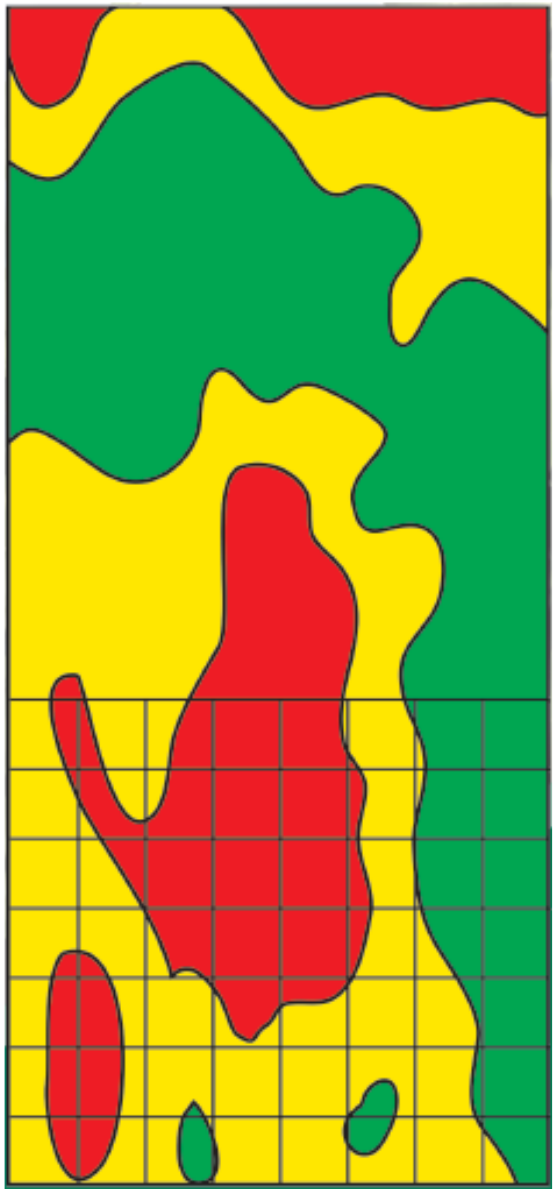
Your Soil Test Questions Answered: A Deep Dive into the AGVISE Soil Test Database



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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

Topics we will explore

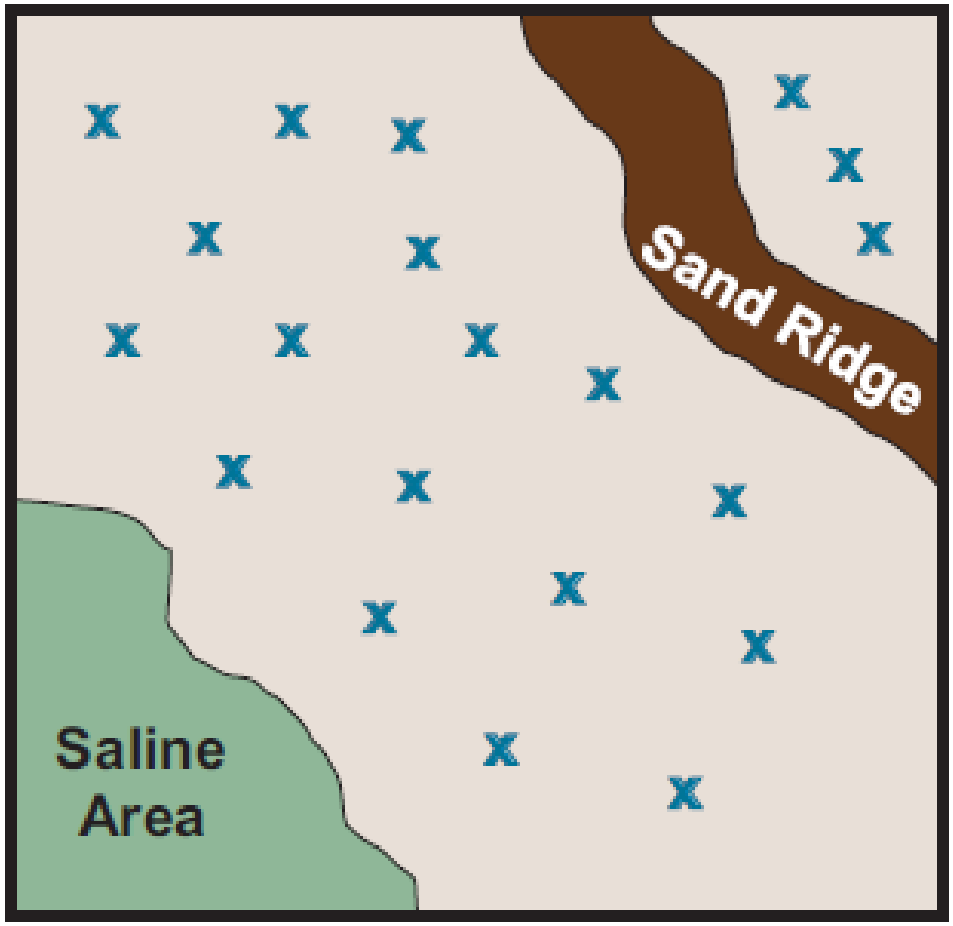
1. Precision soil sampling (grid or zone)
2. Soil pH
3. Soil nitrate-nitrogen
4. Soil phosphorus and potassium

#1: Precision soil sampling (grid or zone)

Questions we can explore

- Trends in precision soil sampling
- Changes in summer (grid) vs. fall soil sampling
- Soil nutrient variability in fields

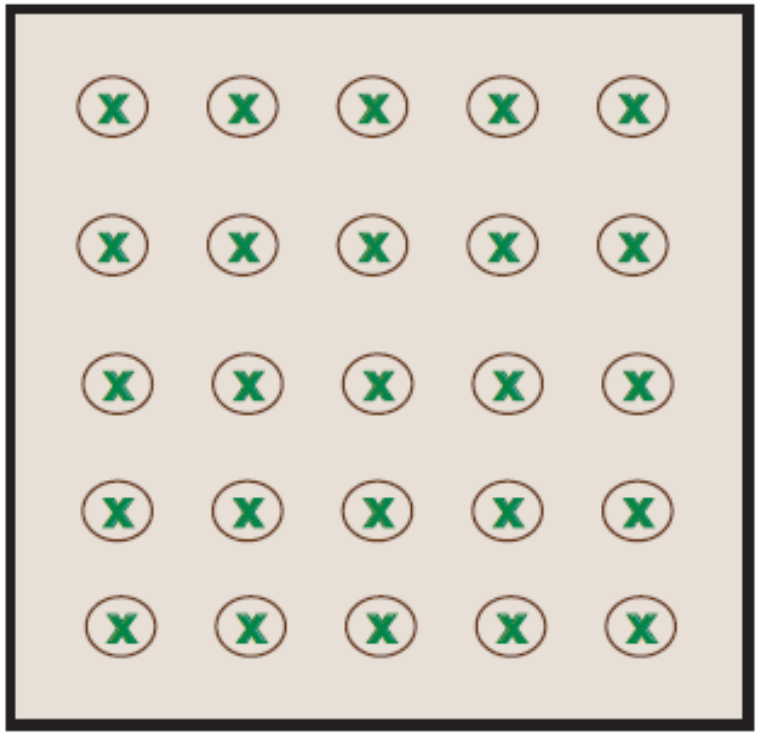
Composite Field Sampling



X = Single soil probe location

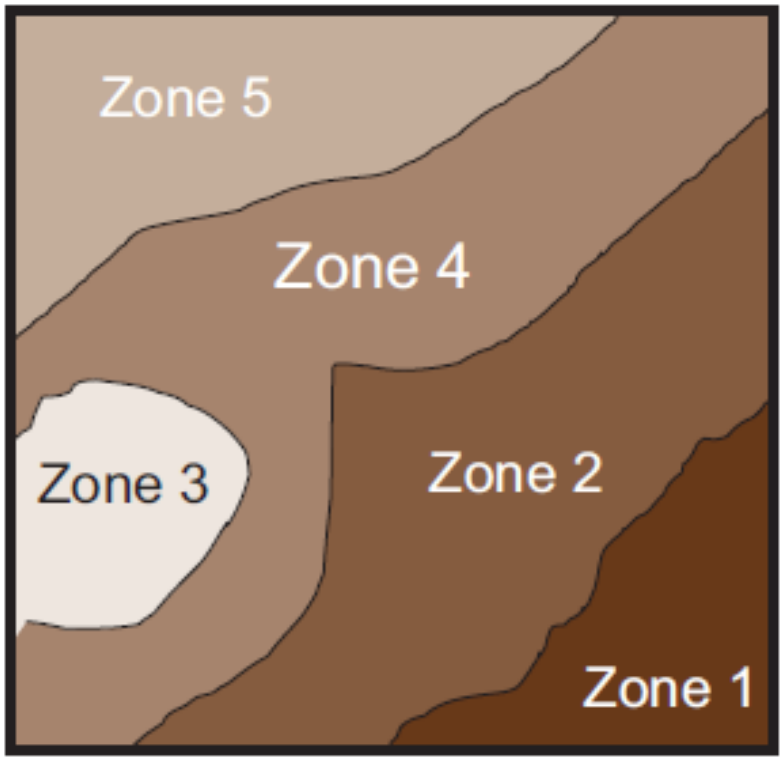
20-25 soil cores collected across entire field
Avoid nonrepresentative areas

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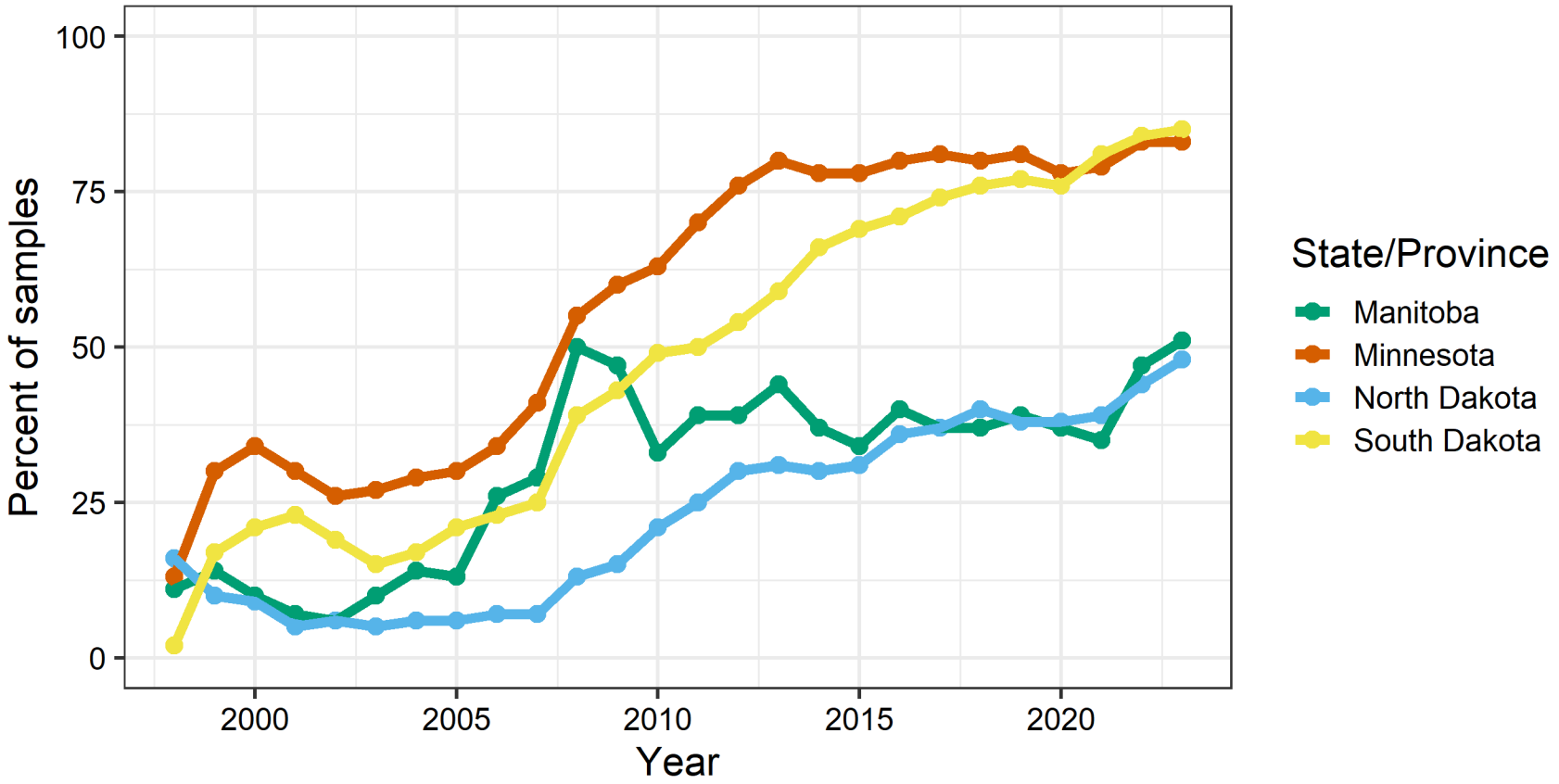
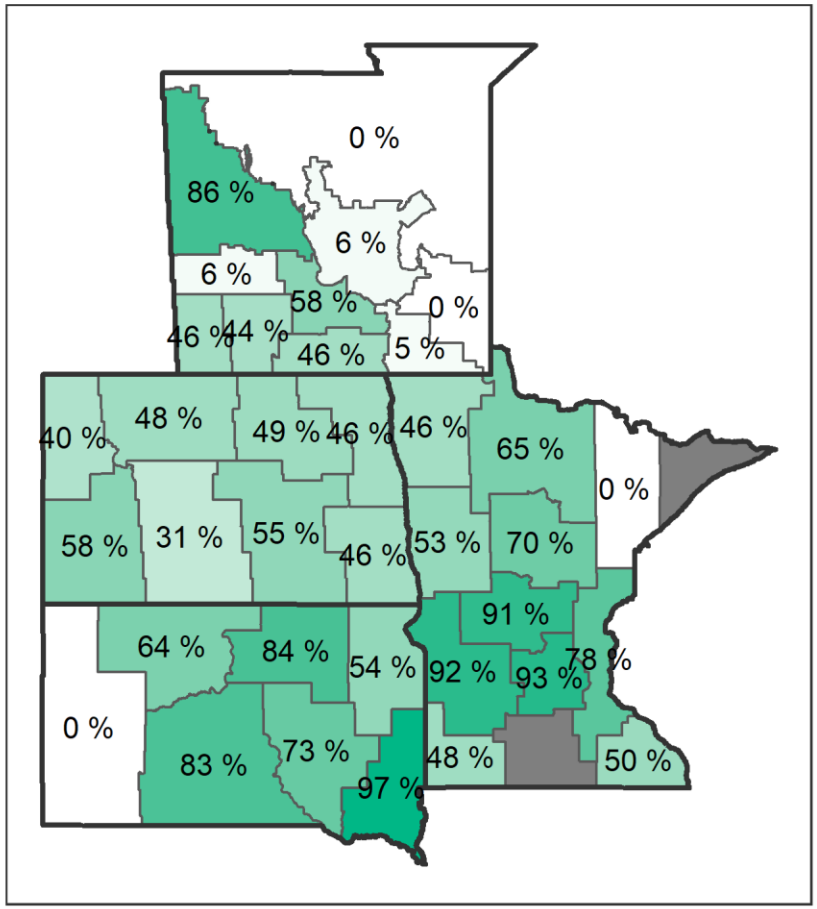
Soil samples collected as a precision sample (grid or zone)

Trend from 1998 to 2023



Data not shown where n< 50
AGVISE Laboratories, Inc.

Soil samples collected as a precision sample in 2023



Data not shown where n< 50
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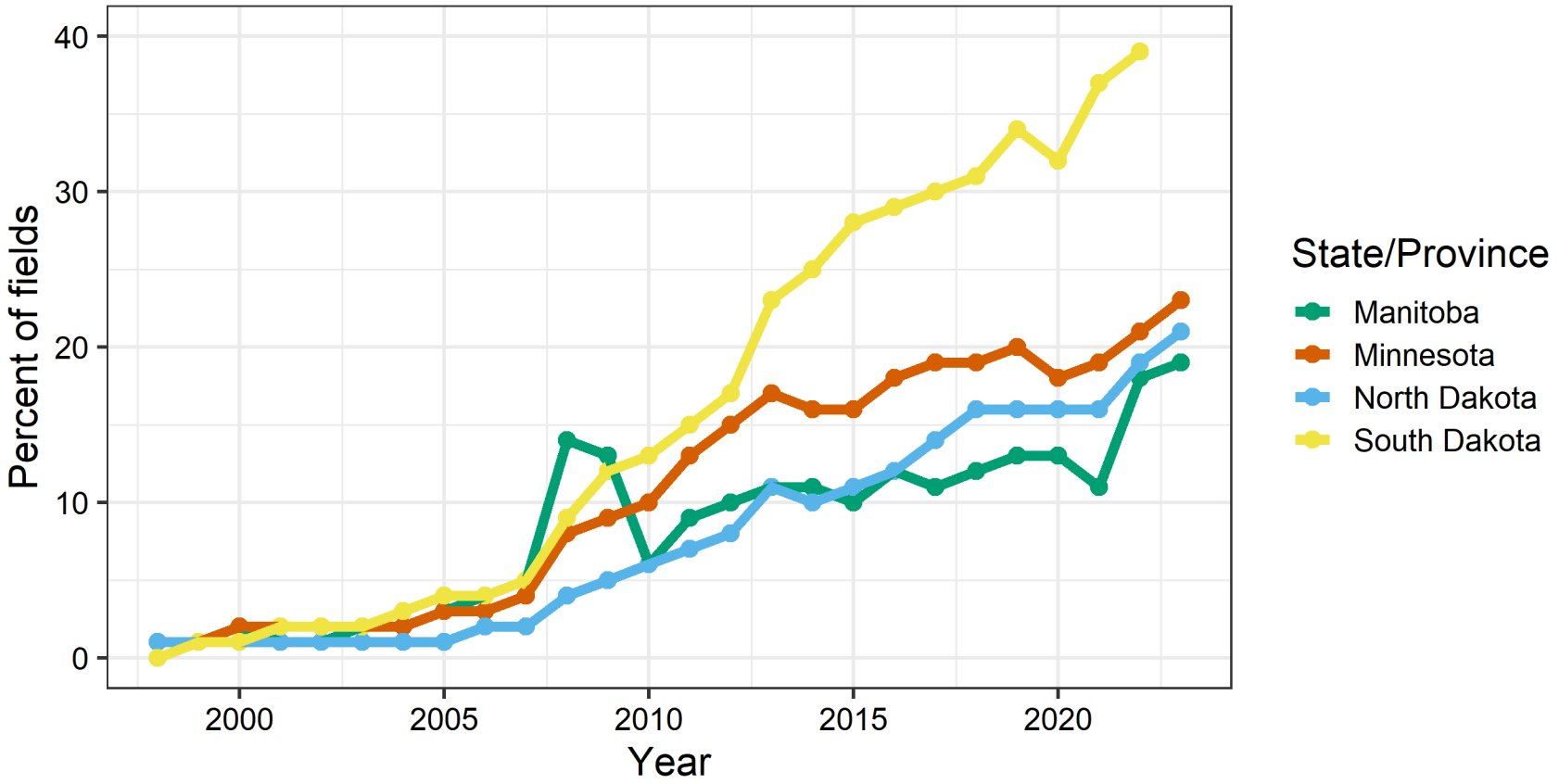
But those are just the total numbers…

- 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?

Fields sampled using precision sampling techniques (grid or zone)

Trend from 1998 to 2023



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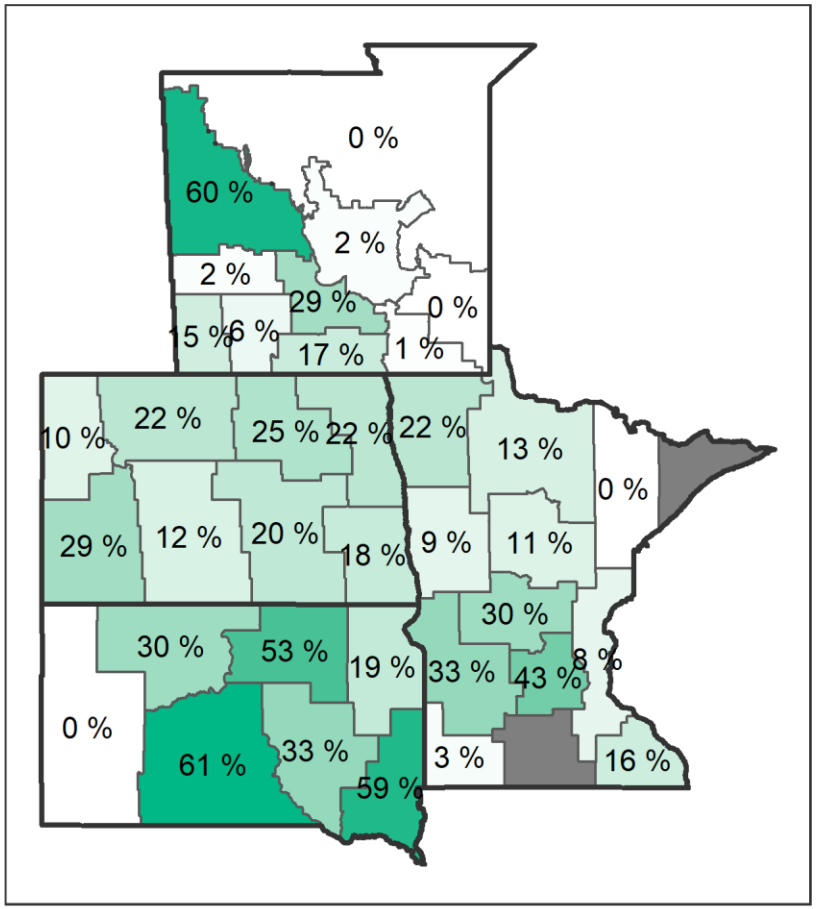
Fields sampled using precision sampling techniques (grid or zone) in 2023



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Transition to summer precision soil sampling to spread workload

- More agronomists and consultants are taking topsoil (0-6 inch) grid soil samples in May and June for non-mobile soil nutrients (e.g., P, K, Zn, pH, OM)
- Works well in unfertilized soybean fields (not for soil nitrate-N sampling)
- Avoiding post-harvest rush and fall logistical hassles
- More available labor (interns) in summer months

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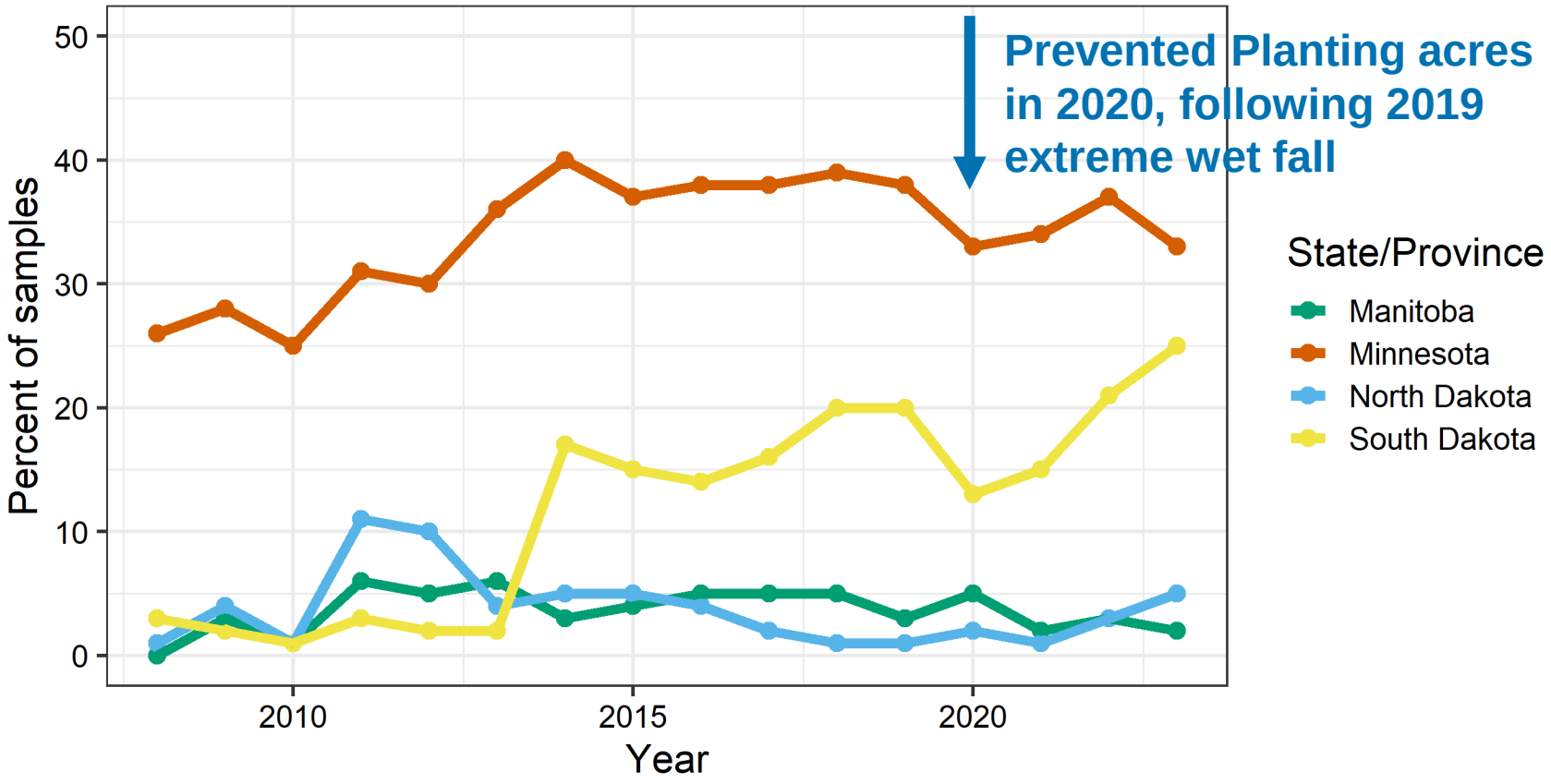
Precision soil samples collected during summer (May 15 to July 31)

Trend from 2008 to 2023



Data not shown where n< 50
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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
4	41	14	111	0.7	0.9	1.5
5	53	17	126	0.8	1.1	2.0
6	65	23	174	1.1	1.3	1.9
7	62	23	171	1.1	1.4	1.8
8	78	26	168	1.2	1.2	2.4

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

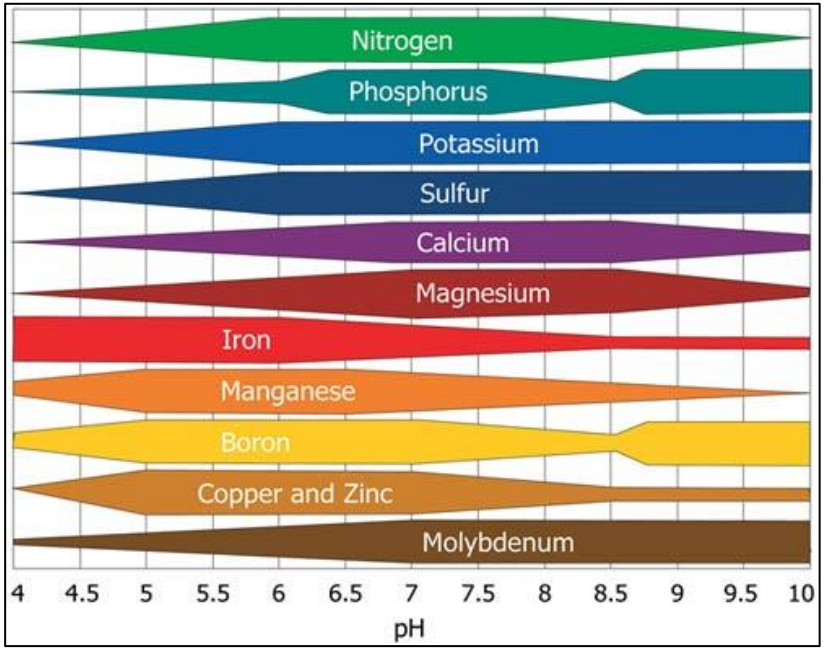
#2: Soil pH

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

Why are acid soils problematic?

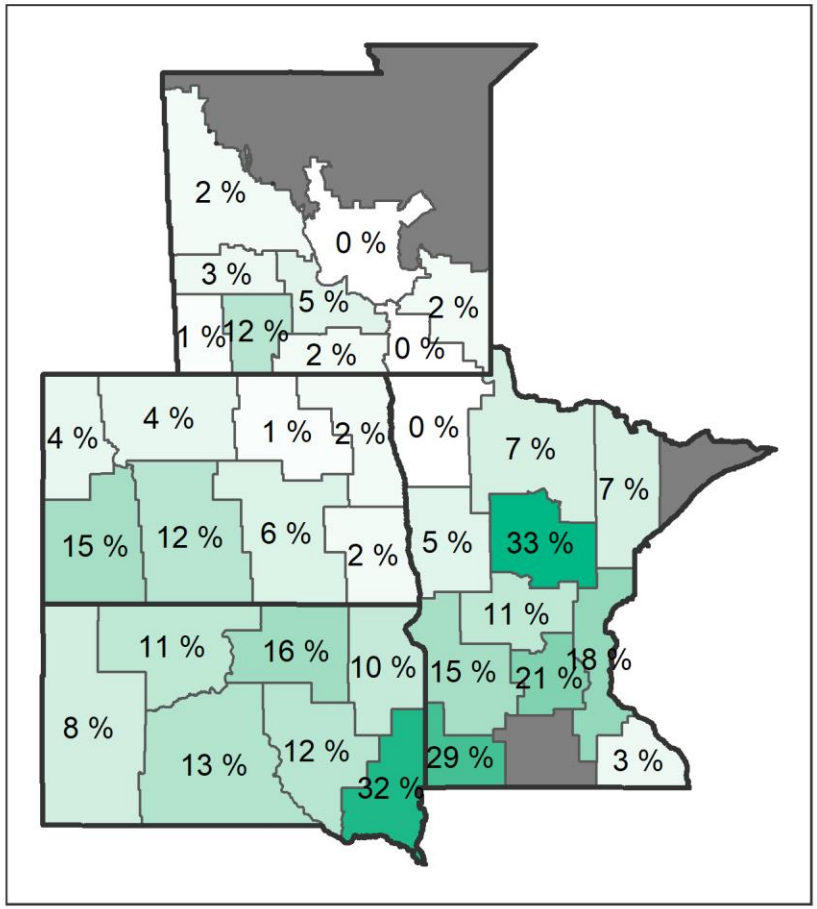
Reduced nutrient availability



Aluminum toxicity

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

Soil samples with soil pH below 6.0 in 2023



Percent of samples (0-6 inch)

30
20
10
0

Data not shown where n< 100
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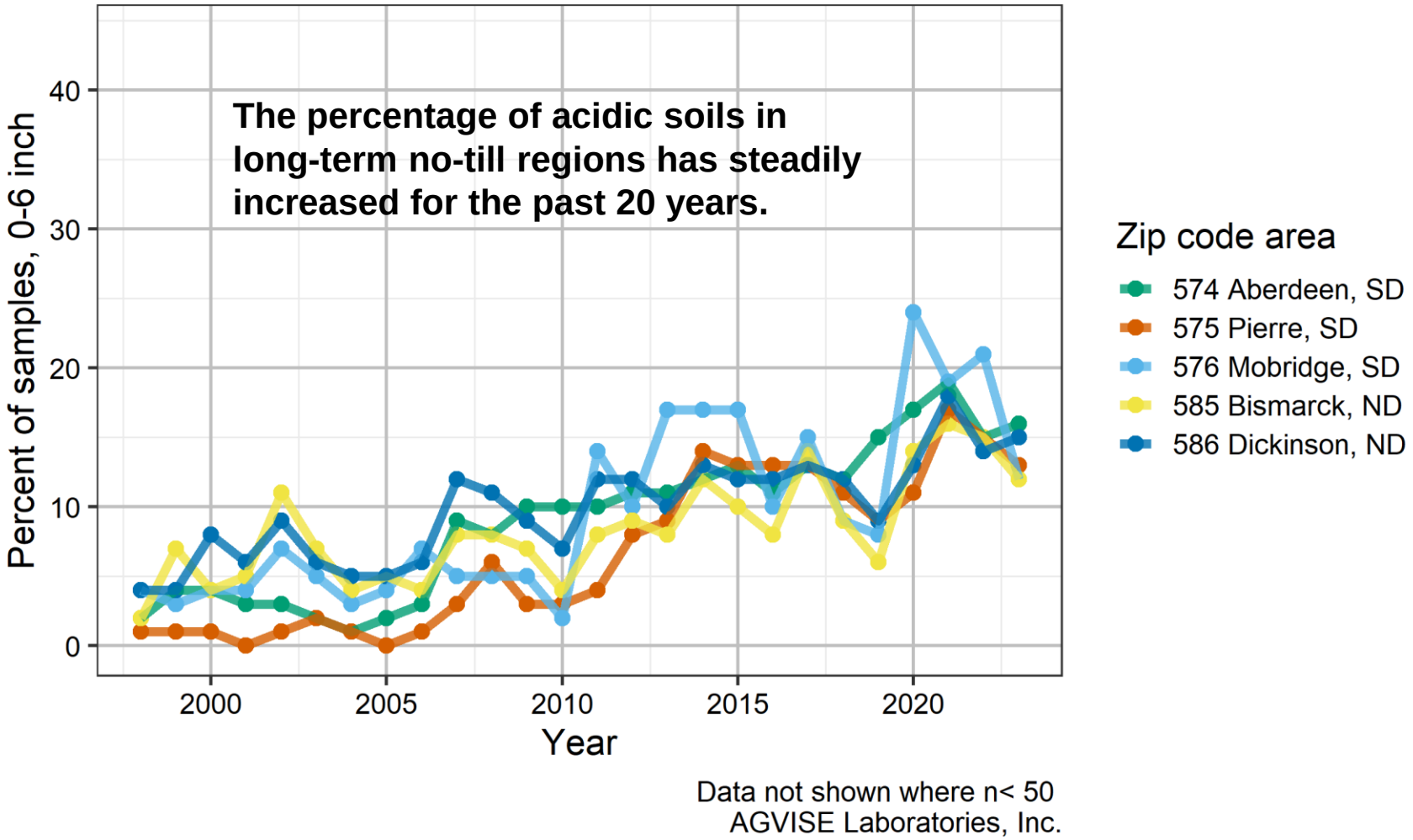
Soil pH trend (pH < 6 1:1) across the northern Great Plains



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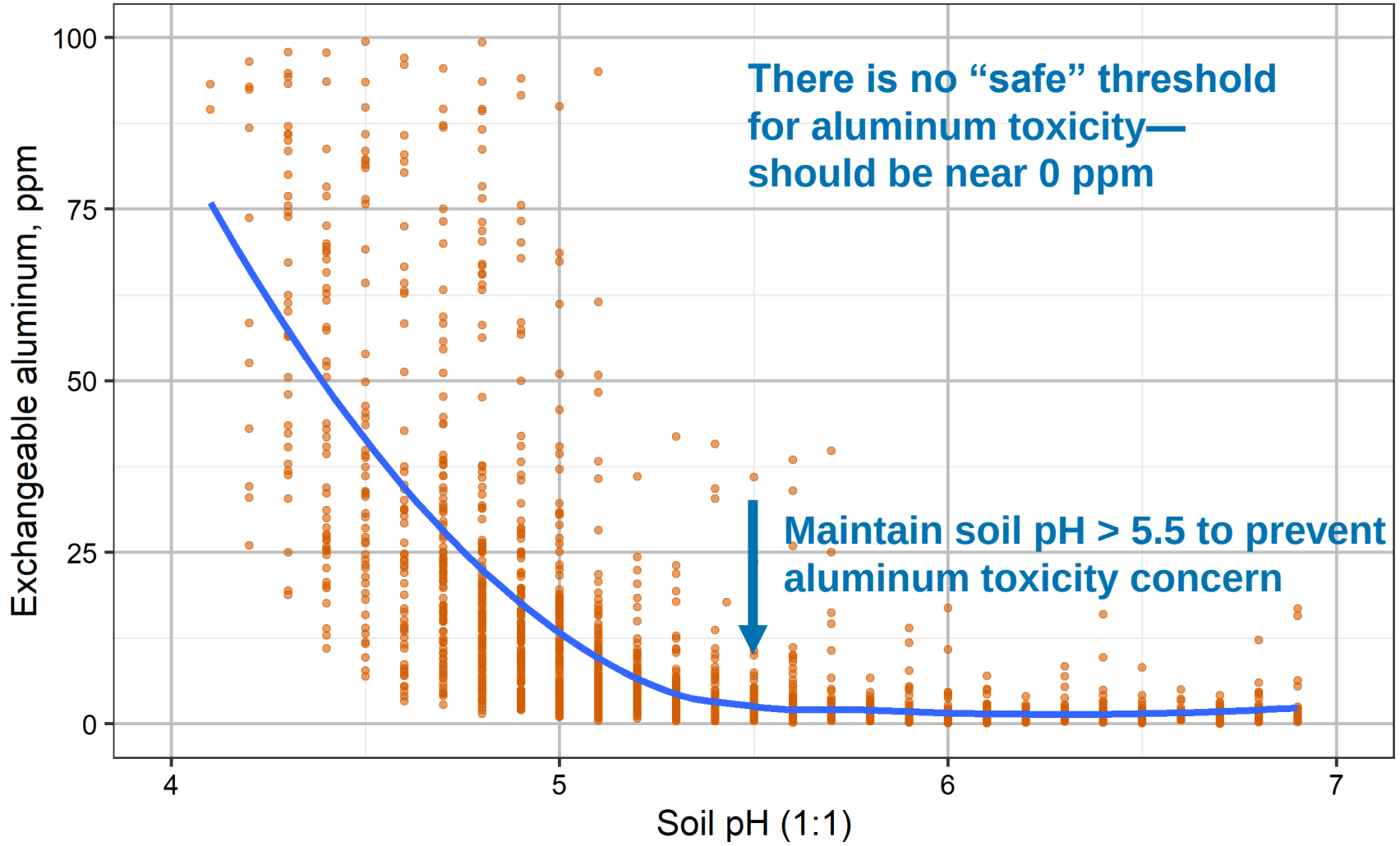
Soil pH controls aluminum availability



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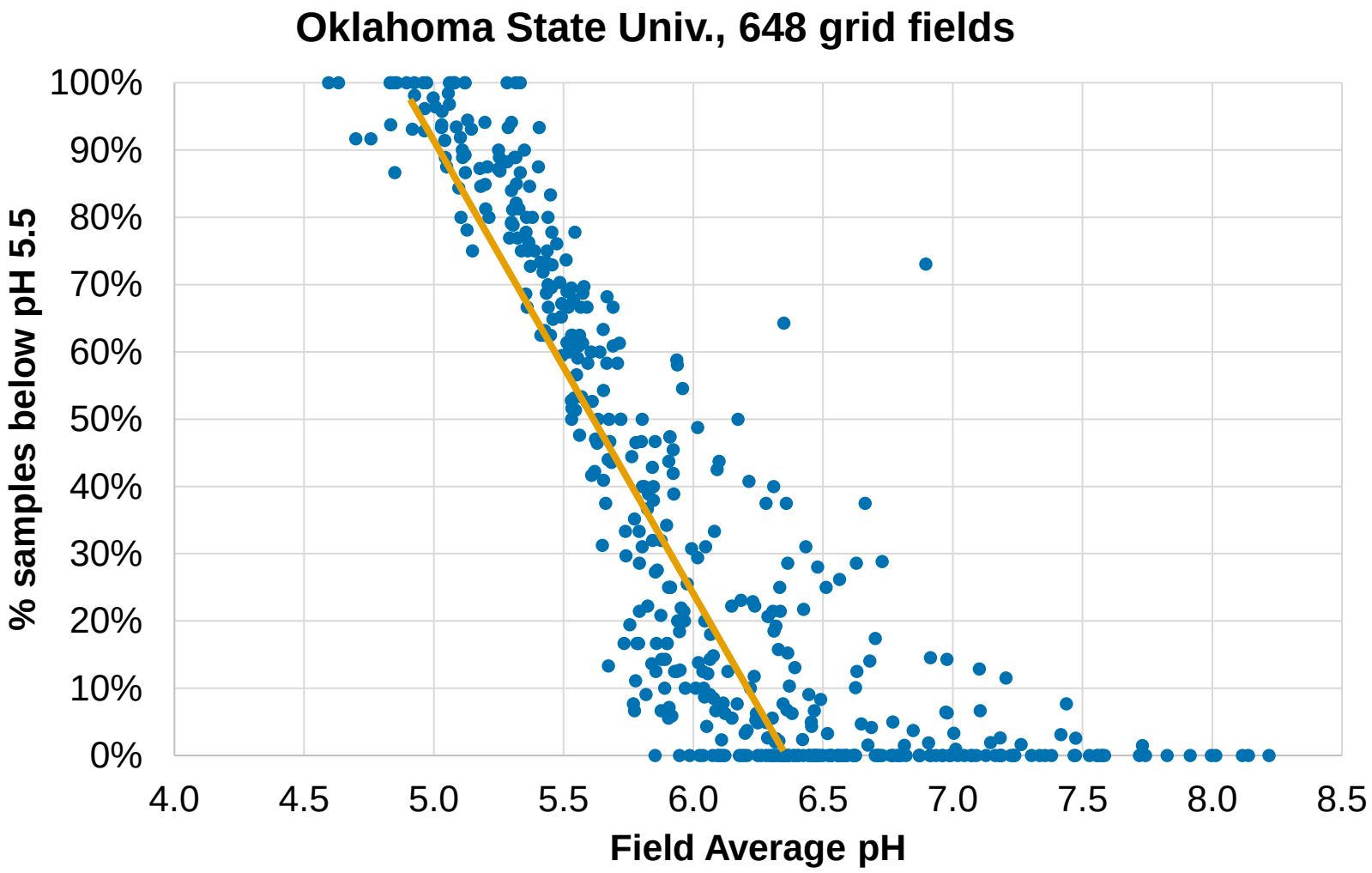
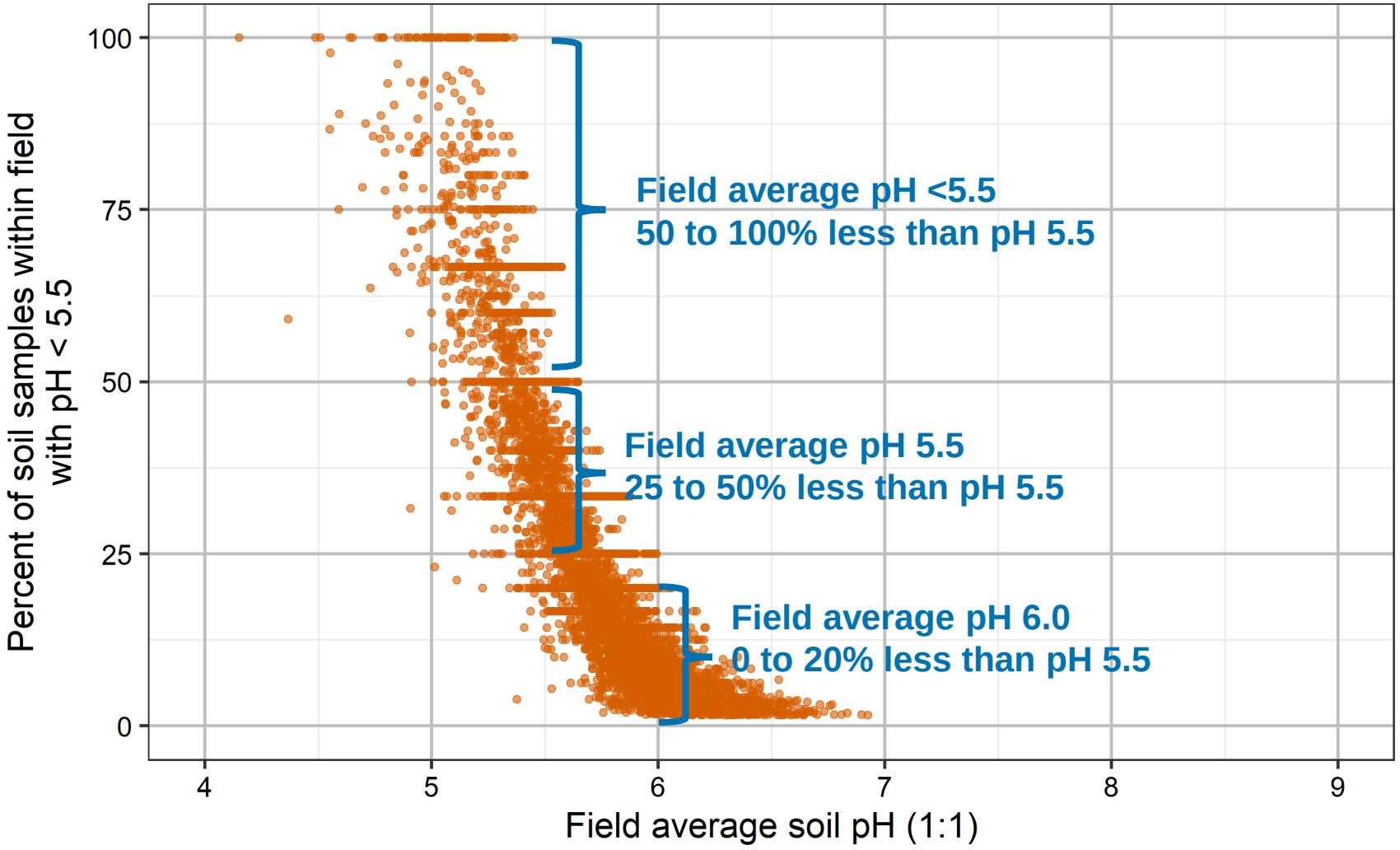
pH variability is hidden in the average



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

pH variabilty is hidden in the average



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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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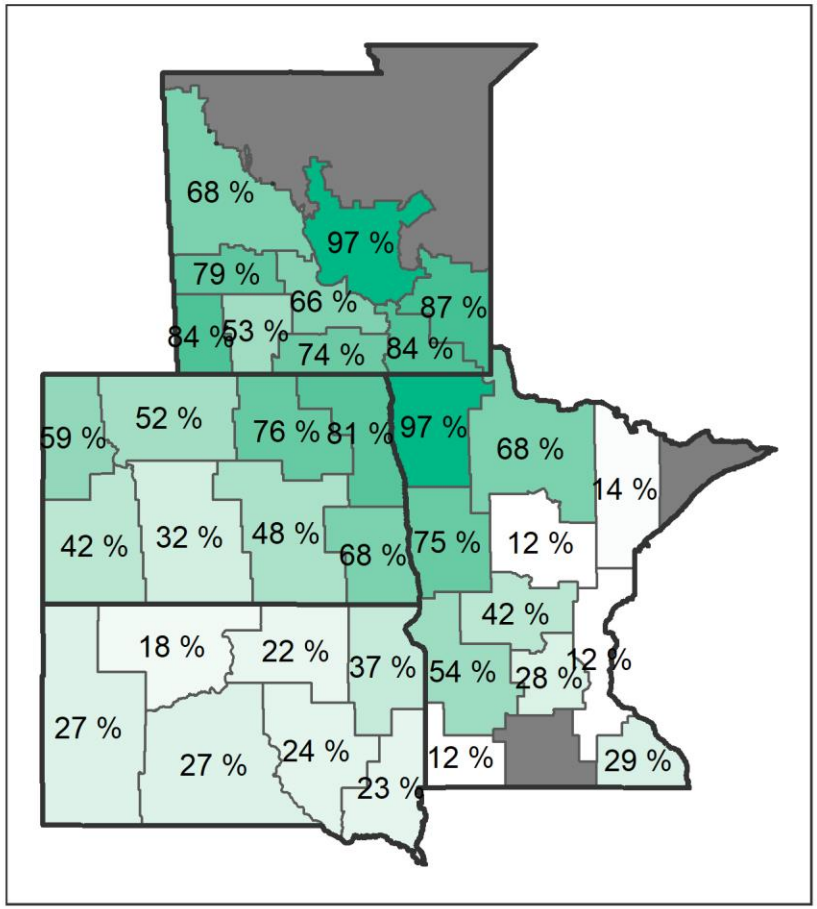
What about high soil pH?

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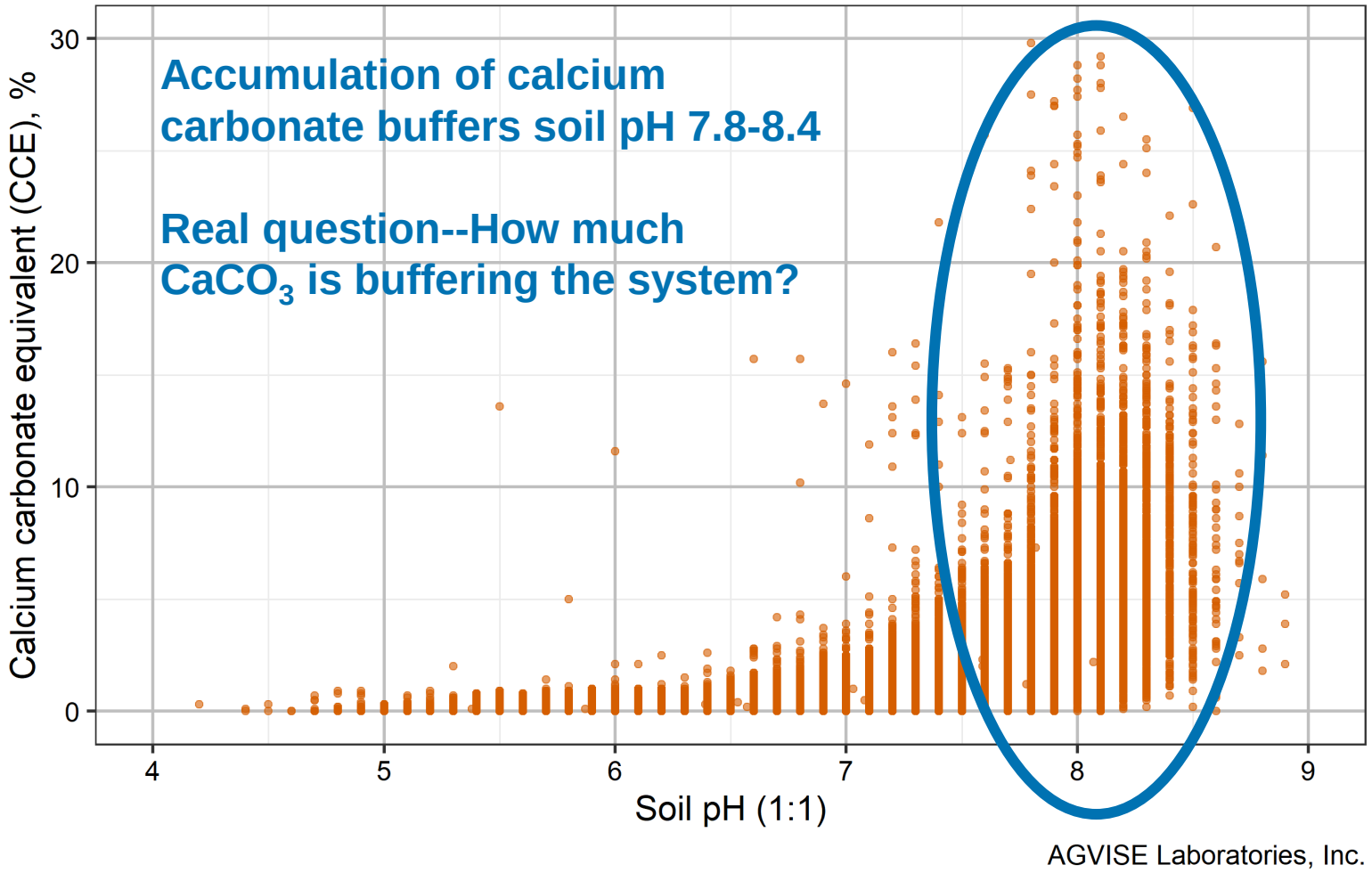
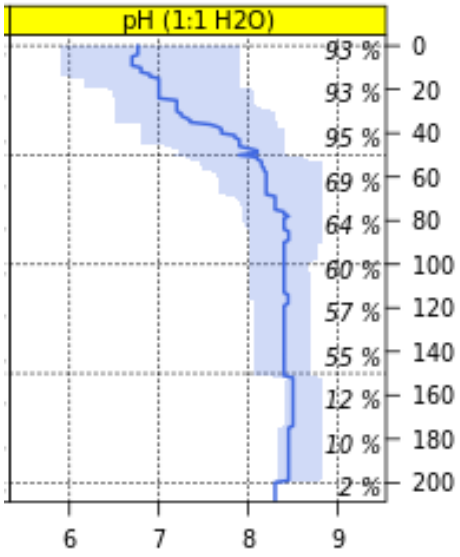
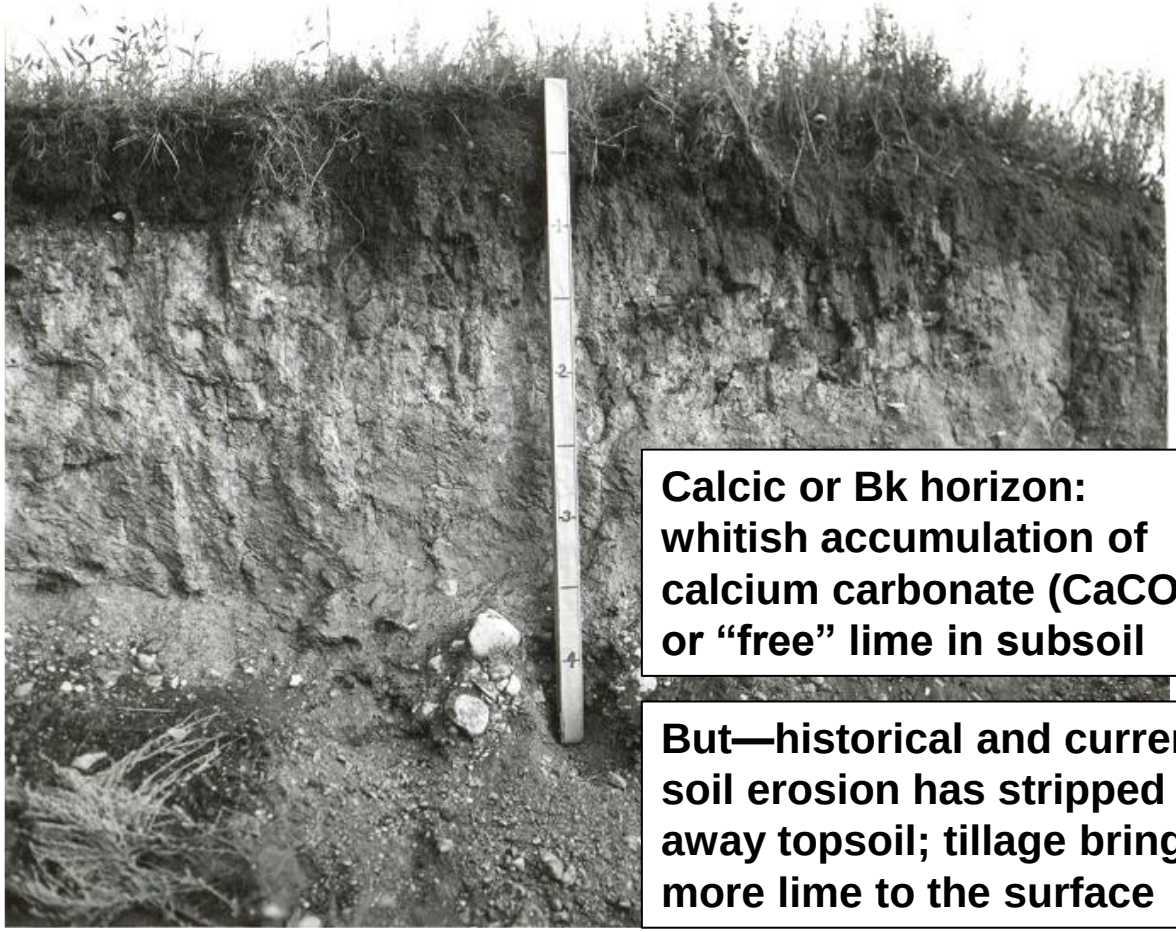
Naturally occurring calcium carbonate ($CaCO_3$, free lime) buffers soil pH



Why is calcium carbonate so important in soil formation?

Barnes series
LaMoure Co., ND



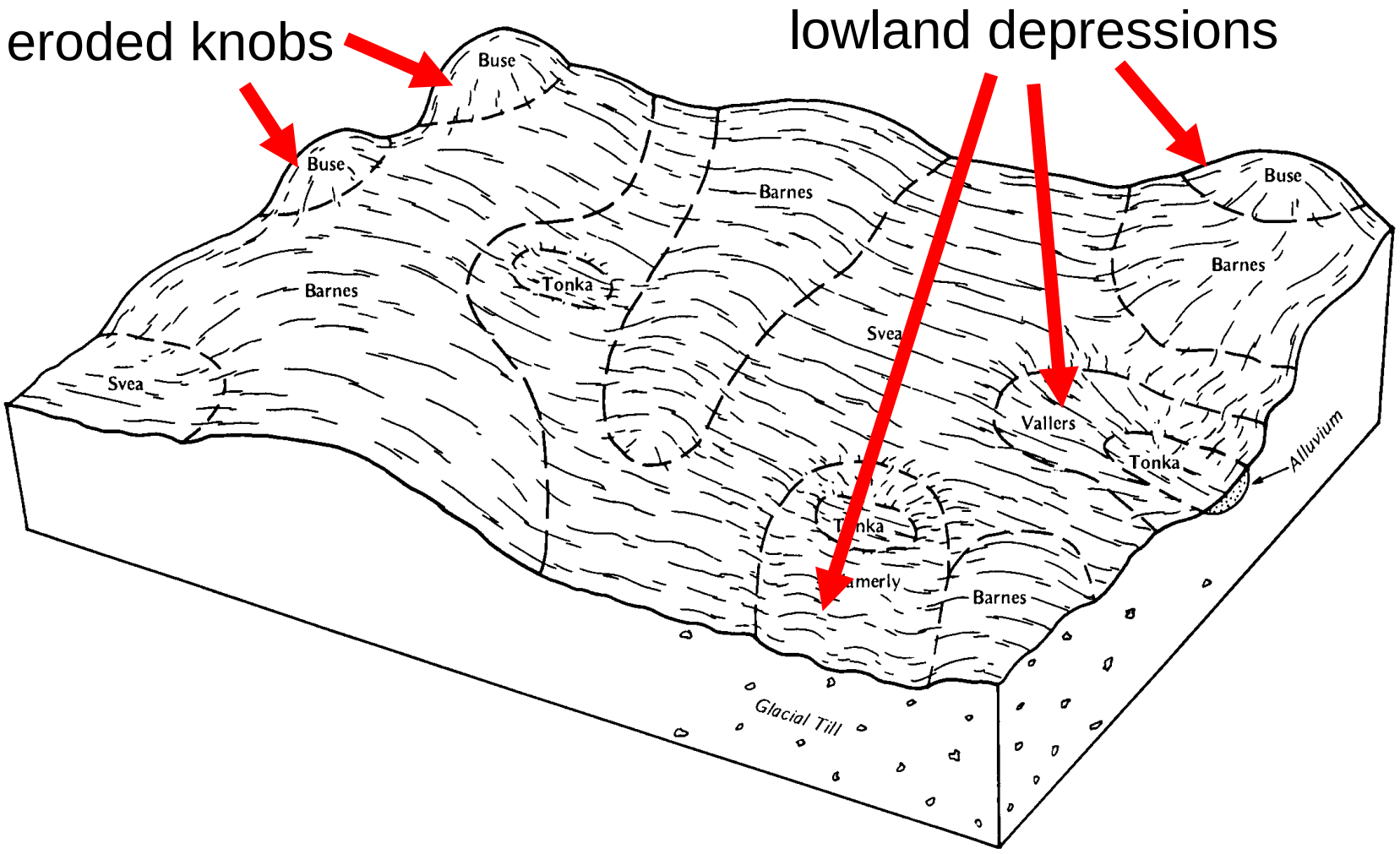


Calcic or Bk horizon: whitish accumulation of calcium carbonate ($CaCO_3$) or "free" lime in subsoil

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?



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!

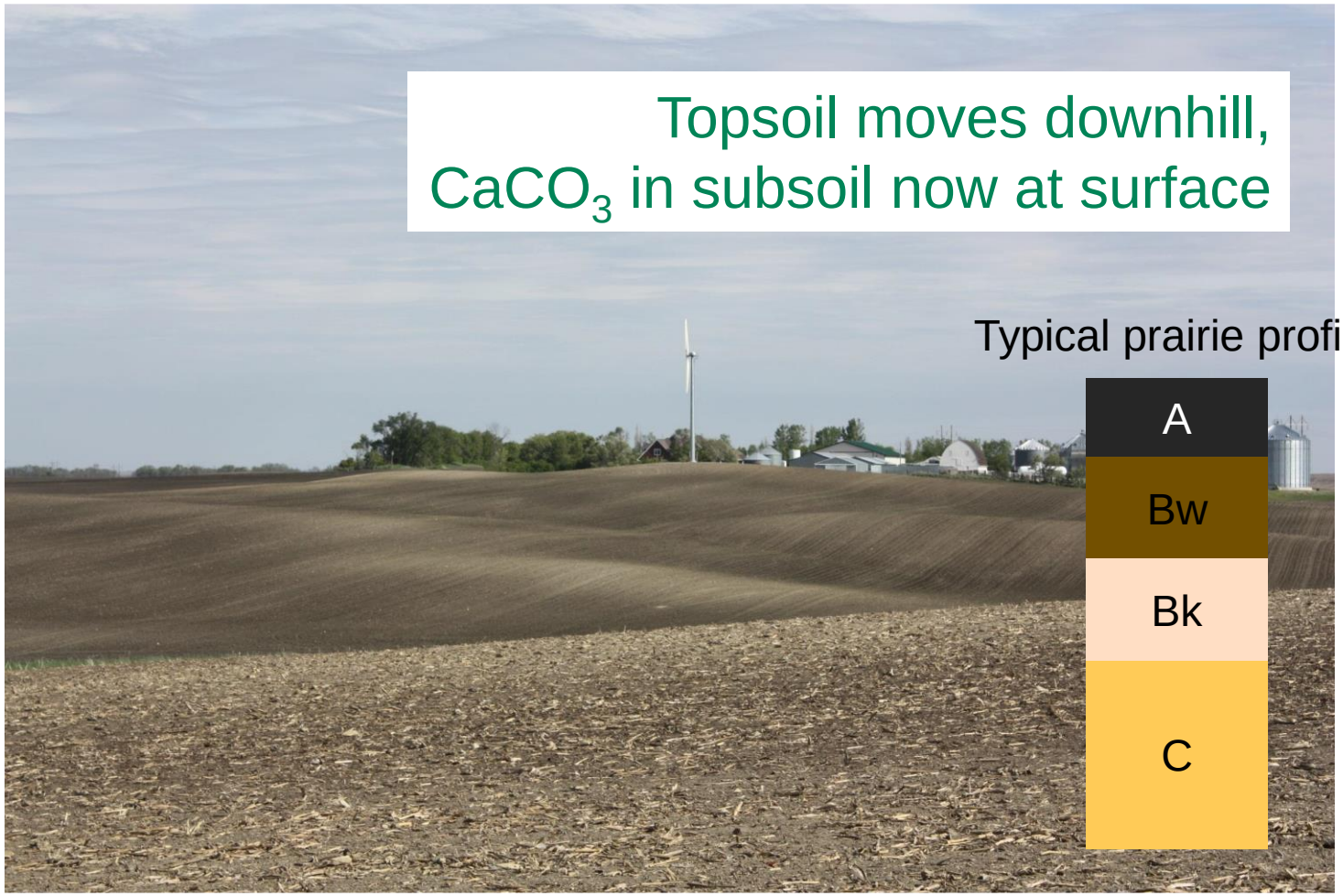


Photo from Bohn, M., D. Hopkins, C. Gasch, D. Steele, and S. Tuscherer. 2018. Predicting soil health and function using remote-sensed evapotranspiration and terrain attributes for a benchmark soil. In: Franzen, D.W., chair, 2018 NDSU Soil and Soil Water Workshop, Fargo, ND. 17 Jan. 2018. North Dakota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

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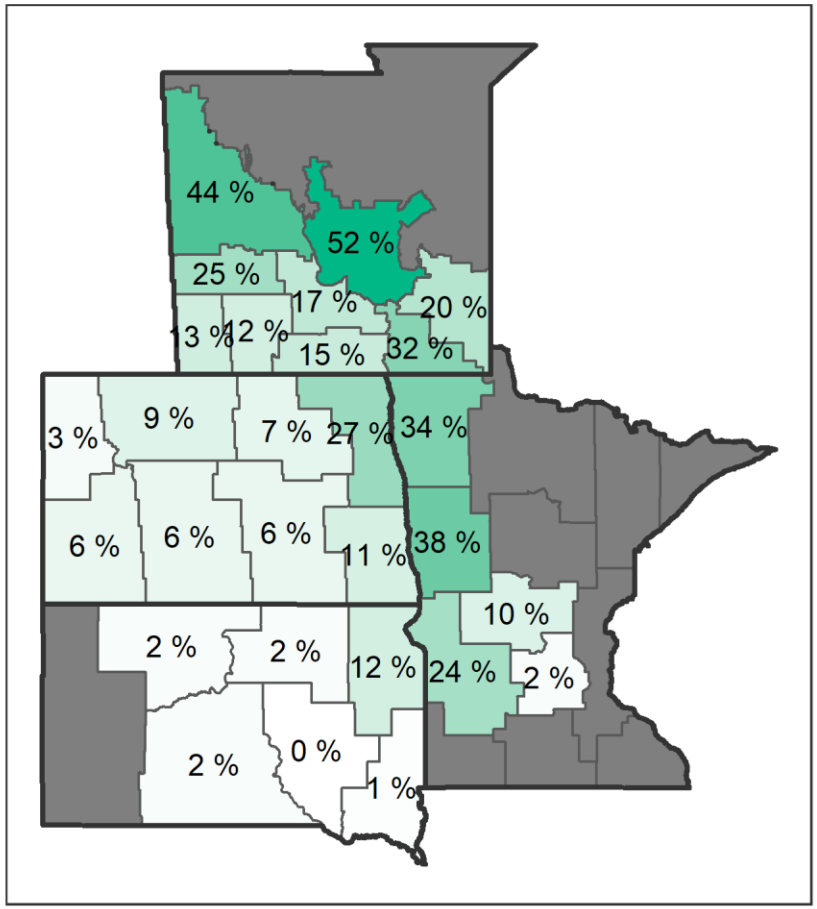
Soil samples with calcium carbonate above 5.0 % CCE in 2023



5% CCE = 100,000 lb/acre $CaCO_3$ in 0-6 inch

Percent of samples (0-6 inch)

50
40
30
20
10
0

Data not shown where n< 100
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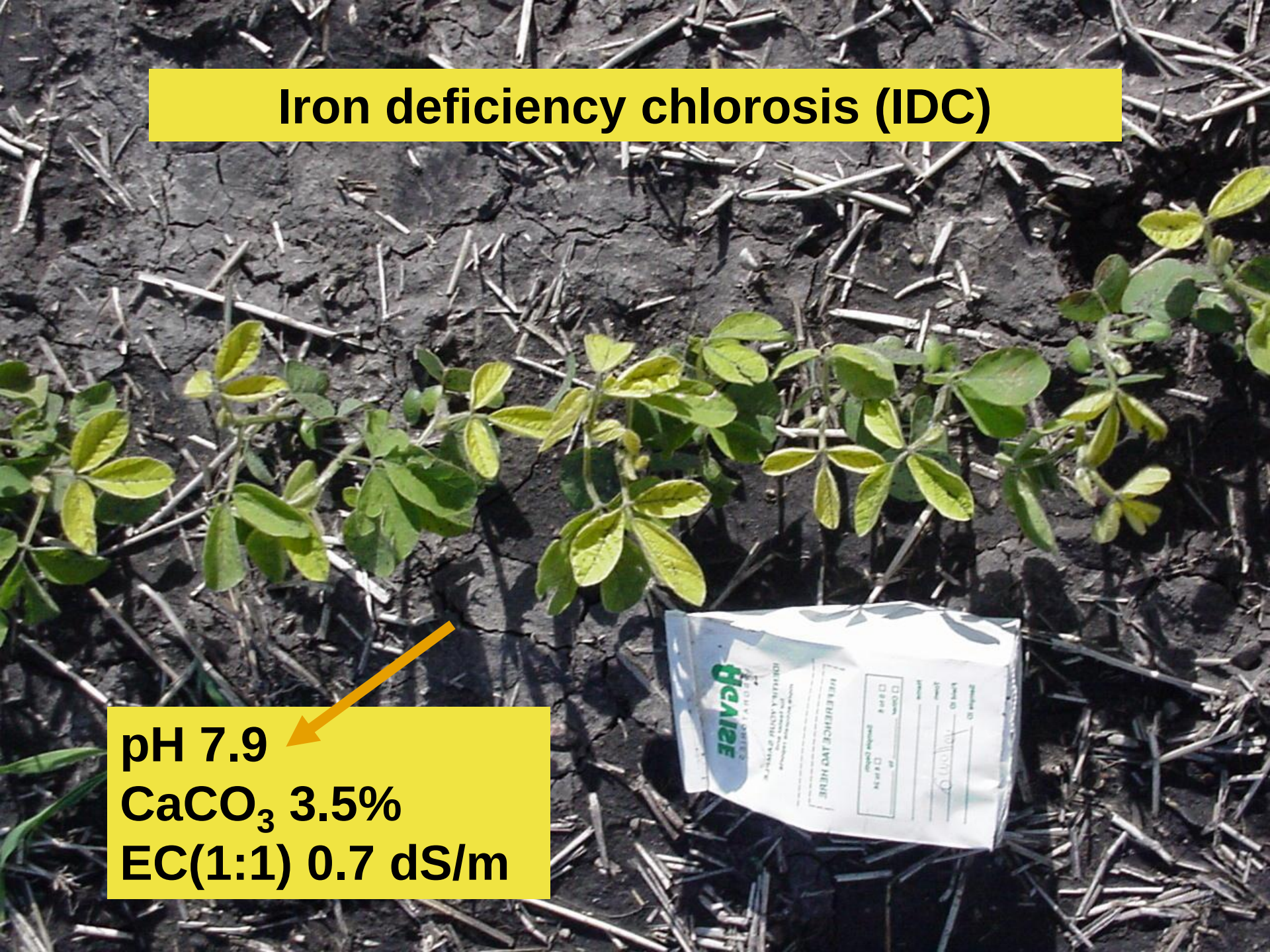
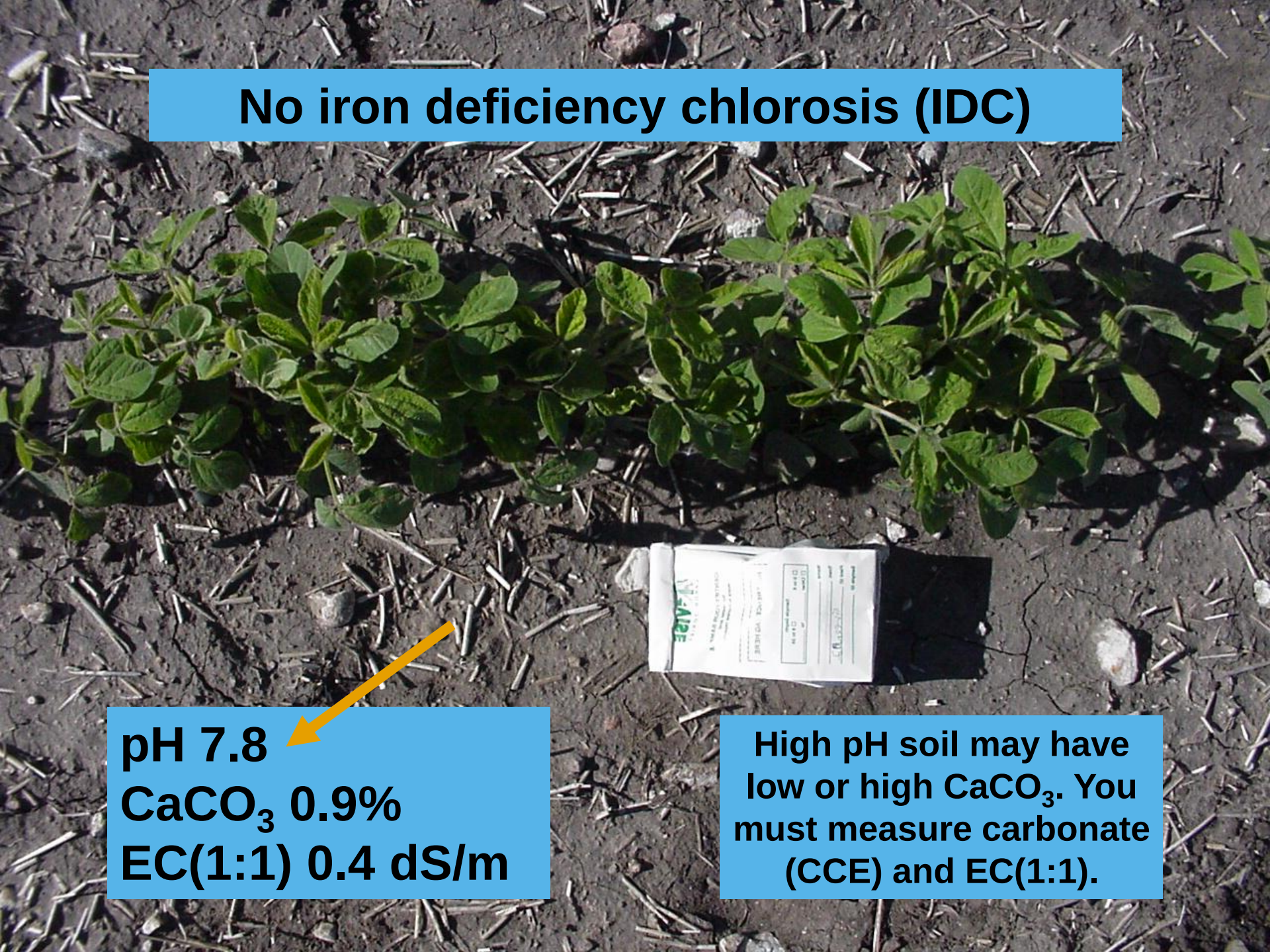

Iron deficiency chlorosis (IDC)
pH 7.9
$CaCO_3$ 3.5%
EC(1:1) 0.7 dS/m

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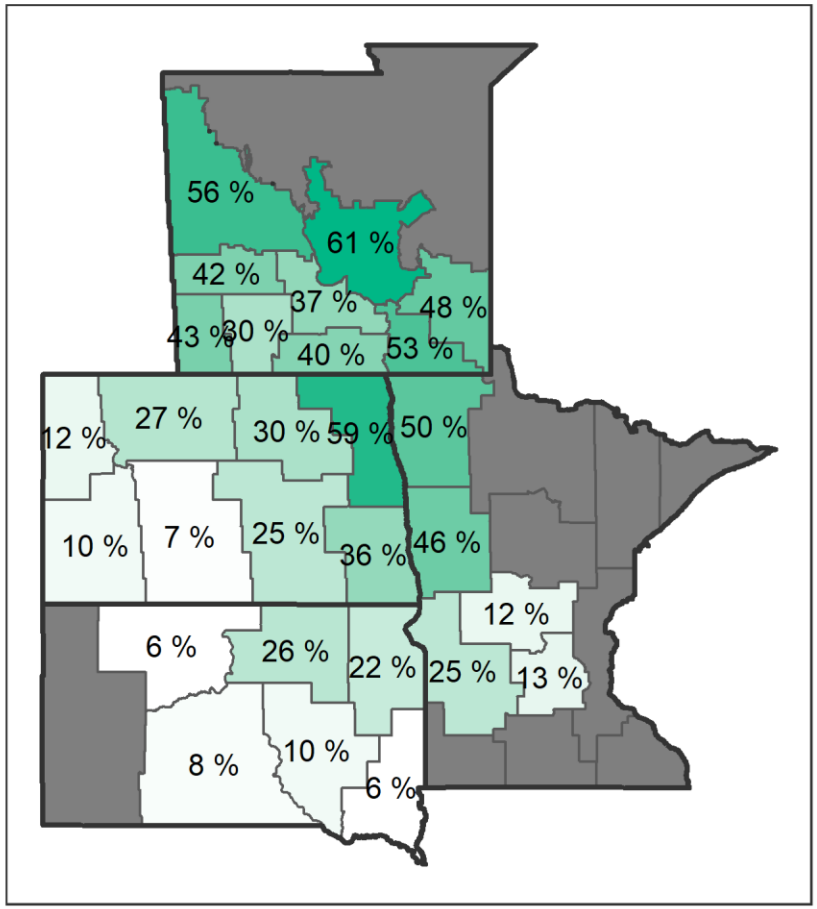
Foundational research from Franzen, D.W., and J.L. Richardson. 2000. Soil factors affecting iron chlorosis of soybean in the Red River Valley of North Dakota and Minnesota. J. Plant Nutr. 23(1):67–78.

Soil samples with high soybean iron deficiency chlorosis risk in 2023



Risk based on carbonate (CCE) and salinity (EC 1:1)

Percent of samples (0-6 inch)

60

40

20

Data not shown where n< 100
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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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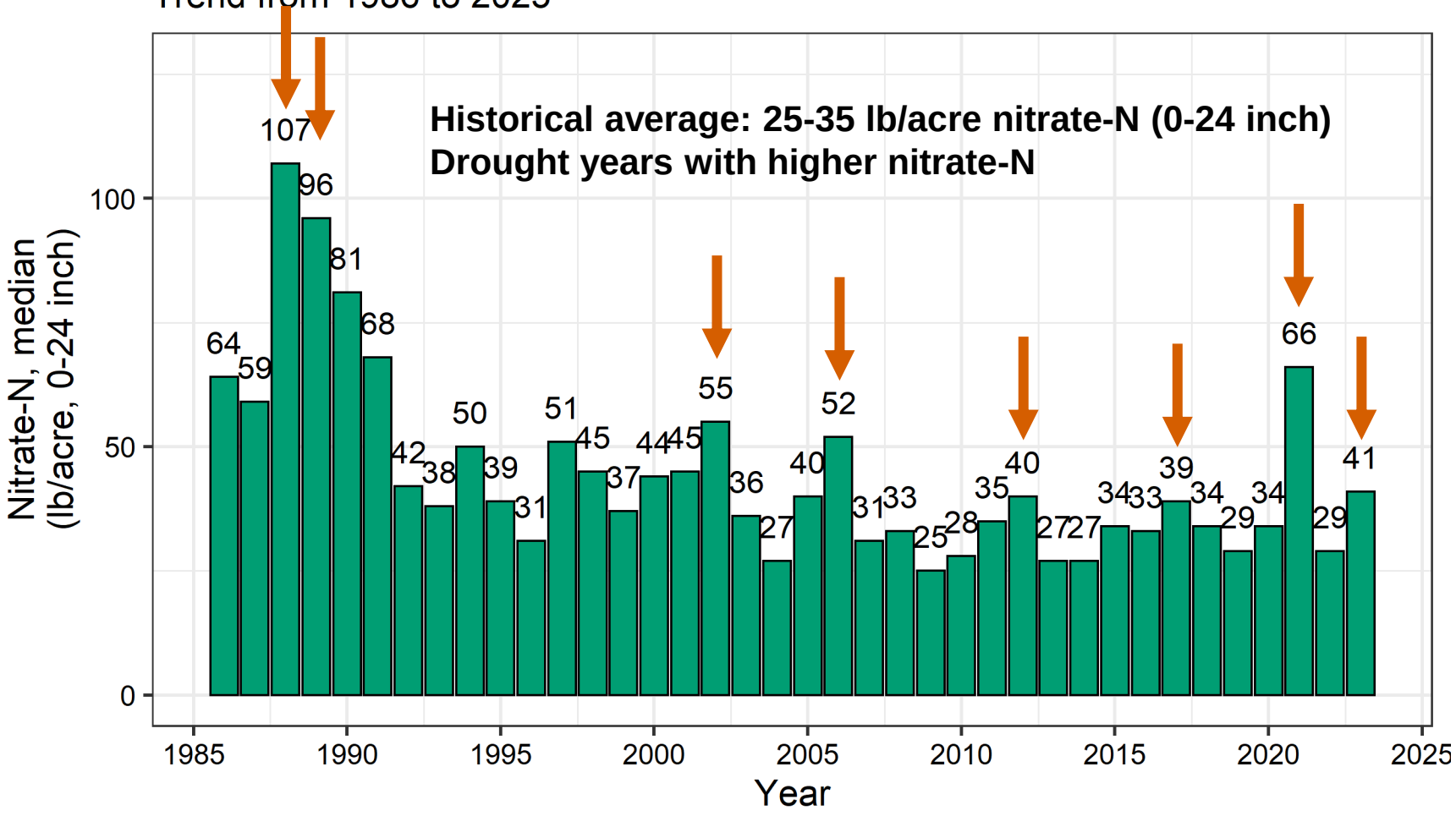
#3: Soil nitrate-nitrogen

Questions we can explore

- Trends in residual soil nitrate-N after crops
  - Weather variation: drought vs. monsoon
  - Crops with excessive nitrogen application
  - Crops with efficient nitrogen application
- Field variability

Residual nitrate following wheat

Trend from 1986 to 2023



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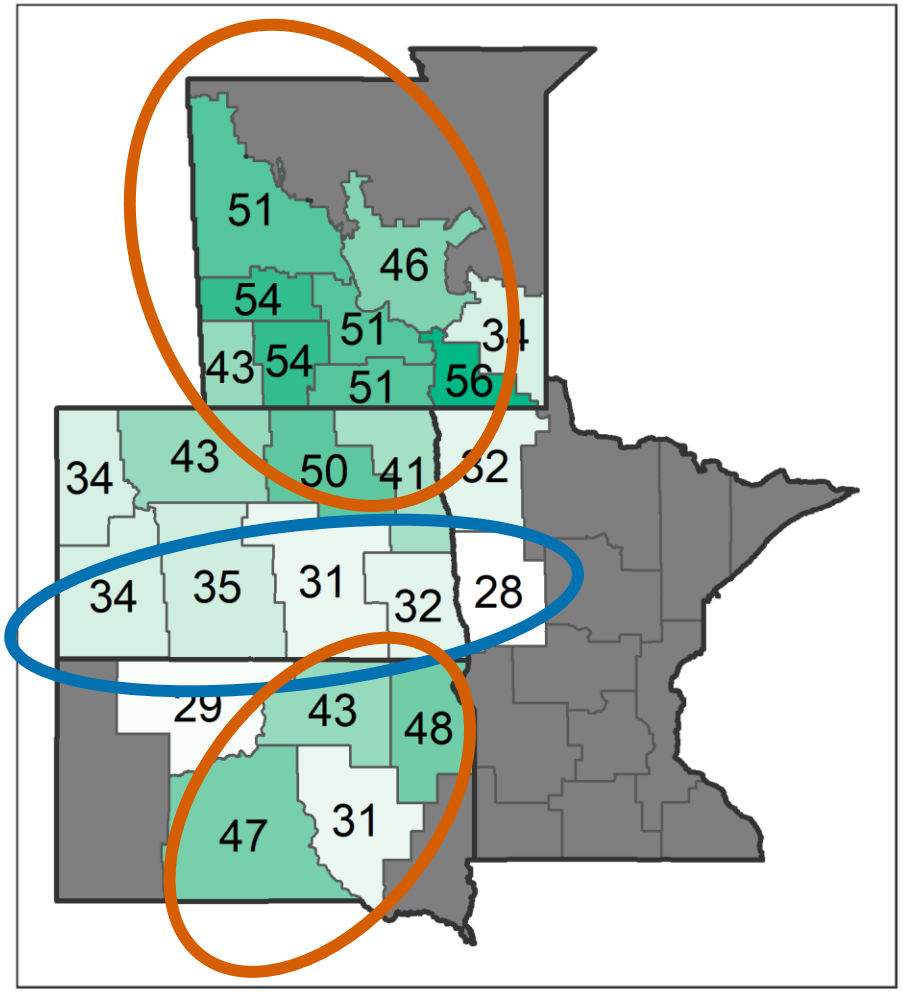
Residual nitrate following wheat in 2023



Nitrate-N, median
(lb/acre, 0-24 inch)

55
50
45
40
35
30

Data not shown where n< 100
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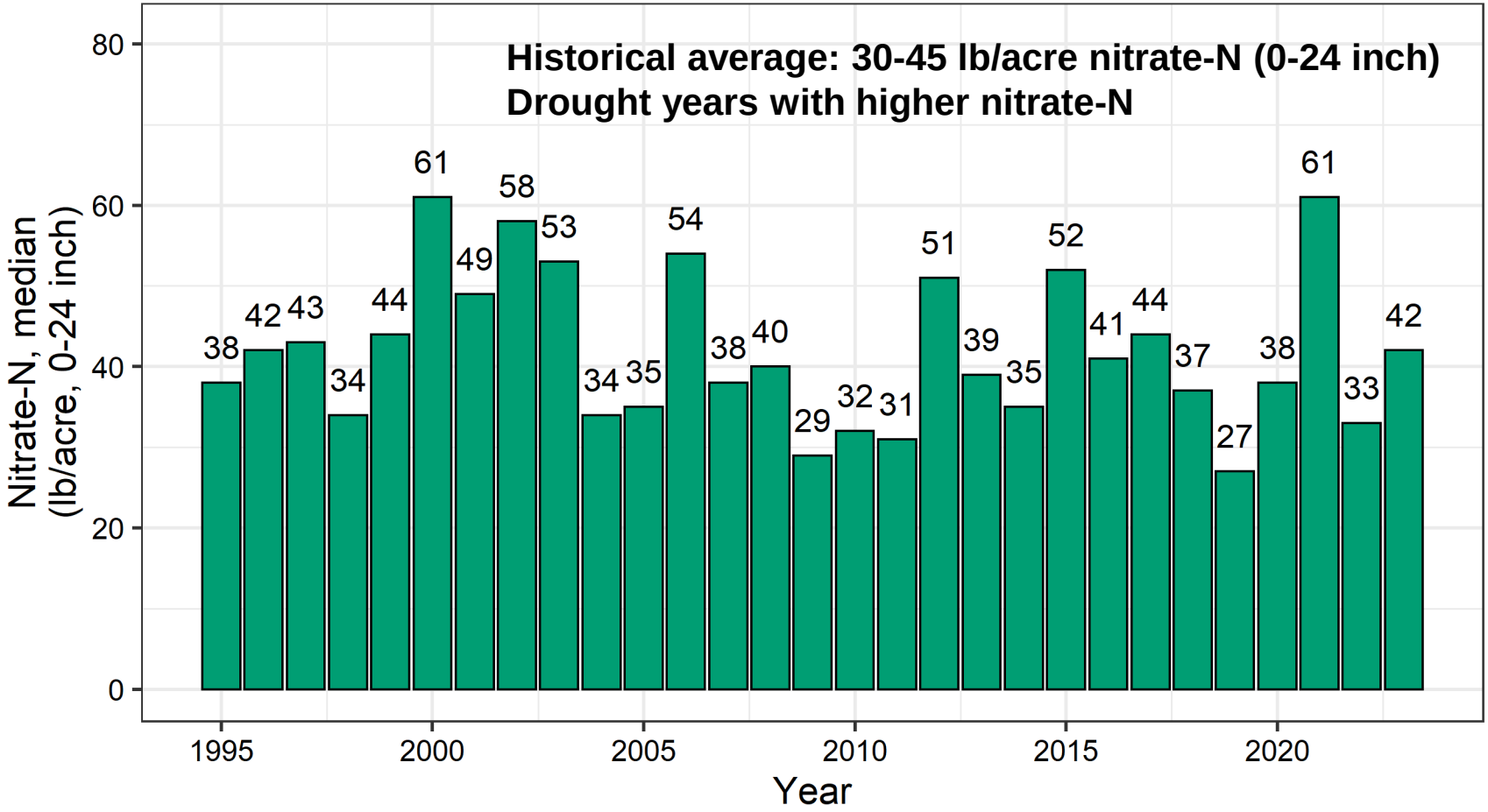
Residual nitrate following corn

Trend from 1995 to 2023



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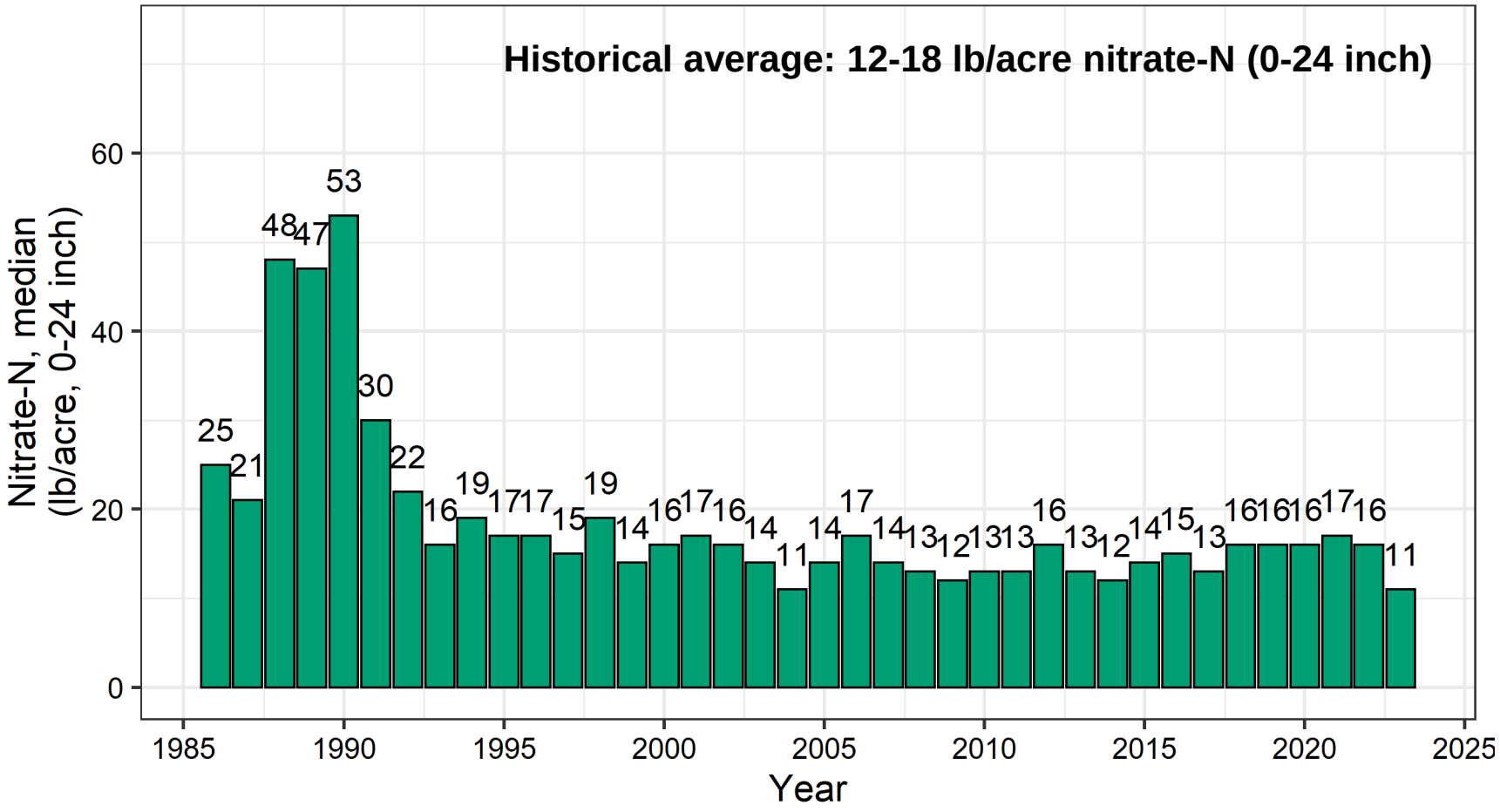
Residual nitrate following sugarbeet

Trend from 1986 to 2023



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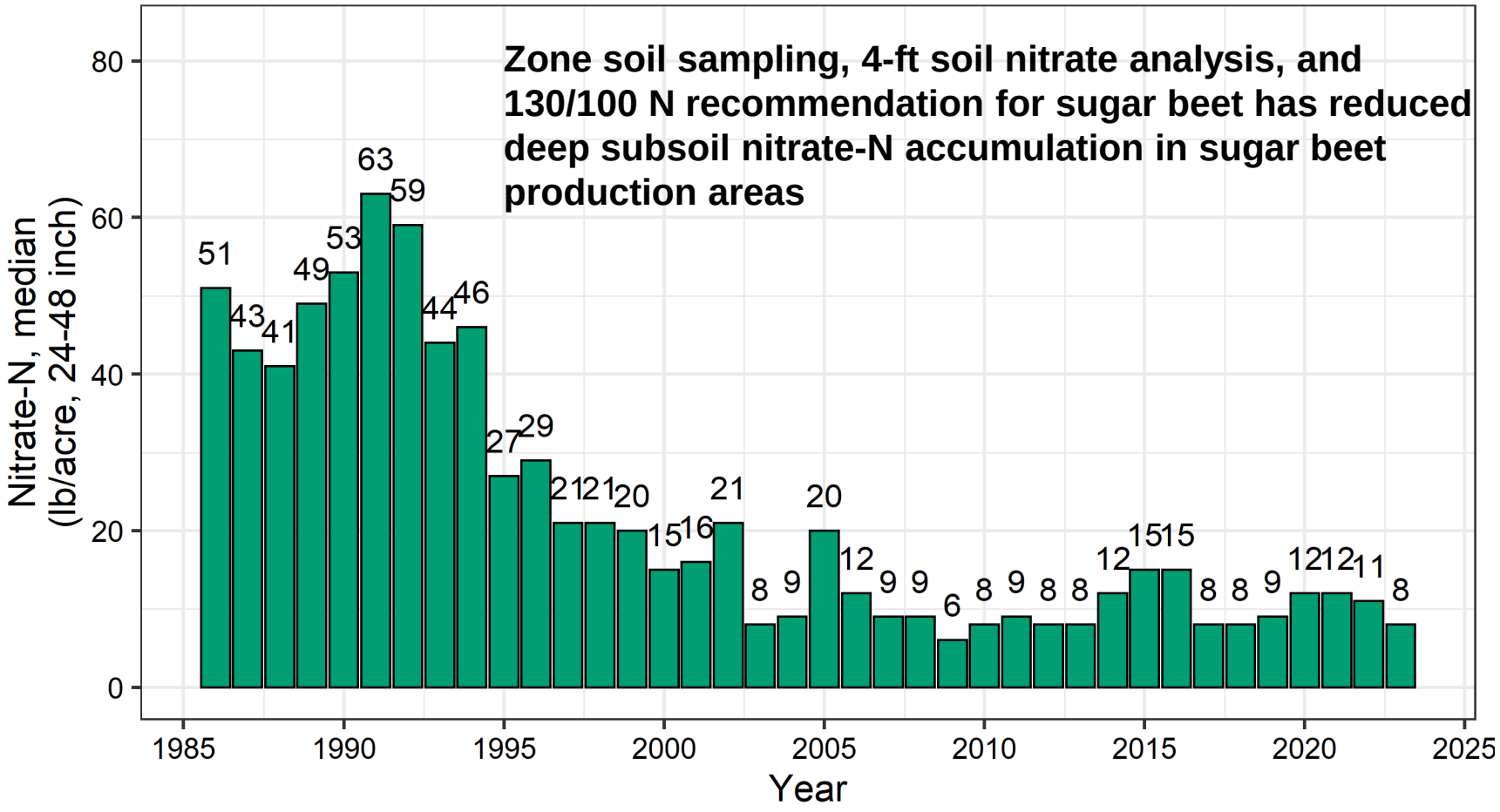
AGVISE Laboratories, Inc.

Residual deep nitrate following wheat

Trend from 1986 to 2023



Data not shown where n< 100
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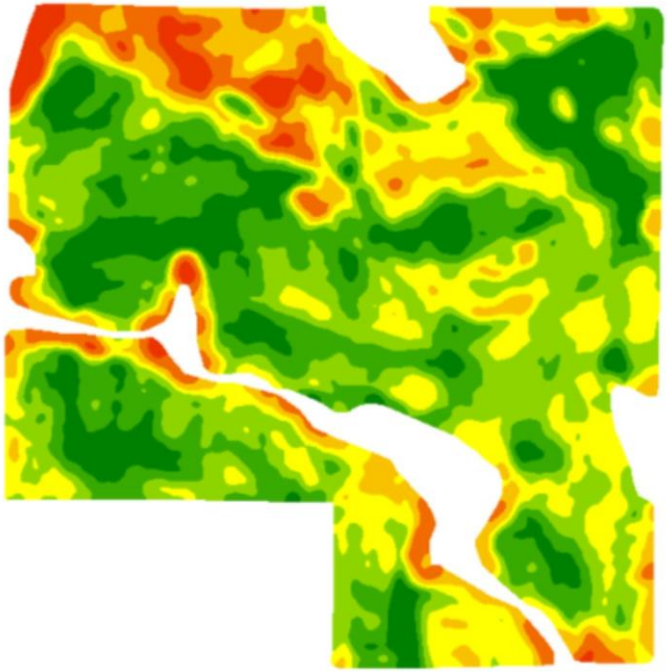
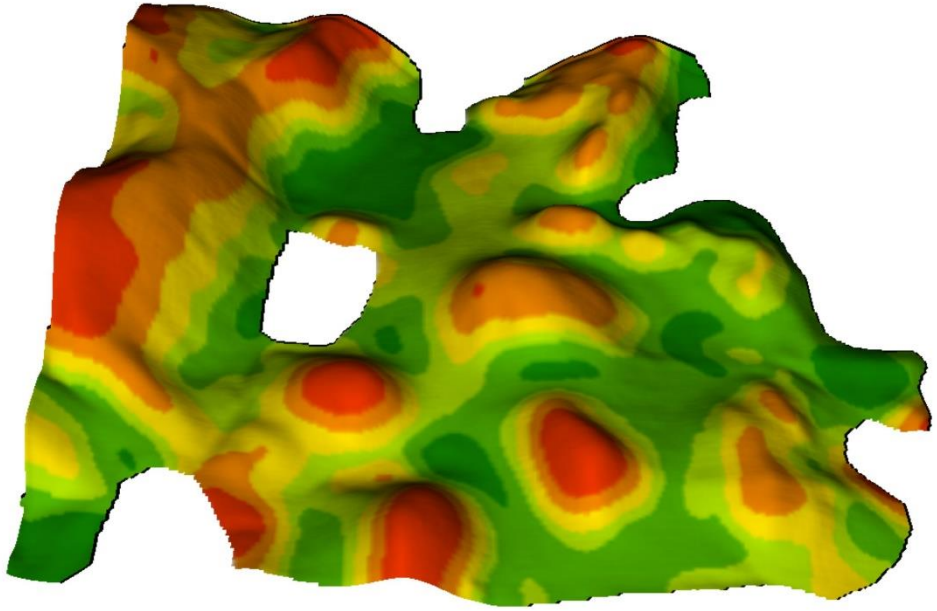
Lessons about soil nitrate-N trends

- Wheat = good barometer of weather and nitrogen management
- Corn = often higher than wheat
- Sugar beet = very low; excellent example of good nitrogen management and zone soil sampling



Factors of Soil Formation (Jenny, 1941)

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



Spatial Variability

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
4	41	14	111	0.7	0.9	1.5
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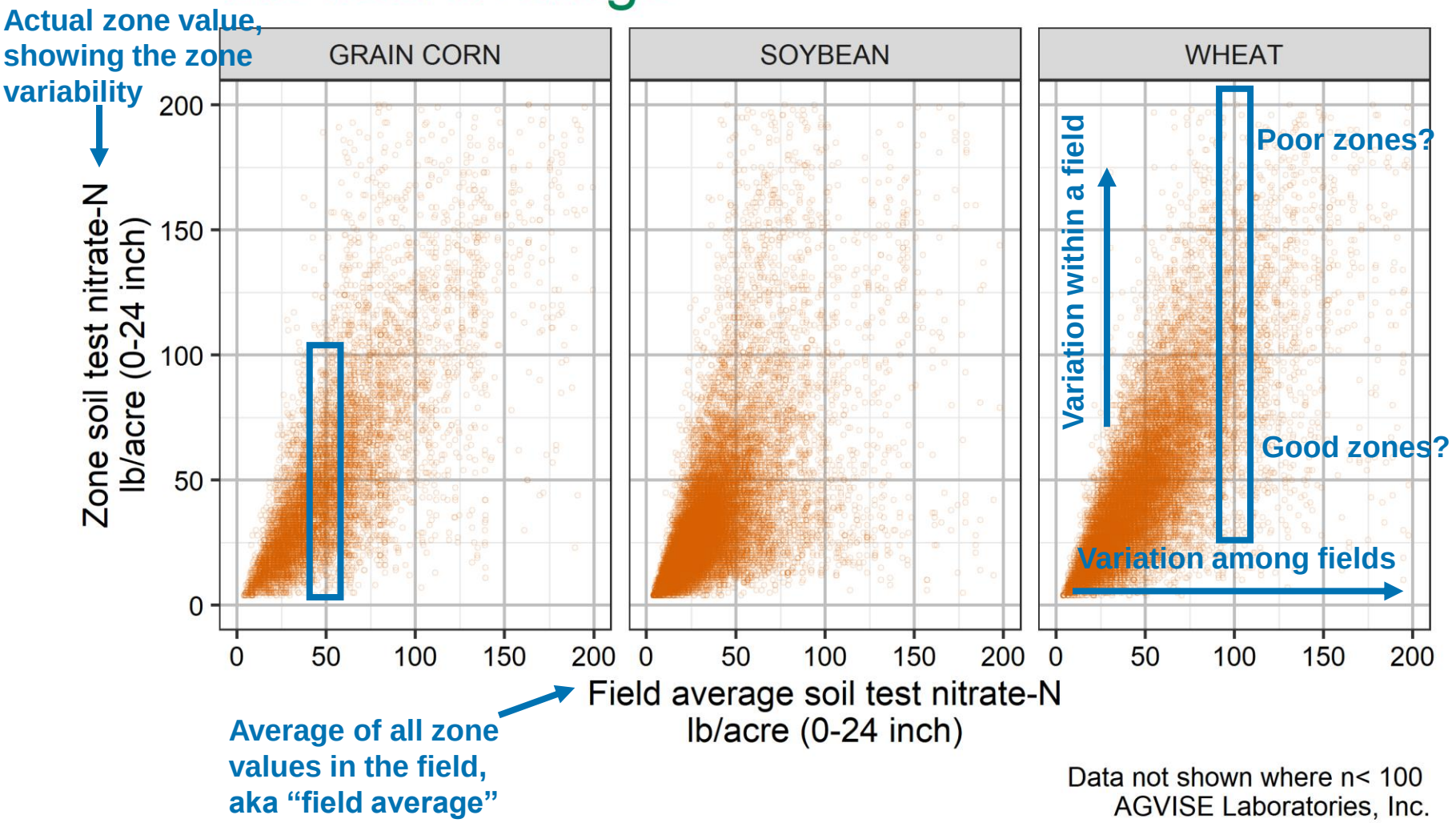
8	78	26	168	1.2	1.2	2.4

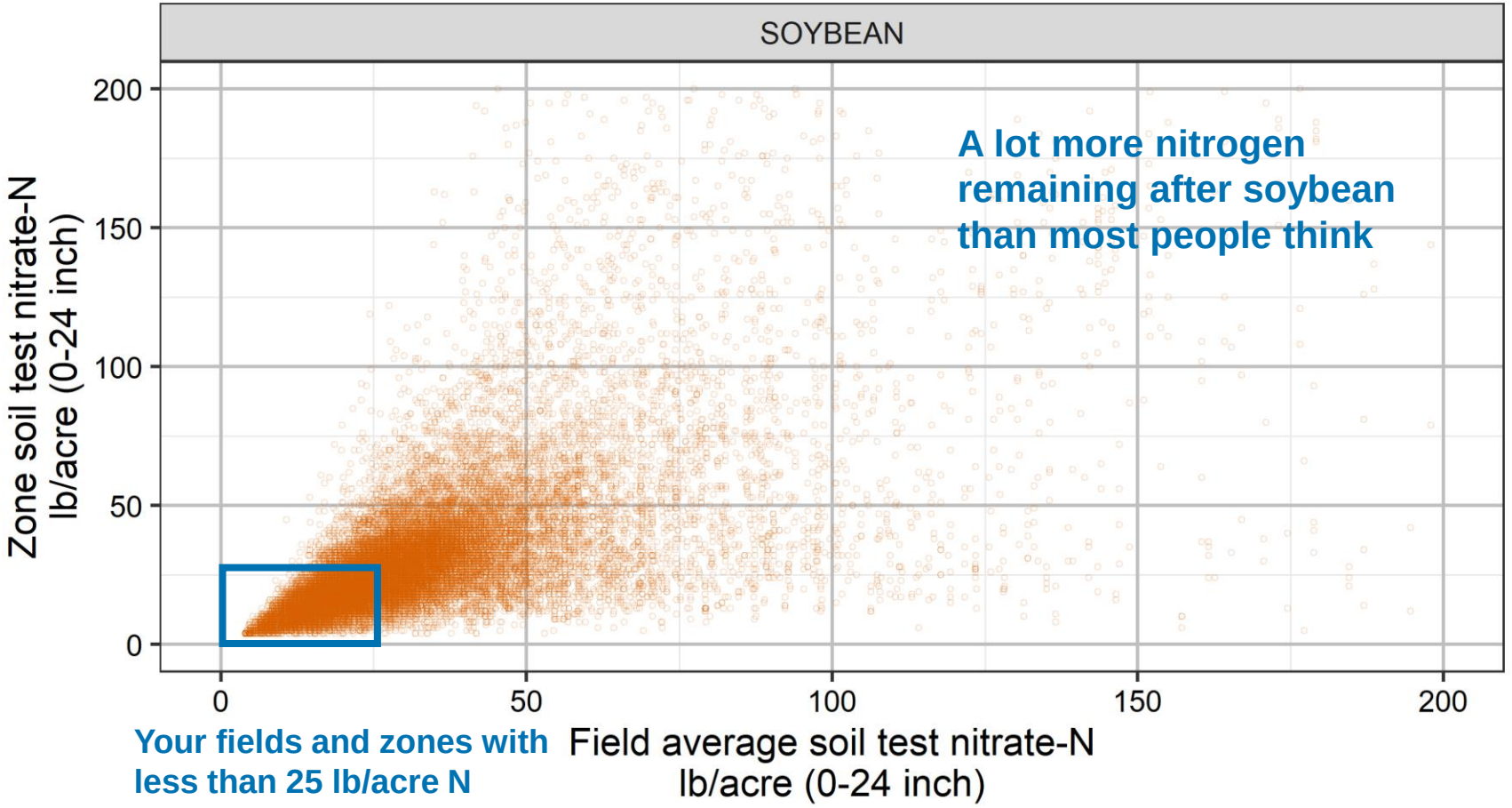
Summary of 24,000 precision soil sampled fields from Manitoba, Minnesota, North Dakota, South Dakota; AGVISE Laboratories, 2023.

Soil test nitrate-N zone variability within the field average



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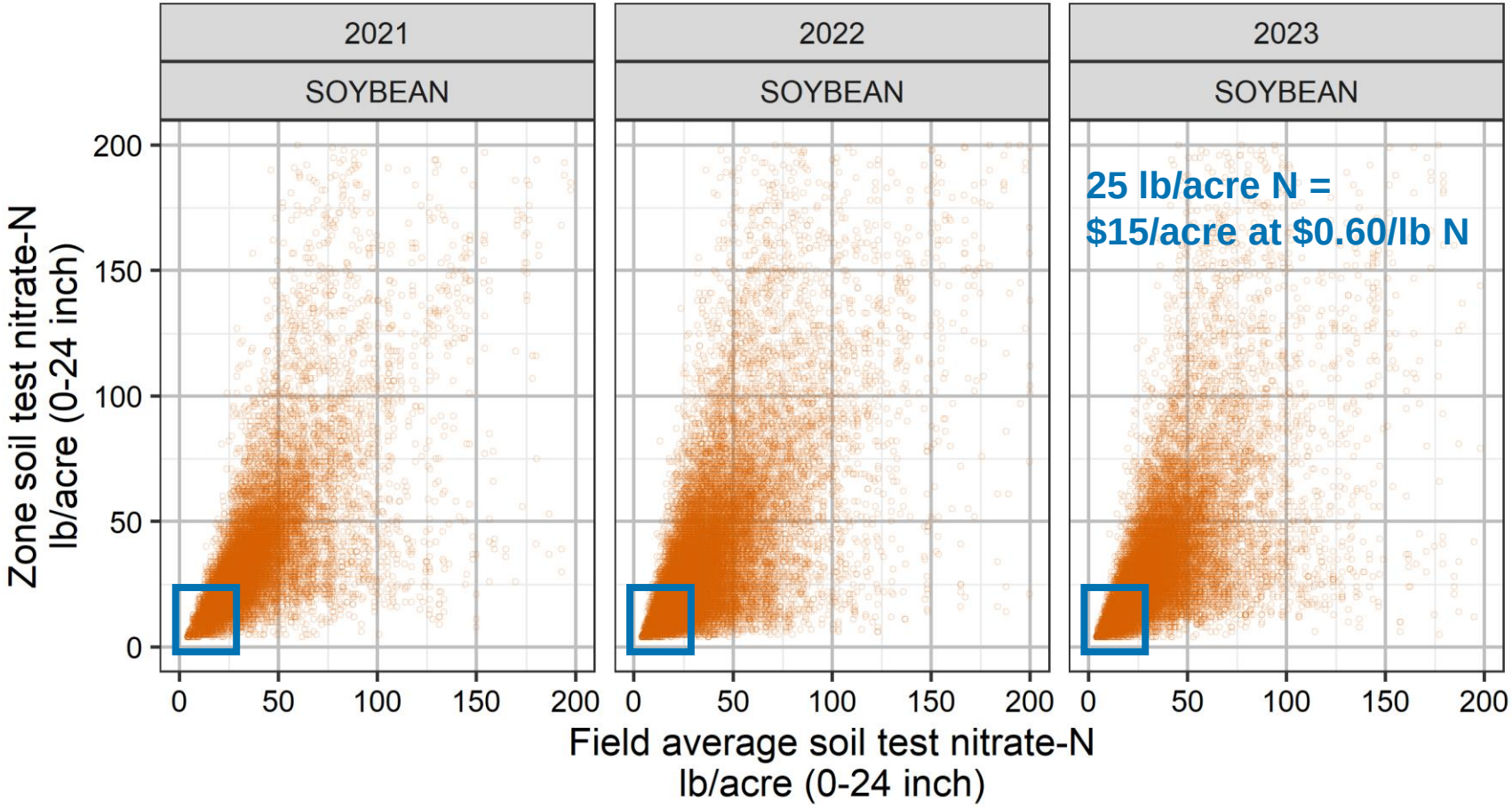
Summary of 27,000 precision soil sampled fields from Manitoba, Minnesota, North Dakota, South Dakota; AGVISE Laboratories, 2023.

Soil test nitrate-N zone variability within the field average



Data not shown where n< 100
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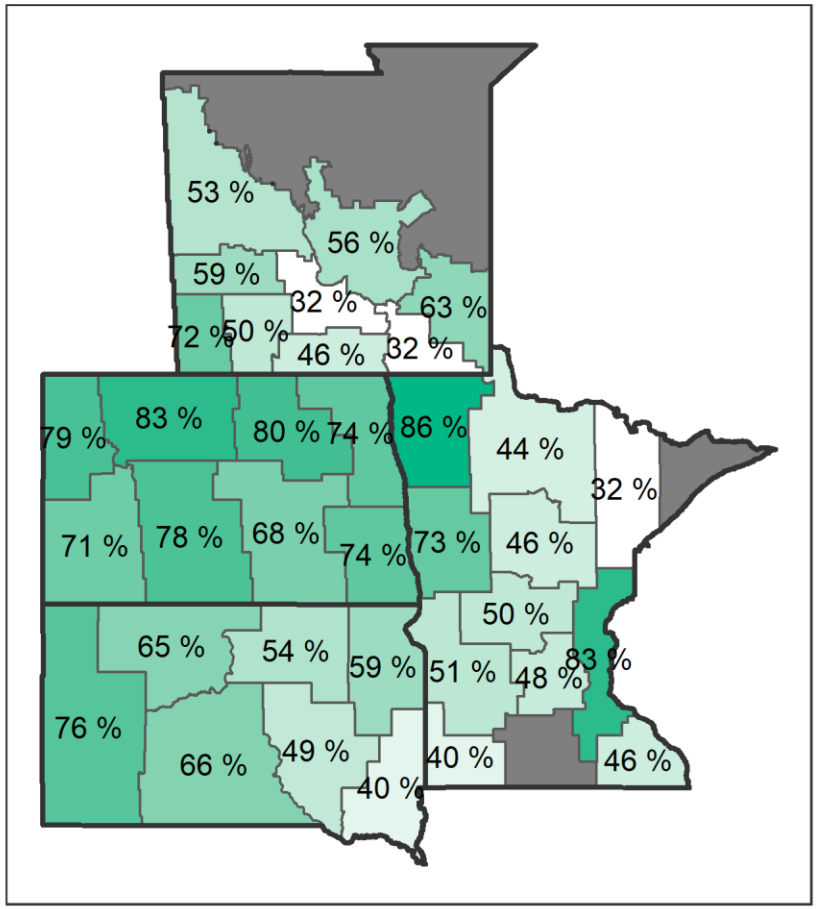
Summary of precision soil sampled fields from Manitoba, Minnesota, North Dakota, South Dakota; AGVISE Laboratories, 2021-2023.

#4: Phosphorus and Potassium

Questions we can explore

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

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



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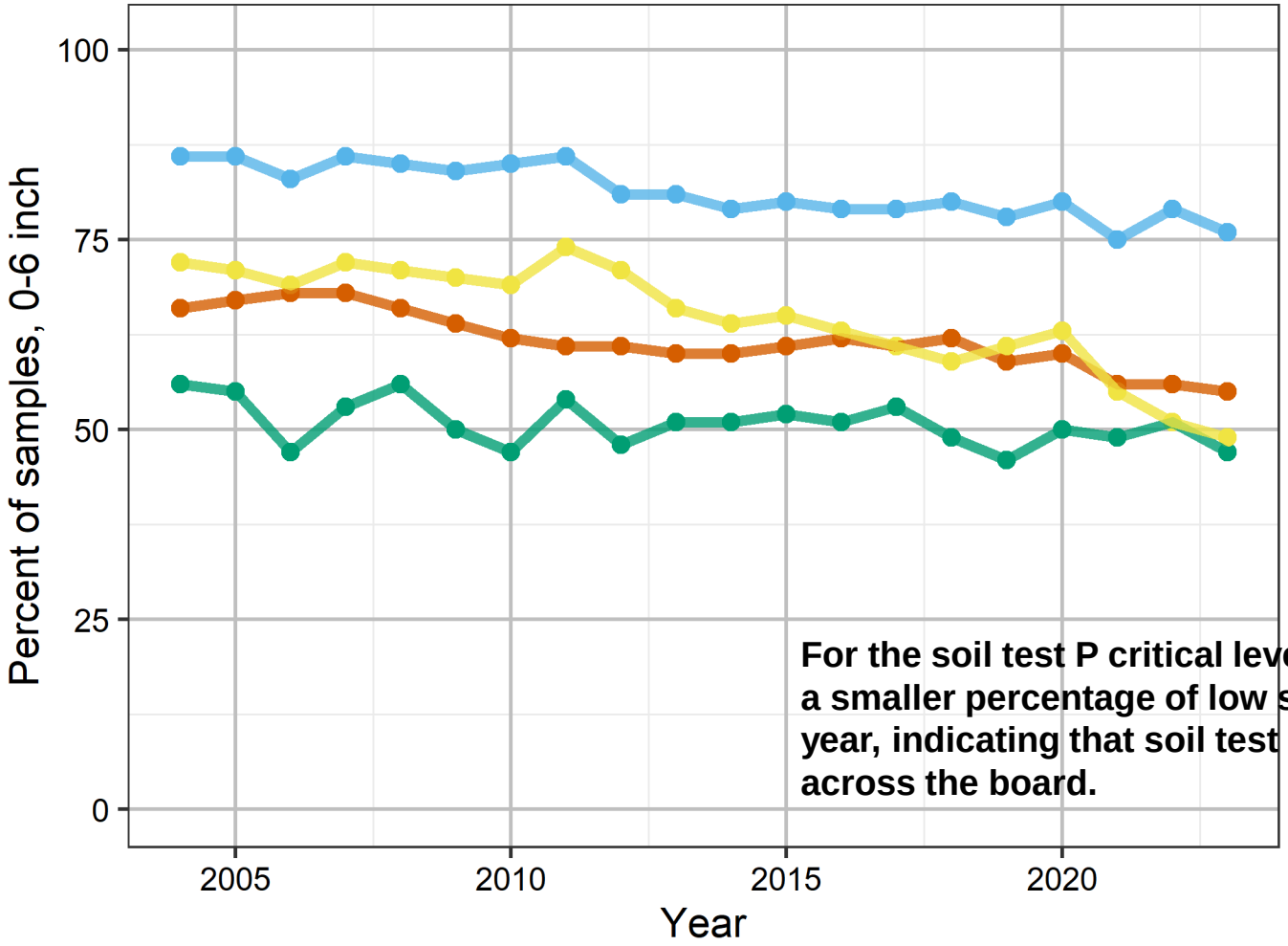
AGVISE Laboratories, Inc.

Trend in low soil test P (Olsen) < 15 ppm



Data not shown where n< 100
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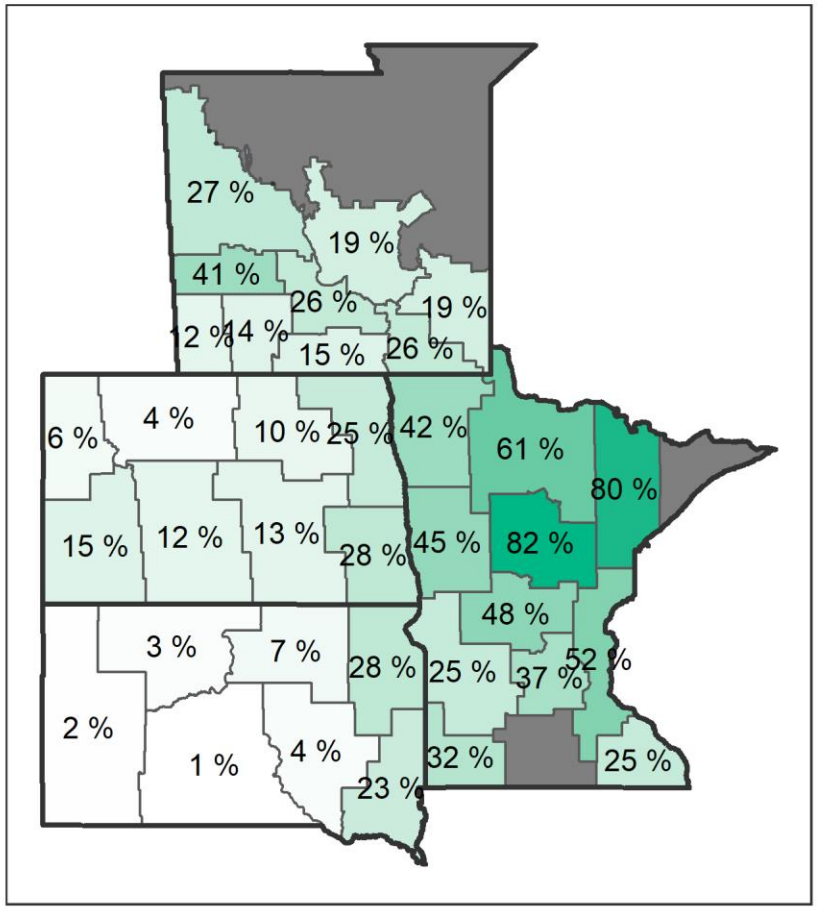
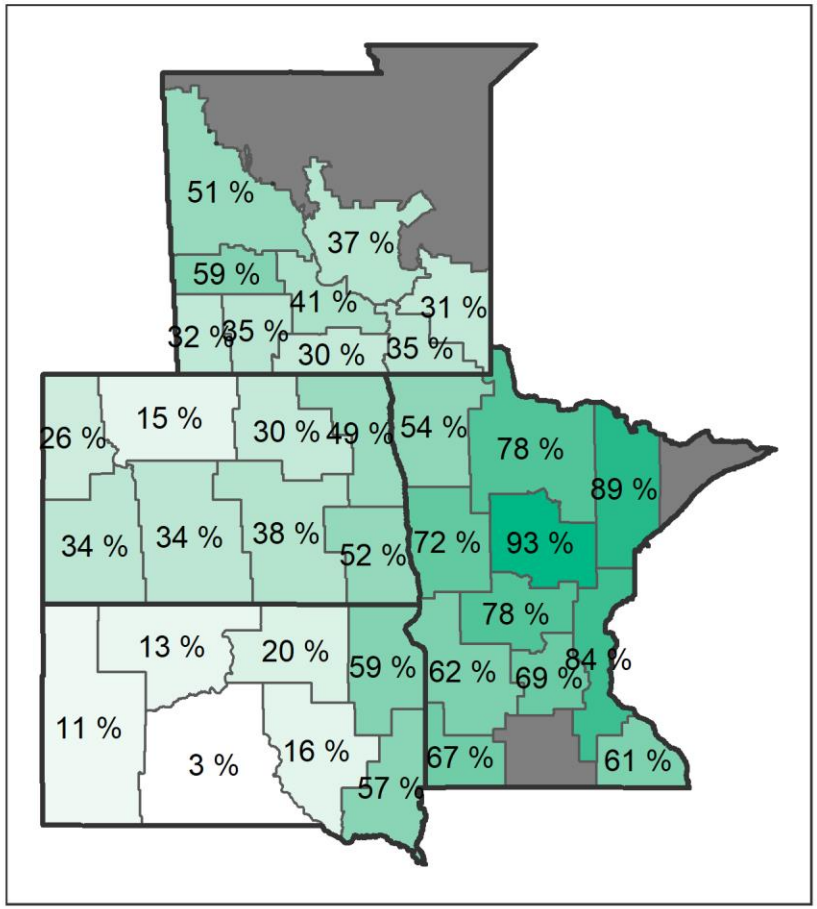
Soil samples with soil test potassium below 150 ppm in 2023



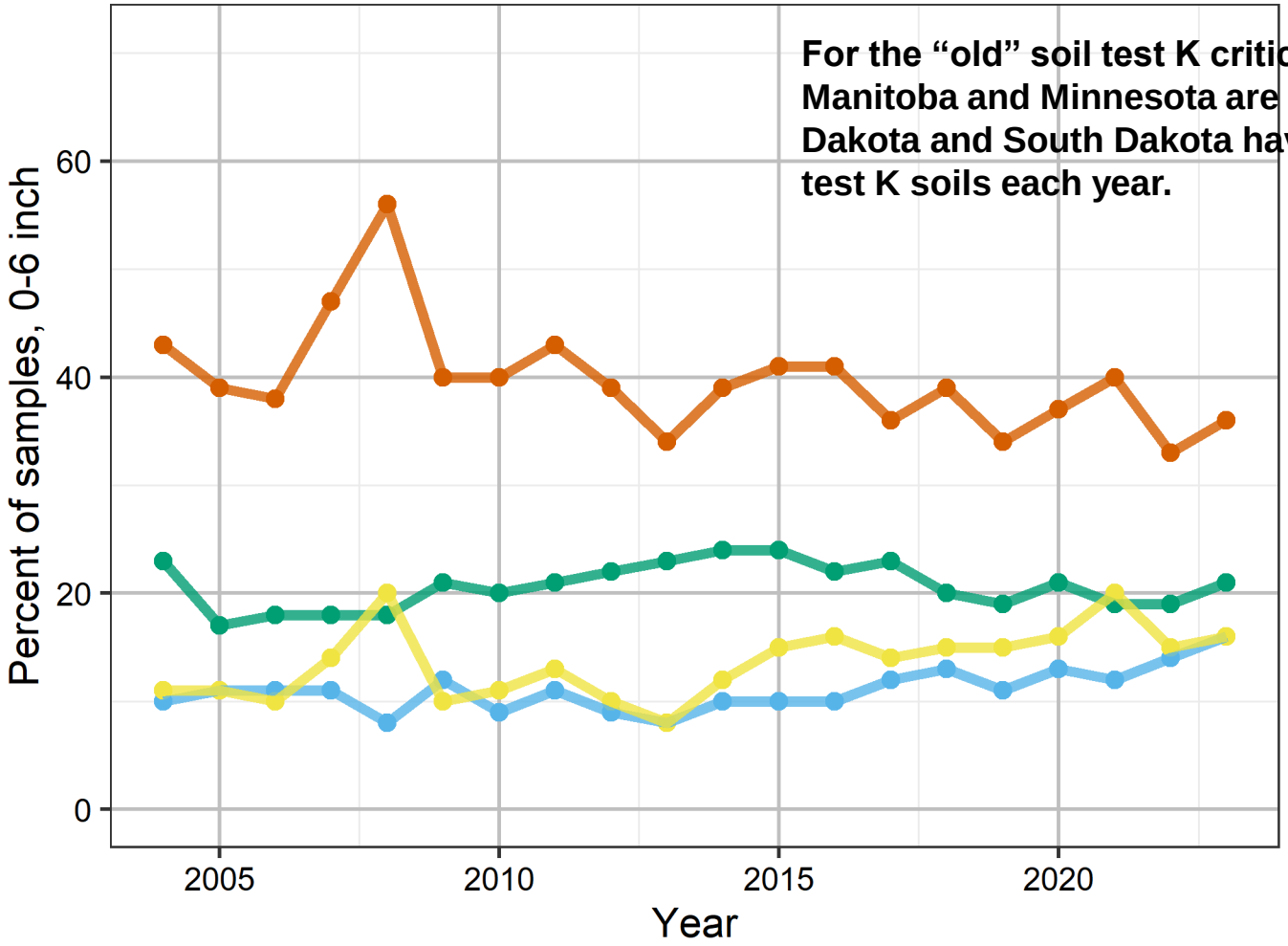
Data not shown where n< 100
AGVISE Laboratories, Inc.

Soil samples with soil test potassium below 200 ppm in 2023



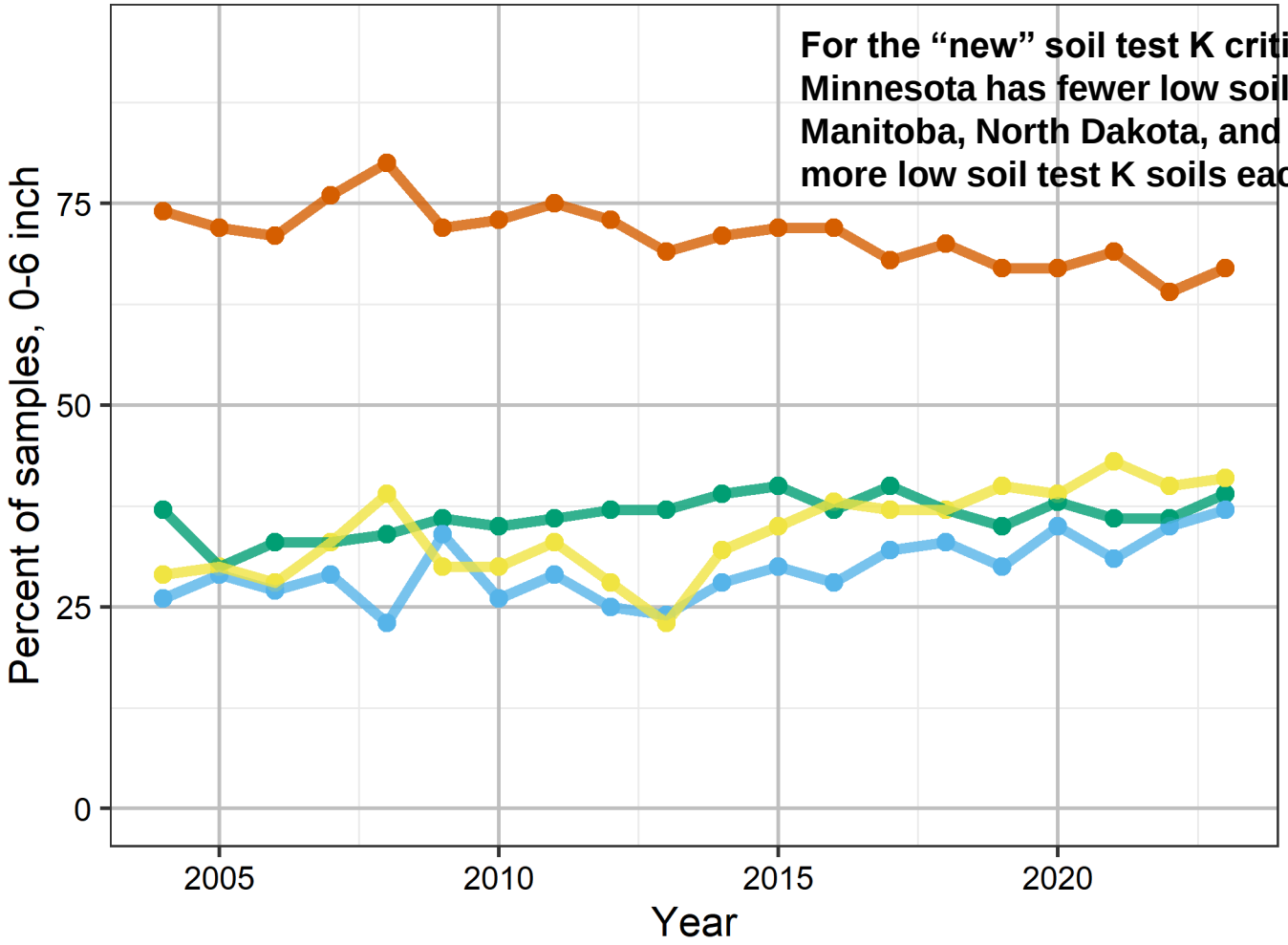
Data not shown where n< 100
AGVISE Laboratories, Inc.

Trend in low soil test K < 150 ppm



Data not shown where n< 100
AGVISE Laboratories, Inc.

Trend in low soil test K < 200 ppm



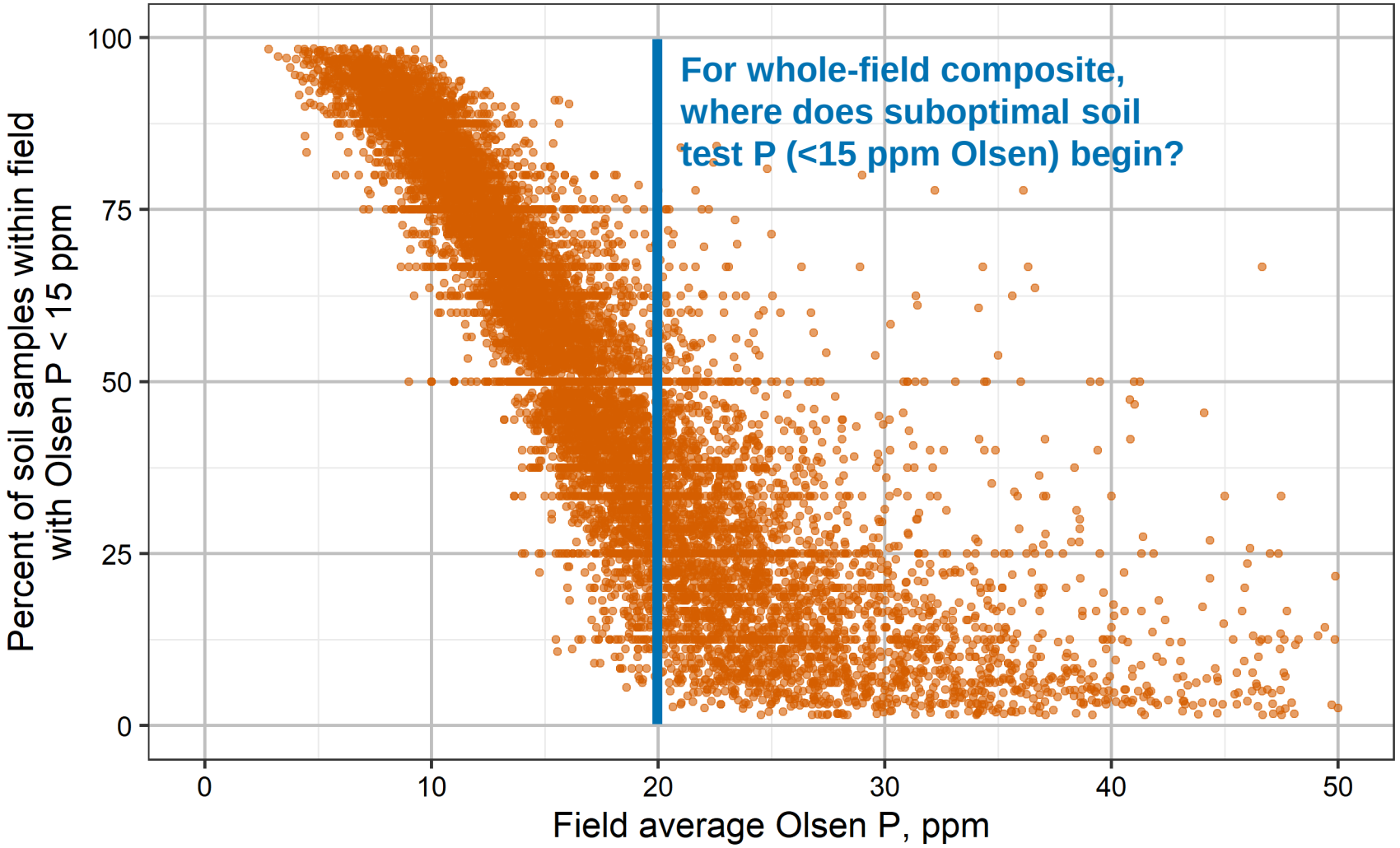
Data not shown where n< 100
AGVISE Laboratories, Inc.

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
4	41	14	111	0.7	0.9	1.5
5	53	17	126	0.8	1.1	2.0
6	65	23	174	1.1	1.3	1.9
7	62	23	171	1.1	1.4	1.8
8	78	26	168	1.2	1.2	2.4

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

Field variability is hidden in the average



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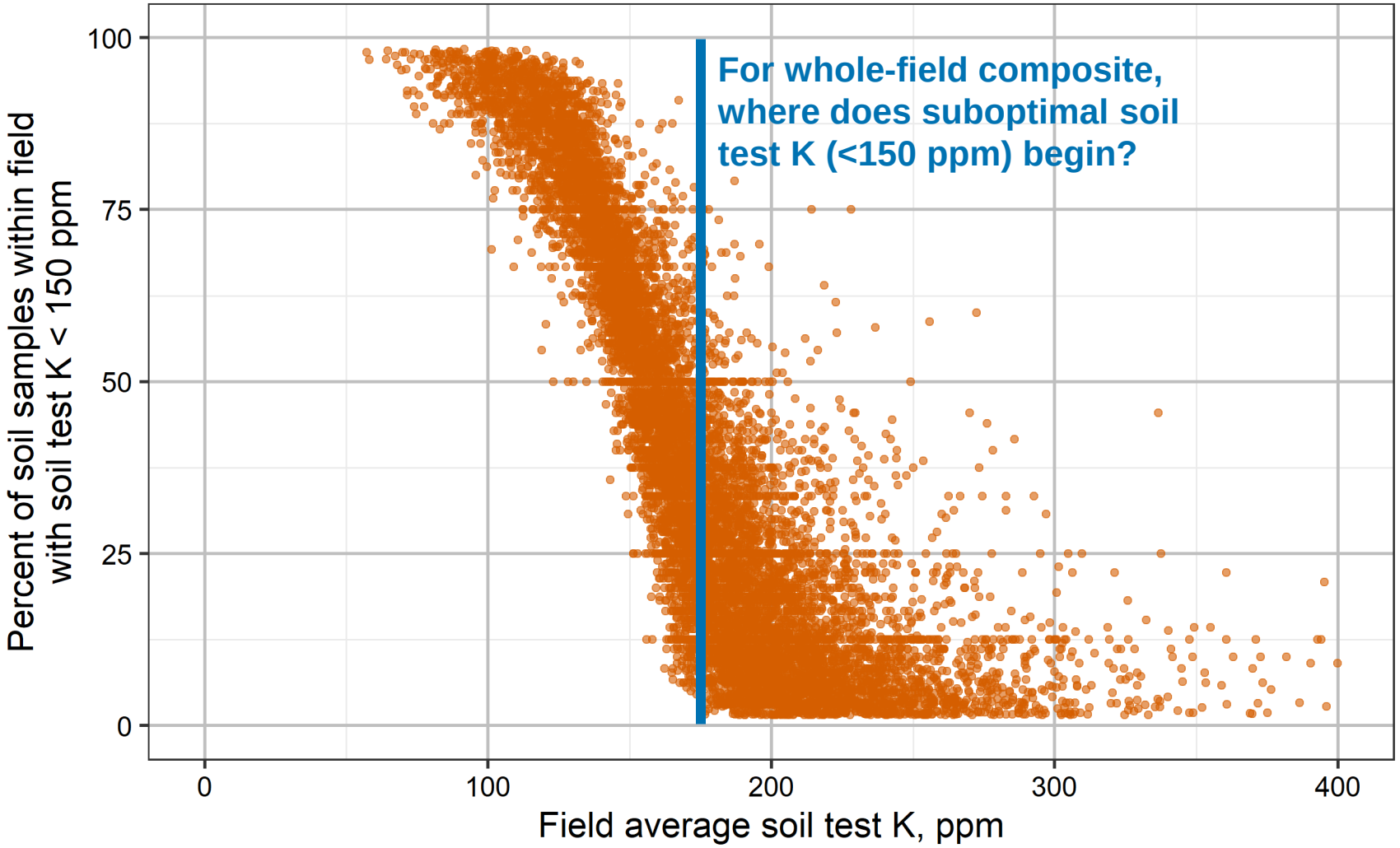
Field variability is hidden in the average



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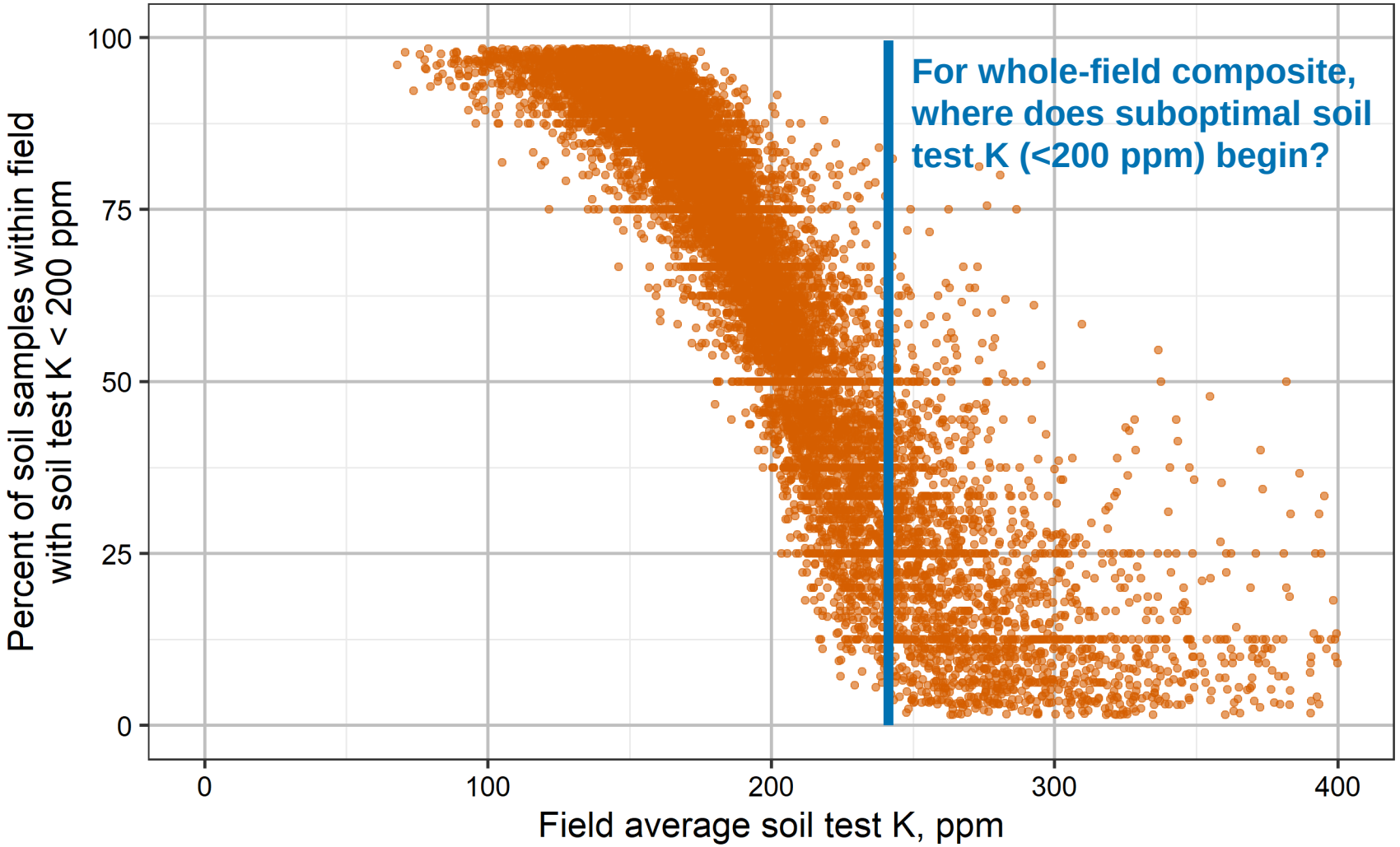
Field variability is hidden in the average



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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
- Fewer suboptimal STP soil samples each year, slowly building STP
- Suboptimal STK is increasing, continued K mining
- STP and STK variability is hidden in whole-field composite soil samples

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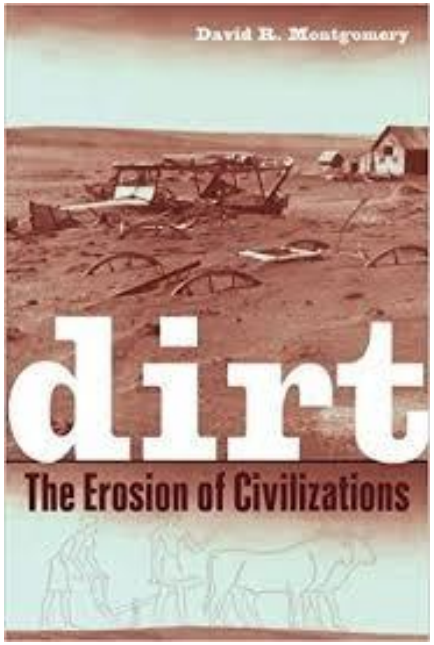

If you want to learn more about humankind's long struggle with soil erosion…

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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