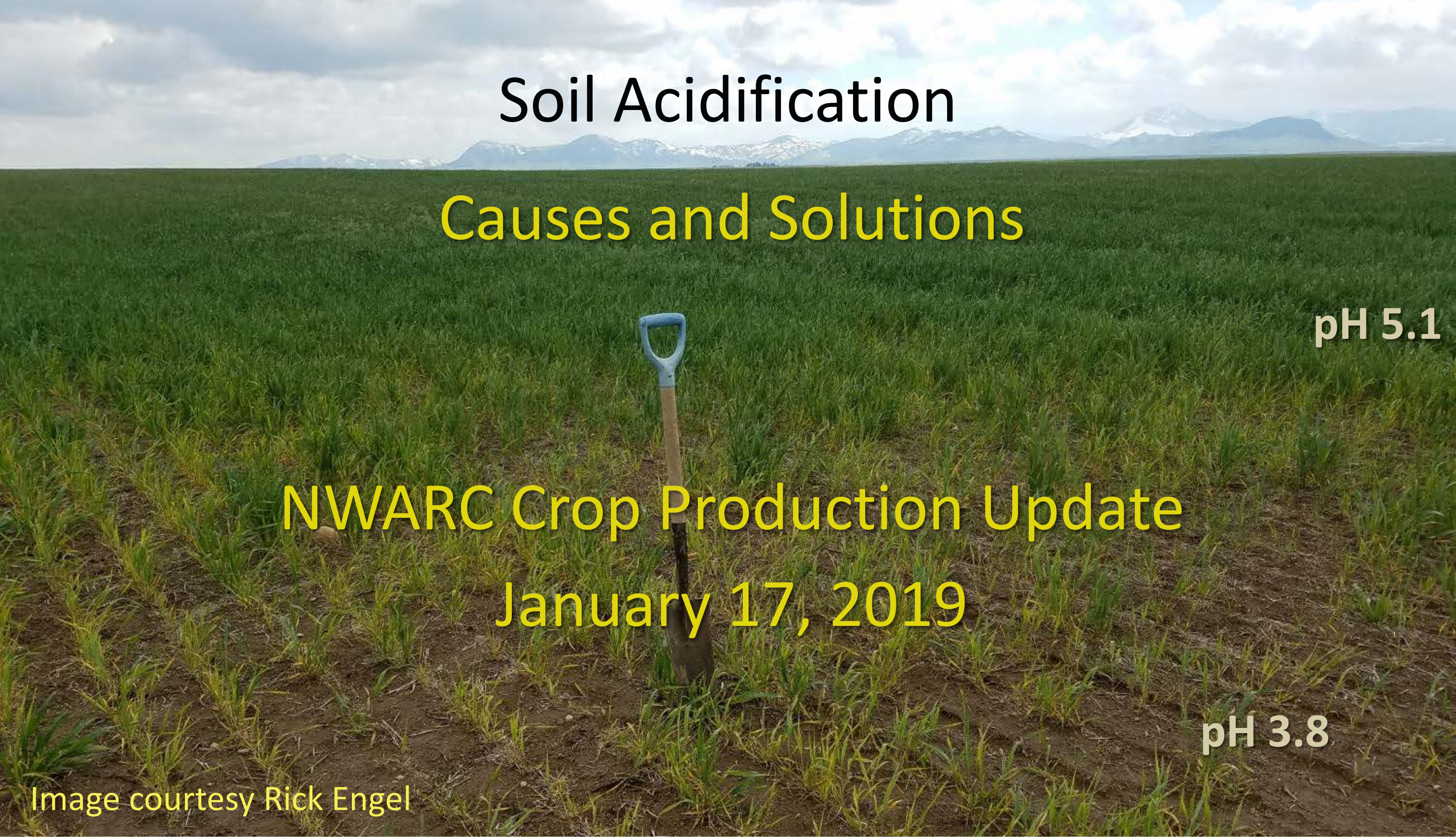
Soil Acidification

Causes and Solutions



NWARC Crop Production Update

January 17, 2019

Image courtesy Rick Engel

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MONTANA STATE UNIVERSITY

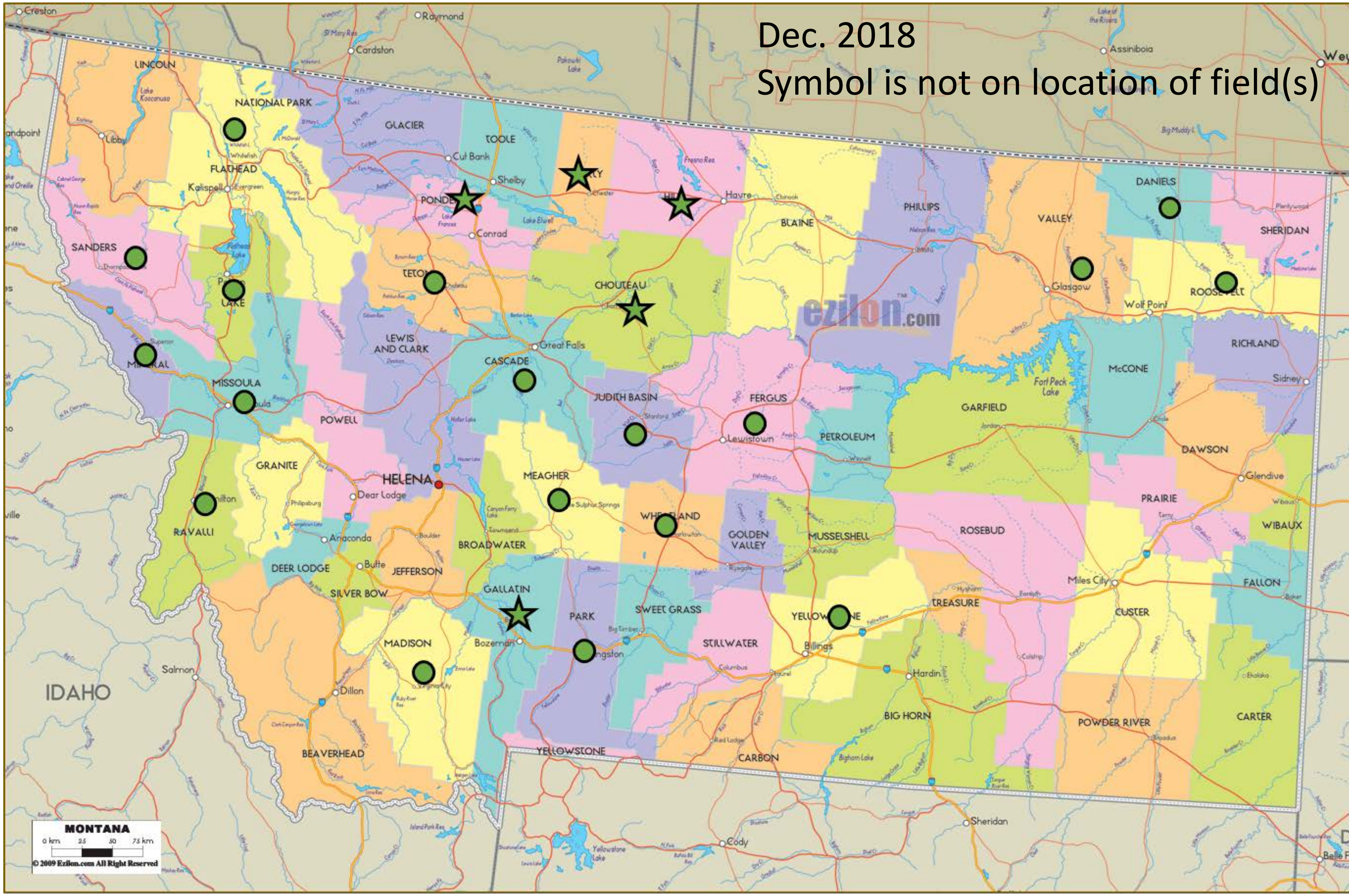
MSU Soil Fertility Extension

Objectives

1. Show prevalence of acidification in Montana (similar issue in WA, OR, ID, ND, SD, and CO)
2. Review acidification's cause and contributing factors
3. Depict low-pH soil affected crops
4. Present ways to identify low soil pH
5. Discuss steps to prevent or reverse acidification
6. Suggest crop management options in low pH soil

The Montana Fertilizer Check-Off and the Western Sustainable Agriculture Research and Education Program help fund our studies.

Prevalence: MT counties with at least one field with pH < 5.5



☆ Measured by MSU ● Reported by CCA, Ext. Agent, or producer

40% of 20 random locations in Chouteau County have pH < 5.5 in top 2”

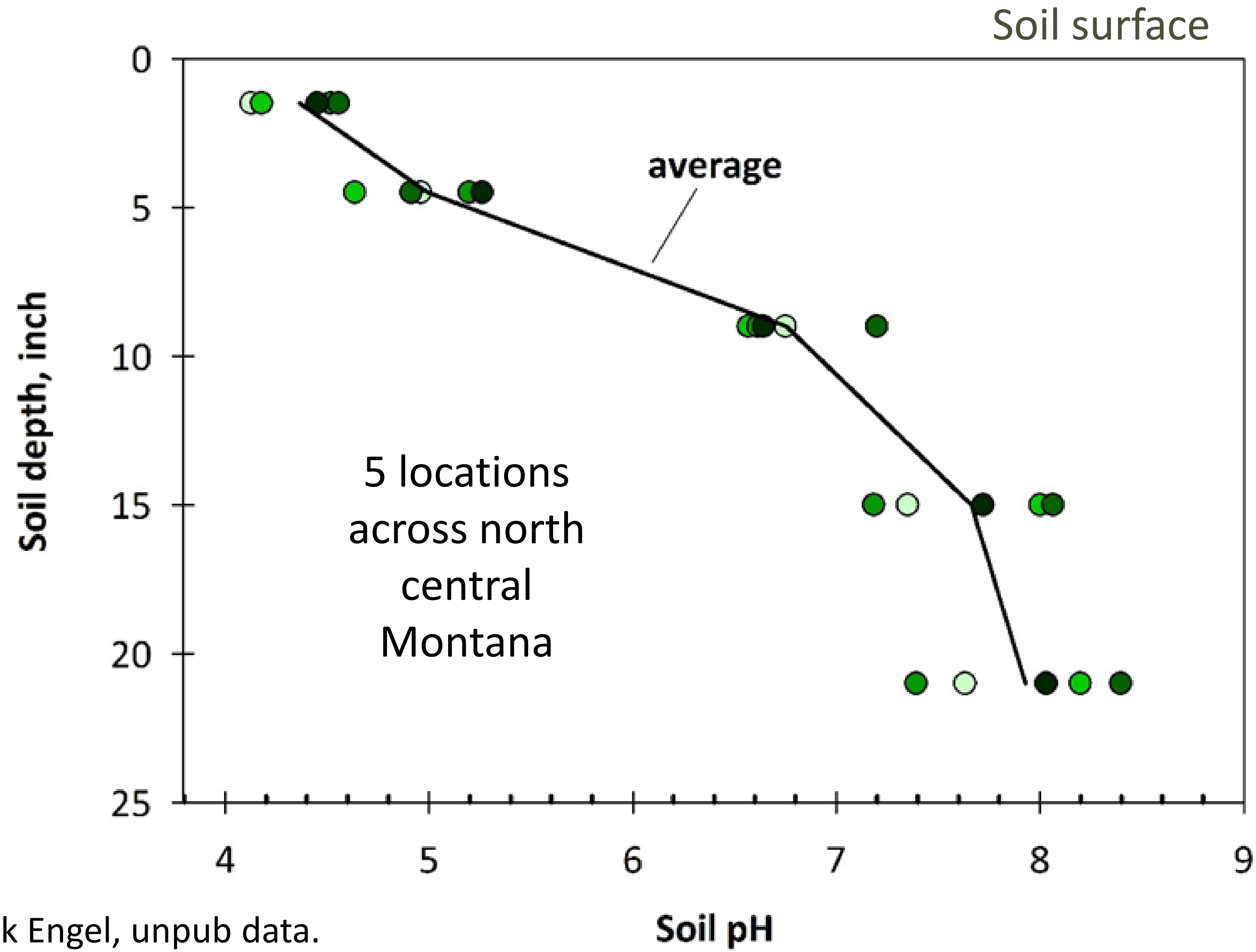
Agronomic reasons for low soil pH

- Ammonium-based N fertilizer above plant needs due to nitrification:

ammonium or urea fertilizer + air + $H_2O \rightarrow$ nitrate (NO_3^-) + acid (H^+)

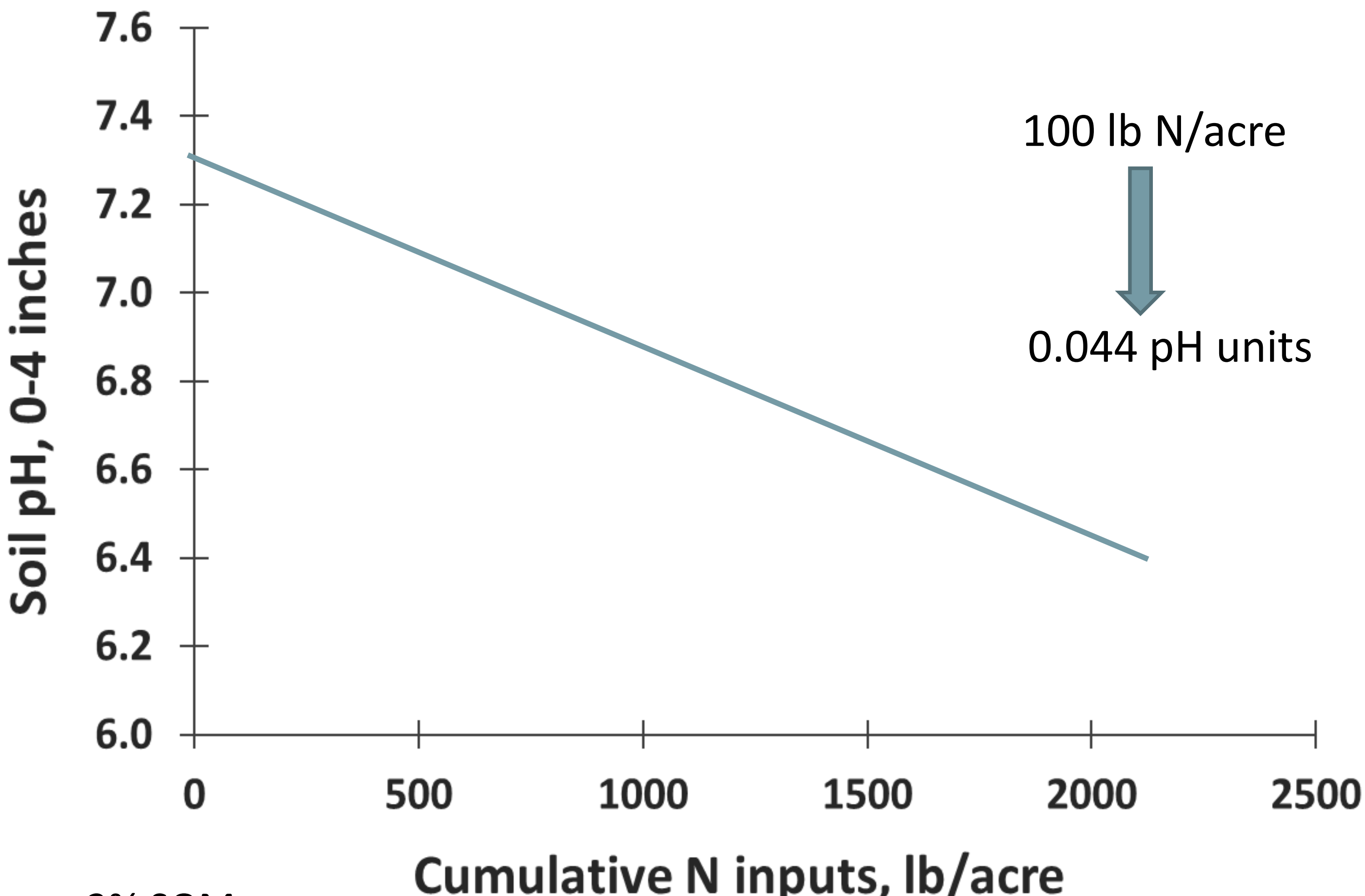
- Leaching loss of nitrate: less nitrate to take up = less root release of basic anions (OH^- and HCO_3^-) to maintain neutral charge in root. Concern under irrigation, sandy soils
- Crop residue removal: removes Ca, Mg, K (‘base’ cations)
- No-till concentrates acidity where N fertilizer applied, though occurs in tilled soils too.
- Legumes acidify their rooting zone through N-fixation. Perennial legumes (e.g., alfalfa) more so than annuals (e.g., pea). Yet apparently much less than fertilization of wheat.

Low soil pH in Montana's historically calcareous soils is generally only in upper 6 inches



Rick Engel, unpub data.

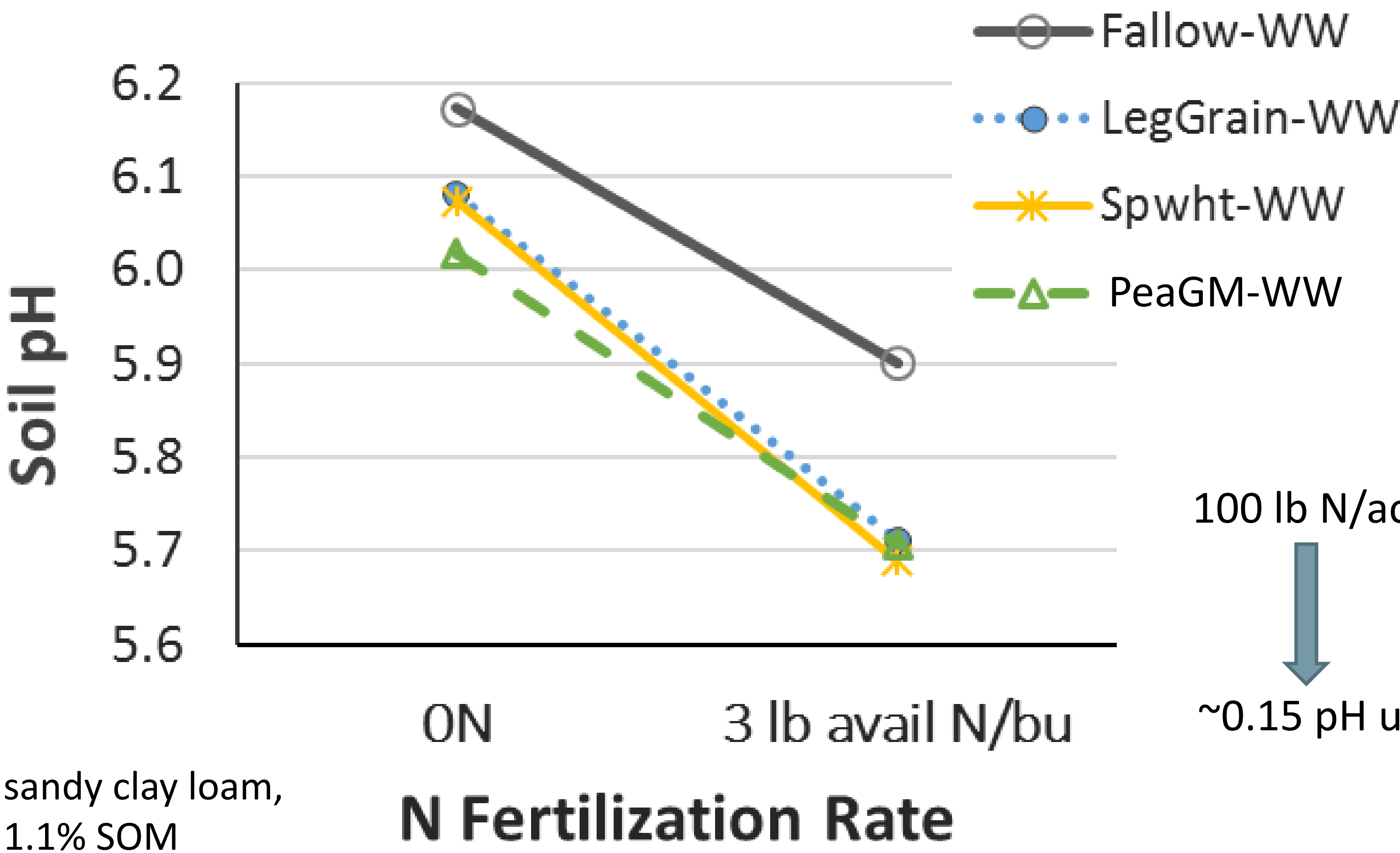
14-yr of N fertilization reduce top 4” pH on dryland cropping west of Bozeman up to 1 pH



Silt loam, 2% SOM

Engel, Ewing, Miller, unpub data

6-yr N fertilization reduce soil pH (0-3") west of Big Sandy



100 lb N/acre

~0.15 pH units

sandy clay loam,
1.1% SOM

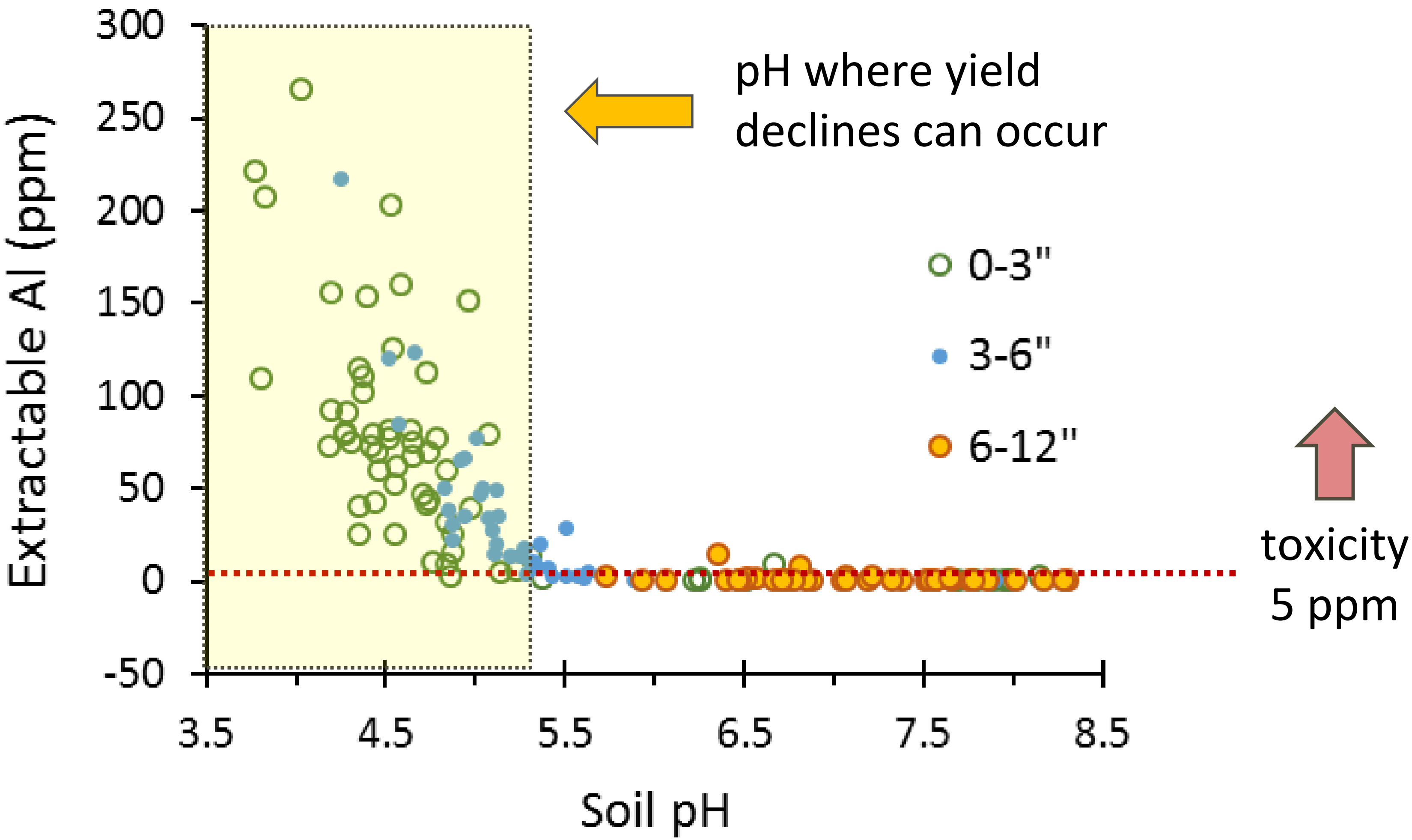
Alternate year was always winter wheat; Jones and Miller unpub data

Have any of you seen decreases in soil pH?

Questions?

On to identifying low soil pH

Dropping pH increases aluminum availability



R. Engel unpub data, 5 locations in north-central MT

What to look for

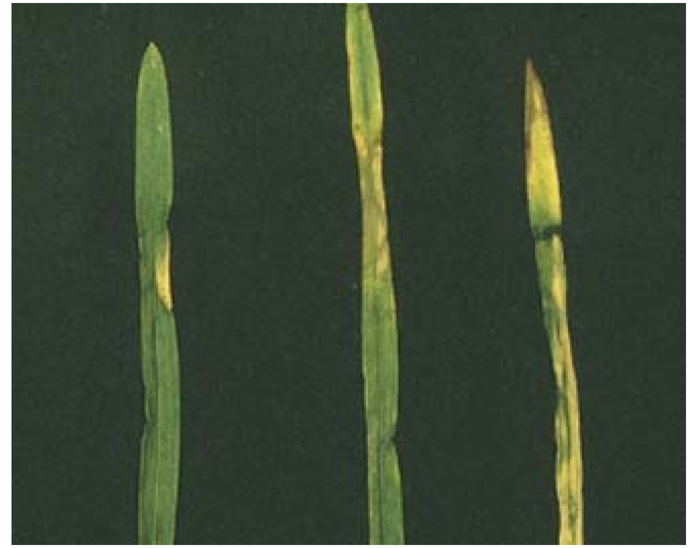
- Unexplained poor health in low or mid-slope areas
- **Al** toxicity
  - stubby club roots, no fine branching (similar to nematode damage)

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

photo sources: Engel

Above ground symptoms of Al toxicity

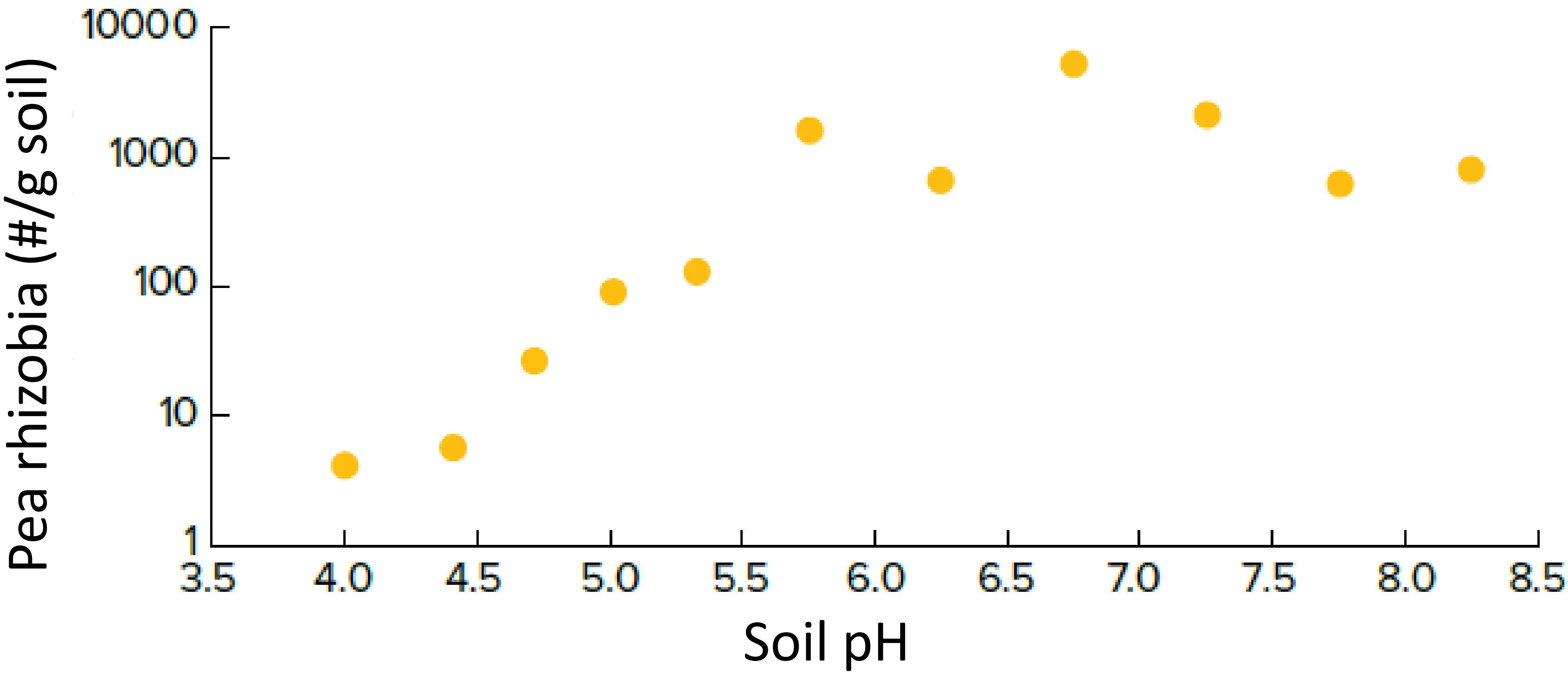
- small leaves, short thick internodes
- yellow along margin near tip on older leaves
- purple or brown lesions in chlorotic regions, indentations
- leaf withering and collapse in center
- similar to N deficiency



Courtesy CIMMYT.org

courtesy Engel

Poor N fixation may be indicator of low pH



Note: Vertical axis goes up by factor of 10s!

Drew et al. 2014

Acid soils have additional negative impacts

- Change in herbicide efficacy and persistence – unexplained damage may indicate pH change.
- Increase in some fungal diseases (e.g., Cephalosporium stripe)
- Mn toxicity – has not yet been found an issue in MT
- Toxic H^+ levels (Kidd and Proctor, 2001, Scotland)

Barley: Thom Weir, FarmersEdge

Image from *Wheat Disease ID*. MWBC

Have any of you seen 'unexplained' poor crop health or low N fixation?

Questions?

On to management

Diagnose: scout, soil test

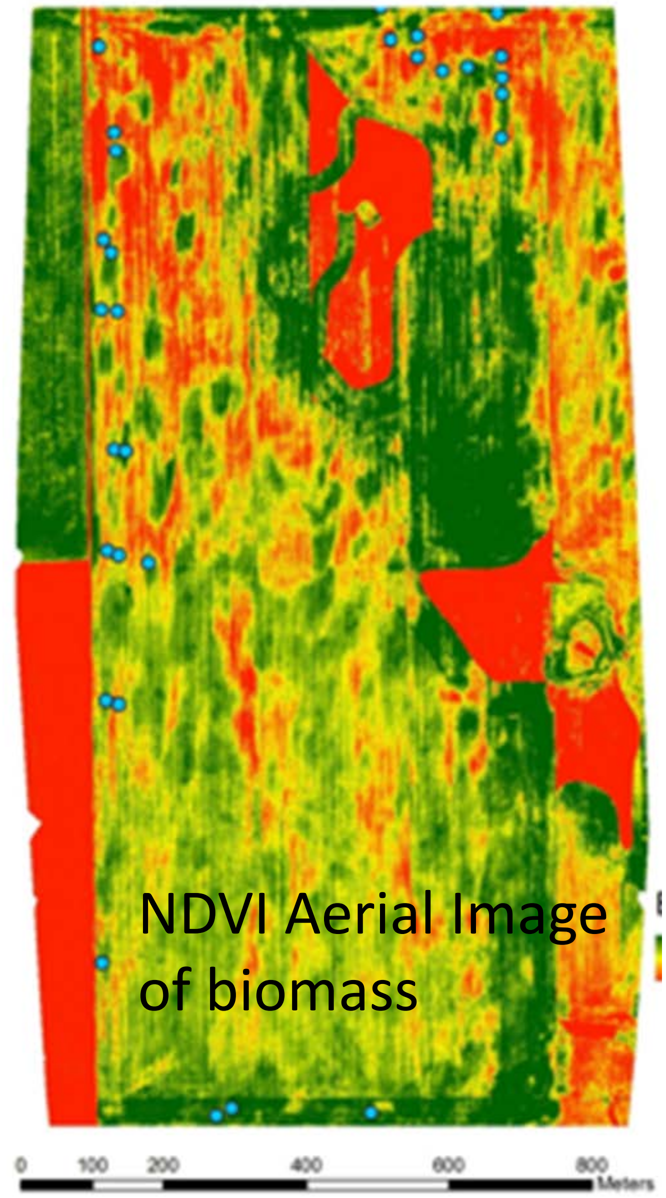
Look at pH on prior soil tests from composited samples

- pH < 6 likely have spots with pH ≤ 5
- 6 < pH < 7.5 don't assume no areas have low pH
- pH > 7.5, likely don't have problem (yet).

Symptoms are not uniform across field landscapes

Ask crop adviser to soil test differently than normal

1. Scout or use aerial maps to locate healthy and unhealthy areas
2. field pH test, use soil/water slurry of top 3”. Why not the standard 6”?
3. Avoid compositing samples from different slope areas.
4. Send 0-3” depth sample to lab for pH (<5?). Test 3-6” if might till.
5. pH varies seasonally and annually, test from same area and time of year by same lab using same procedure to see trend
6. Veris can also sample for pH



Management to prevent acidification:
Increase N fertilizer use efficiency/reduce leaching

- Soil test close to application time. Make sure enough PKS
- Use conservative pre-plant rate, top-dress as needed
- Apply N close to peak crop uptake
- Reduce N rates especially when protein discounts low
- Use variable, site specific rates: Less N in low production areas
- Change N source: minimize MAP (11-52-0) and AS (21-0-0-24), include legumes, manure if available. Consider gypsum as sulfur source

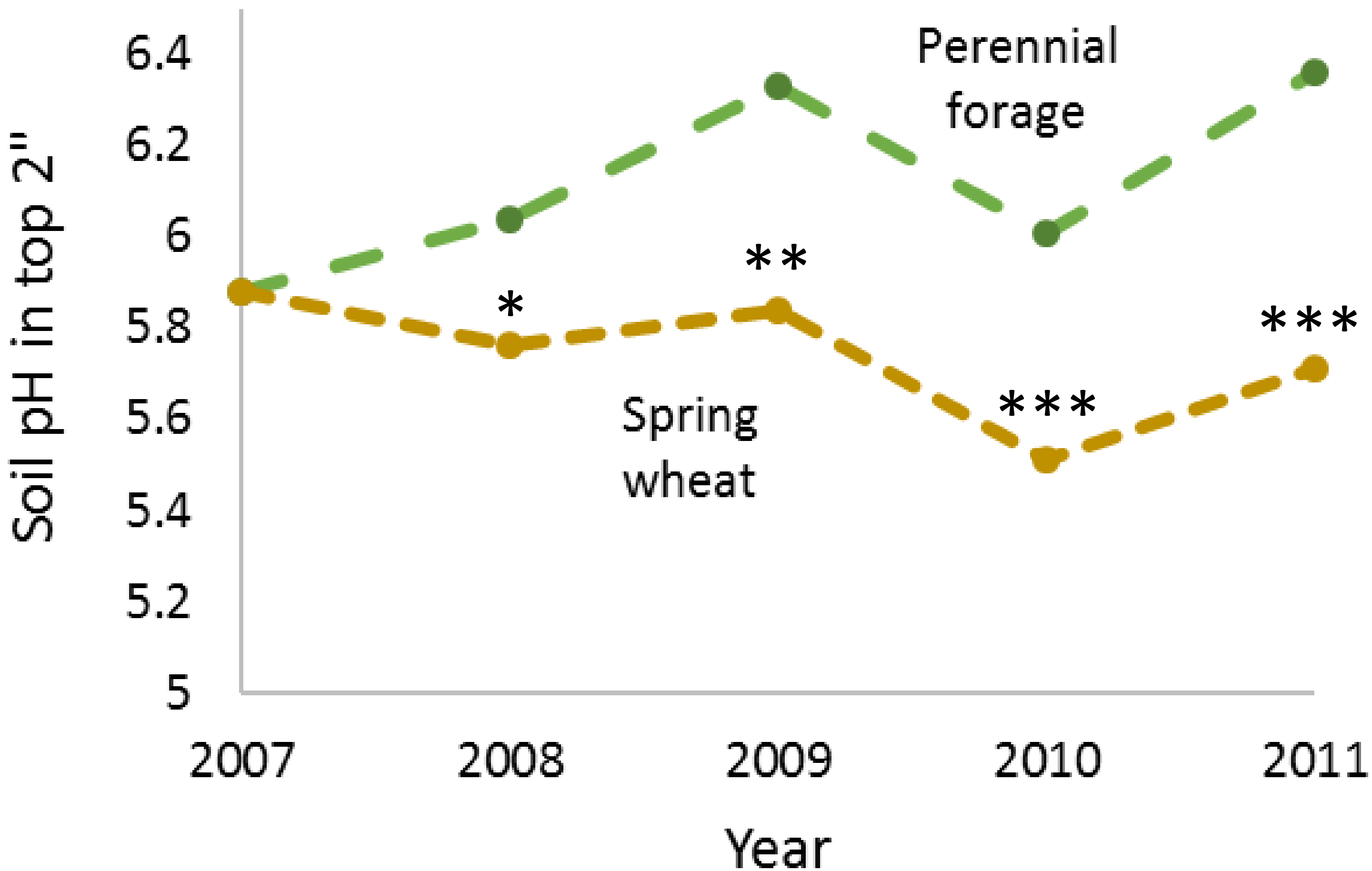
More management options

Image by K. Olson-Rutz

- Leave crop residue in field – retains base cations and SOM buffers pH changes and Al toxicity
- Legumes in rotation – no N fertilizer and residue increases soil surface pH more than non-legumes (Paul et al., 2003)
- Inversion till to mix acid zone throughout plow layer – one-time summer tillage doesn't negate long term benefits of no-till (Norton et al., 2014)

If consider the cost of liming to remediate acidification, and/or lost yield, changing 'standard' practices may be economically reasonable.

Perennial forage can maintain or increase soil pH



pH differs between crops with * > 90%, ** > 95%, *** > 99% confidence Mandan, ND Liebig et al., 2018

Seed-placed P_2O_5 a quick acting 'band-aid' to increase wheat yield even when (or only when?) P soil test is sufficient

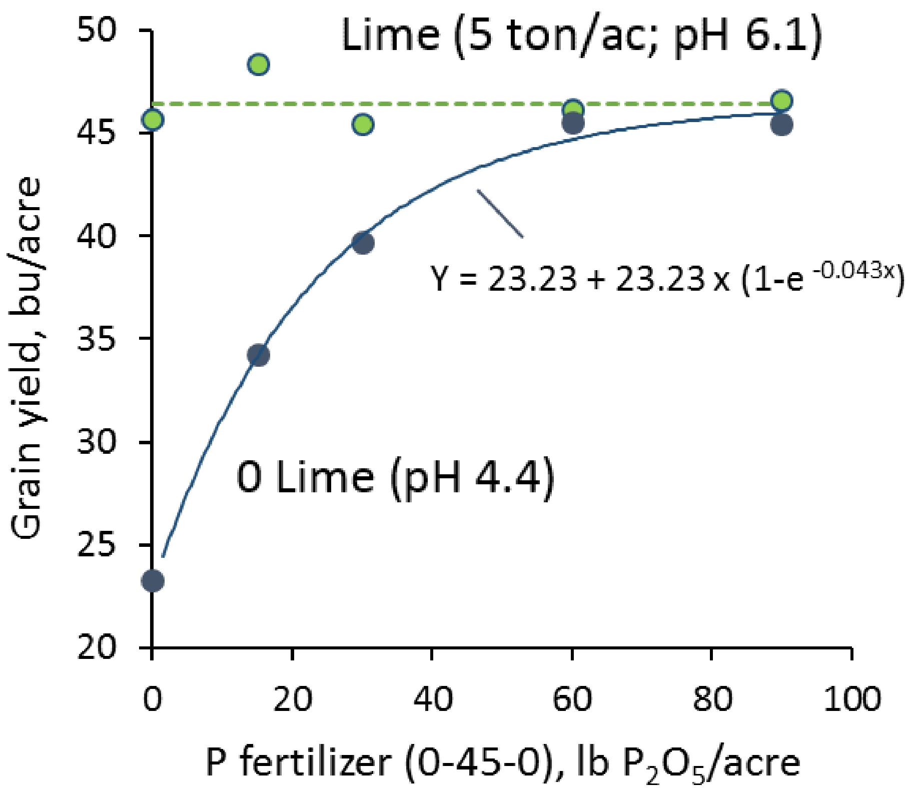
Soil pH 4.4, Olsen P = 49 ppm

0 P_2O_5

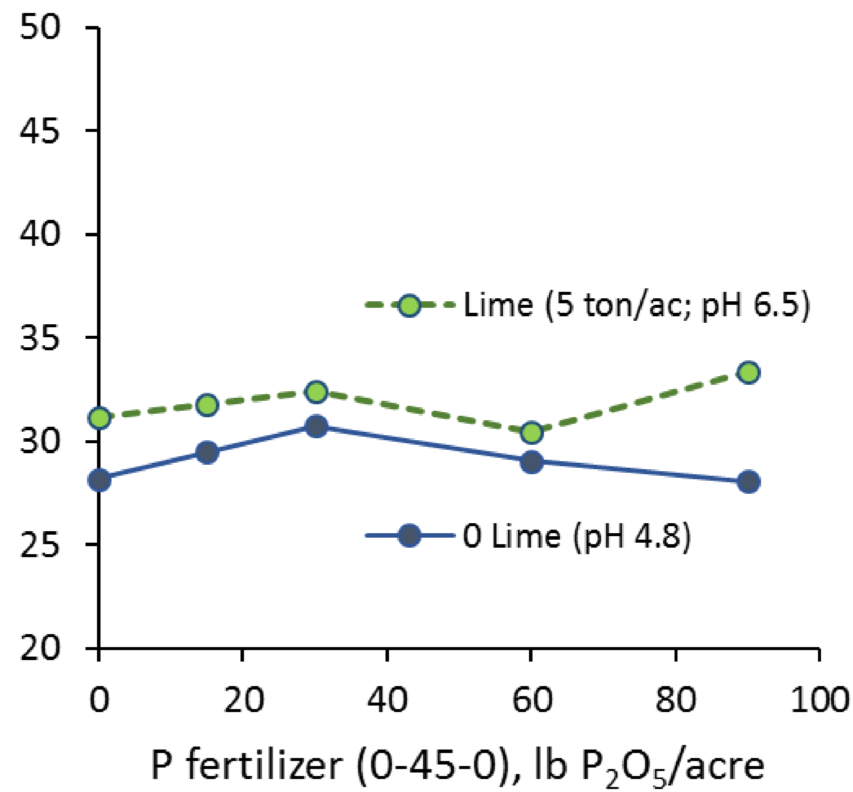
Engel unpub data

90 lb P_2O_5/acre

Seed-placed P_2O_5 or lime increased durum grain yield significantly at pH 4.4 site,



Olsen P = 48 ppm



Olsen P = 53 ppm

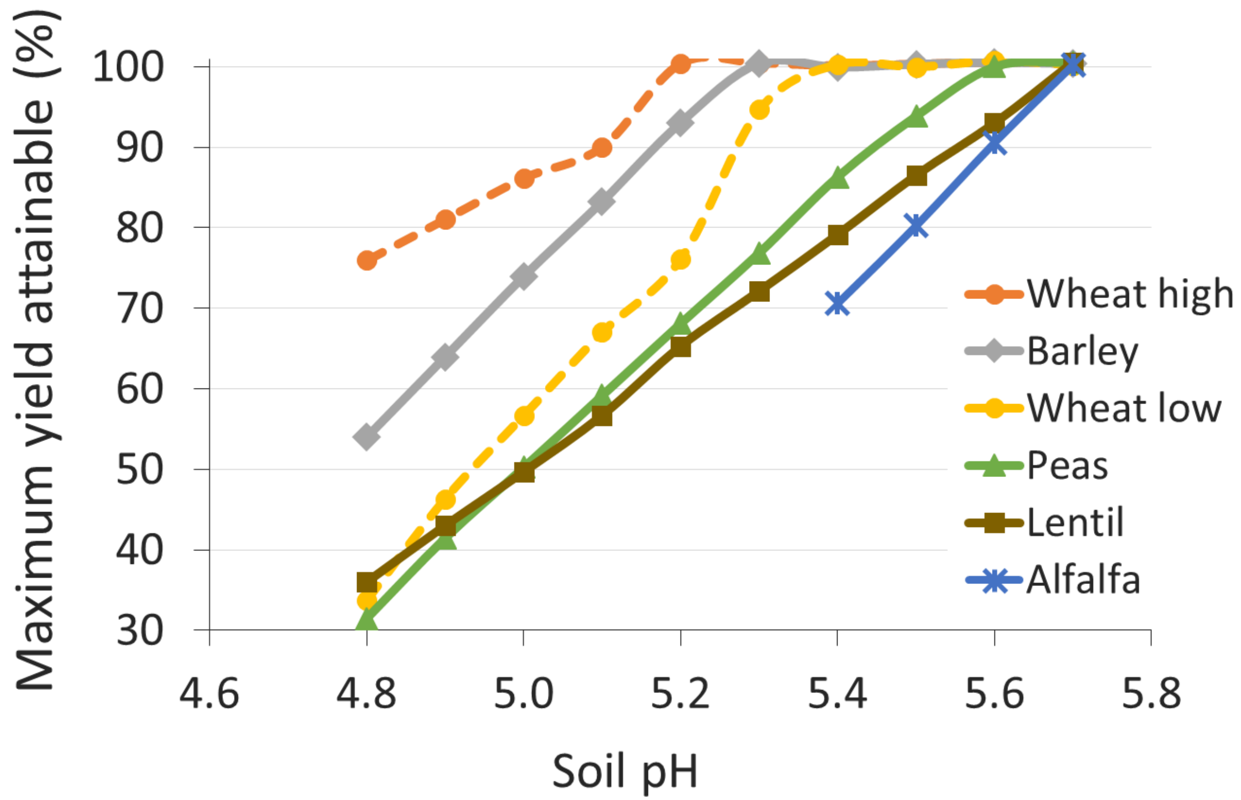
Note at lower pH site, lime or seed-P increased yield by 22 bu/ac!

Engel unpub data

Managing low pH: Adapt

- Plant Al-tolerant crops or varieties, MT variety trial results are available at http://landresources.montana.edu/soilfertility/acidif/index.html

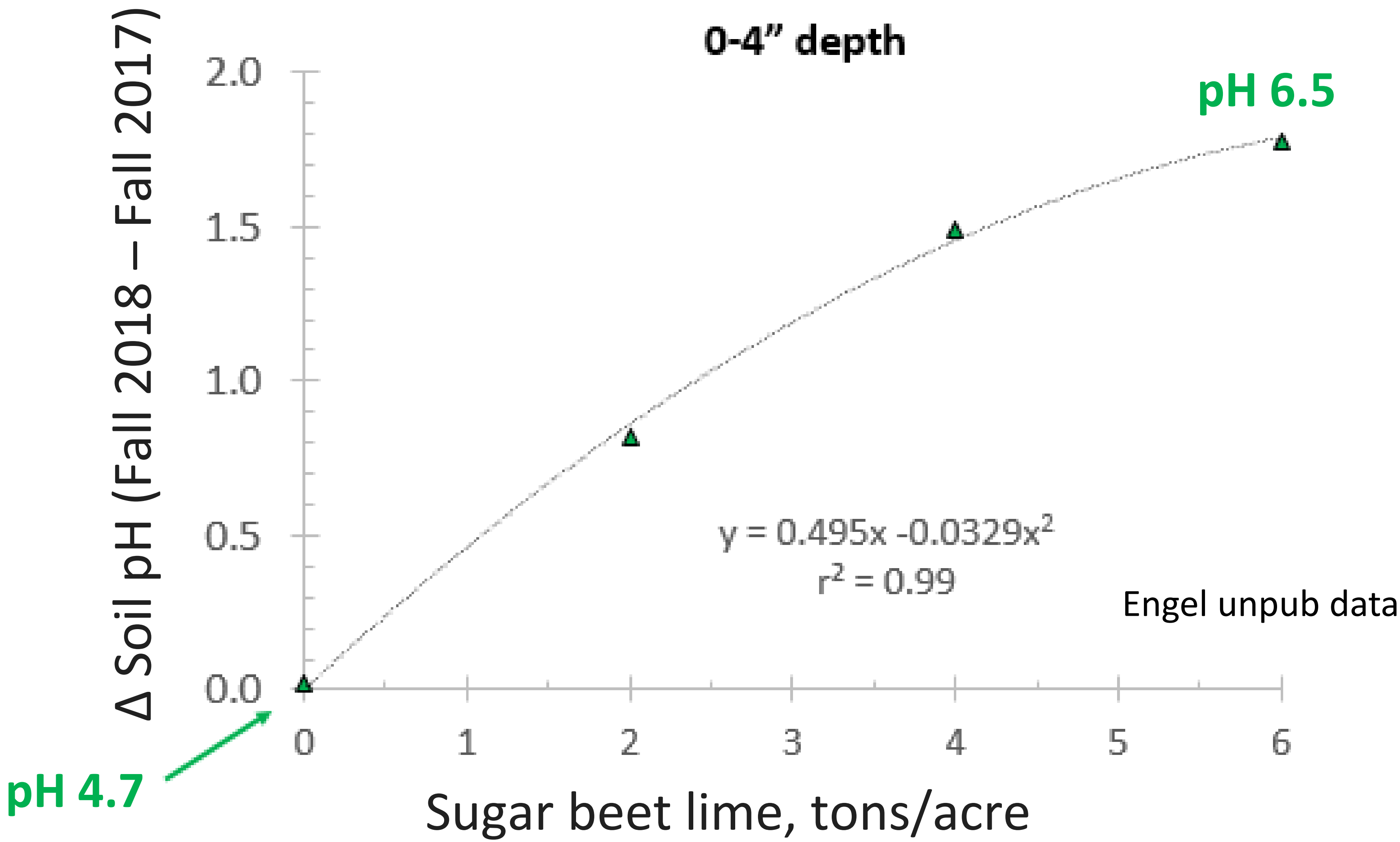
- Fertilize after vulnerable seedling stage
- Seed deeper?



"Wheat high" are Al and acid tolerant varieties

McFarland et al., 2015

Managing low pH: Remediate with lime



- A lot of lime is required to impact soil pH
- Only lime areas with low pH

Summary

- Cropland soils are becoming more acidic, largely due to N fertilization
- This reduces yields for several reasons
- Good new is: if identify a problem **now,** can slow or prevent acidification with sound management
- Selecting crop rotations with lower N needs is likely best way to prevent further acidification
- Crop and variety selection and seed-placed P fertilization can help adapt to acid soils
- Liming, perhaps tilling, or planting perennials can mitigate acidification

Thank you!

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

For more information and links to additional resources on soil acidification see MSU's cropland soil acidification website
http://landresources.montana.edu/soilfertility/acidif/index.html

Questions?