Tackling Salinity for Productive Soil Management

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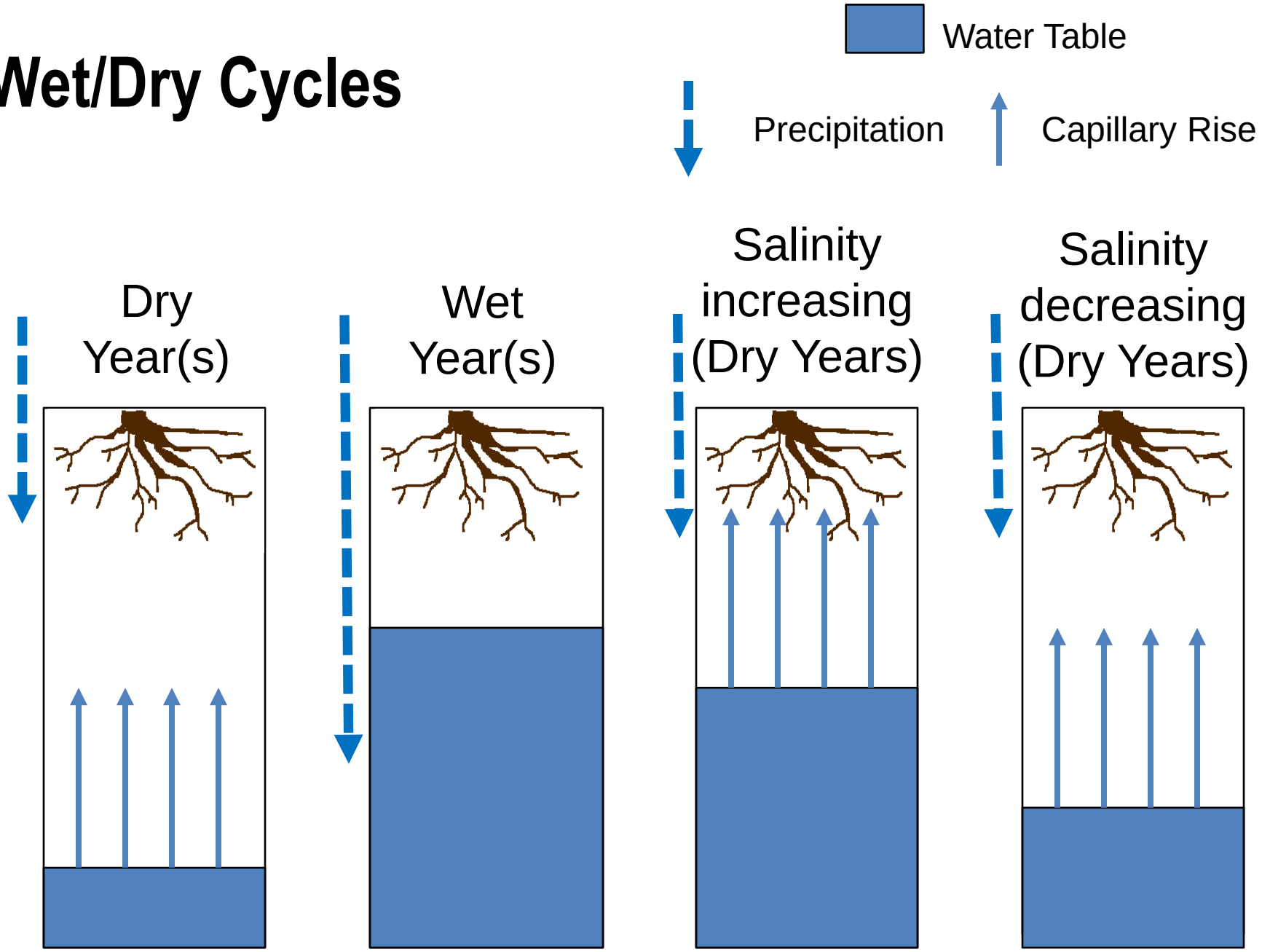
Manitoba

It’s not a salt problem…

It’s a WATER problem!!!

Wet/Dry Cycles



Conditions required to create a soil salinity problem:

1. High water tables to carry soluble salts into root zone by capillary action (<6 ft from surface)

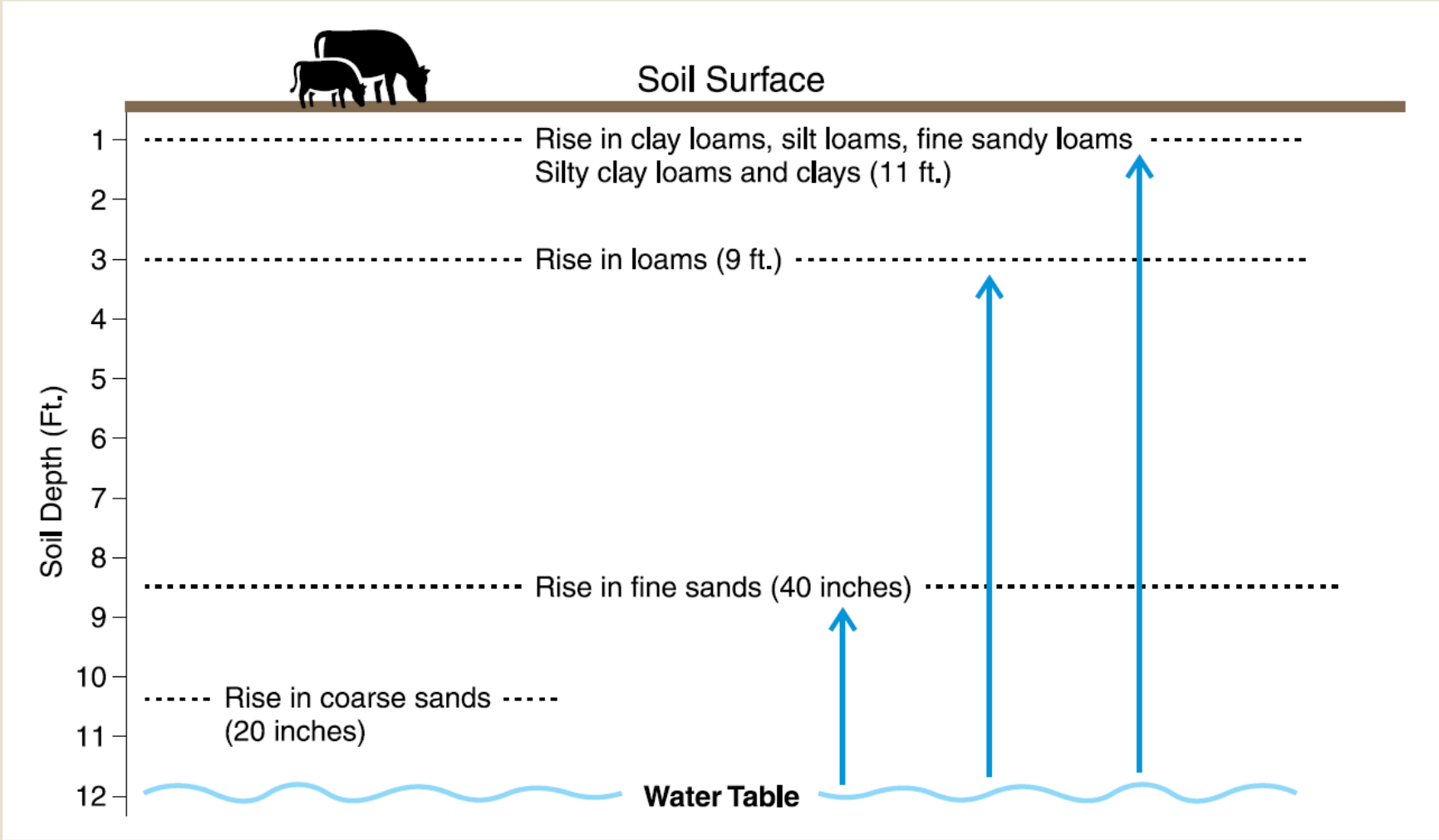


Figure 1. Capillary rise of water from the water table in a silt loam, compared with a sand.

Conditions required to create a soil salinity problem:

1. High water tables to carry soluble salts into root zone by capillary action (<6 ft from surface)
2. Evaporation that exceeds infiltration for significant periods of time
3. Plants susceptible to soil salinity (pulses, vegetables, oilseeds)

Diagnosing the severity:

- **Electrical Conductivity (EC)** – a measure of soluble salts within the soil
  - As the concentration of soluble salts increases, the EC of the soil extract increases
  - EC is expressed in dS/m, mS/cm, or mmho/cm (all equal)
- Soil Sample at 0-6” and 6-24” depths

Diagnosing the Severity

- Can also be mapped using an EM38 or Veris
  - Calibration is critical, so soil sampling will be required

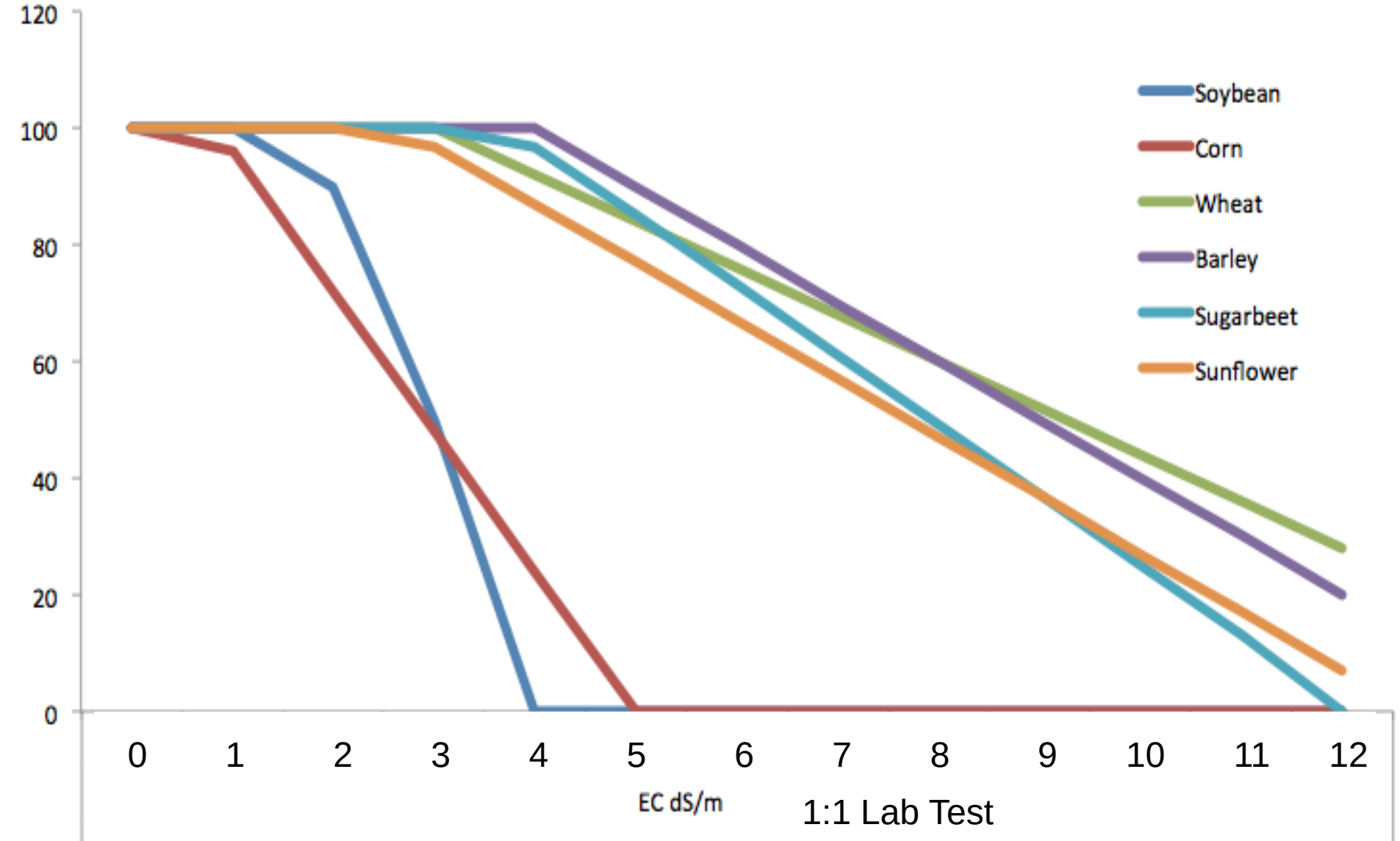
Salinity Analysis in the Lab

- Research or Soil Survey Lab uses the *saturated paste method*
- Commercial Soil Testing Lab uses a *1:1 soil:water ratio* for determining EC
  - Result of the 1:1 method is approximately one-half that of the saturated paste method
  - Multiply the result of the 1:1 method by 2 to approximate EC values from saturated paste

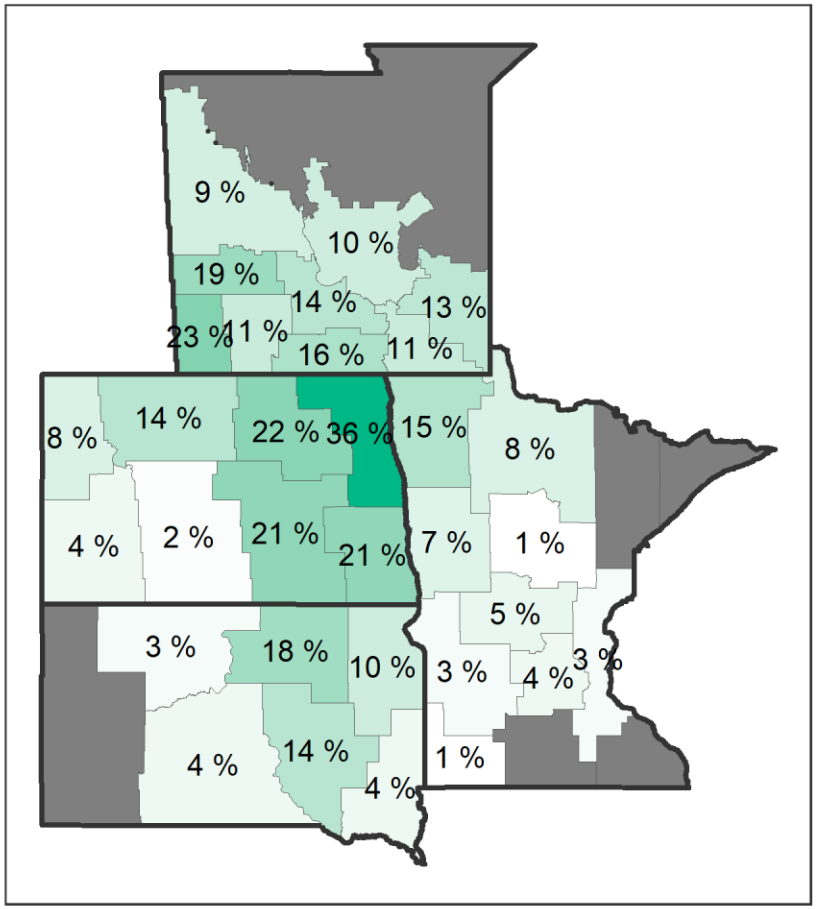
Soil Salinity Ratings

EC Saturation Extract (mS/cm)	Rating	Crop Effects
0-2	None Saline	None
2-4	Slightly Saline	Sensitive crops affected
4-8	Moderately Saline	Most crops affected
8-16	Severely Saline	Only tolerant plants survive
>16	Very Severely Saline	Few plants survive

Salinity Effects on Crops



Soil samples with salinity above 1.0 dS/m (1:1) in 2024



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

Salts occur naturally in soil

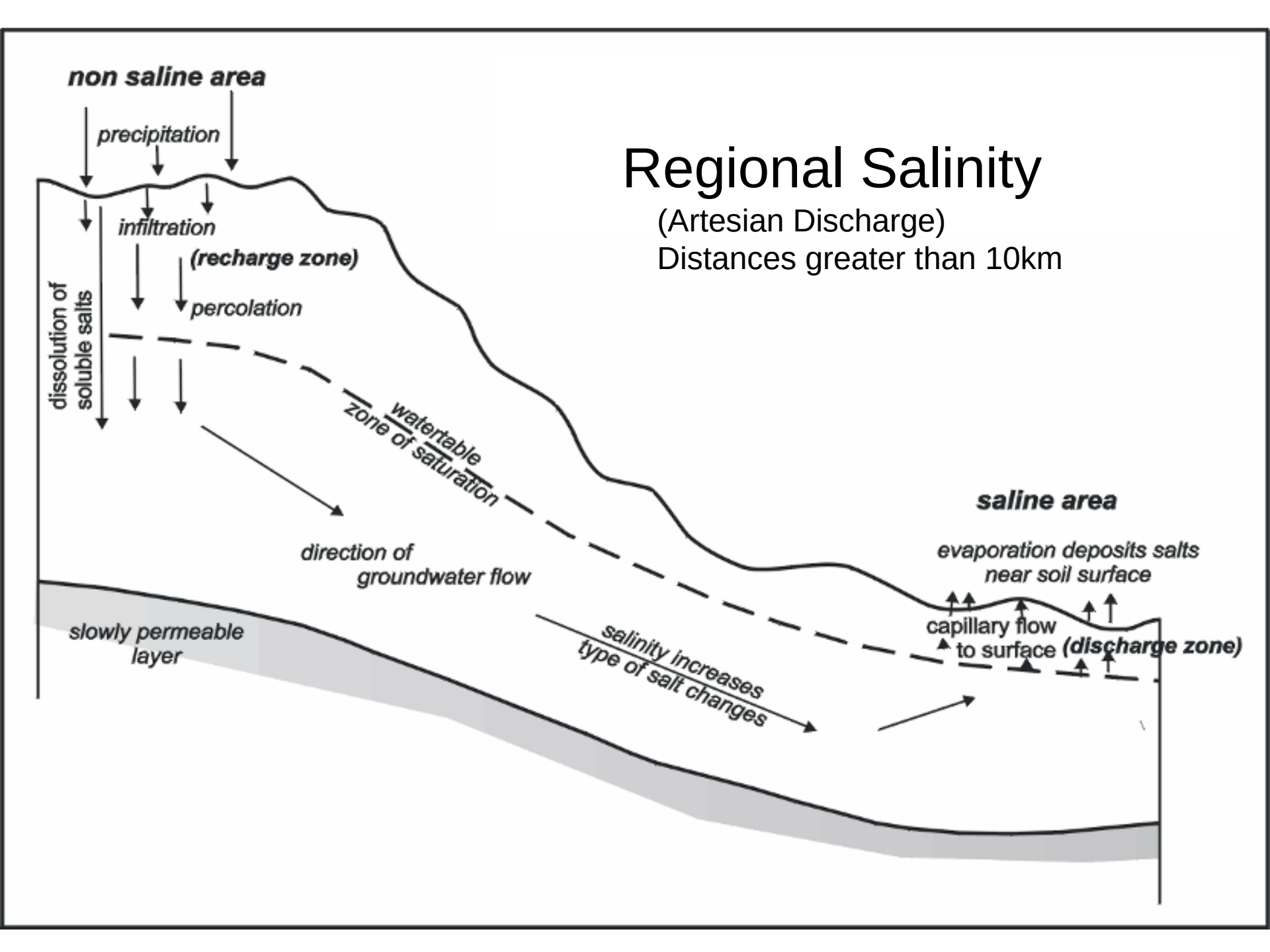
- Common in Prairie Soils:
  - Magnesium sulphate
  - Sodium sulphate
  - Calcium sulphate (slightly soluble)
  - Some areas of chloride salts

Composite soil samples that include saline areas can overestimate sulphate levels in the field

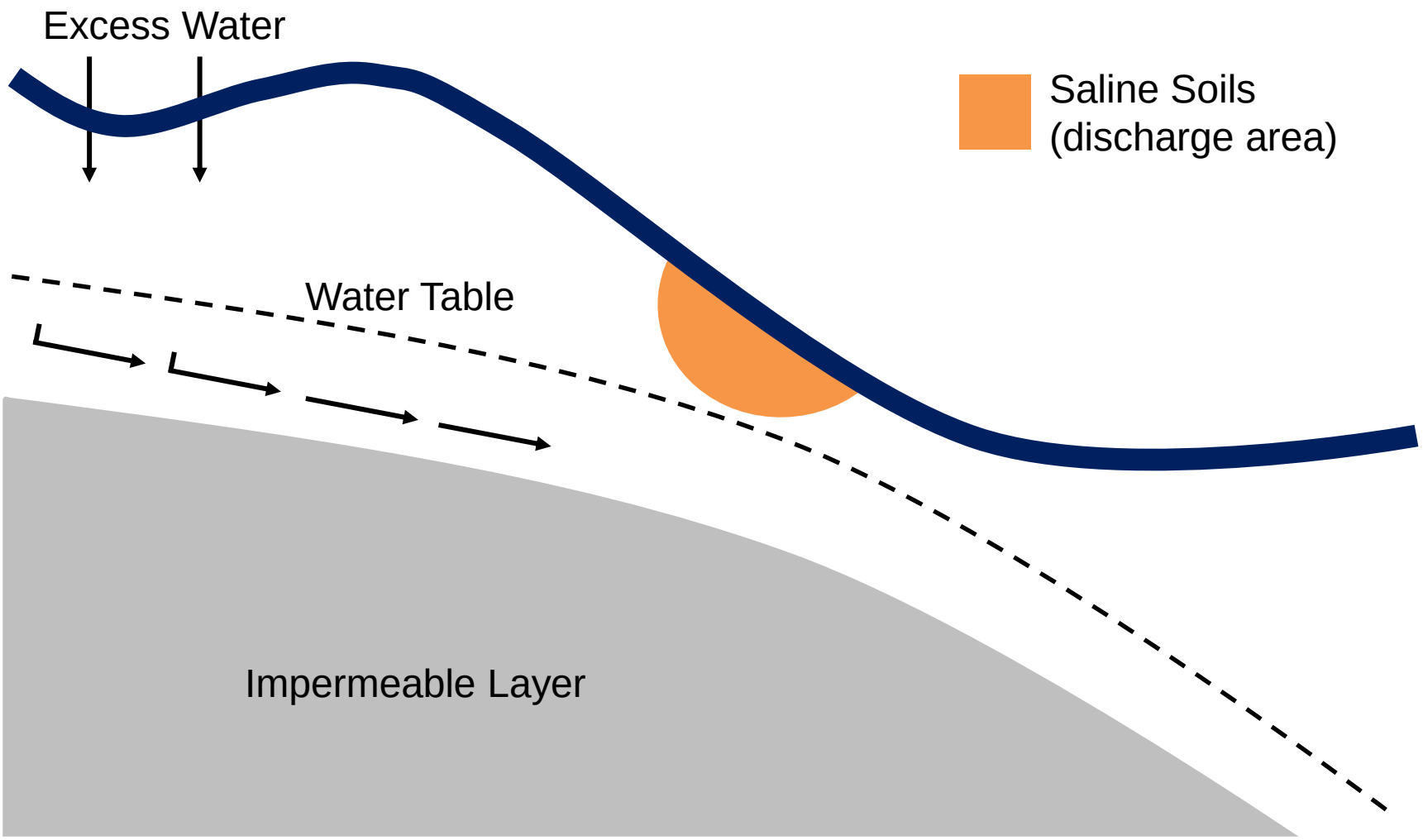
Regional Salinity

(Artesian Discharge)

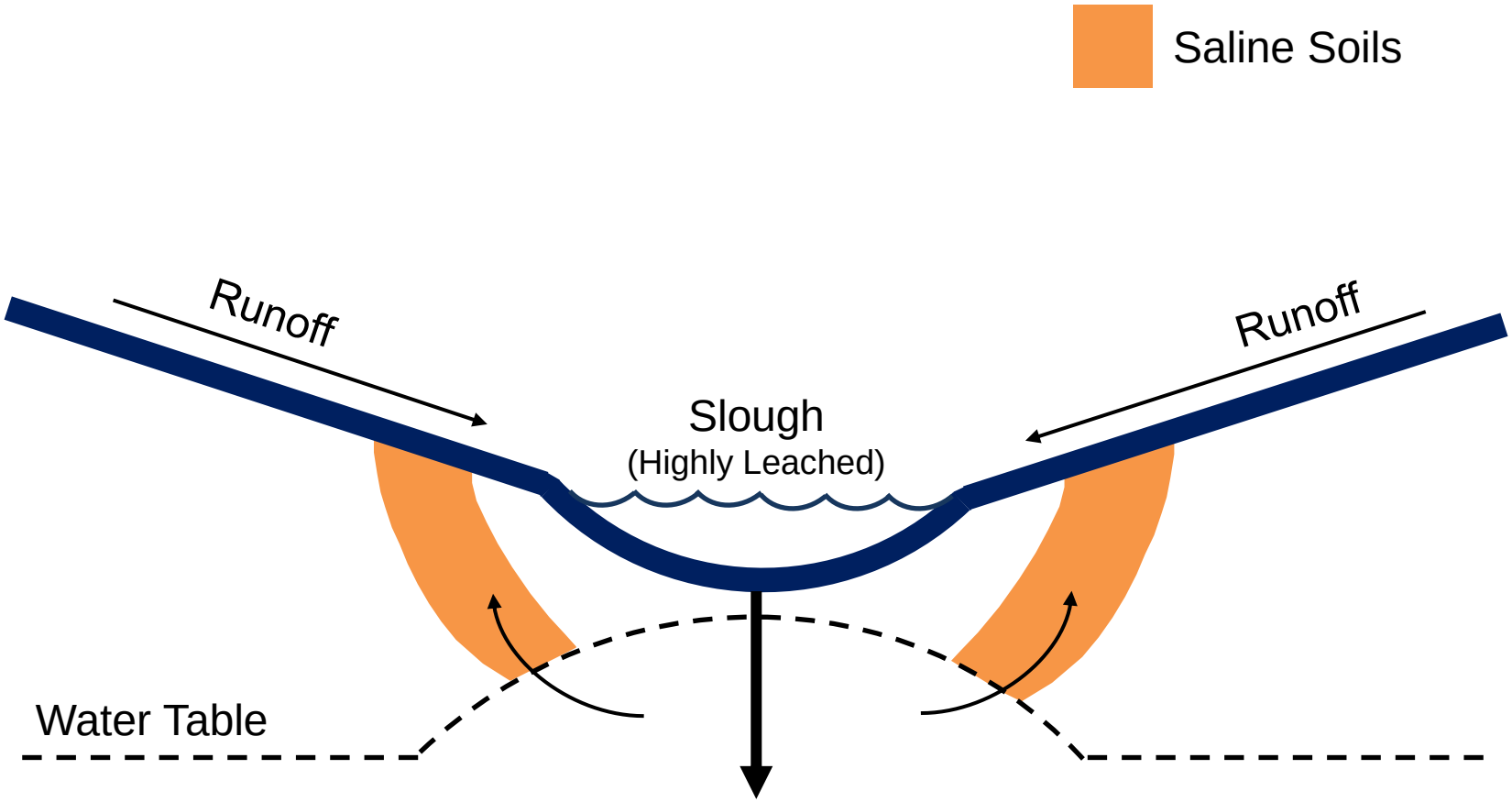
Distances greater than 10km



Side Hill Seep



Bathtub Ring Salinity



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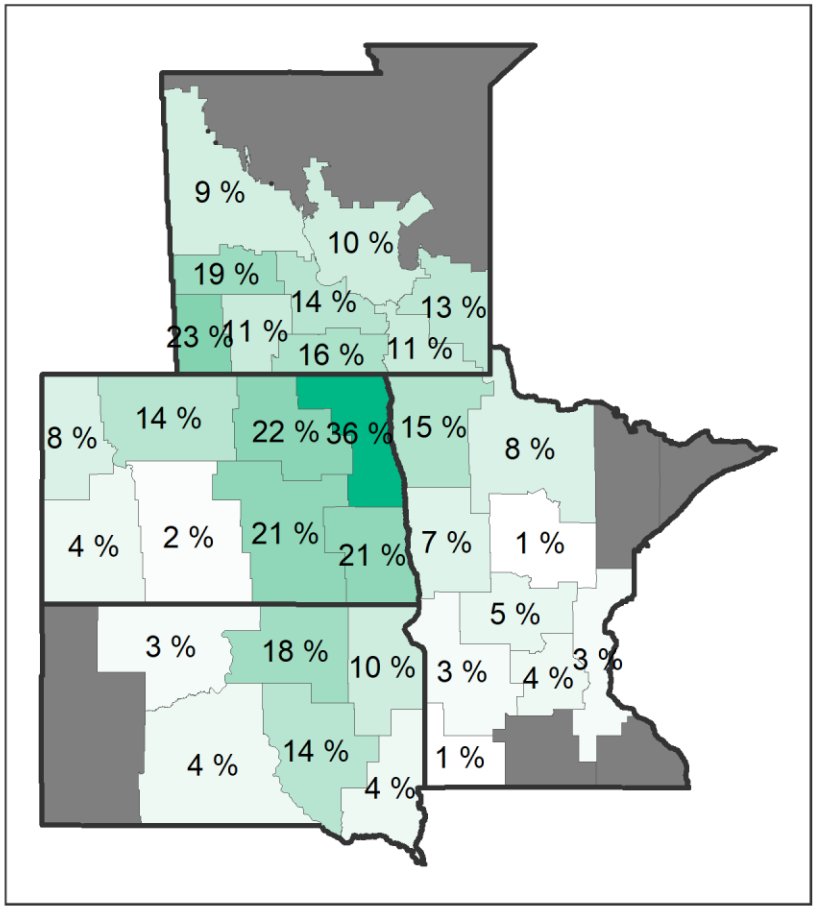

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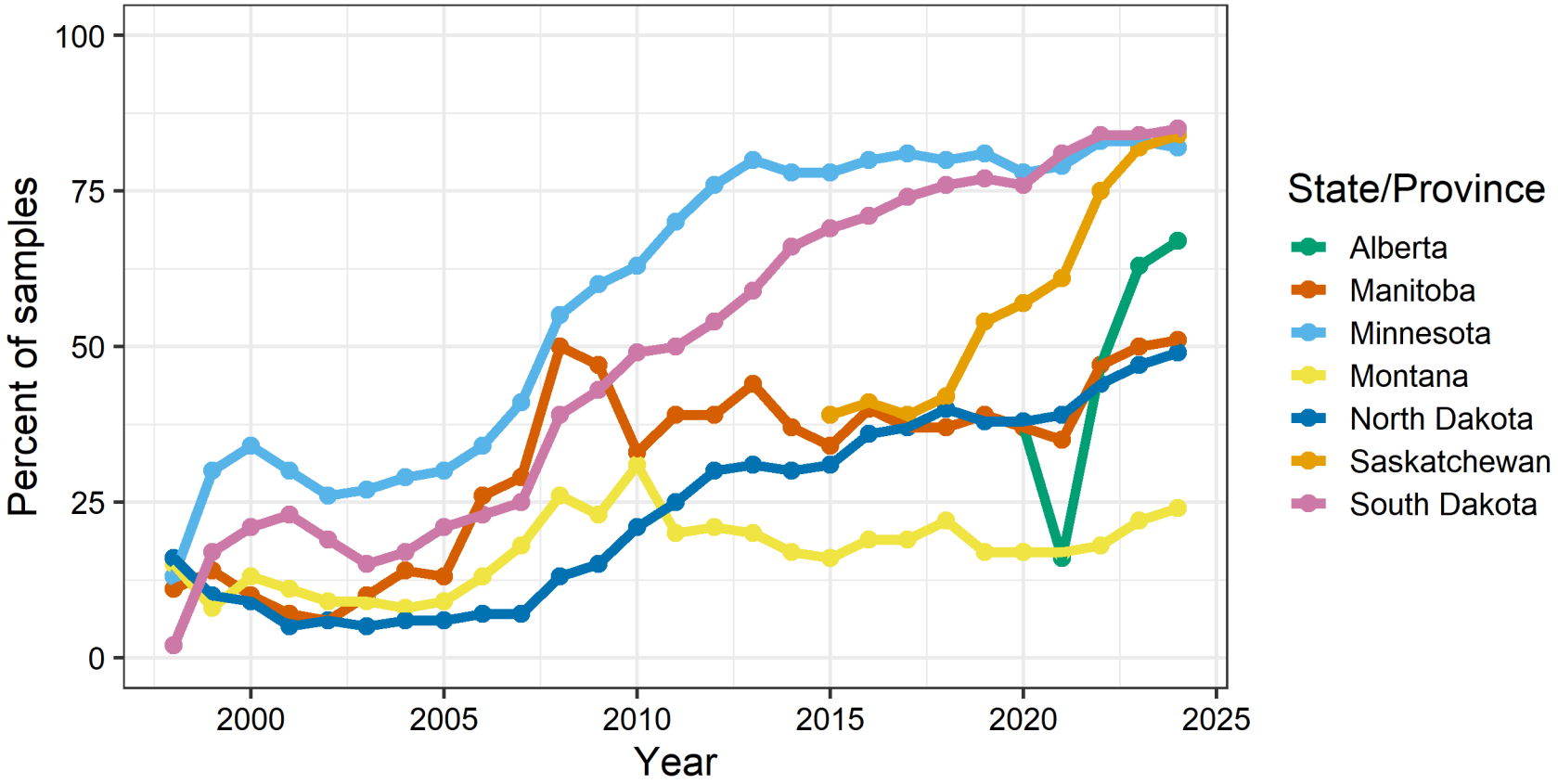
Soil samples collected as a precision sample (grid or zone)

Trend from 1998 to 2024



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Salinity vs. Sodicity

- Salinity and Sodicity are very different
- Sodic (alkali) soils are characterized by:
  - Elevated sodium concentration relative to calcium and magnesium
  - Sodium Adsorption Ratio (SAR) above 13
  - pH values typically above 8.5

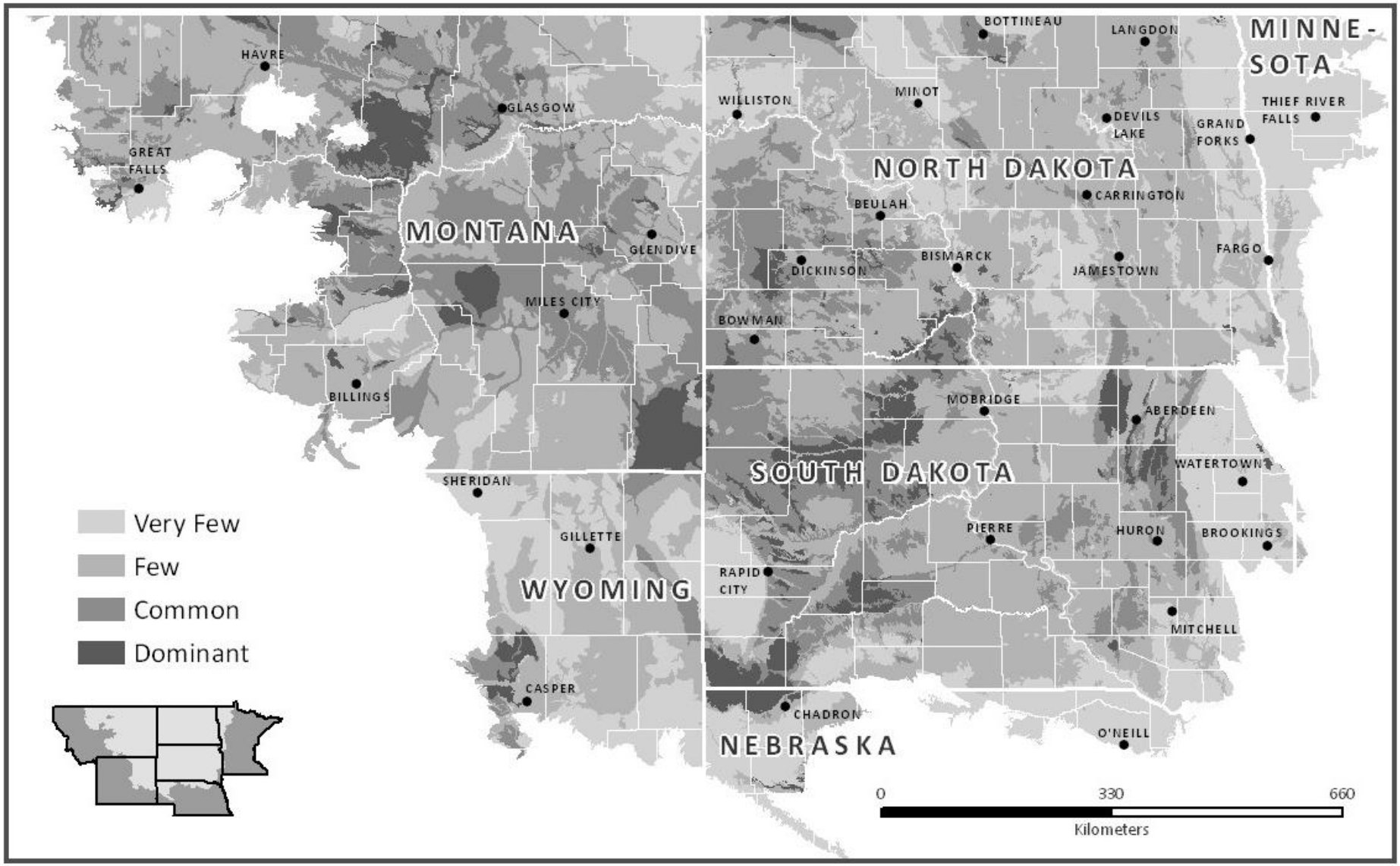


Figure 9. Relative distribution of sodic soils in North Dakota. (J. Brennan, USDA-NRCS, used with permission)

So we know how to identify a salinity problem...
but how do we cope with it???

Managing Salinity

- What can I do RIGHT NOW?
  - Look at your yield maps – where are your poor growing saline areas? How many cropped acres are severely affected?
  - First thing to do…stop spending money on them!
  - Second, consider investing in your saline spots
    - Soil sample to determine how bad the salinity is before planning your crop choices

Recall why salinity happens…

1. High water tables to carry soluble salts into root zone by capillary action (<6 ft from surface)
2. Evaporation that exceeds infiltration for significant periods of time
3. Plants susceptible to soil salinity (pulses, vegetables, oilseeds)

Management Options for Salinity

Lower Water Table	Infiltration > Evaporation	Crop Choice

Prevent

Increase Crop Water Uptake

- Strategic cropping choices to manage water
  - High water use crops in recharge areas

Managing Salinity

Increase Crop Water Uptake

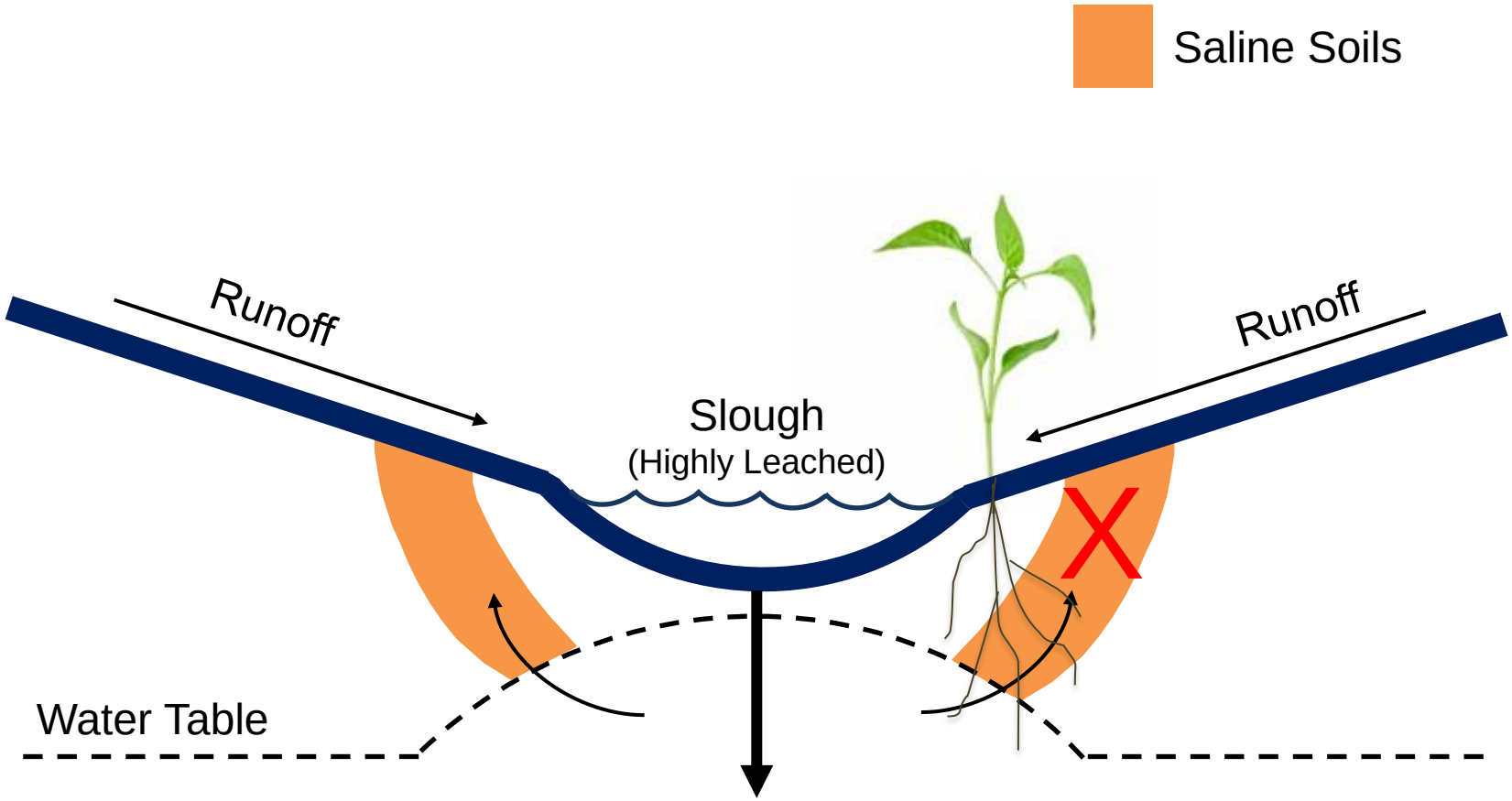
- Strategic cropping choices to manage water
  - High water use crops in recharge areas
  - Get your weeds working for you in discharge areas!


Photo: Joe Widdup

Increase Crop Water Uptake

- Strategic cropping choices to manage water
  - High water use crops in recharge areas
  - Get your weeds working for you in discharge areas!
  - Planting a “buffer crop” to take up water along headlands or intercept water around sloughs

Bathtub Ring Salinity



Impermeable Layer

Increase Crop Water Uptake

- Strategic cropping choices to manage water
  - High water use crops in recharge areas
  - Get your weeds working for you in discharge areas!
  - Planting a “buffer crop” to take up water along headlands or intercept water around sloughs
- Medium/Long term solution

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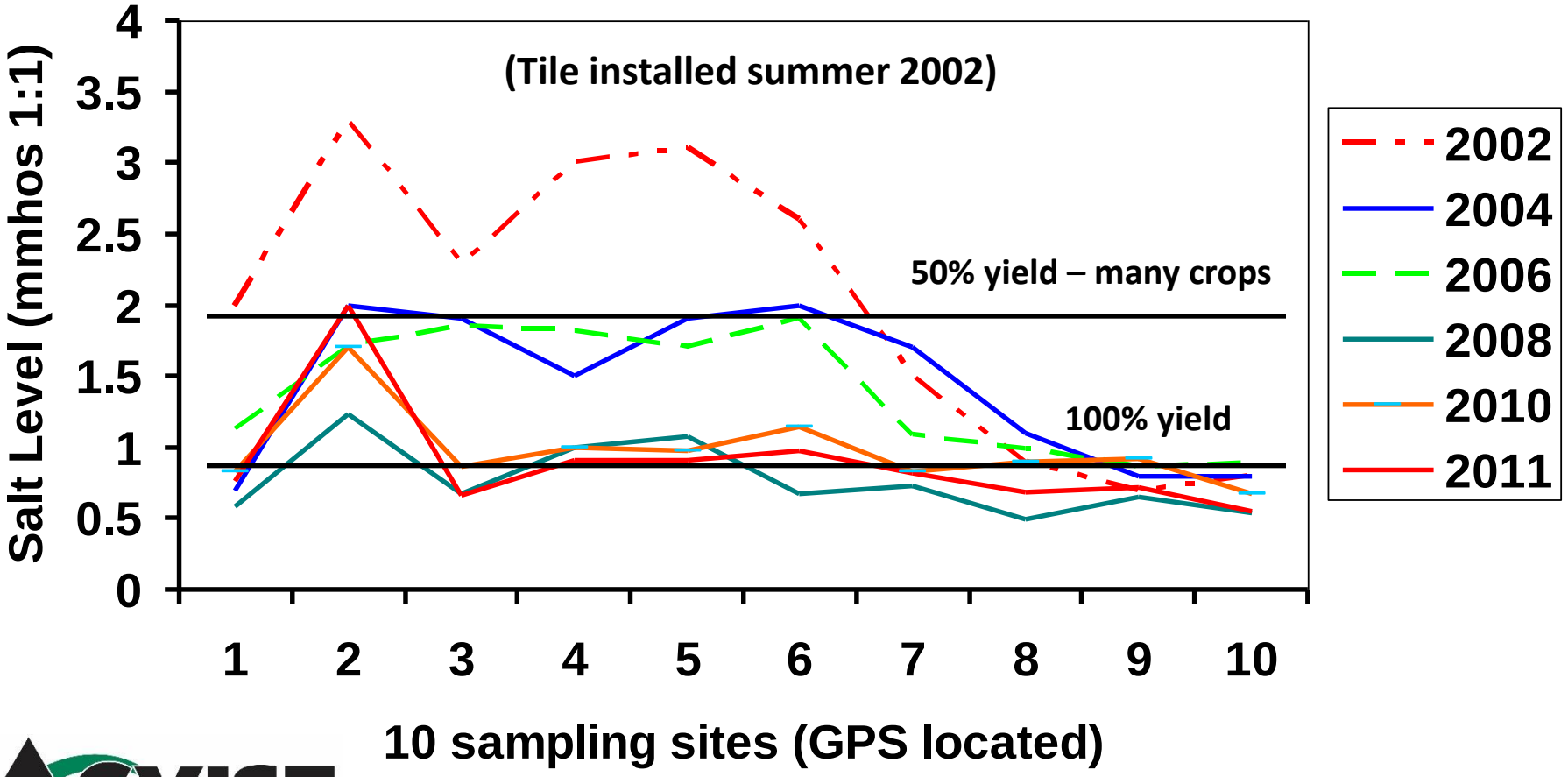
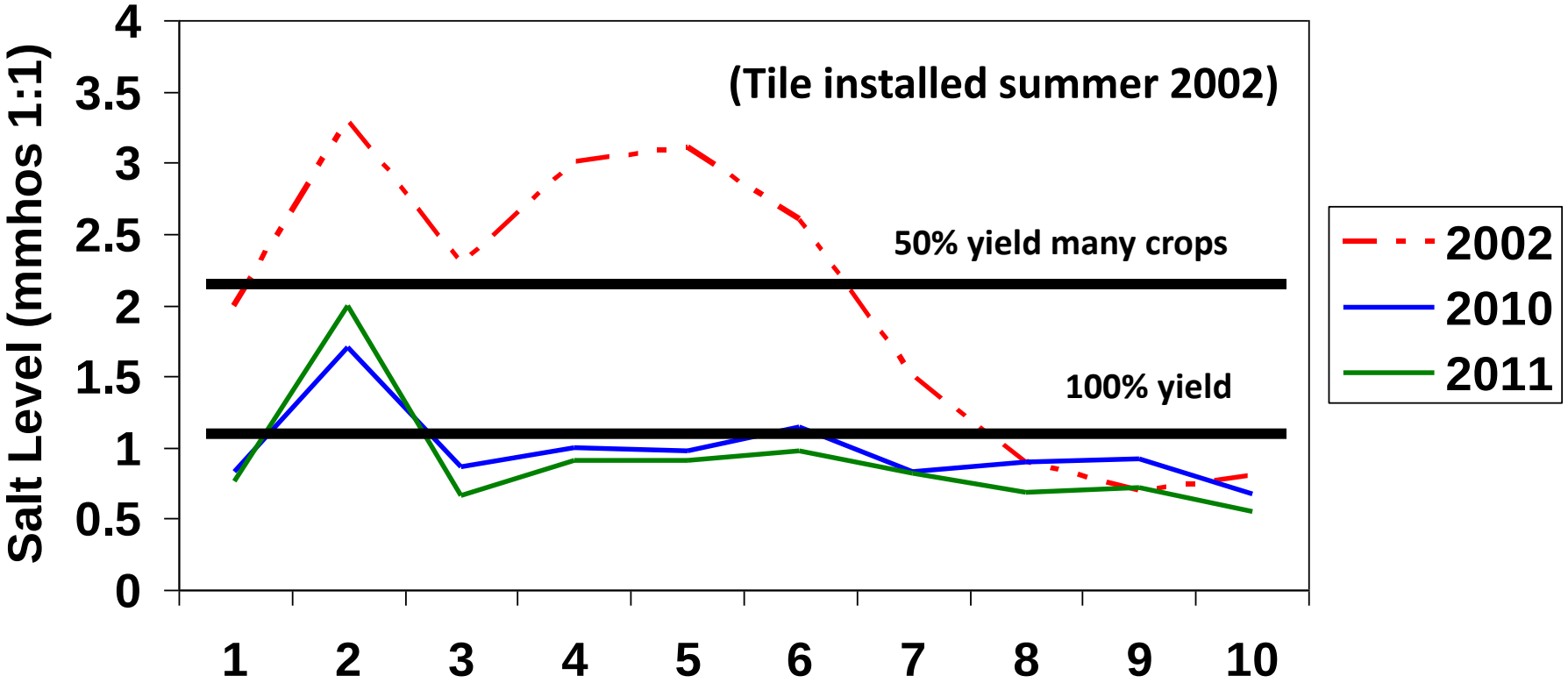
Tile Drainage

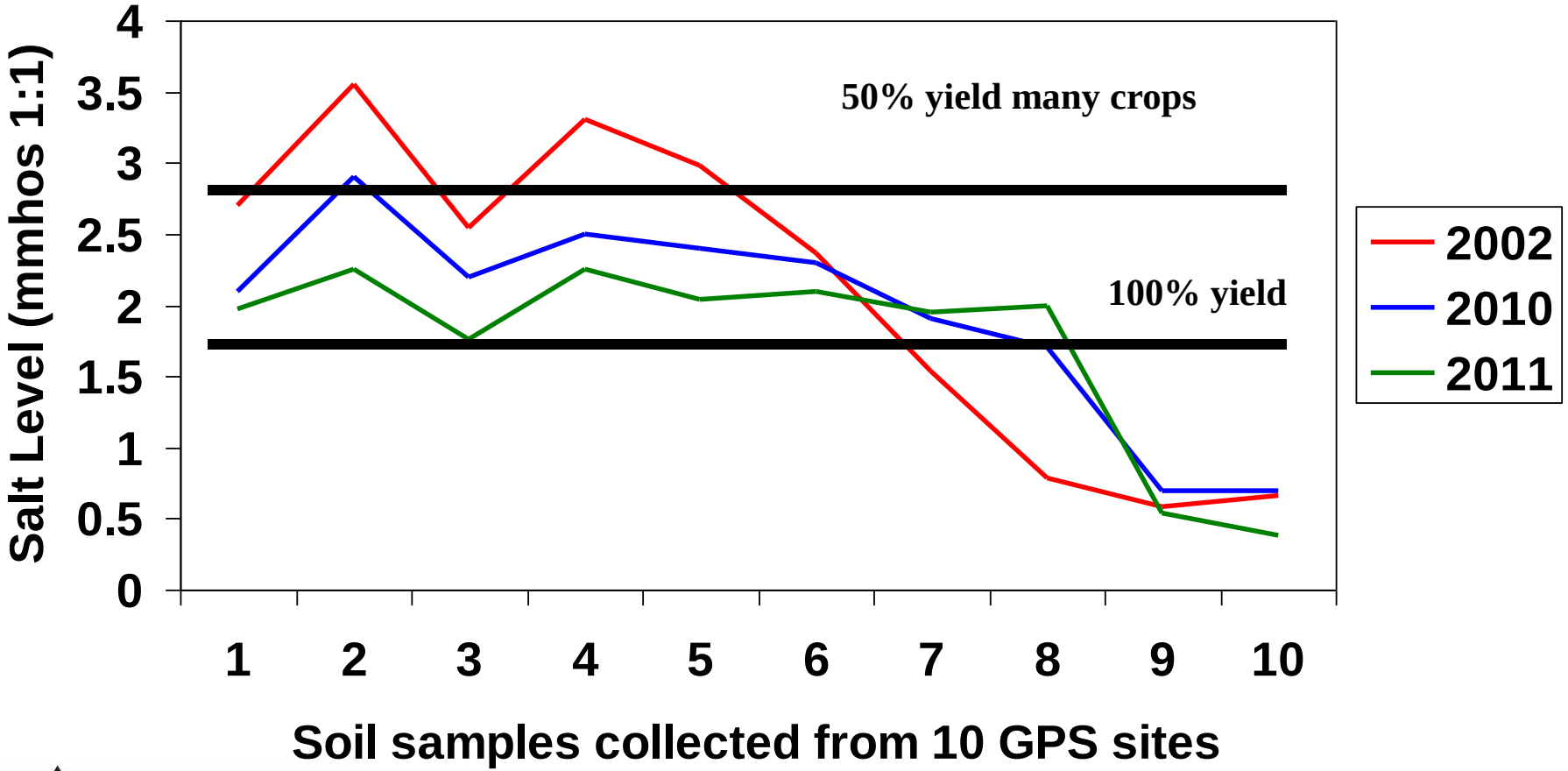


Tile Drainage – Topsoil



samples collected from 10 GPS sites

Tile Drainage - Subsoil



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Keep Soil Covered

- Decrease evaporation from the soil surface by placing mulch/manure/straw/etc over saline patches
- May only be feasible on small areas
- Might not be the most effective solution

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Eliminate Tillage

- If you do nothing else, then do NOTHING at all…resist the urge to till saline soils!!!
- Tillage encourages evaporation from the soil surface, bringing more salts up via capillary rise

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Saline-Tolerant Crops

Table 5.3 Relative salt tolerance of Manitoba crops (adapted from McKenzie, 1988)

EC Tolerance* (dS/m)	Field Crops	Forages	Vegetables
Lab test = 8		Tall wheatgrass Russian wildrye Slender wheatgrass	
Lab test = 4	6-row barley 2-row barley Fall rye Winter wheat Spring wheat Oats Flax Canola	Birdsfoot trefoil Sweetclover Alfalfa Bromegrass Crested wheatgrass Intermediate wheatgrass Meadow fescue Reed canarygrass	Garden beets Asparagus Spinach Tomatoes Broccoli Cabbage
Lab test = 2	Sunflowers Soybeans Corn Peas Field beans	Timothy White Dutch clover Alsike clover Red clover	Potatoes Carrots Onions Strawberries Raspberries

*Crops within a box are ranked from top to bottom as most to least tolerant

Mechanisms of Salinity Tolerance

Exclusion/Avoidance:

- Exclusion of salts at root
- Absorption by xylem cells
- Distribution between growing and non-growing parts of plant
- Effective at low to moderate levels of salinity

Acceptance:

- Ion accumulation by halophytes (salt grass, alkali grass, cordgrass…)
- Compartmentalize ions in vacuole
- Effective at high salt levels

Slide Courtesy of Abbey Wick

Saline-Tolerant Forages

Salt Tolerance Level (dS/m)	Forages	Speed of Forage Establishment	Weed/Crop
Lab test = >8	Tall Wheatgrass Beardless Wild-rye Salt meadow grass AC Saltlander	Slow Medium	Red Samphire Sea Blight
Lab test = 8	Slender Wheatgrass Altai Wild-rye Russian Wild-rye Western Wheatgrass Tall Fescue	Fast Slow Slow Slow Fast	Kochia Foxtail Barley Russian Thistle
Lab test = 4	Alfalfa Sweetclover Birdsfoot Trefoil S. Bromegrass Meadow Fescue Crested WG Intermediate WG	Fast Medium Slow Slow Medium Fast Fast	Barley Wheat Fall Rye Oats
Lab test = 2	Alsike Clover Red Clover White Clover Sainfoin Timothy M. Bromegrass P & A. Ryegrass Reed Canary	Fast Fast Fast Slow Fast	Canola Soybeans Beans Corn Flax, Peas, SF

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Preventing Salinity

- Reduce tillage
- Improve drainage
- Include high water use crops in rotation
- Increase soil organic matter through the addition of manure and crop residues
- Annual soil testing to 24”
- Establish forage buffer strips (10-20 ft wide) adjacent to ditches, field drains, depressional areas

Managing Salinity

Be **skeptical** of “quick fixes”

→Ignore chemicals, commercial soil conditioners and the like that only work in the imagination!

→Remember…it’s not a salt problem, it’s a water problem!!!!

And when all else fails…

"Sell it in the winter time"
– Les Henry


Thank you!
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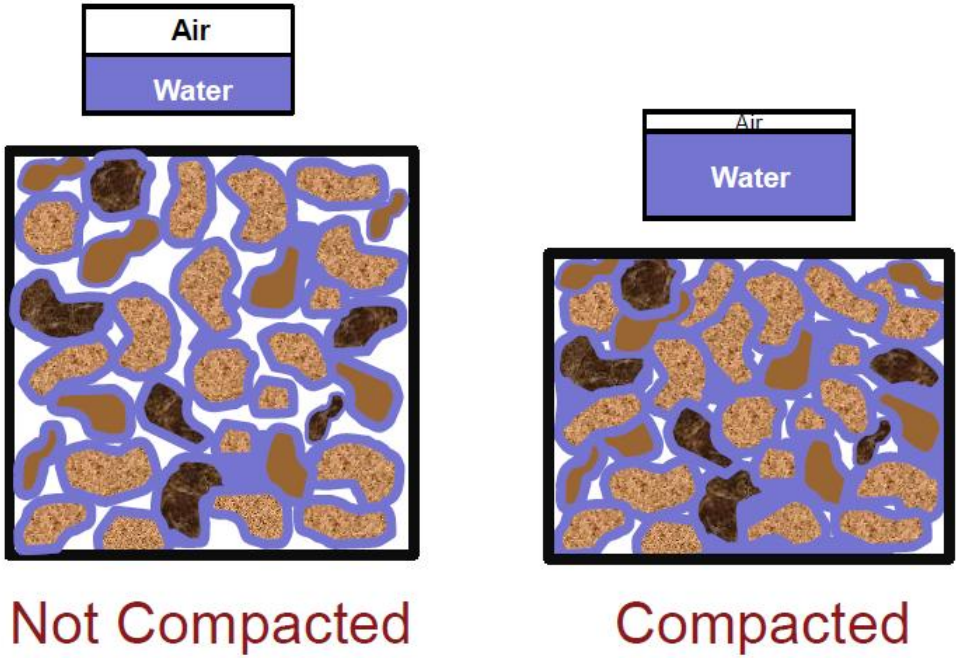
Soil Compaction

- Soil particles squeeze together, reducing the space available for soil and water



Source: UMN Extension


Crop Growth Restricted


Root growth
is restricted

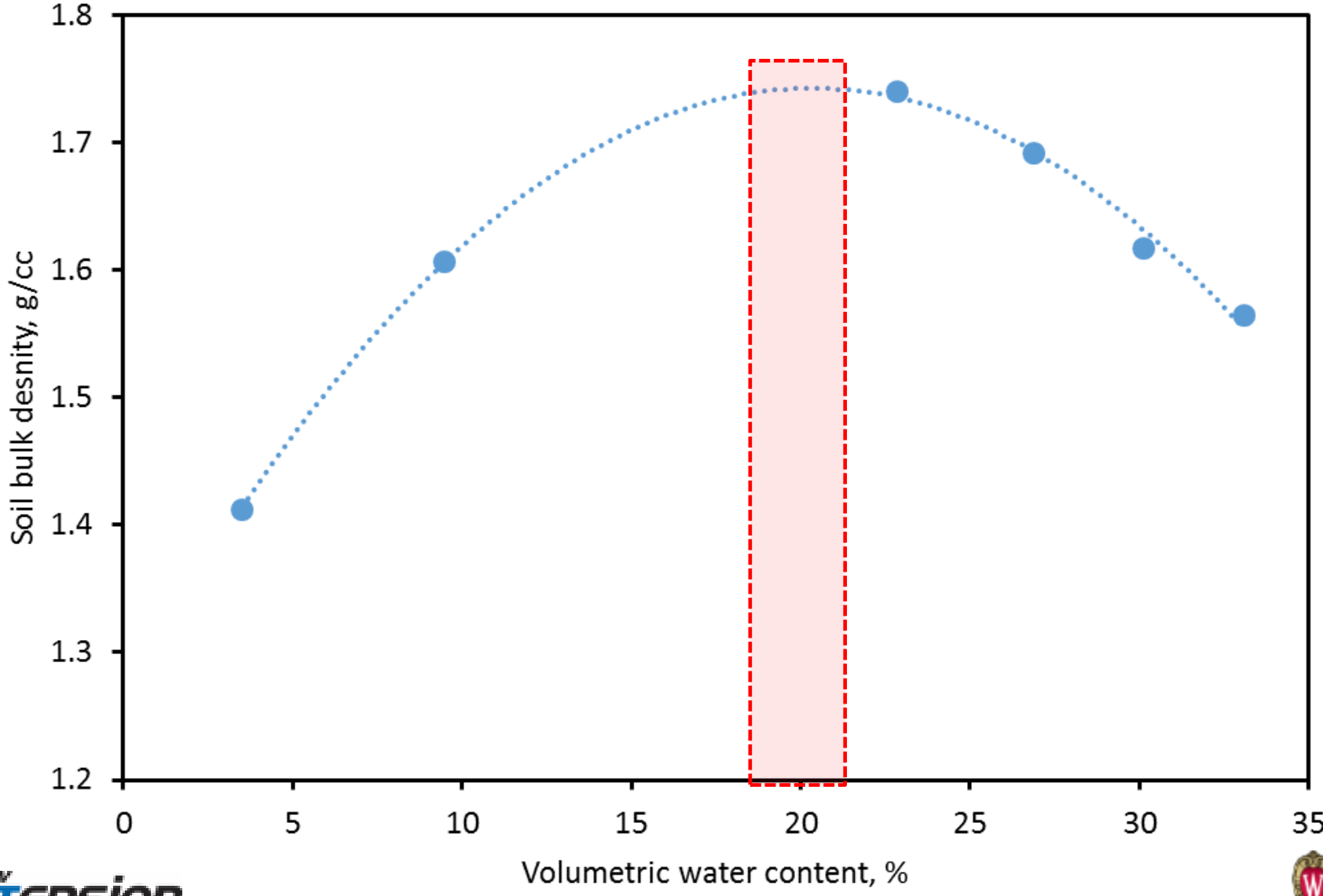
Soil Compaction and Soil Moisture

- Risk depends greatly on Soil Moisture
- When Soil is “dry”
  - Sufficient soil strength to resist compaction
- When soil is “extremely wet”
  - All pores are water filled (saturated)
  - Causes large, deep, muddy ruts with little or no compaction

Soil Compaction and Soil Moisture

- **Be careful when soil is “moist”!!!**
  - Aggregates become lubricated with water and reduce sheer strength
  - Large pores are air-filled, small pores are water-filled
  - With pressure, the large pores collapse, resulting in compaction
  - Greatest compaction occurs when soil is near field capacity

Proctor Soil Density Test - Example

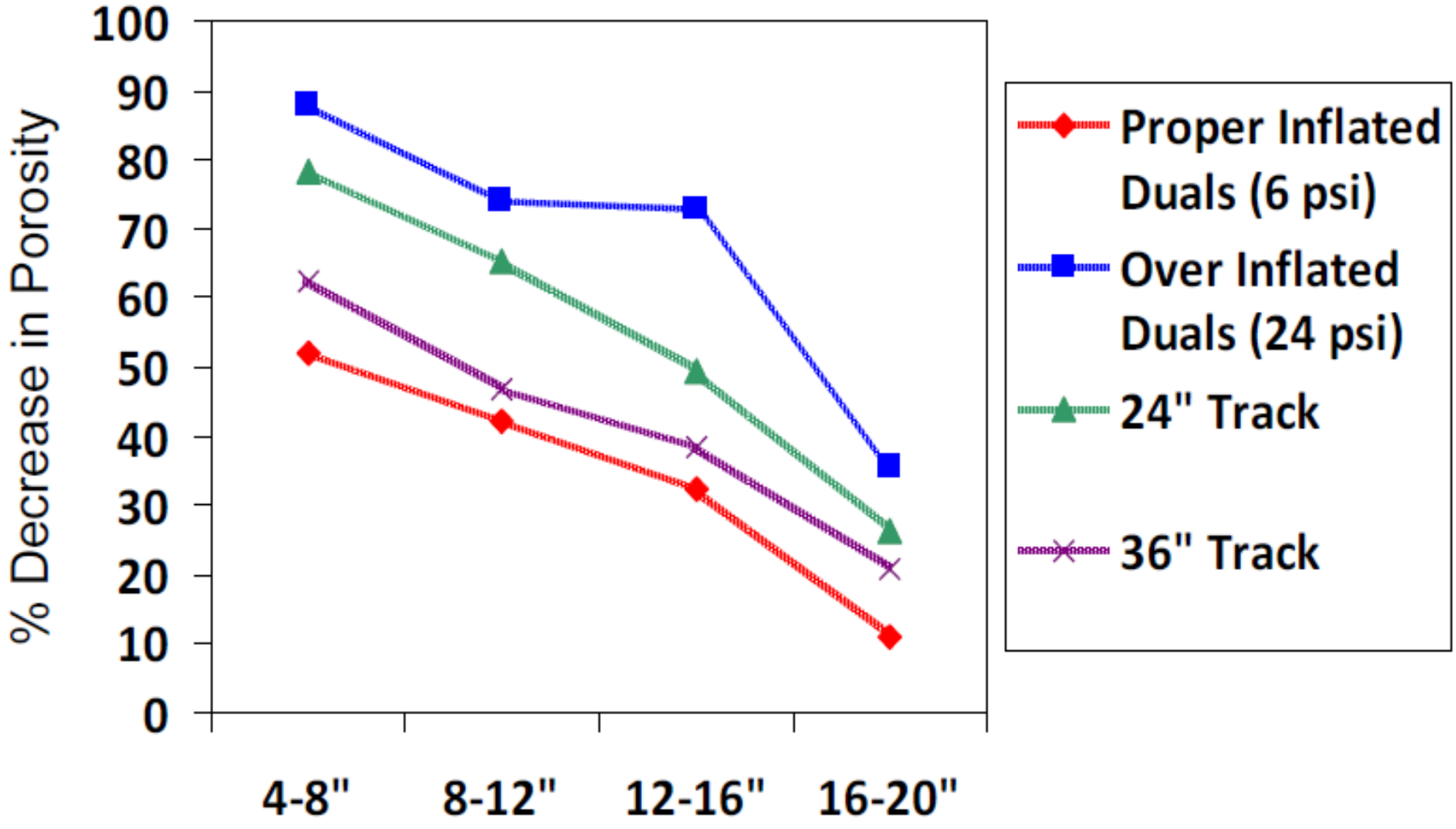


Slide Courtesy of Francisco Arriaga

Prevention is Key!!!!

- Check and maintain tire pressure
- Reduce total axle load
- Minimize the number of trips over a field
- Use duals/large diameter tires or tracks
- Rotate deep rooted, water-loving crops
- Reduce tillage

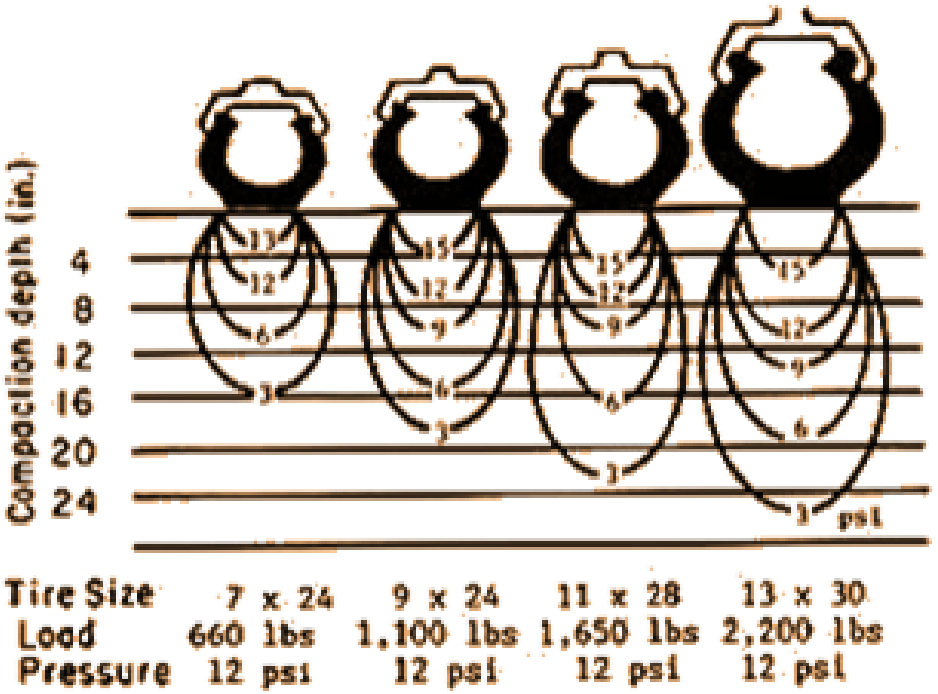
Ohio State Univ. Study



JD 8870 4WD, Tires 710/70R38, 4 reps

Effect of Axle Load (Weight of Equipment)

- Compaction increases with axle load
- Limit axle load when soil is at high risk (moist)



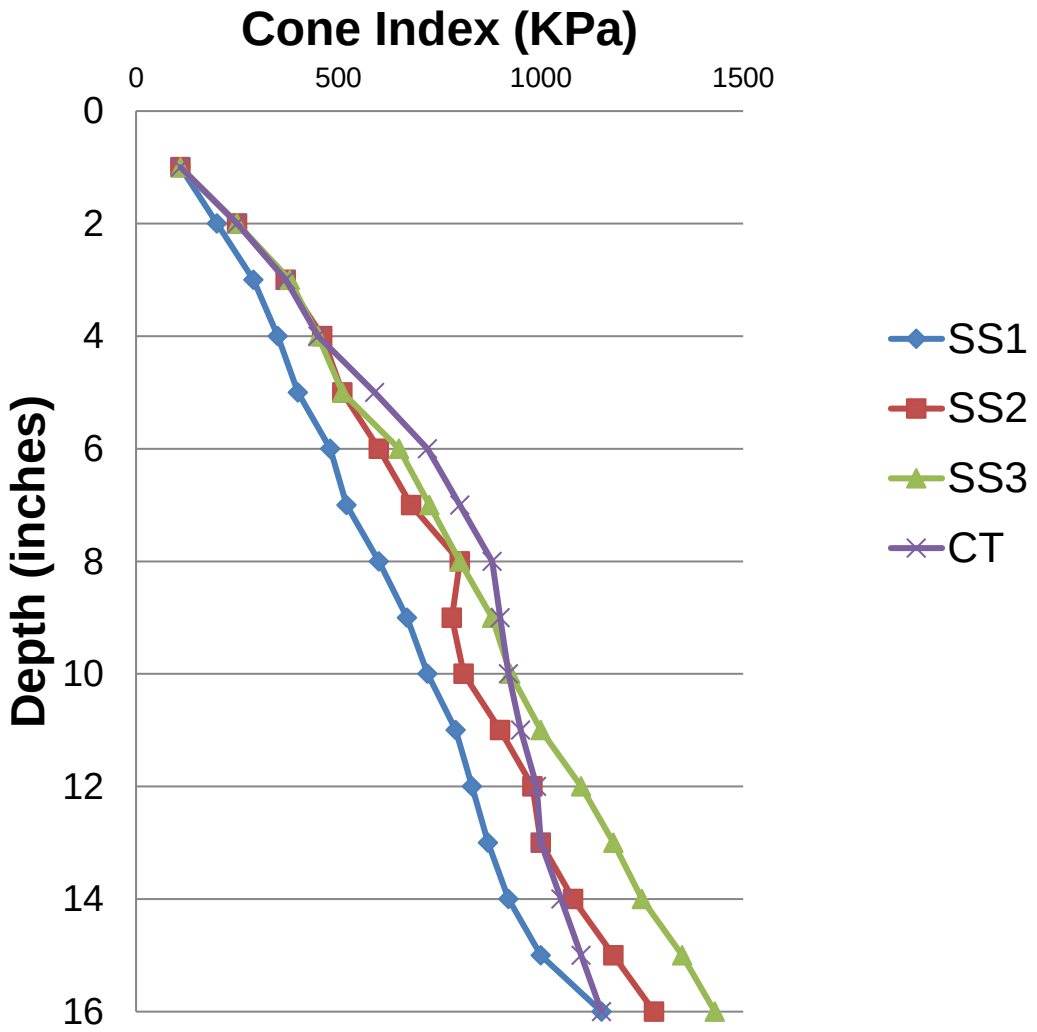
Adapted from Sohne, 1958


About 80% of compaction happens on the FIRST PASS
Wheel Traffic Compaction

If my soil is already compacted

- Can I use deep tillage to fix the problem?
- First, determine the depth of compaction and how extensive it is across the field

Soil Cone Index profiles in 2005



- Soil Cone Index (SCI) was lowered following subsoiling in year 1 (SS1)
- SCI increased over time after subsoiling
- Need to practice rotational subsoiling to maintain the benefit – costly practice needs to pay for itself in yield

From Wang et al. (2009), Canadian Biosystems Engineering

Subsoiling as a solution

- Farm trials in Iowa say that it might not pay
  - Fields divided in half – half subsoiled, half not; Fuel consumption and yield difference recorded
- Only a 50/50 chance that the resulting increase in yield paid for the cost
- Conclusion: focus on the headlands

Subsoiling as a solution

- Subsoil 1 inch below the compacted layer
  - Use most non-invasive, straight shank
- Timing is crucial – make sure you are subsoiling in the fall after harvest IF the soil is dry enough
  - Too wet will not fracture (and most likely cause more compaction)

Subsoiling as a Solution

- Work when soil is dry
- Best when at Permanent Wilting Point

Photo: Jodi DeJong-Hughes

Photo: Mario Tenuta

Photo: Lyndsey Smith

Cover Crops as a solution

- May play an important role in soil drying by increasing length of growing season
  - Manitoba data on berseem clover cover crop increased downward movement of water and reduced soil moisture
- May allow soil to be trafficked at a higher moisture content without causing compaction

CTF as a solution

- Controlled Traffic Farming is a system built of permanent wheel tracks where crop zone and traffic lanes are separated
- Track/wheel spacings should be standardized, equipment widths are multiples of each other
- Traffic lanes heavily compacted, crop zones are not compacted

Soil Compaction

- When it comes to compaction, good soil structure is your best defence
  - Ideally, don't work or traffic soils when wet or moist
  - When working in less than ideal conditions, try to decrease axle loads and make sure tractor is performing optimally
- Soil structure can also improve infiltration and downward movement of water…which can limit compaction and salinity risks