Your Soil Test Questions Answered: A Deep Dive into the AGVISE Soil Test Database

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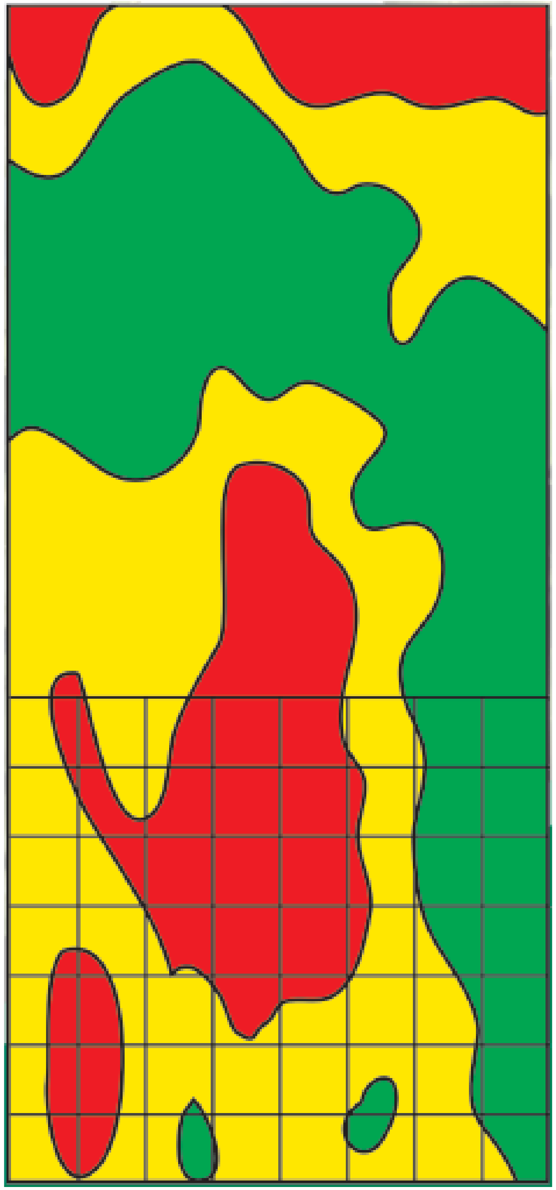
Soil Scientist, CCA, 4R NMS
AGVISE Laboratories



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We get a lot of questions…

- Over 45 years of soil testing experience
- Over 8.5 million soil samples across the region
- Unique opportunity to explore data and try to answer some of those questions

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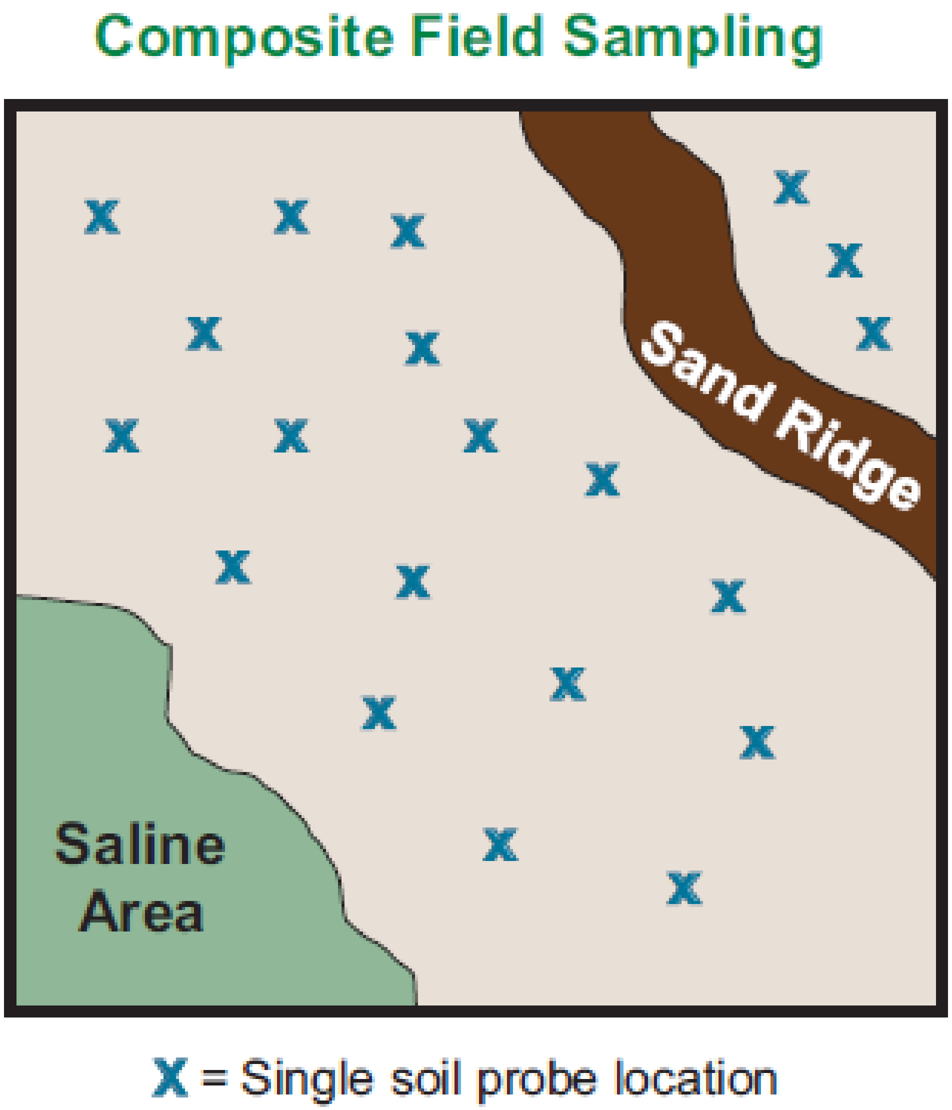
Topics we will explore

1. Precision soil sampling (grid or zone)
2. Soil pH
3. Soil nitrate-nitrogen
4. Soil phosphorus and potassium

#1: Precision soil sampling (grid or zone)

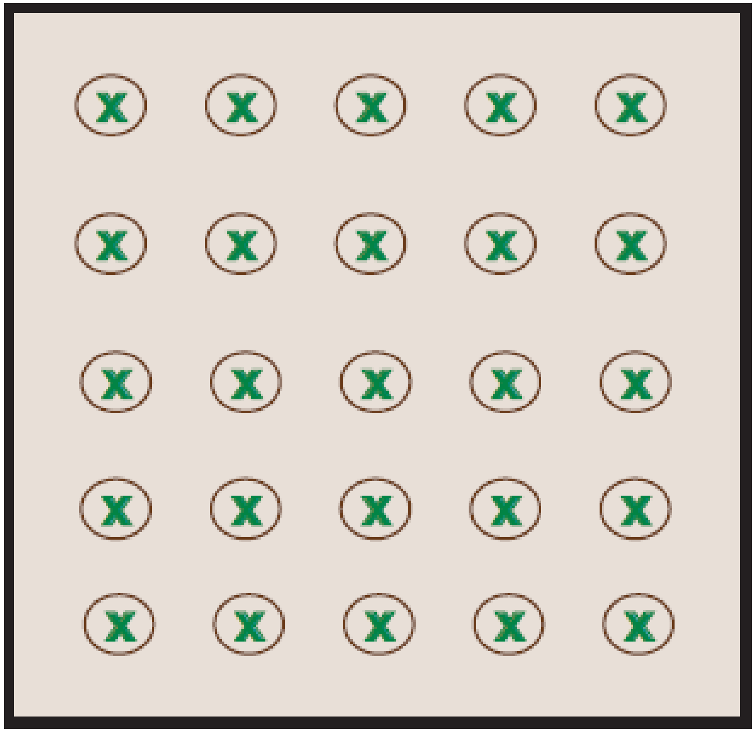
Questions we can explore

- Trends in precision soil sampling
- Soil nutrient variability in fields



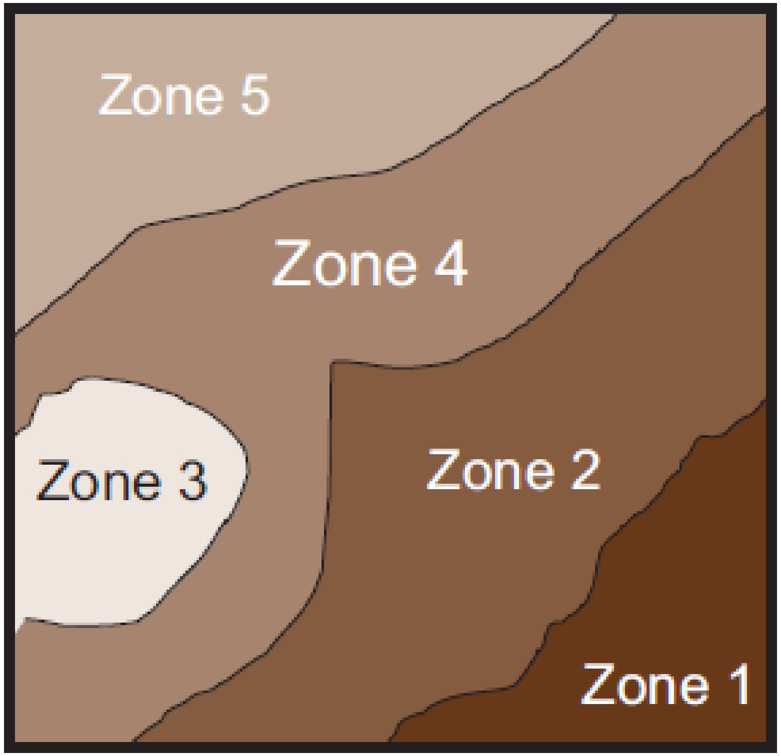
20-25 soil cores collected across entire field
Avoid nonrepresentative areas

Grid Sampling Example



X = 8-10 Probe Sites per grid point

Productivity Zone Sampling Example



10-15 Probe Sites per zone area

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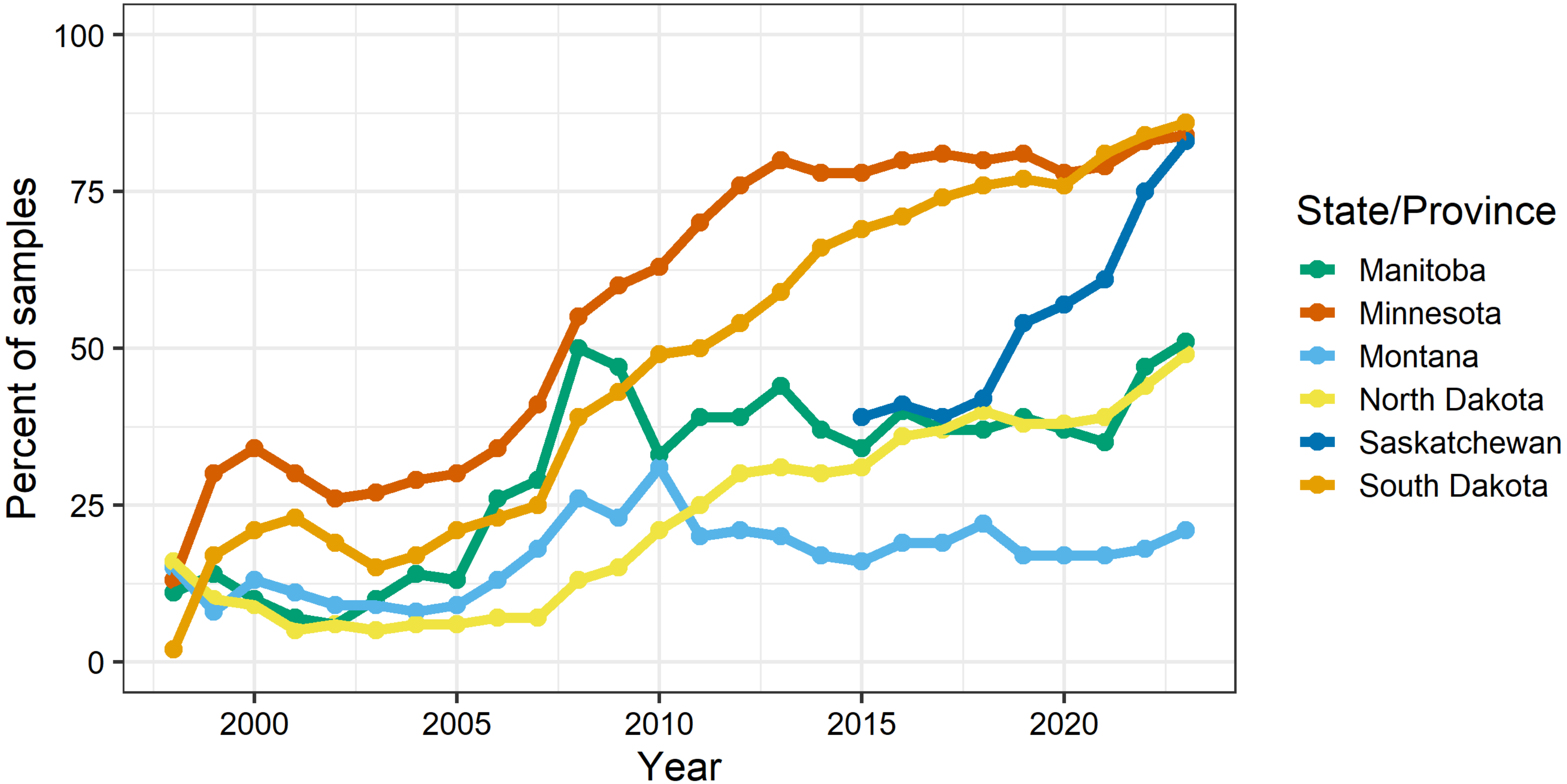
Soil samples collected as a precision sample (grid or zone)

Trend from 1998 to 2023



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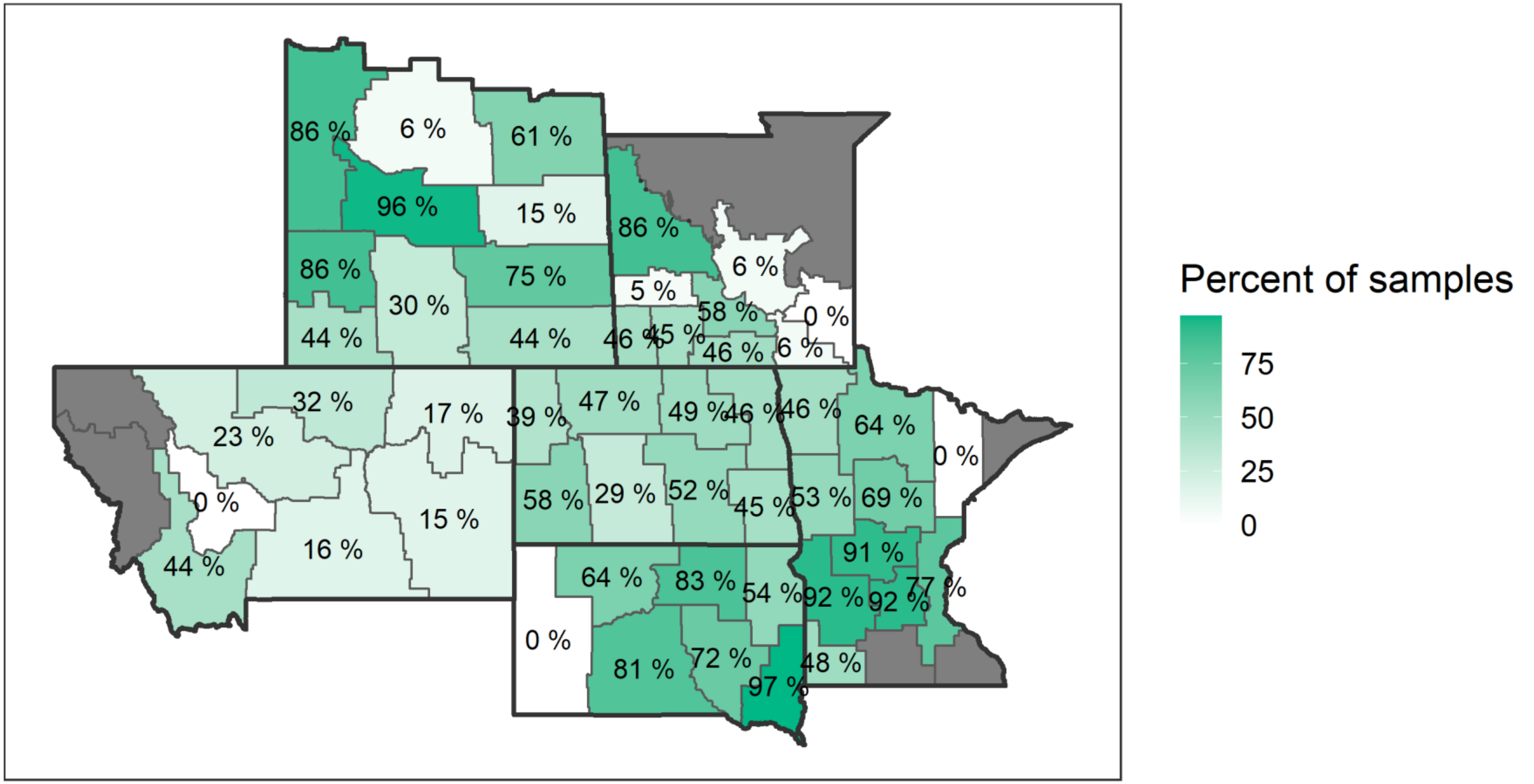
Soil samples collected as a precision sample in 2023



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But those are just the total numbers…

- Any grid sampled field overwhelms the proportion of soil samples (64 samples in 160 field)
- Transition to zone sampling effectively increases your soil sampling by 3-5 times

…what about the actual fields?

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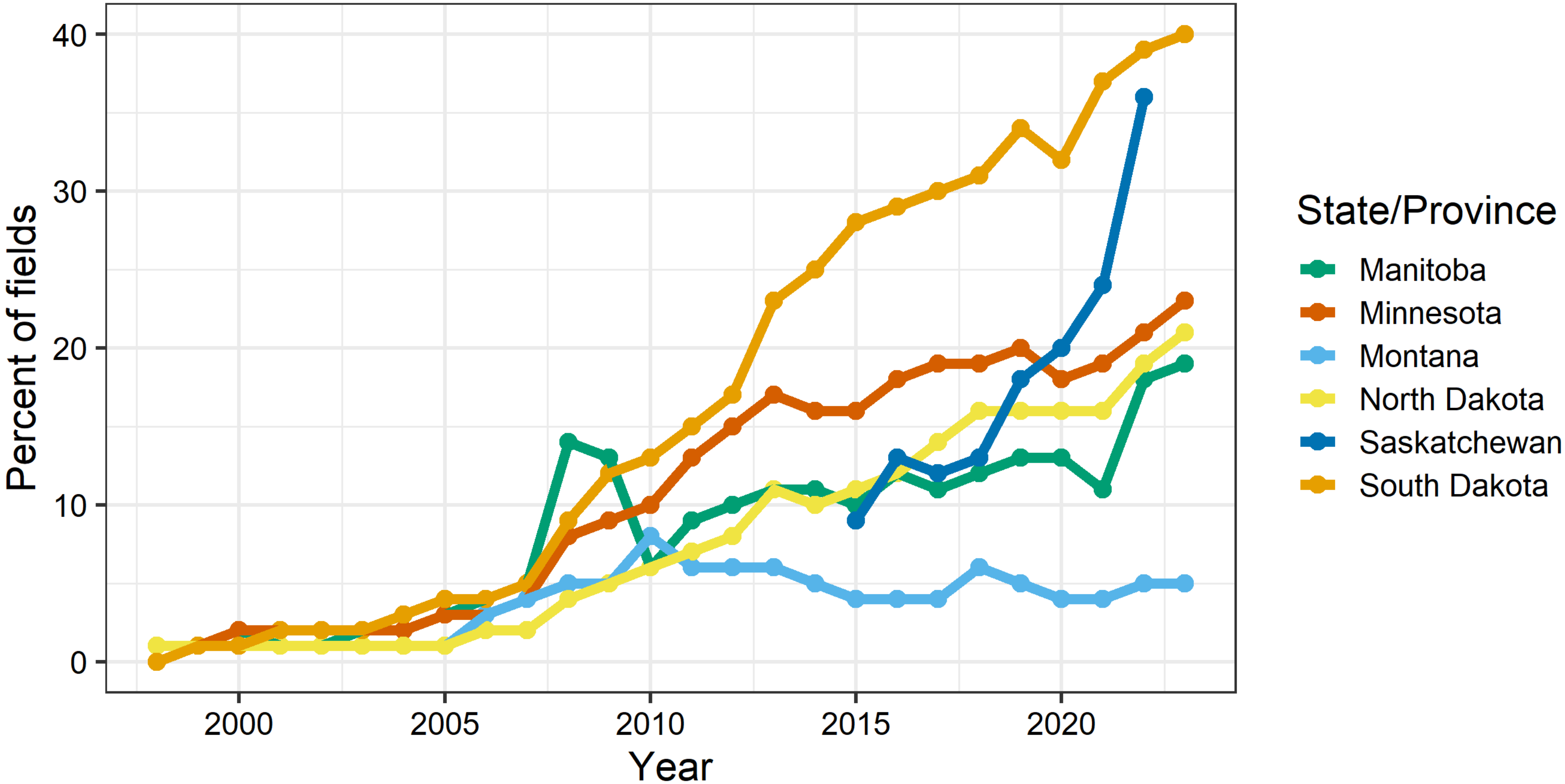
Fields sampled using precision sampling techniques (grid or zone)

Trend from 1998 to 2023



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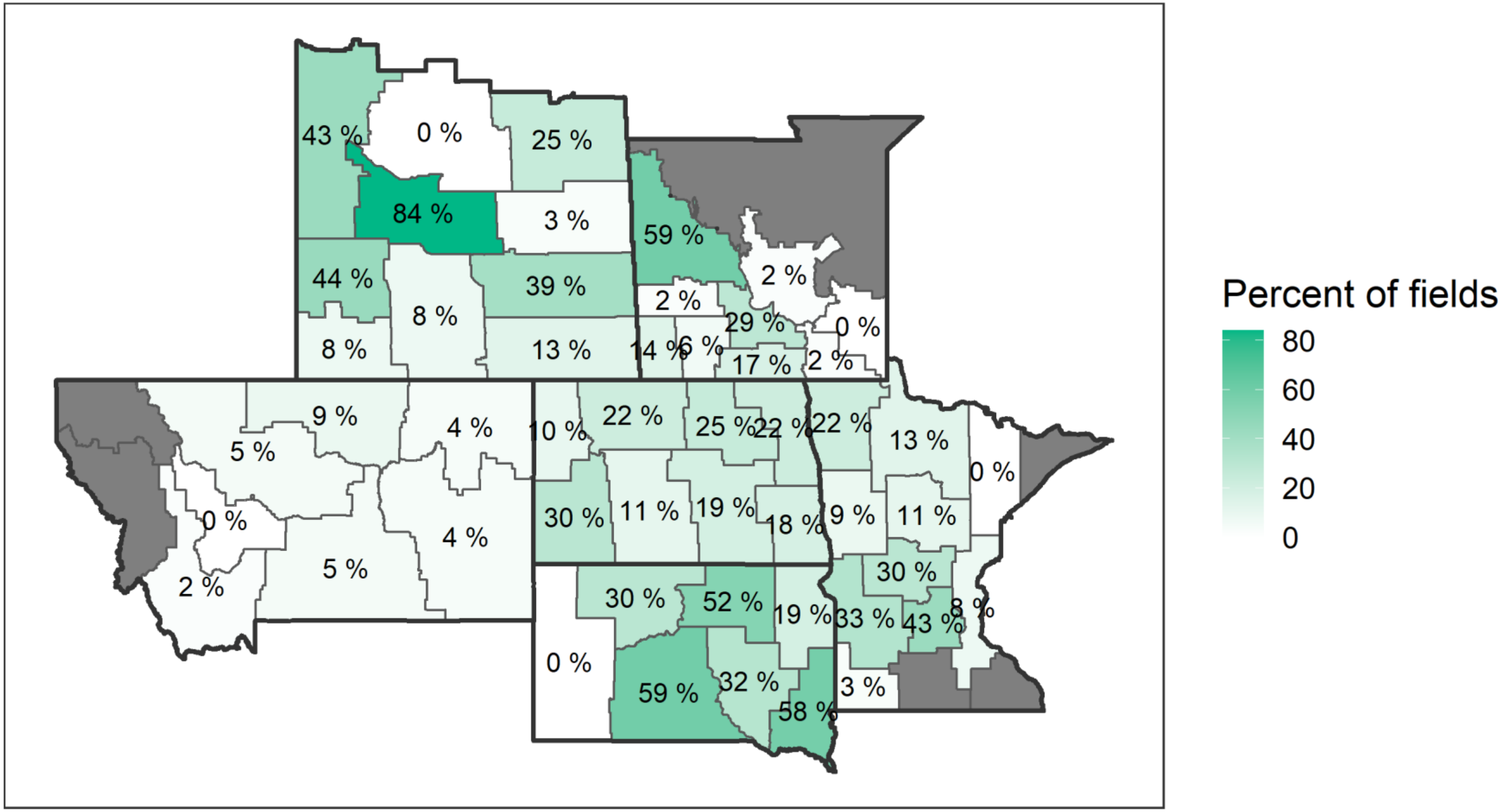
Fields sampled using precision sampling techniques (grid or zone) in 2023



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Zone soil sampling reveals field variability

	Average soil test range within a field (high zone – low zone)					
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Summary of 24,000 precision soil sampled fields from Manitoba, Minnesota, North Dakota, South Dakota; AGVISE Laboratories, 2023.

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#2: Soil pH

Questions we can explore

- Increasing extent and frequency of low pH soils (pH < 6.0)
- Soil pH and aluminum toxicity risk (pH < 5.5)
- Soil pH variability and concern for aluminum toxicity
- Calcium carbonate controls high soil pH
- Soybean iron deficiency chlorosis (IDC) risk

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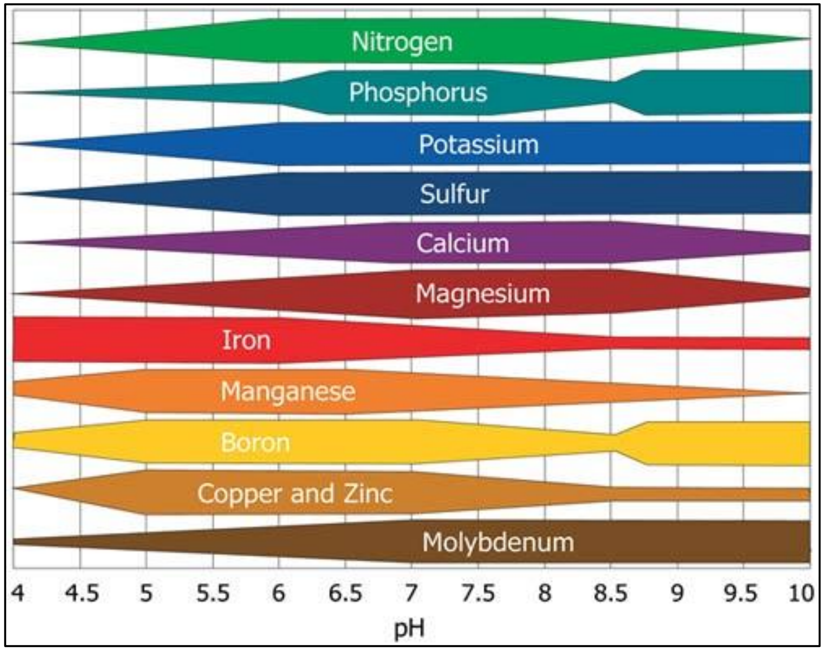
Why are acid soils problematic?

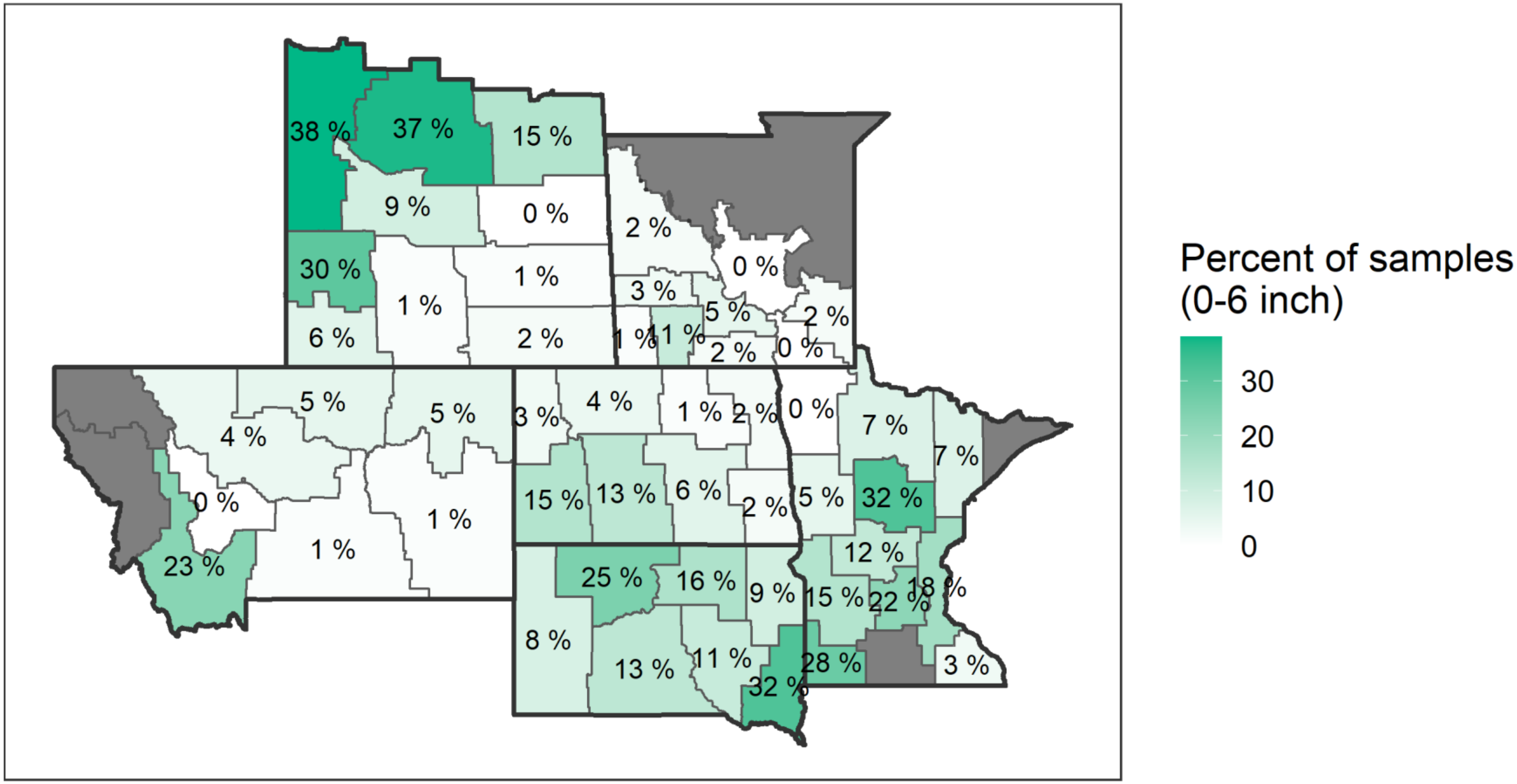
Reduced nutrient availability



Aluminum toxicity

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

Soil samples with soil pH below 6.0 in 2023



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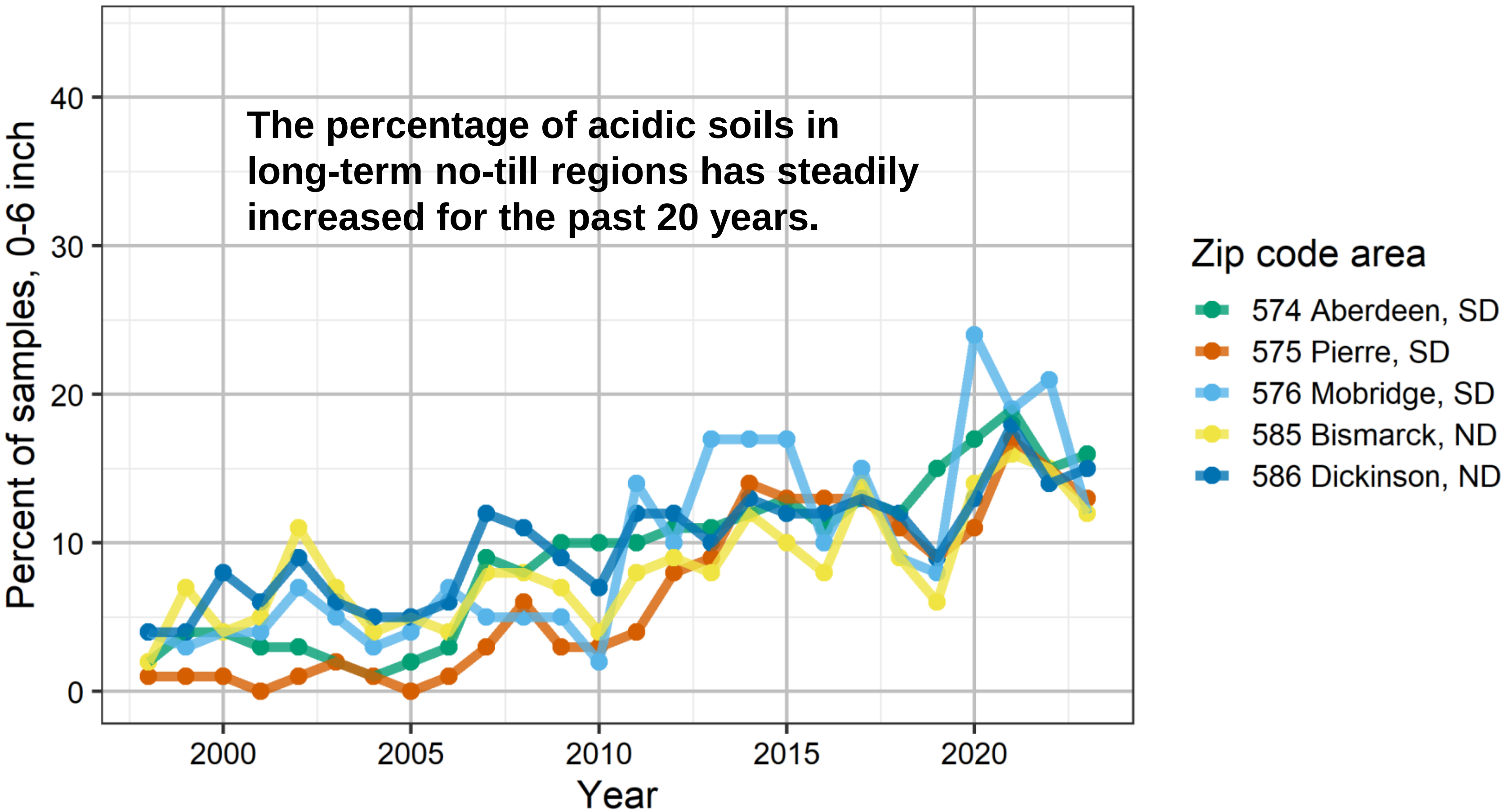
Soil pH trend (pH < 6 1:1) across the northern Great Plains



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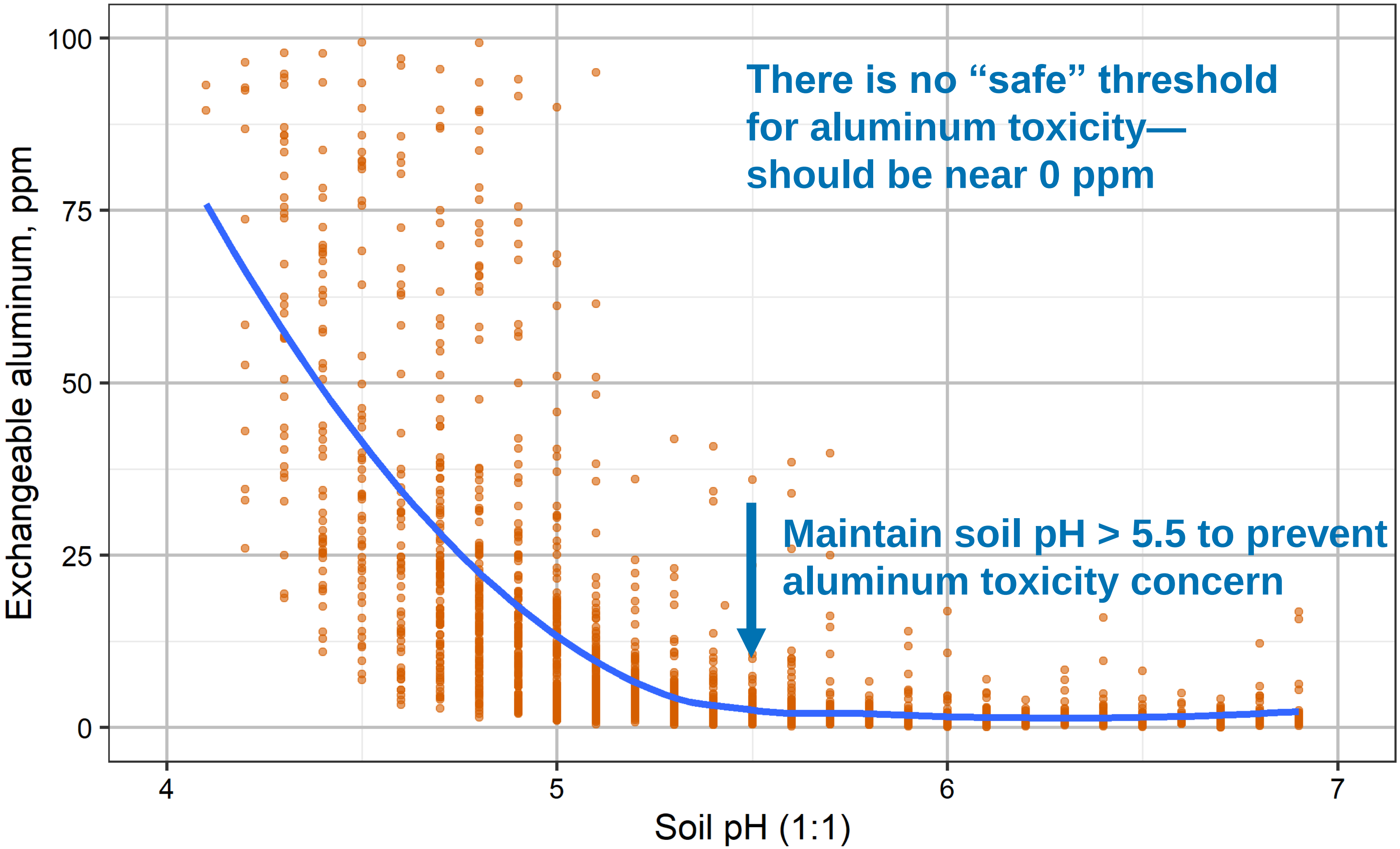
Soil pH controls aluminum availability



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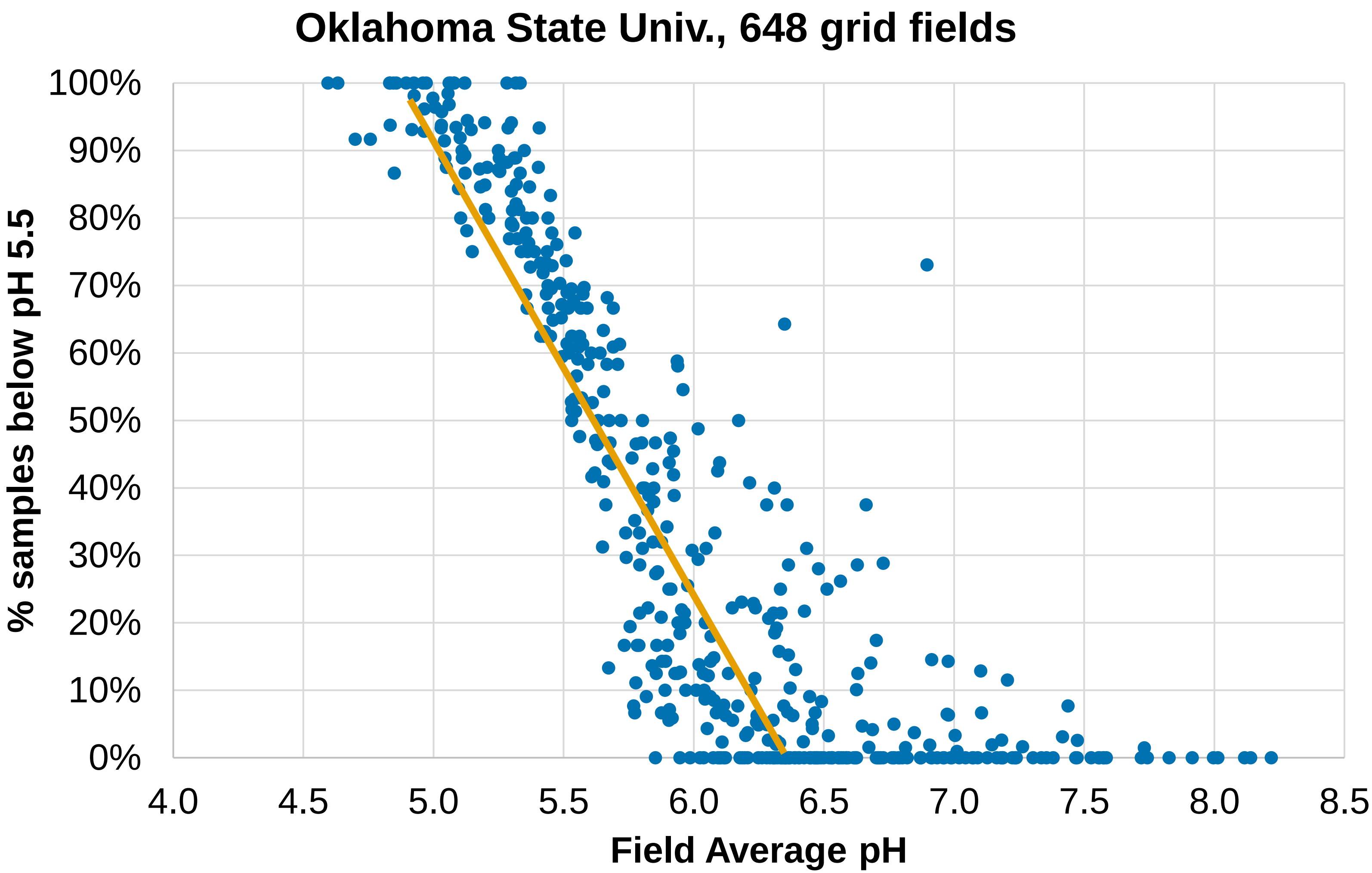
pH variability is hidden in the average



Slide courtesy of Brian Arnall, Oklahoma State Univ., Stillwater, OK.

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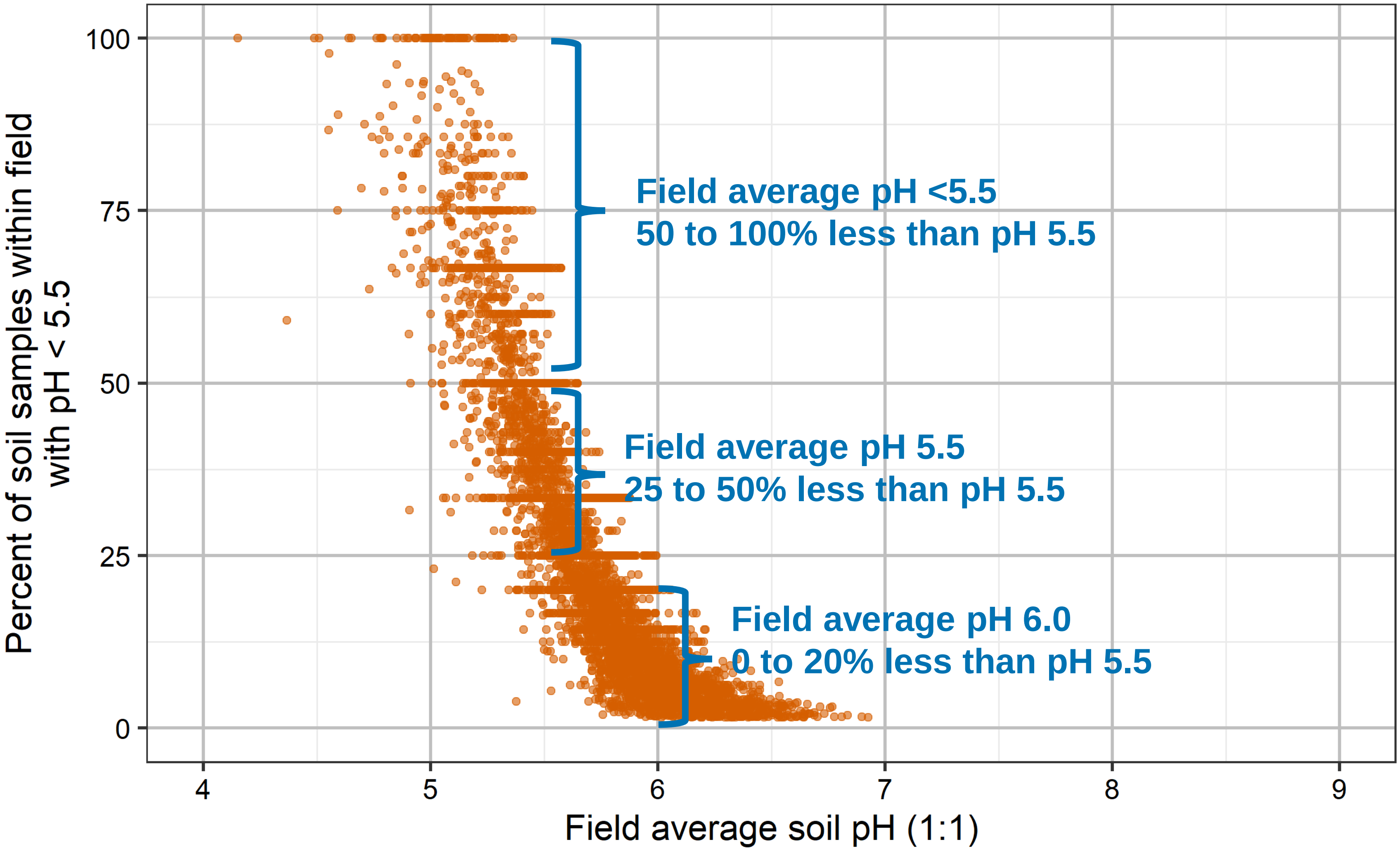

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Summary of 58,000 precision soil sampled fields from Manitoba, Minnesota, North Dakota, South Dakota; AGVISE Laboratories, 2021-2022.

Lessons about low soil pH

- Extent and frequency of low soil pH is increasing
- For soils with pH < 5.5, aluminum toxicity becomes a major crop production-limiting concern
- For whole-field composite soil samples, concern starts when average soil pH < 6.0; if average soil pH < 5.5, then 50 to 100% may lie at risk for serious aluminum toxicity concern, need to grid or zone soil sample

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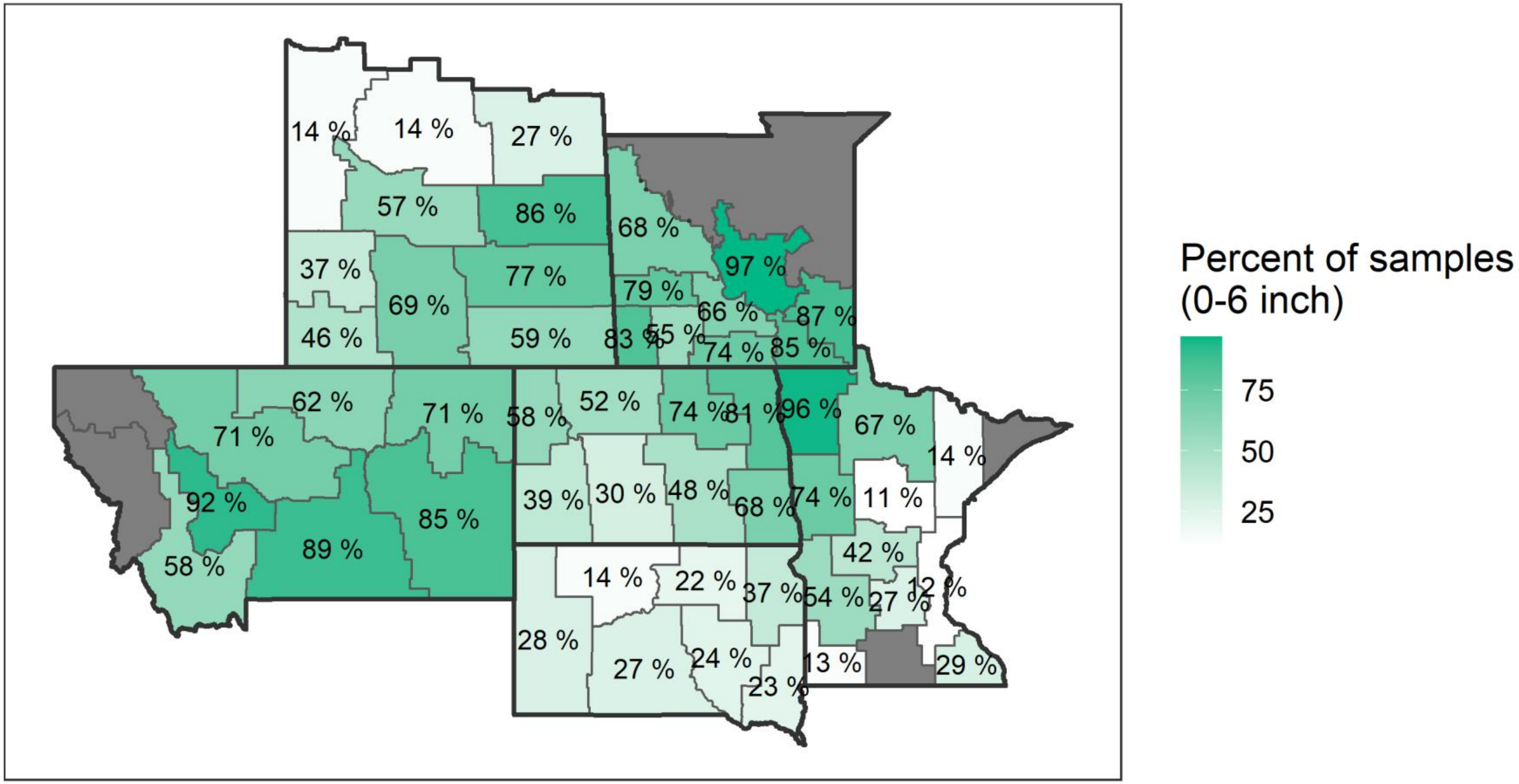
What about high soil pH?

- High soil pH reduces availability of phosphorus (P), zinc (Zn), and iron (Fe)
- Calcium carbonate buffers soil pH near pH 7.8-8.4; naturally occurring in our glaciated soils
- Major concern is soybean iron deficiency chlorosis (IDC) risk, where carbonate and/or salinity presents high IDC risk

Soil samples with soil pH above 7.3 in 2023



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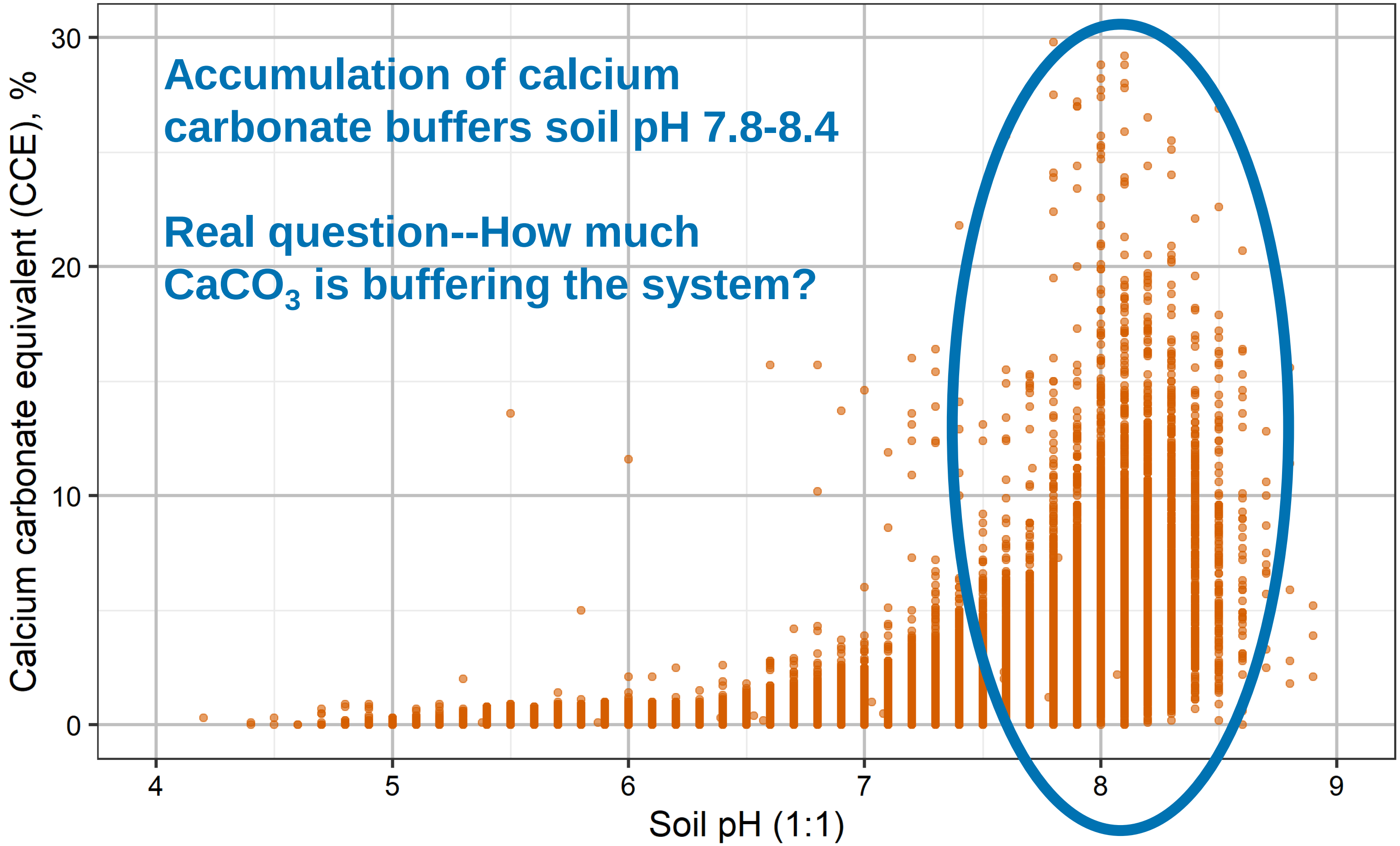
Naturally occurring calcium carbonate ($CaCO_3$, free lime) buffers soil pH



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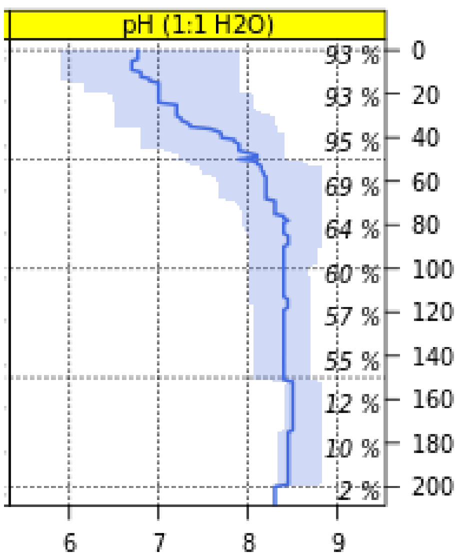
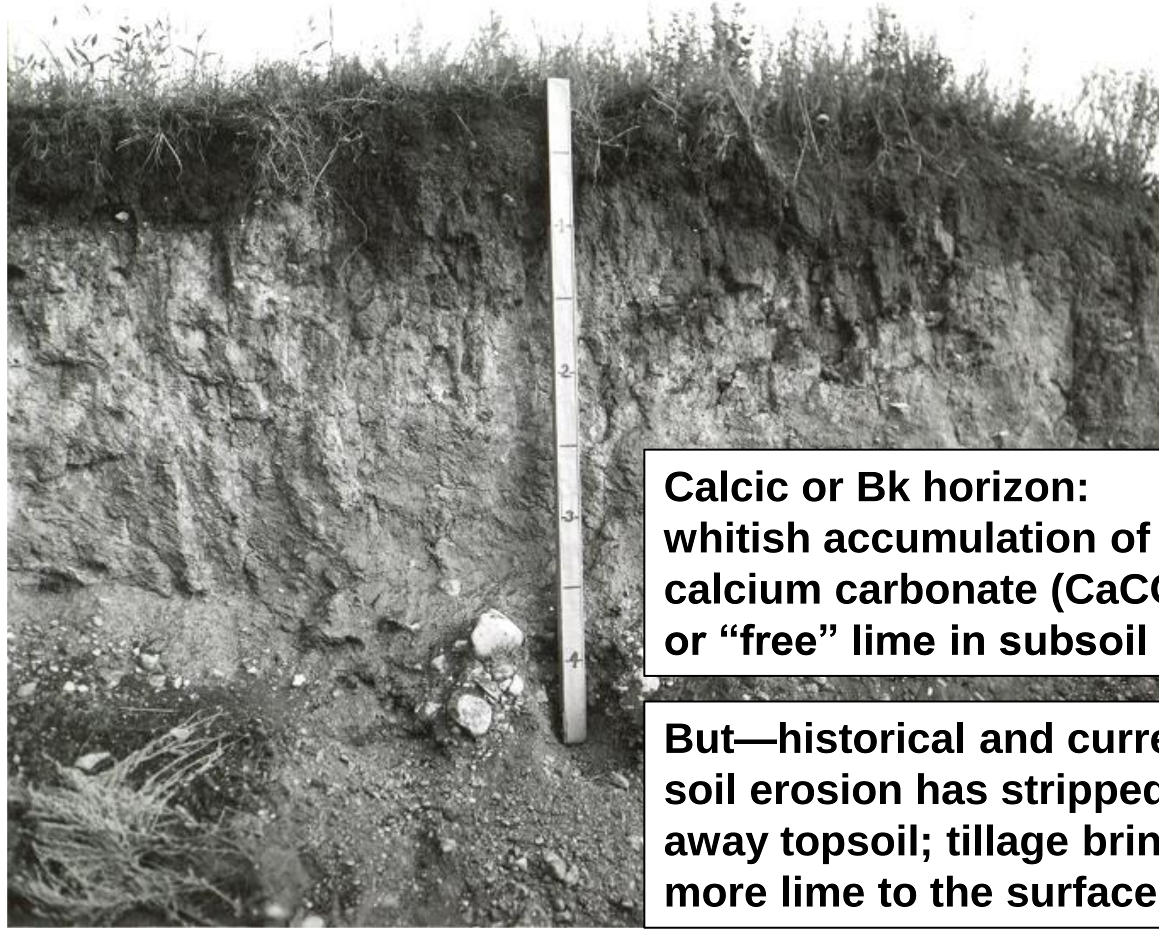
Why is calcium carbonate so important in soil formation?

Barnes series
LaMoure Co., ND





Calcic or Bk horizon: whitish accumulation of calcium carbonate ($CaCO_3$) or "free" lime in subsoil

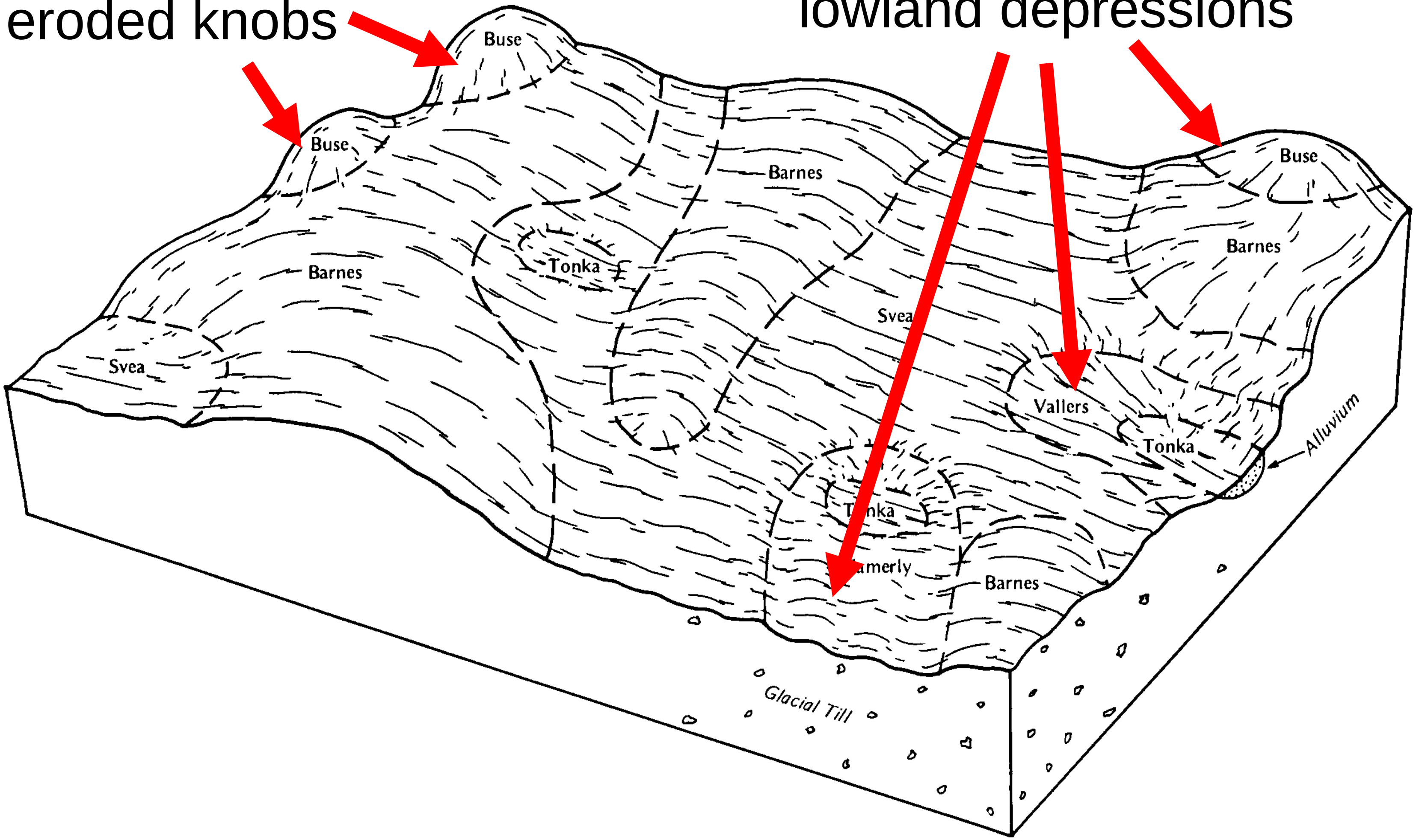
But—historical and current soil erosion has stripped away topsoil; tillage brings more lime to the surface

Photograph from D.G. Hopkins, North Dakota State Univ., Fargo, ND.

Where do you find calcium carbonate in the topsoil?

eroded knobs

lowland depressions



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.

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.

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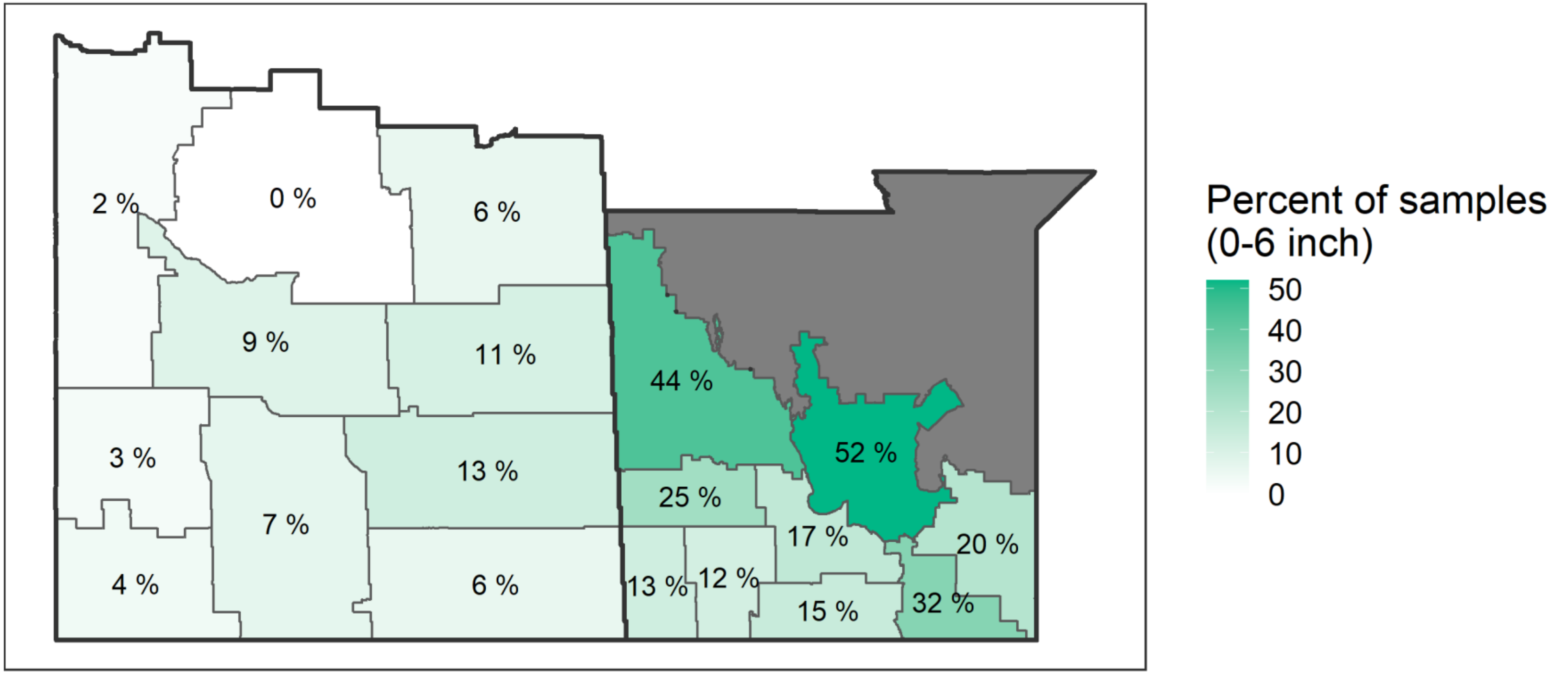
Soil samples with calcium carbonate above 5.0 % CCE in 2023



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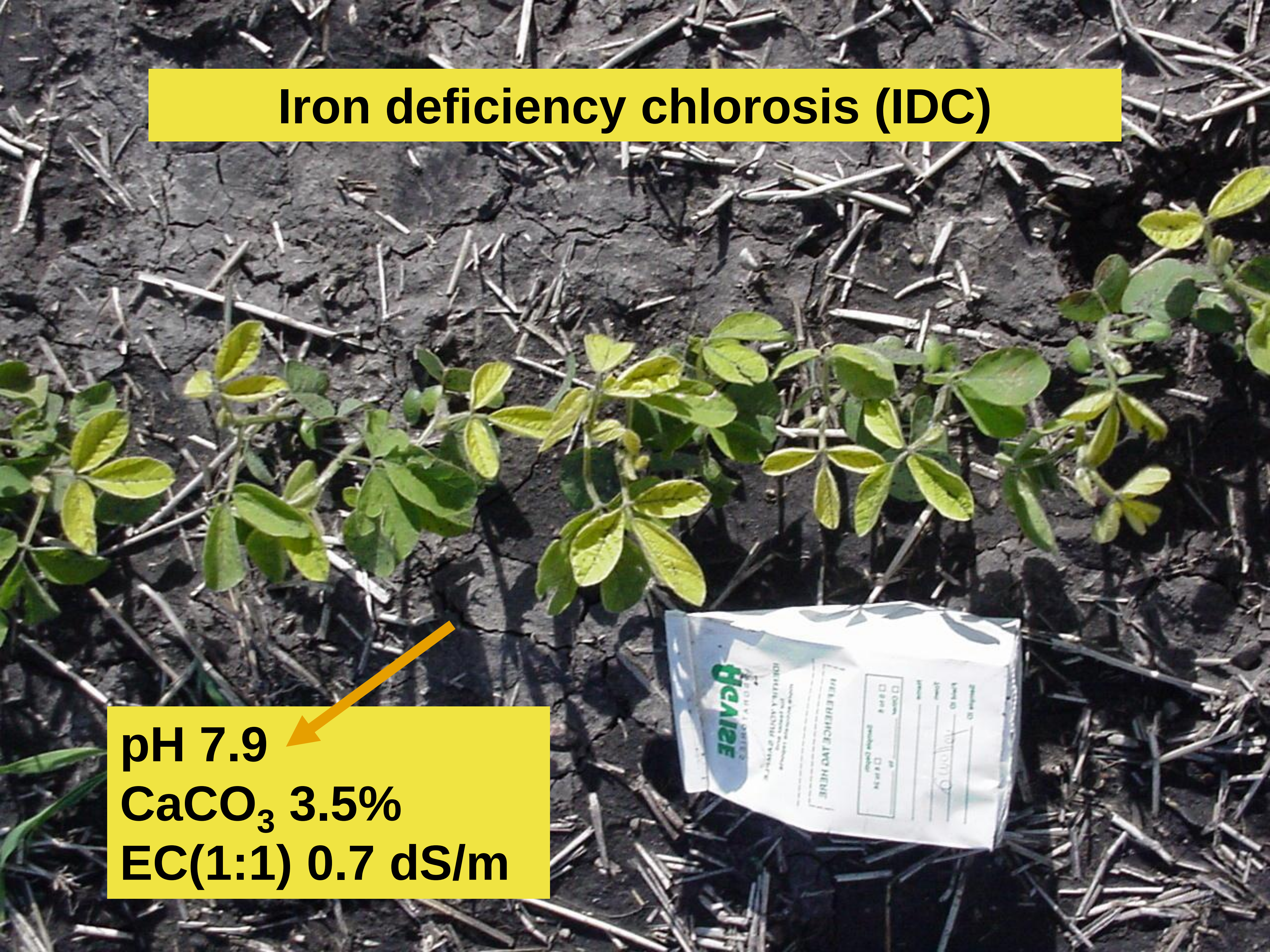
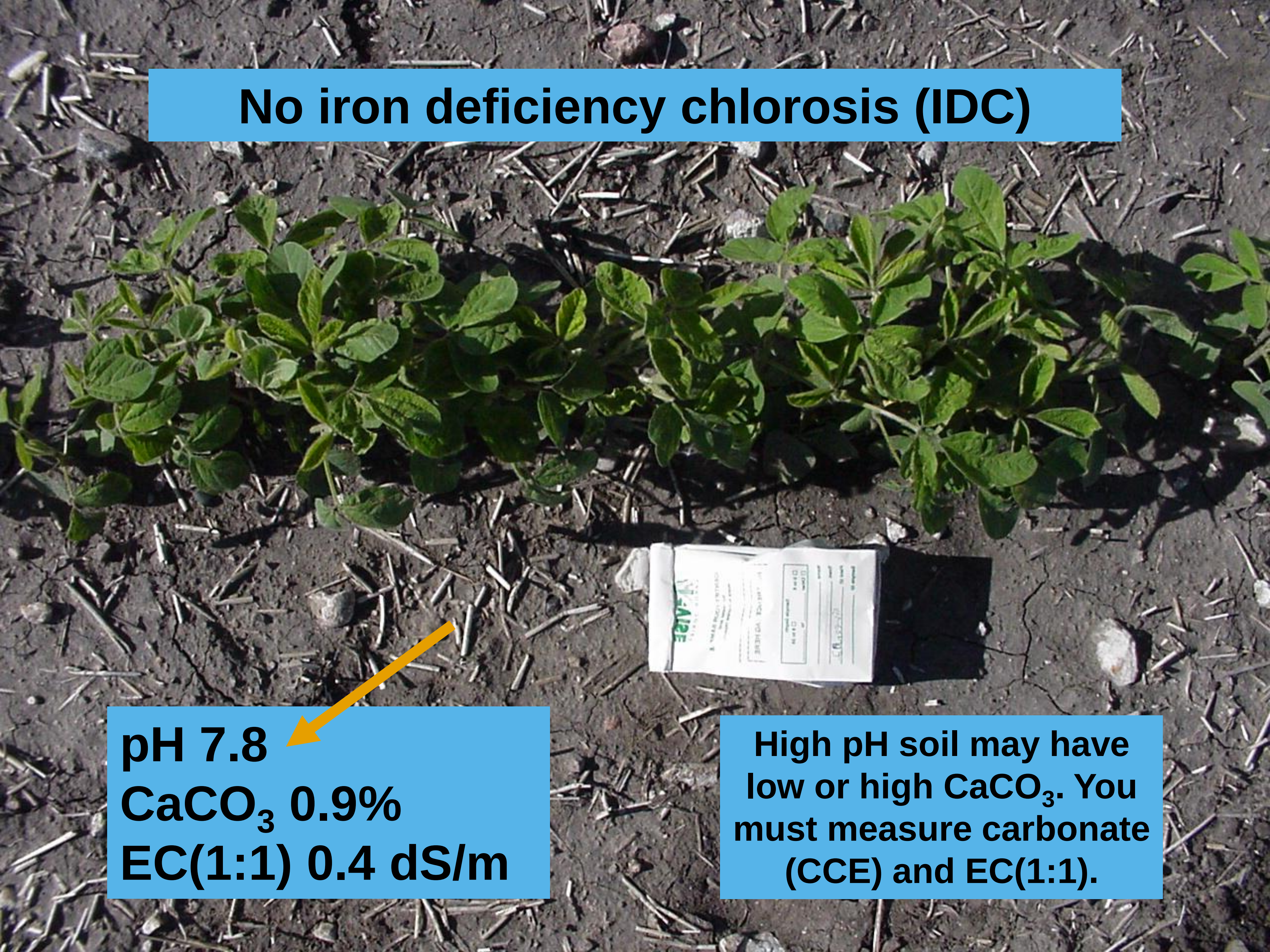
Iron deficiency chlorosis (IDC)




No iron deficiency chlorosis (IDC)
pH 7.8
$CaCO_3$ 0.9%
EC(1:1) 0.4 dS/m
High pH soil may have low or high $CaCO_3$. You must measure carbonate (CCE) and EC(1:1).

AGVISE Soybean IDC Risk Index

	Soybean IDC risk potential		
Salinity (EC 1:1)	**Calcium carbonate equivalent (CCE)**		
dS/m	**< 2.5 %**	**2.6 – 5.0 %**	**> 5.0 %**
< 0.25	Low	Low	Moderate
0.26 – 0.50	Low	Moderate	High
0.51 – 1.00	Moderate	High	Very high
> 1.00	Very high	Very high	Extreme

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

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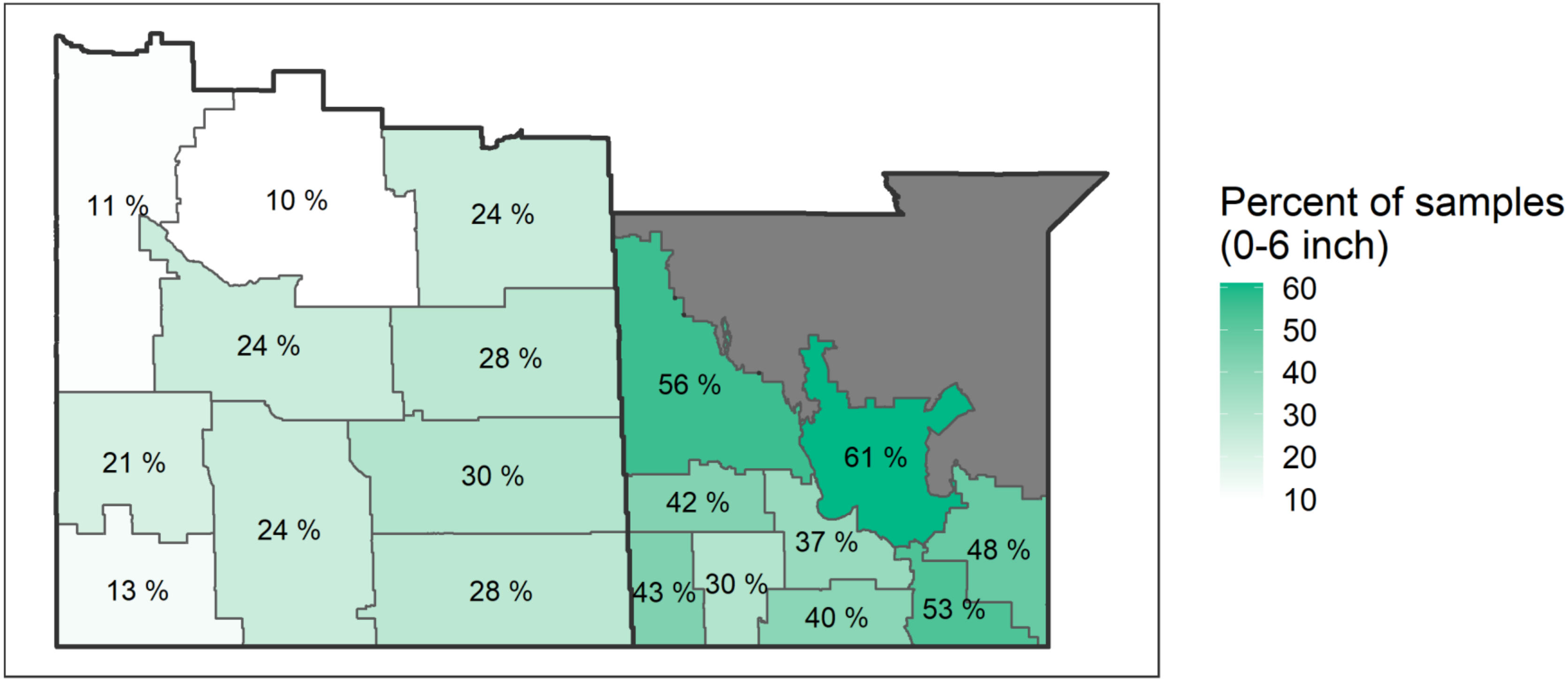
Foundational research from Franzen, D.W., and J.L. Richardson. 2000. Soil factors affecting iron chlorosis of soybean in the Red River Valley of North Dakota and Minnesota. J. Plant Nutr. 23(1):67–78.

Soil samples with high soybean iron deficiency chlorosis risk in 2023



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Manage soybean IDC with soil testing

Identify fields with low IDC risk

- Soil test for carbonate and salinity
- Choose low IDC risk fields

Mitigating moderate to high IDC risk

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

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#3: Soil nitrate-nitrogen

Questions we can explore

- Trends in residual soil nitrate-N after crops
  - Weather variation: drought vs. monsoon
- Field variability

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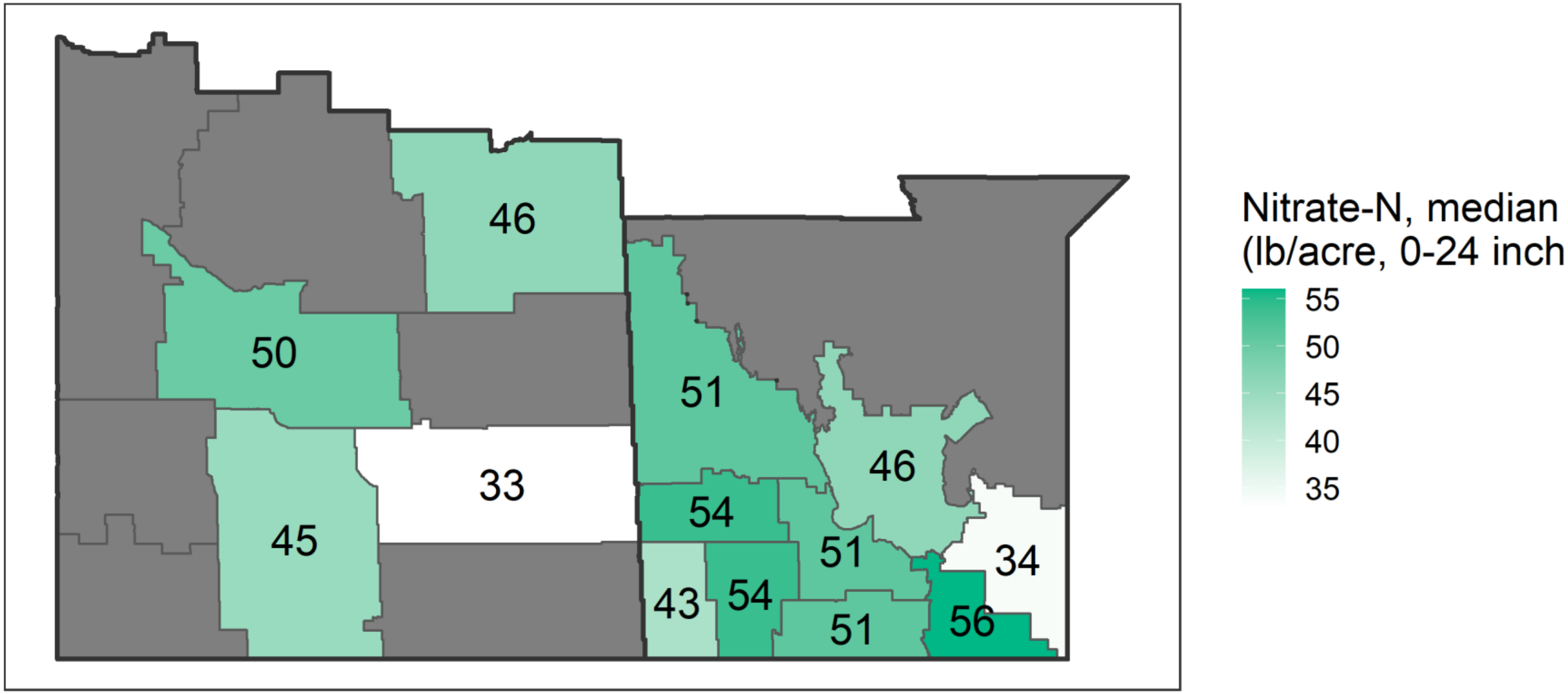
Residual nitrate following wheat in 2023



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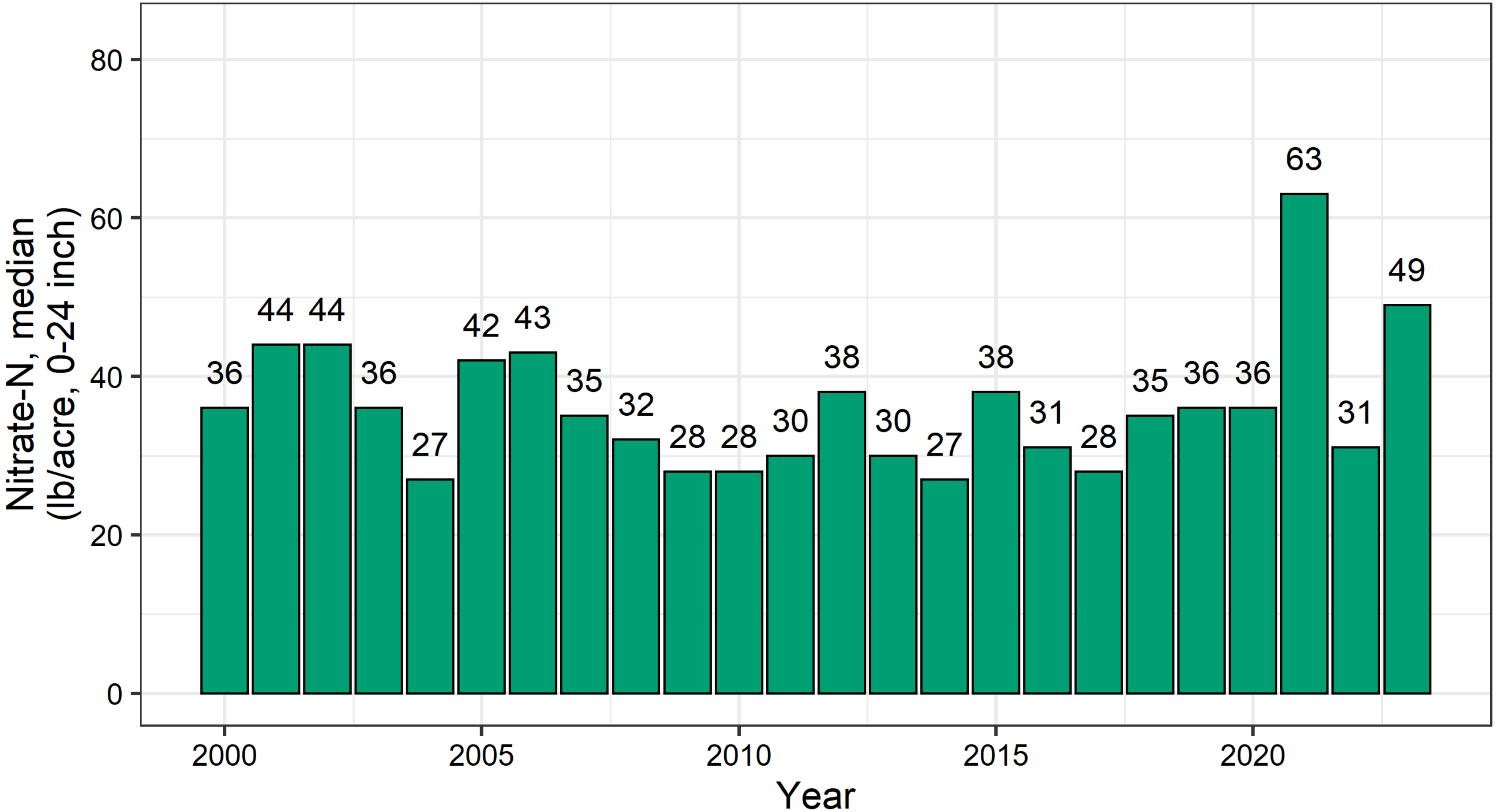
Residual nitrate following wheat

Trend from 2000 to 2023



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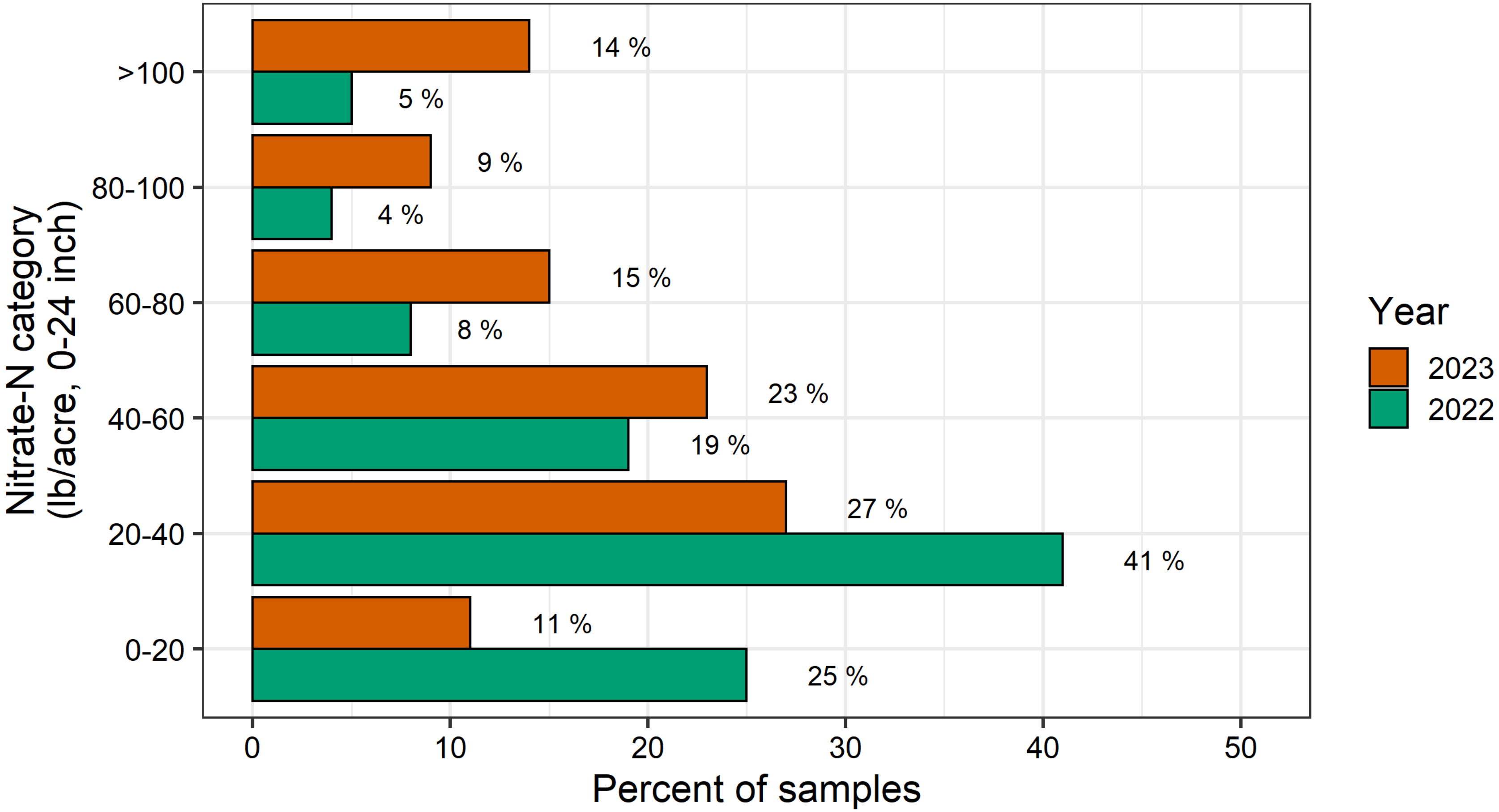
Residual nitrate variability following wheat in 2022 & 2023



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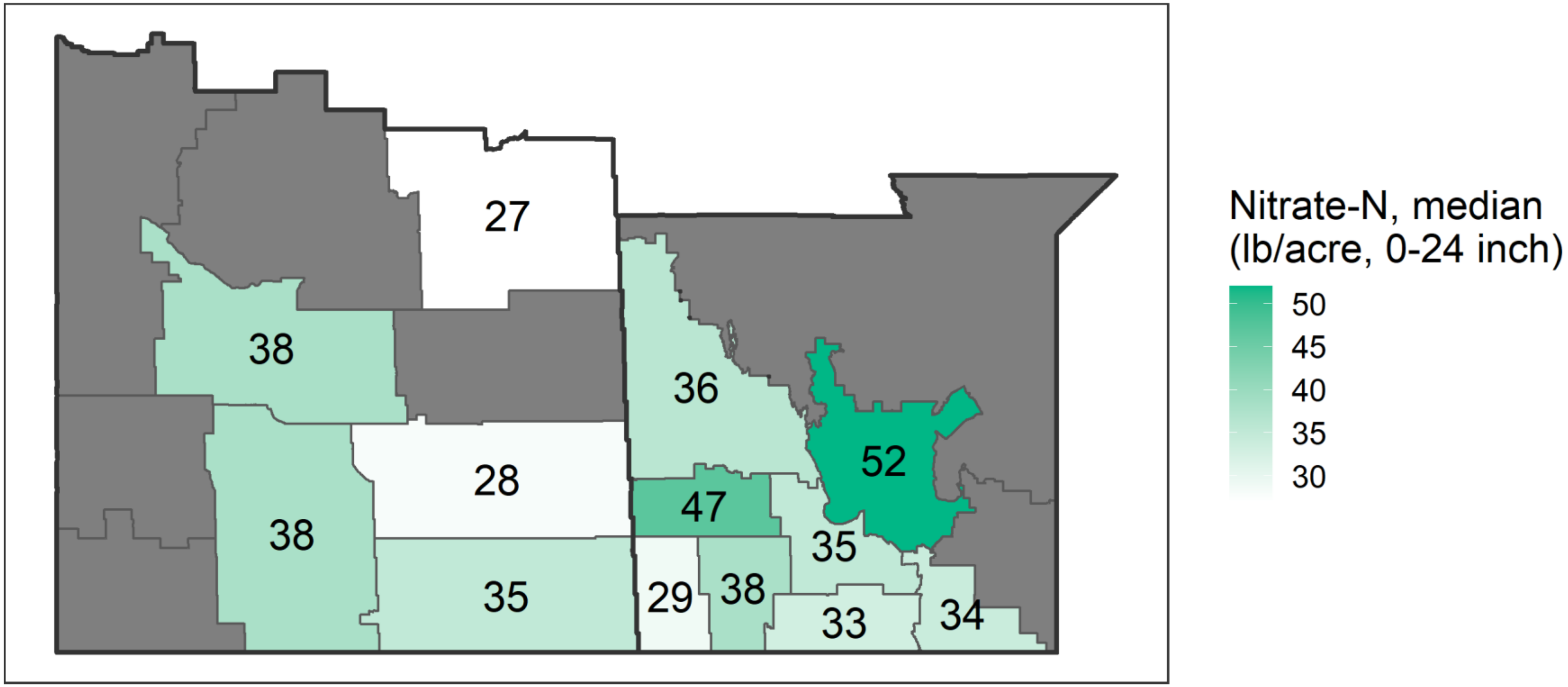
Residual nitrate following canola in 2023



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Residual nitrate following canola

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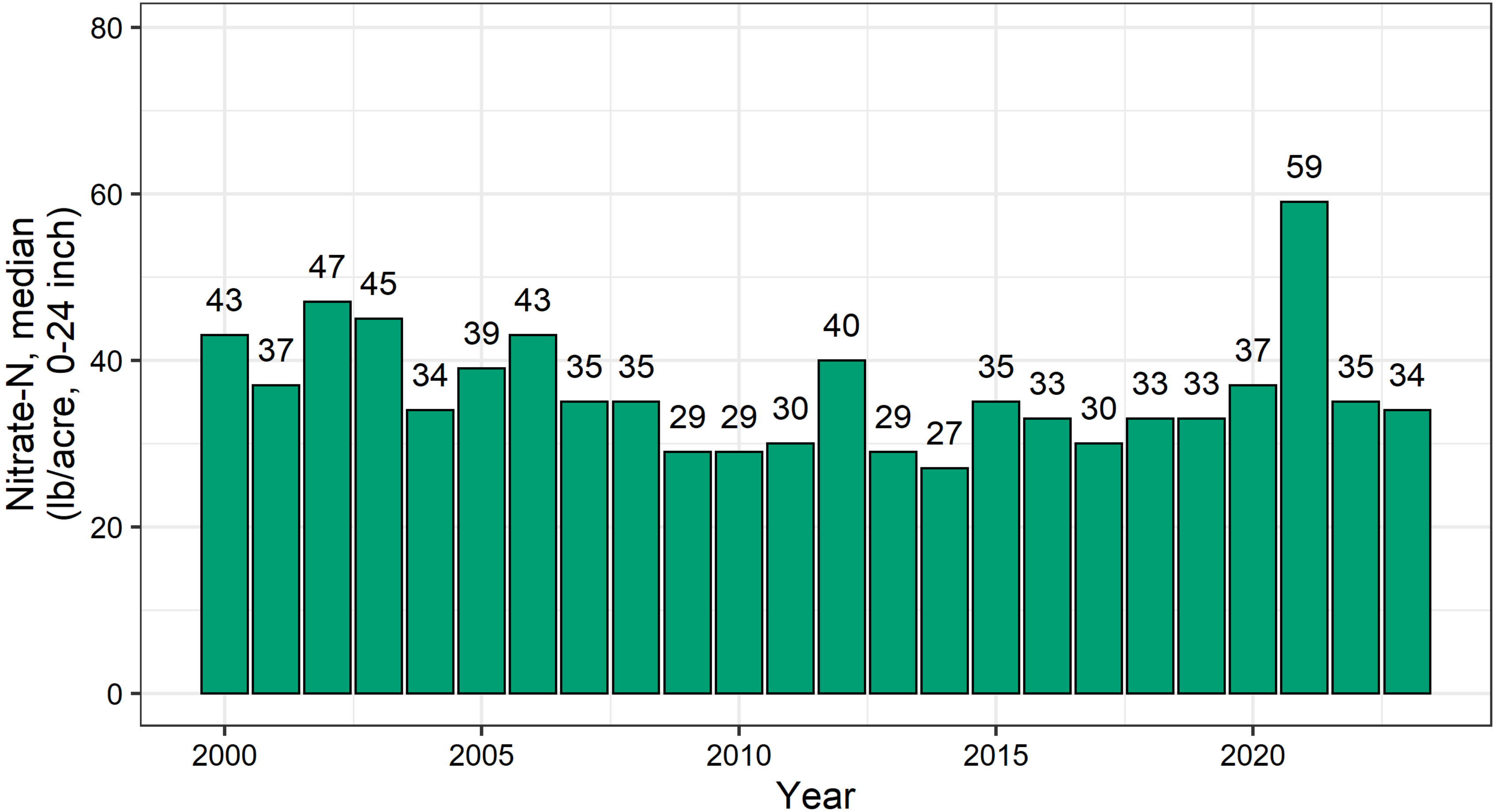

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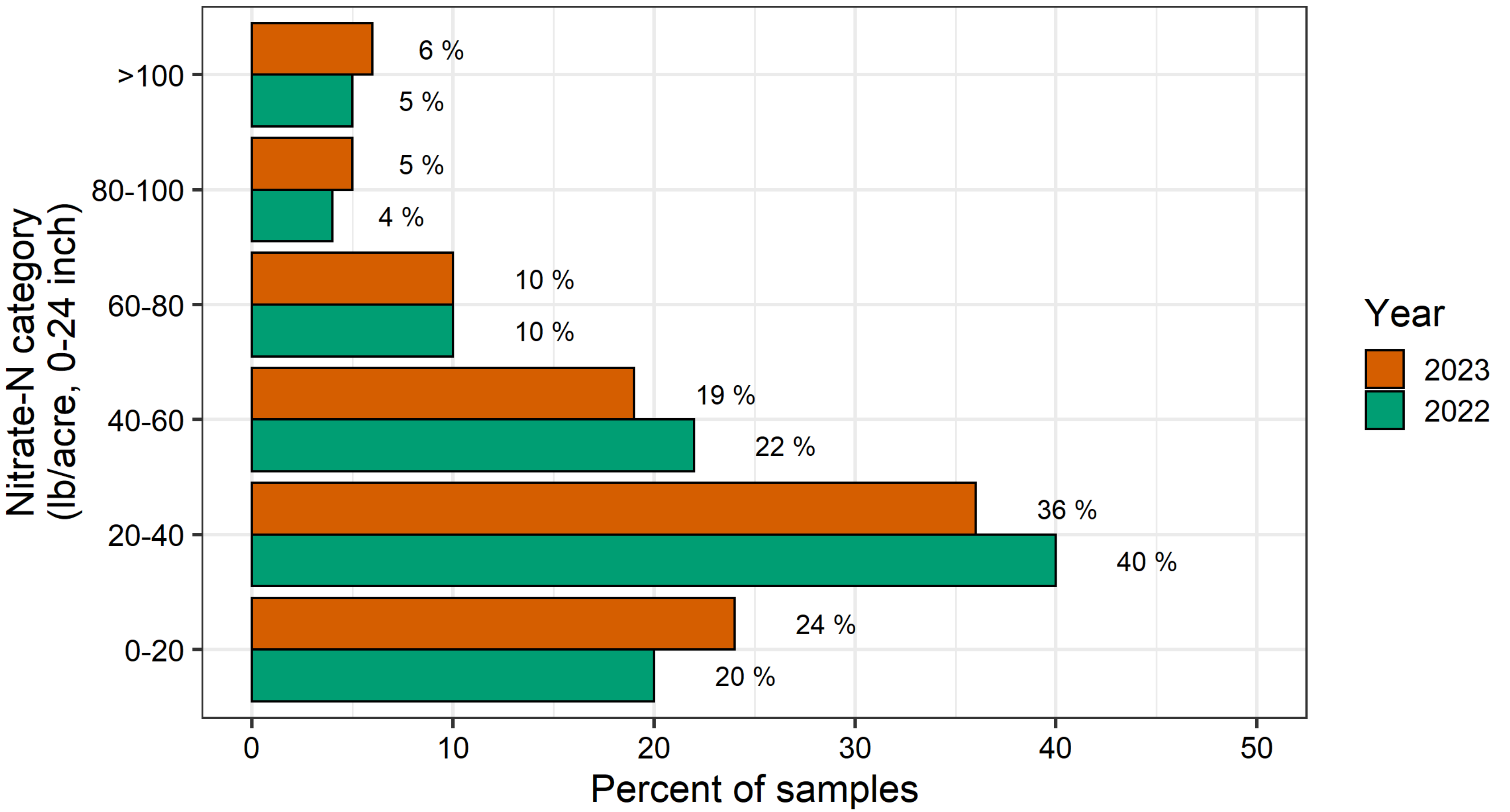

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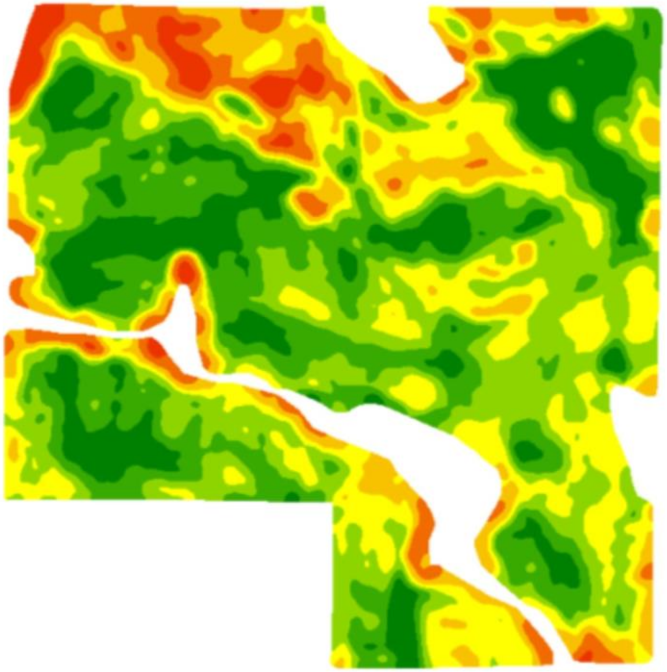
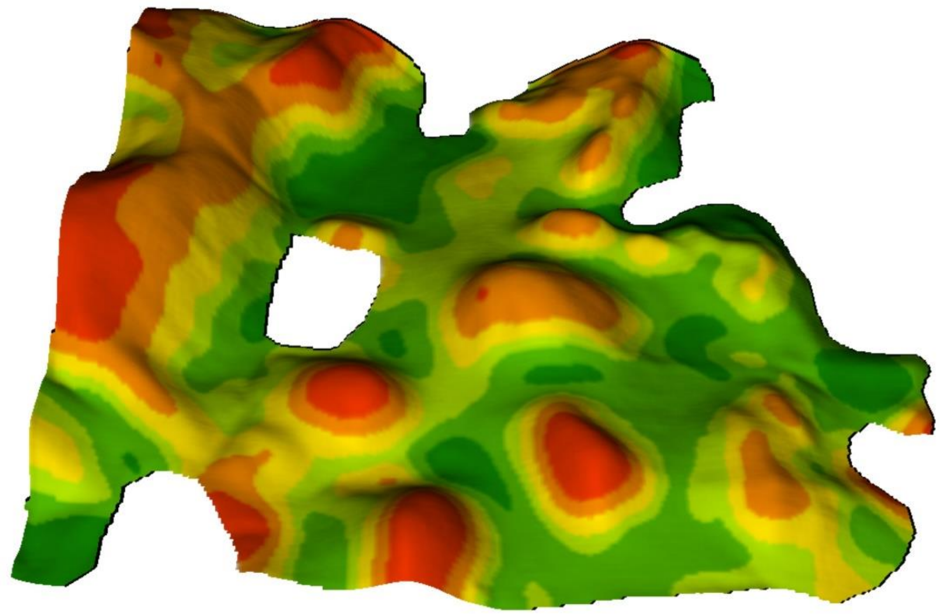


Factors of Soil Formation (Jenny, 1941)

- Climate
- Living organisms
- Relief (topography)
- Parent material
- Time



Spatial Variability

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Courtesy of Phillip Wanner, Centre Crop Consulting, Wishek, ND.

Zone soil sampling reveals field variability

	Average soil test range within a field (high zone – low zone)					
Number of zones per field	**Nitrate-N lb/acre, 0-24 inch**	**Olsen P ppm**	**K ppm**	**pH**	**EC(1:1) dS/m**	**SOM (%)**
3	33	10	90	0.6	0.8	1.1
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Summary of 24,000 precision soil sampled fields from Manitoba, Minnesota, North Dakota, South Dakota; AGVISE Laboratories, 2023.

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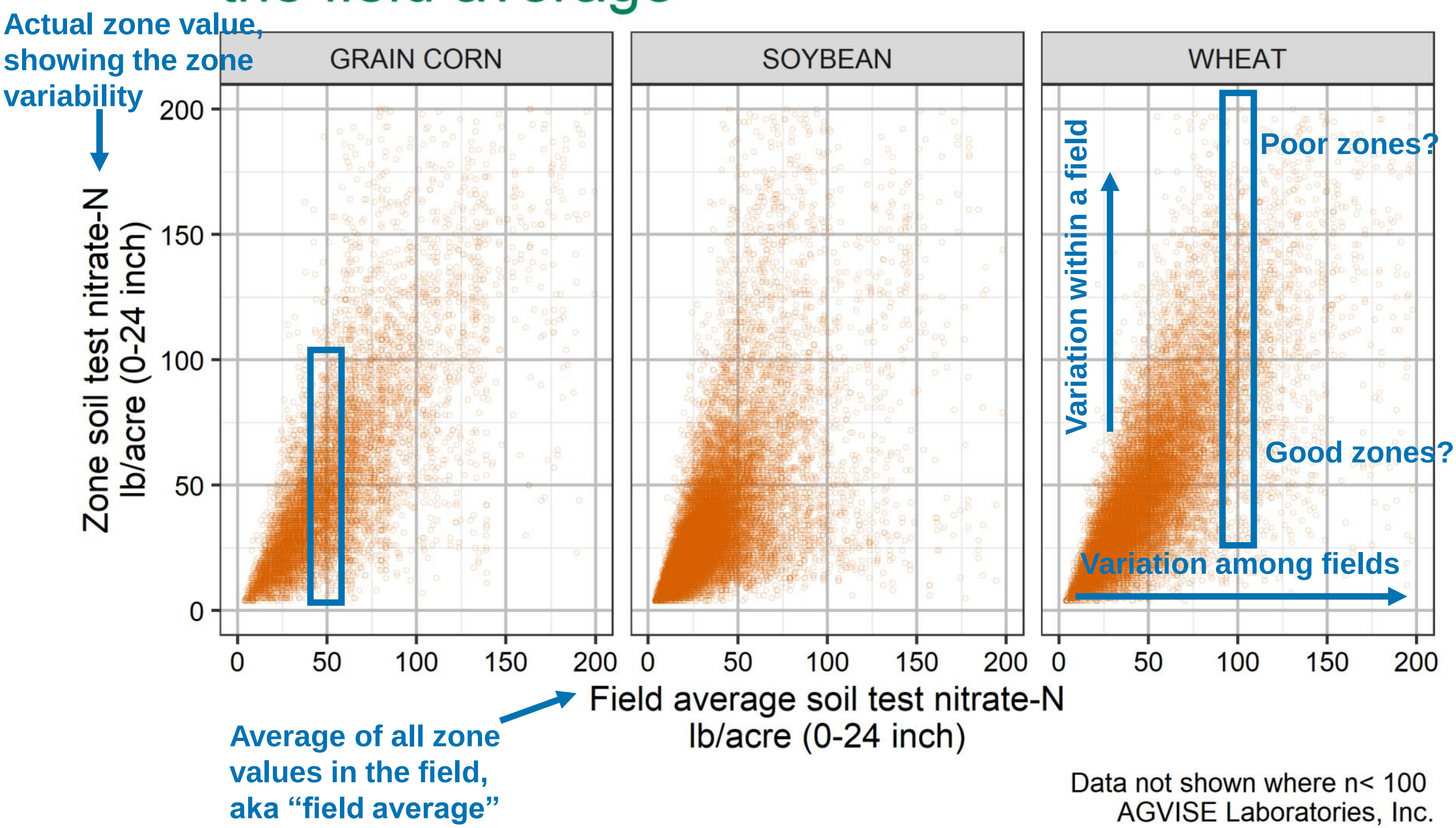
Soil test nitrate-N zone variability within the field average



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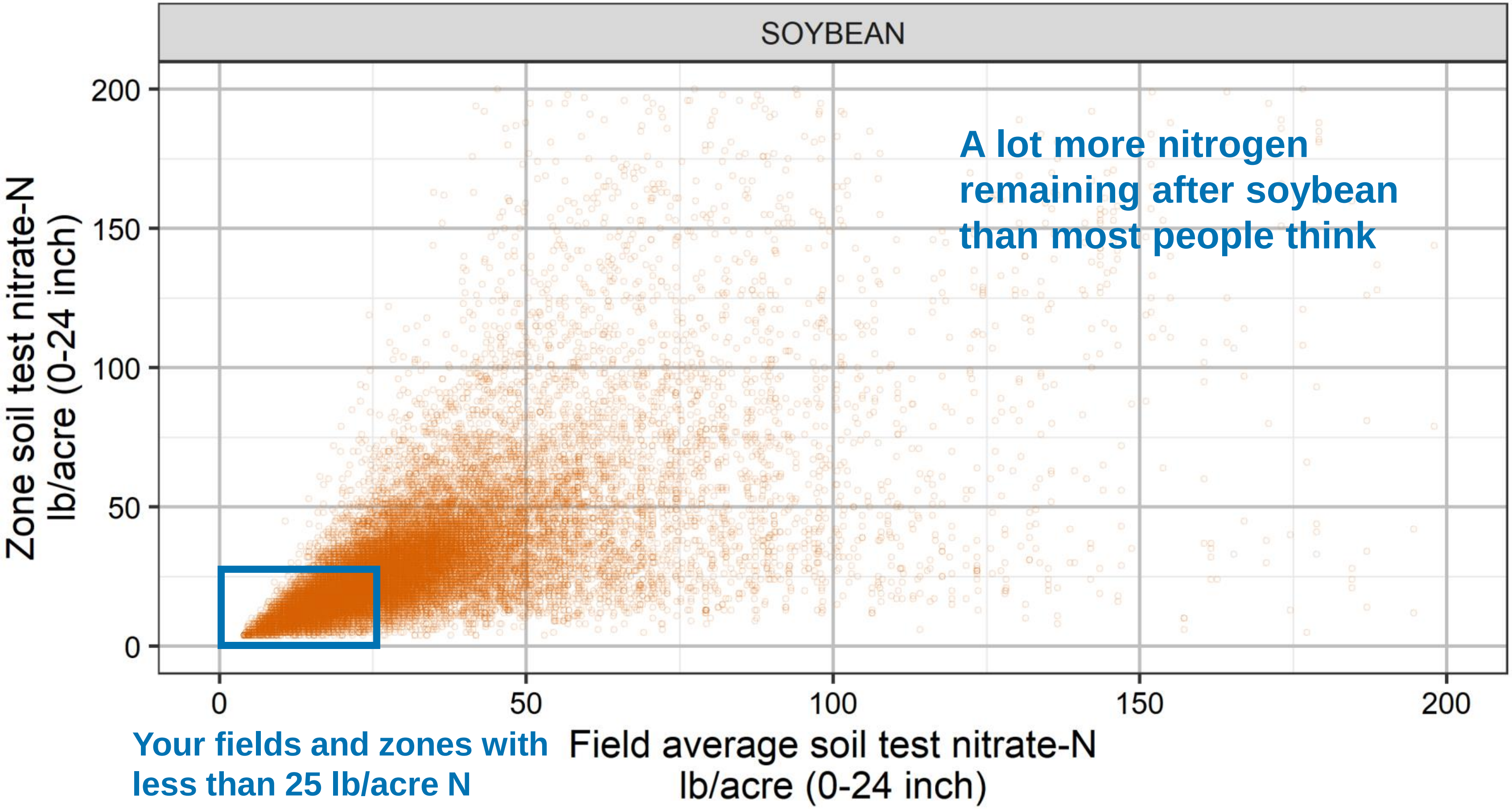
Summary of 27,000 precision soil sampled fields from Manitoba, Minnesota, North Dakota, South Dakota; AGVISE Laboratories, 2023.

Soil test nitrate-N zone variability within the field average



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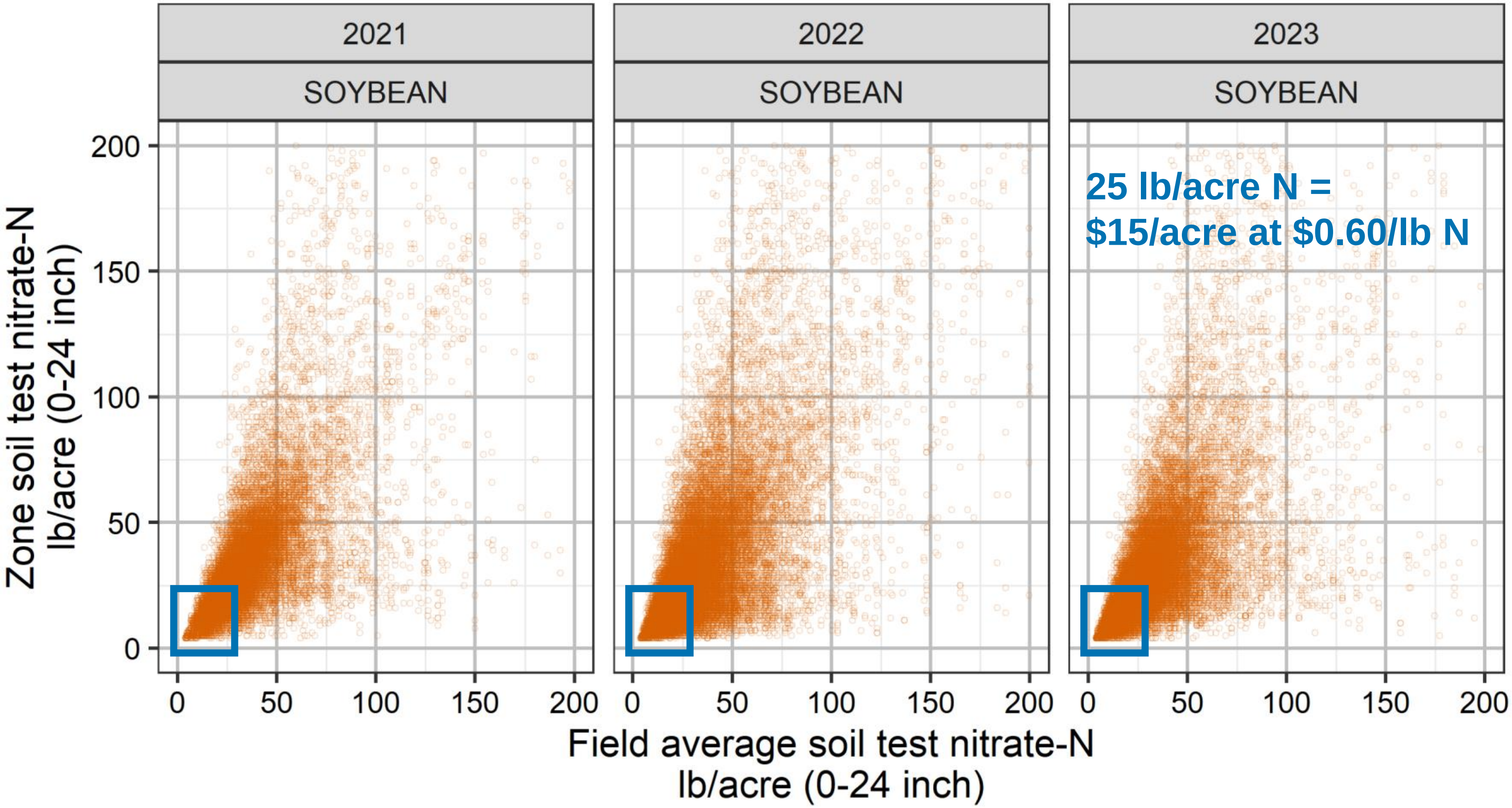
Soil test nitrate-N zone variability within the field average



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Summary of precision soil sampled fields from Manitoba, Minnesota, North Dakota, South Dakota; AGVISE Laboratories, 2021-2023.

#4: Phosphorus and Potassium

Questions we can explore

- Extent of low soil test P and K
- Field variability

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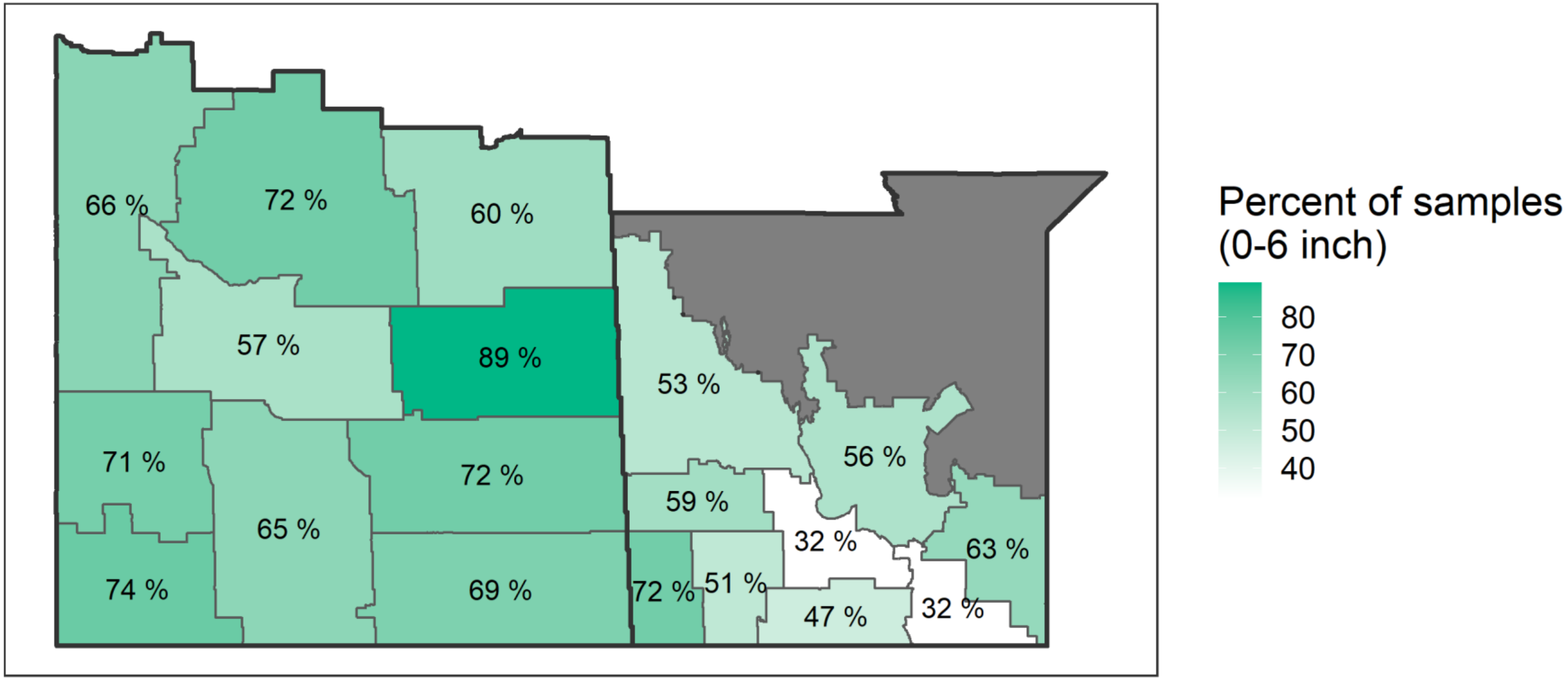
Phosphorus (P), 0-6 inch topsoil

Bray P1 or Olsen P method
Bray P1 fails on calcareous soils, delivers false low STP result.
Olsen P is accepted method throughout the region.

Soil test category	Soil test P (ppm)	
	Bray P1	**Olsen P**
	pH<7.3	**pH 5.5-8.5**
Very Low	<5	<3
Low	6-10	4-7
Medium	11-15	8-11
High	16-20	12-15
Very High	>20	>15

Soil samples with soil test phosphorus below 15 ppm (Olsen P) in 2023



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Potassium (K), 0-6 inch topsoil

Ammonium acetate K method
Soil test K critical level varies based on soil texture and clay mineralogy. Historically, 150 or 160 ppm STK across all soils – still works for low K requirement crops.

Soil test category	Soil test K (ppm)	
	Coarse-textured	**Medium- & fine-textured**
Very low	<30	<50
Low	31-60	51-100
Medium	61-90	101-150
High	91-120	151-200
Very high	>120	>200

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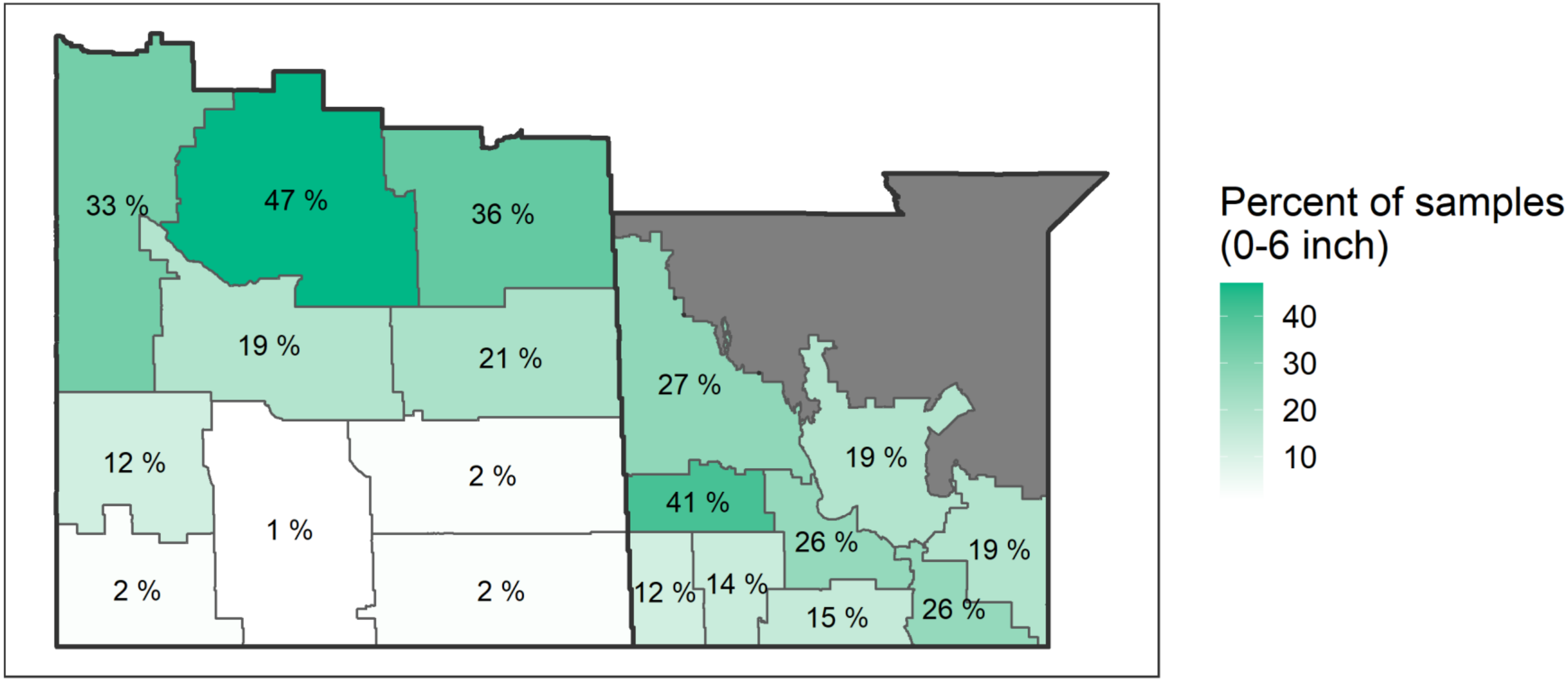
Soil samples with soil test potassium below 150 ppm in 2023



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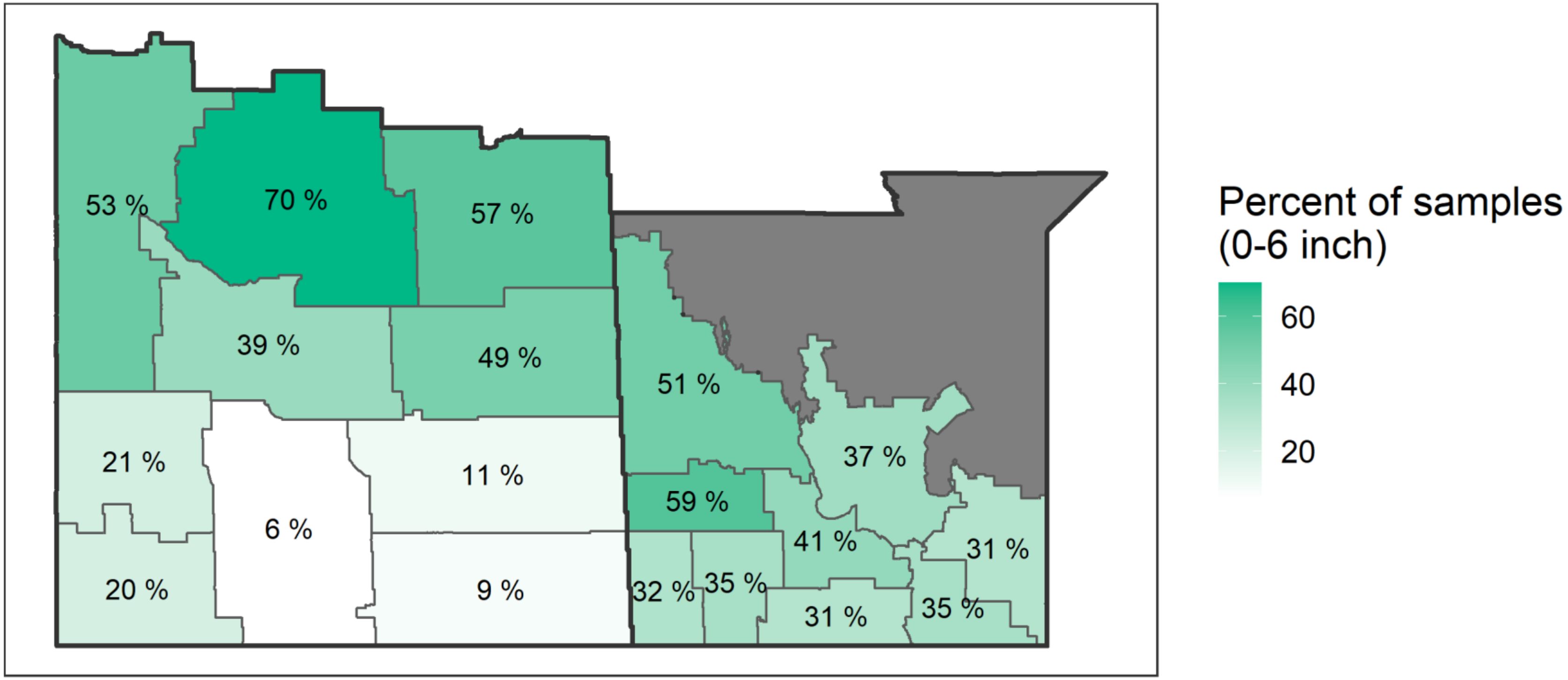
Soil samples with soil test potassium below 200 ppm in 2023



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Summary of 24,000 precision soil sampled fields from Manitoba, Minnesota, North Dakota, South Dakota; AGVISE Laboratories, 2023.

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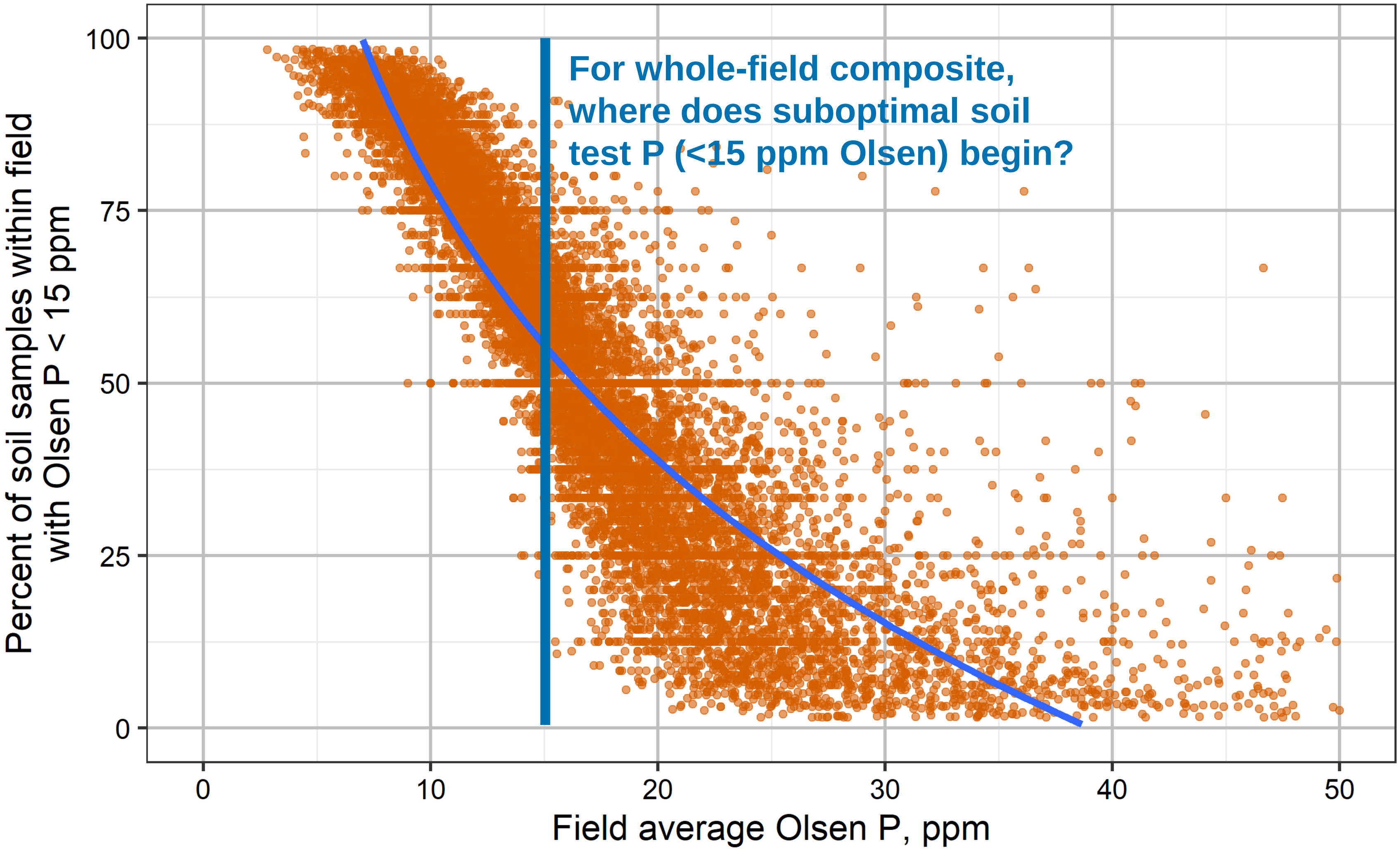
Soil test P (Olsen) variabiltiy within fields



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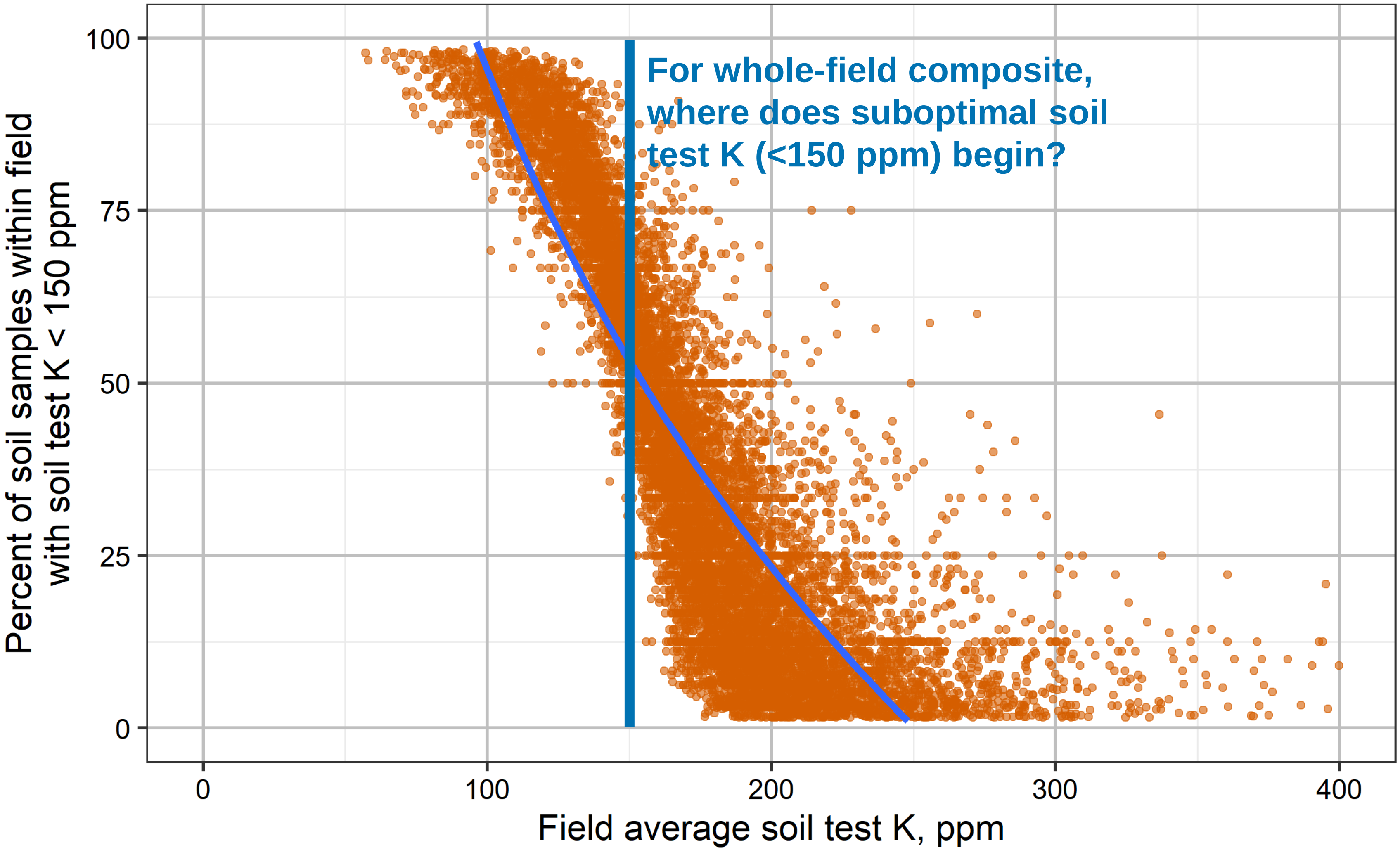
Soil test K variability within fields



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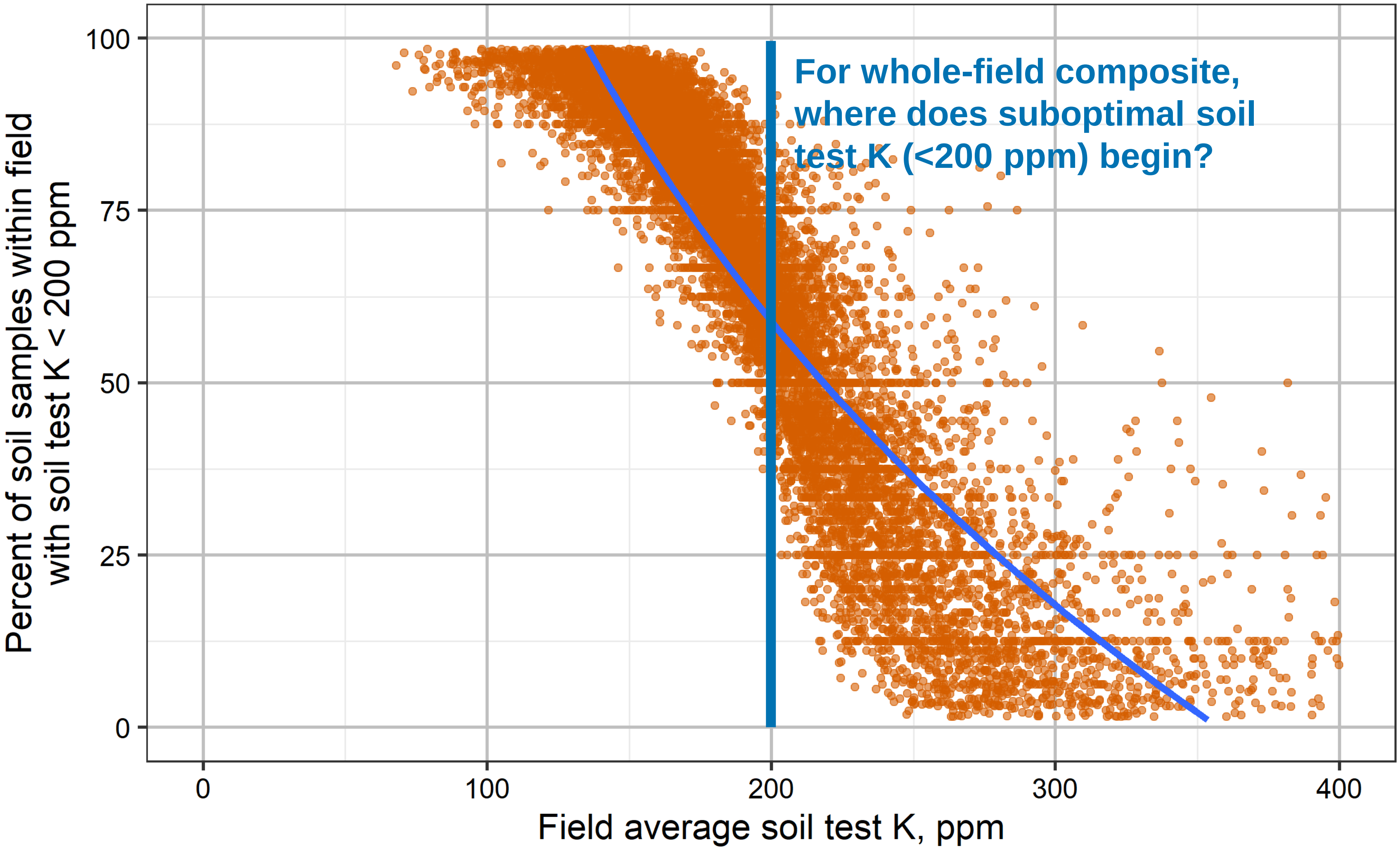
Soil test K variability within fields



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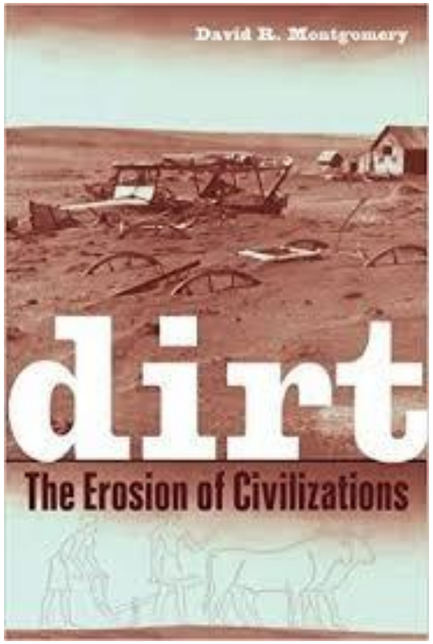
Lessons about phosphorus and potassium

- Distinct regionality in STP and STK trends
- Higher STK critical level at 200 ppm includes FAR more soil samples in the suboptimal soil test category
- STP and STK variability is hidden in whole-field composite soil samples



If you want to learn more about humankind's long struggle with soil erosion…

Thank you for your kind attention!

Are there any questions?

Remember: Your soil test is only as good as the soil sample.

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