Tonight's host and co-host

Clain Jones
MSU Extension
Soil Fertility Specialist
Clainj@montana.edu
994-6076

Juli Snedigar
Blaine County Ext. Agent
Julianne.Snedigar@montana.edu
357-3200

Sustainable Nutrient Management

Winter Soil Fertility Series: Week 6

Feb 10, 2021

Clain Jones, Extension Soil Fertility Specialist
406-994-6076, clainj@montana.edu

Photo by K. Olson-Rutz

Nutrient Management for: Sustainable, resilient, climate-smart agriculture

What I'll cover in this webinar

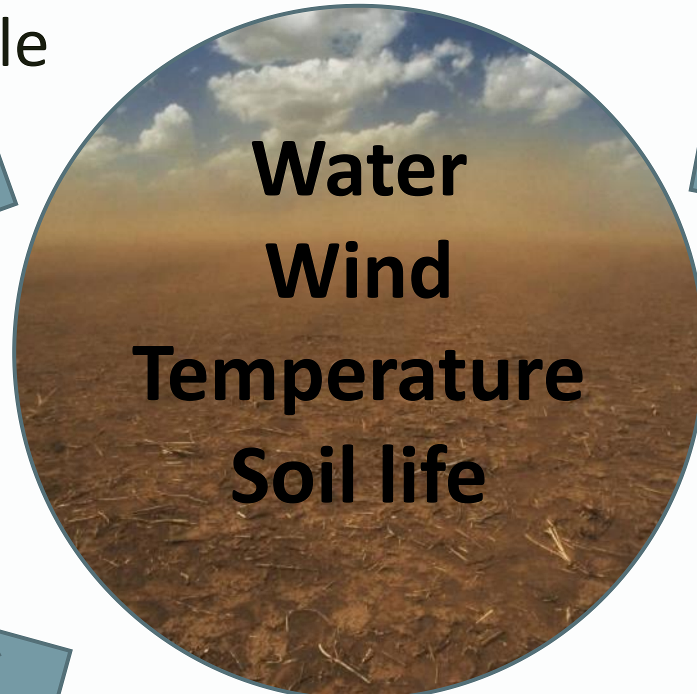
- Present the tools we have to build healthy soils
- Discuss how to build soil organic matter (SOM)
- Illustrate why soil acidification is a threat to healthy soils, and how to prevent it
- Present crop rotations to minimize nitrogen loss (leaching)
- Show options and benefits of crop diversification

Agronomic tools to take care of the soil

Crop residue/stubble

Tillage or no-till

Cropping intensity



Rotations/ Diversity

What else ??

Nutrient/amendment inputs

Image from Freecreatives

Goals, and what science can measure

In the field goals

- Minimize disturbance
- Keep soil surface covered
- Keep living root in soil

What we can measure

- SOM
- Soil N/PMN
- Microbes/enzymes
- Aggregation
- Infiltration
- Soil pH
- Yield, protein, etc.

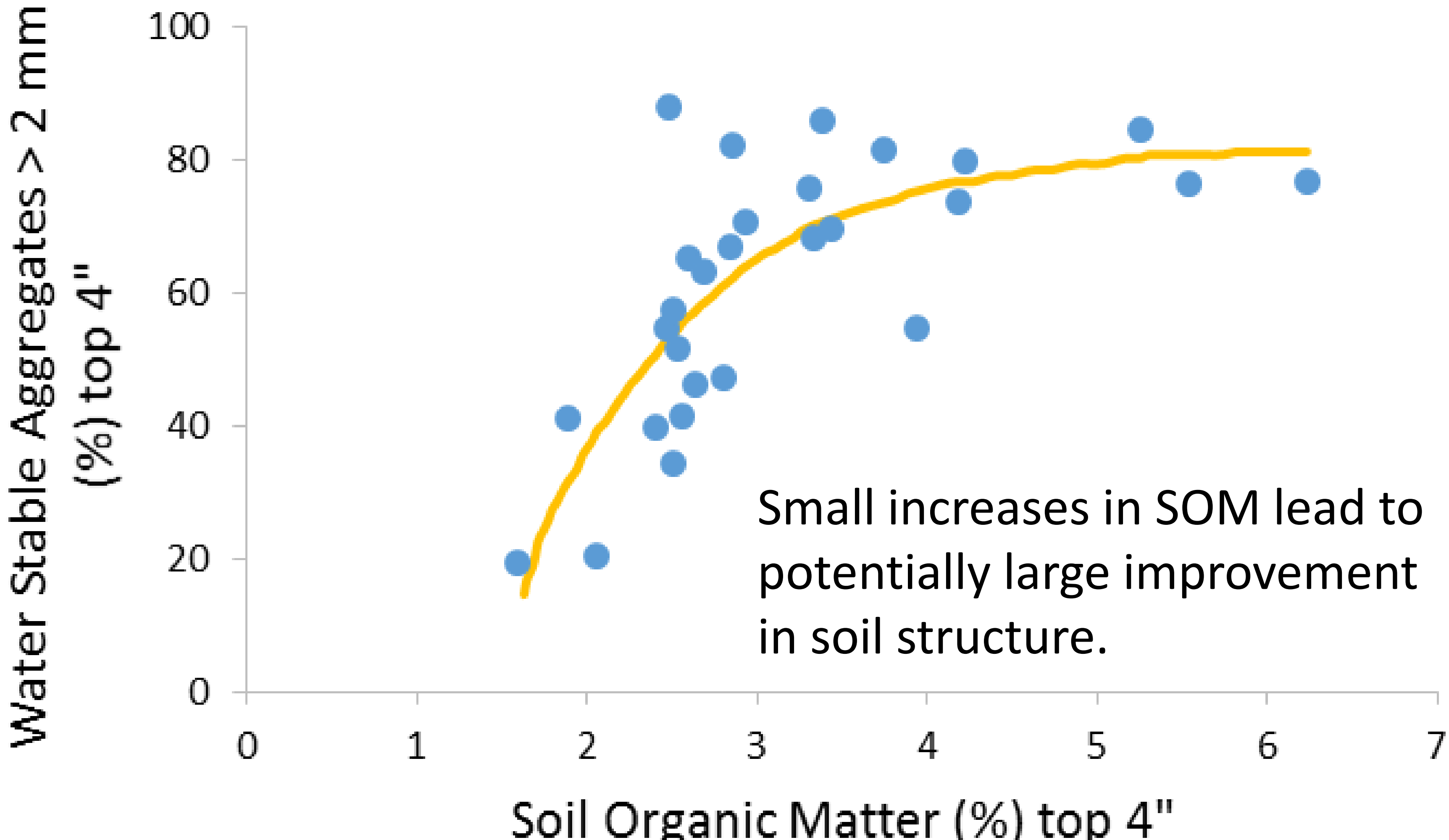
The basis for soil health is biological activity, OM is the fuel for that activity

- When microbes die, a part is recycled as readily available nutrients.
- The rest can end up associated with mineral surfaces, protected from further decomposition.

10,000 lbs/acre of life in soil to feed = 1 elephant

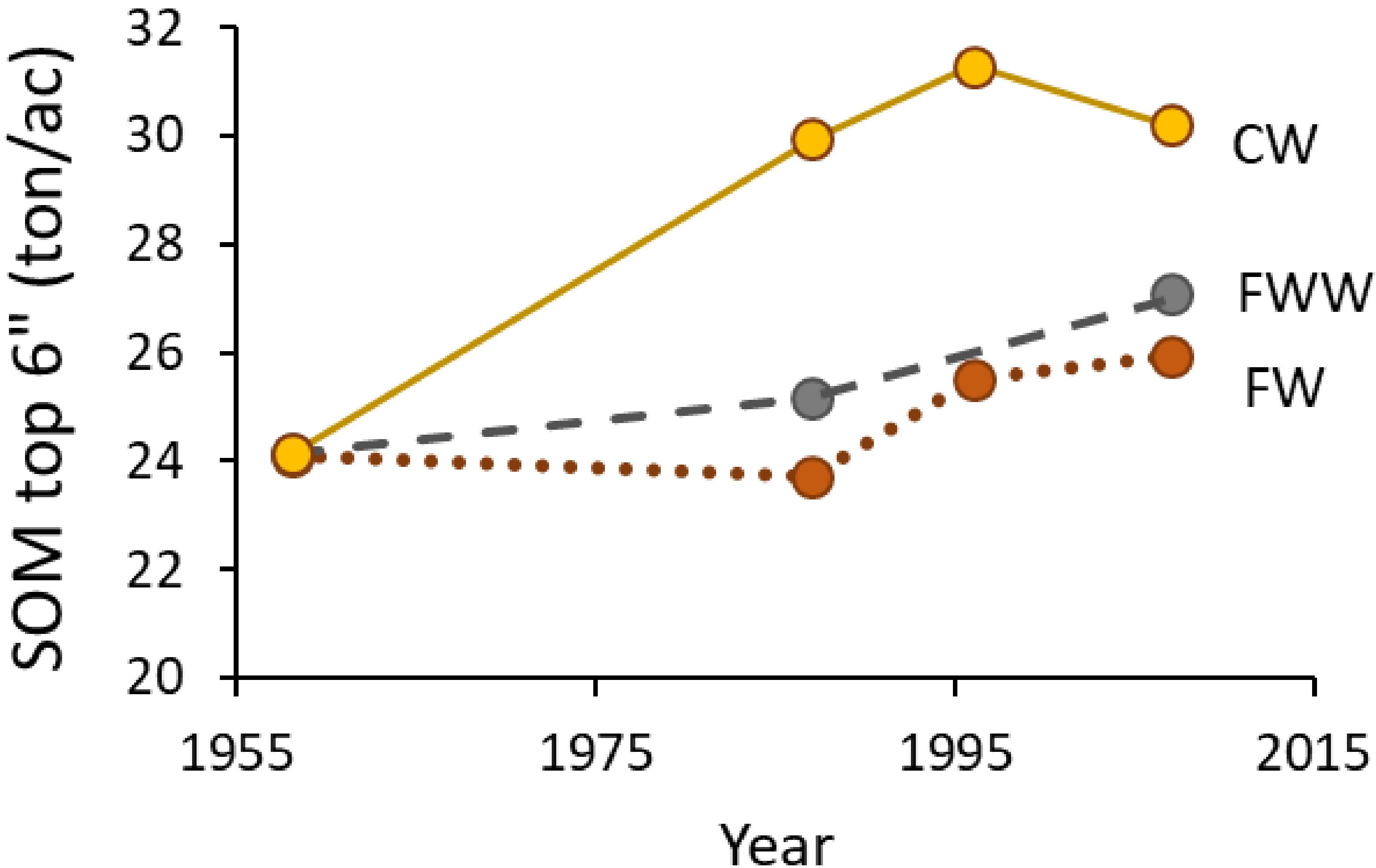
- This long-lived SOM pool is especially important for soil structure, water holding capacity, and ion exchange capacity.
- These determine soil fertility.

Small changes in SOM can cause big physical changes. For example:



Fisher et al., 2007
Australia, irrigated, variety of soil types

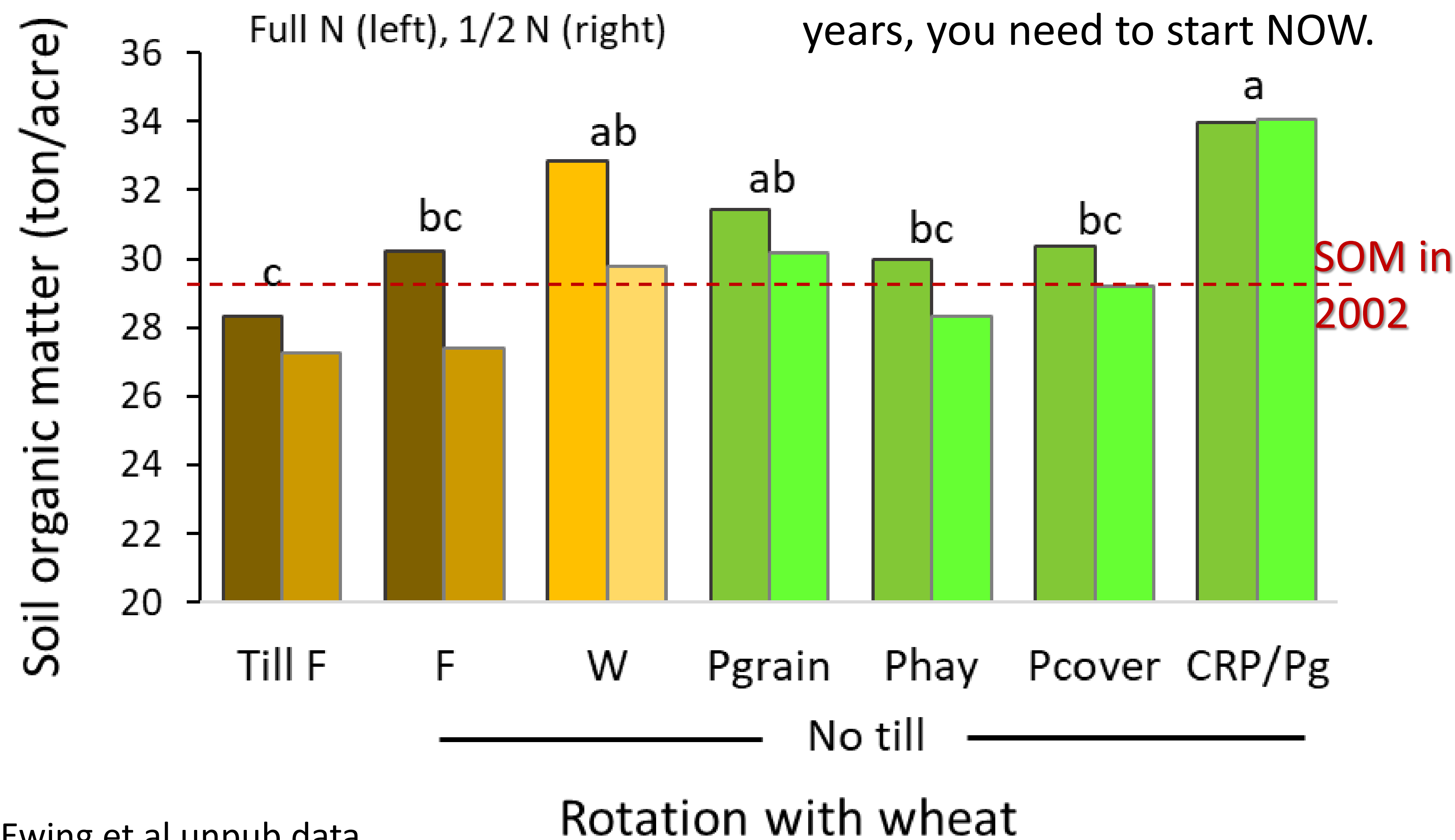
Rotations:
Increase cropping frequency to increase SOM



Lemke et al. 2012. SE SK. Converted to NT in 1987.

SOM in top foot after 14 years of cropping systems at 2 N rates near Bozeman, MT (2016)

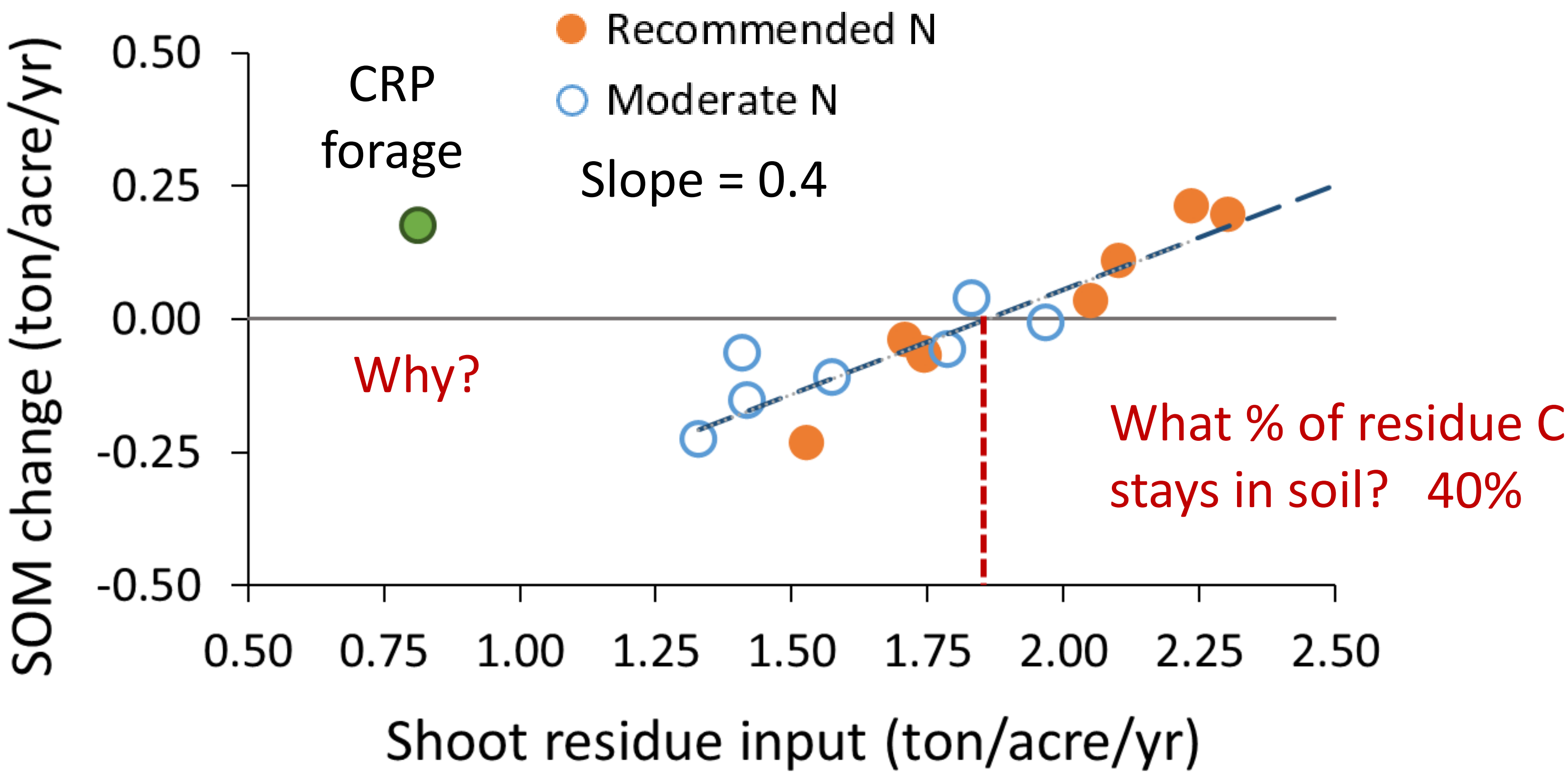
For higher OM soil in say 10-20 years, you need to start NOW.



Ewing et al unpub data

SOM change depends on residue returned & inputs

Need ~1.8 ton shoot residue/ac/yr (Shrestha et al. 2013, SK; Engel et al. 2017, MT), to maintain SOM in more productive NGP regions.



Best way: recrop and apply recommended fertilizer rates, or grow perennials

Engel et al. 2017, Gallatin Valley, MT, 16" precip zone

Questions?

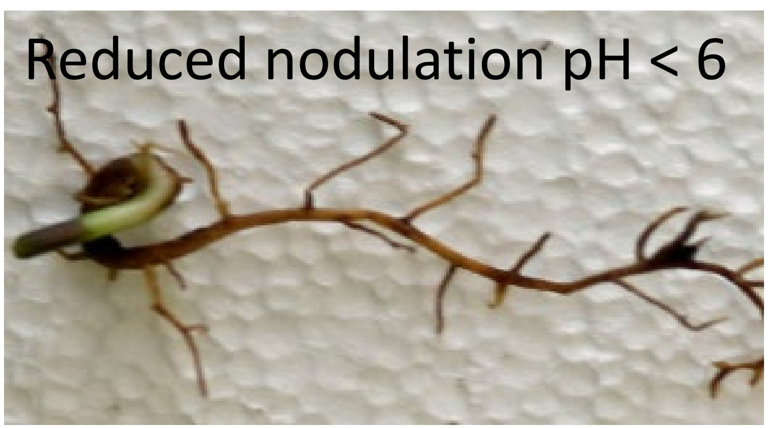
On to soil acidification

Soil acidification is a major problem in parts of Montana, causing:

Safflower field near Big Sandy by Scott Powell

- Yield loss
- SOM loss
- Resiliency loss

Barley: Thom Weir, FarmersEdge



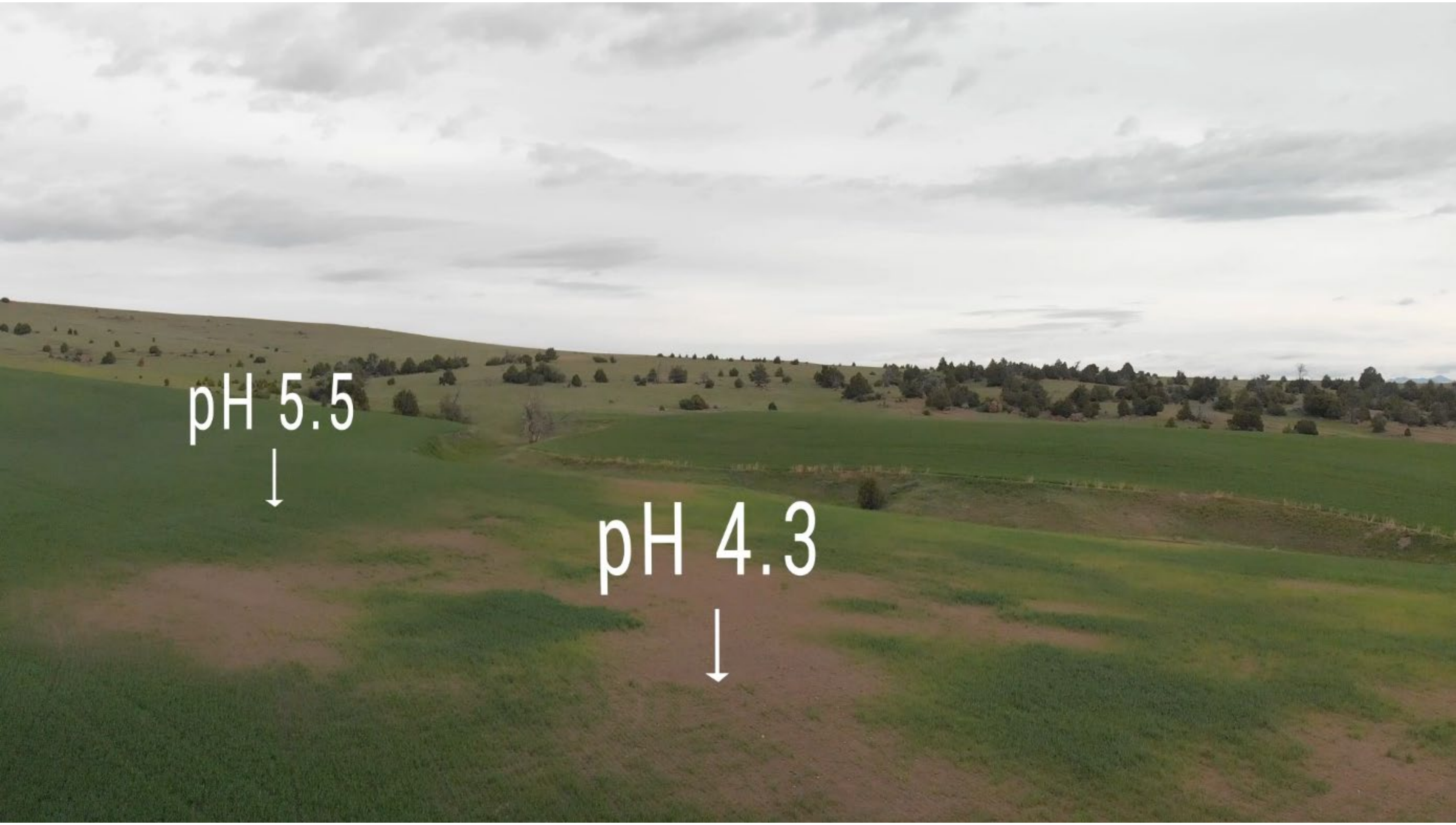
Lentil, Image by R. Engel

Increased disease

Fusarium crown rot image by M. Burrows

Ceph stripe image from *Wheat Disease ID*. MWBC

Crop loss due to soil acidification is not a myth. A Montana farmer's experience



https://youtu.be/cjWneDQVyV8 by Clain Jones and Nate Kenney

Have you found low pH (< 6) in some portion of fields?

1. Yes
2. No
3. Not sure

Please answer in Chat


Image courtesy Rick Engel

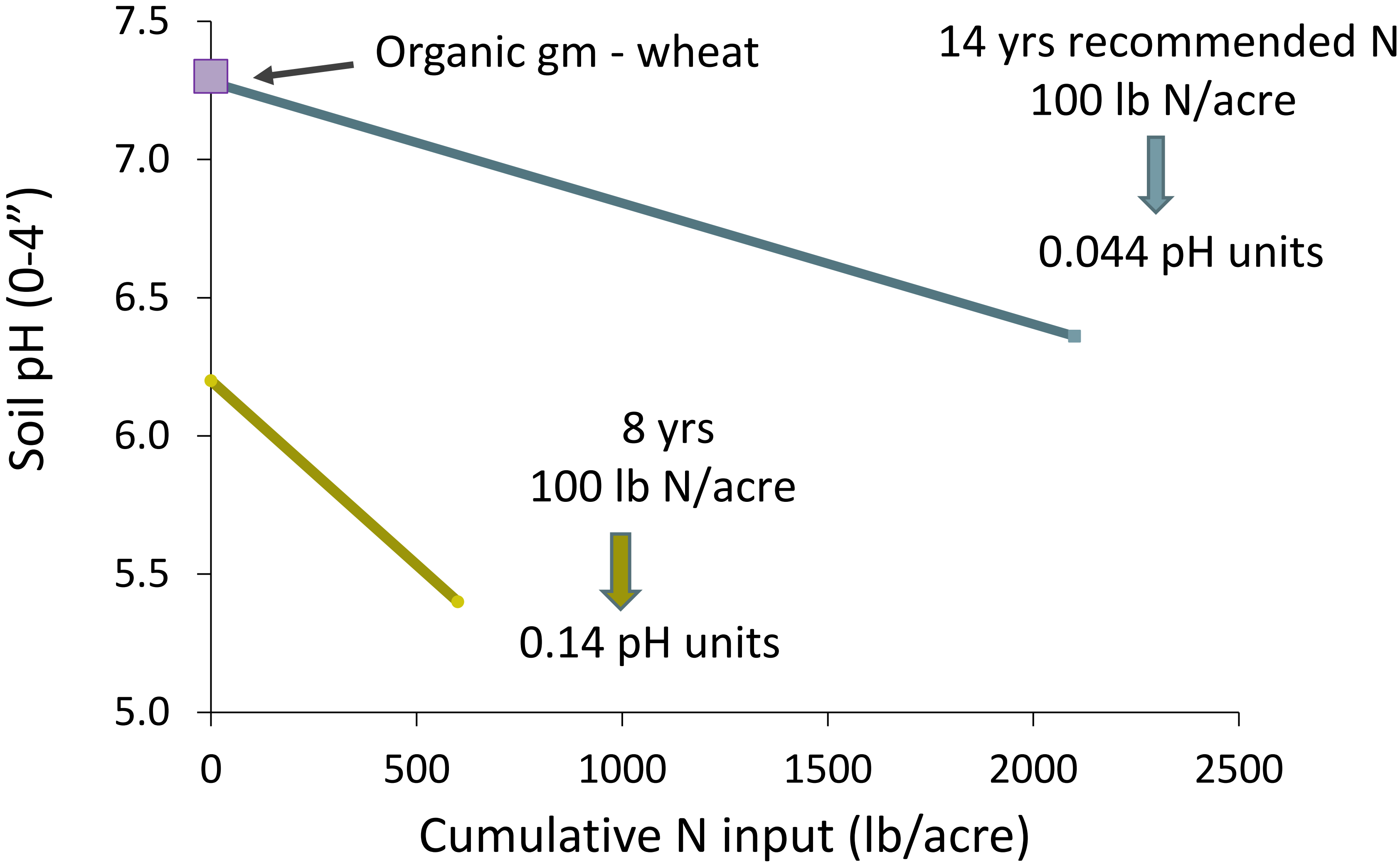
Agronomic reasons for low soil pH

- Ammonium-based N fertilizer due to nitrification:

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

- Leaching loss of nitrate (NO_3-): less nitrate to take up = less root release of basic anions (OH^- and HCO_3^-)
- Crop residue removal: removes Ca, Mg, K (‘base’ cations that buffer pH change)
- Lack of deep tillage concentrates acidity where N fertilizer applied

N at reasonable rates reduced top 4-inch soil pH in MT dryland cropping

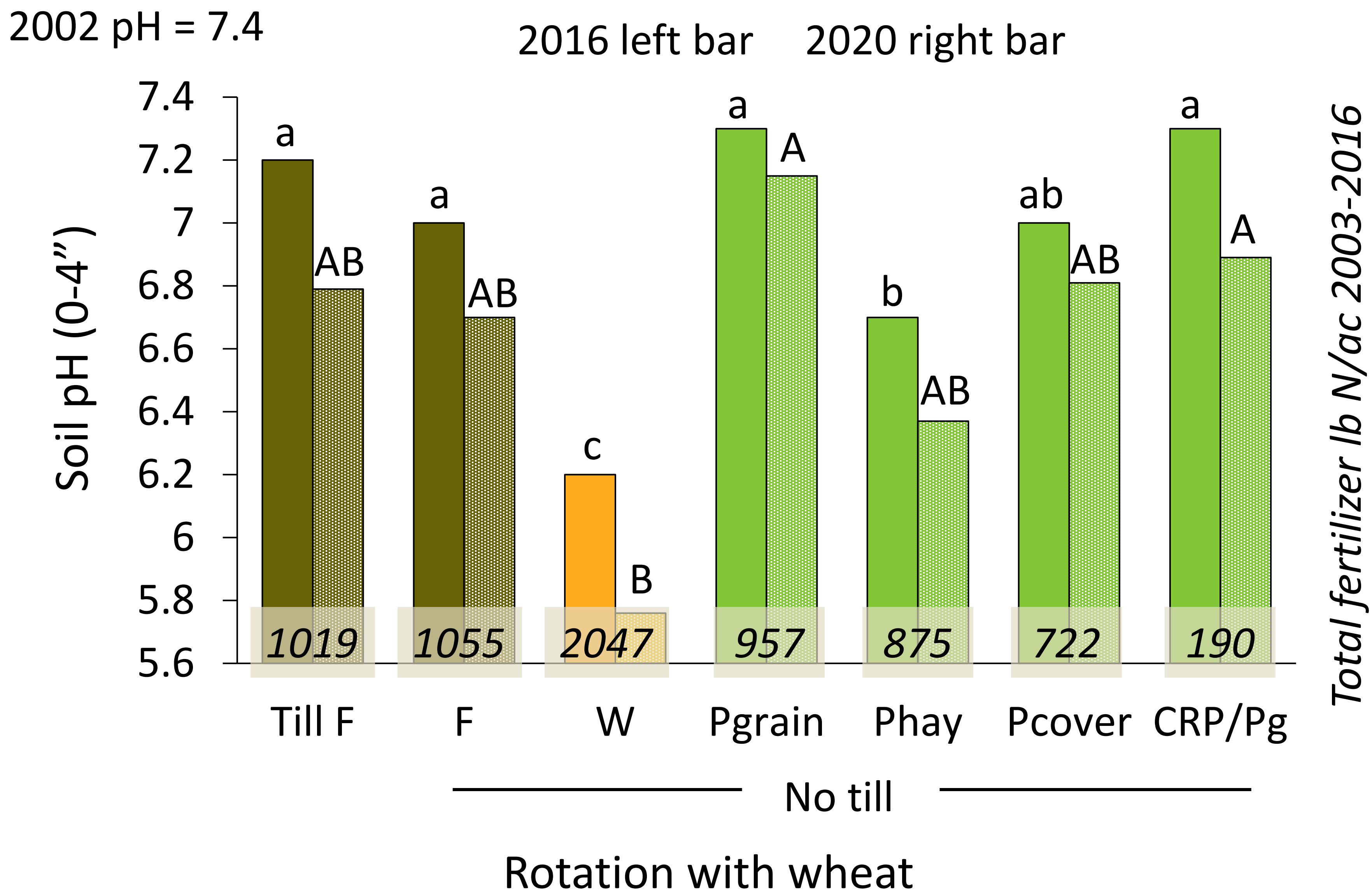


Silt loam, 2% OM

Sandy loam, 1.1% OM

Engel, Ewing, Jones, Miller, unpub data

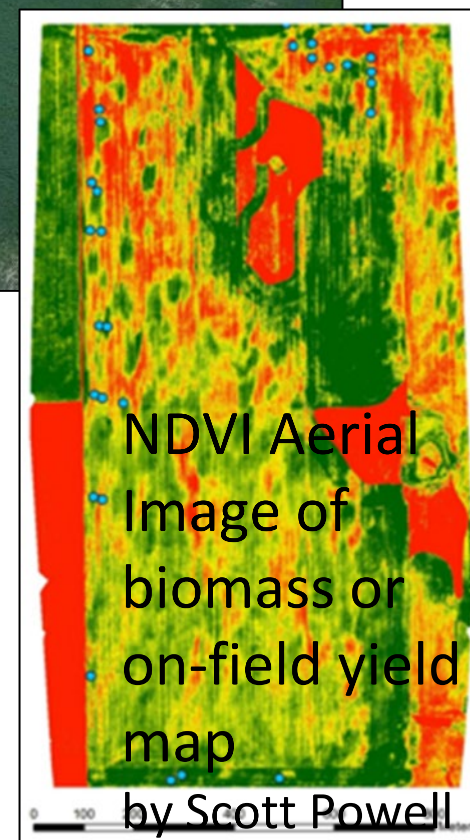
Which systems dropped pH the most and the least?



Ewing, Engel, et al. unpub data

Scout, map, soil test

1. Scout or use aerial maps (Google Earth, satellite, plane or drone) to locate healthy and unhealthy areas.
2. Field test or lab test
3. Veris instrument can map
4. pH varies seasonally and annually, test from same area and time of year by same lab using same method to see trend



Why didn’t ‘standard’ soil testing help us see this problem coming?

- Crop advisers collect about 6 to 10 soils across the field at 0-6” depth and mix into one sample, ‘masking’ problem
- ➢ Field pH test on soil/water slurry of top 3” or send to lab

Symptoms are not uniform across field landscapes

Management to prevent acidification:

- Increase N use efficiency
- 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 ≈ 2-3x urea

DAP (18-46-0)

Urea (46-0-0), UAN (28-0-0), AN (34-0-0), anhydrous

CAN ≈ 1/3x urea

Potassium nitrate (13-0-46)

Legumes and manure

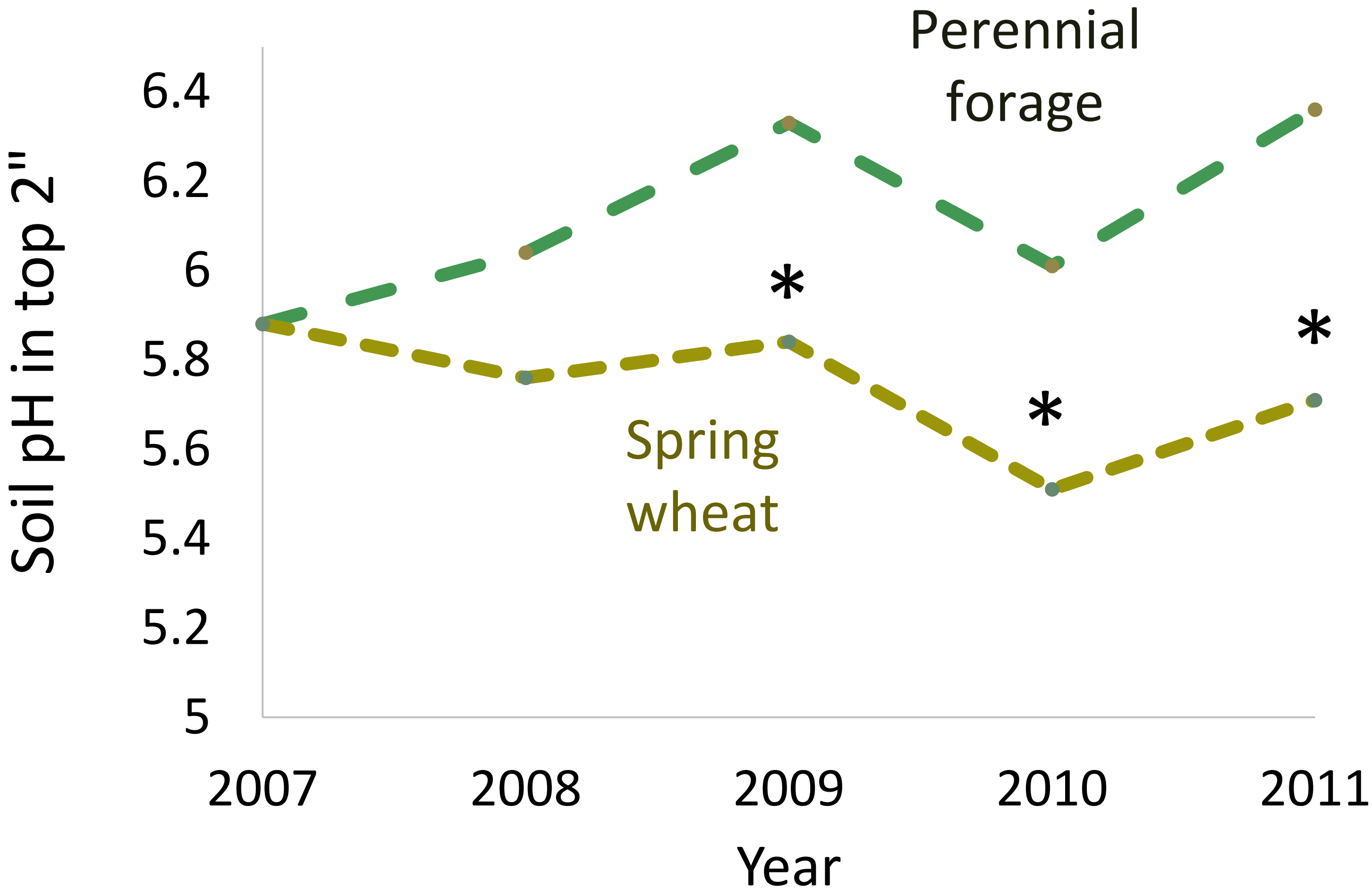
Least acidifying

Management to prevent acidification:

Increase N fertilizer use efficiency

- 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 N rates
- Reduce N leaching
- Use legumes or manure for N source
- Use less acidifying N sources ($$)

Perennial forage can slow or reverse acidification



* Crop pHs differ with > 95% confidence

Liebig et al. 2018, Mandan, ND

Adaptation and Mitigation

- Plant Al or low pH tolerant species/varieties
- Seed place P, even in high P soils
- Lime
  - To raise soil from pH 4.5 to 6 requires 2.25 ton $CaCO_3$/ac
  - SB lime is ~ 60% $CaCO_3$ = 3.75 ton SB lime/ac to raise pH from 4.5 to 6.0.
  - A semi-truck trailer load ≈ 23 ton SB lime, treats 6 acres @ $145/ac
  - Lasts about 15- 20 yrs
- Prevention looks more appealing when look at cost of liming

Acidification summary

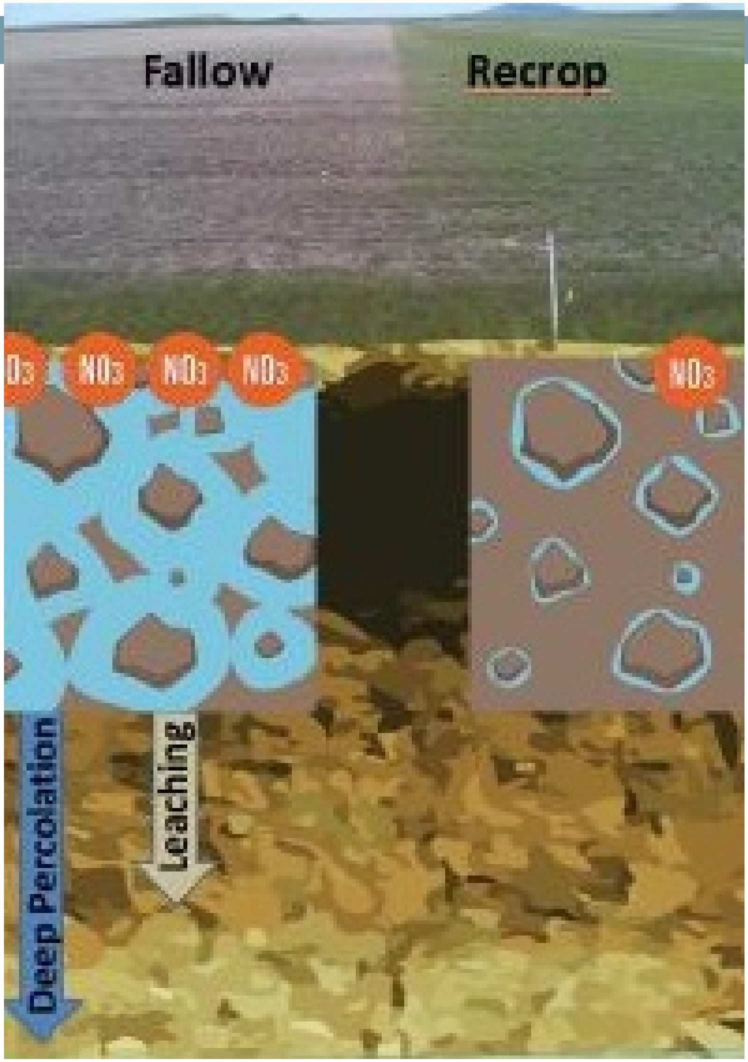
- Cropland soils are becoming acidic, largely due to N fert.
- This reduces yields for several reasons
- Identify whether fields have a problem **now** to slow or prevent acidification with sound management
- Using crop rotations with lower N needs is likely best way to prevent further acidification
- Liming, manure, and planting perennials can raise pH
- Seed-placed P can counter aluminum-toxicity
- Aerial images (e.g. Google Earth) are useful tools to target management areas

Questions?

On to keeping nutrients in the soil – preventing leaching

Rotations can change plant available N

- Keep more N in soil
  - Reduce fallow
  - Include cover crops
  - Plant deep rooted crops
  - Plant fall crops after legume crops
- Supply N with legumes

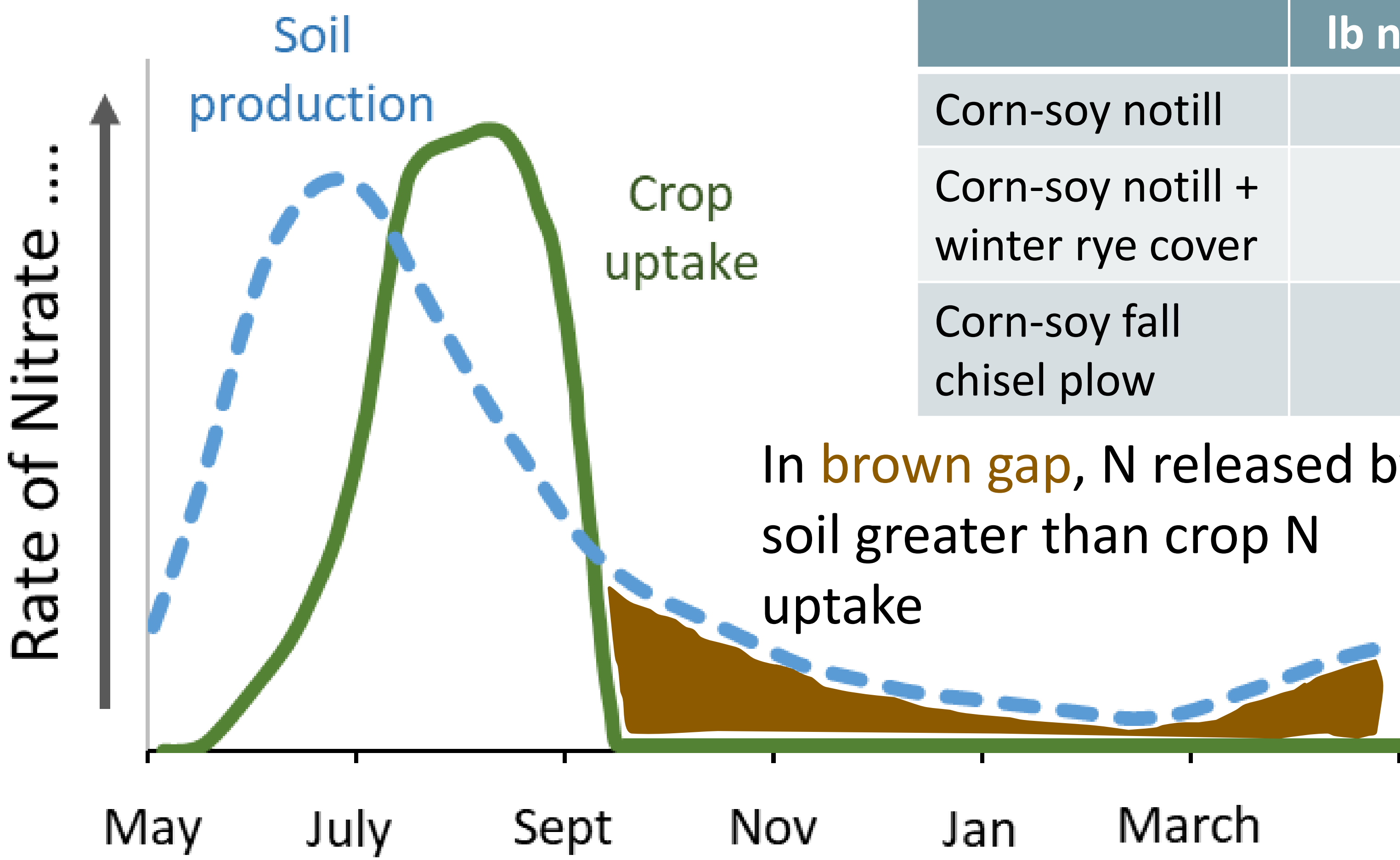


Graphic by A. Sigler

Poor match between uptake timing and availability

Reduce the 'brown gap' by catching the losses with overwinter cover crops.

Rotation	4-yr total N lost in drainage lb nitrate-N/ac
Corn-soy notill	90
Corn-soy notill + winter rye cover	29
Corn-soy fall chisel plow	78

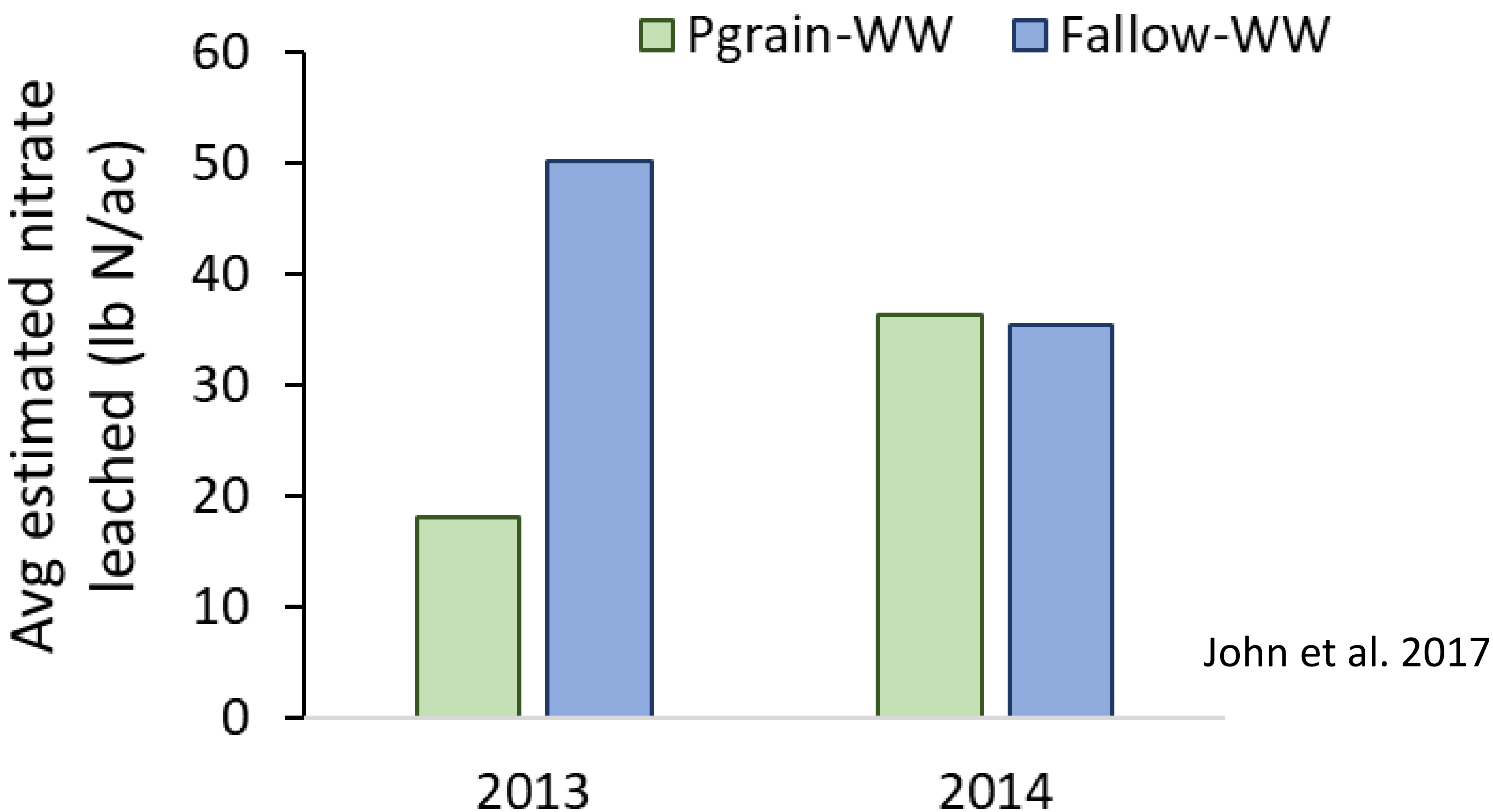


In brown gap, N released by soil greater than crop N uptake

Kaspar et al, 2017 USDA-ARS National Conference on Ccrop and Soil Health

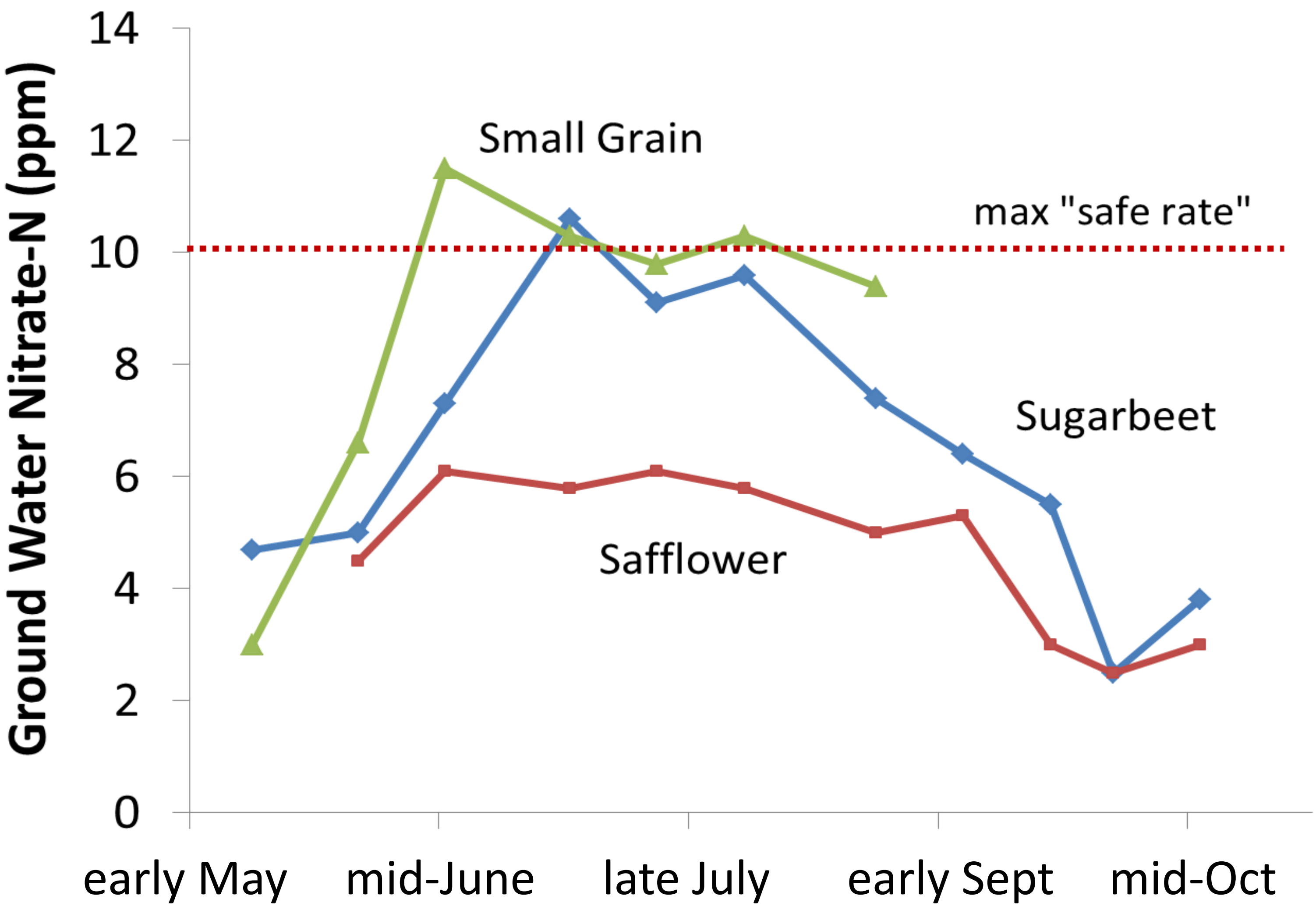
Judith Basin Nitrogen Project

Farmers grew pea for grain instead of fallow for 2 growing seasons, each followed by winter wheat (WW).



Pea grain-wheat leached less one year than fallow-wheat, equal NR.
Leaching no diff between rotations in 2nd year, NR greater with pea-wheat.

Deep rooted crops dig deep for N and help keep nitrate out of groundwater



6-yr average, Sidney, MT, MSU Fertilizer Fact 9

N management factors to decrease N leaching

- Apply N based on spring soil test
- Split N application to match plant needs
- Avoid fall application on shallow and/or coarse soils
- Consider applying less N in areas that yield less or have shallow soils (variable rate application)
- Use an enhanced efficiency fertilizer to reduce leaching (and denitrification) losses

Questions?

On to crop diversity and looking at the whole system

Diversify – how could you & how would it help?

How

- Structural diversity in field, e.g., stubble strips
- Genetic diversity
- Intersperse fields with non-crop vegetation
- Polycultures – mix species w/in field
- Mix of winter and spring crops

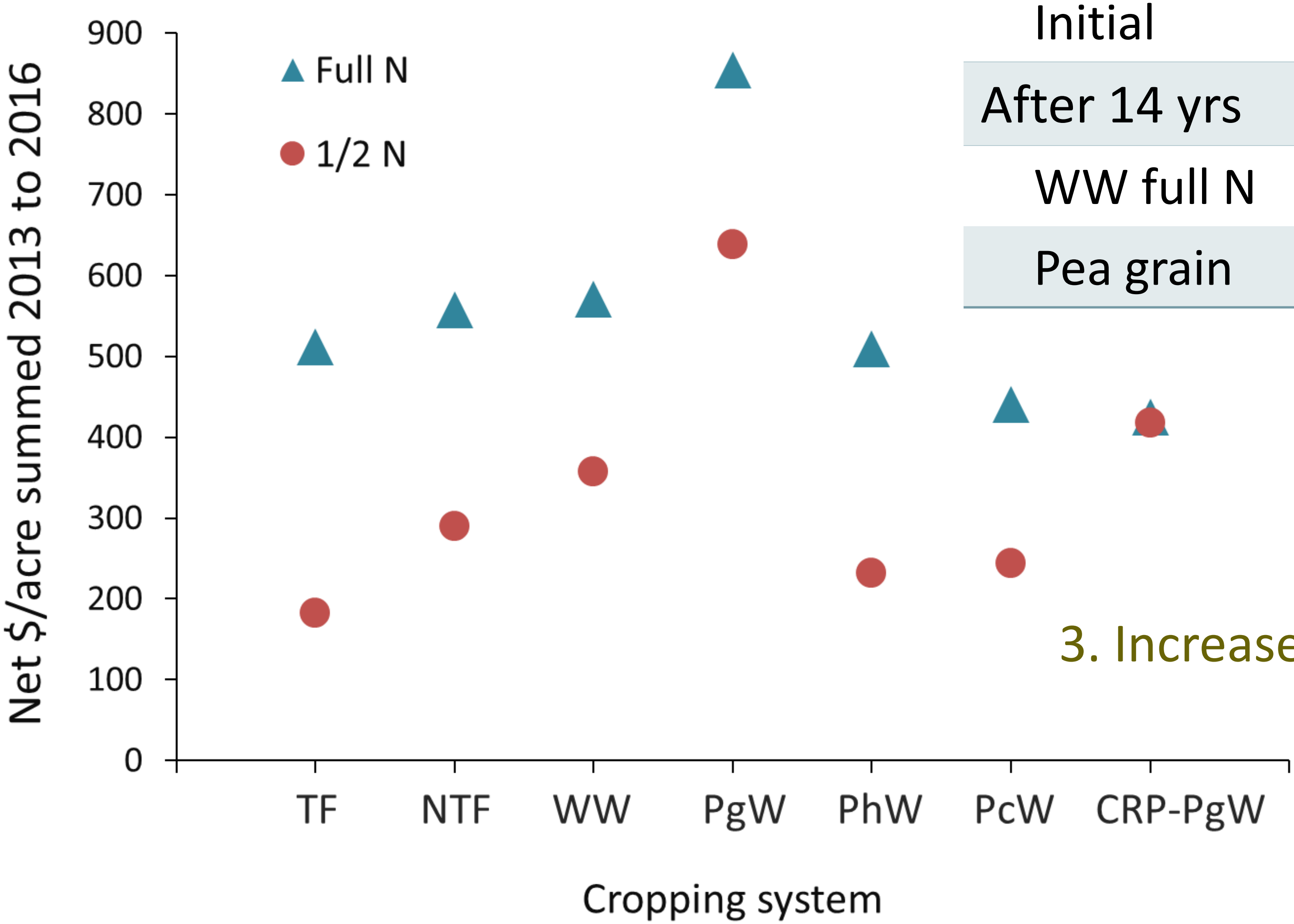
Benefit

- Interrupt pest/disease cycles
- Buffer microclimate extremes
- Increase production
- Increase yield stability, reduce risk

Would you consider using pulse or cover crops to diversify?

Pea grown for grain

1. more profitable than as hay or cover



2. Prevented acidification

Rotation at full N	pH
Initial	7.4
After 14 yrs	
WW full N	6.2b
Pea grain	7.3a

3. Increased SOM

Miller et al. 2017, MSU Fertilizer eFact # 72

Amendments: consider impact on whole biological system

For example:

- Excess N leads to acidification
- Look for a weak link, e.g. insufficient S reduces N fixation or N use efficiency
- Pesticides can affect the soil and root microbial community (Nguyen et al. 2016 meta-analysis)

S deficient pea, image by C. Jones

Soil Health Tests, e.g. Haney or Cornell (Comprehensive Assessment of Soil Health “CASH”)

- Measure and monitor over time or between fields
- Useful to assess effect of management or evaluate problem areas
- Standardized methods may not yet be in place
- Currently no calibration between test values and fertilizer recommendations for N. Great Plains

How can I manage for healthy soils? Feed the microbial community

Based on the few regional medium- and long-term studies available:

- It takes time to change soil health
- Increase crop frequency
- Cover crop biomass and inclusion of legumes appear more important than # of species in cover crop mixes.
- Legumes need to comprise more than ~40% of a cover crop mix to contribute soil available N.

Summary

Tools towards resilient and sustainable farming:

Adaptations

- Develop and use adapted varieties
- Increase diversity
- Use cropping associations, rotations, and sequences
- Manage for efficient water capture, retention, use

Resiliency

- Build and maintain healthy soils now with adequate fertilization
- Enhance and capitalize on natural biological processes
- Avoid degradation of natural resources
- Reduce reliance on non-renewable external inputs if possible

Photo by Ann Ronning

Thank you!
Questions?

Please take a few minutes to evaluate this seminar series by completing the short survey; link provided in chat box soon.

The next and last session
Feb 17: Cover crops

This presentation and more information on soil fertility is available at http://landresources.montana.edu/soilfertility