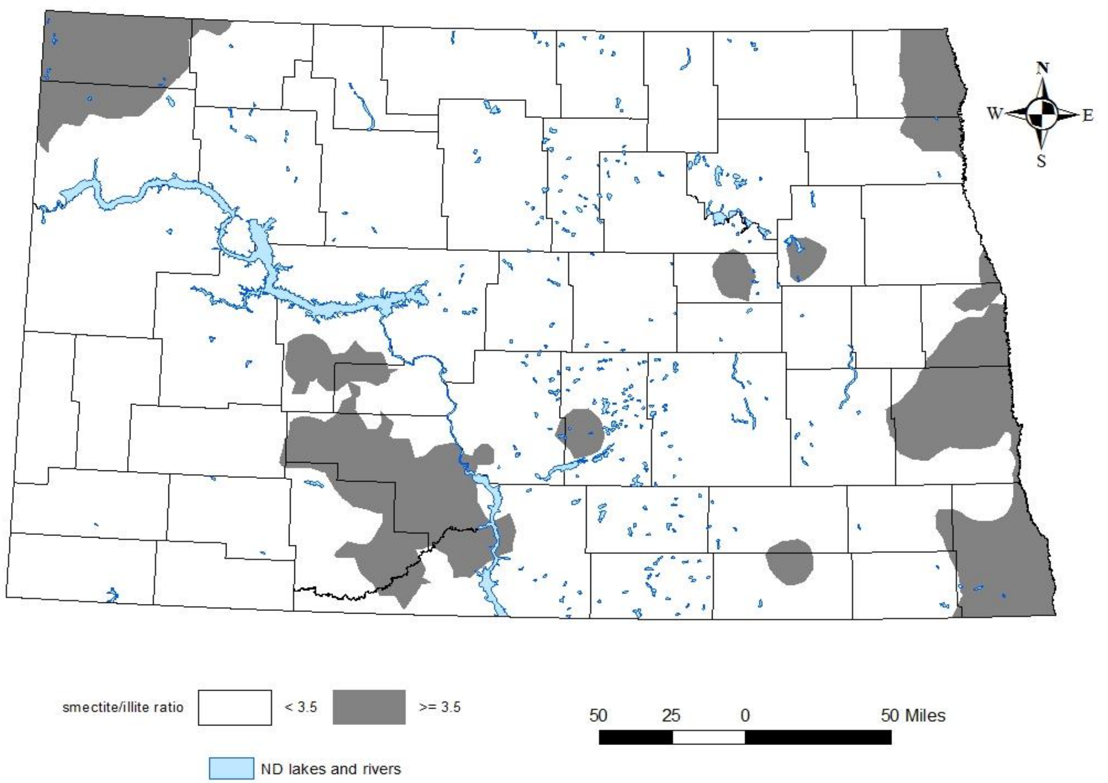
Soils with high smectite clay content require higher soil test K (200 ppm) when it gets dry



Soils with smectite/illite ratio > 3.5 (gray area),

STK_{CL} = 200 ppm

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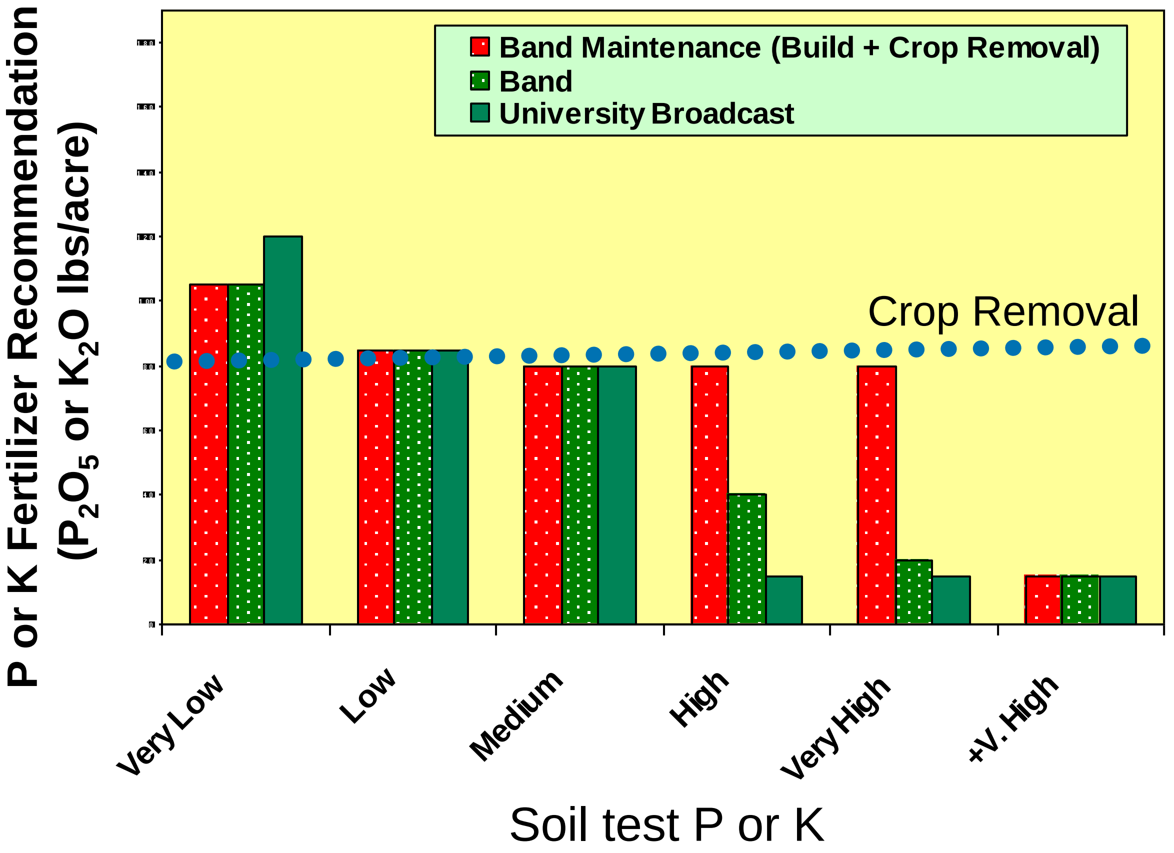
D.W. Franzen, North Dakota State Univ. (personal communication, 2017)

Potassium fertilization

- Soil test K below 150 ppm (zone or grid sample)
- Soil test K below 200 ppm (composite sample/variable)
- Tissue K historically below sufficiency range
- Compaction restricting root growth (confirmed with tissue analysis)
- Replicated strip trials showing significant yield increases
- Low soil chloride (small grains may require Cl from KCl)
- **Base cation saturation ratios are NOT reasons to apply more K fertilizer (leave bad research back in the 1940s)**

Comparison of P & K band guidelines



AGVISE Band Guidelines will build P & K soil test levels to <u>medium range</u> over 5-10 years. Assumes fertilizer is placed at safe distance from seed.

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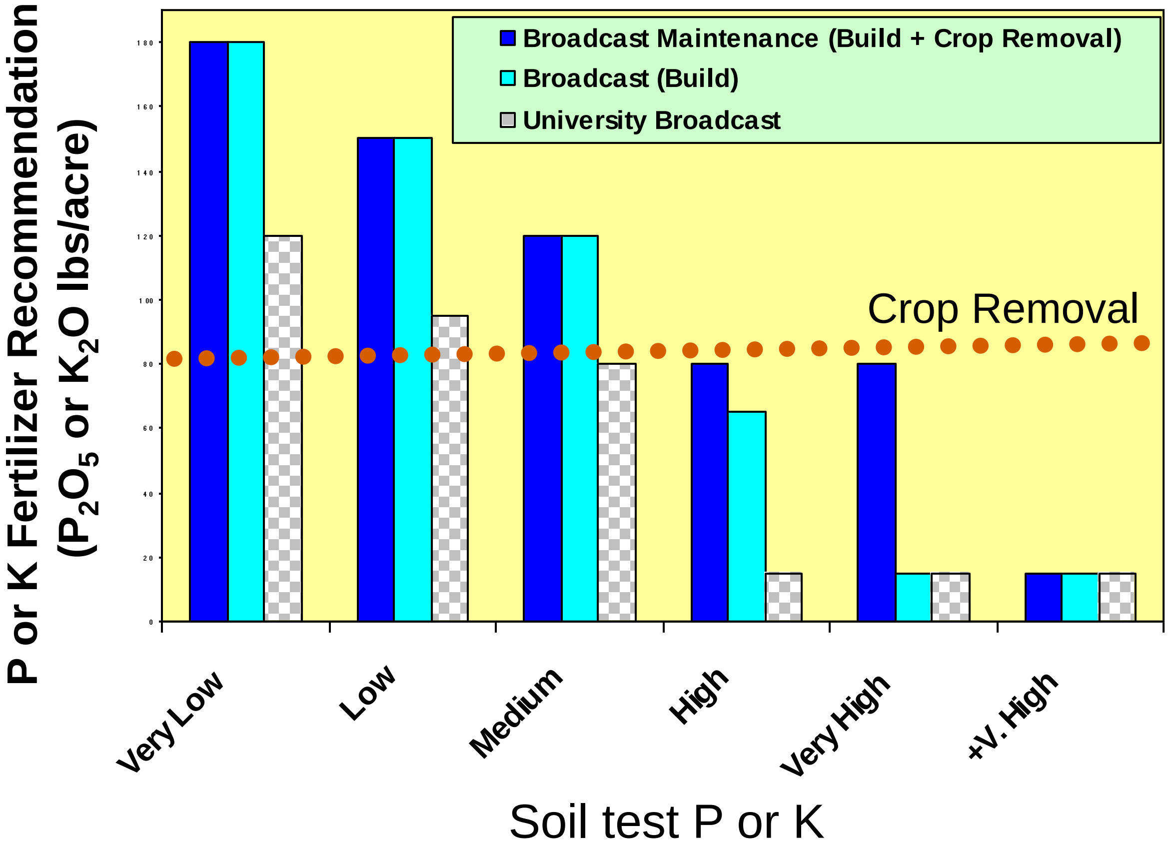
Comparison of P & K broadcast guidelines



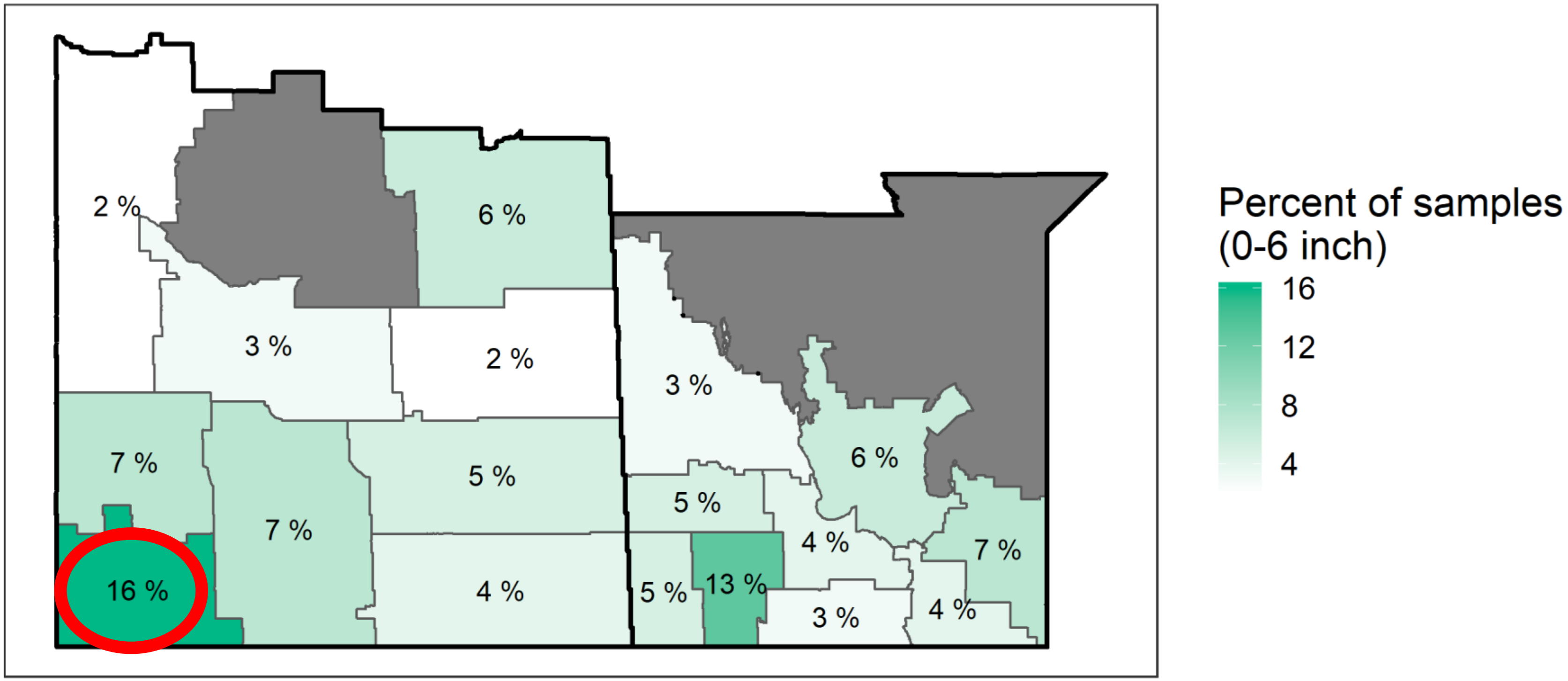
AGVISE Broadcast Guidelines will build P & K soil test levels to <u>high range</u> over 5-7 years. Rate reduced to starter amount once in high range.

Sulfur Testing (S)
0-6" and 6-24" depths

- Mobile nutrient (reported in lb/acre)
- Sensitive crops
  - Canola
  - Forages (alfalfa, clover)
  - Grasses (corn, small grains)

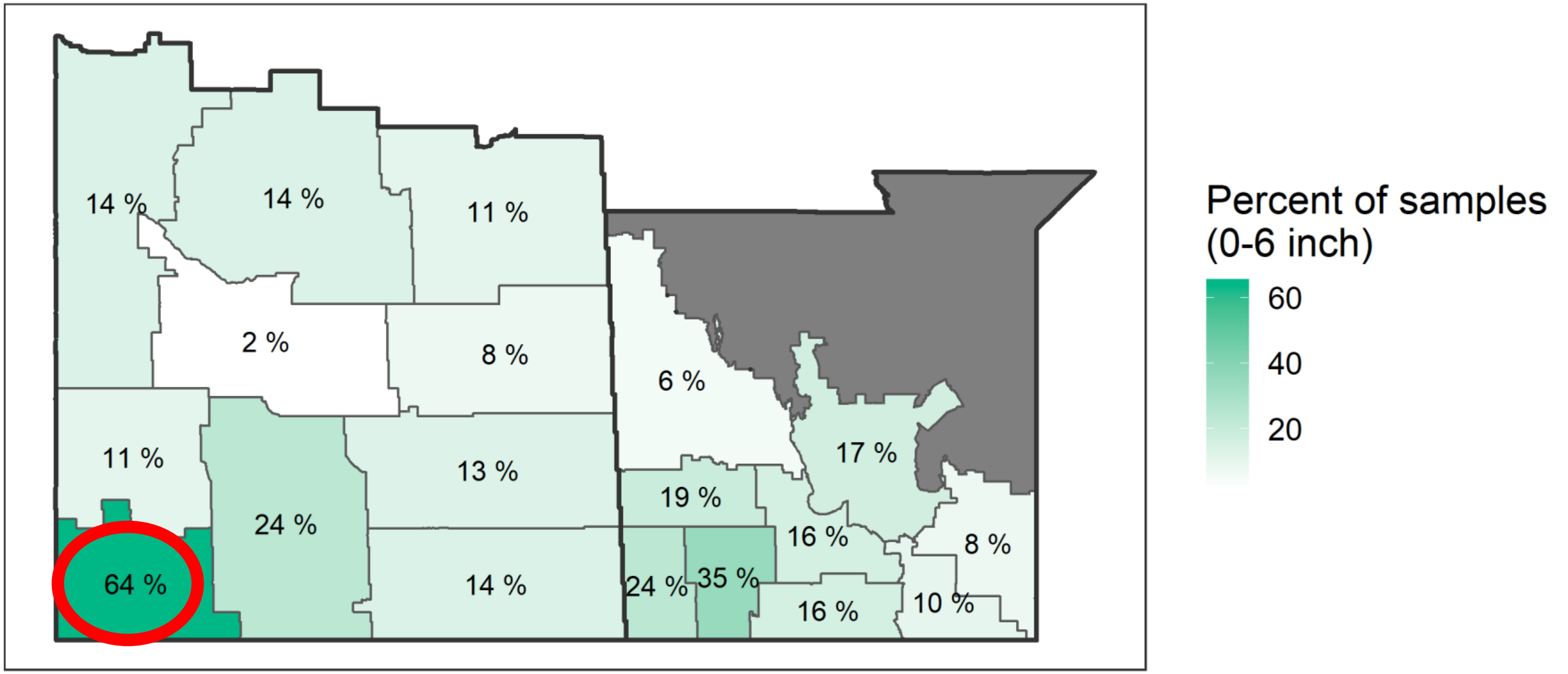
- Sulfate moves with water
  - High rainfall on well-drained soils can leach sulfate (lower sulfur)
  - High water table can bring salts and sulfate upward (higher sulfur)

Soil samples with soil test sulfur below 15 lb/acre in 2018



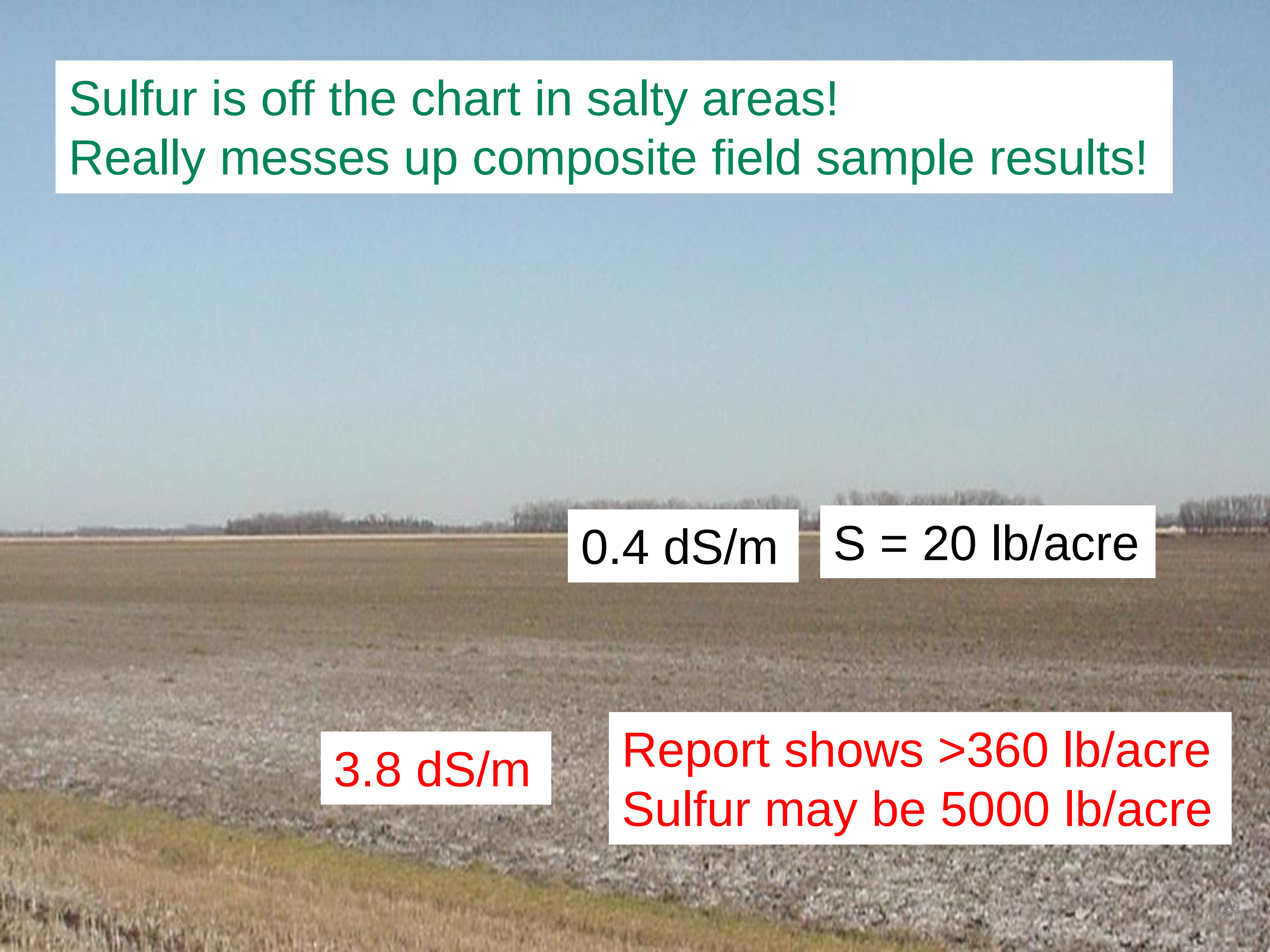
Data not shown where n< 50
AGVISE Laboratories, Northwood, ND

Soil samples with soil test sulfur below 15 lb/acre in 2019

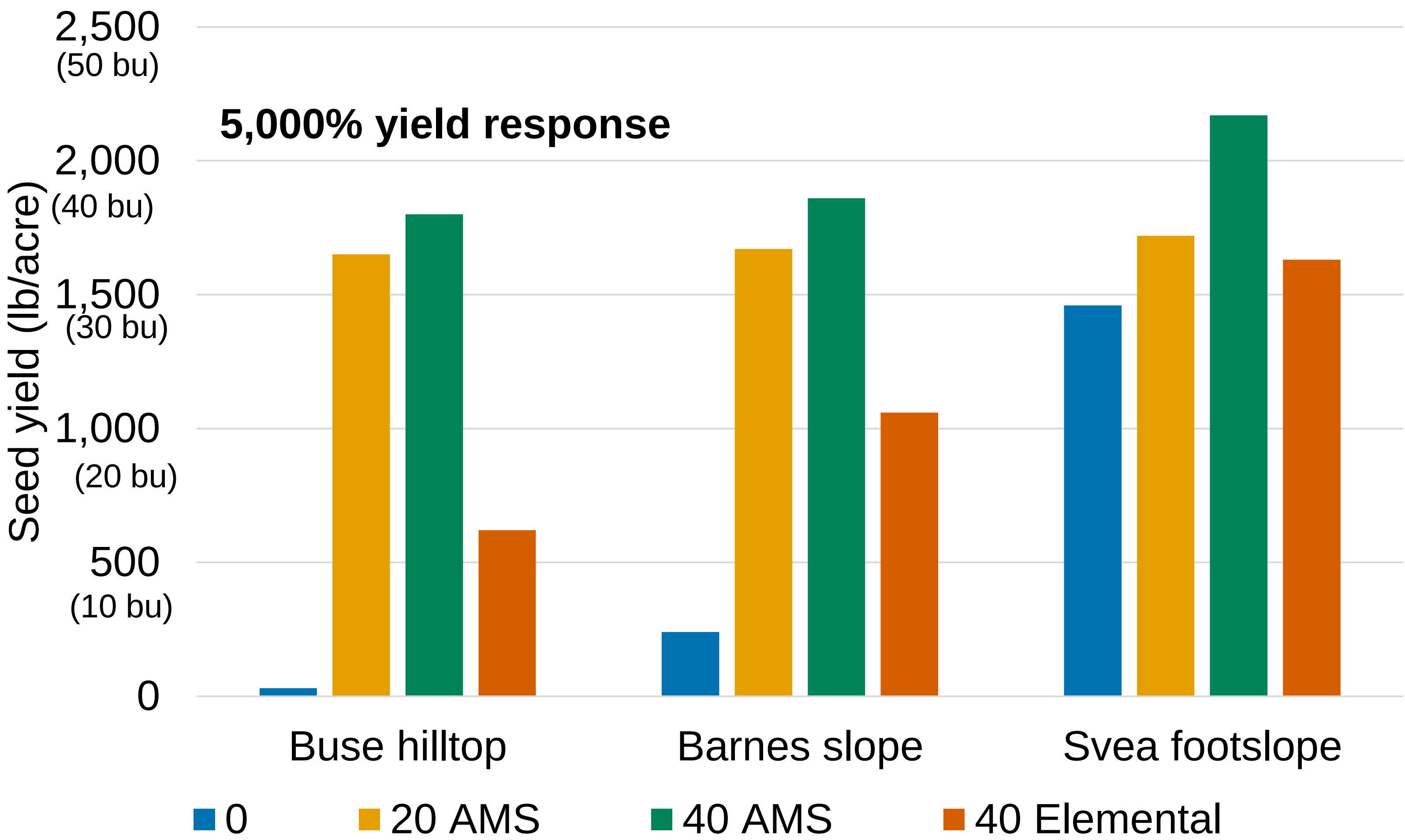


Data not shown where n< 50
AGVISE Laboratories, Northwood, ND

Sulfur is off the chart in salty areas!
Really messes up composite field sample results!



Canola response to sulfur depends on soil series-landscape position



Deibert, E.J., S. Halley, R.A. Utter, and J. Lukach. 1996. Canola response to sulfur fertilizer applications under different tillage and landscape positions. 1996 Annual report to USDA/CSREES/Special Programs North Central Reg. Canola and North Dakota Oilseed Council.

Zinc, Iron, Copper, Manganese DTPA extraction (ppm)

Micronutrient	Very low	Low	Medium	High	Very high
Zinc	<0.30	0.31-0.60	0.61-1.0	1.0-2.0	>2.0
Iron	<2.5	2.6-5.0	5.1-7.5	7.7-10.0	>10.0
Copper	<0.20	0.21-.40	0.41-0.60	0.61-0.80	>0.80
Manganese	<1.0	1.1-2.0	2.1-3.0	3.1-4.0	>4.0

Relative zinc and copper soil test levels are based on research in this region.

Relative iron and manganese soil test levels have little research in this region and should only be used in conjunction with a tissue test to confirm the nutrient deficiency.

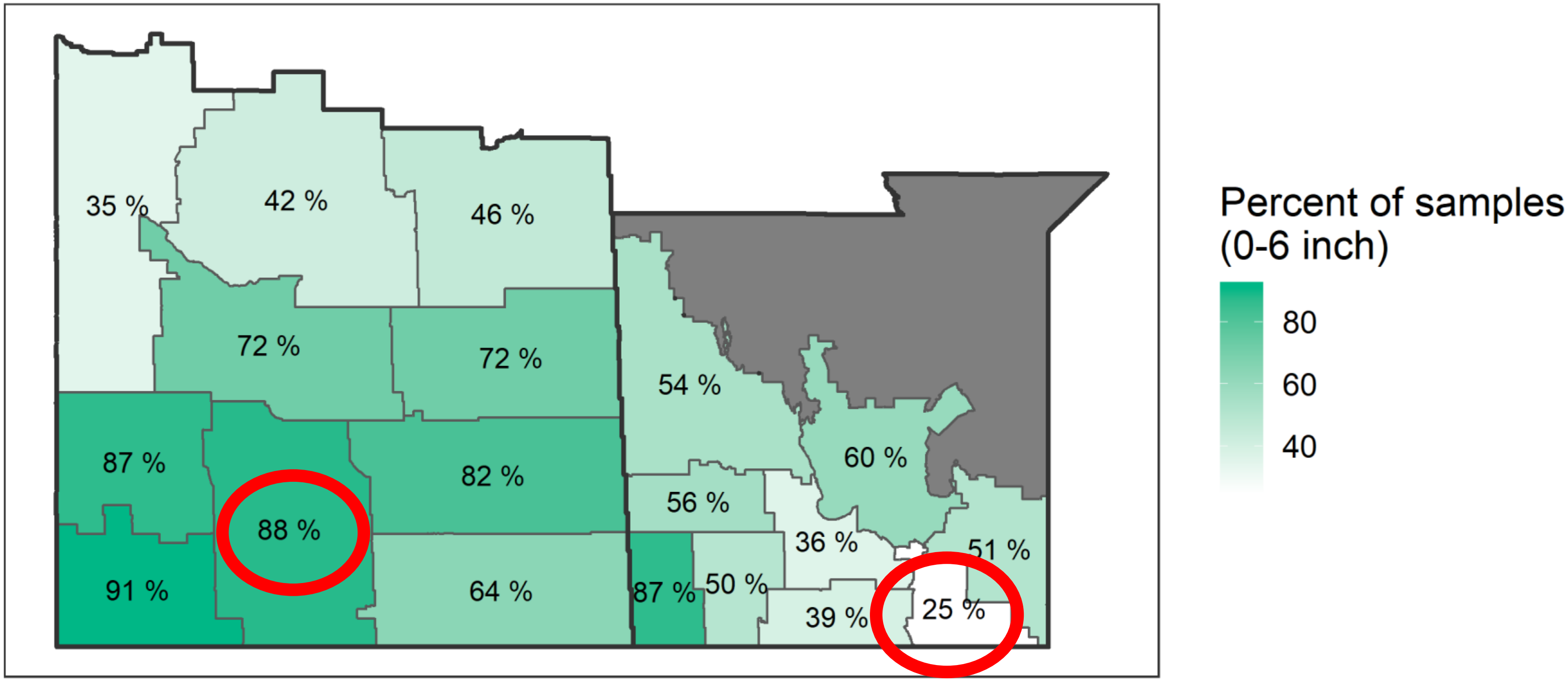
AGVISE LABORATORIES

Crop-specific zinc management
Tested on 0-6” sample only

- Corn, dry bean, flax, potato
  - Soil test zinc less than 1.0 ppm (0-6” depth)
- Low soil test zinc associated with high soil pH, high carbonate and low %OM

- Zinc fertilization
  - Zinc sulfate (36% Zn), broadcast + incorporate
  - Zinc-containing P fertilizer, broadcast or seed-placed
  - Chelated Zn, seed-placed (very common with corn)

Soil samples with soil test zinc below 1.0 ppm in 2019



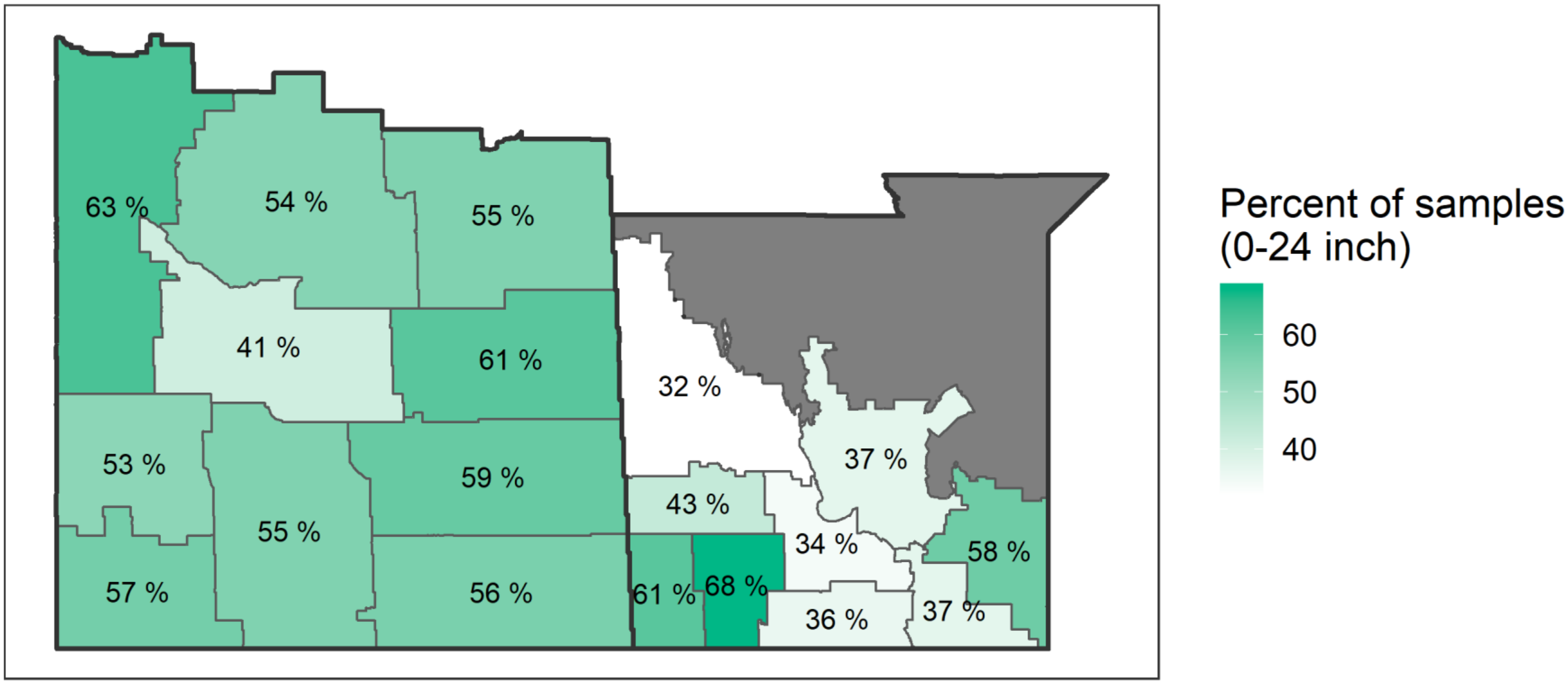
Data not shown where n< 50
AGVISE Laboratories, Northwood, ND

Crop-specific chloride management Tested on 0-24” depth

- Small grains (wheat, barley, oat)
  - Soil test chloride less than 40 lb/acre (0-24” depth)
  - Yield increase usually a few bushels
  - Disease suppression and malting quality
- Low soil chloride found where:
  - Natively low in region, except some saline areas
  - No potash (potassium chloride) application because of high soil test K
- Chloride fertilization
  - Potassium chloride (0-0-60), cheapest and available
  - Ammonium chloride (25-0-0-64Cl)
  - Broadcast or band are effective, chloride is mobile
  - Watch N + K_2O rate with seed-placed fertilizer

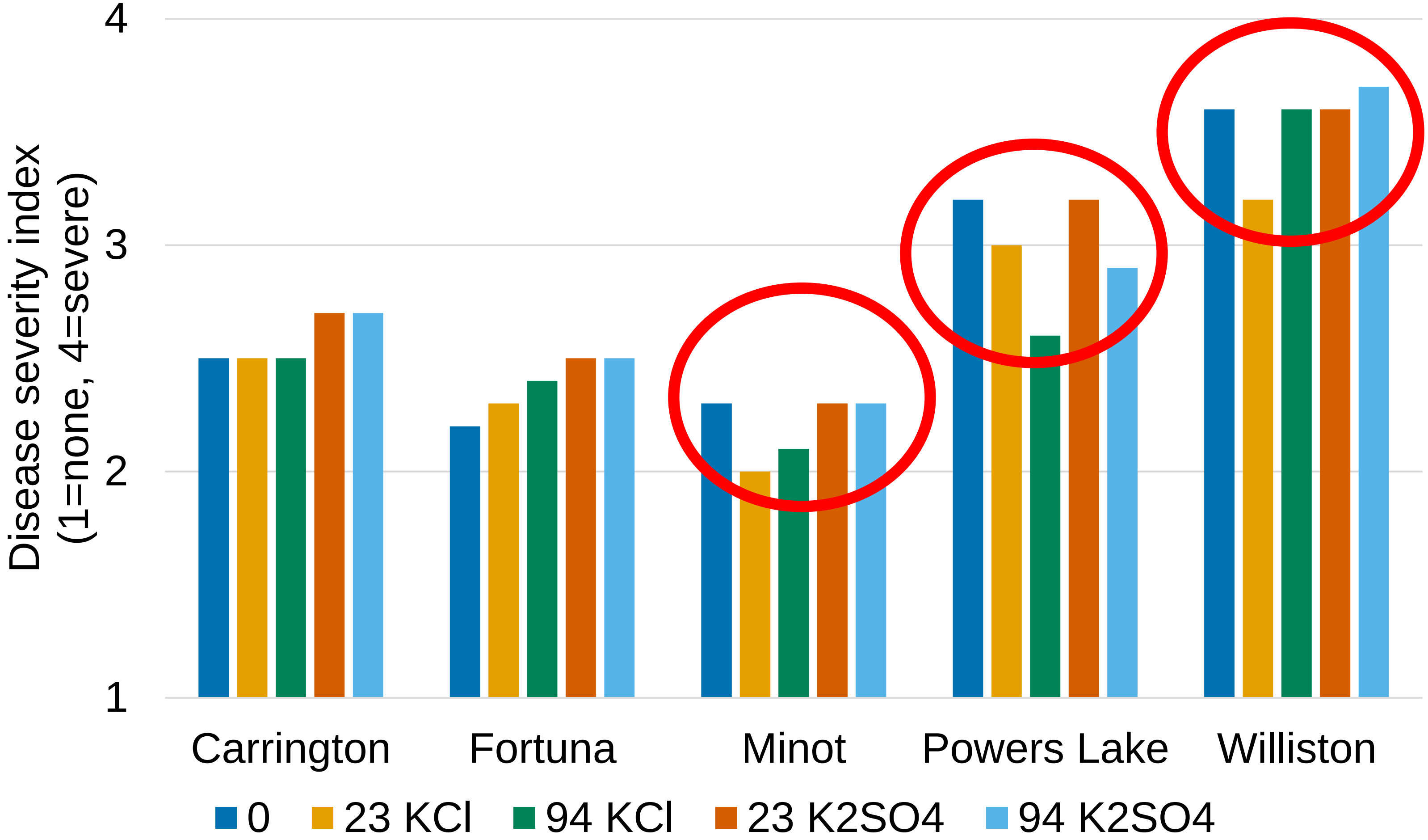
AGVISE LABORATORIES

Soil samples with soil test chloride below 40 lb/acre in 2019



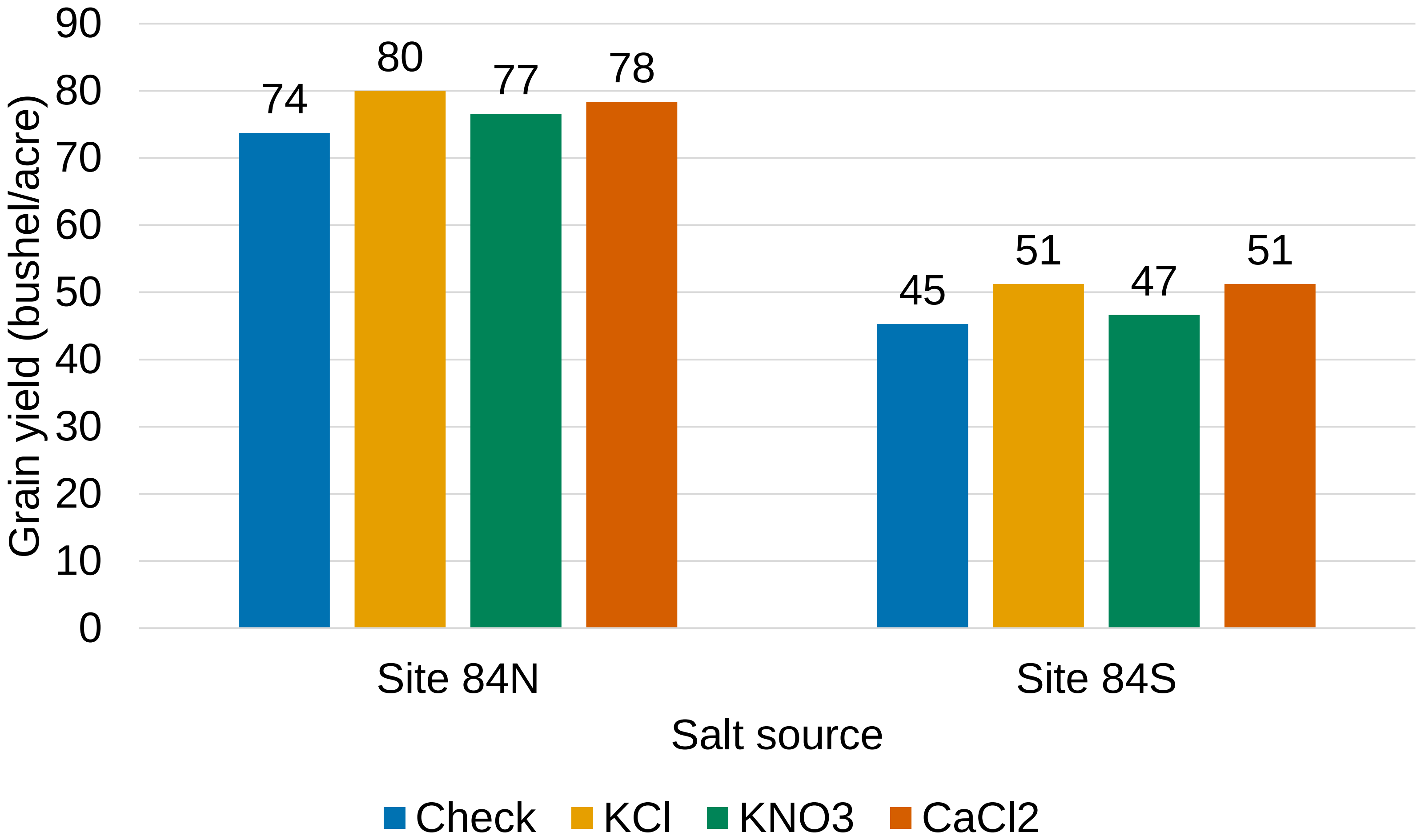
Data not shown where n< 50
AGVISE Laboratories, Northwood, ND

Chloride reduced common root rot severity in barley



Timm, C.A., R.J. Goos, B.E. Johnson, F.J. Sobolik, and R.W. Stack. 1986. Effect of potassium fertilizers on malting barley infected with common root rot. Agron. J. 78(1):197–200.

Wheat yield response to chloride



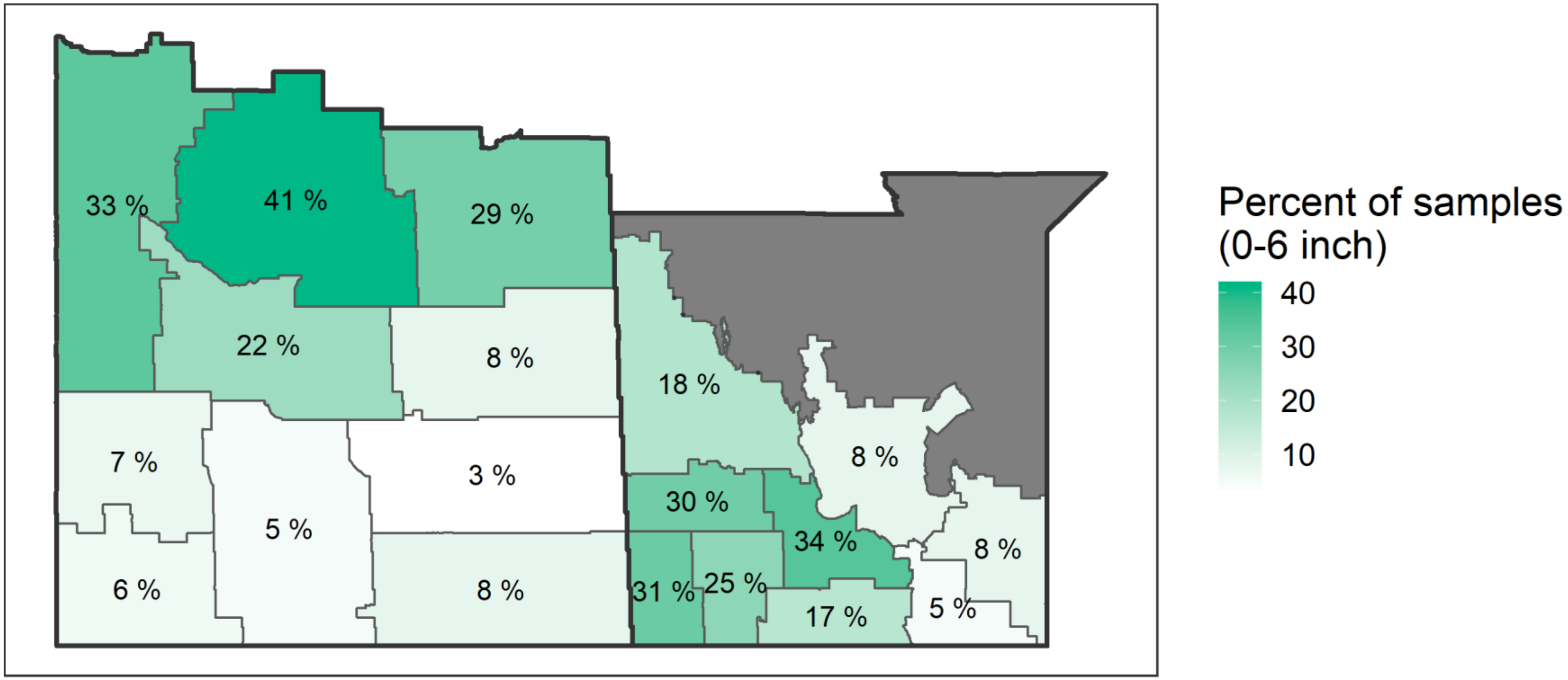
Fixen, P.E., R.H. Gelderman, J. Gerwing, and F.A. Cholick. 1986. Response of spring wheat, barley, and oats to chloride in potassium chloride fertilizers. Agron. J. 78(4):664–668.

Crop-specific copper management Tested on 0-6" sample

- Small grains (wheat, barley, oat), rarely canola
  - Soil test copper less than 0.5 ppm (0-6" depth)
  - Disease suppression (Fusarium head blight)
- Low soil test copper found where:
  - Low organic matter, eroded hilltops, sandy soils
  - Peat soils, where soil test Mn:Cu ratio>15
- Copper fertilization
  - Copper sulfate (25% Cu), broadcast + incorporate
  - Chelated Cu, seed-placed or foliar

AGVISE LABORATORIES

Soil samples with soil test copper below 0.5 ppm in 2019



Data not shown where n< 50
AGVISE Laboratories, Northwood, ND

Crop-specific Boron management Tested on 0-6” sample

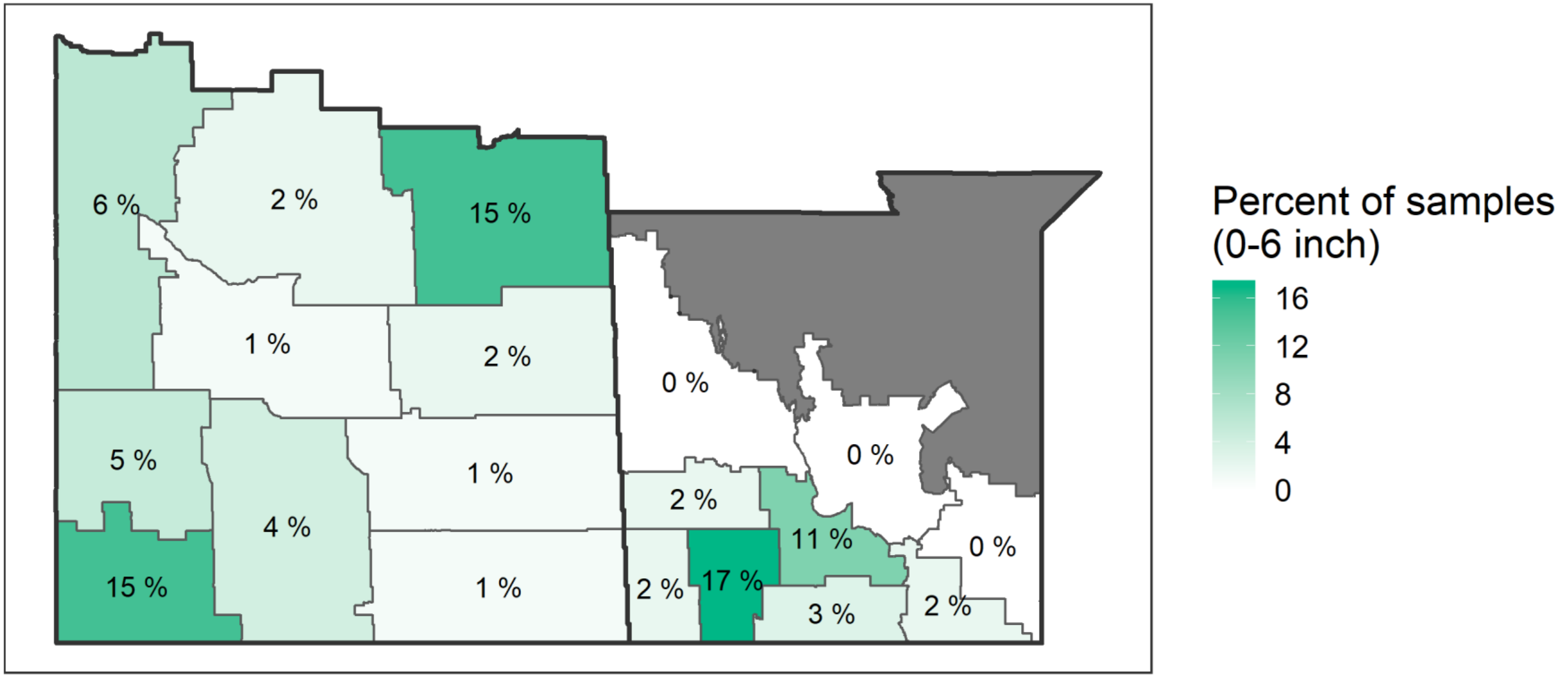
- Alfalfa, legumes, rarely on canola
  - Soil test boron less than 0.8 ppm (DTPA))(0-6”)
  - High removal amount with forages

- Low soil test boron found where:
  - Low organic matter, sandy soils

- Boron fertilization (be careful – none with seed)
  - Toxic when applied at high levels
  - 1-2 lb/a applied to soil/year at most

AGVISE LABORATORIES

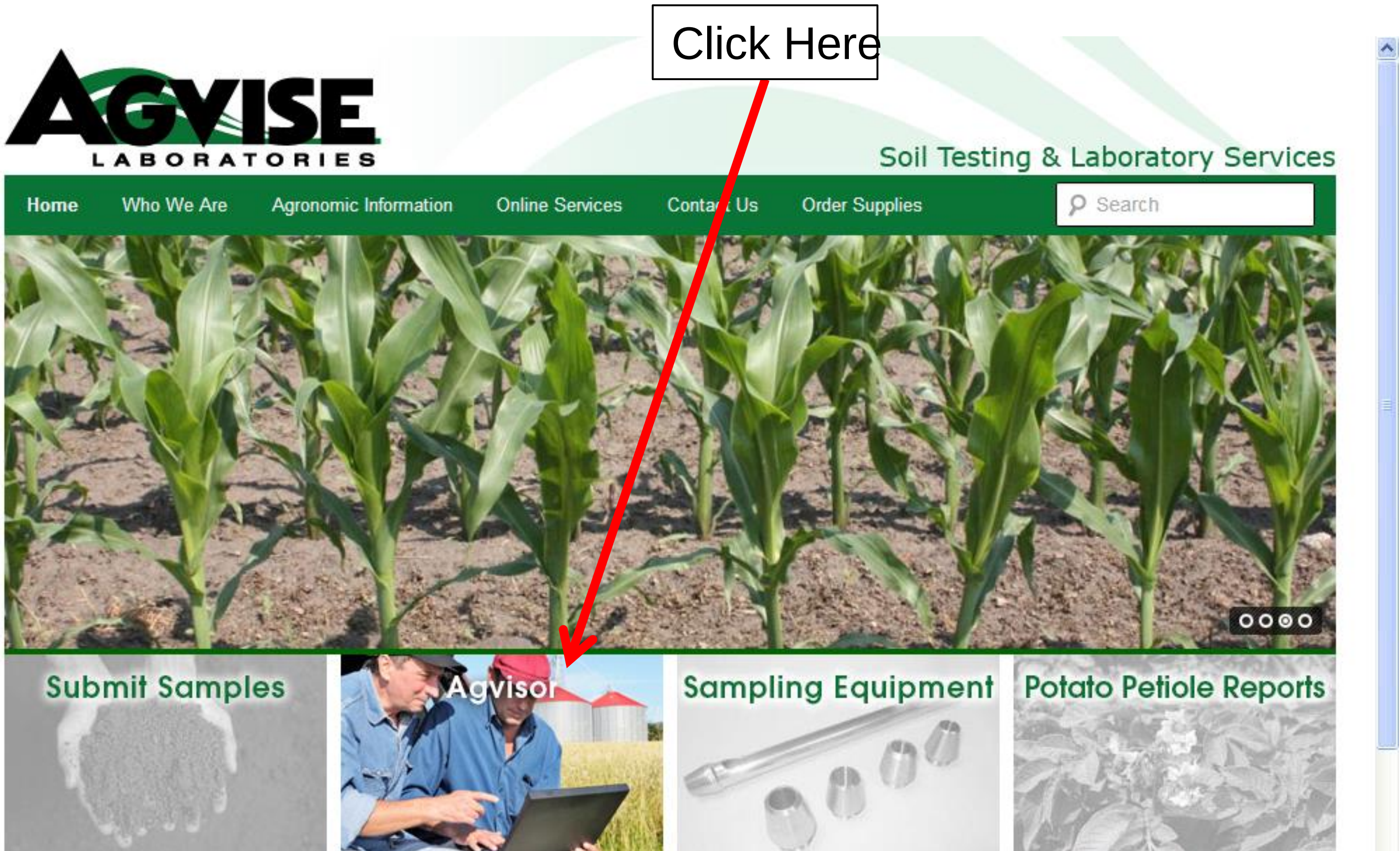
Soil samples with soil test boron below 0.4 ppm in 2019



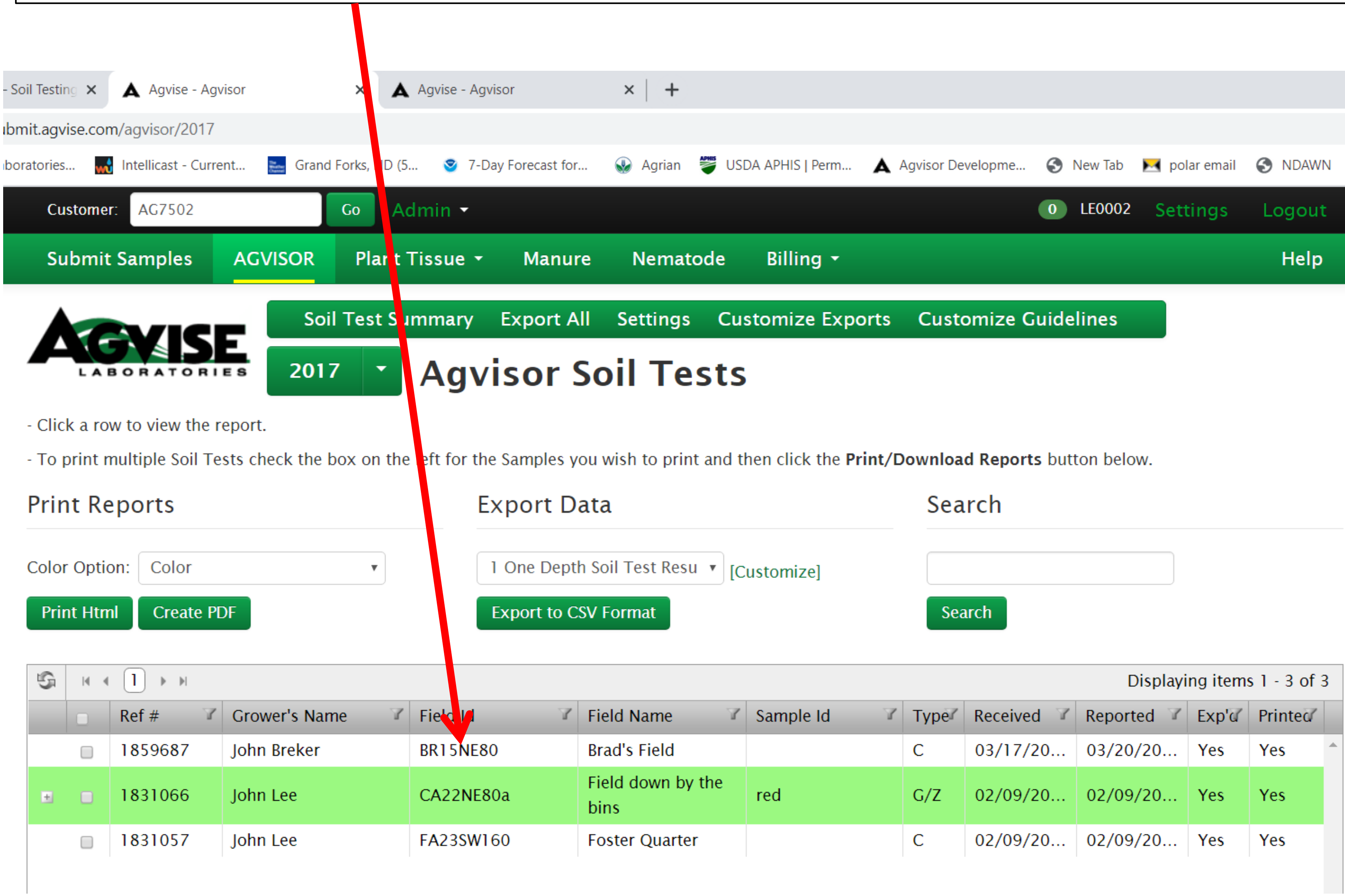
Data not shown where n< 50
AGVISE Laboratories, Northwood, ND

Changing the Crop Choice, Yield Goal, or Fertilizer Guideline on a Soil Report

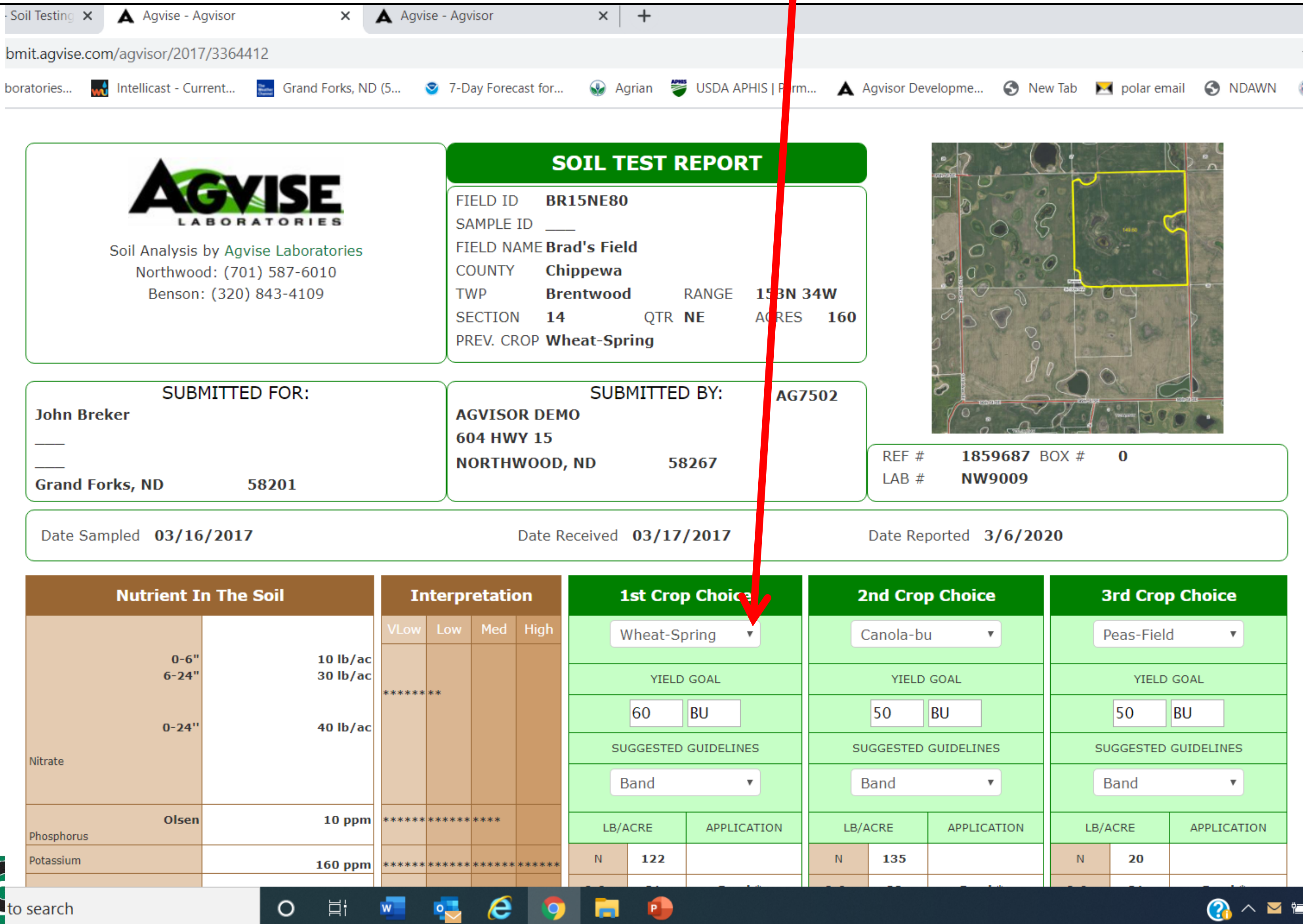
Go to www.agvise.com and login to the AGVISOR program



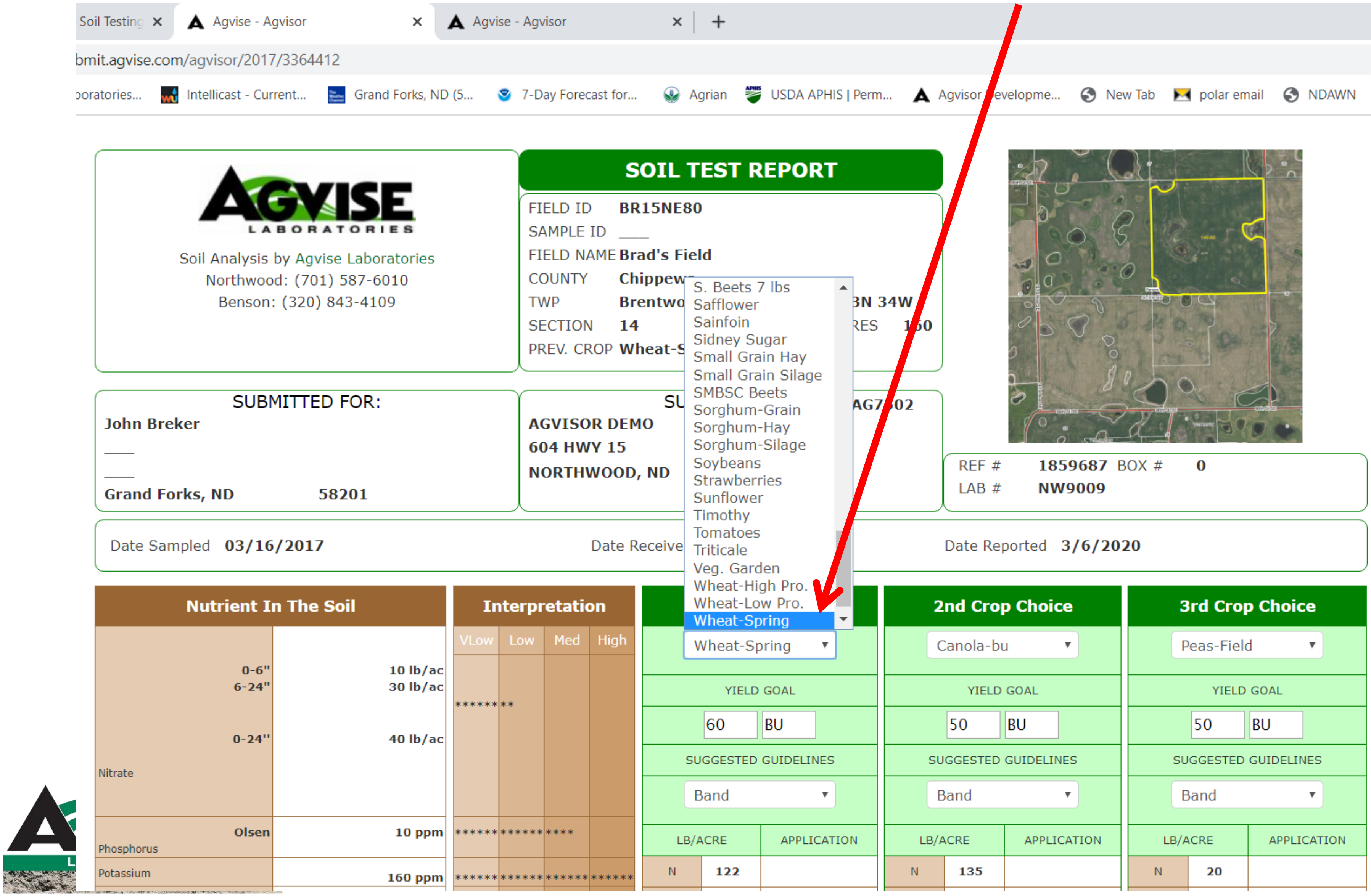
Click on “Field ID” of Soil Report you want to make changes to



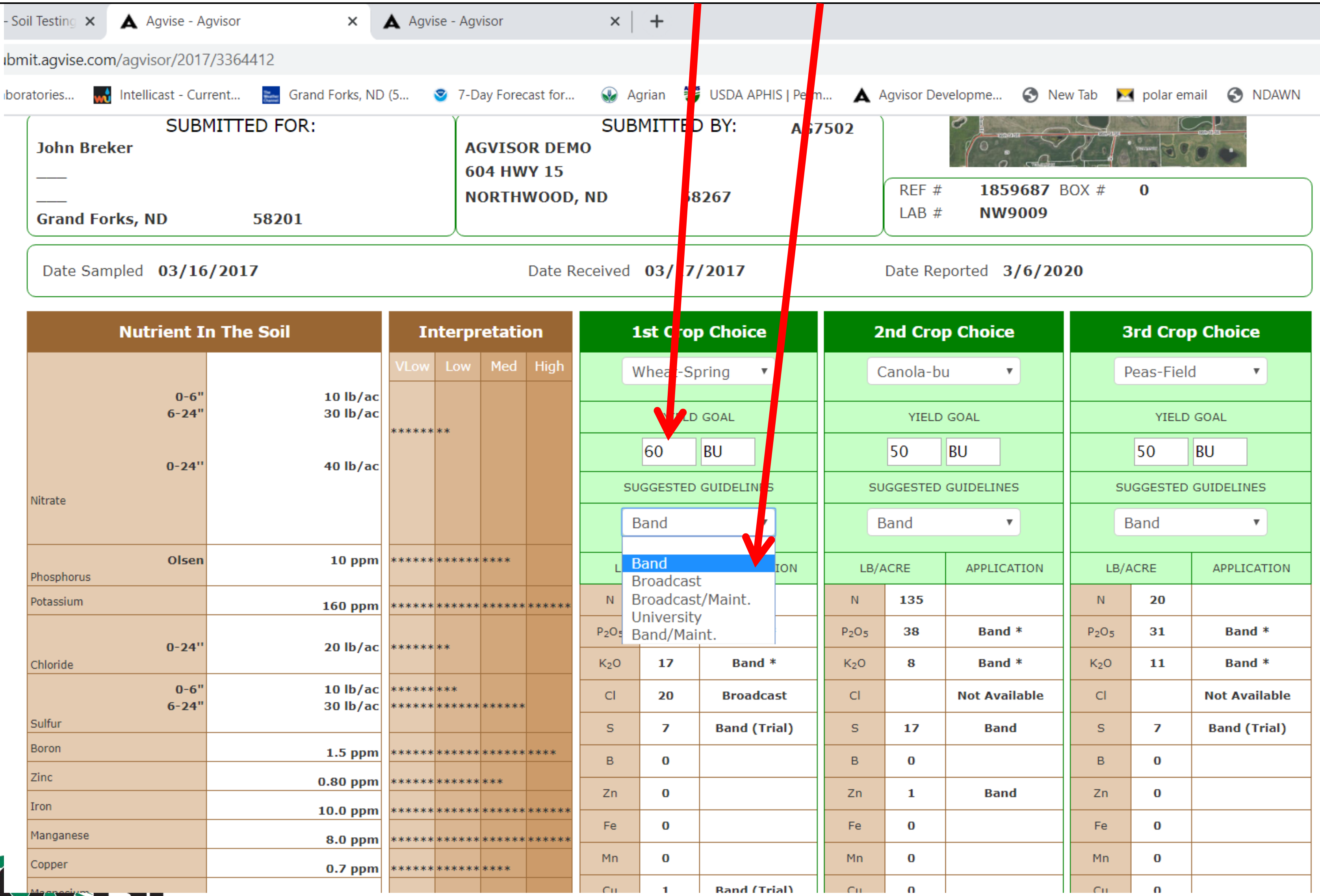
To change the crop choice, click on the down arrow to the right of the current crop choice.



Scroll up or down the list of crop choices and select the new crop choice your want.



Type in the "yield goal" for the new crop choice and select the P & K fertilizer placement guideline option for the new crop and yield goal.


- Soil Testing ✕ | Agvise - Agvisor ✕ | Agvise - Agvisor ✕ | +

ıbmit.agvise.com/agvisor/2017/3364412

ıboratories... | Intellicast - Current... | Grand Forks, ND (5... | 7-Day Forecast for... | Agrian | USDA APHIS | Pe...m... | Agvisor Developme... | New Tab | polar email | NDAWN

SUBMITTED FOR:
John Breker
___
___
Grand Forks, ND 58201

SUBMITTED BY: A_7502
AGVISOR DEMO
604 HWY 15
NORTHWOOD, ND _8267

REF # 1859687 BOX # 0
LAB # NW9009

Date Sampled 03/16/2017 | Date Received 03/_7/2017 | Date Reported 3/6/2020

Nutrient In The Soil			Interpretation	1st Crop Choice		2nd Crop Choice			3rd Crop Choice		
			VLow / Low / Med / High	Whea_-Spring		Canola-bu			Peas-Field		
				YIELD GOAL		YIELD GOAL			YIELD GOAL		
				60 BU		50 BU			50 BU		
				SUGGESTED GUIDELINES		SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
				Band (Band / Broadcast / Broadcast/Maint. / University / Band/Maint.)		Band			Band		
				L...	...ION		LB/ACRE	APPLICATION		LB/ACRE	APPLICATION
Nitrate	0-6" / 6-24"	10 lb/ac / 30 lb/ac		N		N	135		N	20	
	0-24"	40 lb/ac	********								
Phosphorus	Olsen	10 ppm	****************	P_2O_5		P_2O_5	38	Band *	P_2O_5	31	Band *
Potassium		160 ppm	************************	K_2O 17	Band *	K_2O	8	Band *	K_2O	11	Band *
Chloride	0-24"	20 lb/ac	********	Cl 20	Broadcast	Cl		Not Available	Cl		Not Available
Sulfur	0-6" / 6-24"	10 lb/ac / 30 lb/ac	********* / ******************	S 7	Band (Trial)	S	17	Band	S	7	Band (Trial)
Boron		1.5 ppm	**********************	B 0		B	0		B	0	
Zinc		0.80 ppm	*****************	Zn 0		Zn	1	Band	Zn	0	
Iron		10.0 ppm	************************	Fe 0		Fe	0		Fe	0	
Manganese		8.0 ppm	************************	Mn 0		Mn	0		Mn	0	
Copper		0.7 ppm	****************	Cu 1	Band (Trial)	Cu	0		Cu	0	

Once you have selected the new crop choice, yield goal and fertilizer guideline type the fertilizer guidelines are calculated and saved. AGVISOR allows you to have three cop choices or different yield goals

SUBMITTED FOR:	SUBMITTED BY: AG7502	
John Breker	**AGVISOR DEMO**	REF # **1859687** BOX # **0**
____	**604 HWY 15**	LAB # **NW9009**
____	**NORTHWOOD, ND 58267**	
Grand Forks, ND 58201		

Date Sampled **03/16/2017** Date Received **03/17/2017** Date Reported **3/6/2020**

Nutrient In The Soil			Interpretation (VLow / Low / Med / High)
Nitrate	**0-6"** **6-24"** **0-24"**	**10 lb/ac** **30 lb/ac** **40 lb/ac**	**********
Phosphorus	**Olsen**	**10 ppm**	*****************
Potassium		**160 ppm**	************************
Chloride	**0-24"**	**20 lb/ac**	**********
Sulfur	**0-6"** **6-24"**	**10 lb/ac** **30 lb/ac**	********* ******************
Boron		**1.5 ppm**	**********************
Zinc		**0.80 ppm**	***************
Iron		**10.0 ppm**	************************
Manganese		**8.0 ppm**	************************
Copper		**0.7 ppm**	****************
Magnesium		[illegible]	[illegible]

	1st Crop Choice		2nd Crop Choice		3rd Crop Choice	
Crop	Wheat-Spring		Canola-bu		Peas-Field	
YIELD GOAL	60 BU		50 BU		50 BU	
SUGGESTED GUIDELINES	Band		Band		Band	
	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION
N	**122**		**135**		**20**	
P_2O_5	**31**	**Band ***	**38**	**Band ***	**31**	**Band ***
K_2O	**17**	**Band ***	**8**	**Band ***	**11**	**Band ***
Cl	**20**	**Broadcast**		**Not Available**		**Not Available**
S	**7**	**Band (Trial)**	**17**	**Band**	**7**	**Band (Trial)**
B	**0**		**0**		**0**	
Zn	**0**		**1**	**Band**	**0**	
Fe	**0**		**0**		**0**	
Mn	**0**		**0**		**0**	
Cu	**1**	**Band (Trial)**	**0**		**0**	

AGVISE LABORATORIES

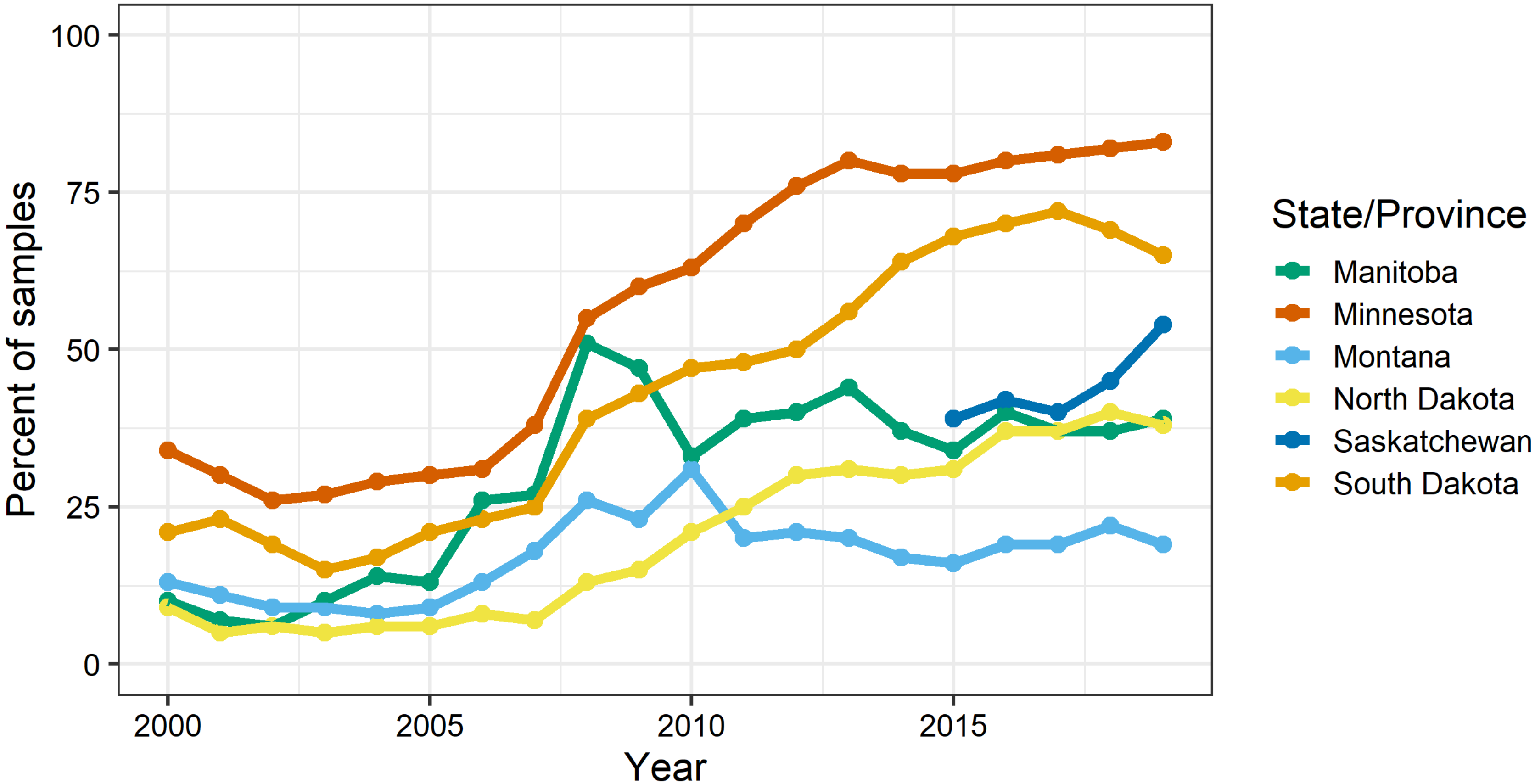
AGVISOR Features

- View and print soil reports
- Change crop choice, yield goal and fertilizer guideline type (band vs broadcast)
- Save report in pdf format to email to growers
- Customize the N factor for each crop
- Create custom data format exports as csv
- Submit soil samples online (no paper work!)

AGVISE LABORATORIES

Soil samples collected as a precision sample (grid or zone)

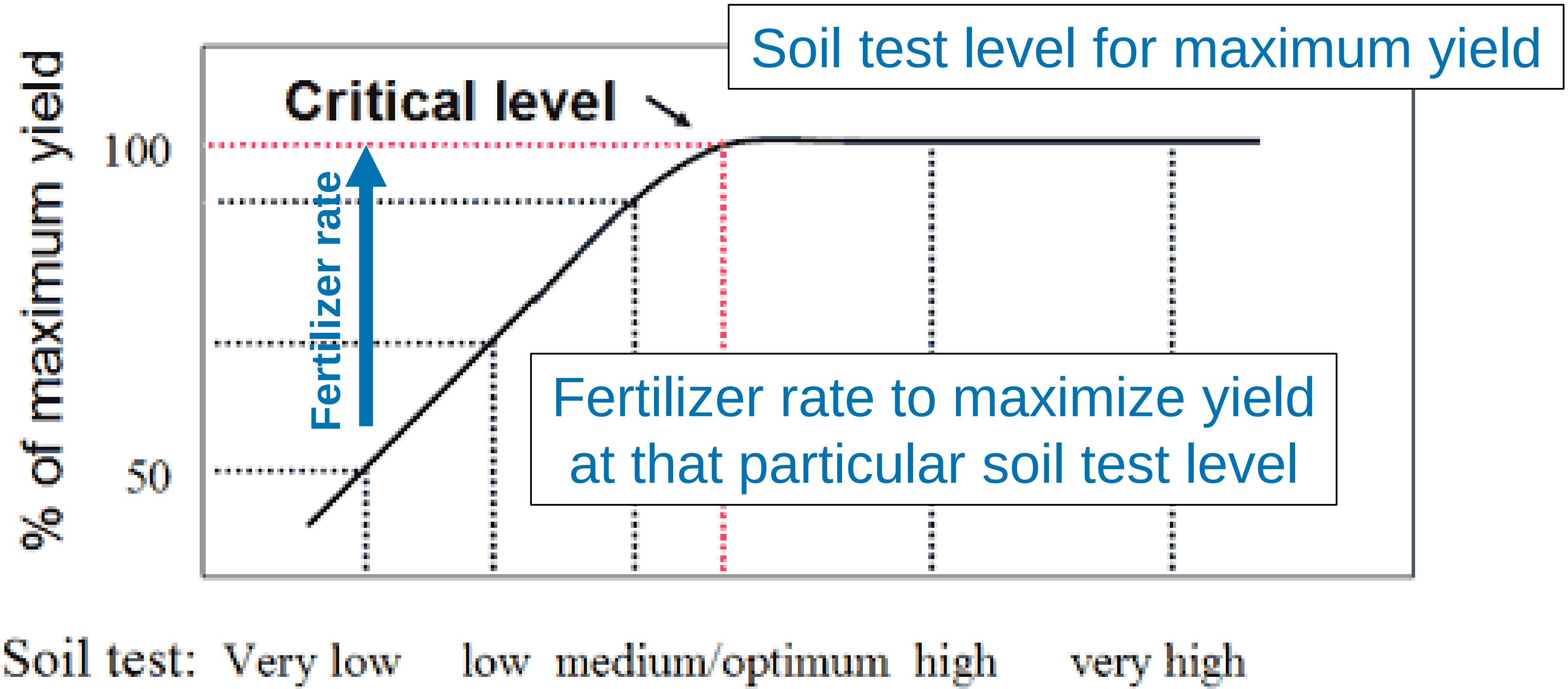
Trend from 2000 to 2019



Data not shown where n< 100
AGVISE Laboratories, Northwood, ND


Thank You
Questions?

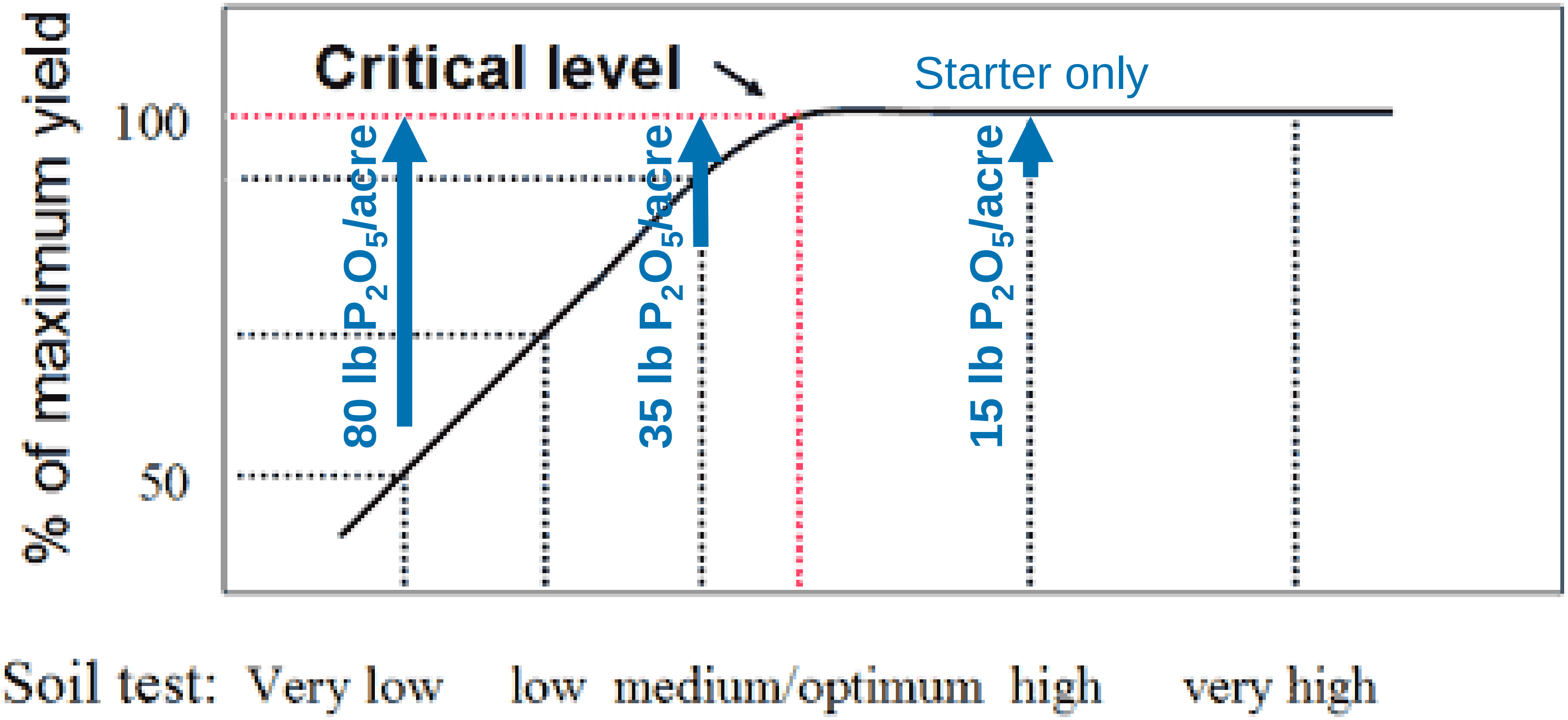
Soil test correlation and calibration
Find the soil test level and fertilizer rate



Optimum fertilizer rate determined with multiple replicated field trials across a range of soil test levels

Image from https://courses.cit.cornell.edu/css412/mod3/ext_m3_pg3.htm

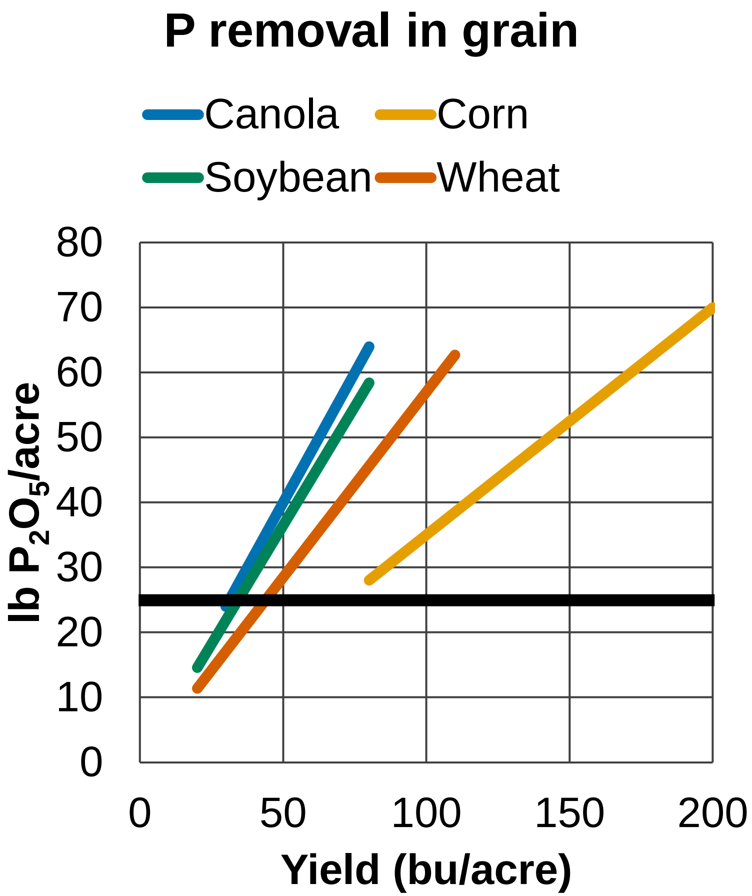
Different fertilizer rates required for different soil test levels

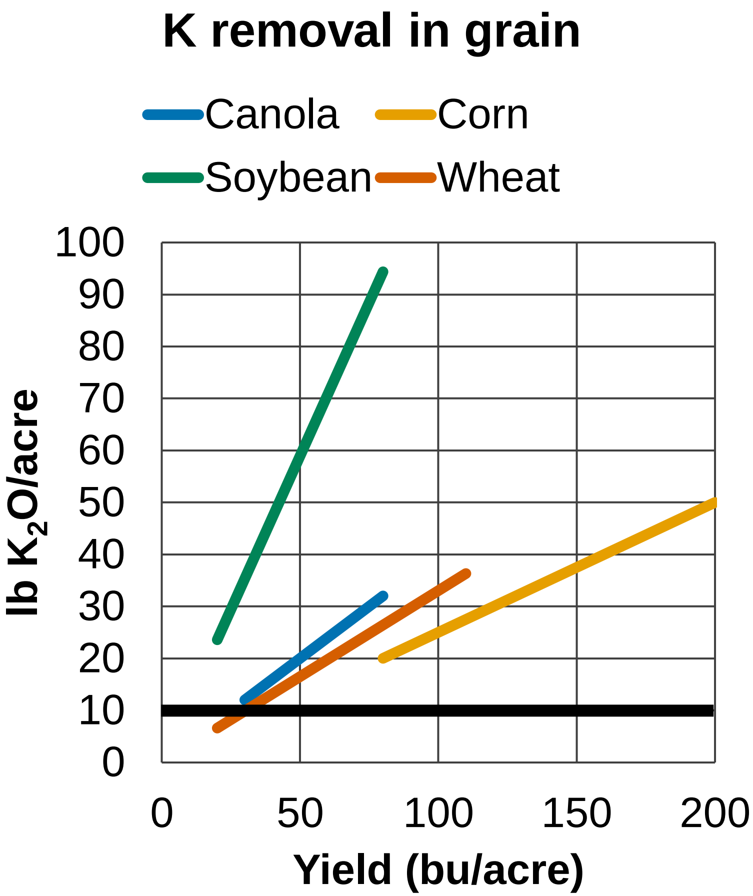


Olsen P (ppm) **0-3** **12-15** **20-40**

Image from https://courses.cit.cornell.edu/css412/mod3/ext_m3_pg3.htm

Is seed-placed P & K your only P & K application?





Canola bushel weight: 50 lb/bu, 2000 lb/acre = 40 bu/acre

More growers asking about "base saturation" and "cation ratios"

- Base saturation is a calculation showing percentage of each cation, relative to total cations
  - Calcium (Ca^{2+}) 5,000 ppm (65-78%)
  - Magnesium (Mg^{2+}) 1,000 ppm (15-35%)
  - Potassium (K^{+}) 150 ppm (1-7%)
  - Sodium (Na^{+}) 50 ppm (0-5%)
- Poor research from 1930s and 1940s suggested an "optimum" percentage range of each cation for an "ideal soil" to achieve high yields
- Research from <u>1930s through today</u> has shown percentage of each cation is not important and does not limit crop yield
- What is important? Part per million (ppm) of each cation!

AGVISE LABORATORIES

AGVISE Demonstration Project

Illustrate one simple flaw in base cation saturation ratio concept

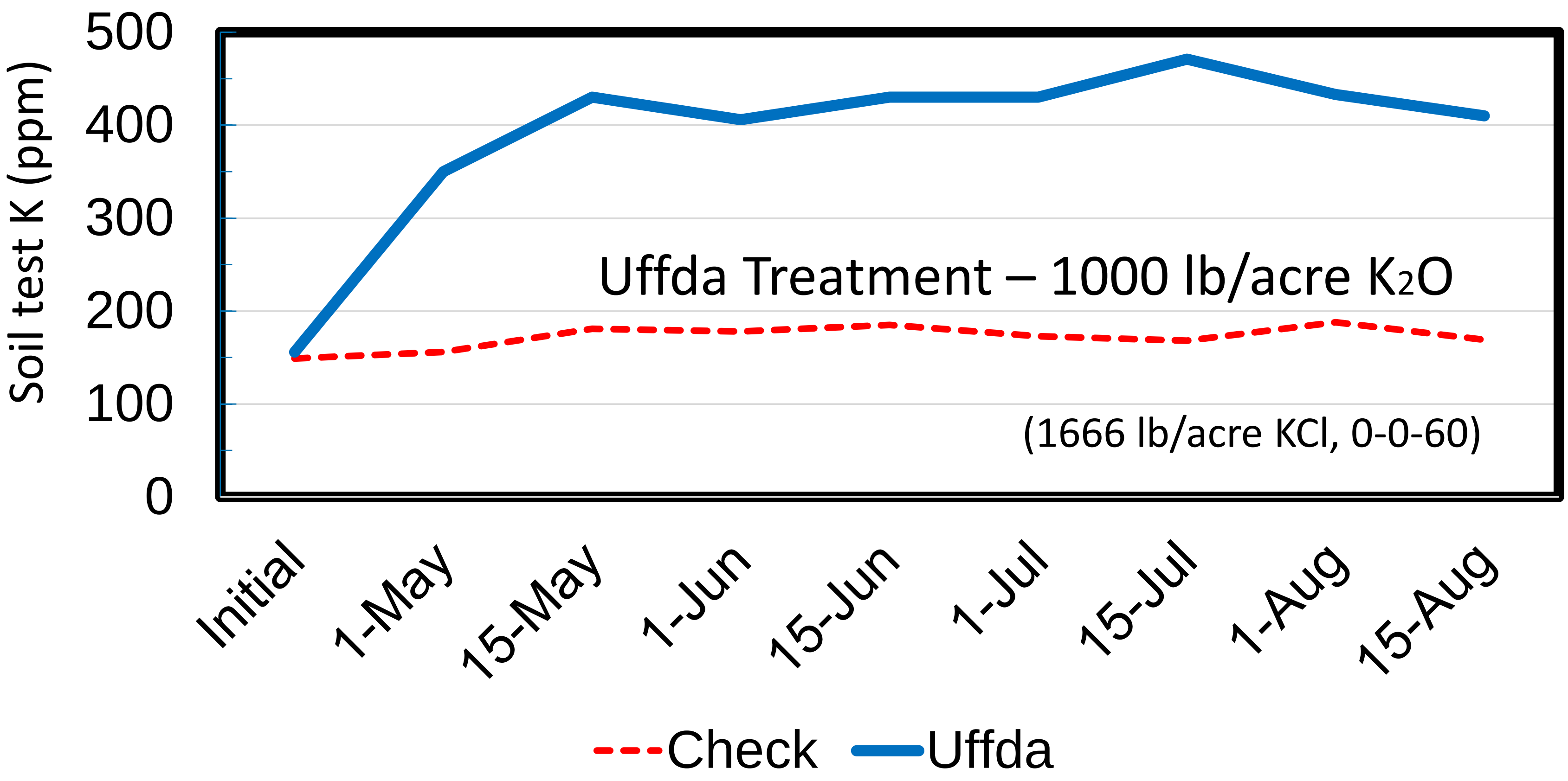
Can you increase the %K saturation to the reported 4-8% range?

<u>The Uffda Project</u>

Apply 1000 lb/acre K_2O

(1666 lb/acre KCl, 0-0-60)

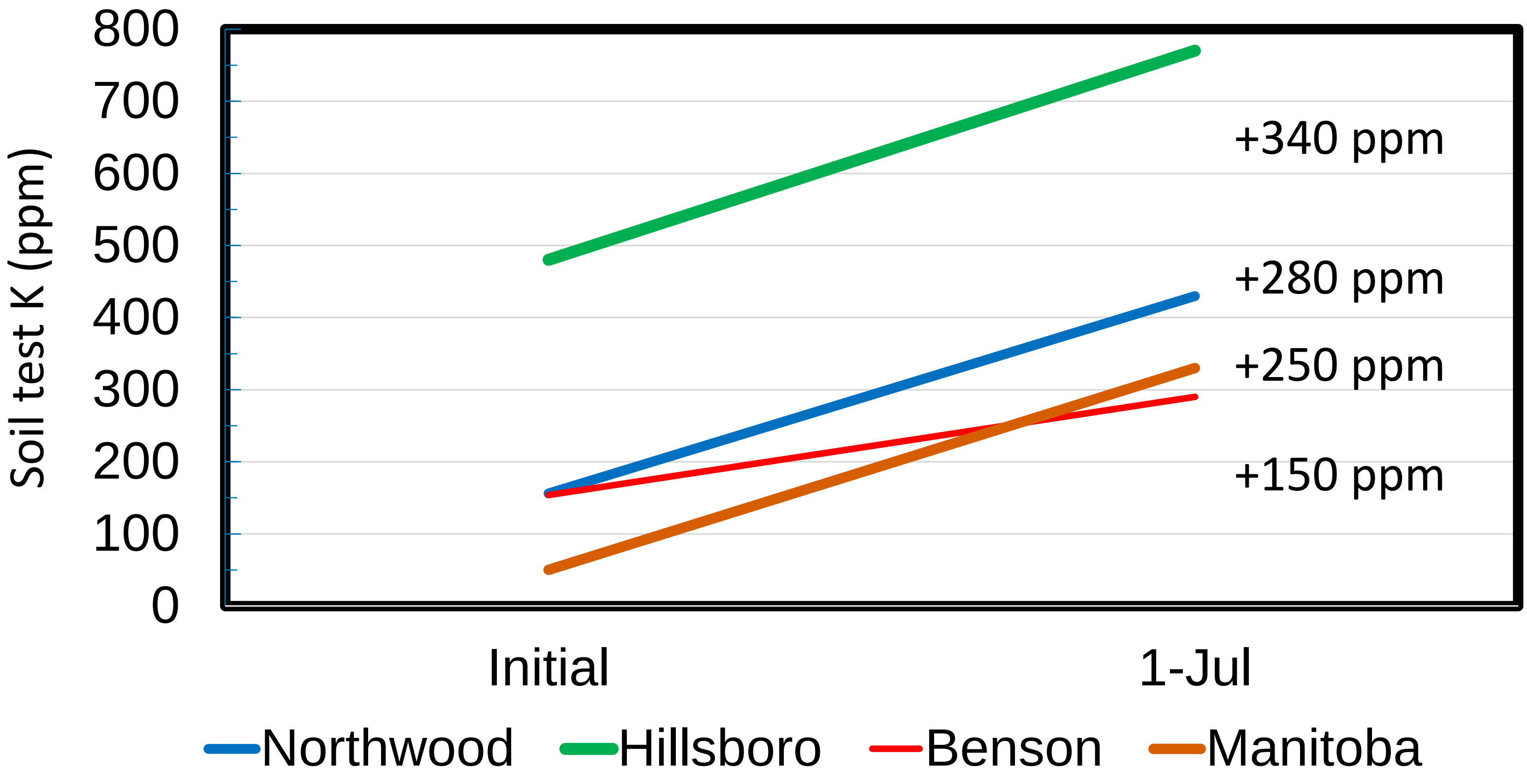
Uffda Project – Northwood, ND
1000 lb/acre K_2O on soil test K (ppm)



AGVISE LABORATORIES

Sandy clay loam, EC 2.0 dS/m, carbonate 6.0%, pH 8.0

1000 lb/acre K_2O consistently increased soil test K (ppm)



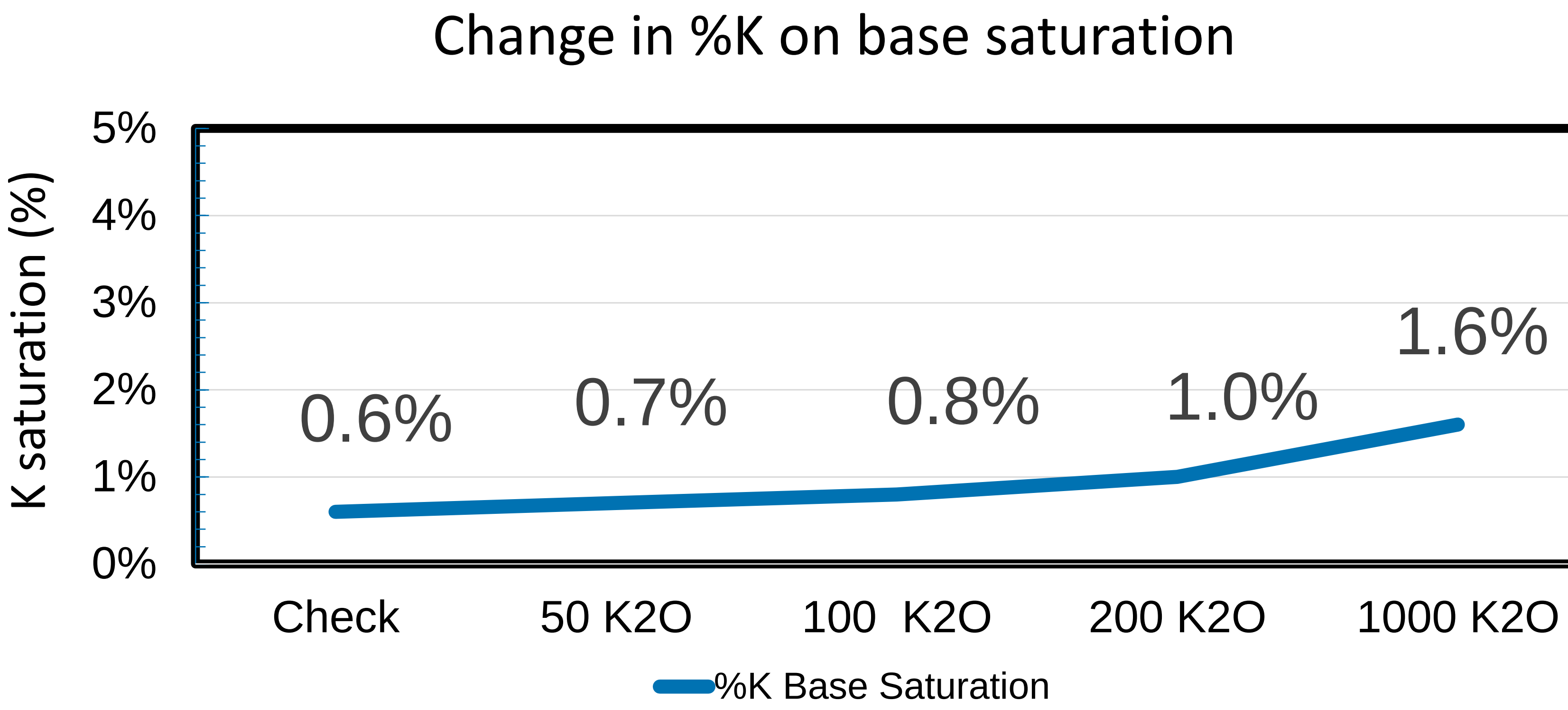
Uffda Project Conclusion #1

- Did soil test K increase after large fertilizer K application? **YES!**
  - Soil test K increased 150-350 ppm on 4 sites

- Would fertilizer K still be recommended based on the soil test K (ppm) after this large application? **NO!**
  - Soil test K critical level is 150 ppm

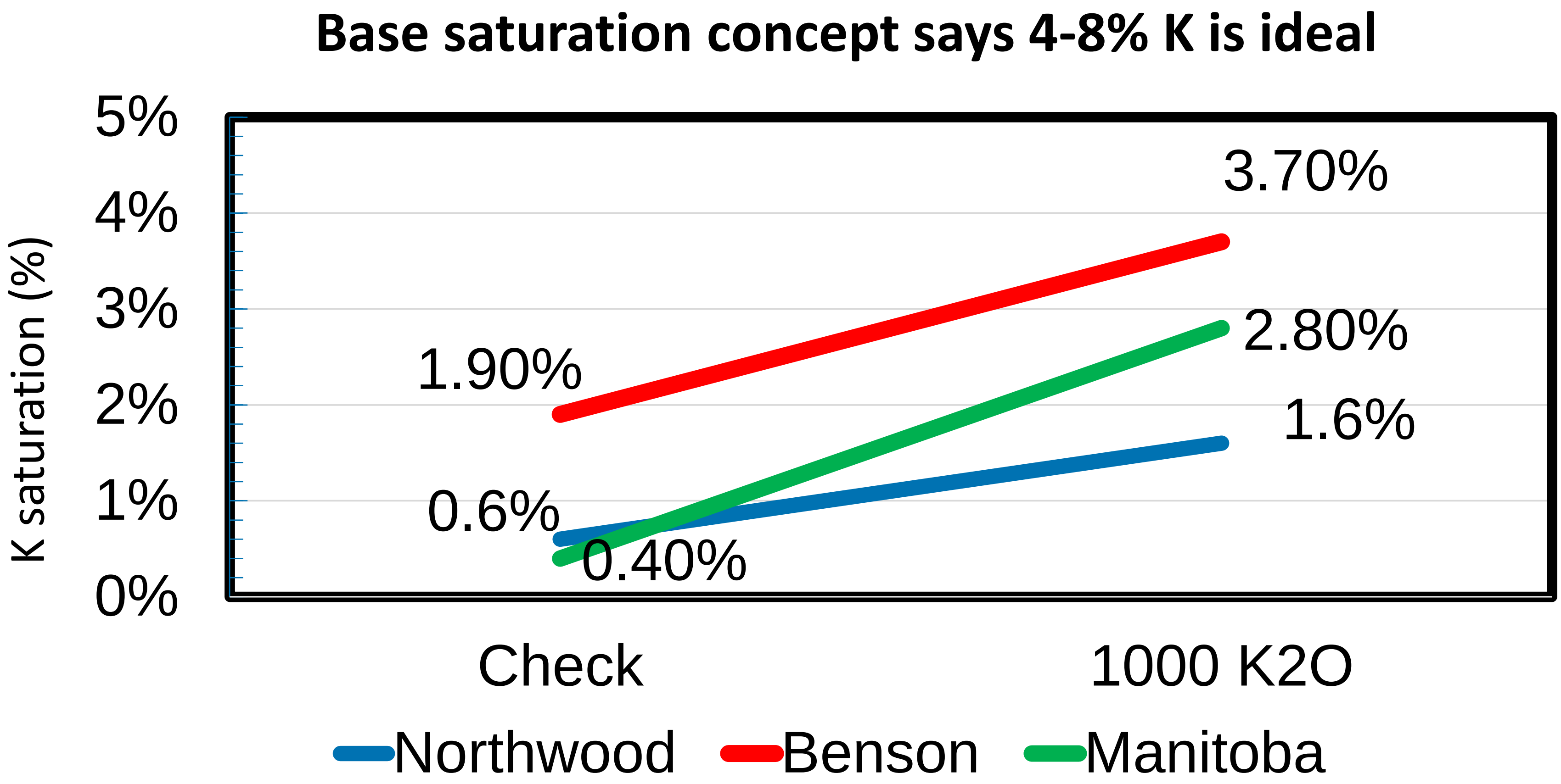
AGVISE LABORATORIES

Did 1000 lb/acre K_2O change %K on soil test? – Northwood, ND



Sandy clay loam, EC 2.0 dS/m, carbonate 6.0%, pH 8.0

1000 lb/acre K_2O increased %K by only 1.0-2.5%



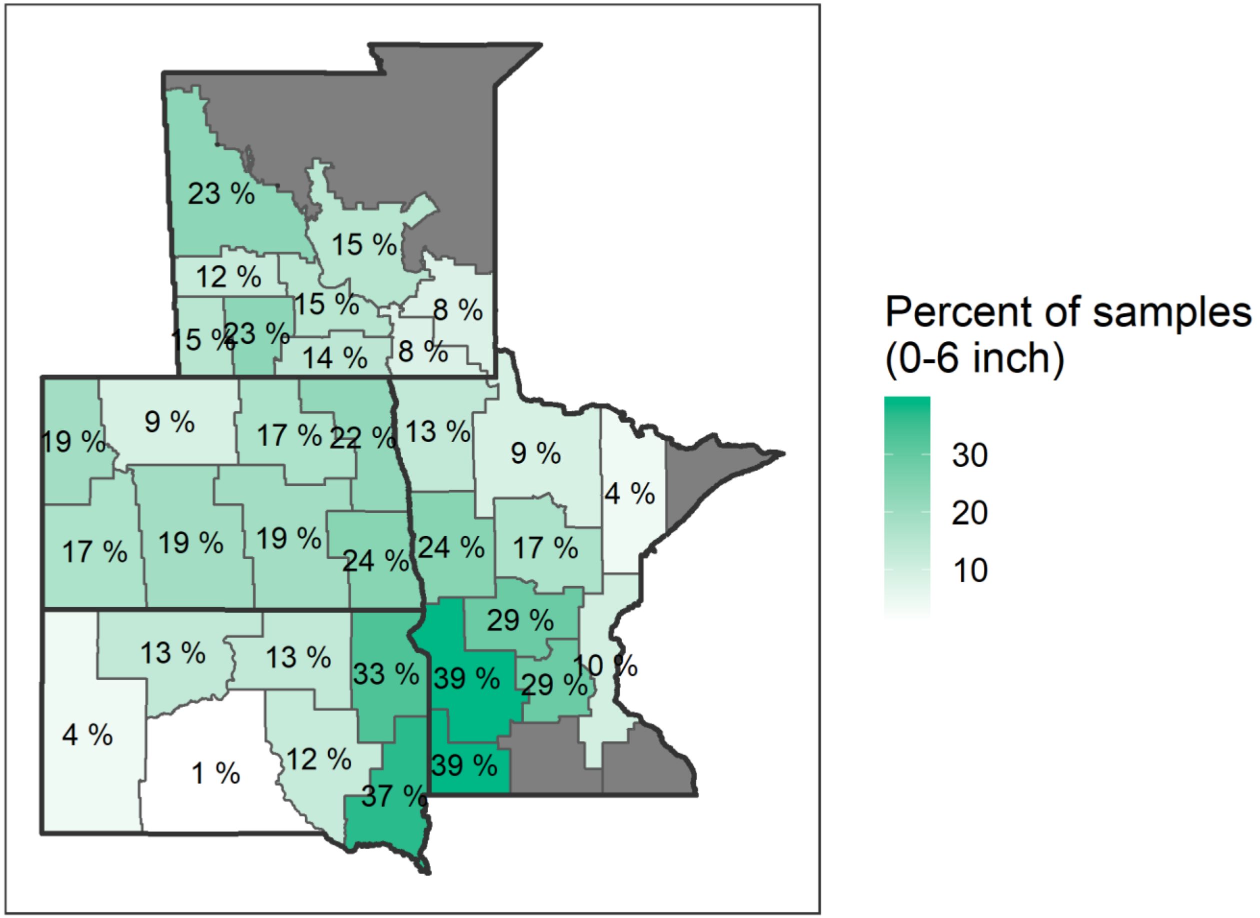
Uffda Project
Conclusion #2

- Did 1000 lb/acre K_2O increase the %K base saturation?
  - Yes, but only increased 1.0 to 2.5% (with 1000 lb/acre K_2O)
- **Base saturation concept would still recommend more K fertilizer because %K below 4-8% ideal range**
- Apparently 1000 lb/acre K_2O (1666 lb KCL) is not enough!

AGVISE LABORATORIES

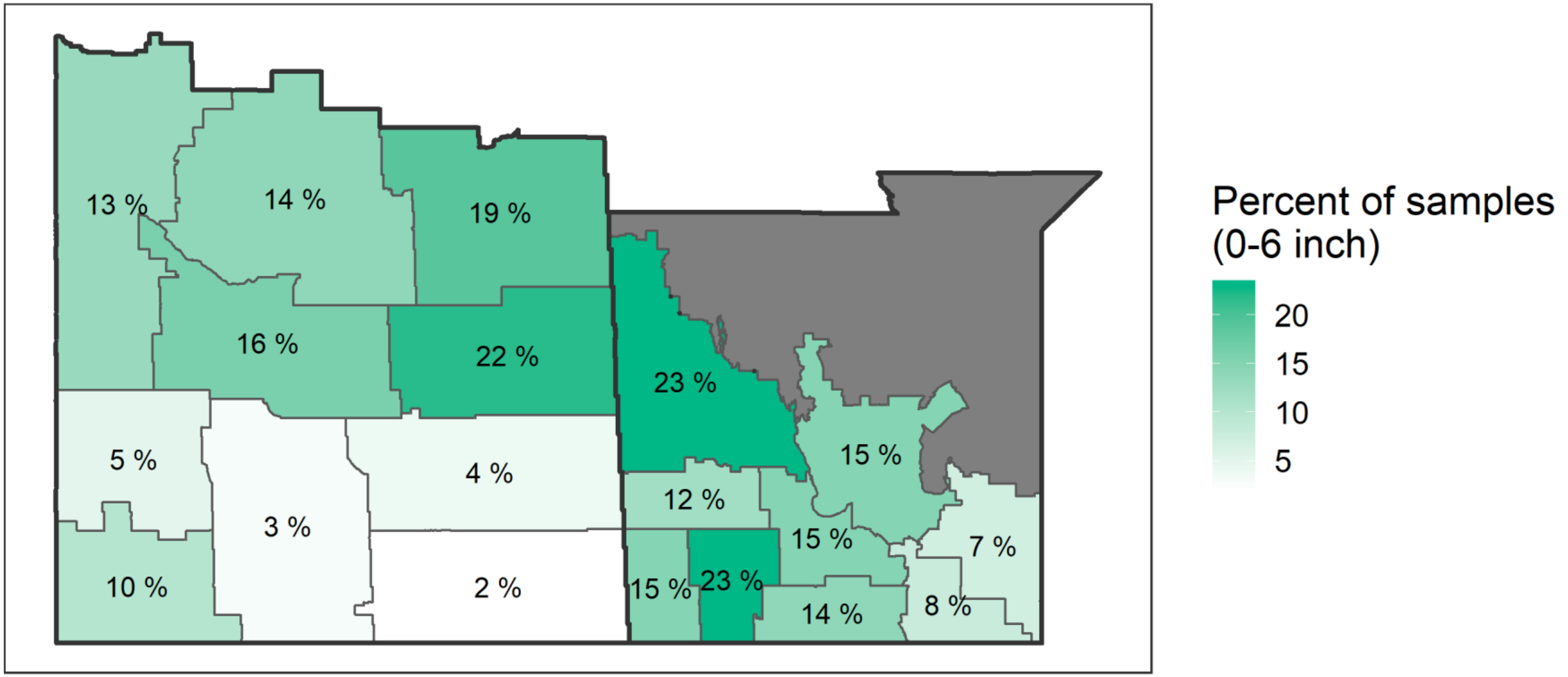
Spur says..

Soil samples with soil test potassium between 150 and 200 ppm in 2019



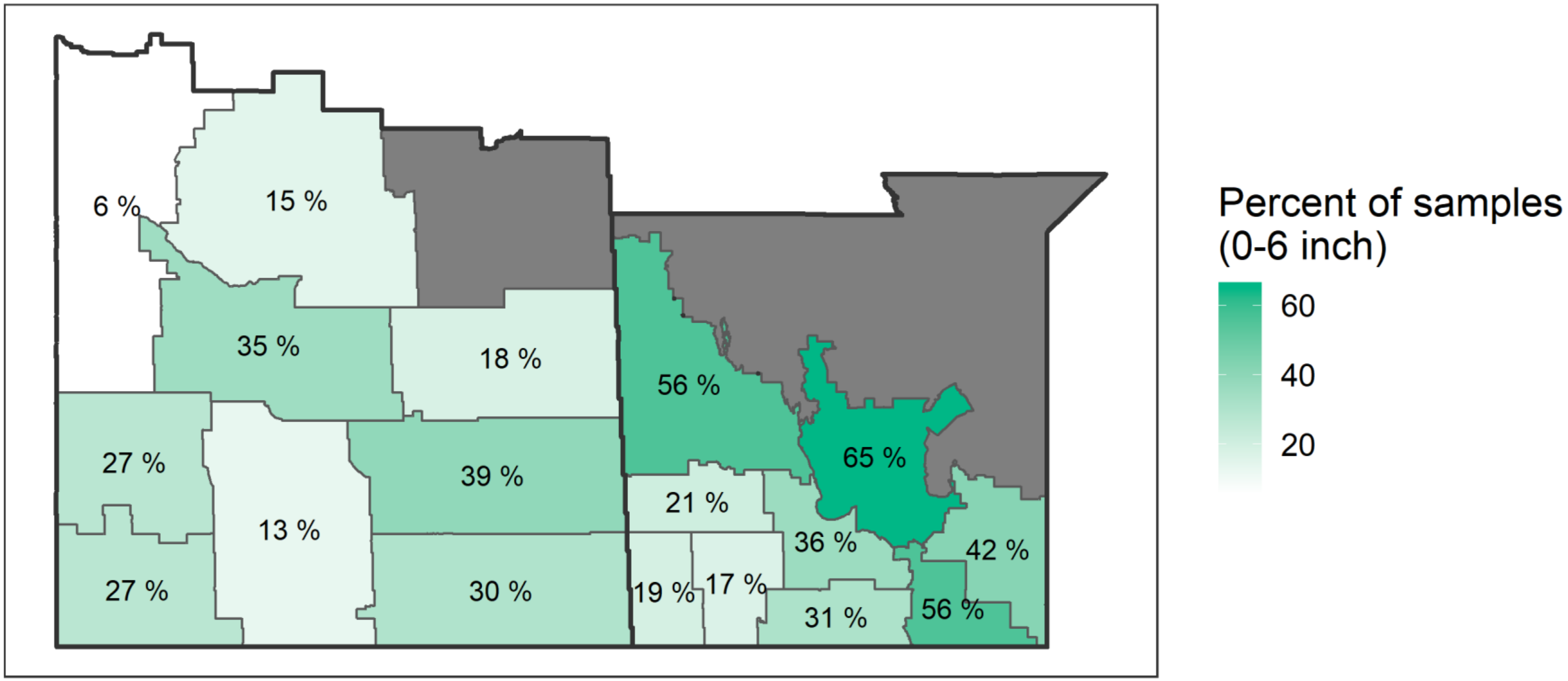
Data not shown where n< 100
AGVISE Laboratories, Northwood, ND

Soil samples with soil test potassium between 150 and 200 ppm in 2019



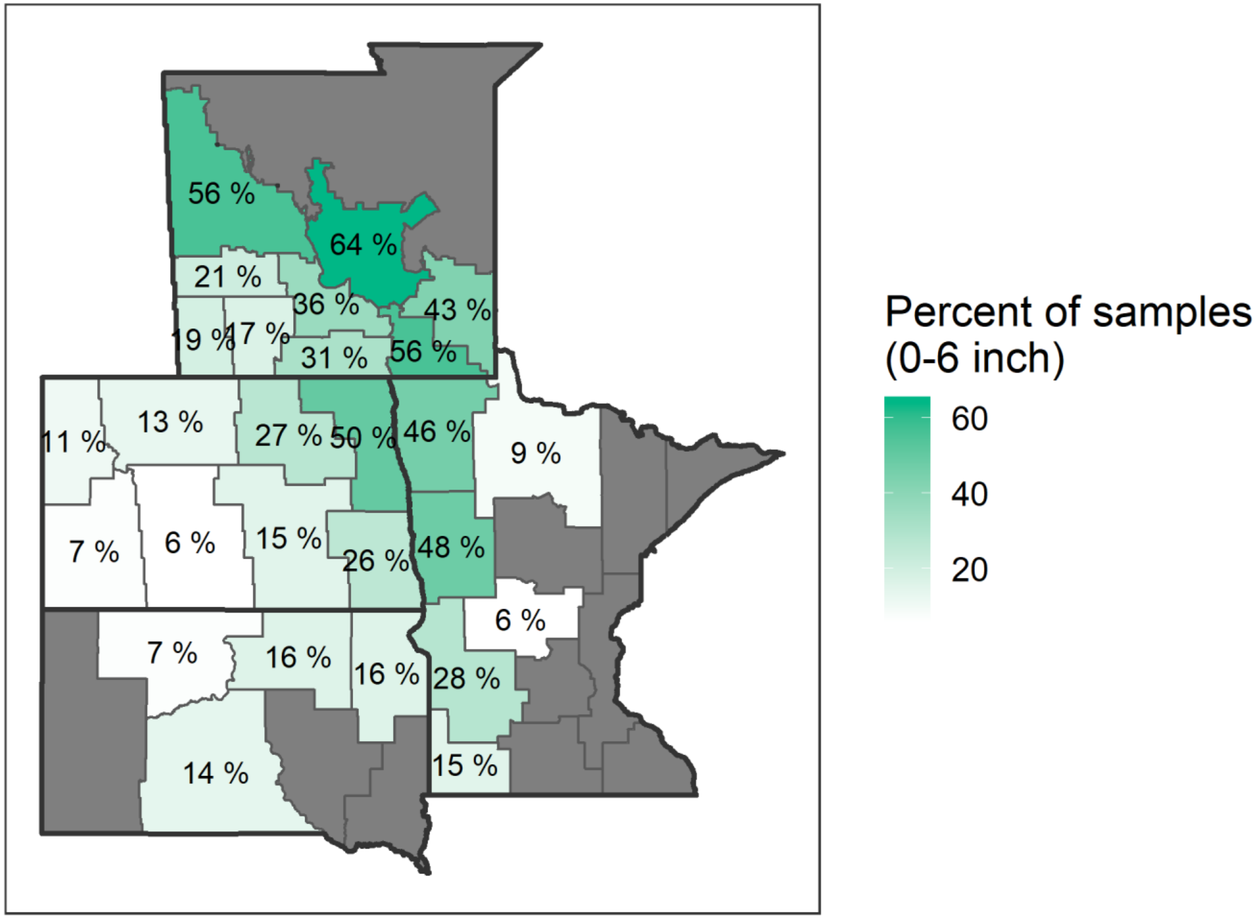
Data not shown where n< 50
AGVISE Laboratories, Northwood, ND

Soil samples with high risk of soybean iron deficiency chlorosis (IDC) in 2019

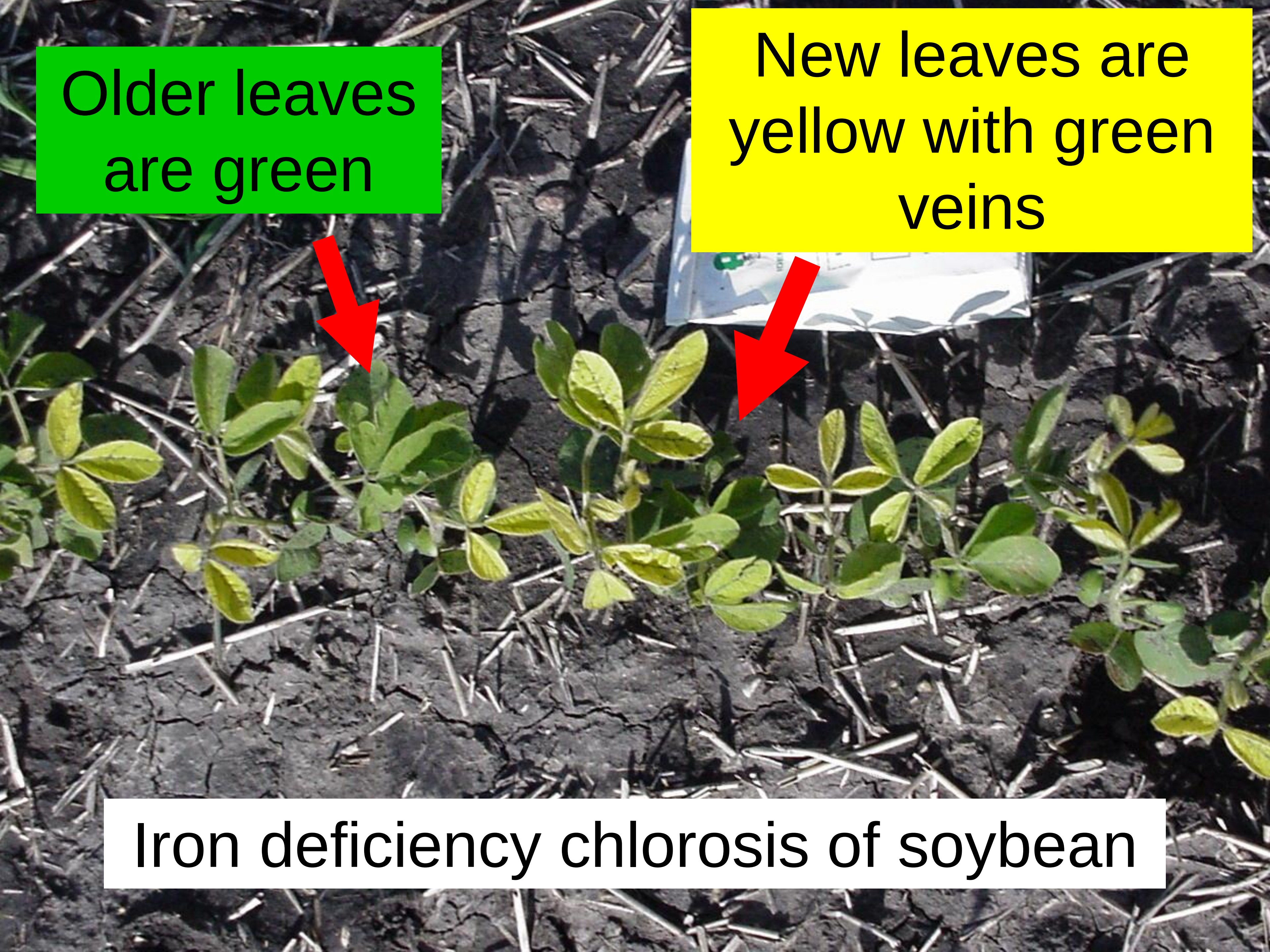


Data not shown where n< 50
AGVISE Laboratories, Northwood, ND

Soil samples with high risk of soybean iron deficiency chlorosis (IDC) in 2019



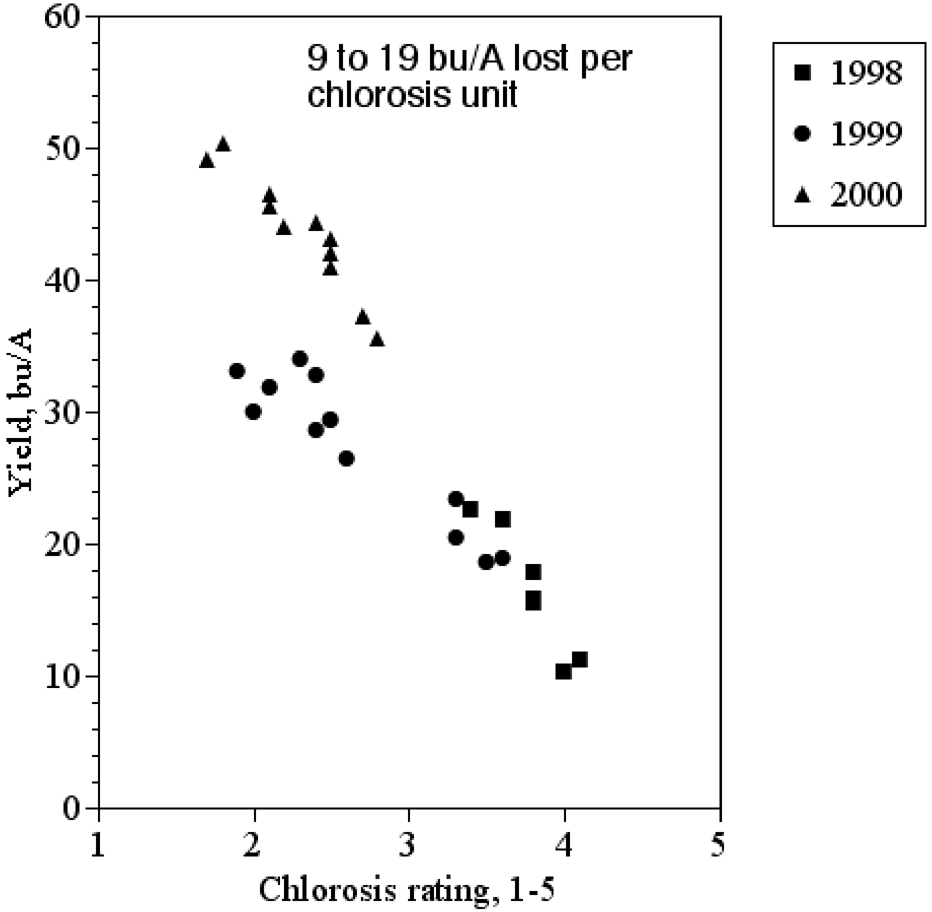
Data not shown where n< 100
AGVISE Laboratories, Northwood, ND


Older leaves are green
New leaves are yellow with green veins
Iron deficiency chlorosis of soybean

Severe IDC persisting into 5-6 trifoliate stage greatly reduces yield

IDC rating scale

1. No chlorosis
2. Slight yellowing
3. Distinct interveinal chlorosis, no stunting
4. Stunting, some necrosis
5. Necrosis of upper leaves and growing point, dead plants



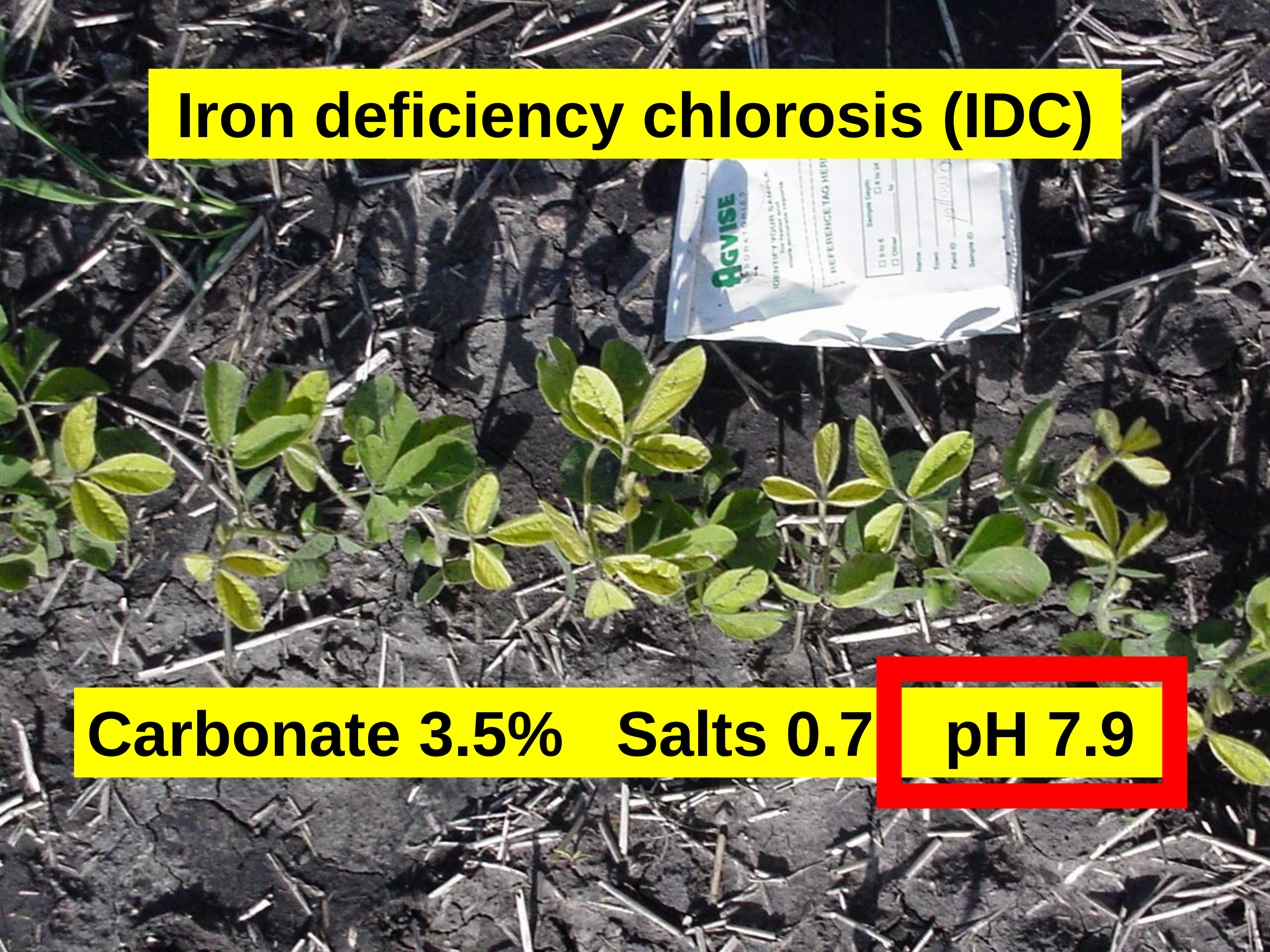
Goos, R.J. 2018. Iron deficiency chlorosis: Soil and plant answers to a Festering problem. In: Endres, G. and Glogoza, P., chairs, 26th Advanced Crop Advisers Workshop, Fargo, ND. 13-14 Feb. 2018. North Dakota State Univ., Fargo, ND; Univ. Minnesota, St. Paul, MN.

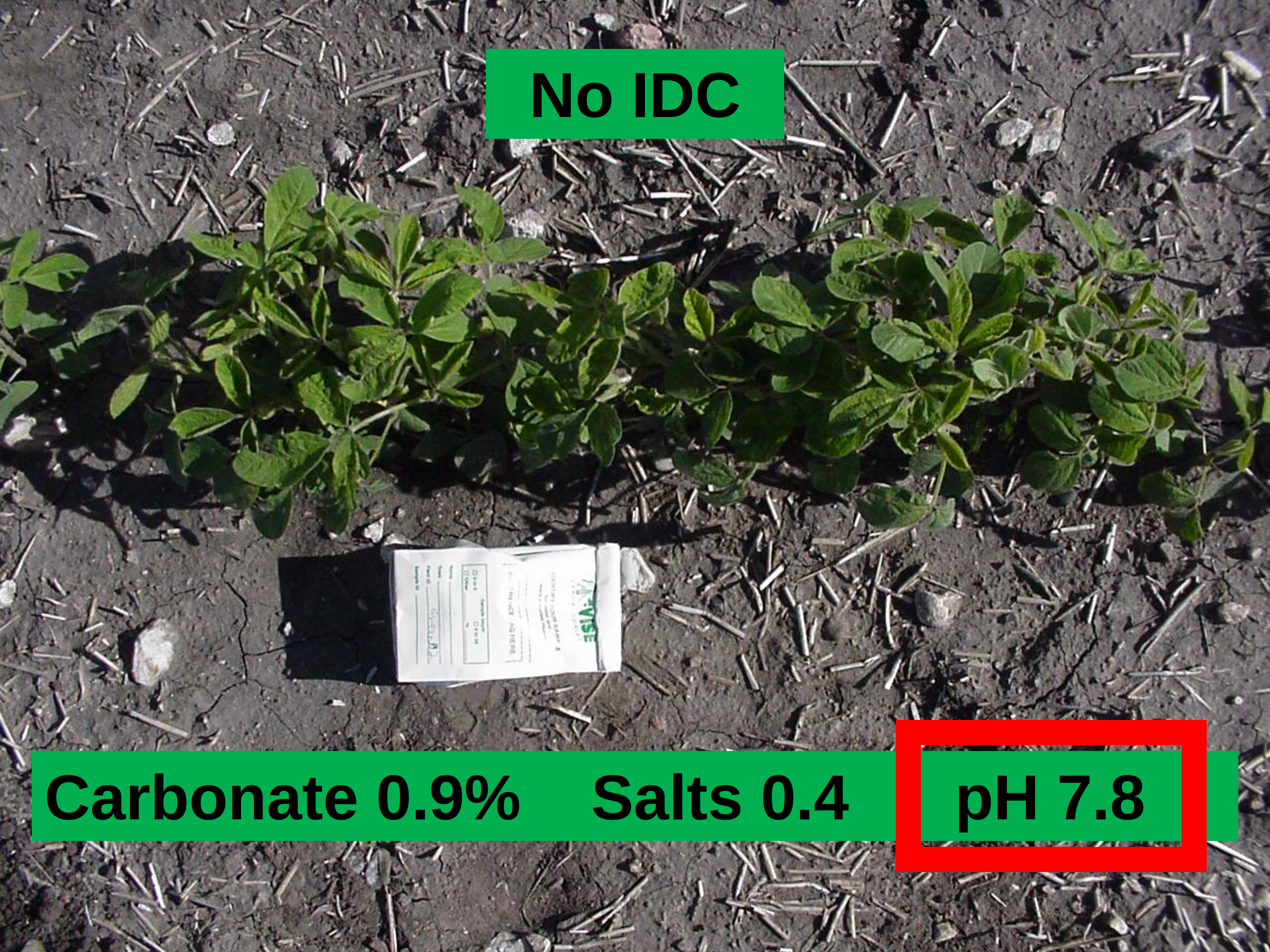
AGVISE Soybean IDC Risk Index

Based on observations and soil samples from 103 fields (2001)

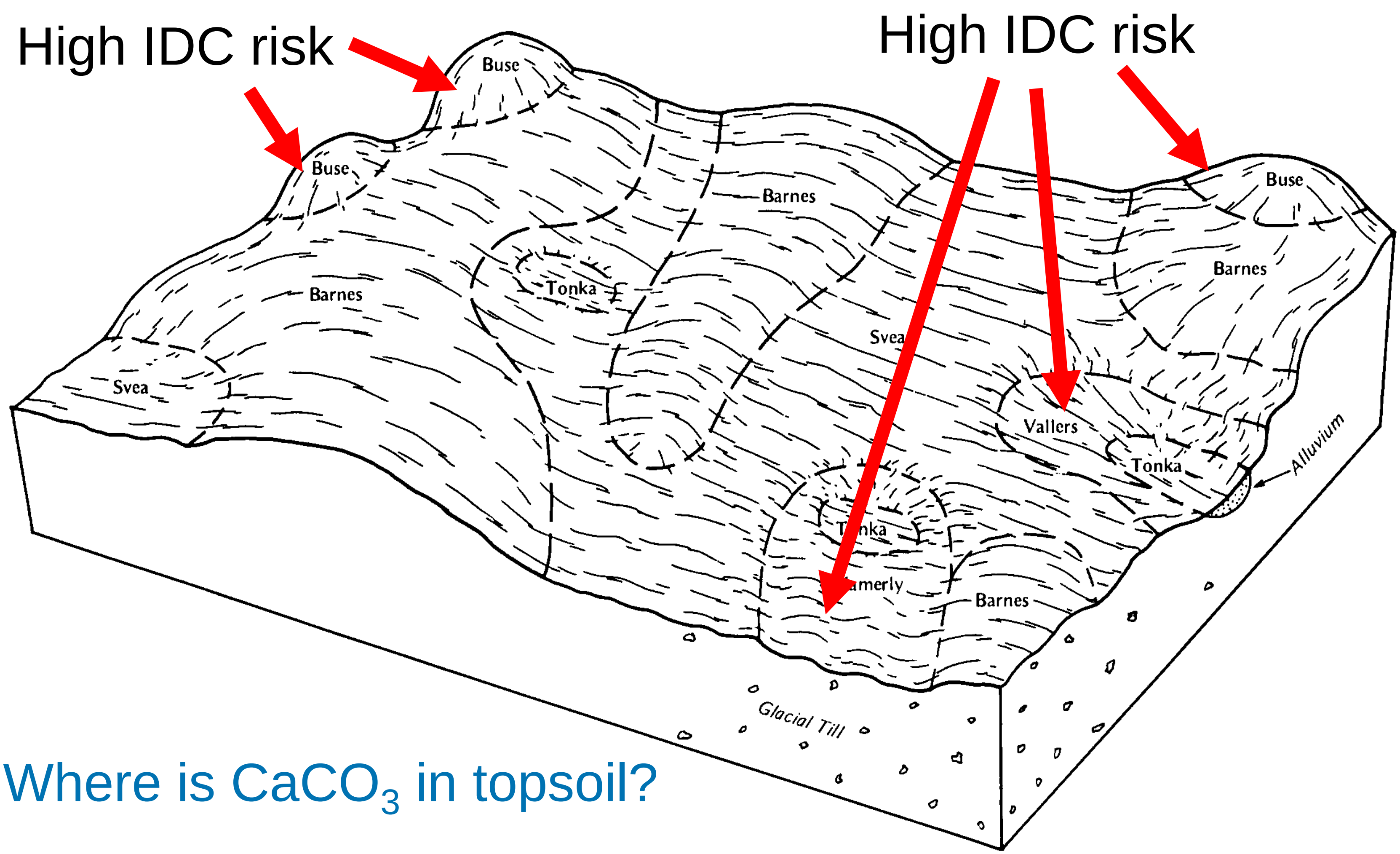
Calcium carbonate (CCE)	Electrical conductivity (EC)	Relative IDC risk
%	dS/m (1:1)	
<2.5	<0.5	Low
<2.5	0.5 – 1.0	Moderate
<2.5	>1.0	Very High
2.6-5.0	<0.25	Low
2.6-5.0	0.26-0.50	Moderate
2.6-5.0	0.51-1.0	High
2.6-5.0	>1.0	Very High
>5.0	<0.25	Moderate
>5.0	.26-0.50	High
>5.0	0.51-1.0	Very High
>5.0	>1.0	Extreme

Foundational research from Franzen, D.W., and J.L. Richardson. 2000. Soil factors affecting iron chlorosis of soybean in the Red River Valley of North Dakota and Minnesota. J. Plant Nutr. 23(1):67–78.


Iron deficiency chlorosis (IDC)
Carbonate 3.5%
Salts 0.7
pH 7.9


No IDC
Carbonate 0.9%
Salts 0.4
pH 7.8

IDC on the glacial till landscape

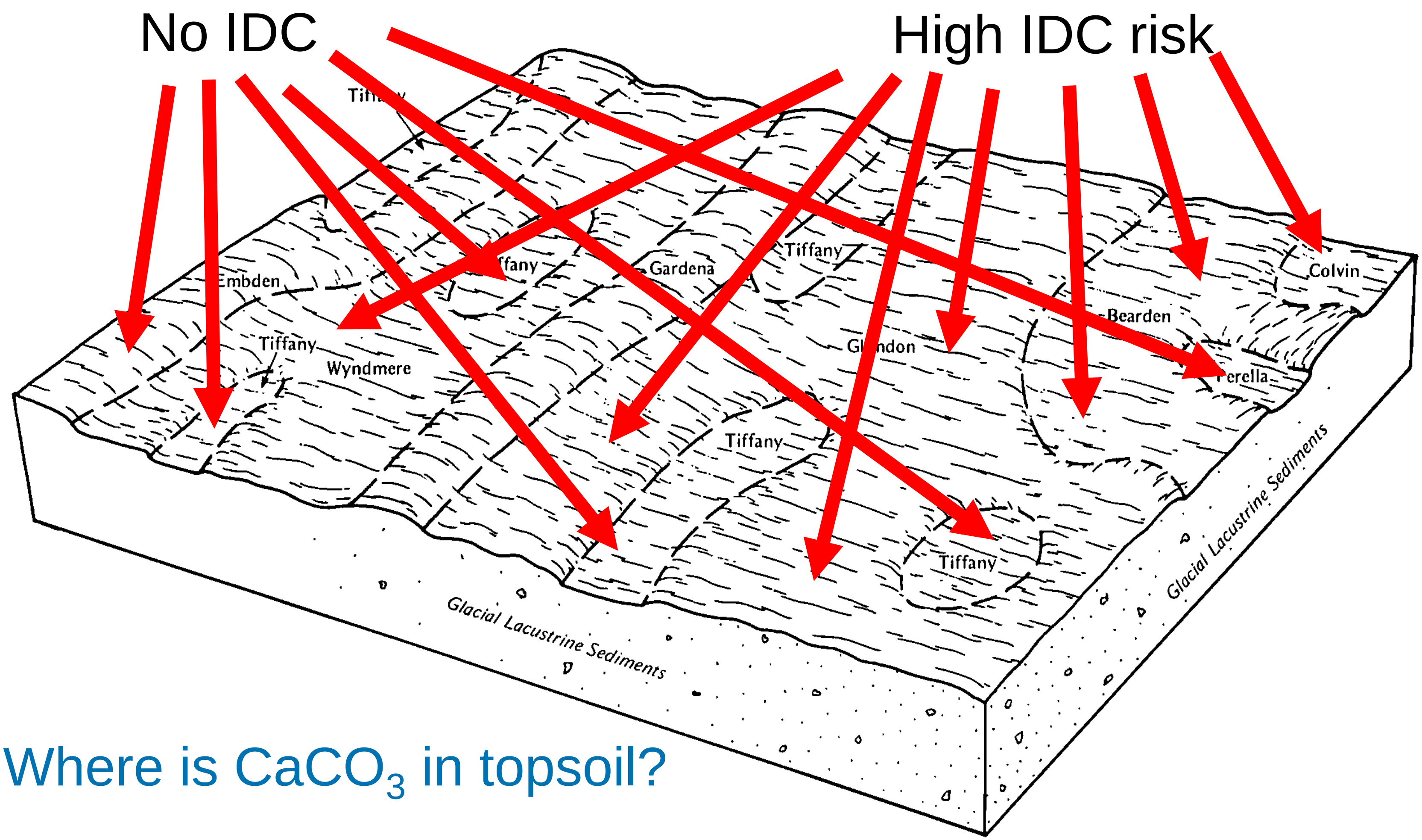


Where is $CaCO_3$ in topsoil?

Adapted from Goos, R.J. 2018. Iron deficiency chlorosis: Soil and plant answers to a Festering problem. In: Endres, G. and Glogoza, P., chairs, 26th Advanced Crop Advisers Workshop, Fargo, ND. 13-14 Feb. 2018. North Dakota State Univ., Fargo, ND; Univ. Minnesota, St. Paul, MN.

On the rolling till plain:
High carbonate and salinity around closed depressions

IDC on the glacial lake plain



Where is $CaCO_3$ in topsoil?

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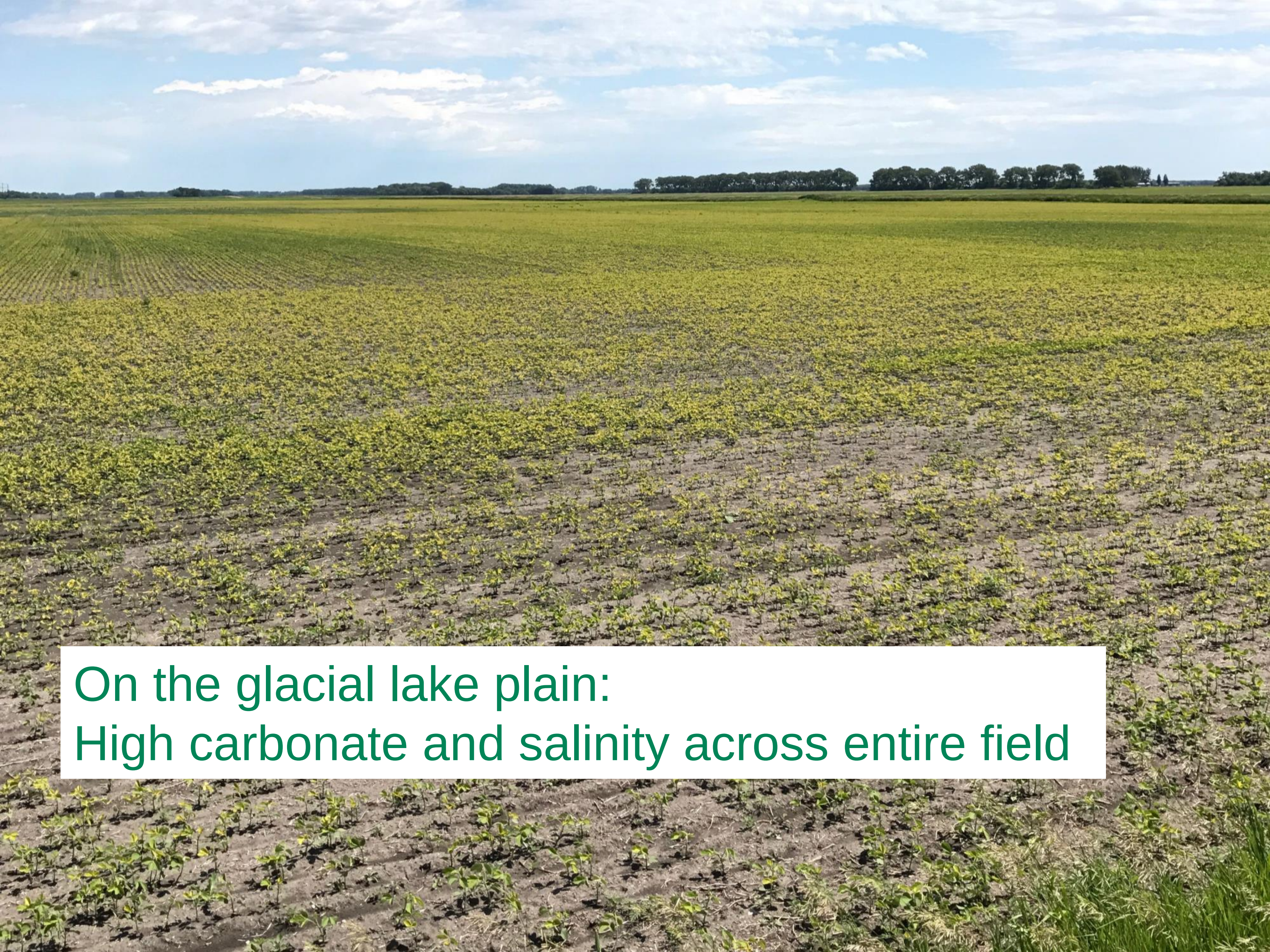
Adapted from Goos, R.J. 2018. Iron deficiency chlorosis: Soil and plant answers to a Festering problem. In: Endres, G. and Glogoza, P., chairs, 26th Advanced Crop Advisers Workshop, Fargo, ND. 13-14 Feb. 2018. North Dakota State Univ., Fargo, ND; Univ. Minnesota, St. Paul, MN.


On the glacial lake plain:
High carbonate and salinity across entire field

Managing IDC with soil testing

Identify fields with low IDC risk

- Soil test for carbonates and salinity
- Choose low IDC risk fields for soybean

Mitigating moderate to high IDC risk

1. Variety selection
2. Variety selection
3. Variety selection
4. Wider rows (plant closer together reduces IDC)
5. Apply high quality ortho-ortho FeEDDHA with seed
6. Plant companion cereal with soybean (uses excess water and nitrate)

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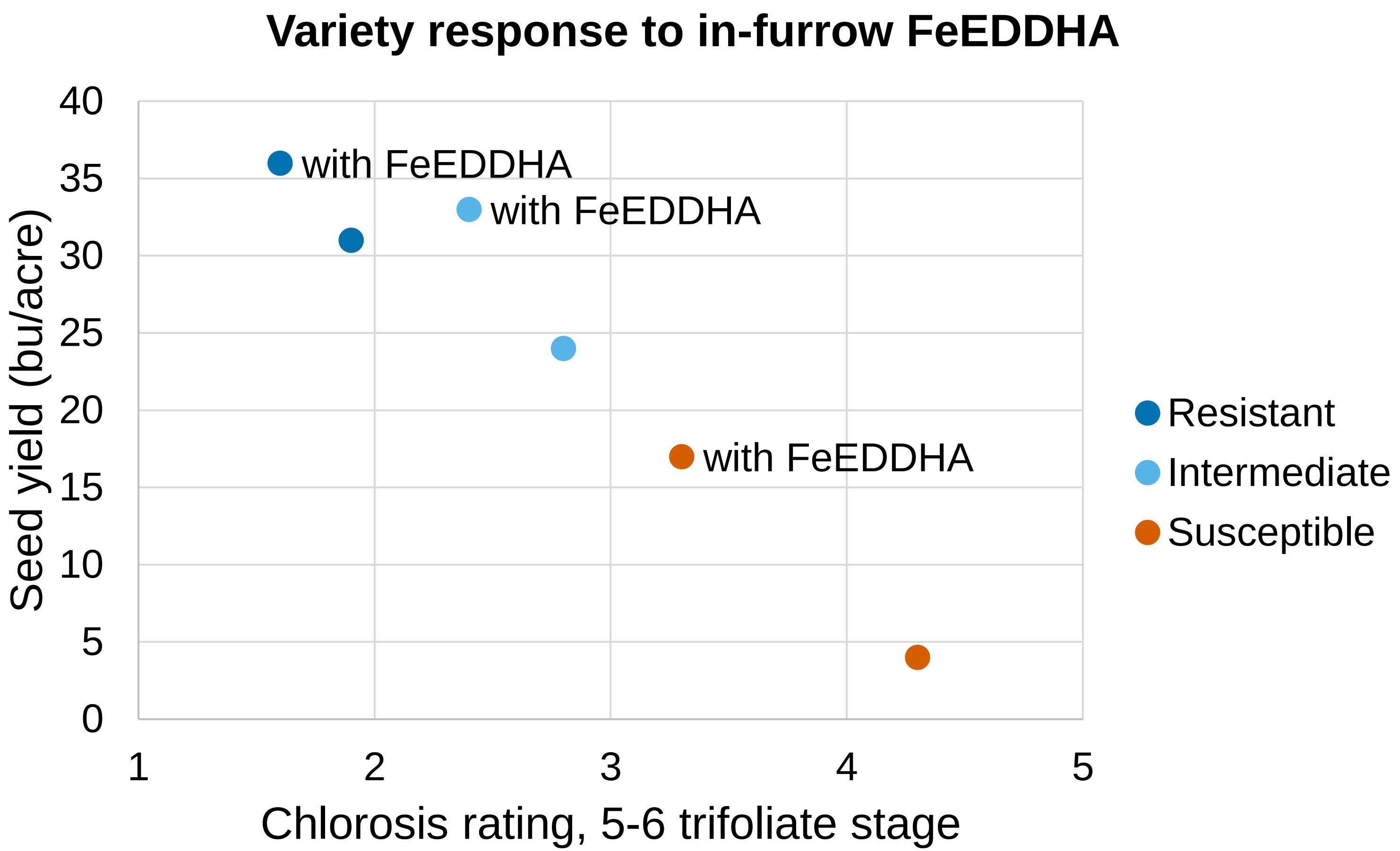
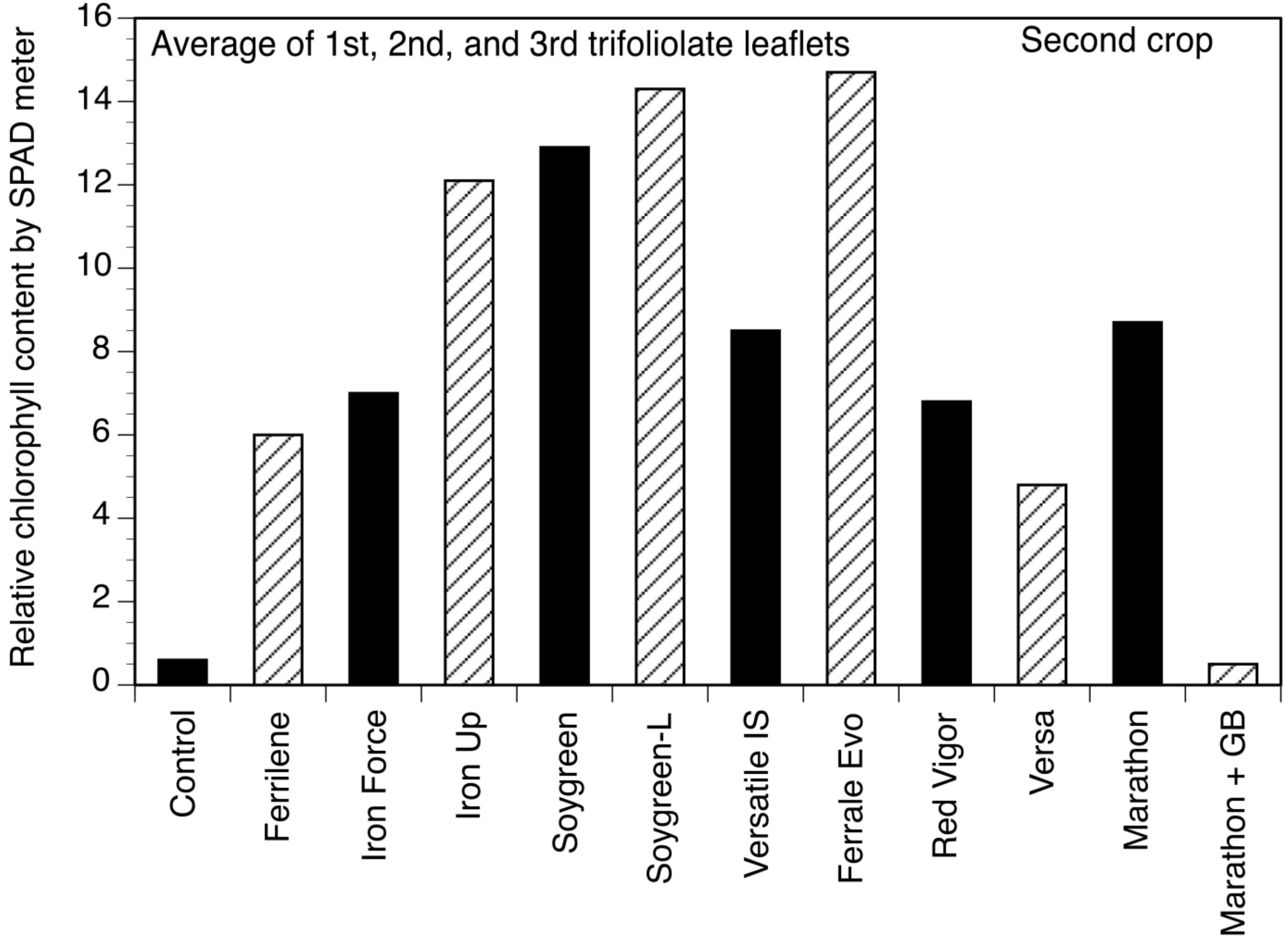
You cannot turn a weak variety into a strong variety



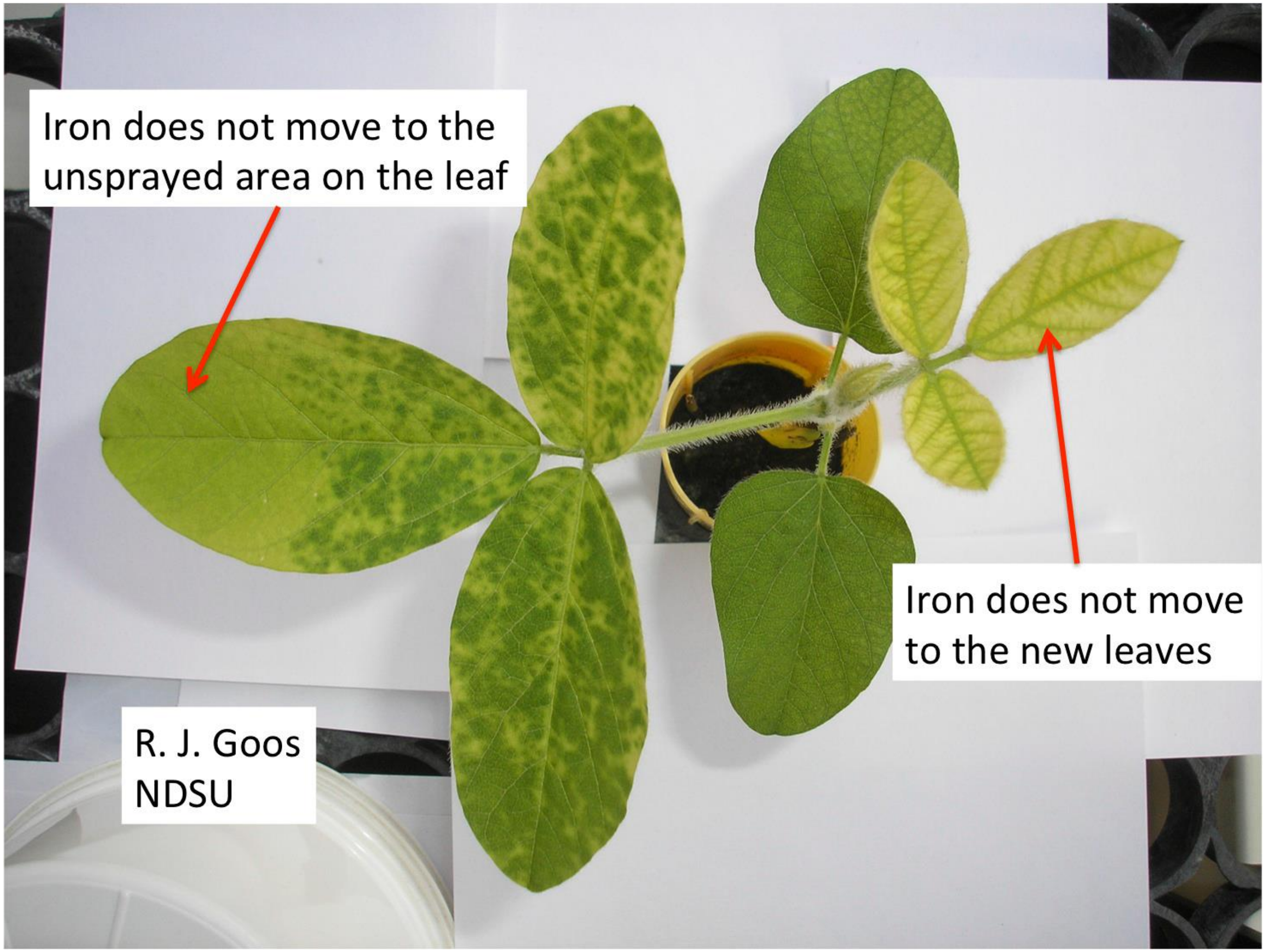
Goos, R.J. 2018. Iron deficiency chlorosis: Soil and plant answers to a Festering problem. In: Endres, G. and Glogoza, P., chairs, 26th Advanced Crop Advisers Workshop, Fargo, ND. 13-14 Feb. 2018. North Dakota State Univ., Fargo, ND; Univ. Minnesota, St. Paul, MN.
Goos, R.J., and B.E. Johnson. 2000. A comparison of three methods for reducing iron-deficiency chlorosis in soybean. Agron. J. 92(6):1135–1139.

Know your FeEDDHA quality



Goos, R.J. 2018. Iron deficiency chlorosis: Soil and plant answers to a Festering problem. In: Endres, G. and Glogoza, P., chairs, 26th Advanced Crop Advisers Workshop, Fargo, ND. 13-14 Feb. 2018. North Dakota State Univ., Fargo, ND; Univ. Minnesota, St. Paul, MN.

Foliar Fe not effective for rescue



Goos, R.J. 2018. Iron deficiency chlorosis: Soil and plant answers to a Festering problem. In: Endres, G. and Glogoza, P., chairs, 26th Advanced Crop Advisers Workshop, Fargo, ND. 13-14 Feb. 2018. North Dakota State Univ., Fargo, ND; Univ. Minnesota, St. Paul, MN.

Be careful when interpreting cation exchange capacity (CEC)

Zone	Organic matter (%)	EC (1:1) dS/m	Calcium carbonate (% CCE)	CEC (routine) cmol(+)/kg	CEC (NH_4 saturation) cmol(+)/kg
1	5.4	1.2	1.6	44	35
2	5.4	1.2	3.1	47	34
3	5.4	1.2	2.1	46	34
4	5.8	**2.7**	**4.1**	**57**	**36**
5	5.4	**3.3**	**6.4**	**79**	**35**

Salinity and calcium carbonate will inflate cation exchange capacity results using routine CEC method (summation of cations)

Acidic soils require buffer pH test to estimate exchangeable acidity

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How much nitrogen can my soil hold?

An idea being promoted at some grower meetings:

N holding capacity (lb/acre) = 10 × CEC(cmol(+)/kg)

Let's break this apart:

- Cation exchange capacity (CEC) holds positive ions
  - Ammonium (NH_4^+) is positive, but soil bacteria will convert ammonium to nitrate (NO_3^-) within two to three weeks
  - Negatively charged nitrate is free to leach with soil water
- CEC is related to soil texture (clay content), but you must be careful about inflated CEC results
- CEC is only calculated on 0-6 inch depth, plant roots can reach 24 inches easily

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Soil nitrate movement depends on soil texture and rainfall

Soil texture	Approximate wetting depth (inch)	
	2 inch rain	4 inch rain
Sand	34	69
Sandy loam	18	37
Loam	13	27
Clay loam	11	23

- Coarse-textured soils with low CEC are prone to leaching N loss
- Fine-textured soils with high CEC are prone to denitrification N loss
- Assess N loss risk based on soil texture, environmental conditions, and mitigate high risk potential with spring or split application

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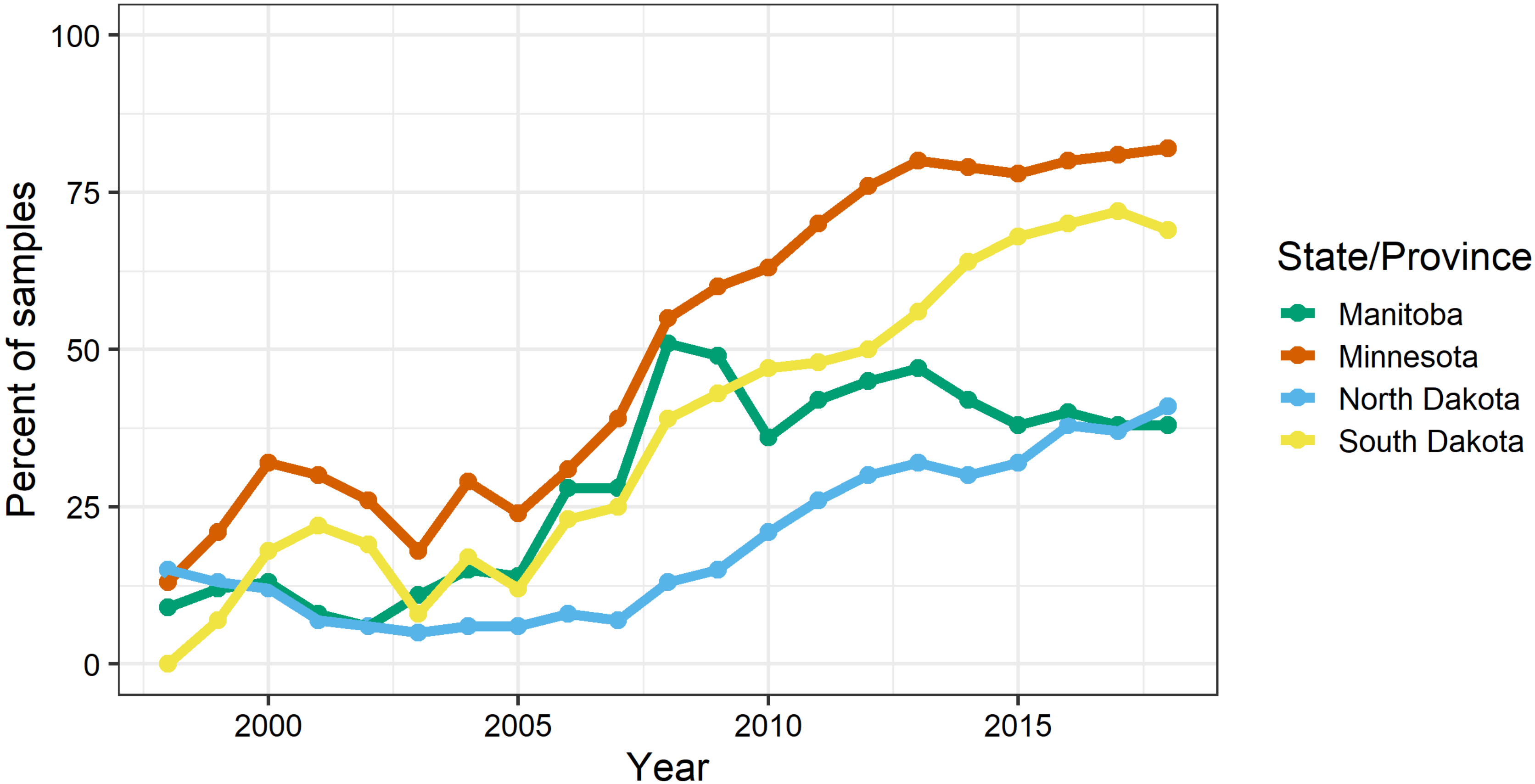
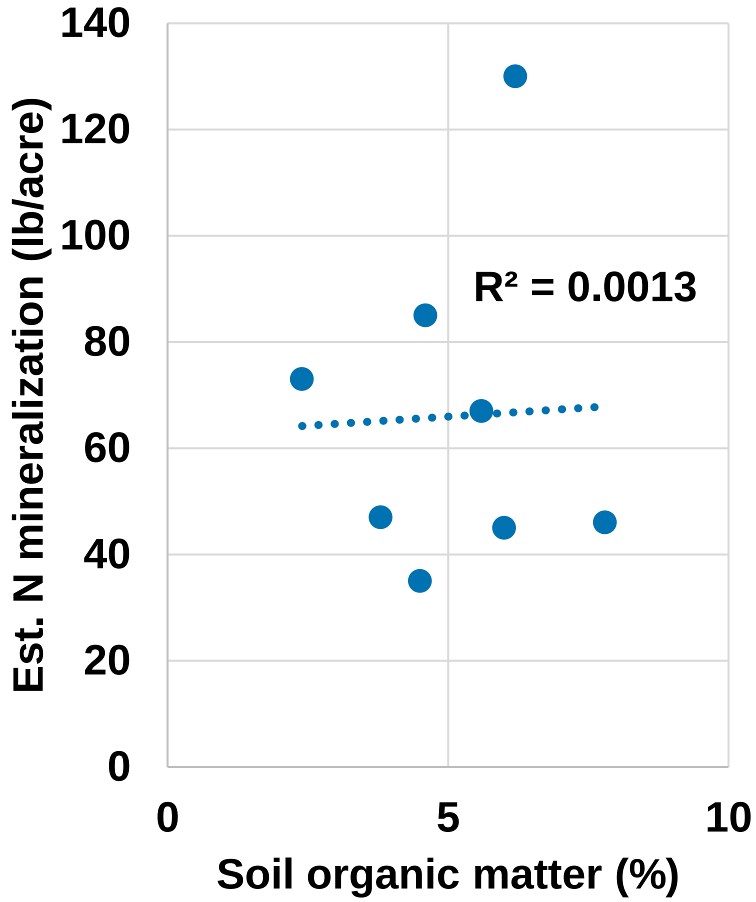
Soil samples collected as a precision sample (grid or zone)

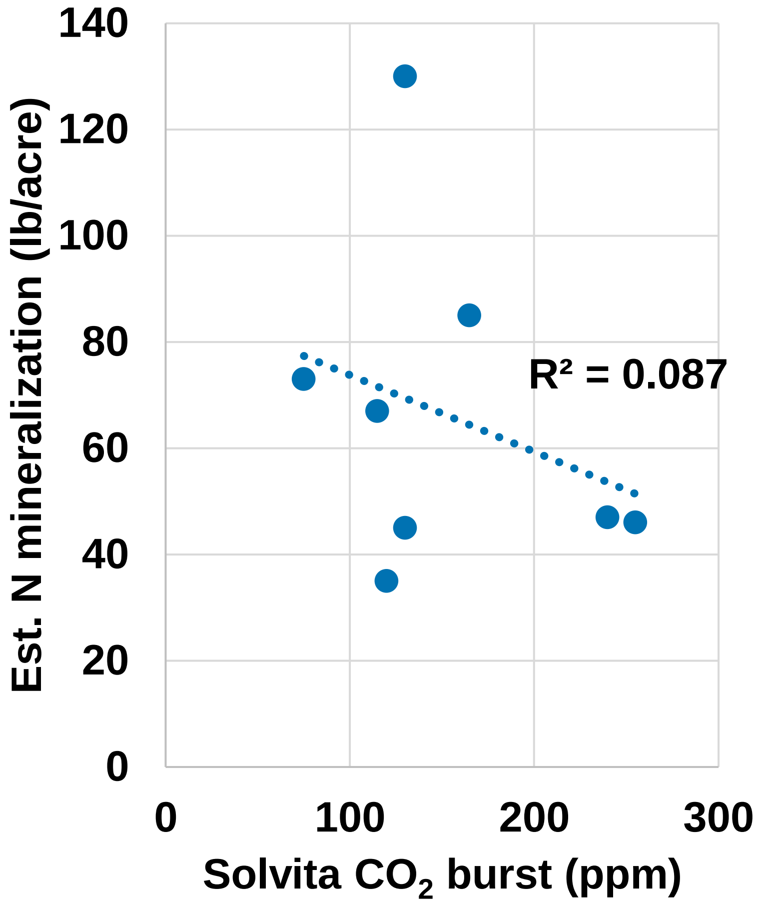
Trend from 1998 to 2018



Data not shown where n< 100
AGVISE Laboratories, Northwood, ND

What about those other organic N mineralization tests?





Flaten, D., A. Mangin, T. Fraser, J. Seward, and J. Heard. 2018. Estimating the nitrogen supplying power of Manitoba soils. In: Lee, J.T., chair, 19th AGVISE Soil Fertility Seminar - Canada, Portage la Prairie, MB. 14 Mar. 2018. AGVISE Laboratories, Northwood, ND.

How much lime to add?

Lime requirement: the amount of lime needed to raise soil pH to a target pH

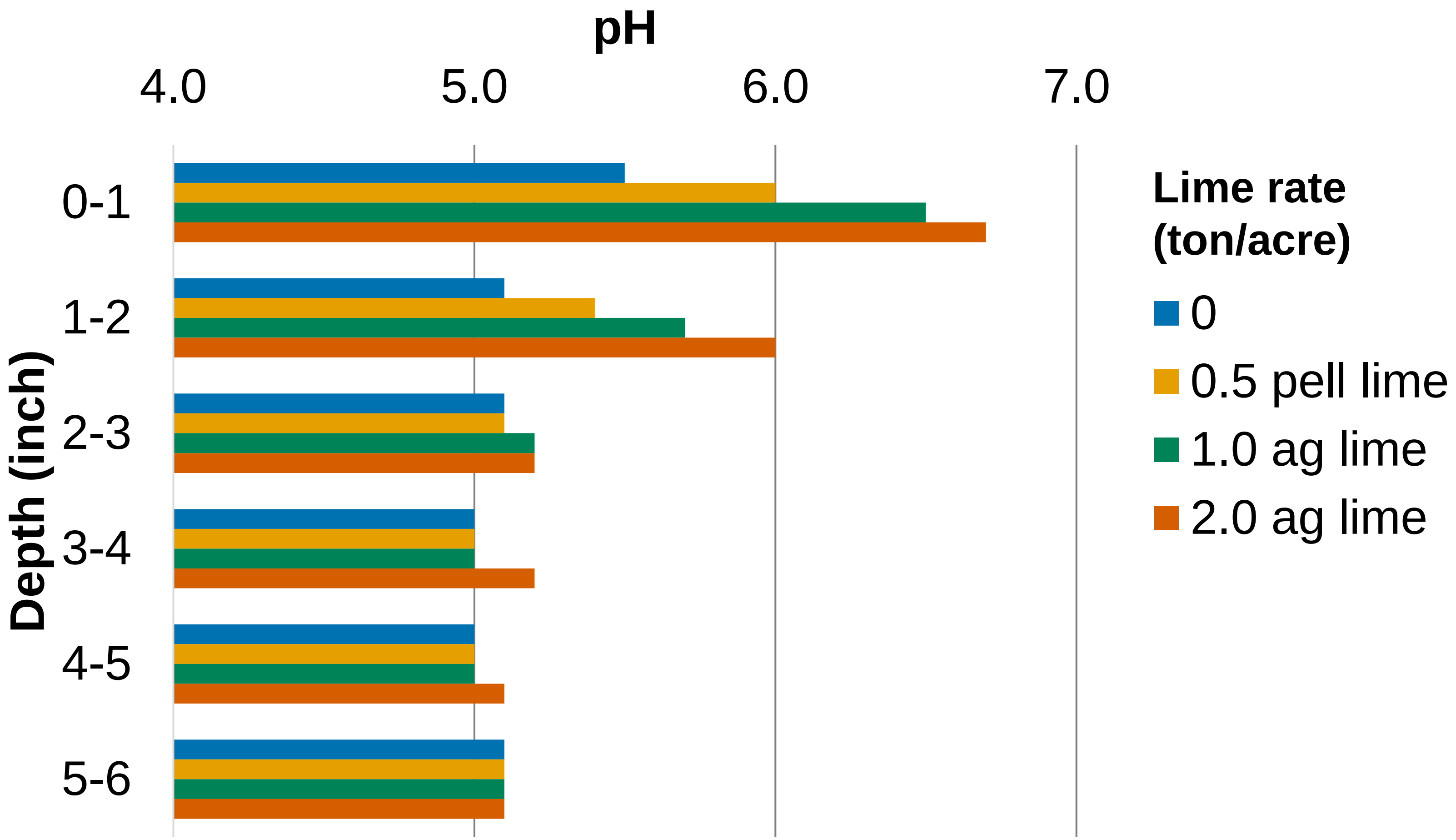
Target pH varies for different crops, usually most sensitive crop in rotation

- Most crops: pH 6.0
- Alfalfa: pH 6.5

Buffer pH test determines how much lime needed to raise pH

- Adjusted for lime purity and fineness

Surface liming on no-till effective in Kansas, after 4 years



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Godsey, C.B., G.M. Pierzynski, D.B. Mengel, and R.E. Lamond. 2007. Management of soil acidity in no-till production systems through surface application of lime. Agron. J. 99(3):764–772.

Low subsoil pH increases chance of crop response to lime

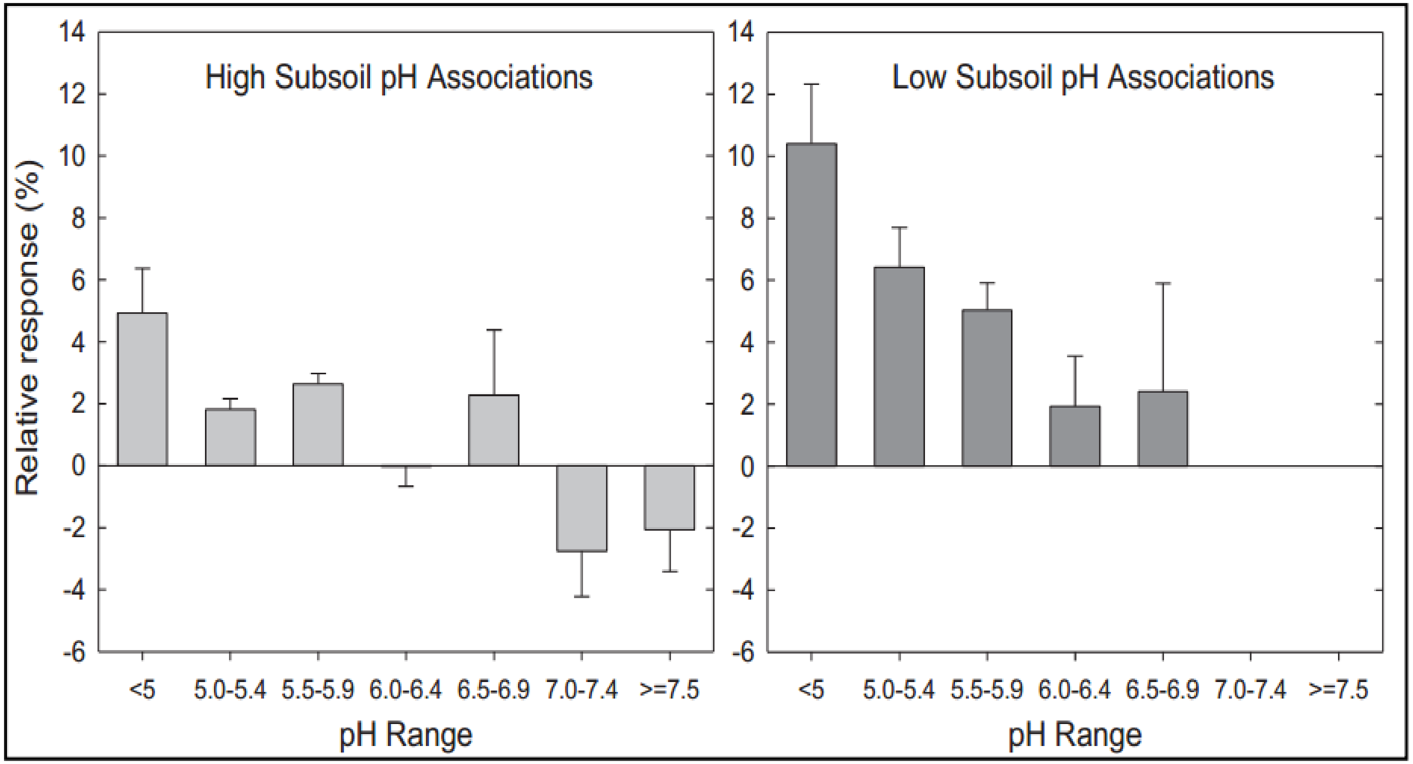

Figure 6. Relative yield response (combined for corn and soybean) to 3 ton ECCE/acre according to pH for soil associations areas with or without high-pH subsoil (lines represent standard errors).

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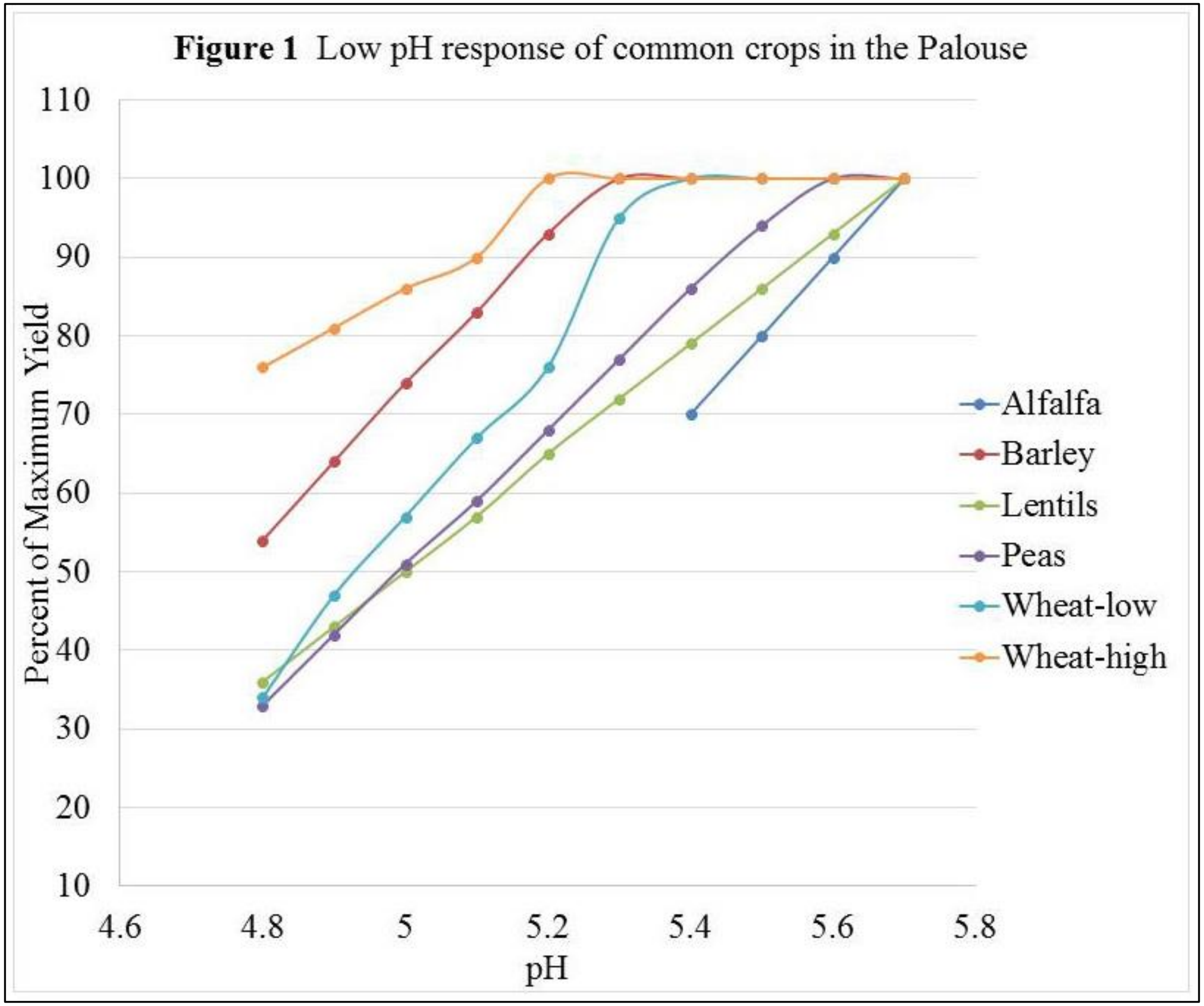
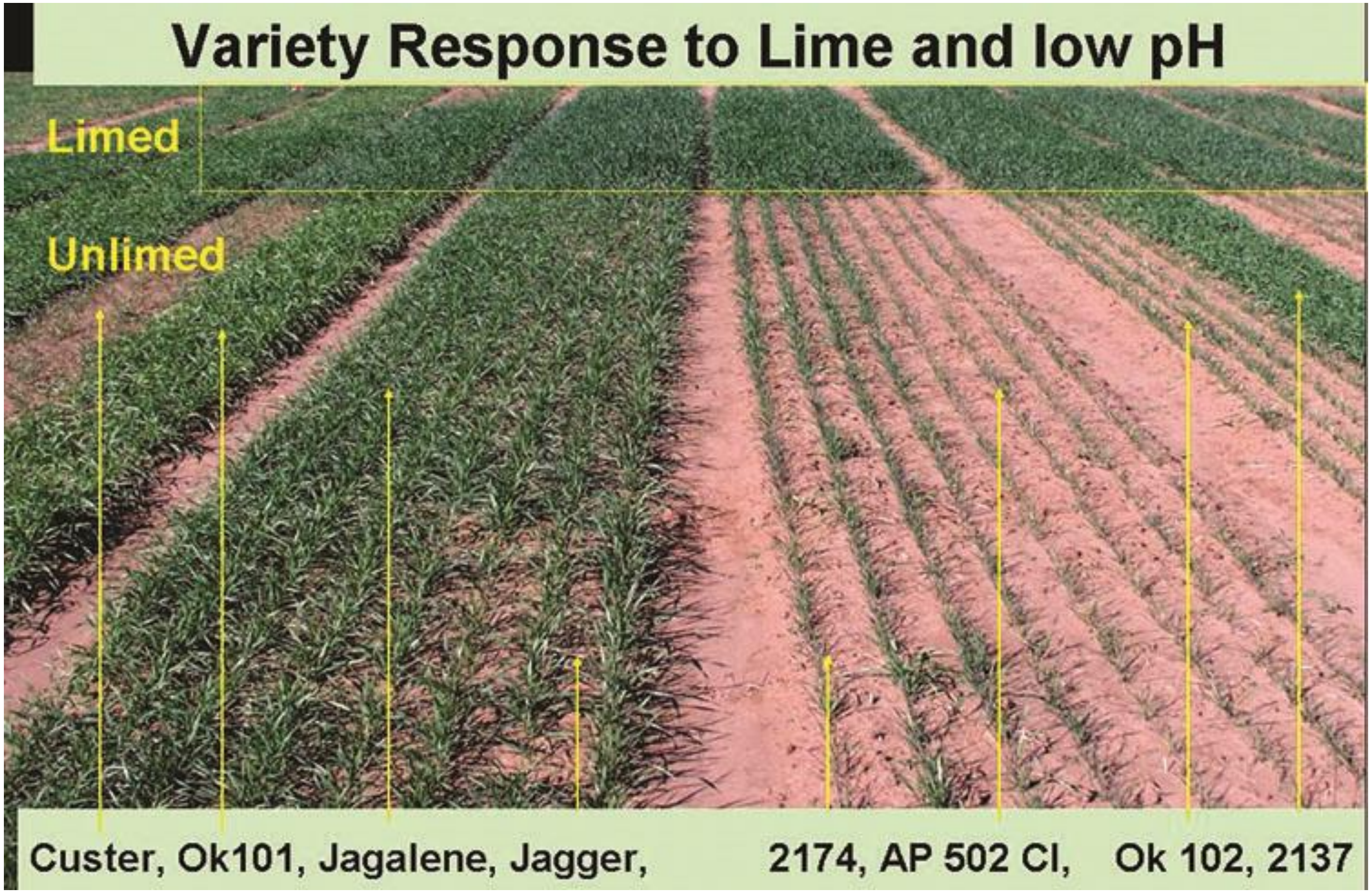
Mallarino, A.P., A. Pagani, and J.E. Sawyer. 2011. Corn and soybean response to soil pH level and liming. In: Proceedings of the 23rd Integrated Crop Management Conference. Ames, IA. 30 Nov. – 1 Dec., 2011. Iowa St. Univ., Ames, IA. p. 93-102.

Low pH tolerance of different crops



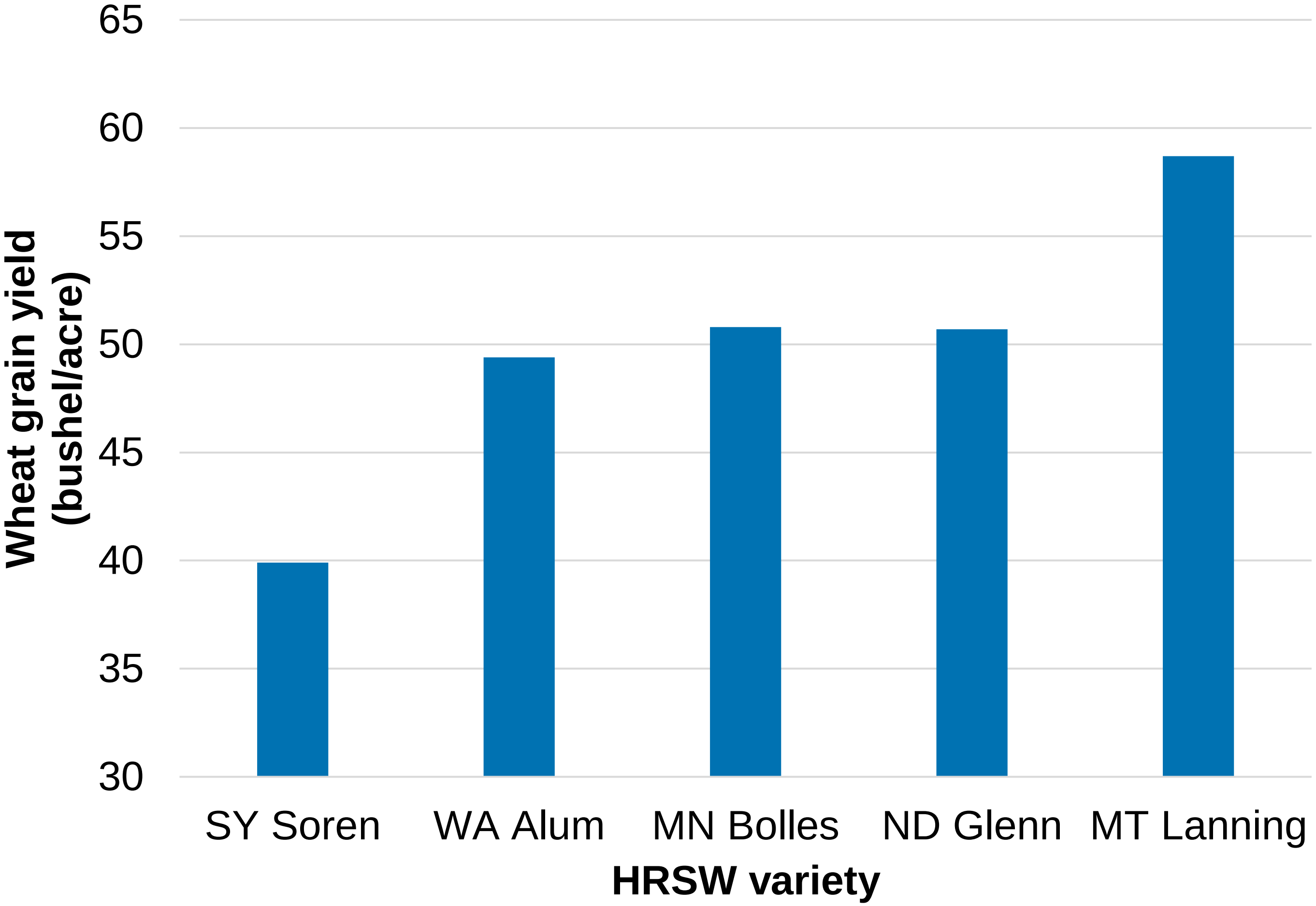
Froese, P.S., A.H. Carter, and M.O. Pumphrey. 2015. Recommended crop species and wheat varieties for acidic soil. WSU Ext. Circ. FS-169E. Washington St. Univ., Pullman, WA.

Winter wheat variety tolerance to low soil pH in Oklahoma



Zhang, H., J. Edwards, B. Carver, and B. Raun. 2017. Managing acid soils for wheat production. OSU Ext. Circ. PSS-2240. Oklahoma St. Univ., Stillwater, OK. http://factsheets.okstate.edu/documents/pss-2240-managing-acid-soils-for-wheat-production/ (accessed 26 Jan. 2018)

HRSW variety evaluation for acidity tolerance (Dickinson, ND 2018)



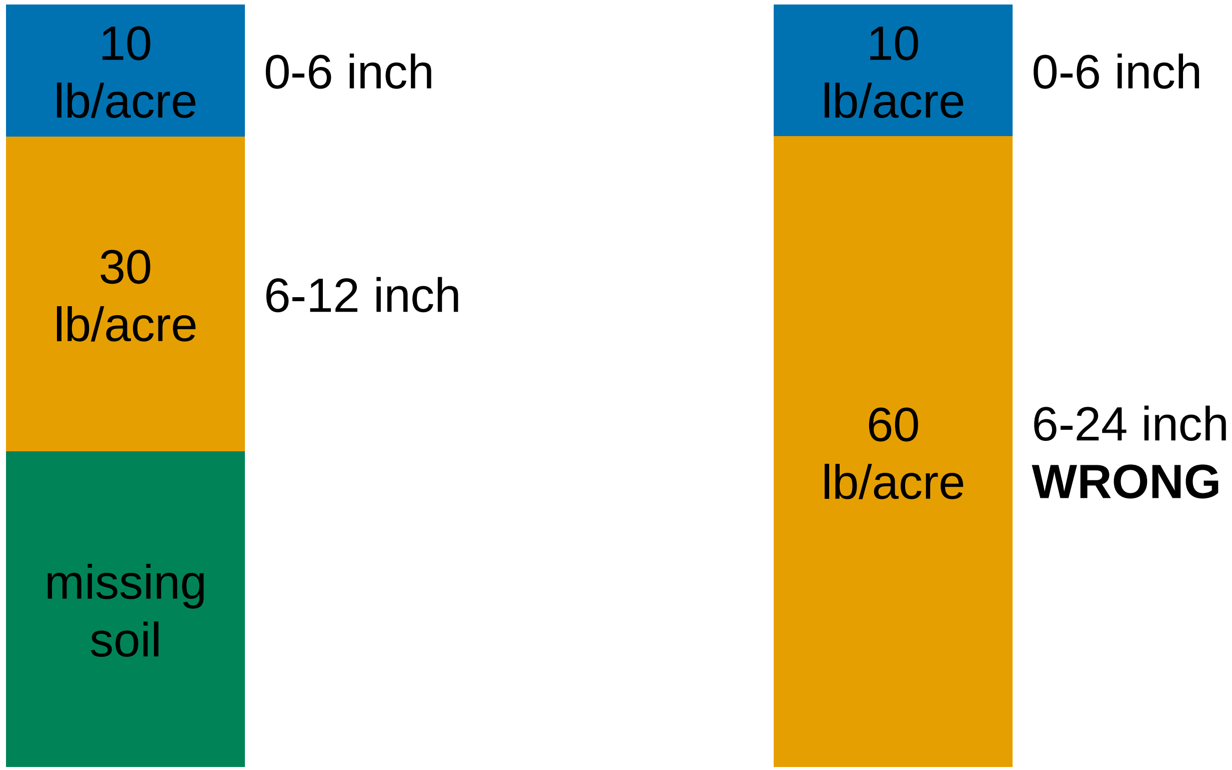
Depth (inch)	Soil pH
0-2	5.7
2-6	4.5
6-12	4.2

R. Buetow, North Dakota State Univ. (personal communication, 2018)

Correct sampling depth is critical

Correct nitrogen based on actual sample depth

Inflated nitrogen based on wrong sample depth



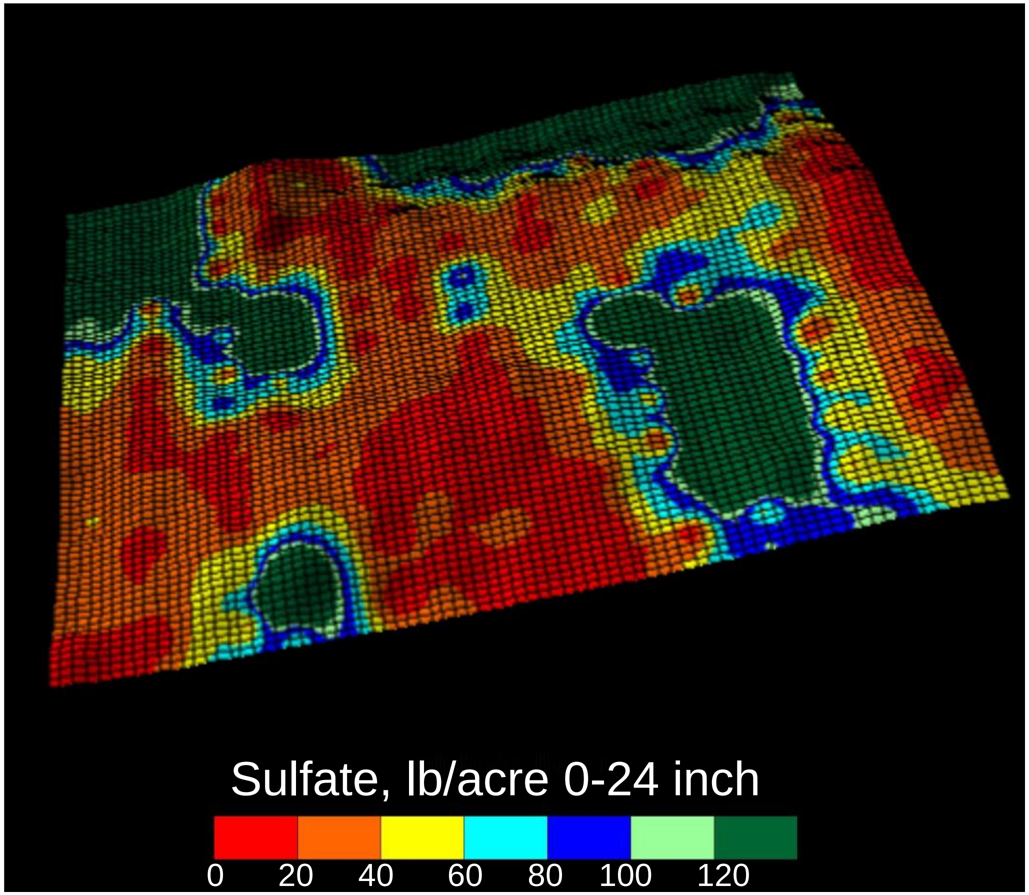
Total N = 40 lb/acre

Total N = 70 lb/acre from incorrect depth

It is always best to write down actual sample depth and talk over adjustment with grower.

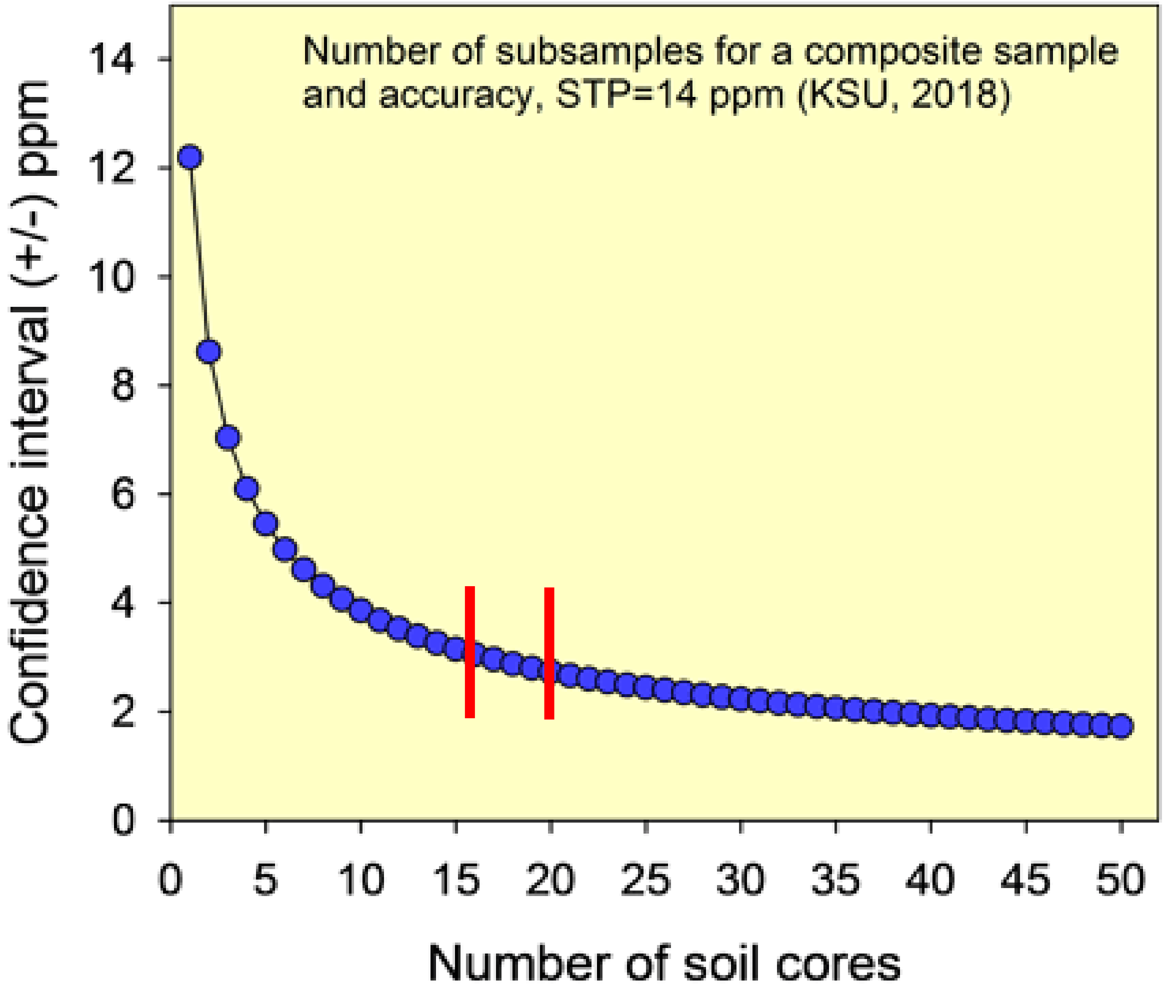
Landscape drives sulfur variability and crop response to sulfur fertilization

- Sulfate-S moves with water on landscape
  - Low sulfate-S on hilltops and ridges
  - High sulfate-S where water table is high
- Zone sampling required for accurate soil test S information



Franzen, D.W. 2015. Sulfur sources, chemistry, extent of deficiencies, and application considerations in the North Central Region of the USA. In: Proceedings of the 45th North Central Extension-Industry Soil Fertility Conference. Des Moines, IA. 4-5 Nov. 2015. Intl. Plant Nutr. Inst., Brookings, SD. p. 28–41.

At least 15-20 soil cores needed per soil sample



Ruiz Diaz, D. 2018. The challenge of collecting a representative soil sample. KSU Ext. Agron. eUpdate 712, 28 Sept. 2018. Kansas State Univ., Manhattan, KS. https://webapp.agron.ksu.edu/agr_social/eu_article.throck?article_id=1991 (accessed 12 Jan. 2019).

Is soil organic matter factored in when you use the 24" Nitrate test to make guidelines?

Soil test method	Barley yield response to fertilizer N explained by soil test N (r^2)
Soil nitrate-N (0-48")	**95%**
Soil organic matter (0-6")	24%
Easily hydrolyzed organic N (0-6")	69%
N release during incubation (0-6")	84%

Average N mineralization from all sites is included in nitrate research
Wide range of N rates applied to determine correct rate for returns
(N mineralized from organic matter is where portion of N came from

Nitrogen mineralization from soil organic matter is difficult to predict and environment dependent from year to year

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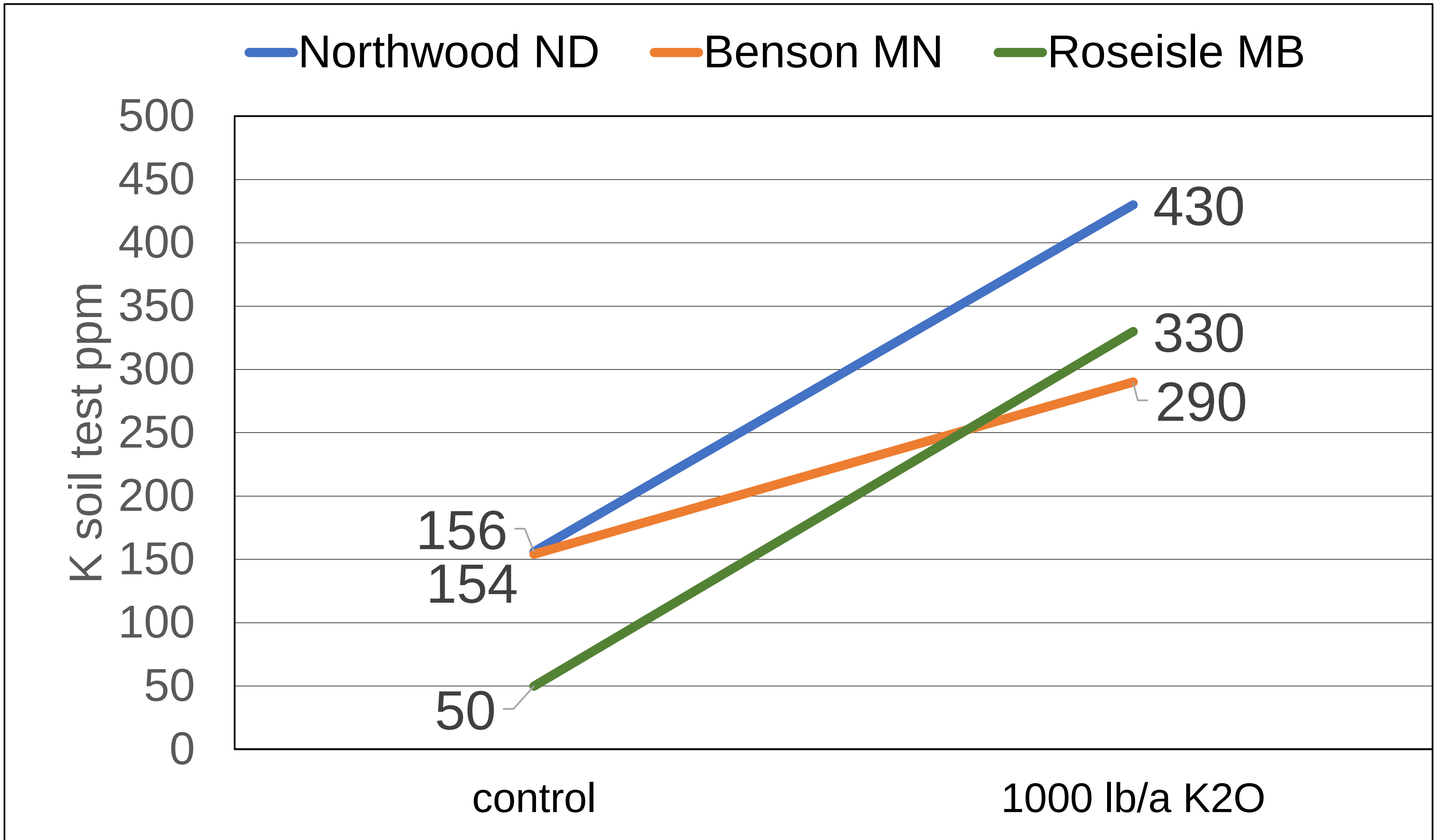
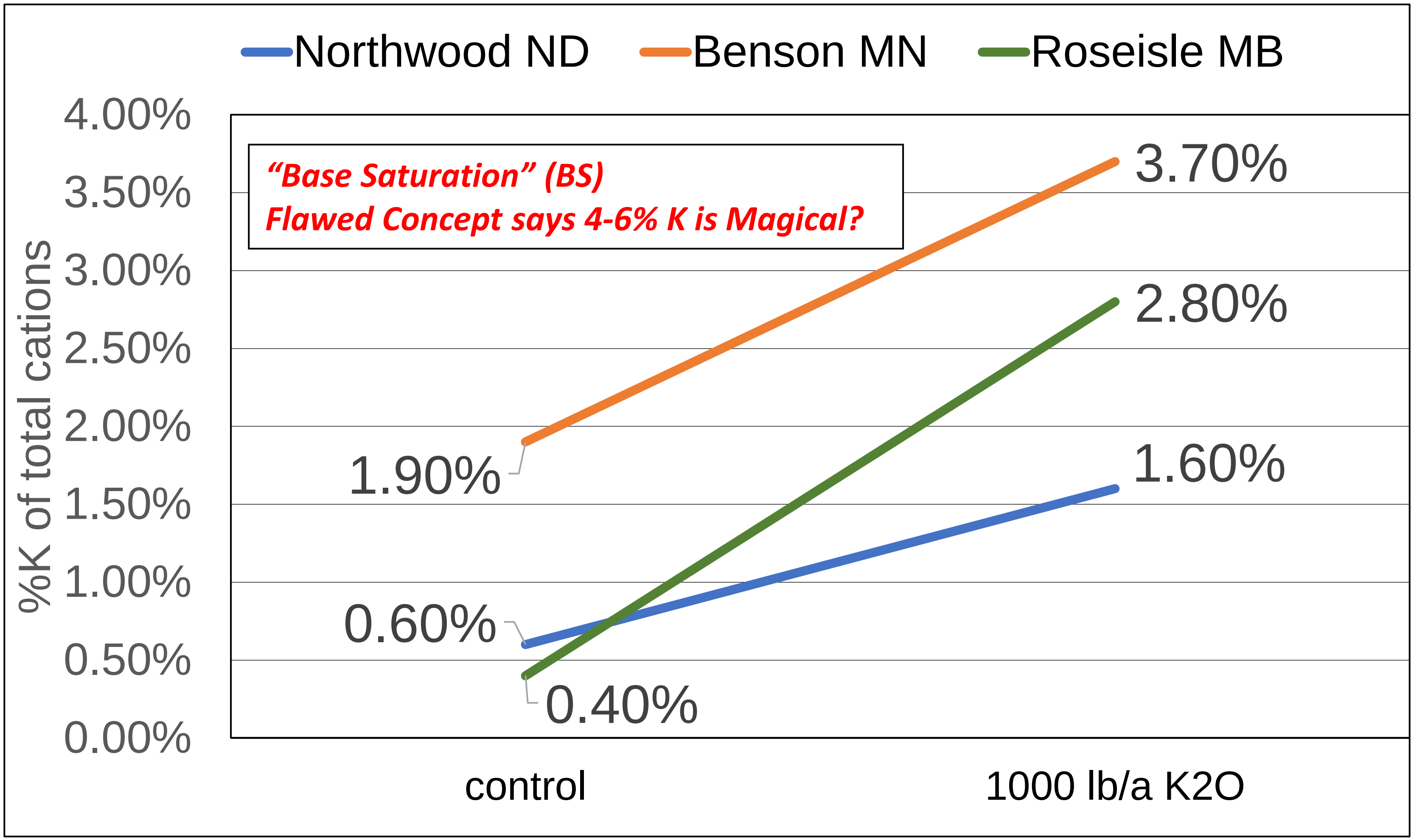
Soper, R.J., and P.M. Huang. 1963. The effect of nitrate nitrogen in the soil profile on the response of barley to fertilizer nitrogen. Can. J. Soil Sci. 43(2):350–358.

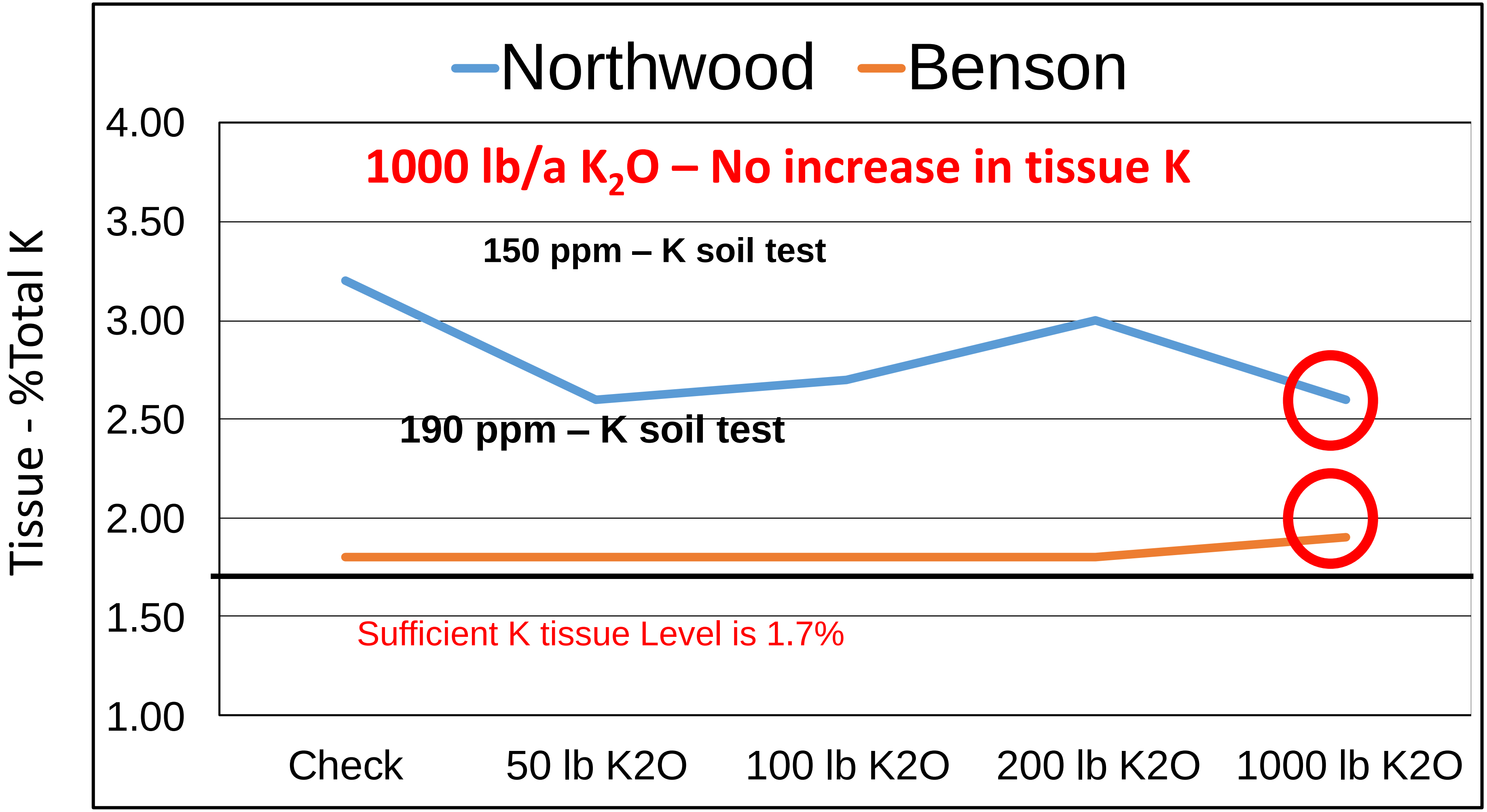
Effect of 1000 lb/a K_2O on K soil test ppm



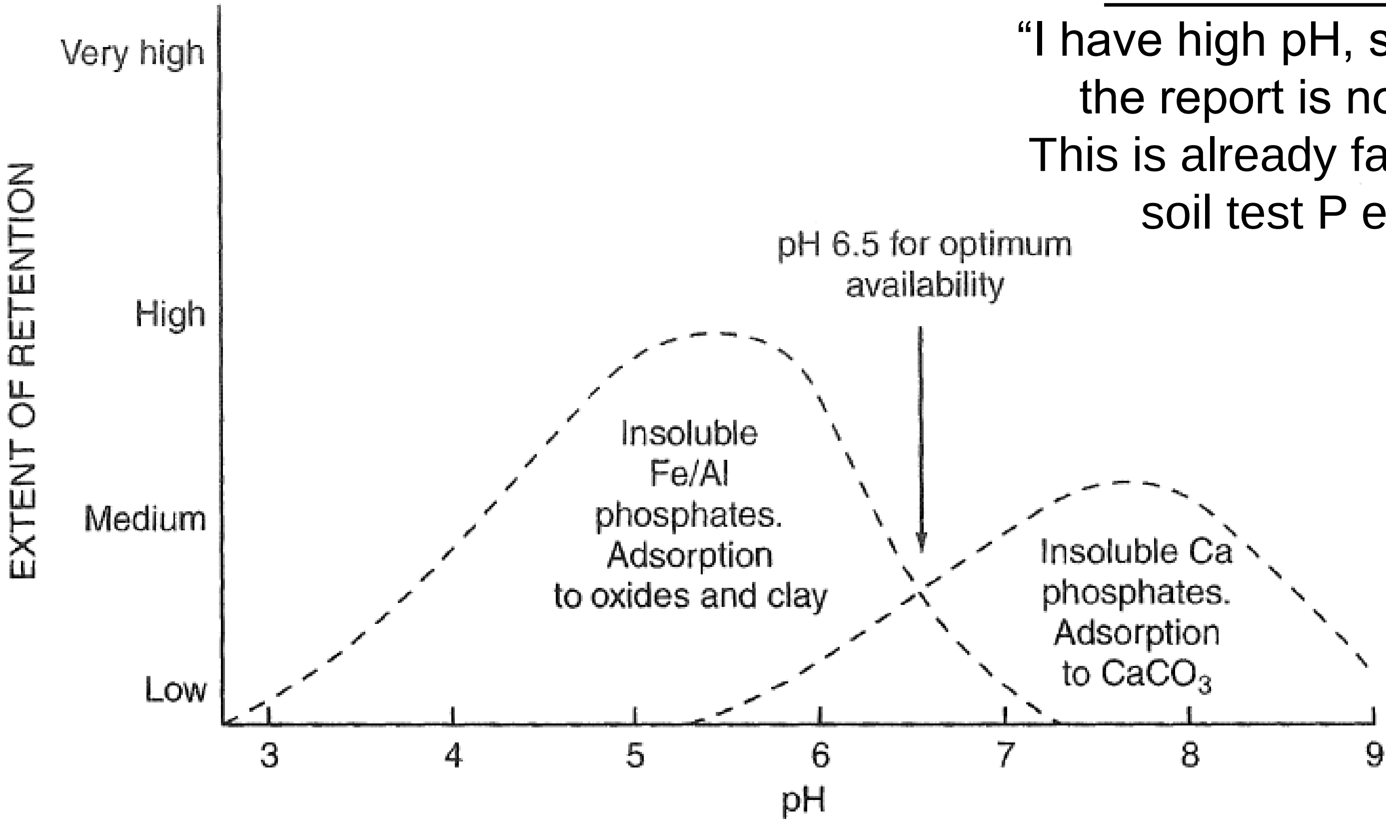
Effect of 1000 lb/a K_2O on %K (Base Saturation)



Effect of 1000 lb/a K_2O on Soybean Tissue levels



Soil pH controls soil phosphorus availability



<u>Common misconception</u>

"I have high pH, so soil test P on the report is not available."
This is already factored into the soil test P extraction.

- Soil test extraction measures plant availability
- When soil P is less available, maximize efficiency with banding

Havlin, J.L., J.D. Beaton, S.L. Tisdale, and W.L. Nelson. 2005. Soil Fertility and Fertilizers: An Introduction to Nutrient Management. 7th ed. Pearson Prentice Hall, Upper Saddle River, NJ.

Your observations are important
Do not ignore the obvious!