# Soil Salinity: Annual Problems, Perennial Solutions?

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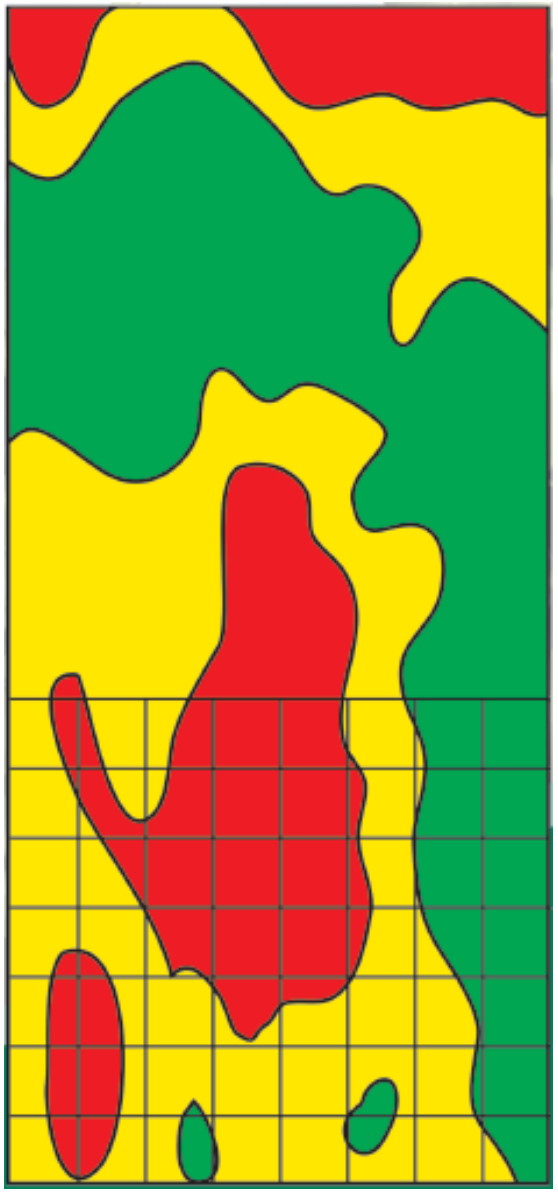

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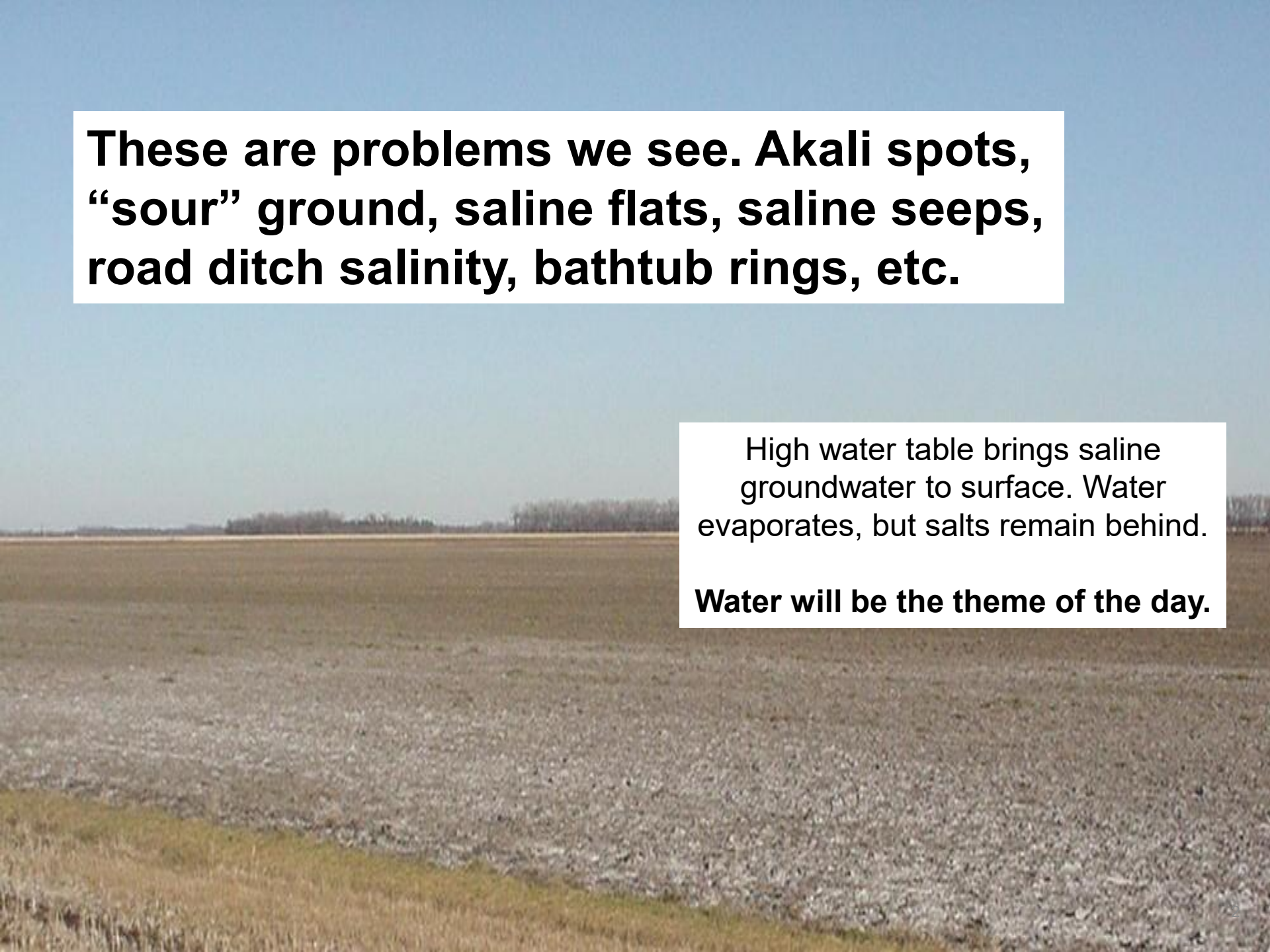
@jsbreker

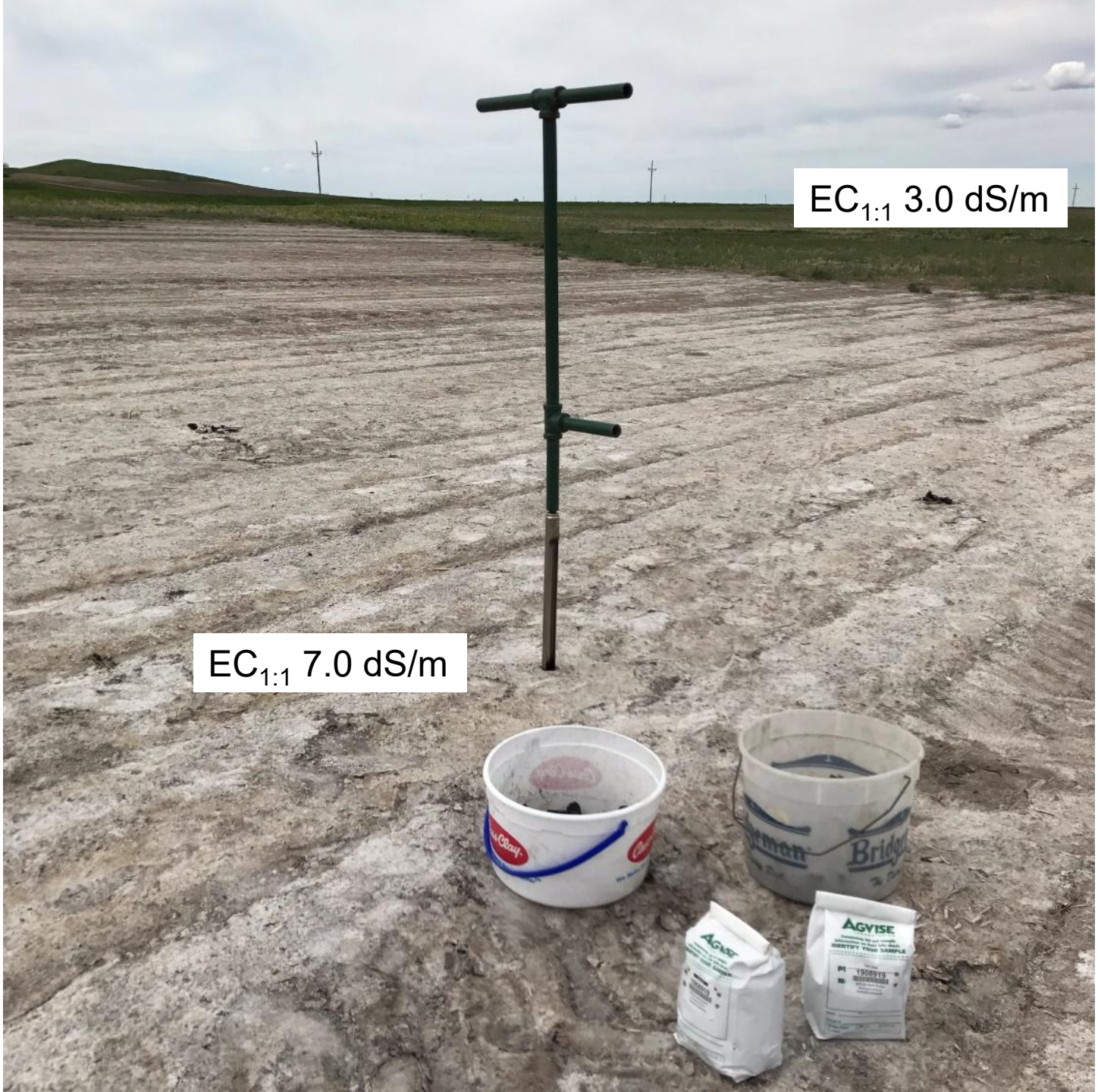


**These are problems we see. Akali spots, “sour” ground, saline flats, saline seeps, road ditch salinity, bathtub rings, etc.**

High water table brings saline groundwater to surface. Water evaporates, but salts remain behind.

**Water will be the theme of the day.**


$EC_{1:1}$ 2.5 dS/m
$EC_{1:1}$ 6.0 dS/m


$EC_{1:1}$ 3.0 dS/m
$EC_{1:1}$ 7.0 dS/m
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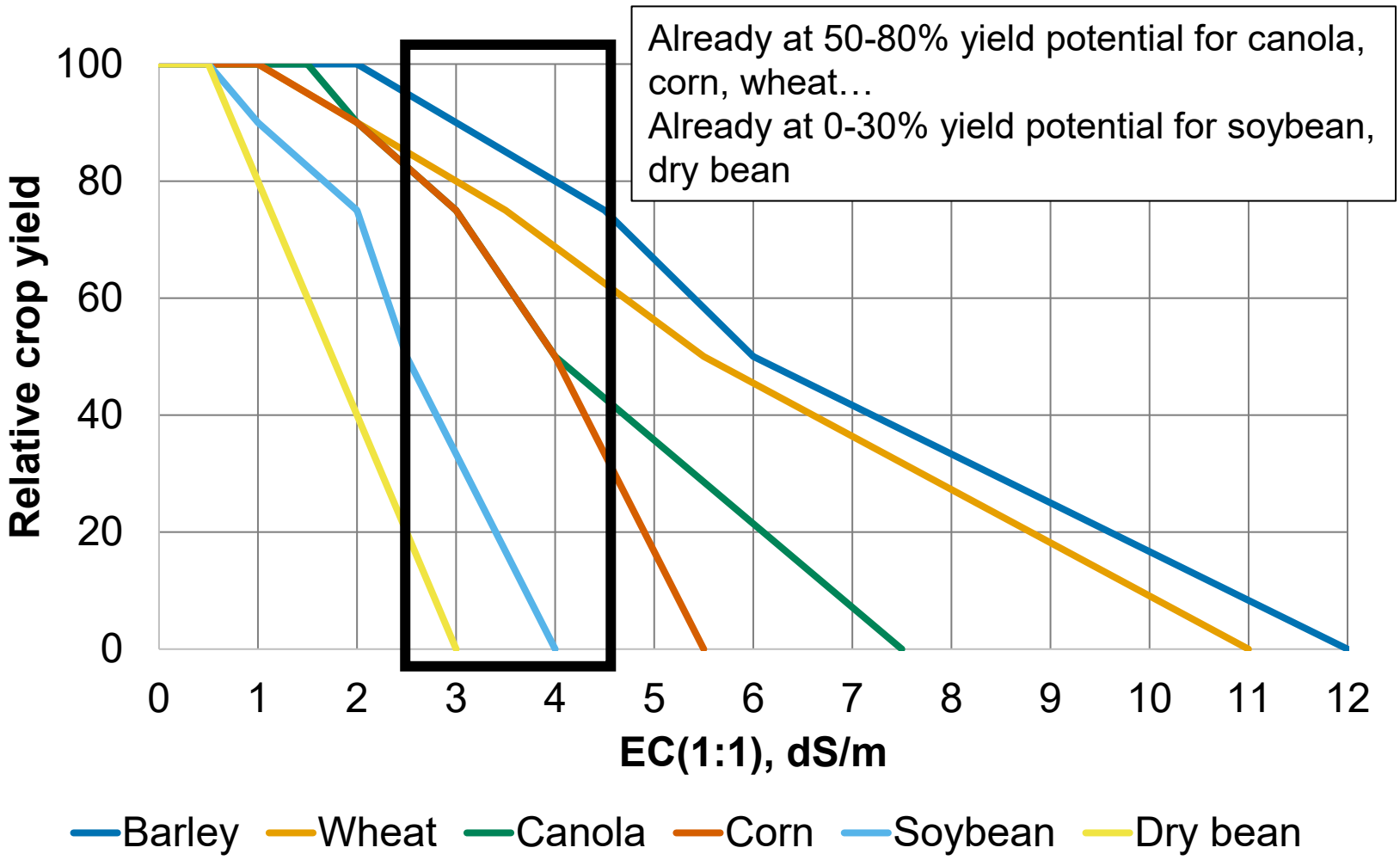
# Salinity tolerance of annual crops




Franzen, D., C. Gasch, C. Augustin, T. DeSutter, N. Kalwar, et al. 2019. Managing saline soils in North Dakota. NDSU Ext. Circ. SF1087 (revised). North Dakota State Univ., Fargo, ND.

# What are salts?

- Soluble salts are dissolved solutes or ions in water
  - e.g., Table salt (sodium chloride) dissolved in a glass of water
- Salts are classified by the paired cation (+ charge) and anion (- charge)
- Solubility describes how much can dissolve in water—higher solubility means more salt can dissolve in the soil solution

| Name | Chemical Formula | Solubility (g/L) |
|---|---|---|
| Calcium chloride | $CaCl_2$ | 427 |
| Magnesium chloride | $MgCl_2$ | 353 |
| Magnesium sulfate | $MgSO_4$ | 300 |
| Sodium chloride | NaCl | 264 |
| Sodium sulfate | $Na_2SO_4$ | 160 |
| Calcium sulfate | $CaSO_4$ | 2 |
| Calcium carbonate | $CaCO_3$ | 0.01 |

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# Salt-affected soils: saline & sodic

**Salinity, electrical conductivity (EC) 1:1 soil:water method**
Overall abundance of soluble salts. Saline soils compete with plant roots for water uptake, causing a "physiological drought" stress and reduce crop productivity.

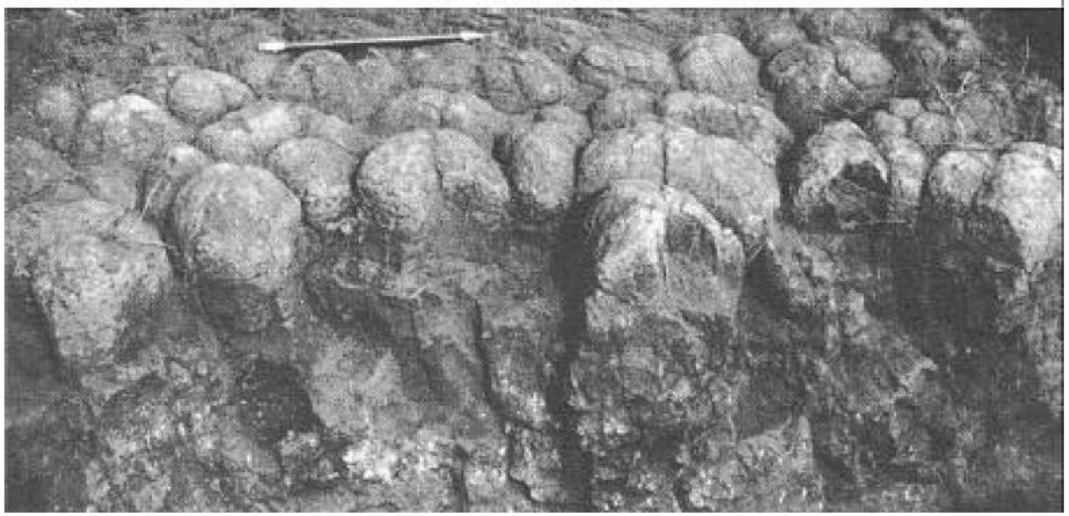
**Sodicity, extractable Na percentage (%Na) method**
Specifically high sodium. Sodic soils have poor soil structure: poor water movement and poor trafficability when wet and severe compaction when dry.

| Salinity (EC1:1) | Extractable sodium percentage (%Na) | |
|---|---|---|
| | <5% | >5% |
| <1.0 dS/m | normal | sodic |
| >1.0 dS/m | saline | saline-sodic |

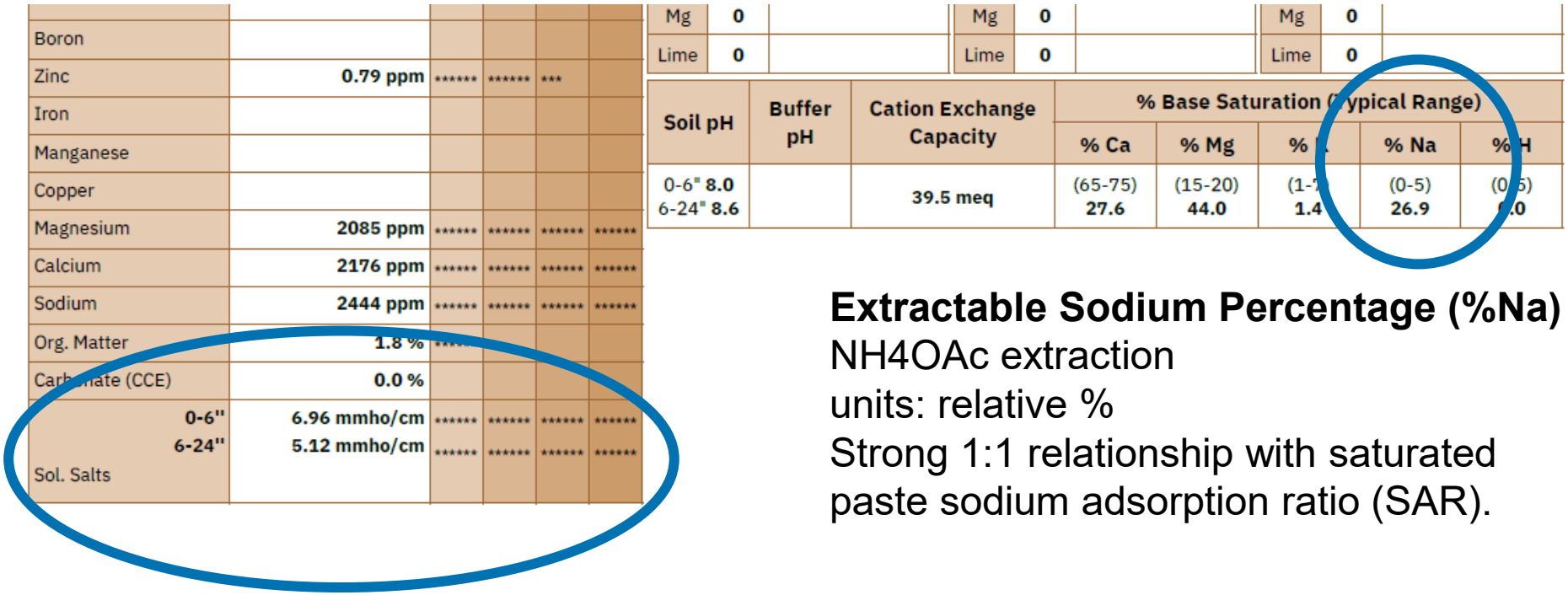
>0.75 dS/m will stress sensitive crops: dry bean, pea, lentil, soybean

**Saline soil (high salts)**
Salts compete with plant roots for water uptake. Poor or no crop growth, only salt-tolerant plants will grow.

**Sodic soil (high sodium)**
Sodium creates poor soil structure. Hard compacted natric horizon, poor water movement, root-restricting layer.



Seelig, B.D. 2000. Salinity and sodicity in North Dakota Soils. NDSU Ext. Bull. EB-57. North Dakota State Univ., Fargo, ND.



| | | | | | |
|---|---|---|---|---|---|
| Boron | | | | | |
| Zinc | 0.79 ppm | ****** | ****** | *** | |
| Iron | | | | | |
| Manganese | | | | | |
| Copper | | | | | |
| Magnesium | 2085 ppm | ****** | ****** | ****** | ****** |
| Calcium | 2176 ppm | ****** | ****** | ****** | ****** |
| Sodium | 2444 ppm | ****** | ****** | ****** | ****** |
| Org. Matter | 1.8 % | ****** | | | |
| Carbonate (CCE) | 0.0 % | | | | |
| 0-6" | 6.96 mmho/cm | ****** | ****** | ****** | ****** |
| 6-24" | 5.12 mmho/cm | ****** | ****** | ****** | ****** |
| Sol. Salts | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Mg | 0 | | Mg | 0 | | Mg | 0 | |
| Lime | 0 | | Lime | 0 | | Lime | 0 | |

| Soil pH | Buffer pH | Cation Exchange Capacity | % Base Saturation (Typical Range) | | | | |
|---|---|---|---|---|---|---|---|
| | | | % Ca | % Mg | % K | % Na | % H |
| 0-6" **8.0**<br>6-24" **8.6** | | **39.5 meq** | (65-75)<br>**27.6** | (15-20)<br>**44.0** | (1-7)<br>**1.4** | (0-5)<br>**26.9** | (0-5)<br>**0.0** |

**Extractable Sodium Percentage (%Na)**
NH4OAc extraction
units: relative %
Strong 1:1 relationship with saturated paste sodium adsorption ratio (SAR).

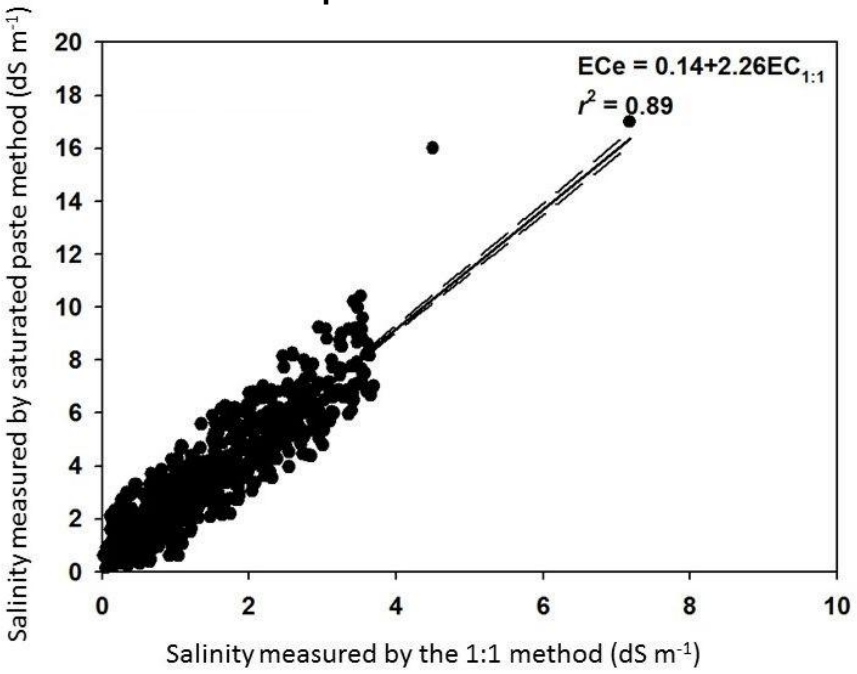
**Soluble Salts aka Salinity or Electrical Conductivity (EC)**
1:1 soil:water method
units: dS/m or mmho/cm
These units are numerically equivalent (1 dS/m = 1 mmho/cm).

# Relating “routine” laboratory analysis to classic saturated paste analysis

Collaborative projects between AGVISE and NDSU to improve routine assessment of saline and sodic soils

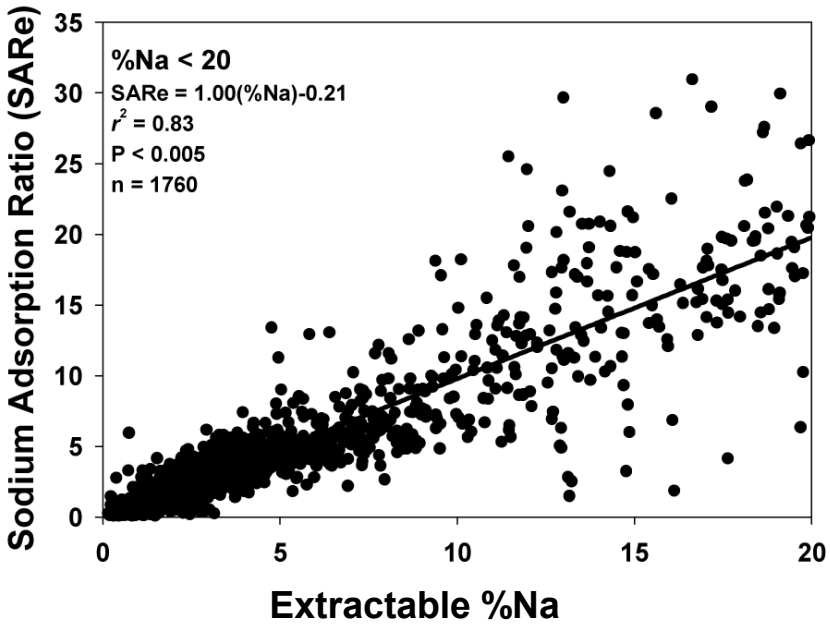
**Salinity conversion**

**$EC_{sat.\ paste} = 2.26*EC_{1:1}$**




**Sodicity “conversion”**

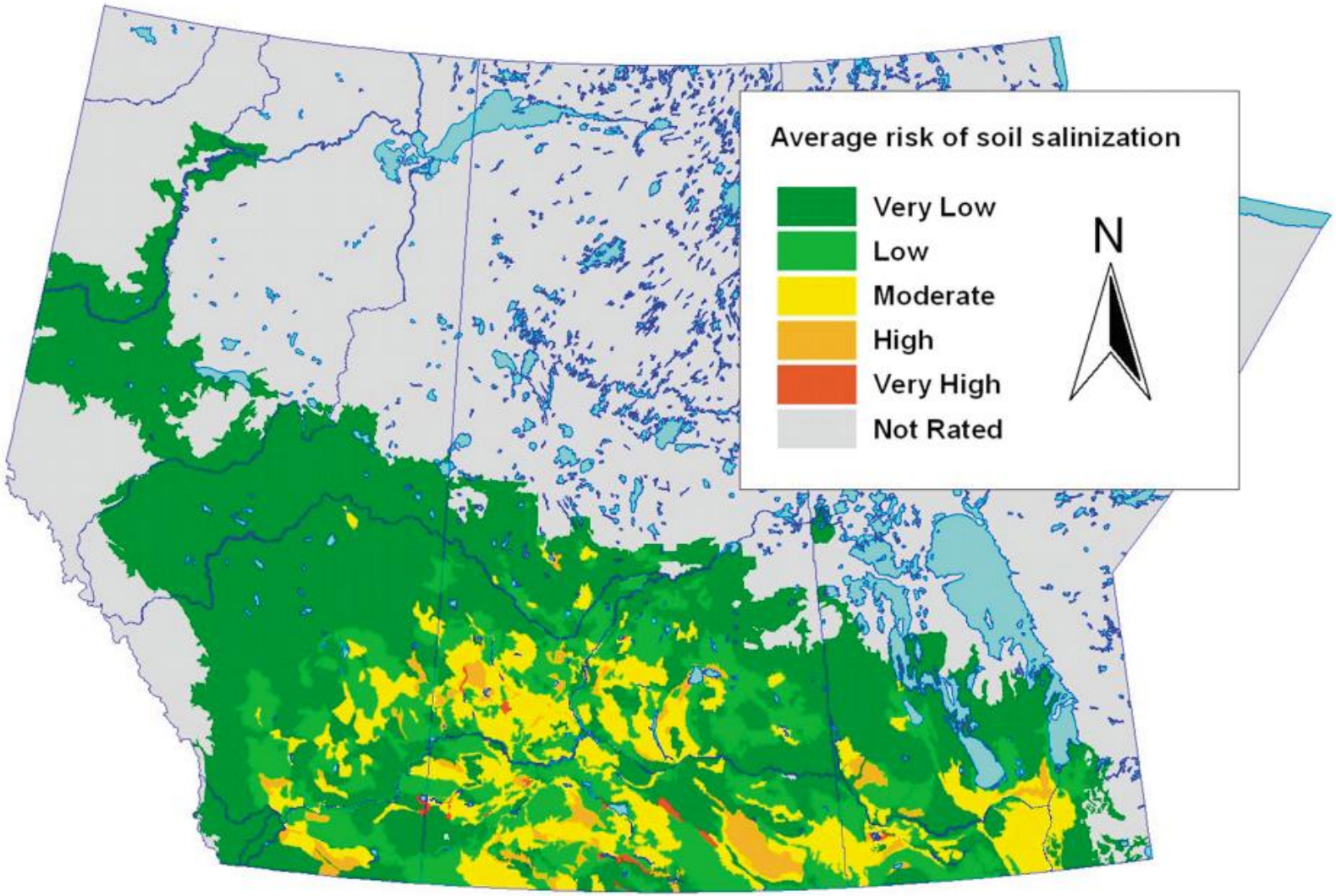
**$SAR_{sat.\ paste} \approx$ Extractable %Na**





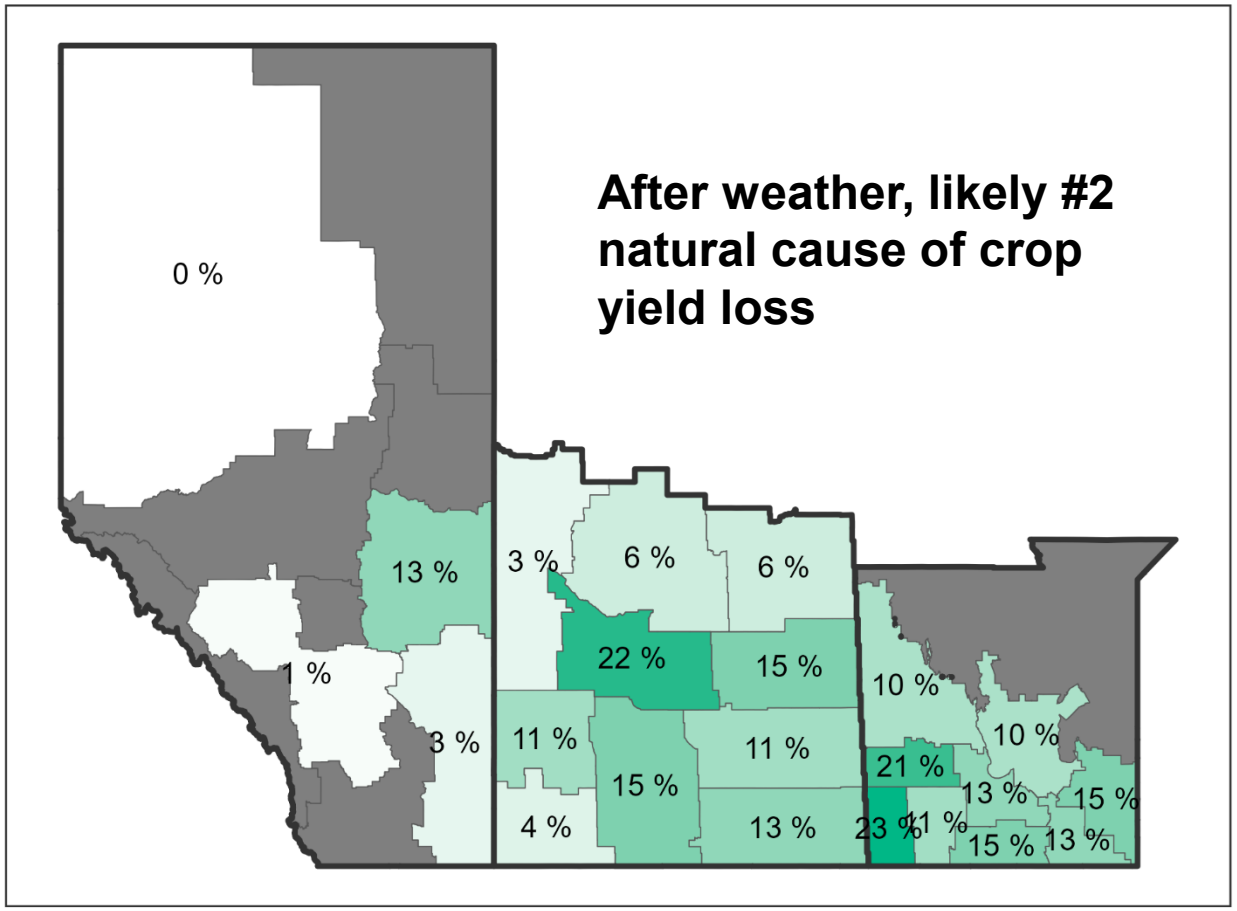
Matthees, H. L., He, Y., Owen, R. K., Hopkins, D., Deutsch, B., Lee, J., Clay, D. E., Reese, C., Malo, D. D., & DeSutter, T. M. 2017. Predicting soil electrical conductivity of the saturation extract from a 1:1 soil to water ratio. Communications in Soil Science and Plant Analysis, 48(18), 2148-2154.

DeSutter, T., Franzen, D., He, Y., Wick, A., Lee, J., Deutsch, B., and Clay, D. 2015. Relating sodium percentage to sodium adsorption ratio and its utility in the Northern Great Plains. Soil Sci. Soc. America J., 79(4):1261-1264. https://doi.org/10.2136/sssaj2015.01.0010n




Wiebe, B. H., Eilers, R. G., Eilers, W. D., and Brierley, J. A. 2007. Application of a risk indicator for assessing trends in dryland salinization risk on the Canadian Prairies. Canadian J. Soil Sci. 87:213-224. https://doi.org/10.4141/S06-068

# Soil samples with salinity above 1.0 dS/m (1:1) in 2025




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

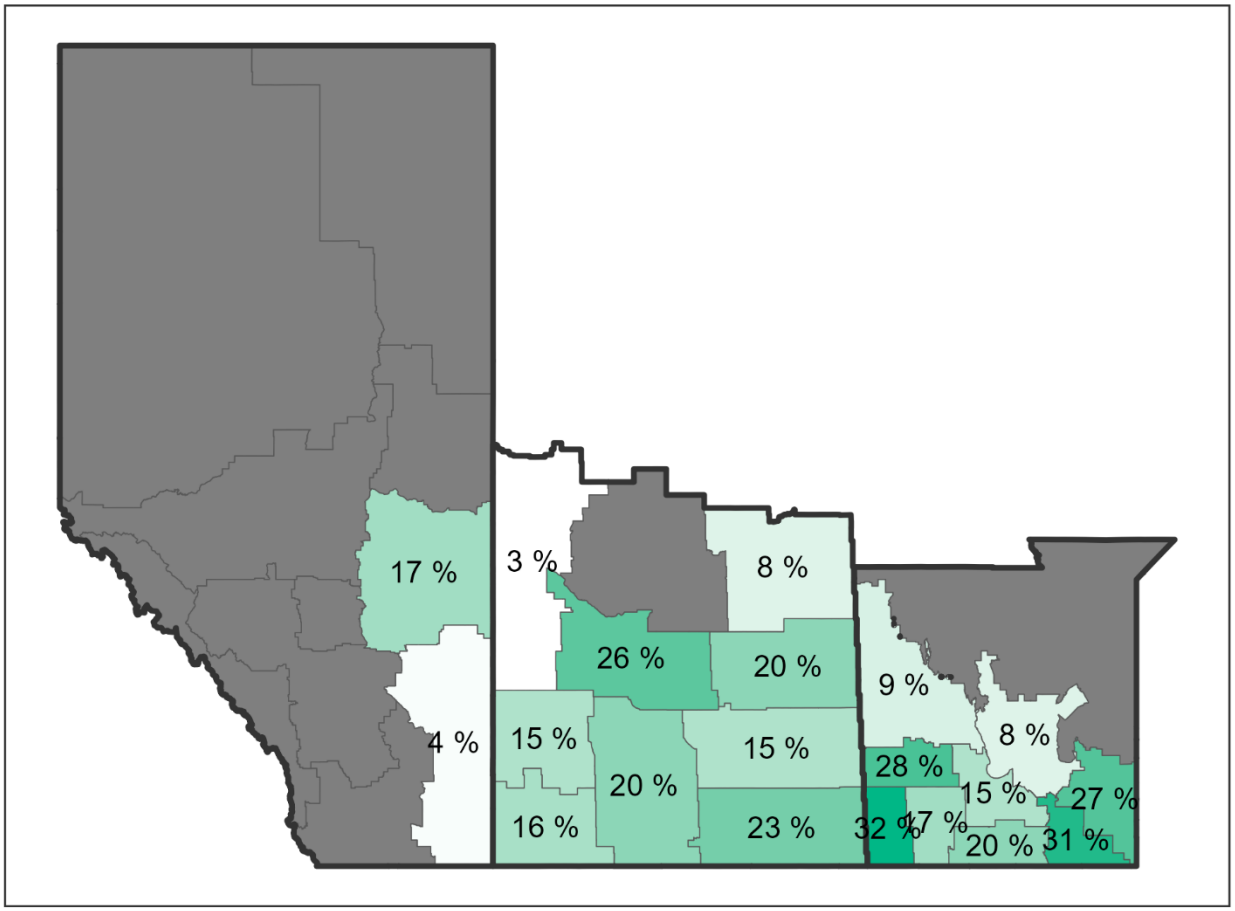
# Saline patches really mess up soil test results

Smart soil samplers purposefully avoid the “white” spots for whole-field composite soil samples to avoid the salinity skew.

**0.4 dS/m**
**28 lb/acre N**
**20 lb/acre S**

**3.8 dS/m**
**441 lb/acre N**
**>60 lb/acre S**
**maybe 5000+ lb/acre S**

# Precision soil samples (grid or zone) with salinity above 1.0 dS/m (1:1) in 2025




Data not shown where n< 50
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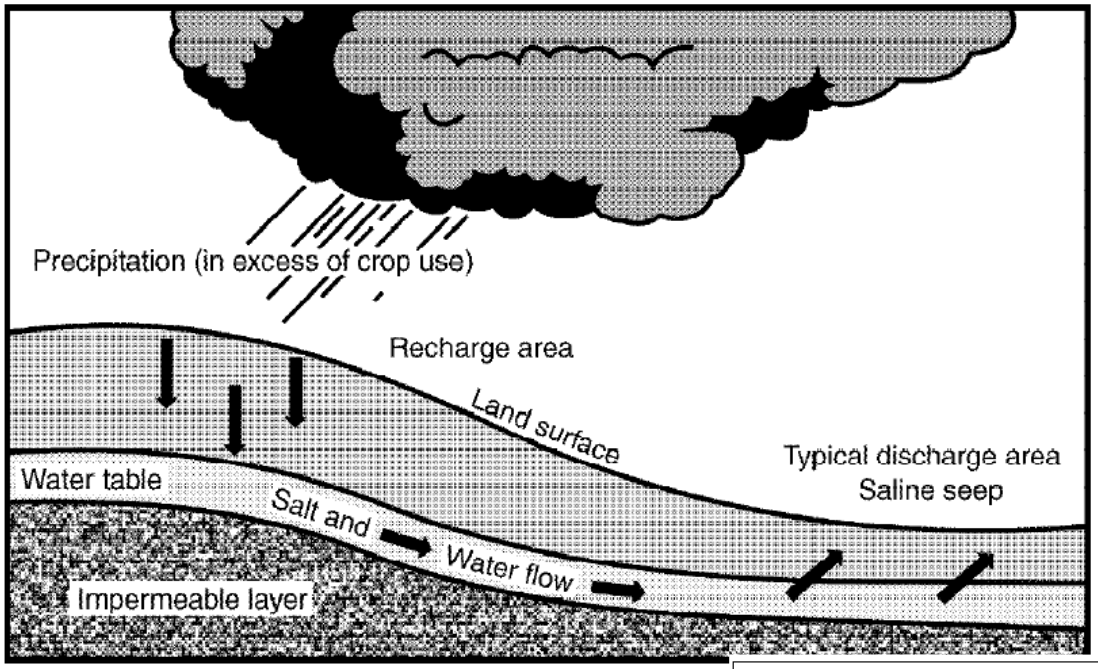
# Where do you find salinity on the landscape?

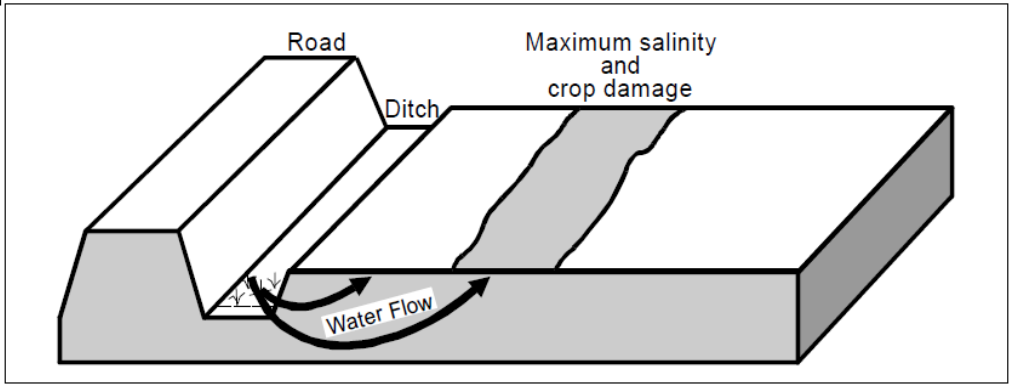



**Saline seep**

**Salinity signs**

- Apparent drought stress
- High soil test nitrate-N and sulfate-S
- High IDC risk for soybean and flax
- Soil surface is white

**Low lying, road ditch, slough**






Seelig, B.D. 2000. Salinity and sodicity in North Dakota Soils. NDSU Ext. Bull. EB-57. North Dakota State Univ., Fargo, ND.

# The Sargent County “duck ponds” June 1990

**A Study in Road Ditch Salinity**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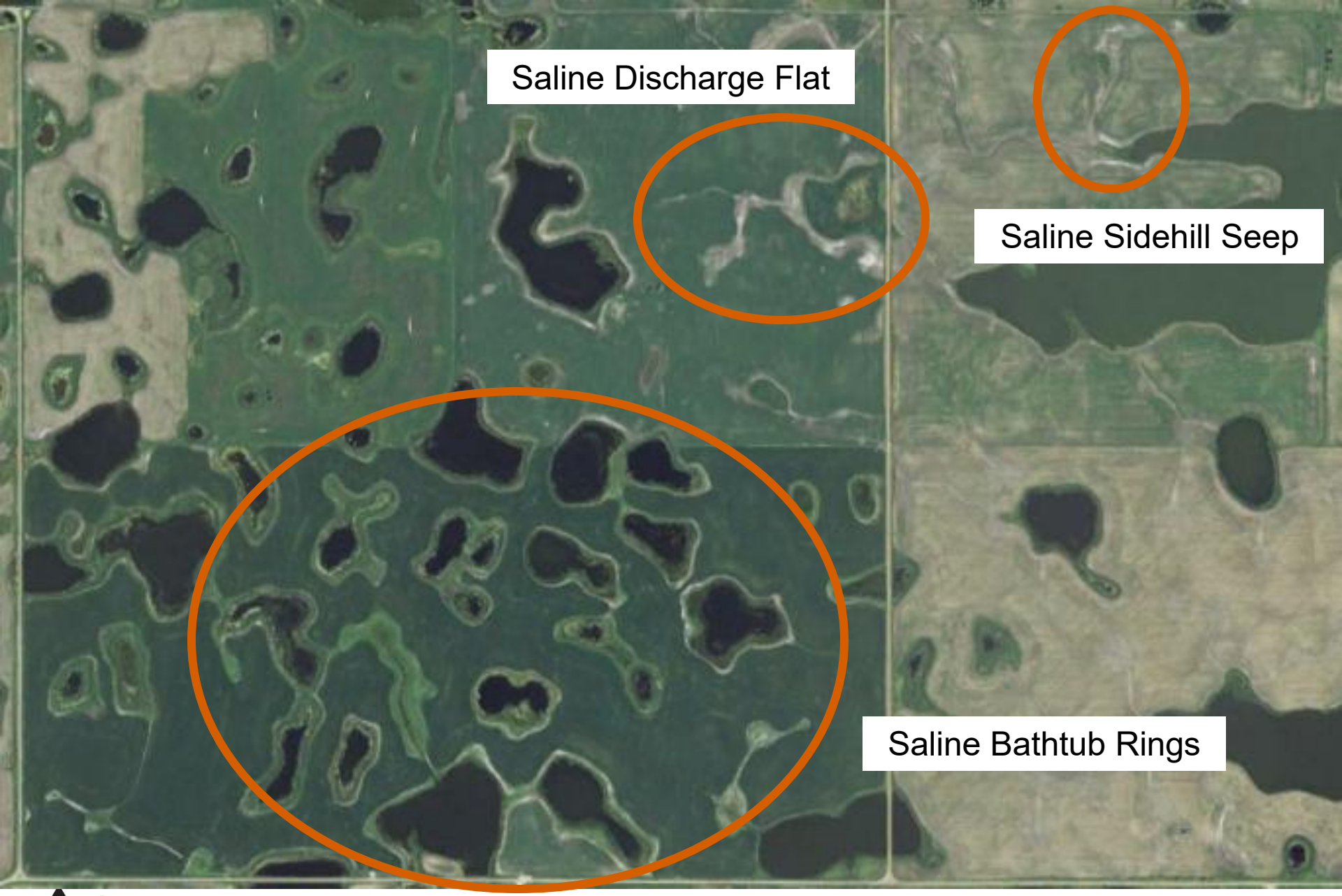
# The Sargent County “duck ponds” August 2009

# The Sargent County “duck ponds” June 2010


Wherever water is allowed to collect and evaporate, the salts will accumulate.

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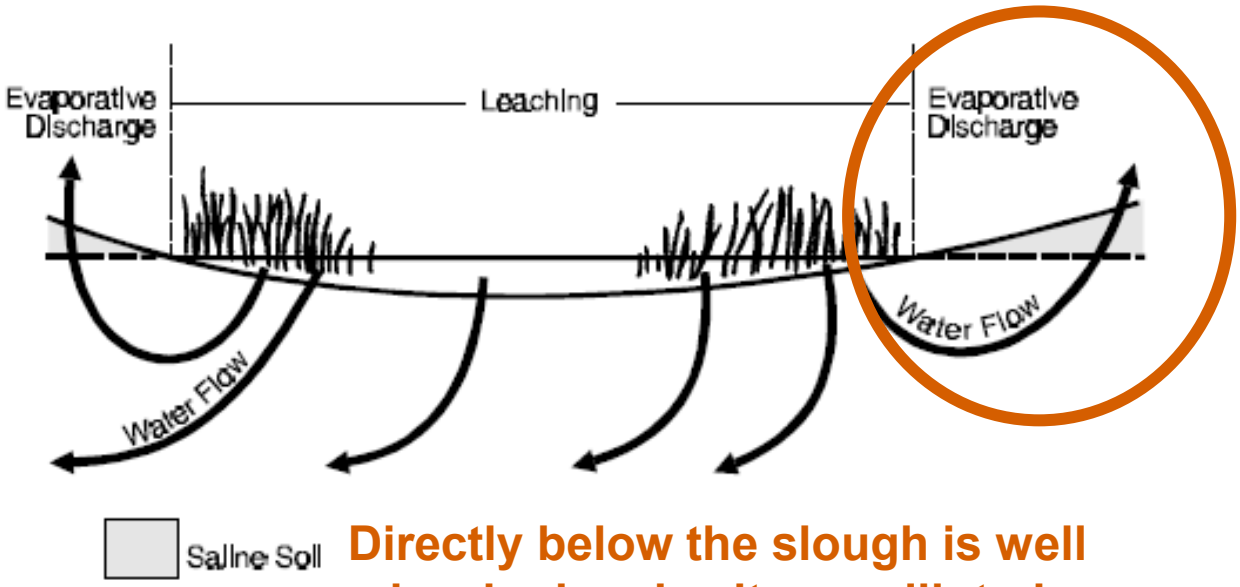
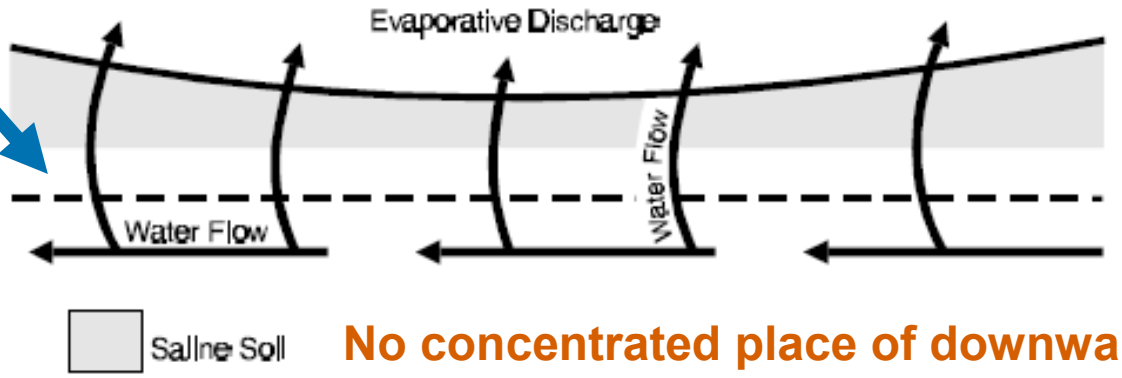
**Slough or permanent wetland with saline "bathtub" rings**




**Directly below the slough is well leached and salts are diluted**

**Where is the water table on the landscape?**

**High water table on "level" landscape or temporal wetland**




**No concentrated place of downward water movement and leaching, all upward evaporation**

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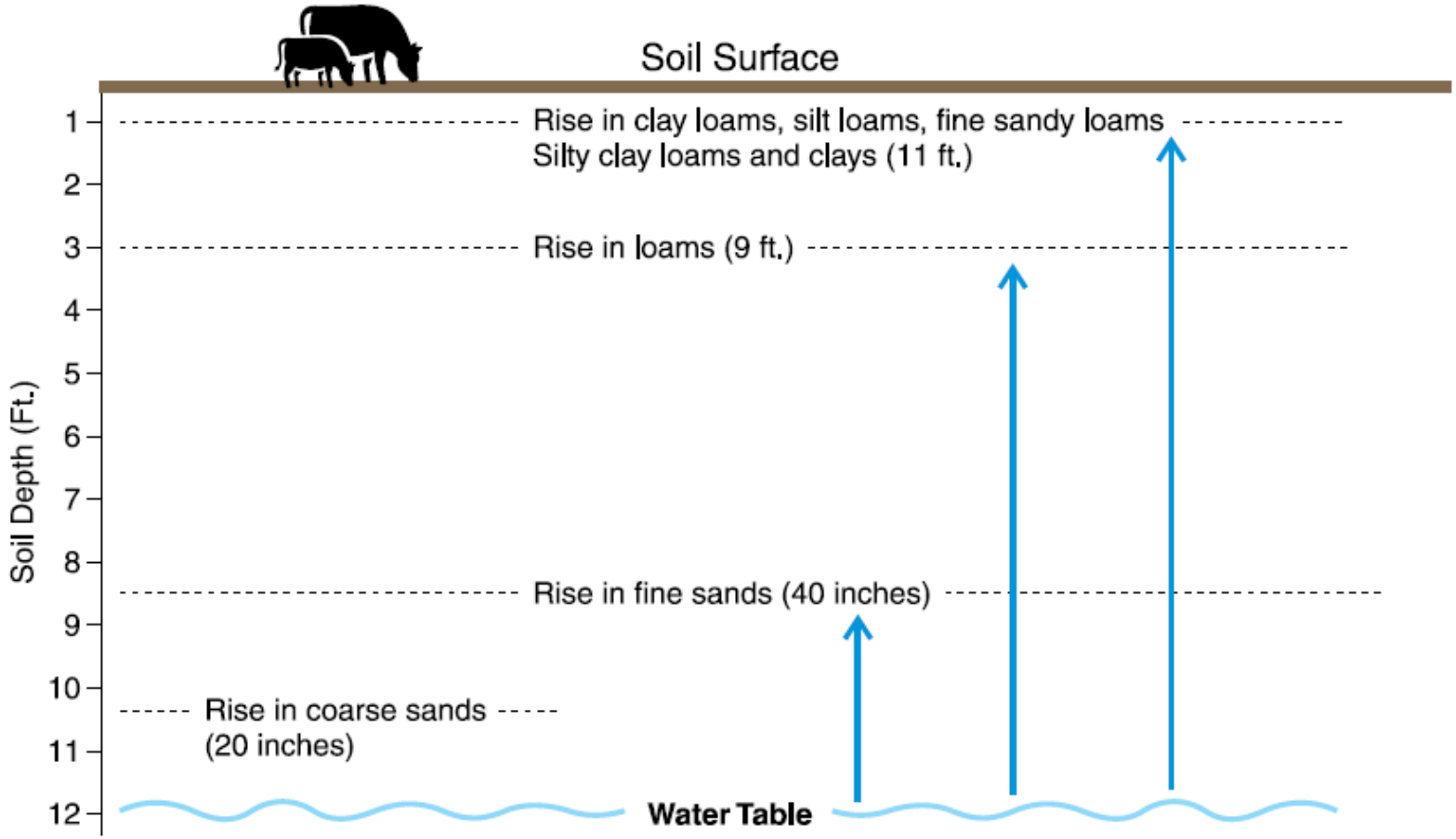
# Soil texture controls capillary rise height from water table (where the salts originate)

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# Salinity management is all about water management

- Subdivide field into saline and non-saline areas
- Select salt-tolerant crops (barley, oat, sugar beet)
- Plant salt-tolerant grasses, cut for hay or graze; better salt tolerance and higher water use
- Install tile drainage
- 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 salt
  - Sodic soils (high sodium) are special cases where amendments like gypusm may be necessary

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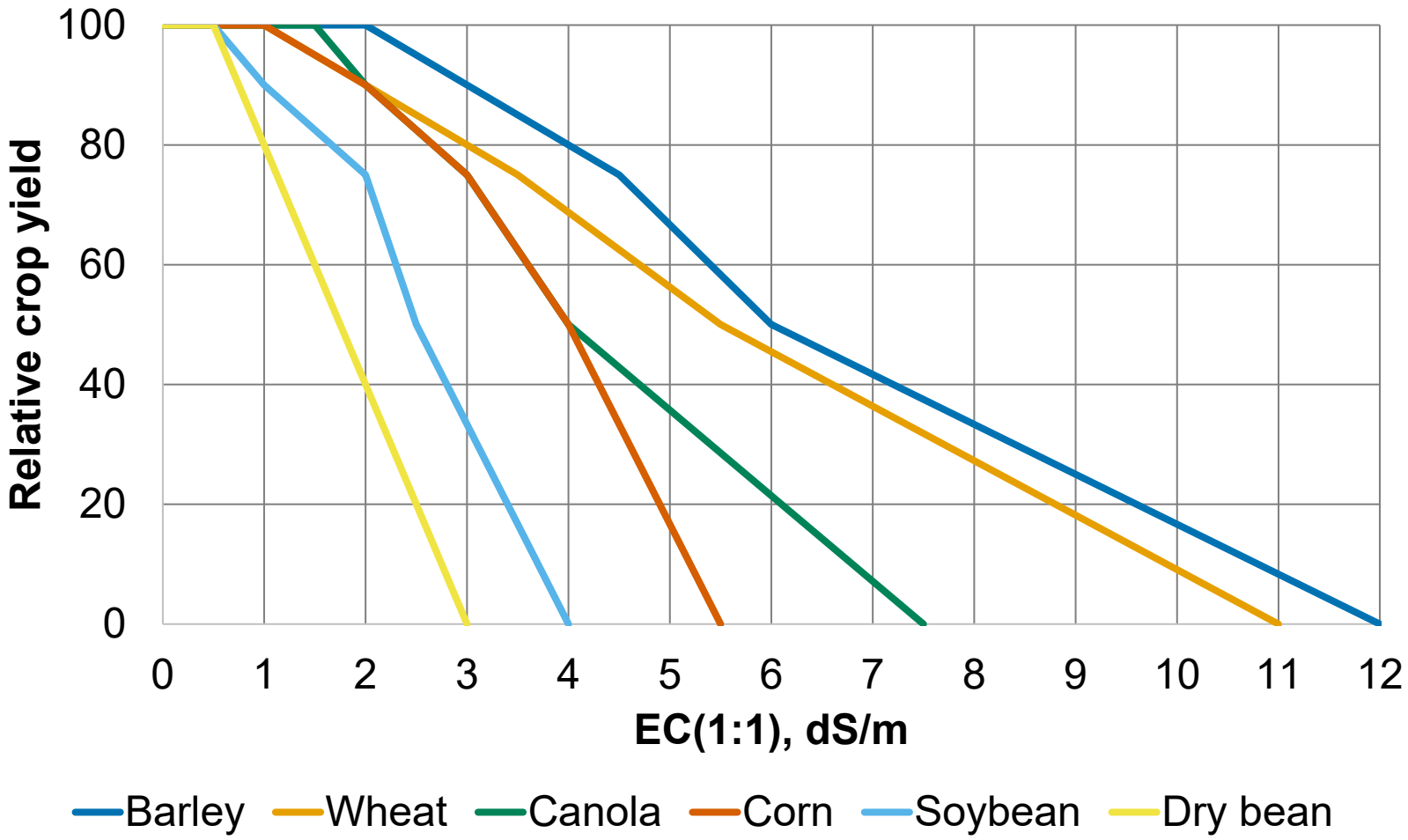
# Salinity tolerance of annual crops

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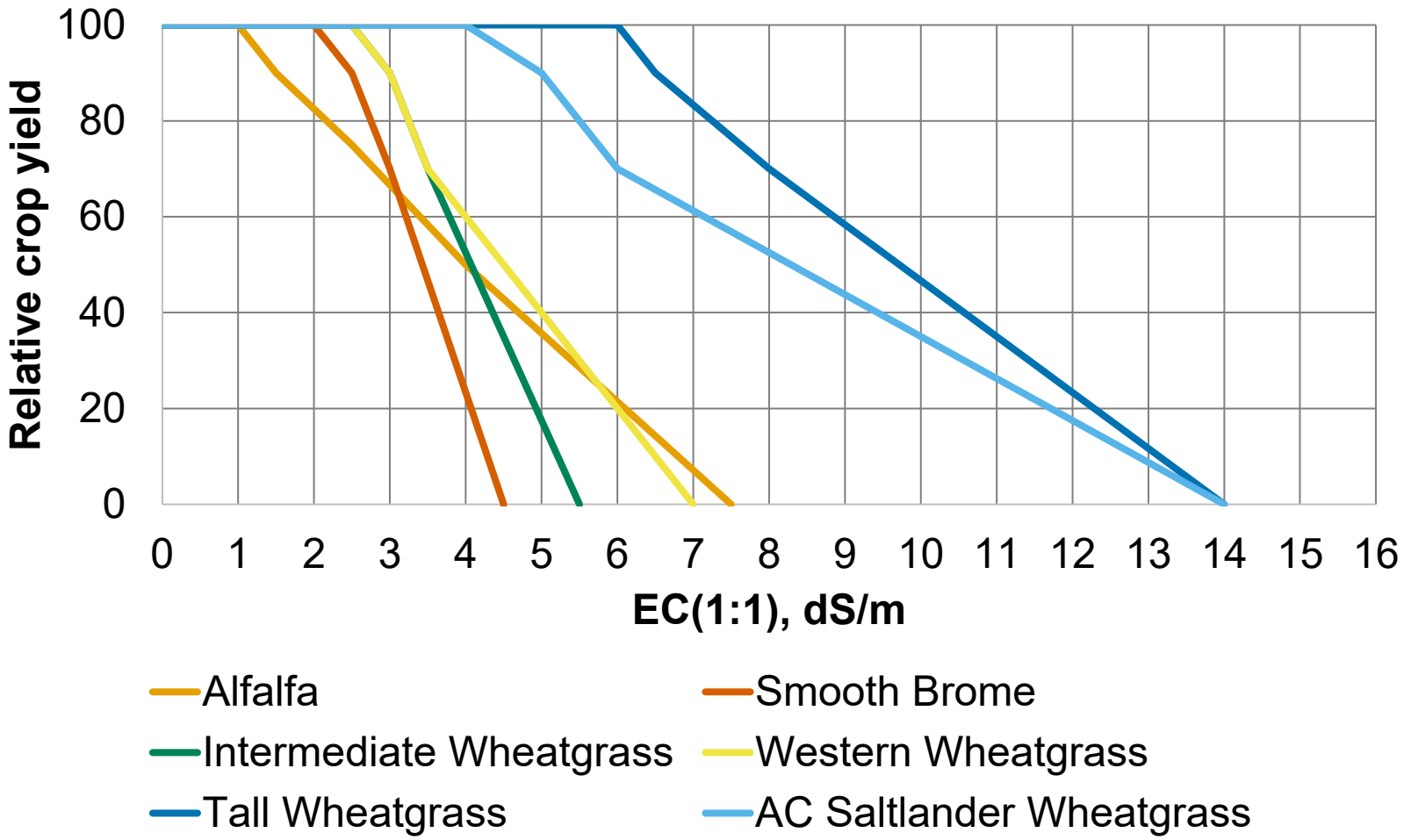
# Salt-tolerant perennial grasses offer better options

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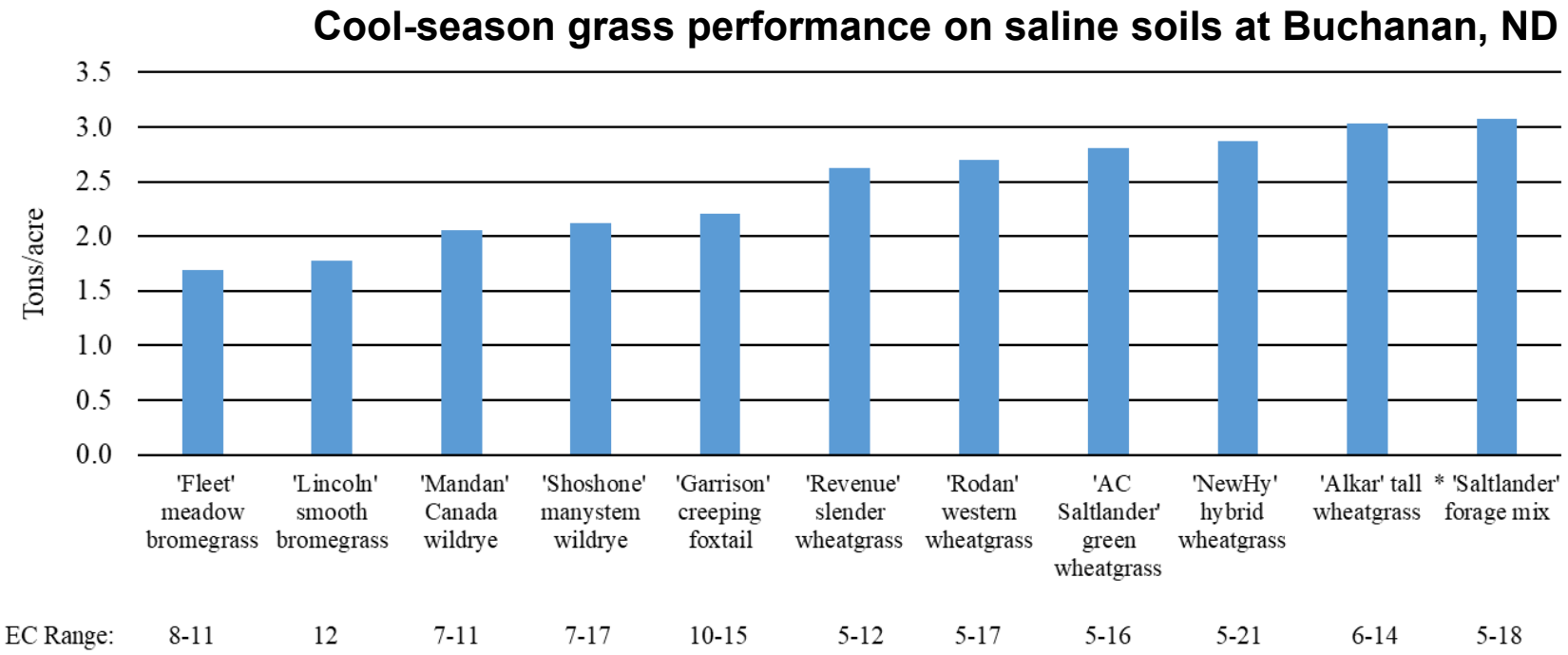
# Forage production of salt-tolerant grasses, 5-year average




**USDA Bismarck Plant Materials Center and NDSU Carrington REC Trials at Buchanan and Carrington, ND**
EC measured as 1:1 soil:water method
* 'Saltlander' forage mix consists of 50% 'AC Saltlander', 25% 'Revenue' slender wheatgrass, 25% 'Courtney' tall fescue.

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Duckwitz, W., W. Markegard, N. Jensen, E. Aberle, and S. Sieler. 2019. Cool-season grass performance on saline soils in the northern Great Plains. USDA-NRCS, Bismarck, ND.

# Forage quality of salt-tolerant grasses

| Cultivar | Salinity Tolerance | Biomass Production | Forage Quality |
|---|---|---|---|
| ‘Saltlander’ forage mix | Medium High | Very Good | Very Good |
| **‘AC Saltlander’ Green Wheatgrass** | **High** | **Very Good** | **Very Good** |
| **‘NewHy’ Hybrid Wheatgrass** | **High** | **Very Good** | **Good** |
| ‘Alkar’ Tall Wheatgrass | High | Very Good | Very Poor |
| ‘Rodan’ Western Wheatgrass | Medium High | Good | Good |
| ‘Revenue’ Slender Wheatgrass | Medium | Good | Good |
| **‘Lincoln’ Smooth Brome** | **Slight** | **Fair** | **Very Good** |
| ‘Fleet’ Meadow Brome | Slight | Fair | Good |

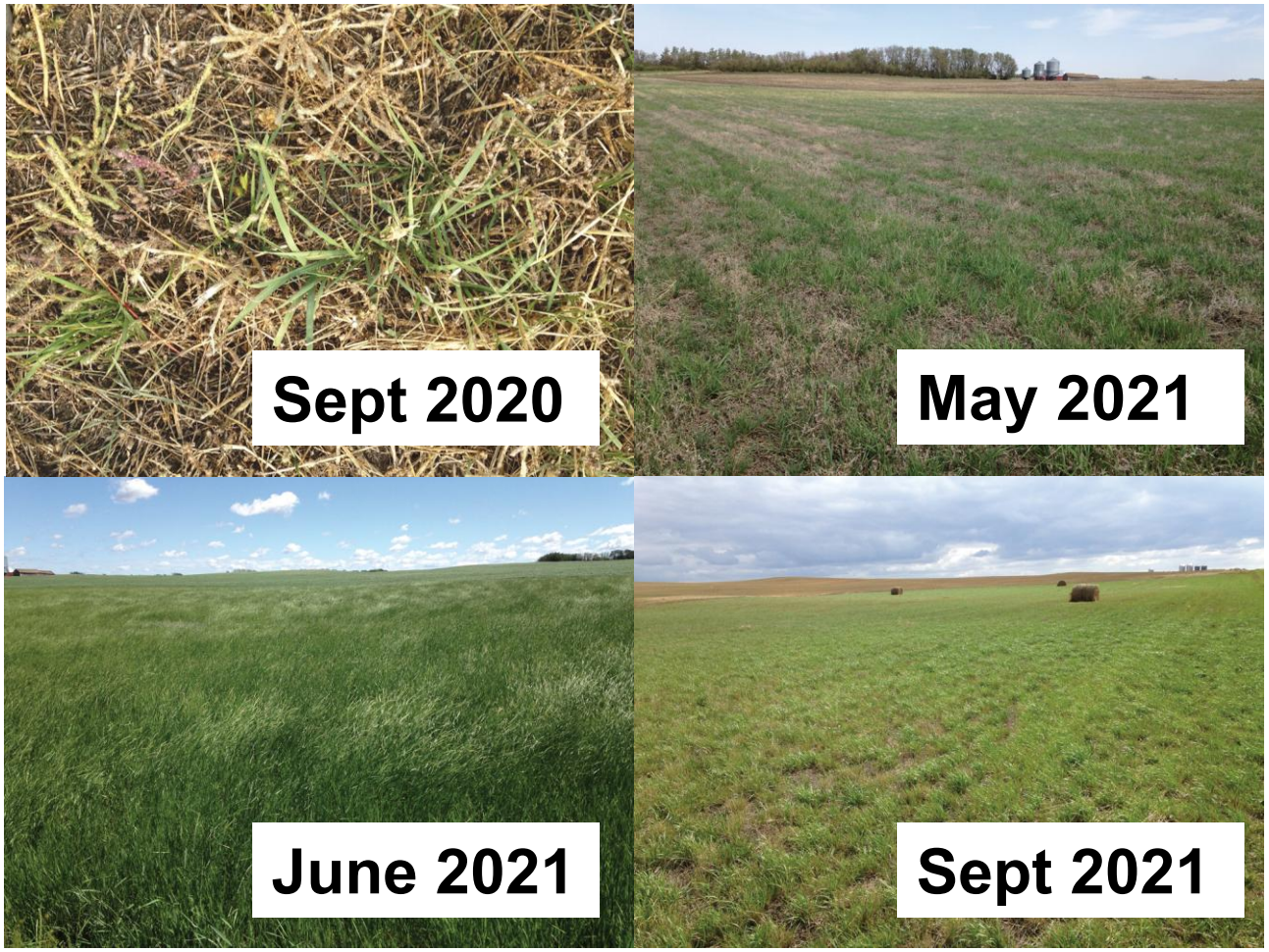
* ‘Saltlander’ forage mix consists of 50% ‘AC Saltlander’, 25% ‘Revenue’ slender wheatgrass, 25% ‘Courtney’ tall fescue.

AGVISE LABORATORIES

Duckwitz, W., W. Markegard, N. Jensen, E. Aberle, and S. Sieler. 2019. Cool-season grass performance on saline soils in the northern Great Plains. USDA-NRCS, Bismarck, ND.

# AC Saltlander grown on Les Henry's farm near Dundurn, SK

Seeded in May 2020



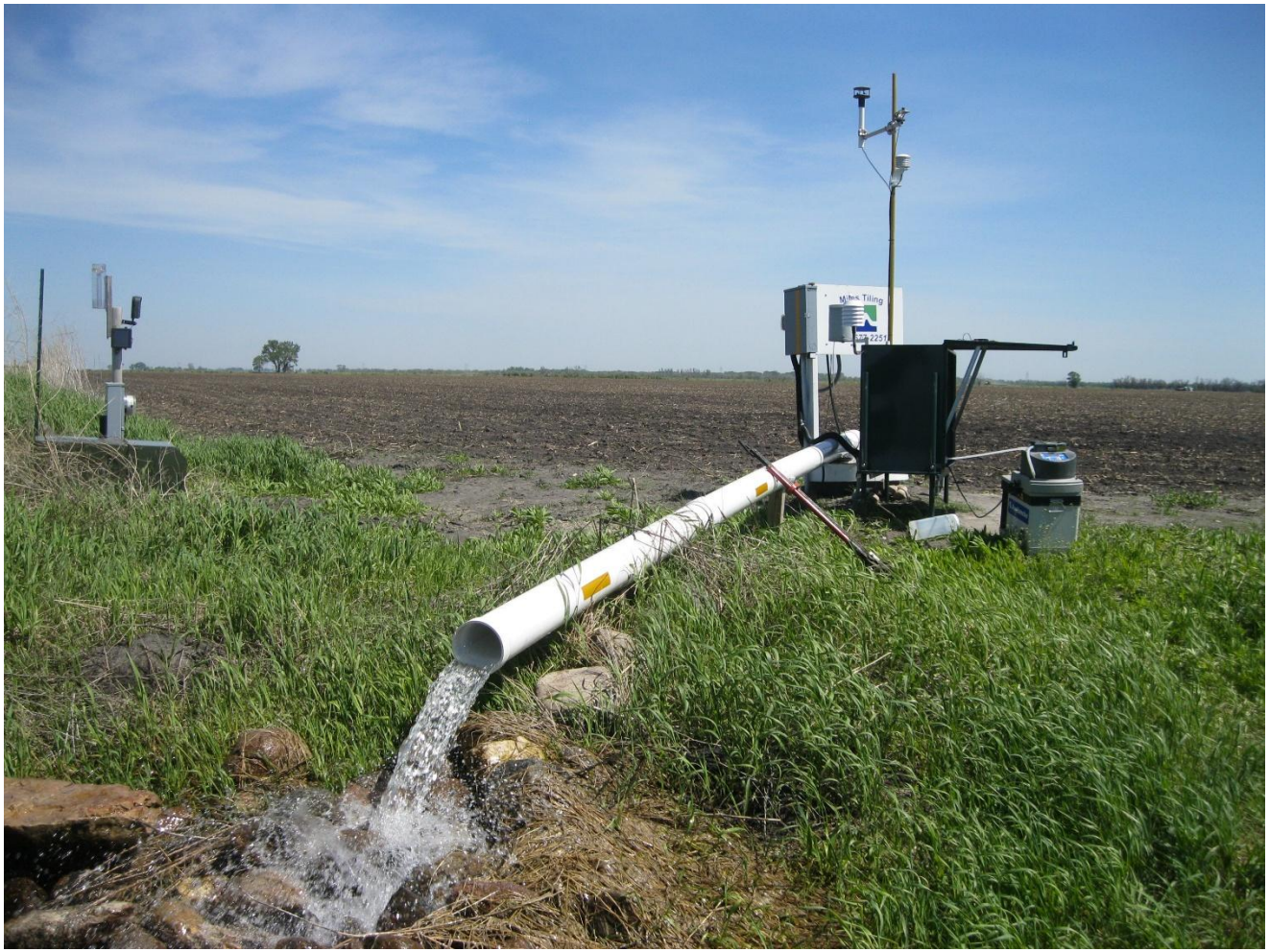

Henry, L. 2022. Saltlander grass for salty ground. GrainNews 22 Apr. 2022. Available at https://www.grainews.ca/columns/les-henry-saltlander-grass-for-salty-ground/ (accessed 13 Feb. 2026).

# Hay, I am walking here! Let's walk through some numbers

- 2.7 tonne per acre grass hay
- $120 to 210 CAD per tonne grass hay in 2025
- $324 to 567 CAD per acre gross revenue
- Find a neighbor haying equipment and strike a deal

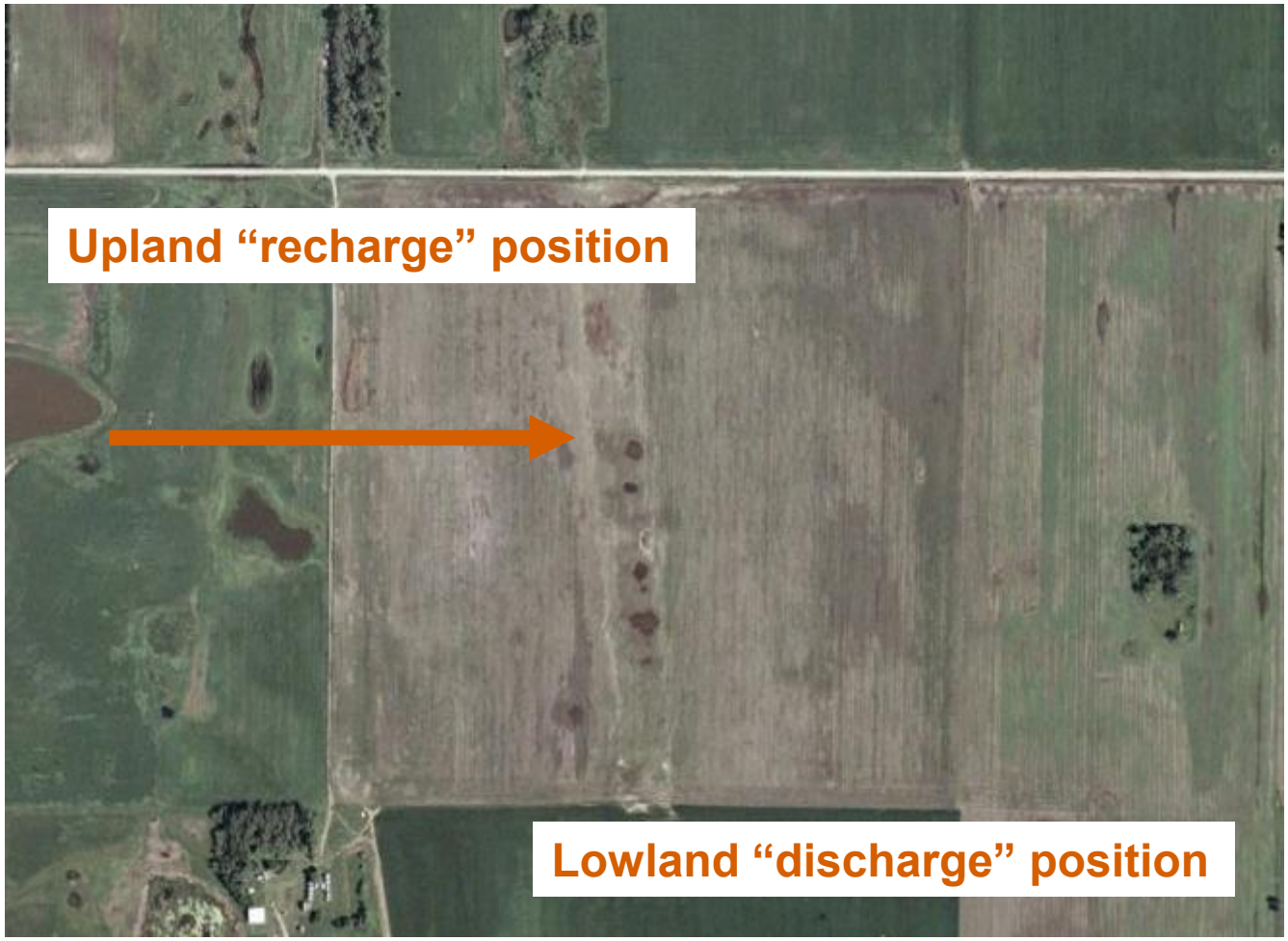

Prices from Saskatchewan Forage Council Fall 2025 Forage Market Pricing Discovery (September 2025). Available at https://static1.squarespace.com/static/5ea33346bc51e476ad5b82a0/t/691bc16ef4fa5332c063c18d/1763426670887/Fall+2025+FINAL+Nov+17.pdf (accessed 13 Feb. 2026).

# How about tile drainage? An engineering solution to managing water



Radatz, T. 2018. Tile flow and nutrient movement in Northwest Minnesota. Ag Water Exchange 13 Sept. 2018. https://agwaterexchange.com/2018/09/13/tile-flow-and-nutrient-movement-in-northwest-minnesota/ (accessed 18 Mar. 2019)

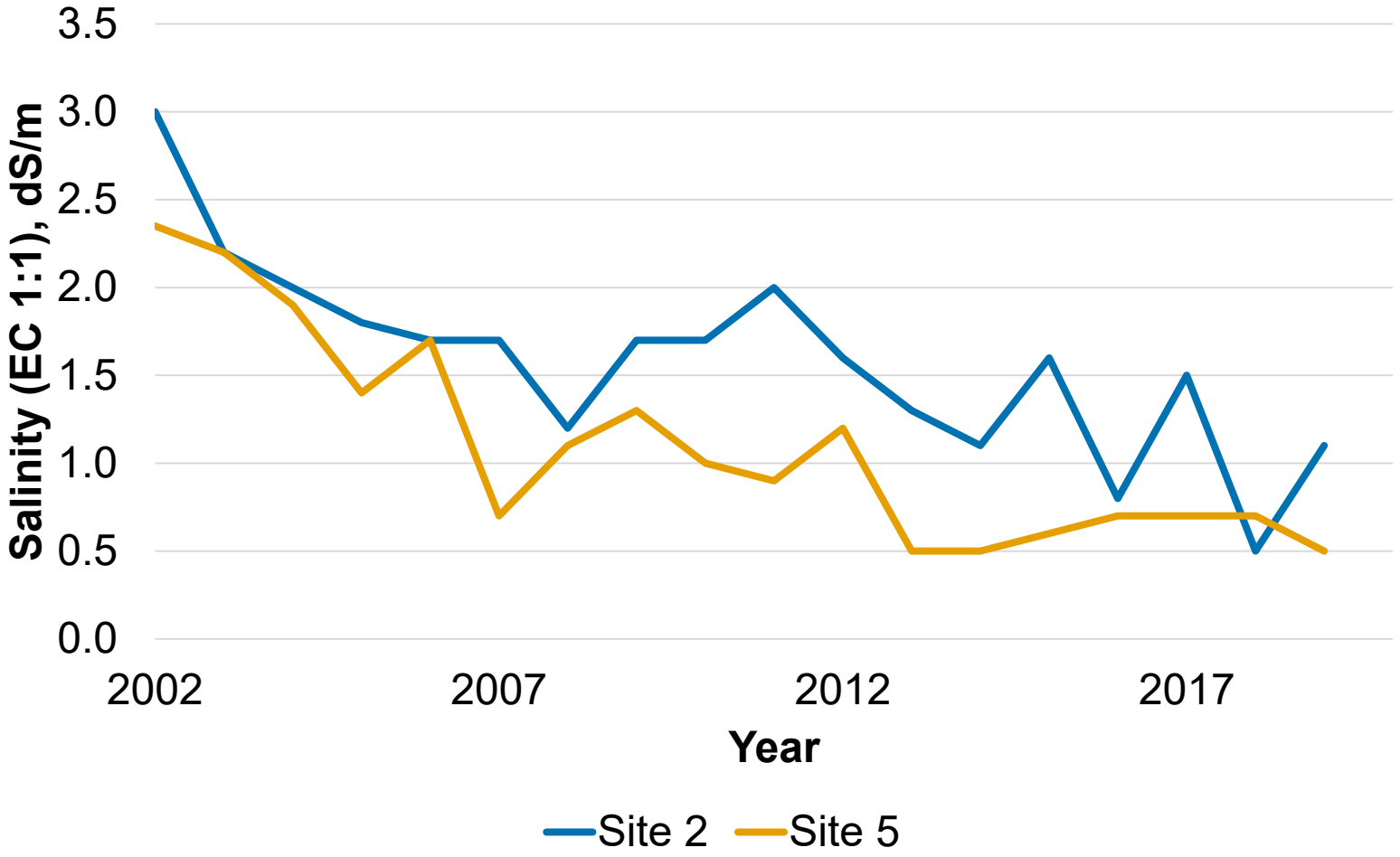
# AGVISE Tile Drainage Project Started 2002 at Northwood, ND



# AGVISE Tile Drainage Project Started 2002 at Northwood, ND

Installed 2002
Coarse-textured soils
(sandy loam to loam)
pH 7.9-8.2

# Tile drainage can reduce salinity over time

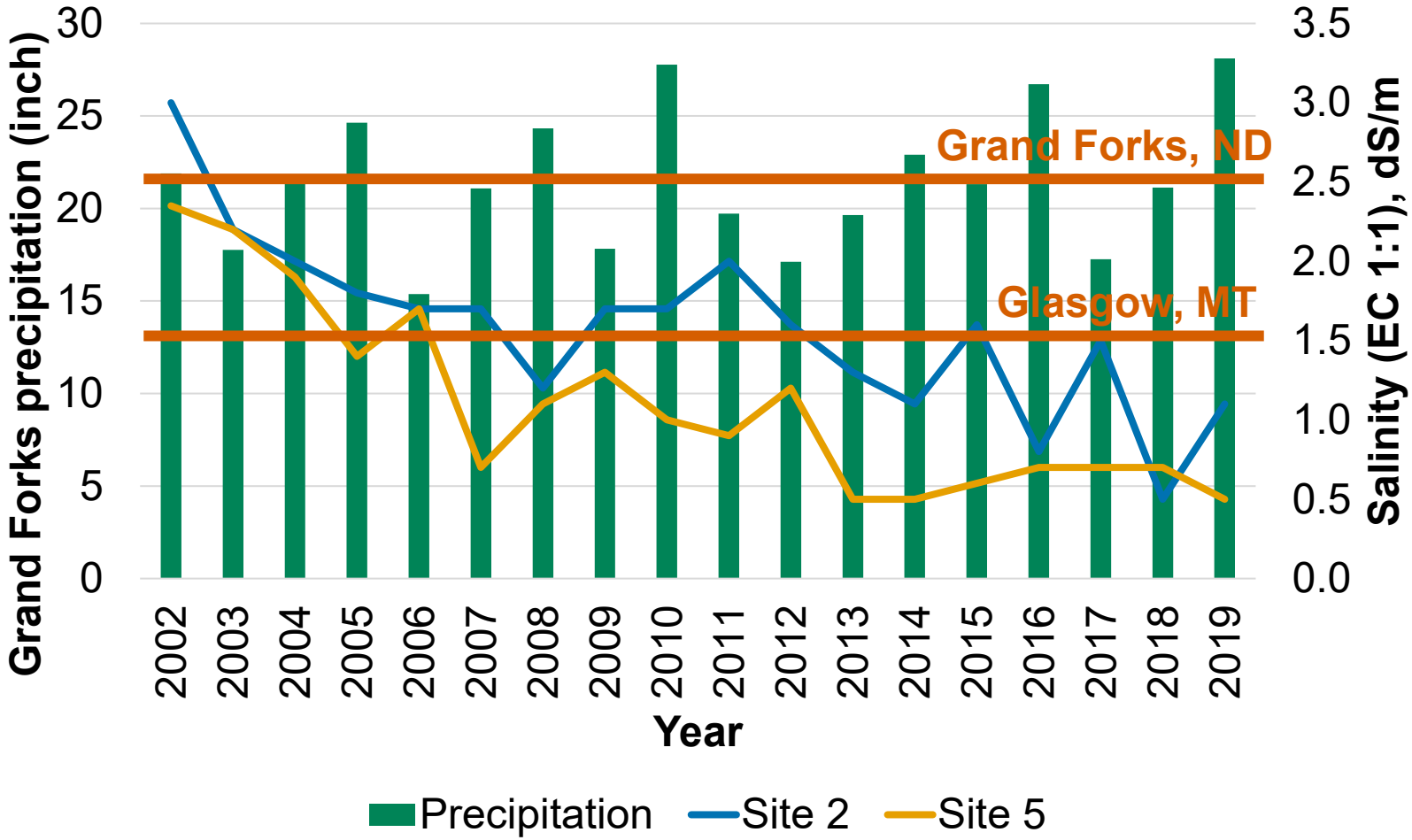


# AGVISE Tile Drainage Project Started 2002 at Northwood, ND

**Soybean 2007**

**Corn 2008**

# Tile *drainage* requires *excess* water



# How far can you drain excess water?

**Scenario**

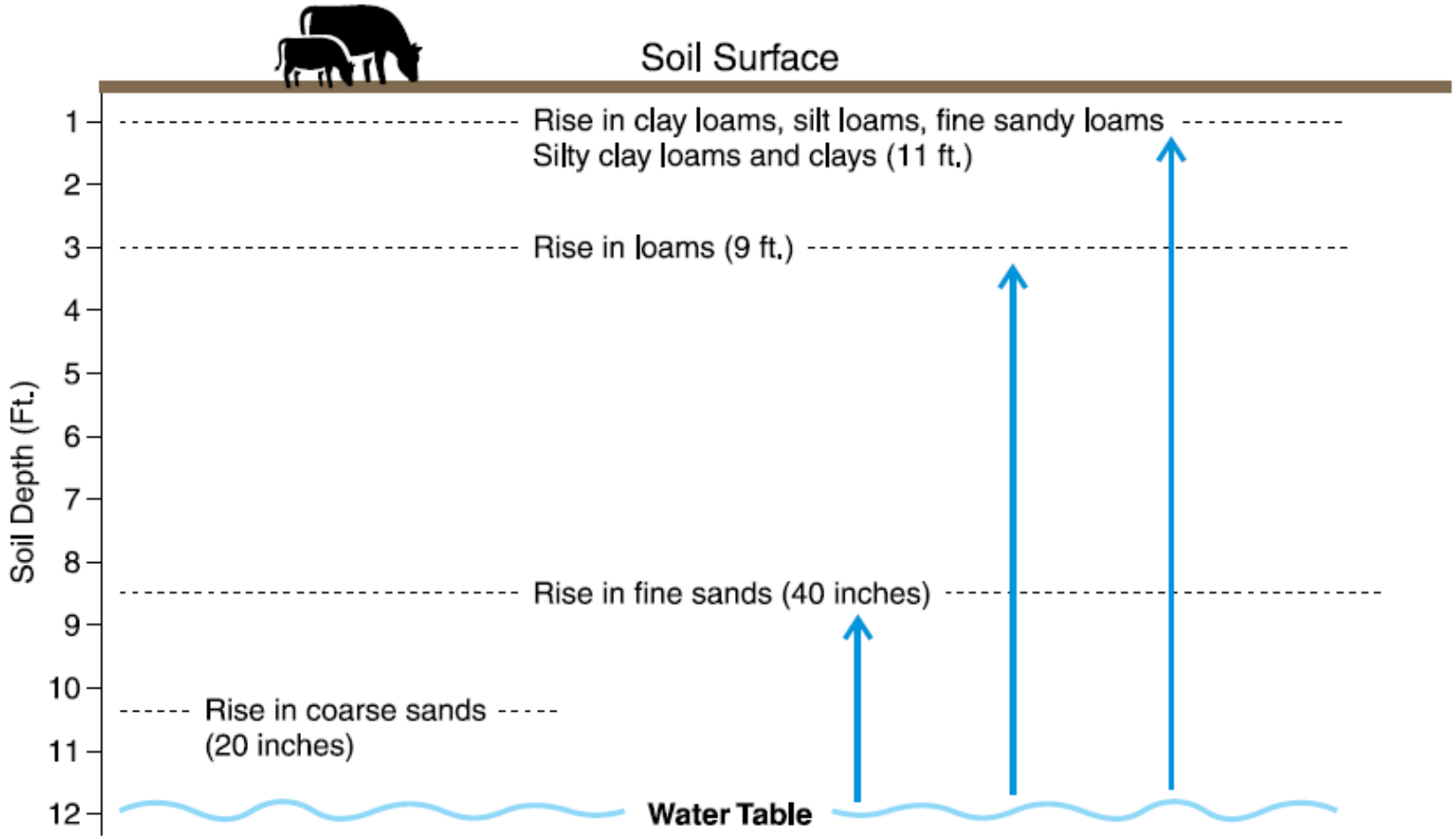
- Initial soil water content: 50% available water capacity
- Precipitation: 22 inches
- Crop water use: 18 inches for corn at 175 bu/acre
- Excess water: 4 inches available for leaching (or lost to runoff/evaporation)

| Soil texture | Drainable porosity (%) | Depth of drainable water (ft) |
|---|---|---|
| Sand | 23 | 8.3 |
| Sandy loam | 22 | 5.6 |
| Loam | 16 | 3.9 |
| Clay loam | 13 | 3.7 |
| Silty clay | 11 | 3.3 |
| Clay | 9 | 2.9 |

Tile at 3-4 ft?

Schwab, G.O., D.D. Fangmeier, and W.J. Elliot. 1996. Soil and water management systems. 4th ed. John Wiley & Sons, Inc.

# At what soil depth do you install tile drainage to lower the water table?

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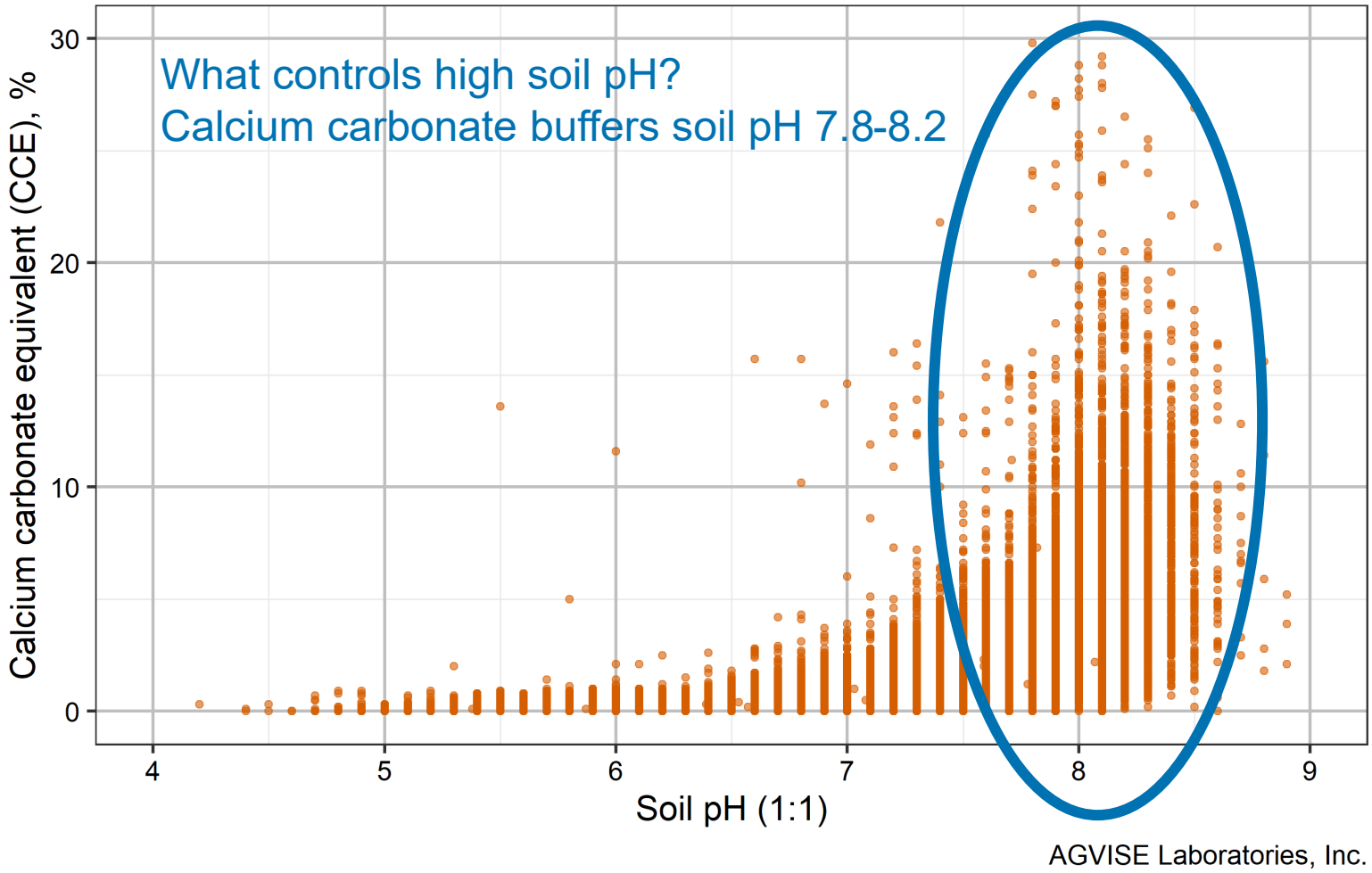
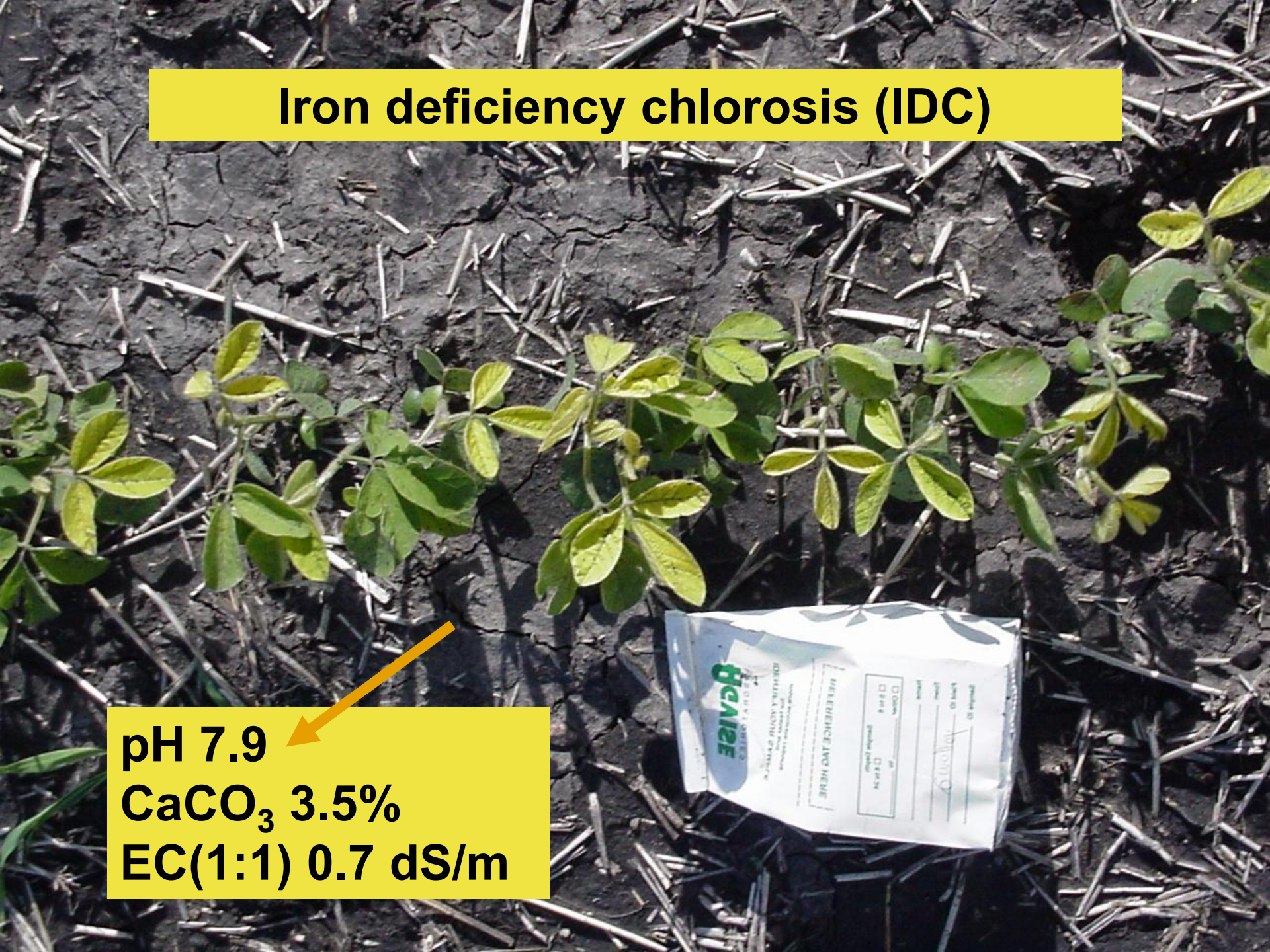
# Benefits of tile drainage beyond salinity

- Lower water table
  - Less saturation and potential denitrification (GHG, $N_2O$ emissions)
- Earlier planting date (more plant water use)
- Better trafficability (less compaction)
  - Planting, spraying, harvesting

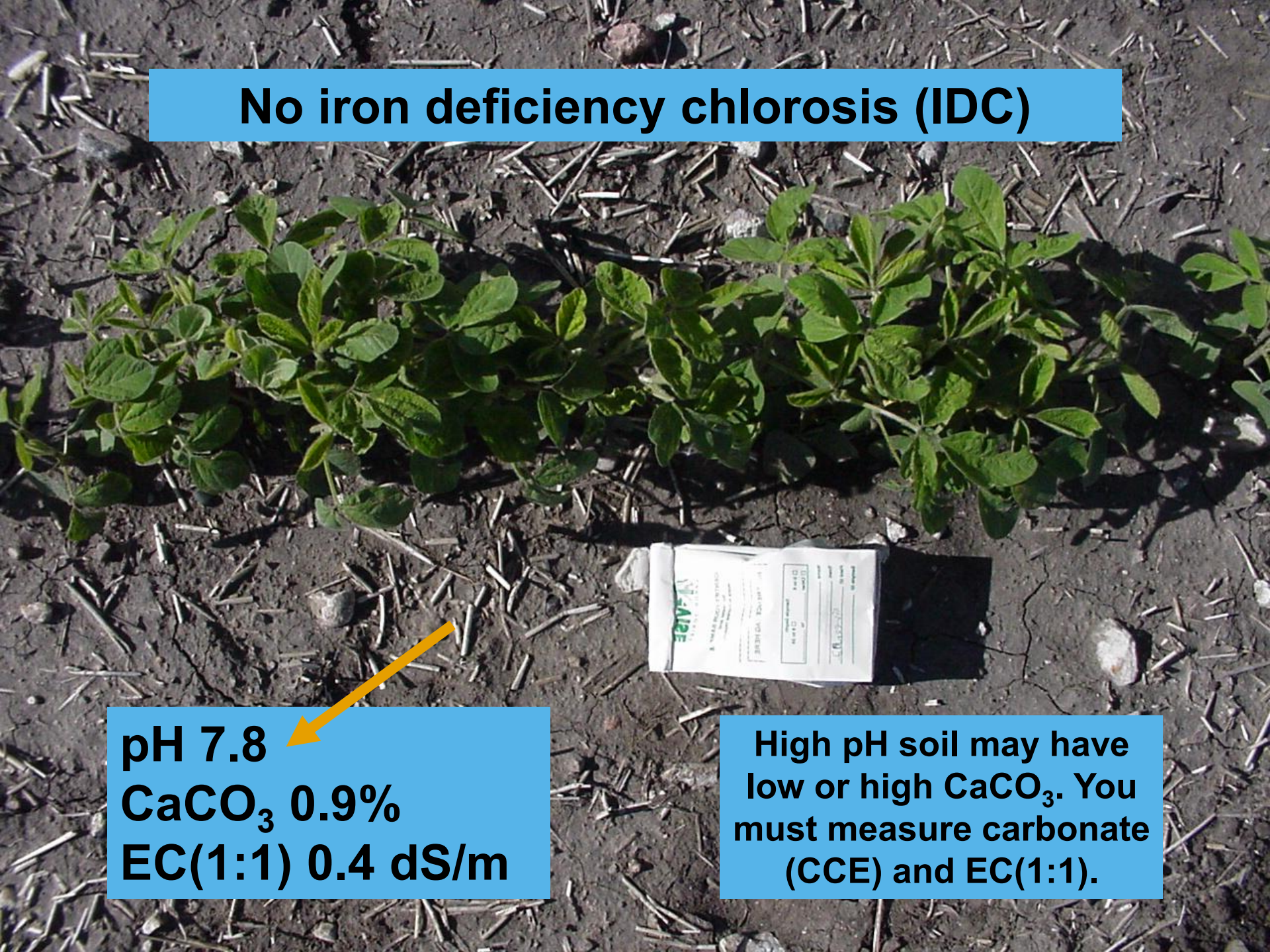
# Does tile drainage lower soil pH?



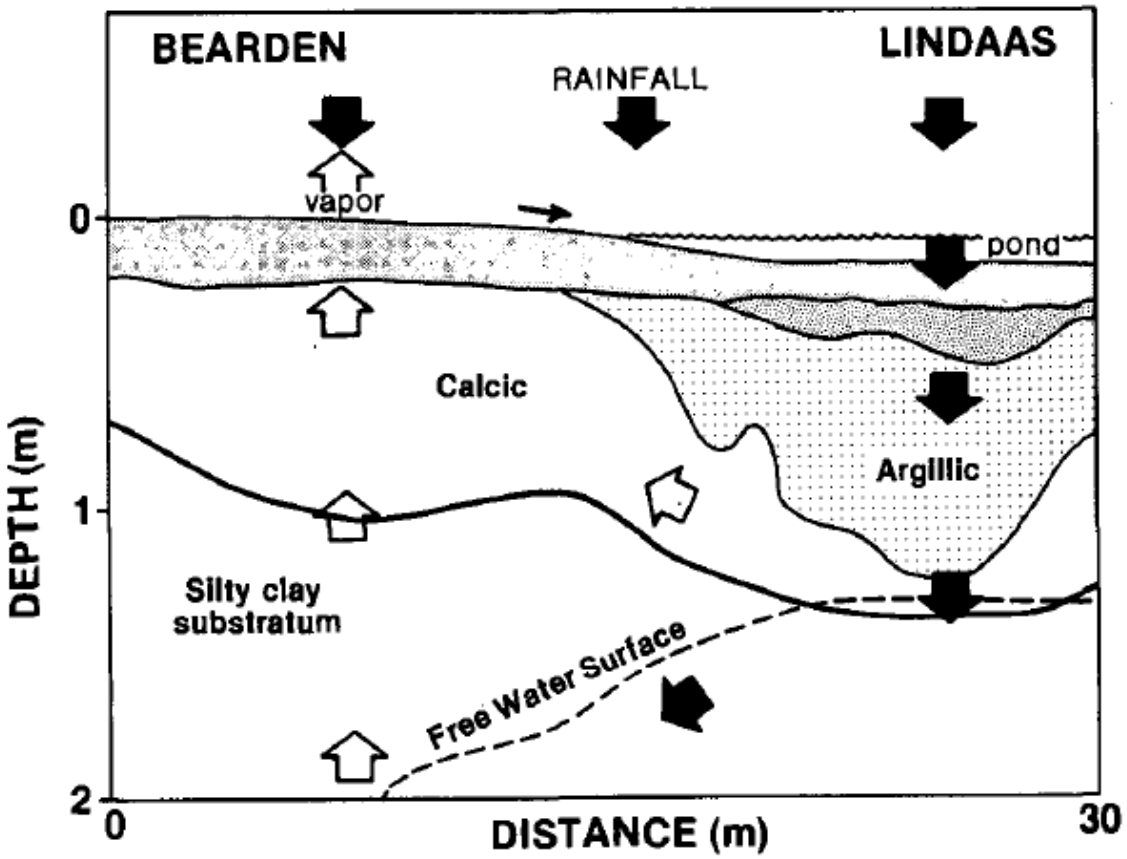
# Iron deficiency chlorosis (IDC)



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).

# Will tile drainage help remove carbonate?



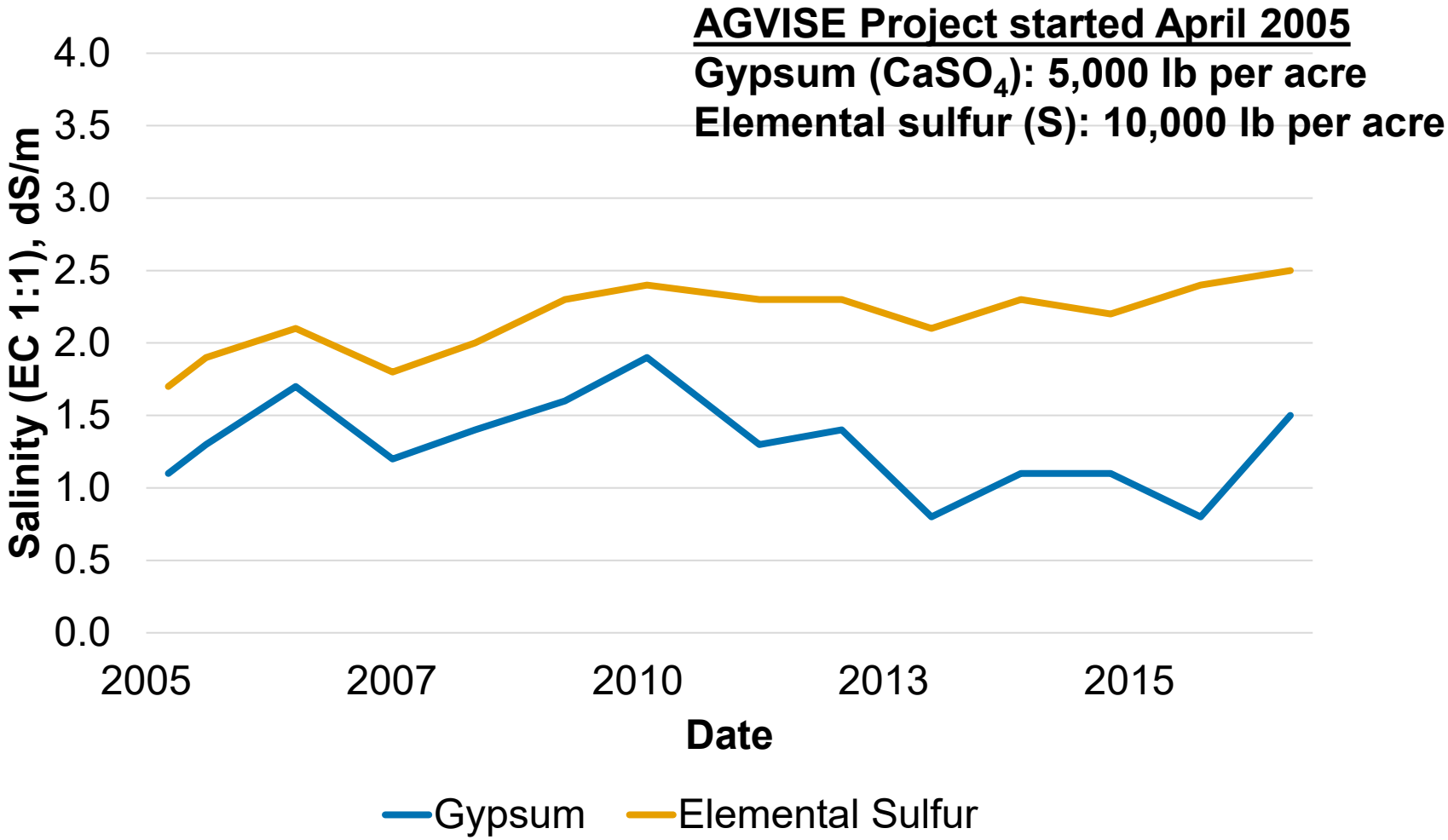

Calcium carbonate (lime) has very low solubility

| | | |
|---|---|---|
| $CaCO_3$ | 0.01 | g/L |
| $CaSO_4$ | 2 | g/L |
| $CaCl_2$ | 427 | g/L |

Bk horizons (10-30% CCE) required 5,000 years of water movement and carbonate accumulation

Knuteson, J.A., J.L. Richardson, D.D. Patterson, and L. Prunty. 1989. Pedogenic carbonates in a Calciaquoll associated with a recharge wetland. Soil Sci. Soc. Am. J. 53(2):495–499.

# Can amendments like gypsum or elemental sulfur remove salts?



# Salinity management is all about water management

- Subdivide field into saline and non-saline areas
- Select salt-tolerant crops (barley, oat, sugar beet)
- Plant salt-tolerant grasses, cut for hay or graze; better salt tolerance and higher water use
- Install tile drainage
- 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 salt
  - Sodic soils (high sodium) are special cases where amendments like gypsum may be necessary

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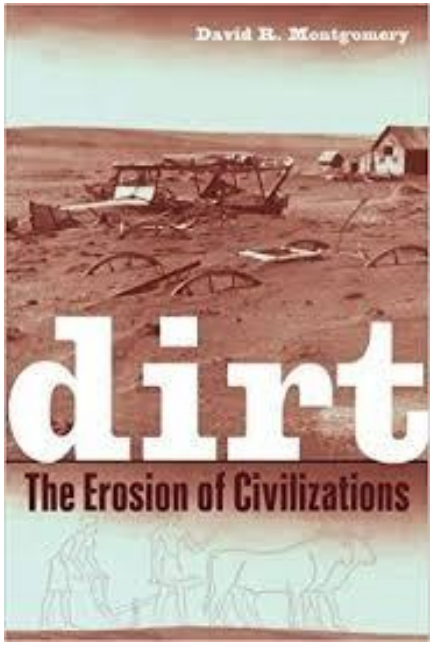


If you want to learn more about humankind's long struggle with soil erosion…

# 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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