Soil Acidification

How to Diagnosis, Prevent, Adapt

CARC Research Roundup, Lewistown

December 10, 2019

Image courtesy Rick Engel

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MONTANA STATE UNIVERSITY

MSU Soil Fertility Extension and CARC

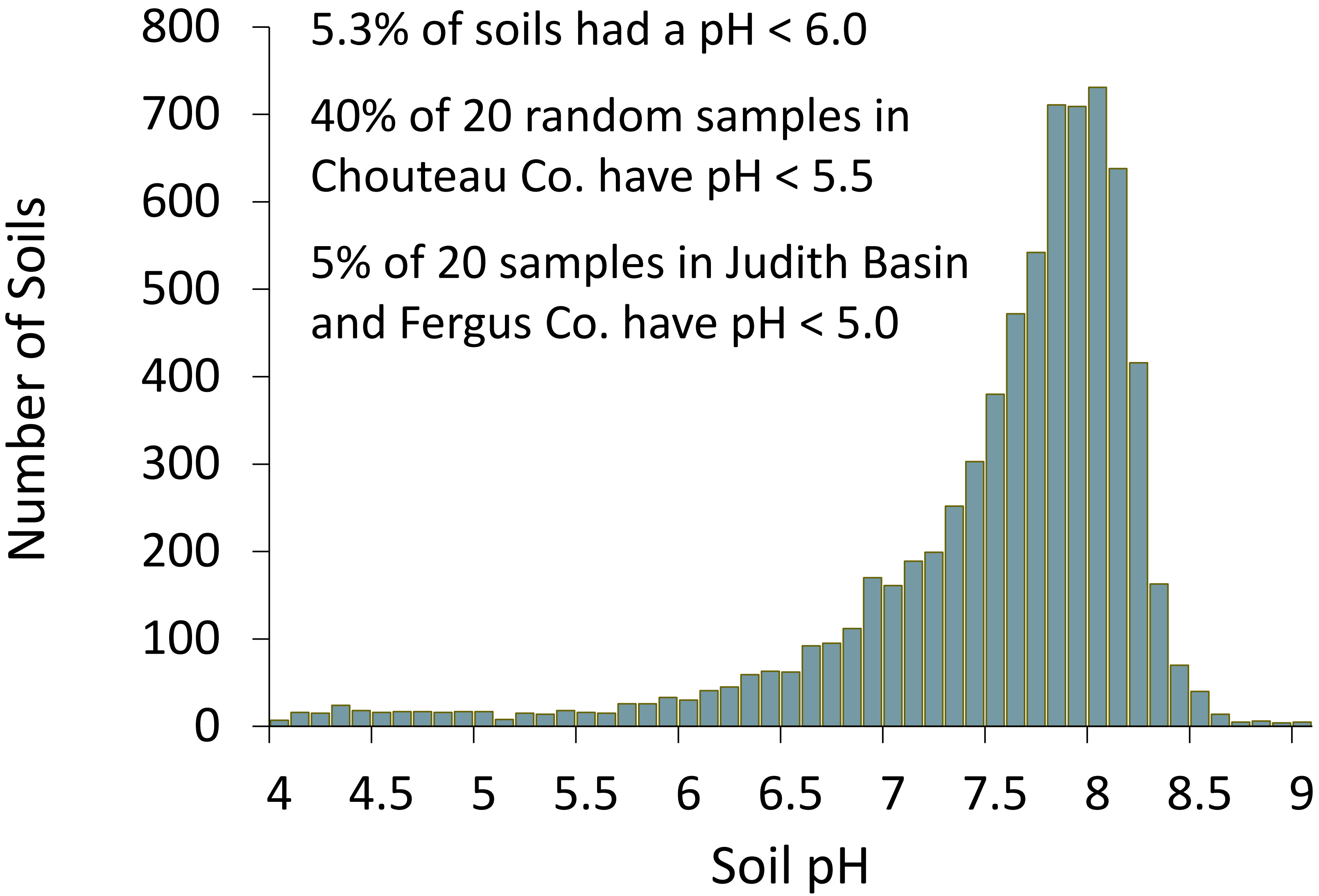
Objectives

Safflower field near Big Sandy by Scott Powell

1. Show prevalence of acidification in Montana (similar issue in WA, OR, ID, ND, SD, CO, AB, and SK)
2. Review acidification's cause and contributing factors
3. Show plant symptoms in low-pH soil
4. Suggest soil sampling approaches
5. Discuss steps to prevent 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.

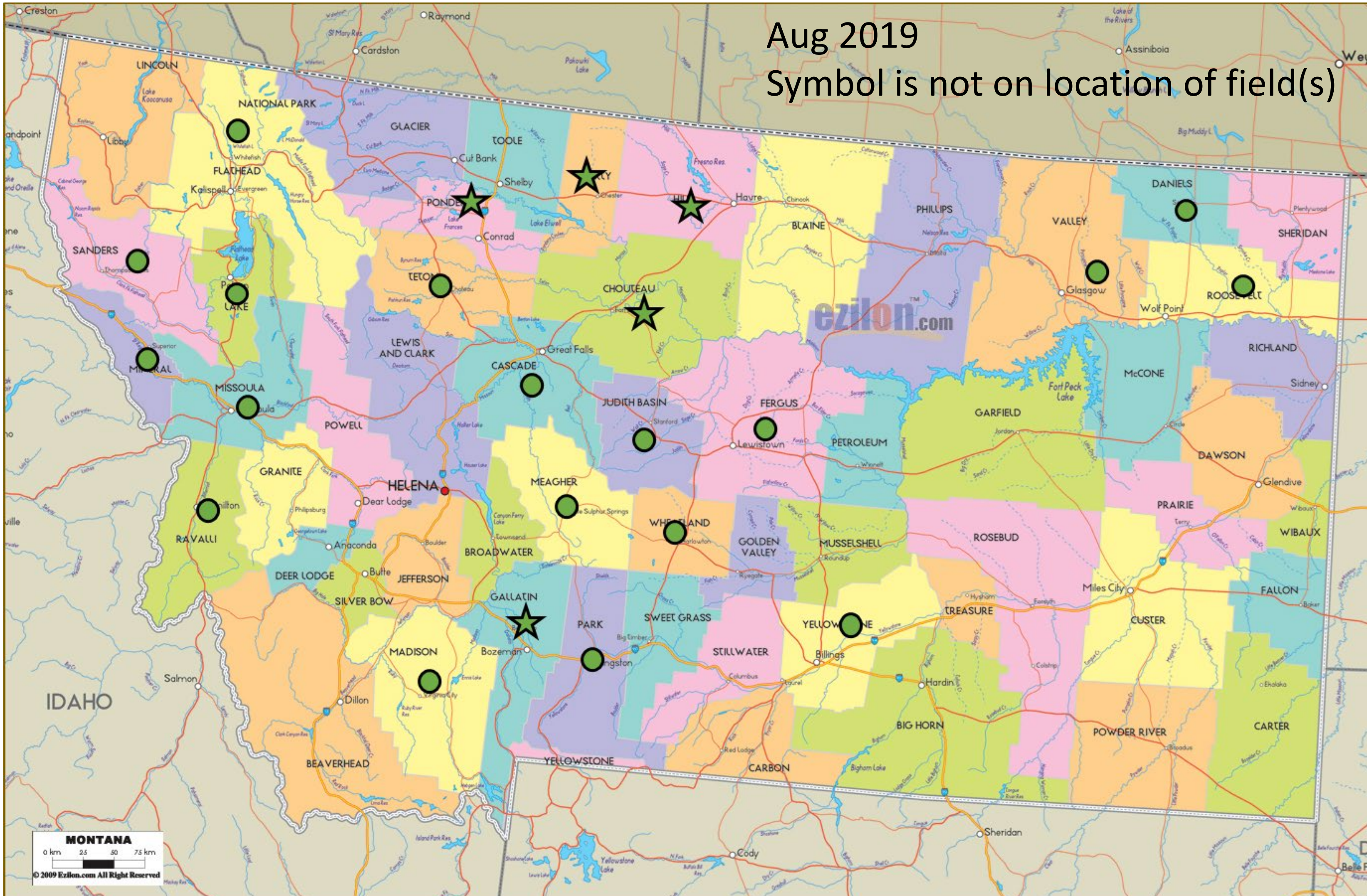
Soil pH distribution north central MT, 2018



AgVise Lab, ND, 7,130 samples, 1 year.

Graphed by Bob Miller, Agriculture Laboratory Proficiency (ALP)

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

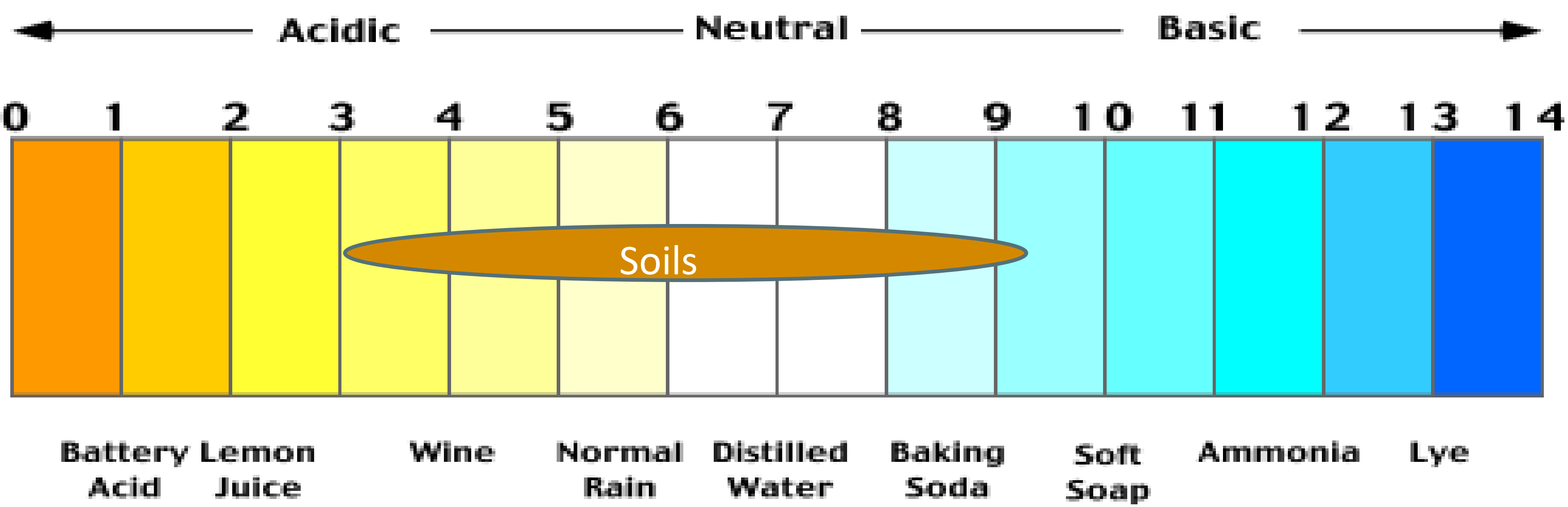


☆ Measured by MSU ● Reported by CCA, Ext. Agent, or producer

A question for you

How many have found low pH in some portion of your fields:

- <6.0?
- <5.5?
- <5.0?



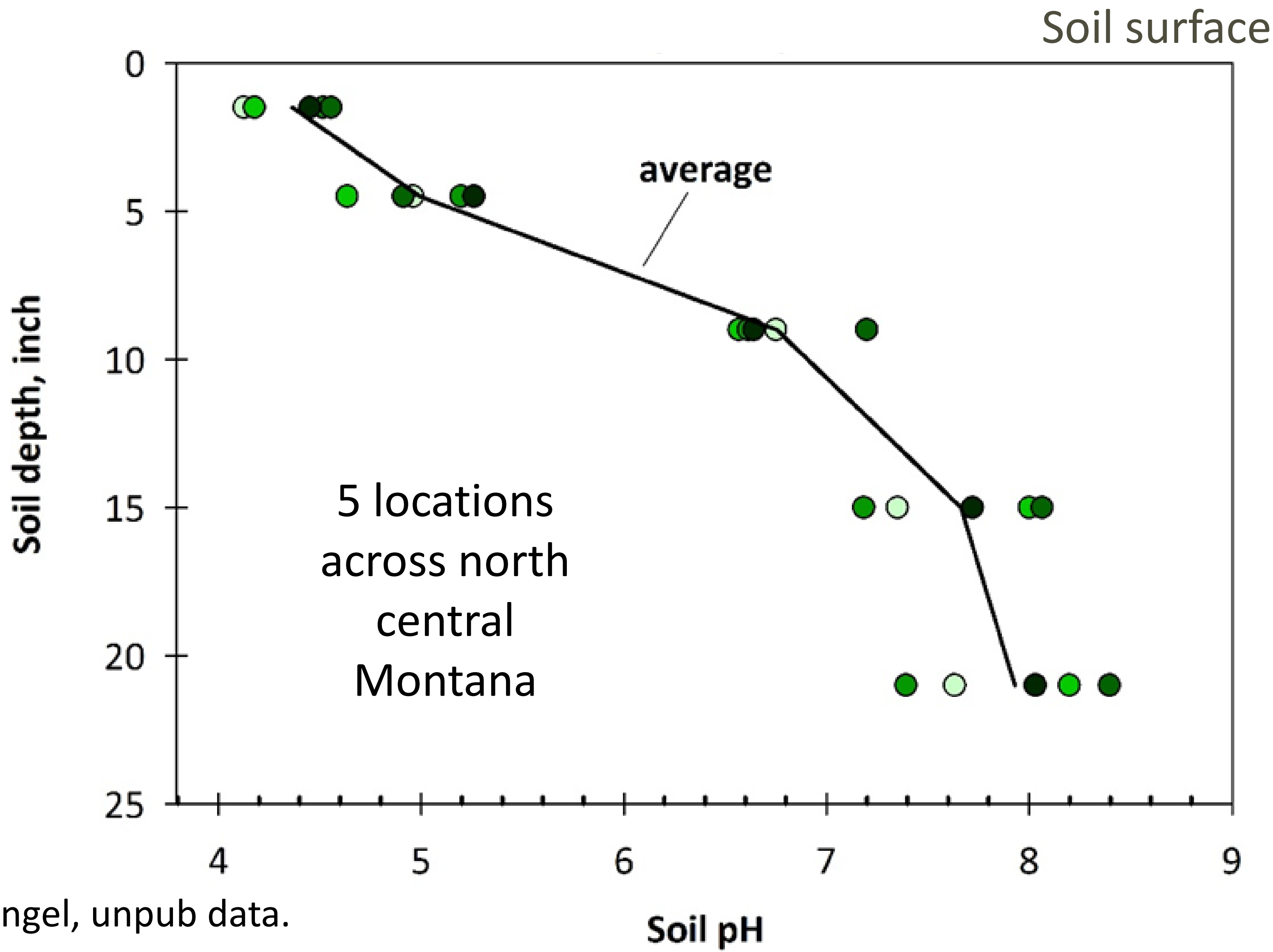
Agronomic reasons for low soil pH

- 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^-)
- Crop residue removal: removes Ca, Mg, K ('base' cations).
- Lack of deep tillage 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). Yet apparently much less than fertilization of wheat.

In no-till, most soil acidification happens near depth of N fertilizer placement = upper 6” in MT’s historically calcareous soils



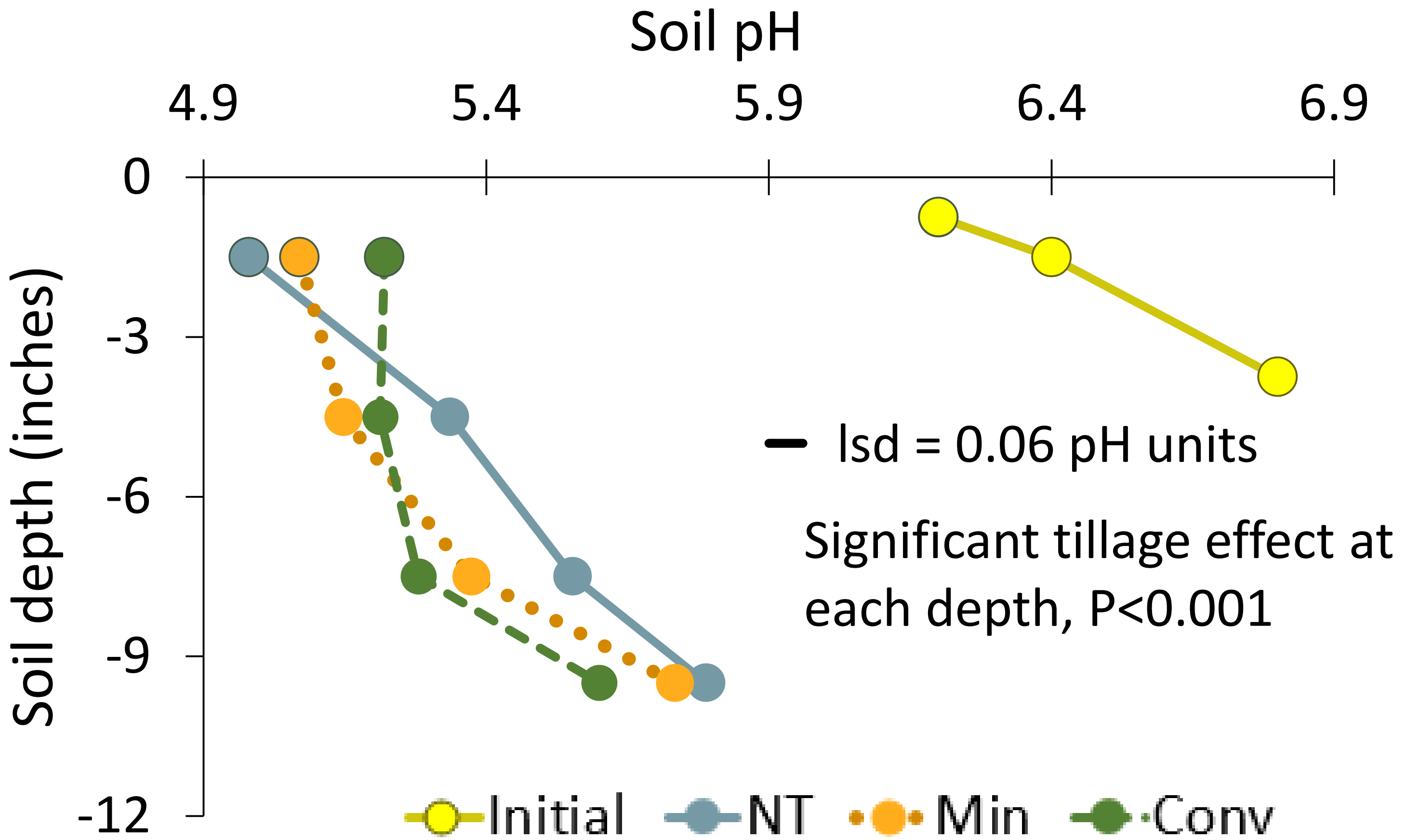
Rick Engel, unpub data.

Effects of N rates, tillage, and crop rotation

N causes acidification, and NT concentrates acidity, but acidification also happens with tillage

No-till often concentrates low pH in top layer.

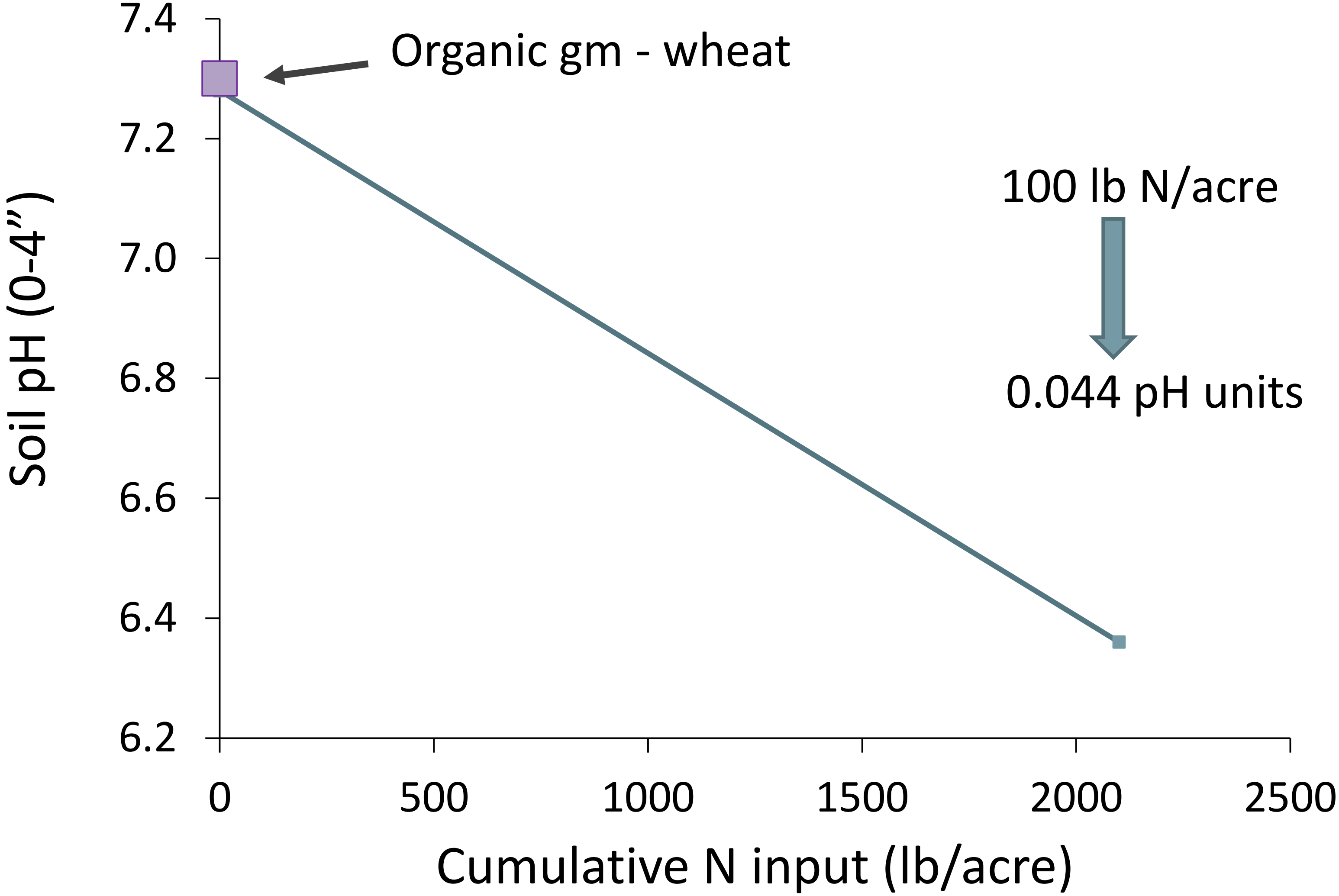
Tillage spreads the low pH across deeper soil



350 to 375 lb N/ac total applied over 8 years

Mahler and Harder 1984, Idaho

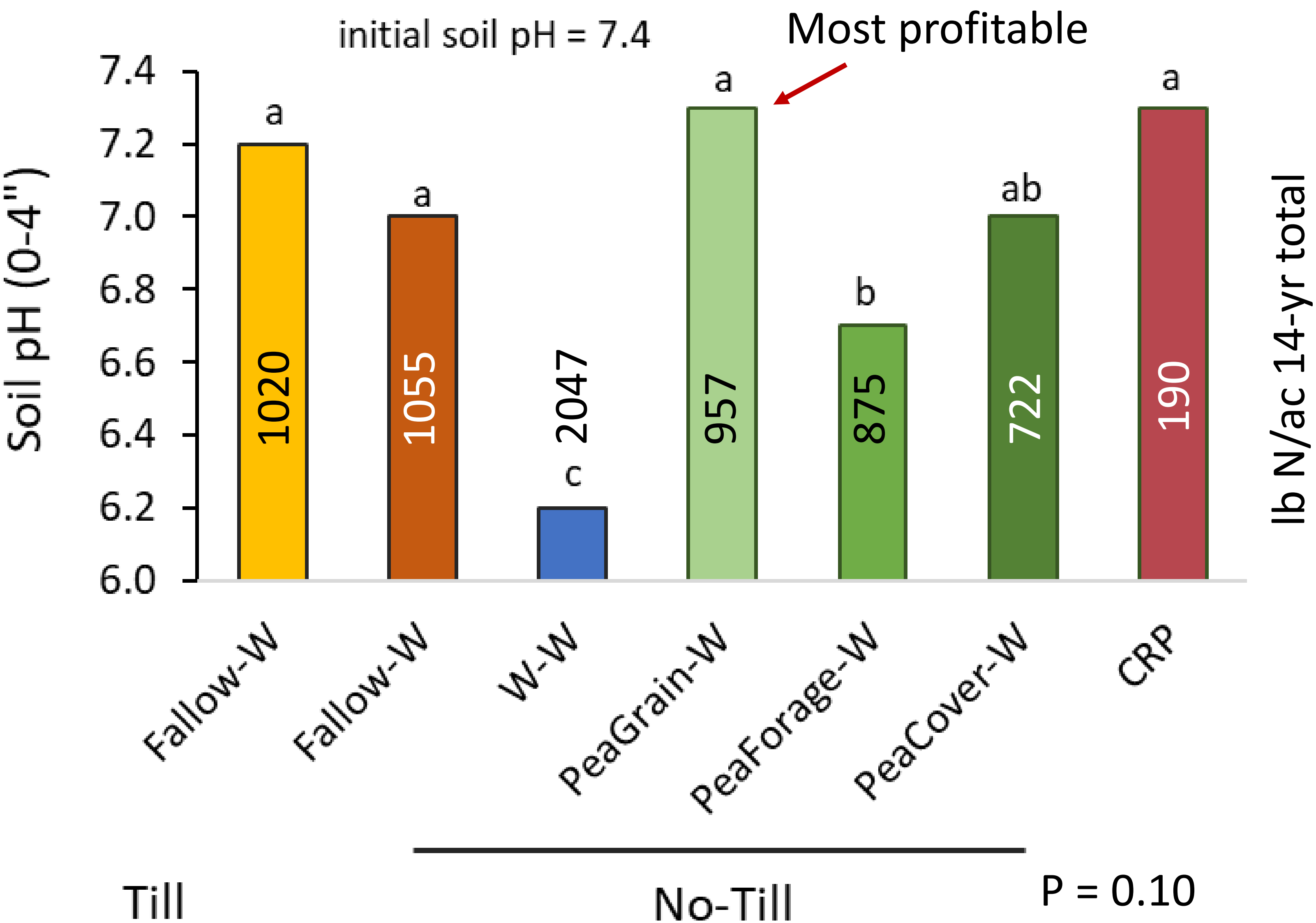
14-yrs of N at recommended rates reduced top 4-inch soil pH in dryland near Bozeman



Silt loam, 2% OM

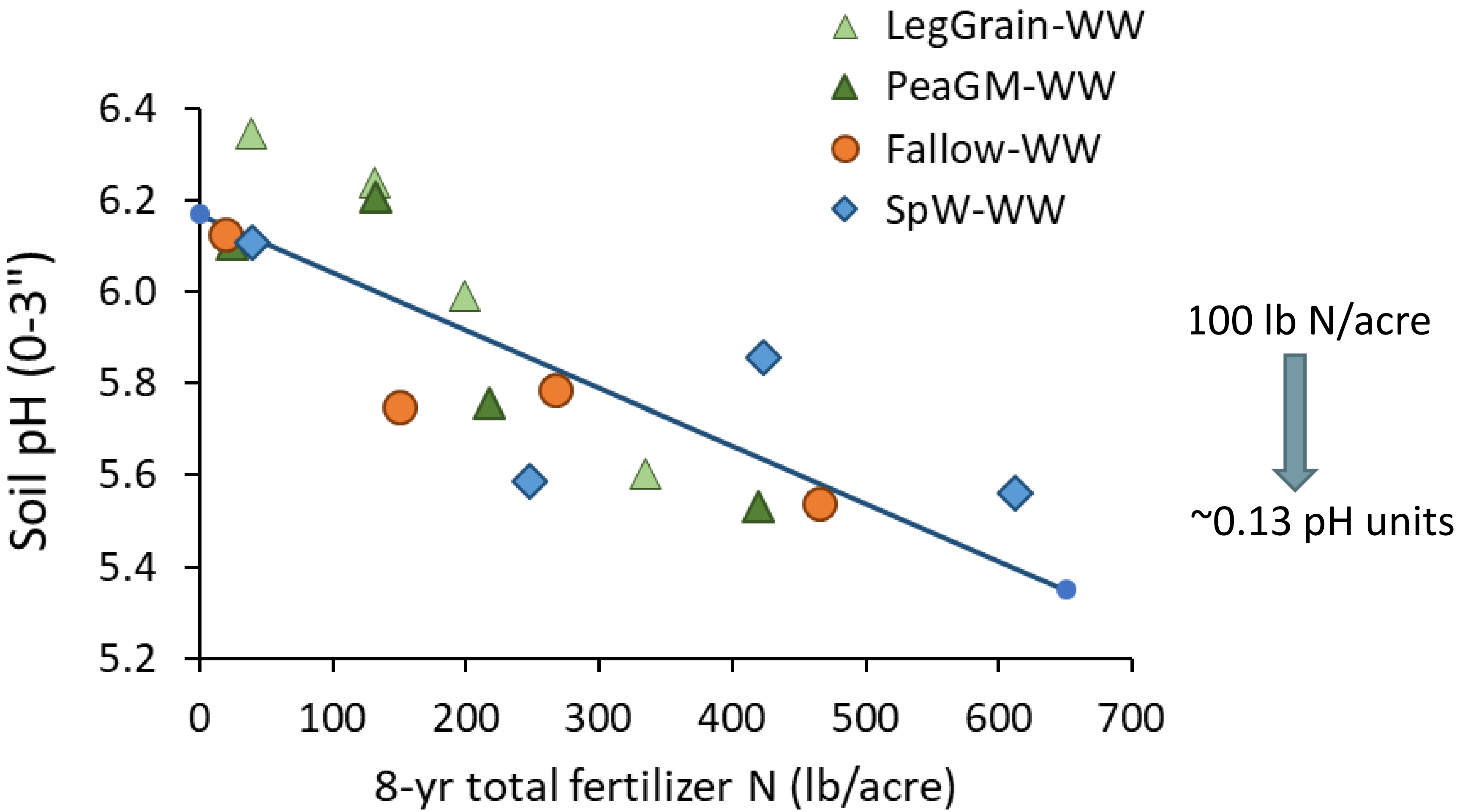
Engel, Ewing, Miller, unpub data

Some rotations reduced top 4-inch soil pH more than others on Gallatin Valley dryland production



R. Engel unpub data

8-yr N fertilization reduce soil pH (0-3”) west of Big Sandy

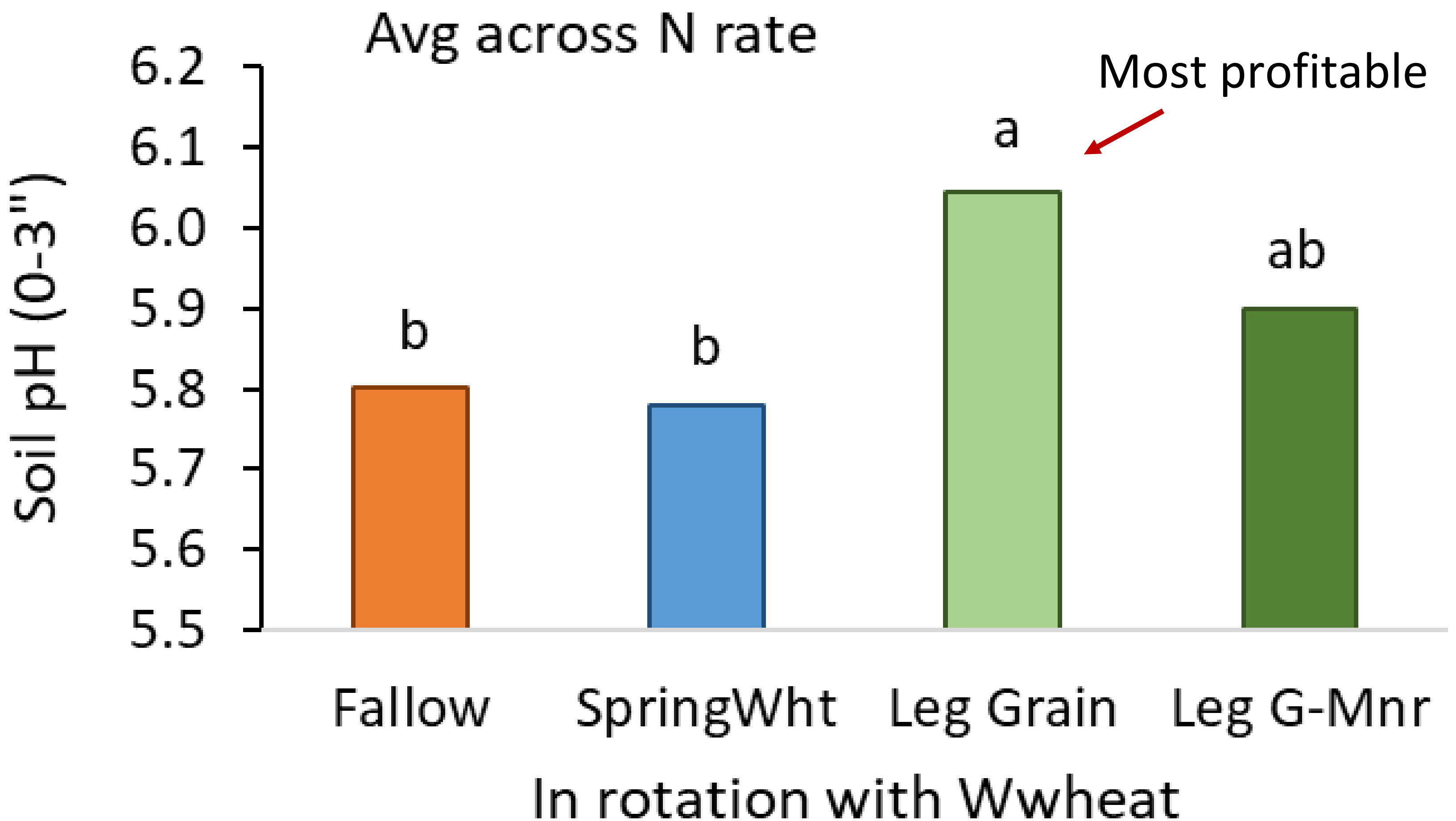


why faster rate?

sandy clay loam, 1.1% OM

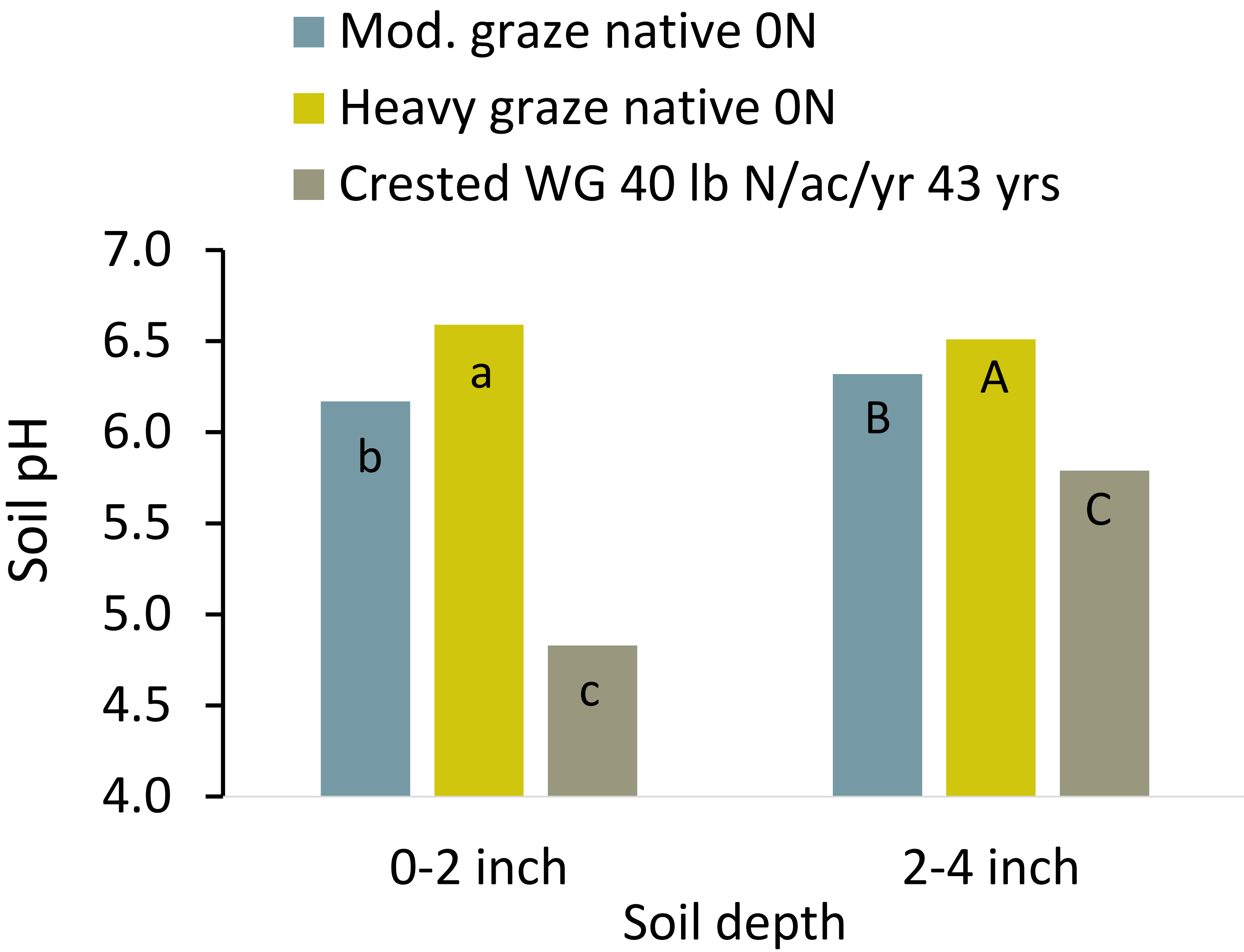
Alternate year was always winter wheat; Jones and Miller unpub data

Some rotations reduced top 3-inch soil pH more than others at Big Sandy dryland production



Jones and Miller unpub data

N fertilization of forage can cause acidification



Liebig et al. 2014, Mandan, ND

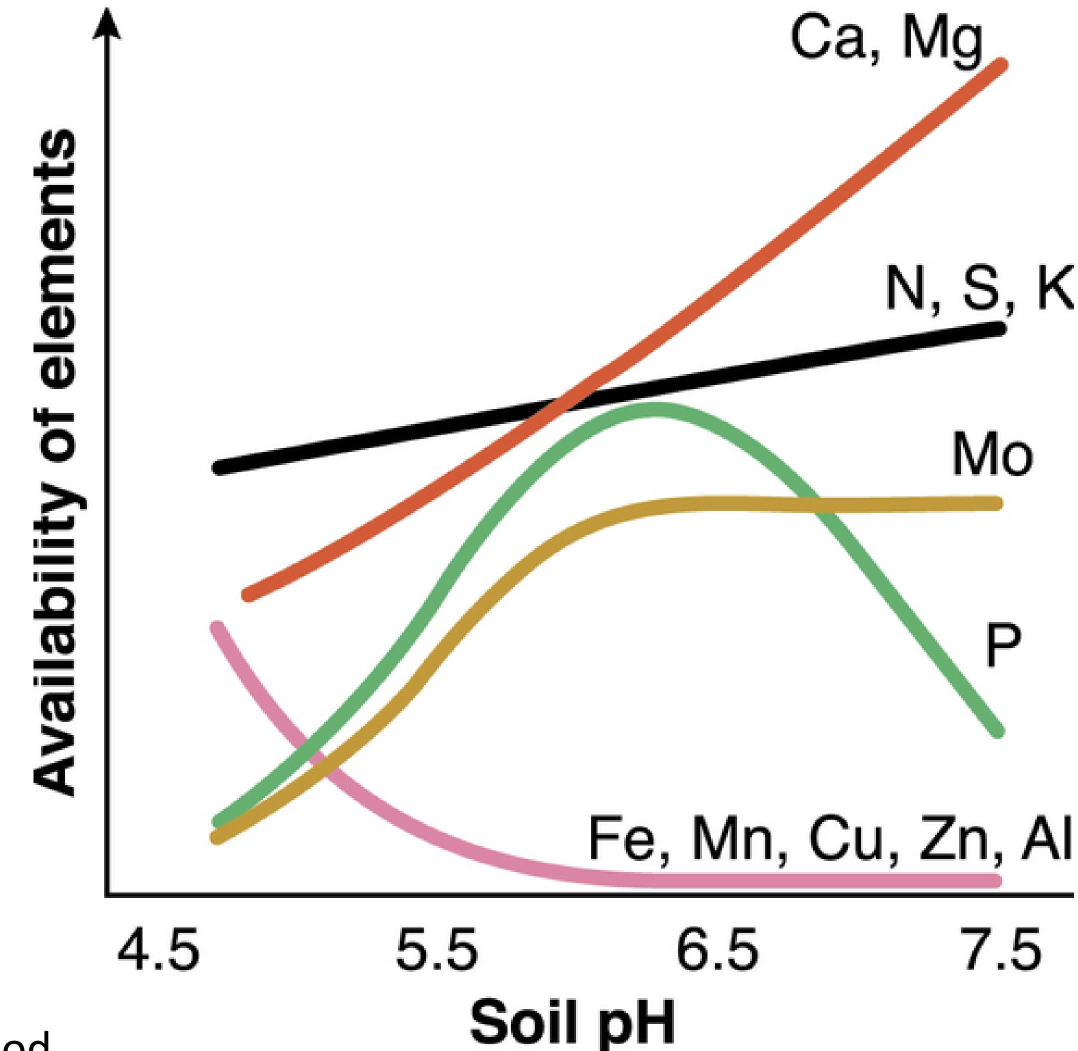
Questions?

On to impact on crop

Soil pH and nutrient availability

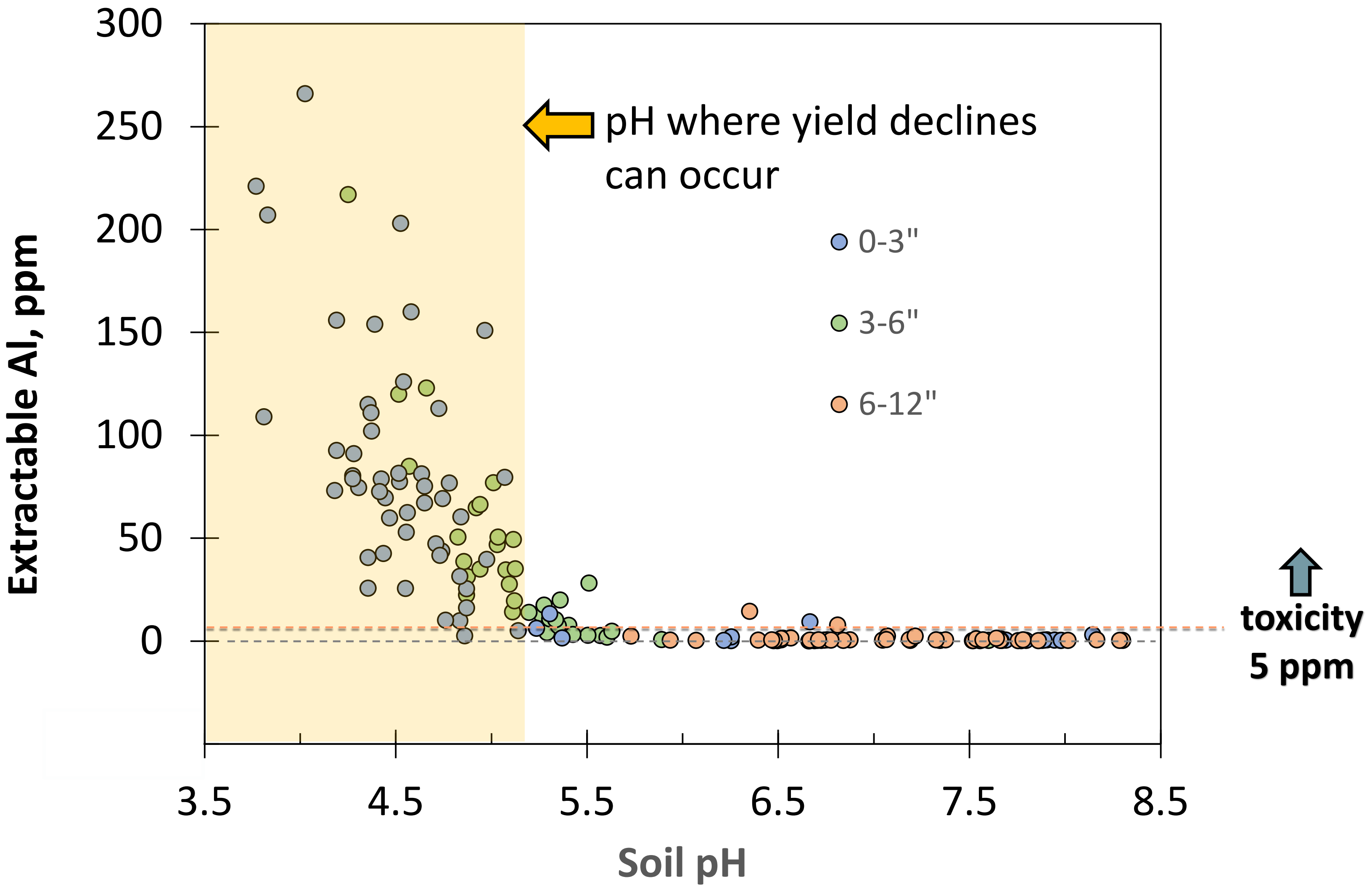
At low soil pH:

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



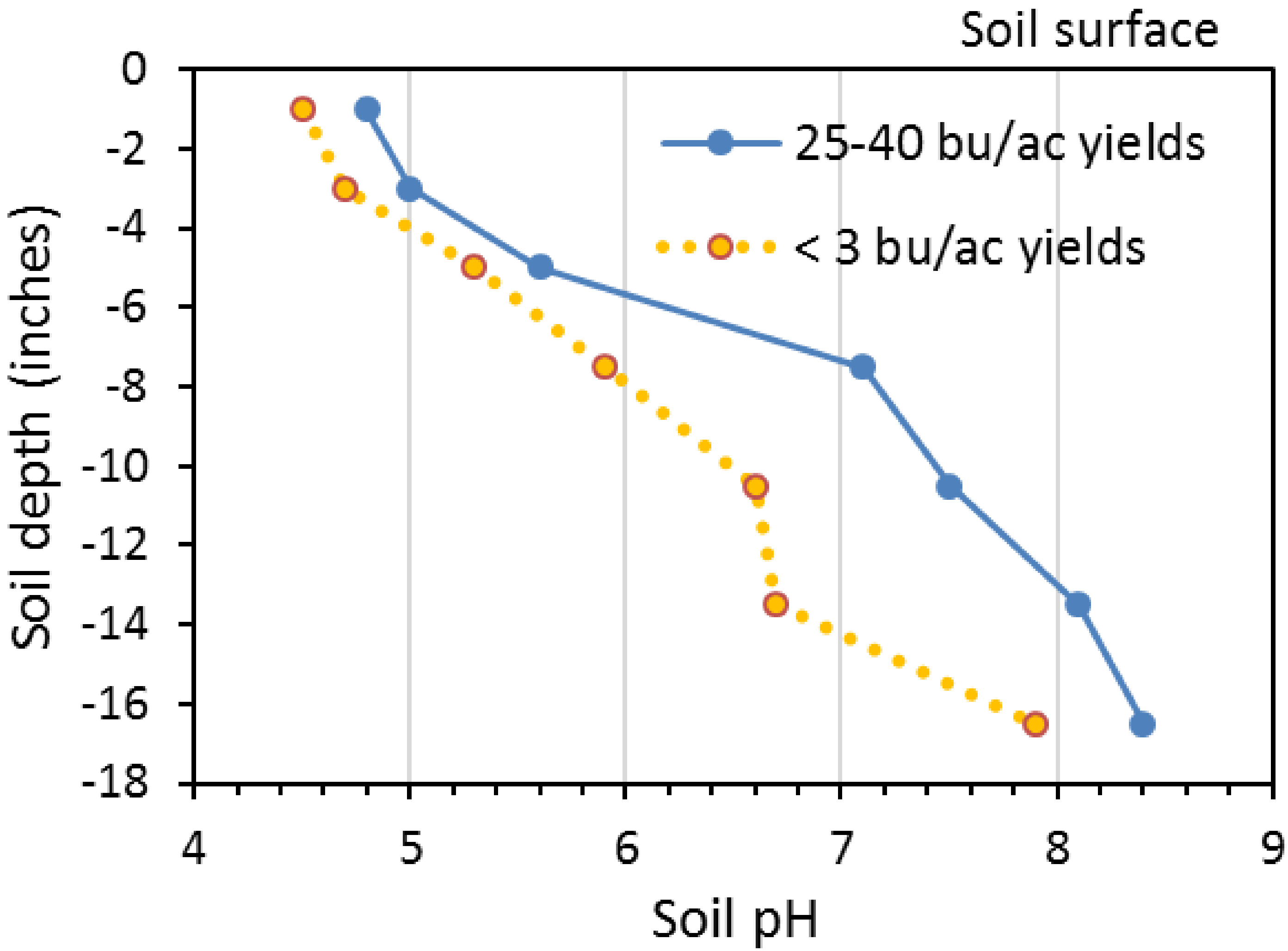
Gov. W. Australia, Dept. Ag. and Food

Low pH increases soil Al to toxic levels



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

0.3 pH unit difference in top 6” has huge impact on barley yields



Long farm, Highwood Bench, unpub Nov 2016 data. Measured. By R. Long.

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)
  - small leaves, short thick internodes
  - yellow along margin near tip on older leaves
  - purple or brown lesions in chlorotic regions, indentations

photo sources: Engel

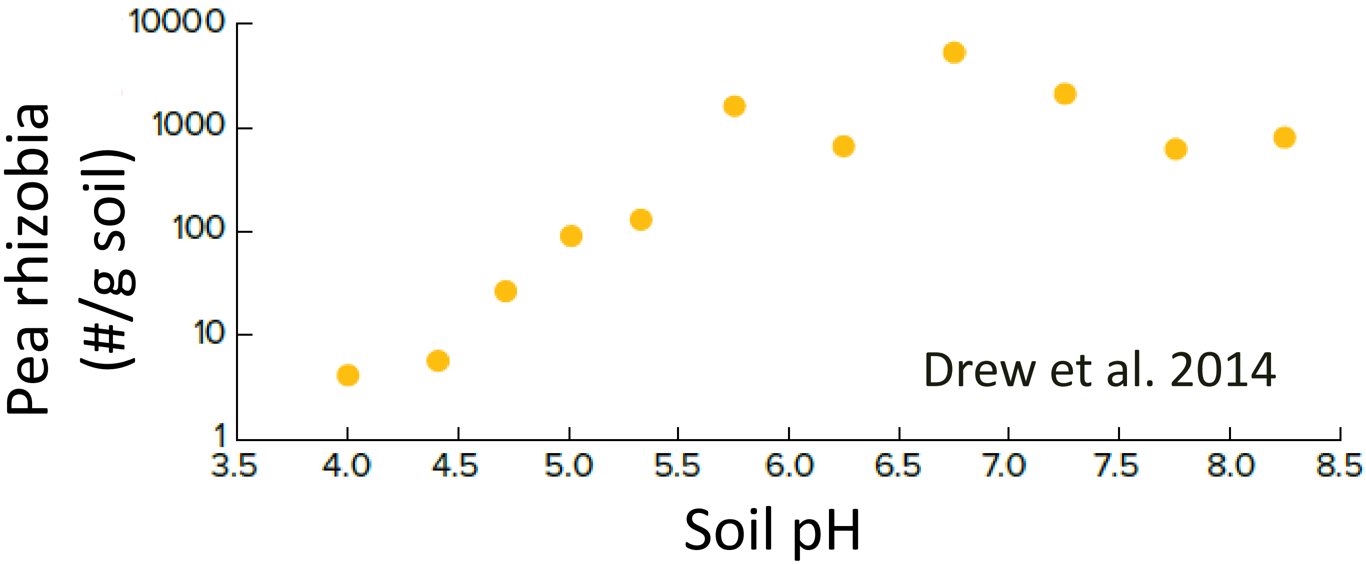
A. Robson, https://agric.wa.gov.au/n/4487

Acid soils have additional negative impacts

- Change in herbicide efficacy and persistence

http://pubs.cahnrs.wsu.edu/publications/pubs/fs189e/

- Poor N-fixation in legumes



- Increase in some fungal diseases (e.g. Cephalosporium stripe) and root rot

"unexplained problems" may be first indicator of pH change

Questions?

On to diagnosis and prevention

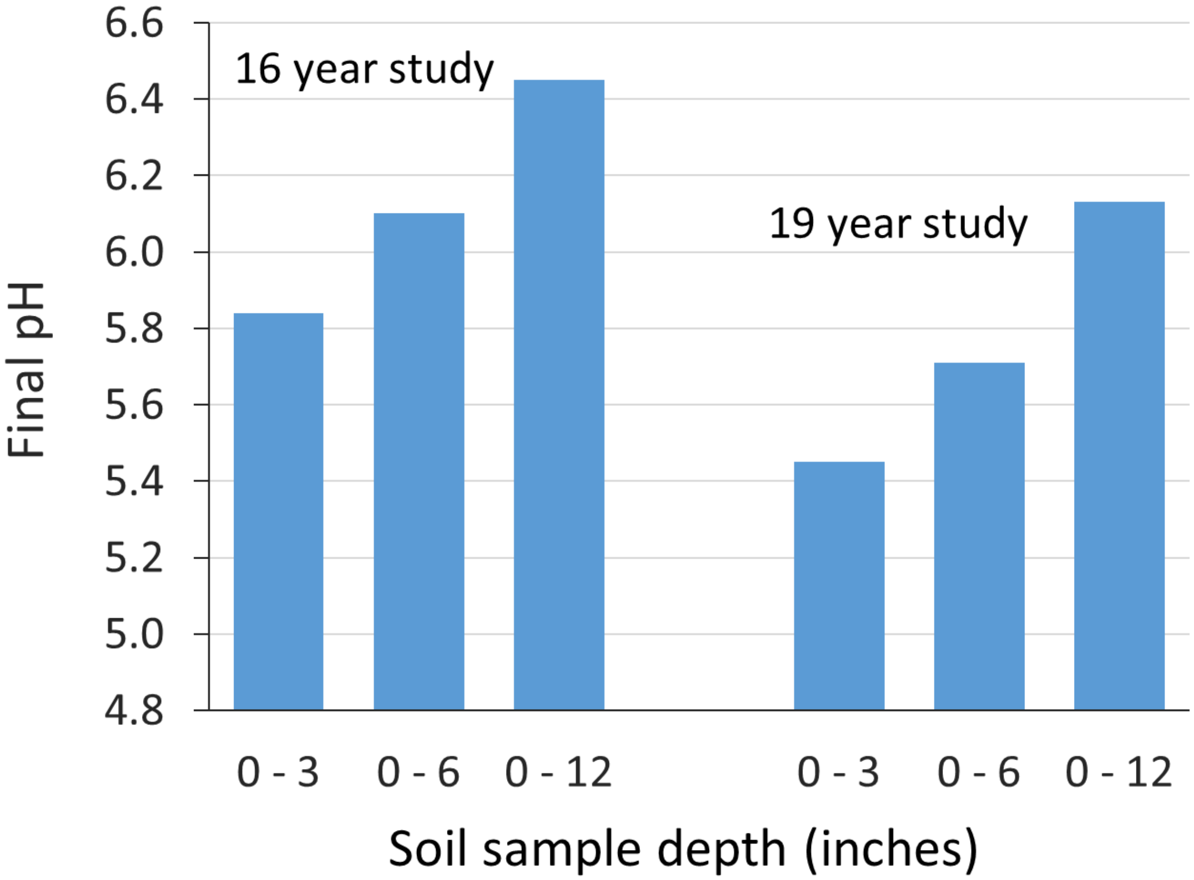
Diagnose: scout, soil test

1. Scout or use aerial maps to locate healthy and unhealthy areas

2. pH varies seasonally and annually, test from same area and time of year by same lab using same method to see trend
3. Veris can sample for pH
4. Can use Google Earth, satellite, plane or drone imagery to look for poor growth spots to focus sampling, and target management areas

Soil sampling for pH

1. Field pH test on soil/water slurry of top 3” or send to lab. Why not the standard 6”?



2. Test 3-6” if might till.
3. Avoid compositing samples from different slope areas.

Reeves and Liebig, 2016, Mandan, ND

Management to prevent acidification:
Increase N fertilizer use efficiency

- Large overlap with management to reduce N leaching (see our N Leaching Extension bulletin and MTGuide)
- Soil test close to application time. Make sure enough PKS
- Use conservative pre-plant rate, top-dress if adequate moisture
- Apply N close to peak crop uptake
- Use variable, site specific rates: Less N in low production areas limited by factors other than N (e.g., low pH, shallow soils)
- Reduce N rates especially when protein discounts low

Management to prevent acidification:

- Change N source
- Legumes in rotation – no N fertilizer and residue increases soil surface pH more than non-legumes (Paul et al., 2003)
- Leave crop residue in field – harvest of oat straw can result in 6x the acidification of just oat grain harvest (Pierre and Banwart 1973)

Most acidifying

MAP = AS ≈ 2x urea

DAP (18-46-0)

Urea (46-0-0), UAN (28-0-0)

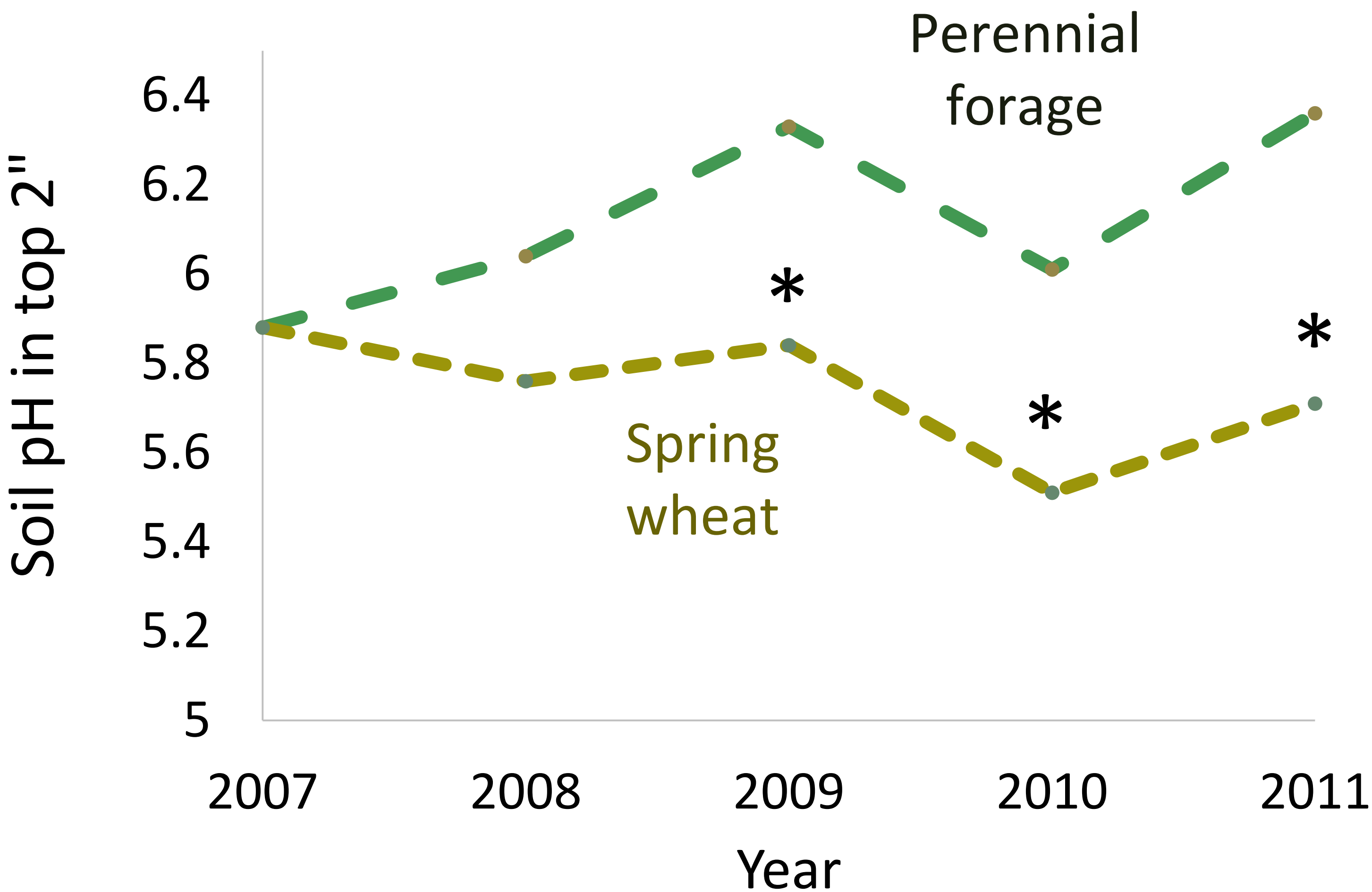
CAN ≈ 1/3x urea

Potassium nitrate (13-0-46)

Legumes and manure

Least acidifying

Perennial forage can slow or reverse acidification



* Crop pHs differ with > 95% confidence

Liebig et al. 2018, Mandan, ND

What else are you trying?

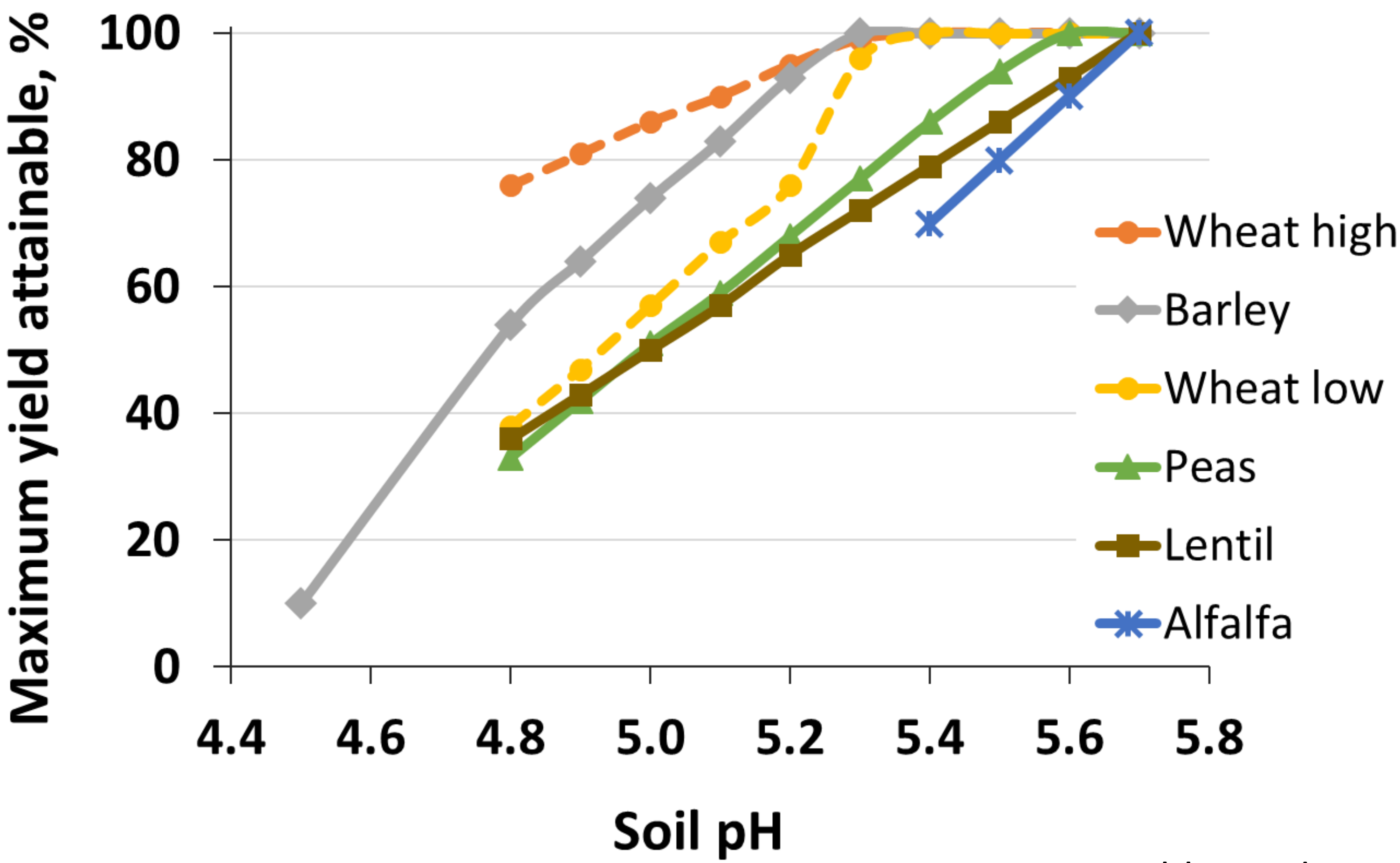
Questions?

On to adaptation options

Rick Engel will speak about repairing acidic soils

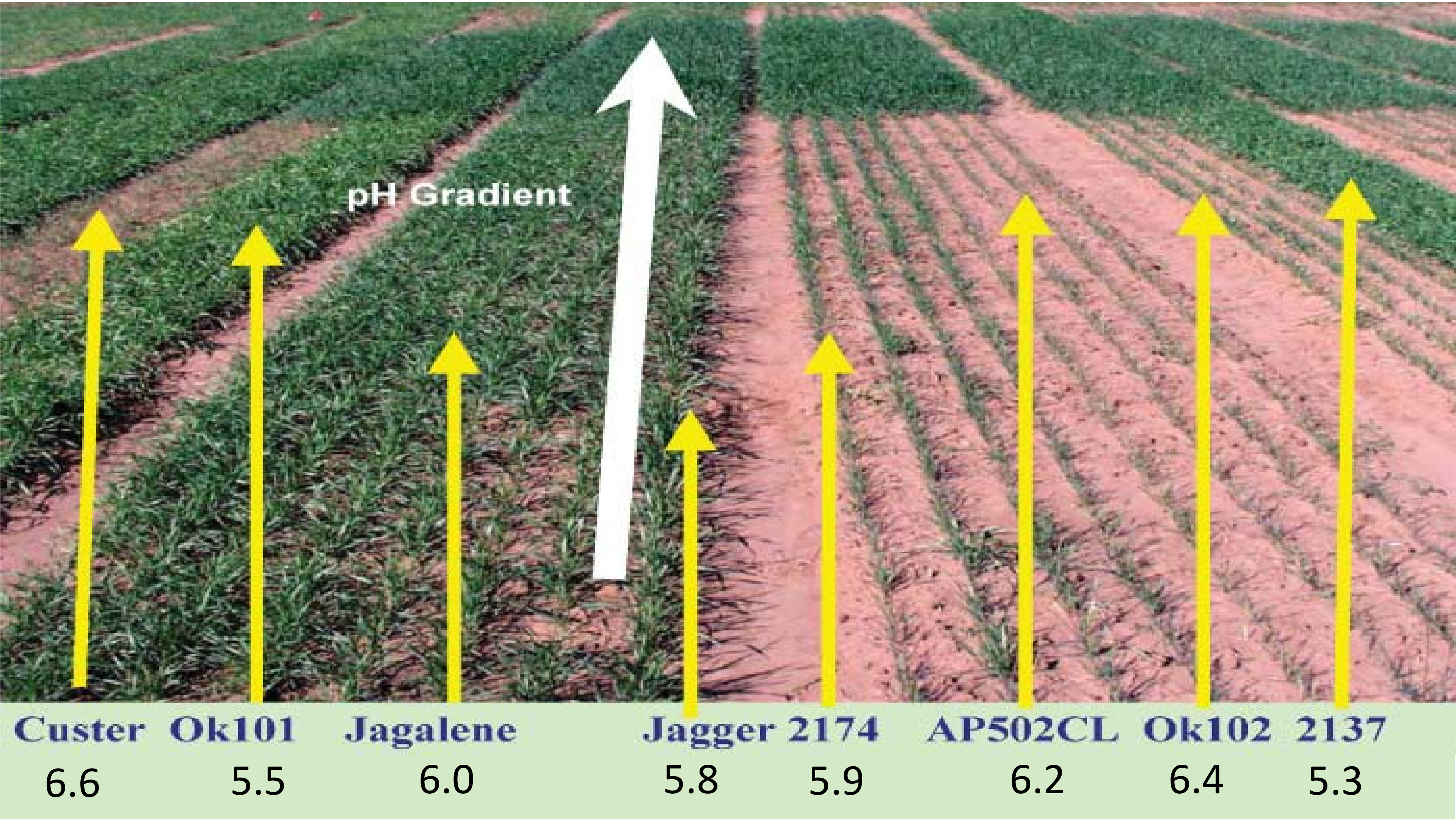
Adaptation: Plant tolerant crop species. Durum is low tolerant cereal, legumes (or their rhizobia) are least tolerant.

"Wheat high" are Al and acid tolerant varieties



Mahler and McDole 1987
Long pers comm

Wheat varieties have different tolerance to pH and Al



Threshold pH

(Kariuki et al, 2007)

MT variety trial results are available at

http://landresources.montana.edu/soilfertility/acidif/index.html

Good news

- MT has less acidic soil issues than other regions; catch and prevent now.
- MT's issue generally in upper 3", PNW and SK have low pH at 3-6". Why important?
- Many MT cropland soils have large pH range with calcareous parent material
- P and metal micronutrient availability better at low to neutral pH

Soil survey northern Idaho

Soil pH	% of fields in each category	
	1982-'84	2014-'15
>6.4	6	<1
6.0-6.4	11	4
5.8-5.9	16	3
5.6-5.8	22	7
5.4-5.5	18	9
5.2-5.3	11	25
5.0-5.1	10	26
<5.0	6	26
Schroeder, Univ of Idaho, unpub data		

Summary

- Cropland soils are becoming acidic, largely due to N fert.
- This reduces yields for several reasons
- Identify whether fields have a problem **now** to slow or prevent acidification with sound management
- Using crop rotations with lower N needs is likely best way to prevent further acidification
- Crop and variety selection can help adapt to acid soils
- Planting perennials can reverse acidification
- Aerial images (e.g. Google Earth) are useful tools to target management areas

Thank you!

Questions?

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

If you have questions about soil and buffer pH tests go to https://www.youtube.com/watch?v=w9PWZSaFfb4