SOIL ACIDIFICATION
CAUSES and CONCERNS

Montana Association of Conservation Districts Convention

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Montana SWCD and MSU Extension

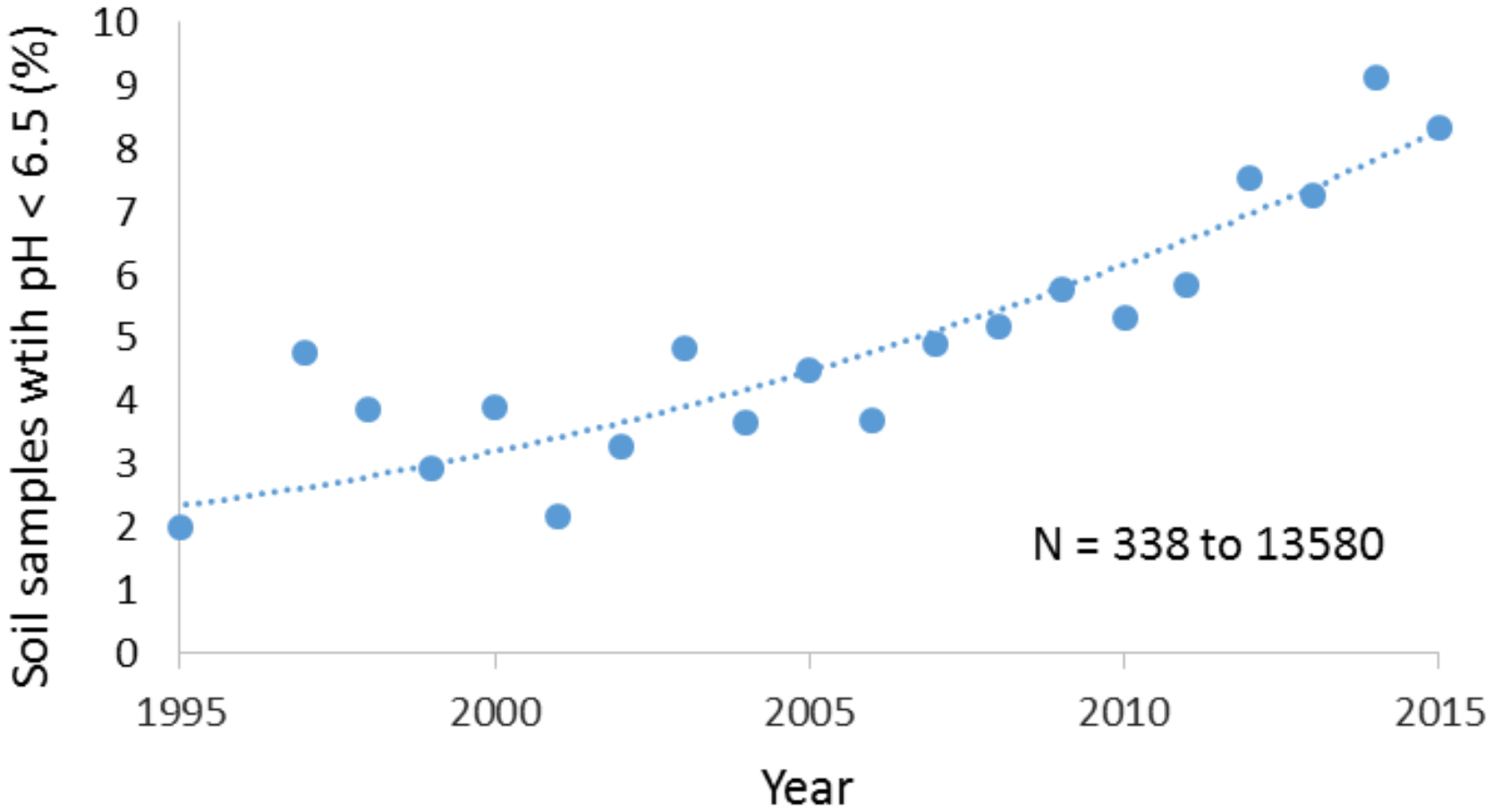
Questions for you

- How many think you have seen yield losses from acidic soils?
- How many of you have soil pH levels below 5.5?
- How many have observed decreasing pH levels on your soil test reports?
- Suggestions for determining how widespread this problem is?

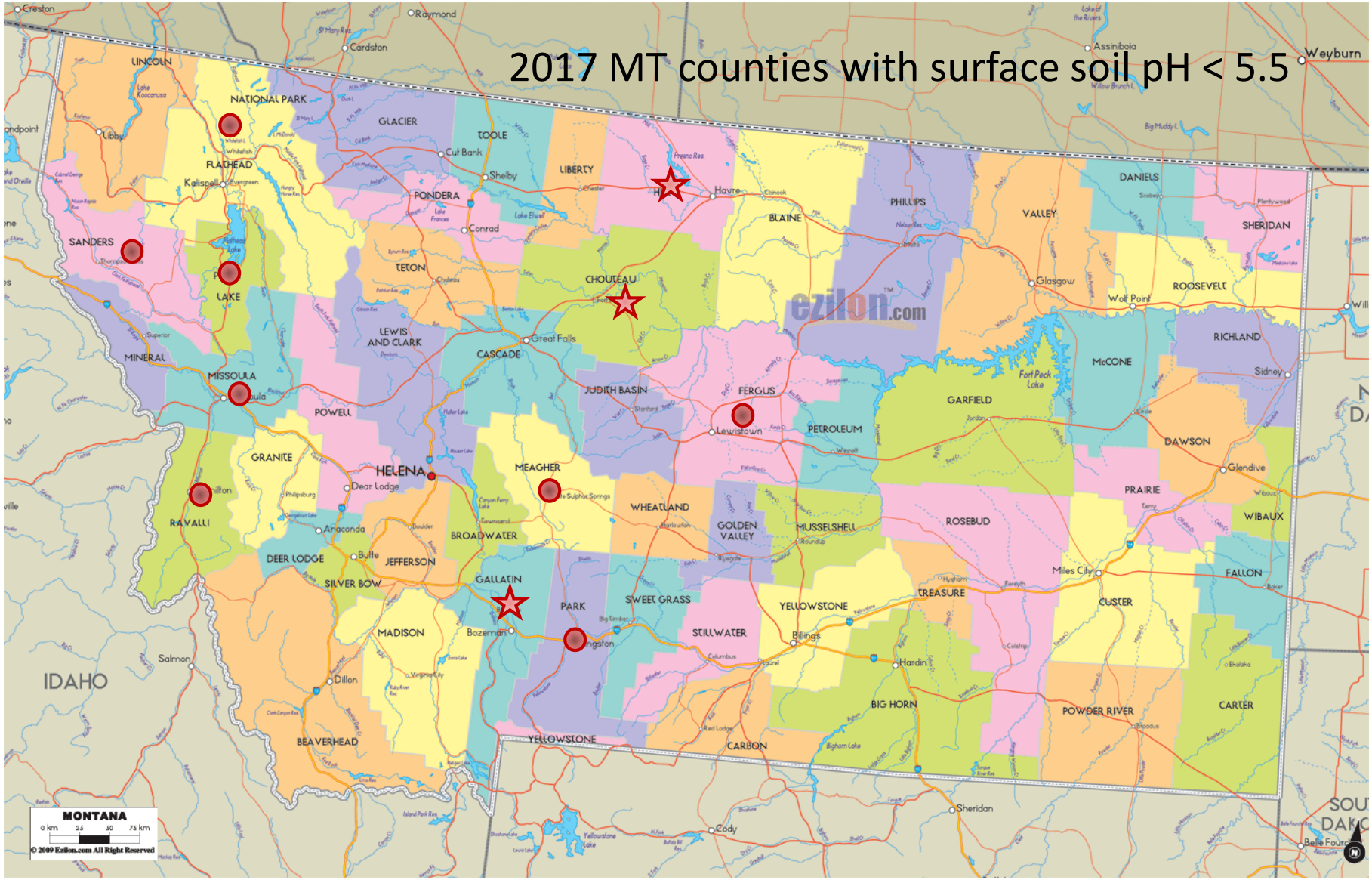
Objectives

- Show how number of acidic soils have been increasing in Montana
- Present natural and agronomic conditions that lead to acidic soils and some negative impacts
- Depict low-pH soil affected crops
- Present management options to slow acidification and increase productivity of acidic soil

Acidic soil samples (pH<6.5) are increasing in MT (though still rare)



Unpub data Agvise

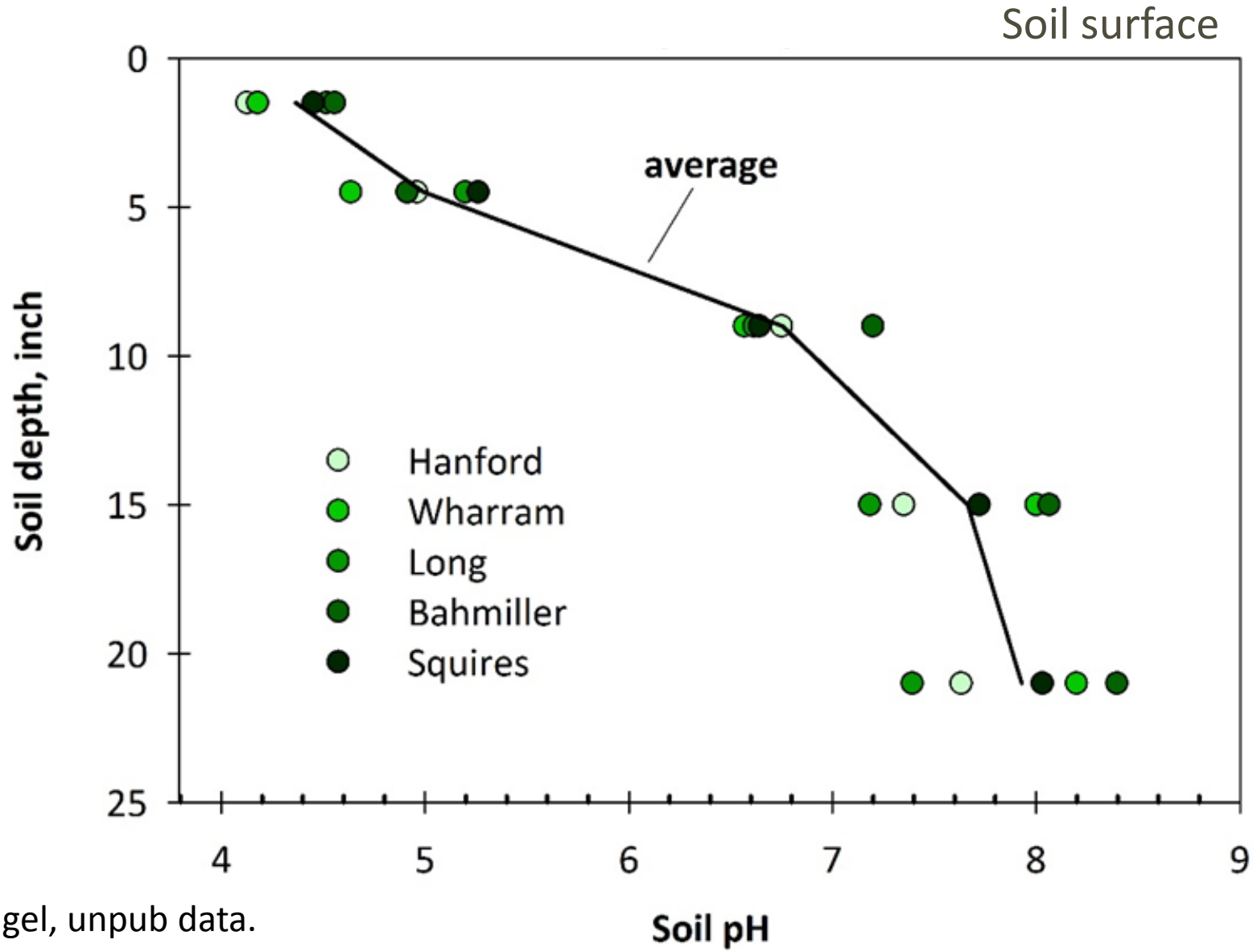


★ Sampled by MSU, low pH and/or high Al

● Reported by CCA or Ext Agent

Durum wheat – aluminum toxicity due to low pH

Low soil pH is generally only in upper 6 inches



Engel, unpub data.

Natural reasons for low soil pH

- Soils with low buffering capacity (low soil organic matter, coarse texture), granitic > calcareous
- Historical forest vegetation > historical grassland, which developed greater buffering capacity

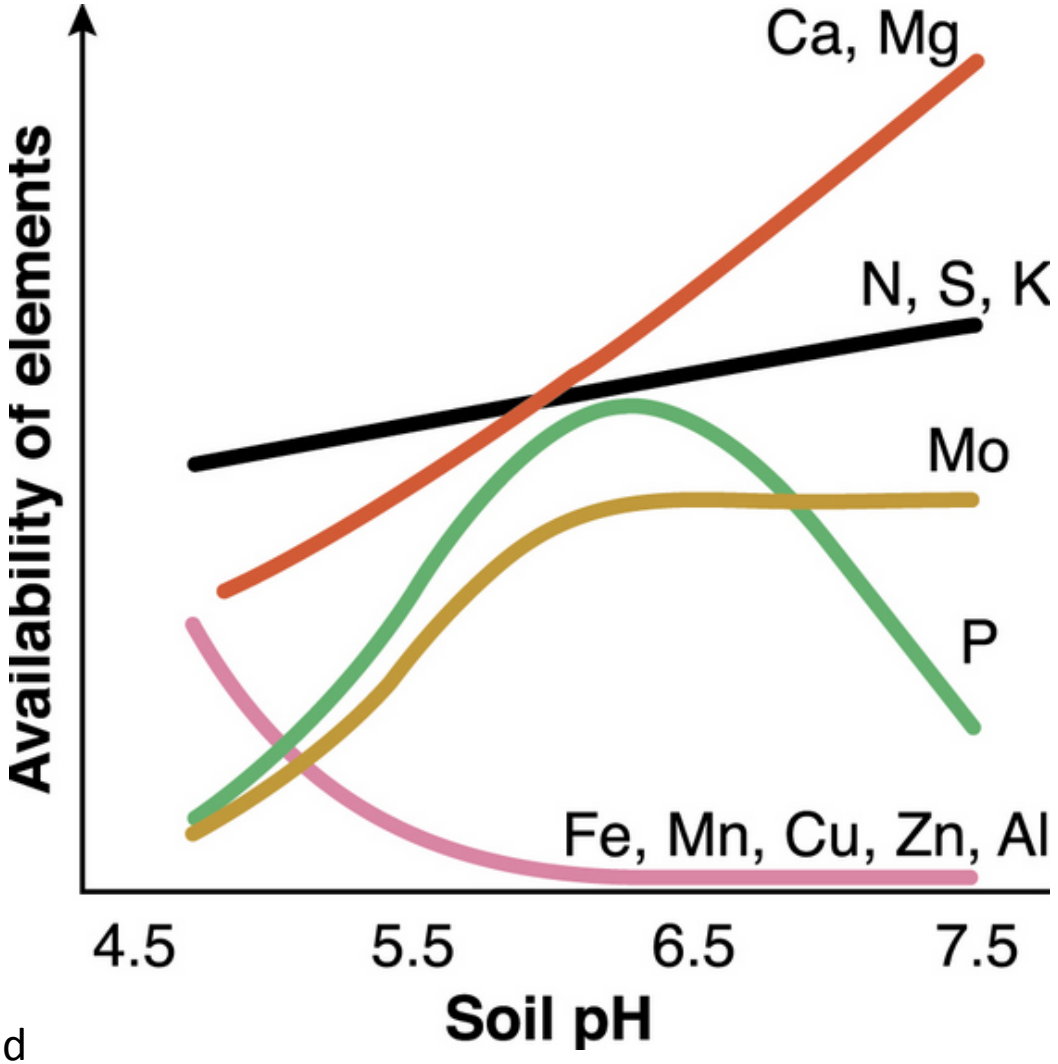
Agronomic reasons for low soil pH

- Ammonium-based N fertilizer above plant needs due to Nitrification: ammonium or urea fertilizer + air + H_2O→ nitrate (NO_3^-) + acid (H^+)
- Leaching loss of nitrate prevents plants from buffering soil with basic anions (OH^- and HCO_3^-)
- Crop residue removal – removes Ca, Mg, K ('base' cations)
- No-till concentrates acidity where N fertilizer applied
- Legumes acidify their rooting zone through N-fixation. Perennial legumes (e.g., alfalfa) more so than annuals (e.g., pea).

Soil pH and nutrient availability

At low soil pH:

- Plants go hungry for some nutrients
- Nutrients can be lost to environment
- Al and Mn reach toxic levels



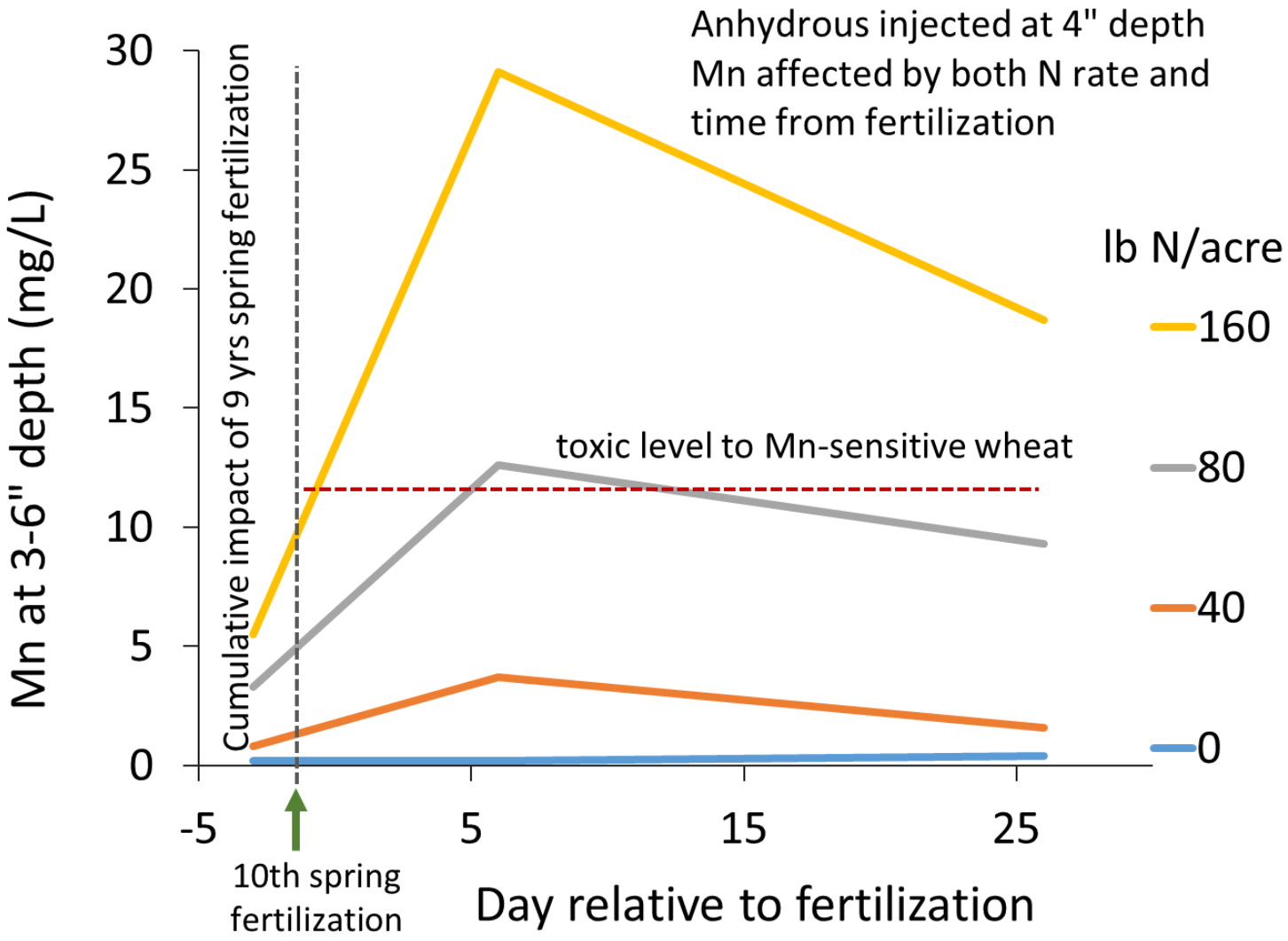
Gov. W. Australia, Dept. Ag. and Food

Low pH increases soil Al to toxic levels

Witches broom roots

Engel unpub. data, 2016, 5 farms near Highwood, MT

9 years of differing N rates on soil Mn levels in SK



Bouman et al., 1995, Scott, SK. Mn toxic level from Moroni et al., 1991

Acid soils have many additional negative impacts

- Herbicide persistence
  (Raeder et al., 2015)
- Damage to rhizobia
  (N-fixing by legumes)
- Increase in fungal diseases
- Toxic H^+ levels
  (Kidd and Proctor, 2001)

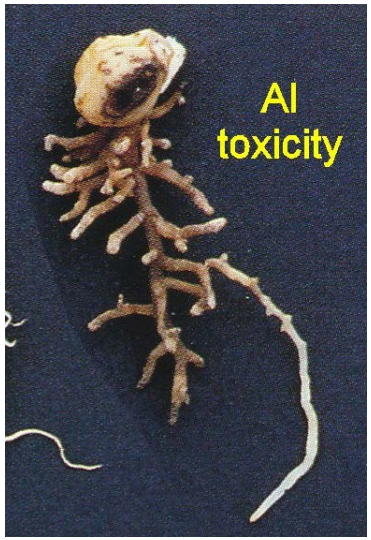
Images from Creative Commons

What to look for. Unexplained poor health in low or mid-slope areas

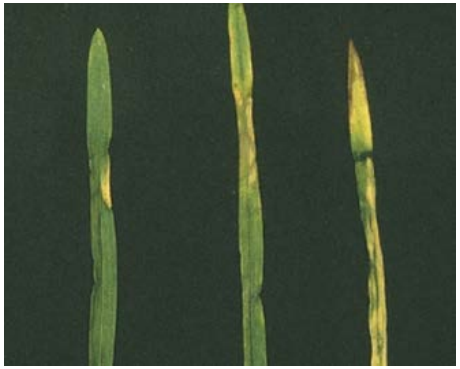
Image KS State Research and Extension

Al toxicity

- stubby club roots (similar to nematode damage)
- small leaves, short thick internodes
- yellow along margin near tip on older leaves
- purple or brown lesions in chlorotic regions, indentations
- leaf withering and collapse in center



Field pea. A. Robson, https://agric.wa.gov.au/n/4487



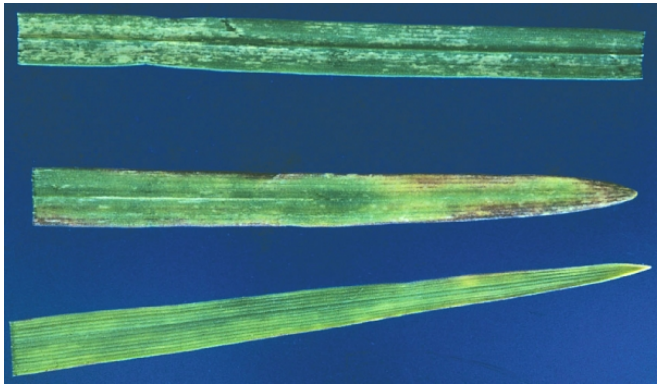
Information and photo source: CIMMYT.org

What to look for. Unexplained poor health in low or mid-slope areas

Mn toxicity

- cupping and crinkling
- chlorotic and reddening spots to necrosis
- starting on older leaves at tips and margins

Image R. Norton, IPNI



Information and photo source: CIMMYT.org

What to do if suspect low pH soil?

1. Soil test top 6”
   - pH < 6 likely have spots with decreased yields (go to 2 below)
   - 6 < pH < 7 don’t assume you have no areas with low pH
   - pH > 7, likely don’t have problem (skip 2-4).
2. On top 3” where have low pH symptoms: Use pH color strips on a soil/water slurry or send sample to lab for pH (<5?) and KCl-extractable Al (> 5 ppm). Test 3-6” if might till.
3. OR: Compare Al and Mn tissue analysis from ‘good’ and ‘bad’ crop areas.

Managing low pH

Remediate

- Use lime amendments (sugarbeet or Ag Lime)
- Consider occasional tillage (once in 5 years?)
- Plant acid-tolerant perennial crops

Adapt

- Plant Al-tolerant crops or varieties (e.g. Judee, Alum. See CARC webpage for variety trial data)
- Seed deeper?
- Fertilize after vulnerable seedling stage

Prevent

- Optimize N use efficiency – no left-over N
- Consider different N sources
- Retain crop residue

Steps to minimize and prevent soil acidification due to fertilizer N

Increase efficiency of N use
Base nitrogen rate on spring soil test and realistic yield potential
Split nitrogen applications
Reduce nitrate loss
Use slow-release nitrogen sources
Use nitrogen sources with nitrification inhibitors
Recrop or plant deep rooted crops to ‘catch’ deep nitrate
Consider using nitrogen sources other than urea, UAN, anhydrous, ammonium phosphate, or ammonium sulfate
Legume rotations, manure
Calcium ammonium nitrate (27-0-0)

Summary

- Cropland soils are becoming more acidic, largely due to N fertilization
- This reduces yields for several reasons
- Sound N fertilizer, crop, and residue management can slow or prevent soil acidification
- Crop and variety selection can help adapt to acid soils
- Liming, perhaps tilling, or planting perennials can mitigate acidification

Questions?

Image from Oregon State University, Lane County, OR 1926.

For more information see the 2 *Soil Scoops* on soil acidification at MSU Soil Fertility website:

http://landresources.montana.edu/soilfertility/soilscoop.html

Eastern Oregon Liming Guide OSU EM9060, Soil Acidity in Oregon: Understanding and Using Concepts for Crop Production OSU EM9061

https://catalog.extension.oregonstate.edu/