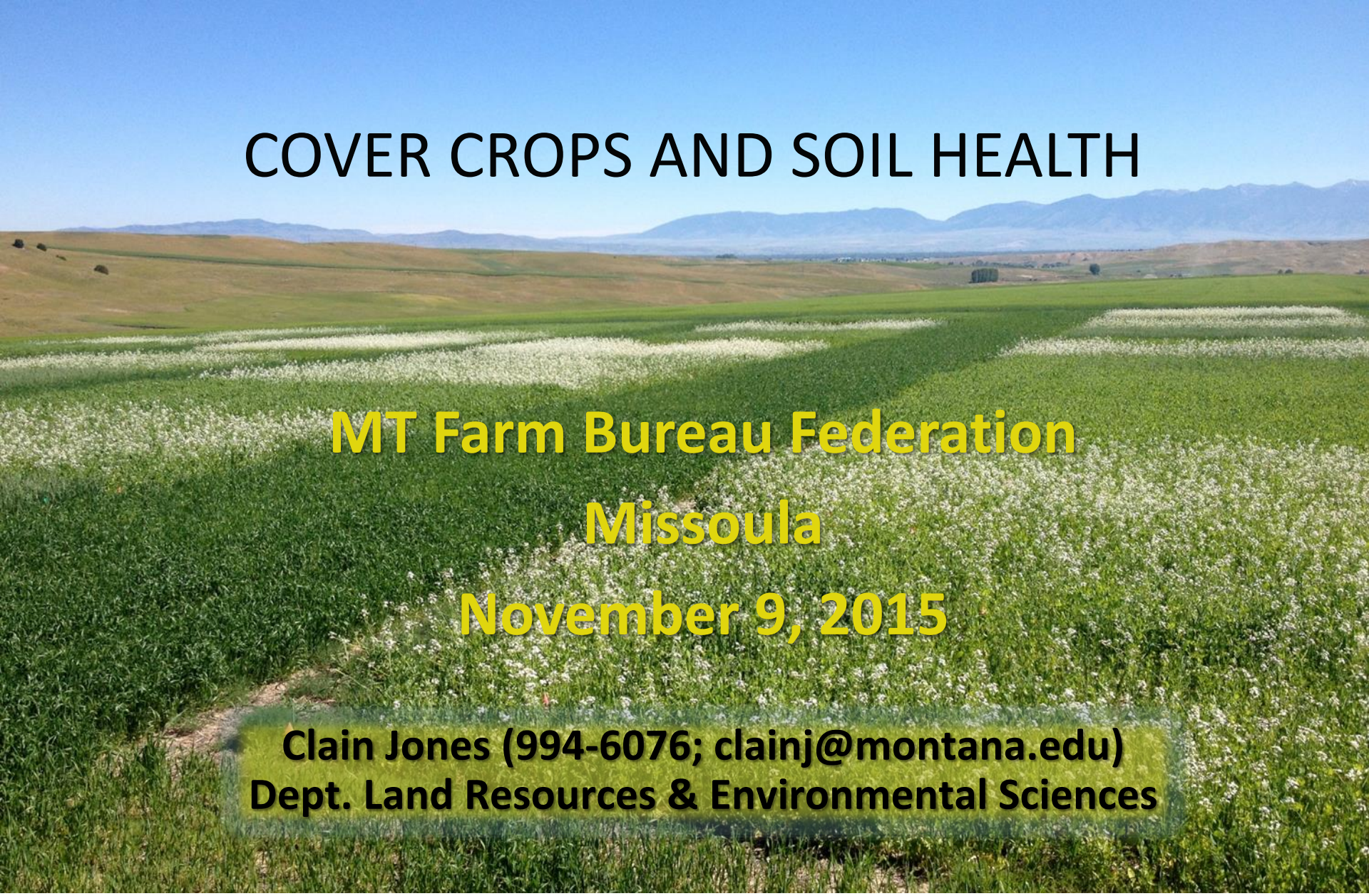

COVER CROPS AND SOIL HEALTH

MT Farm Bureau Federation

Missoula

November 9, 2015

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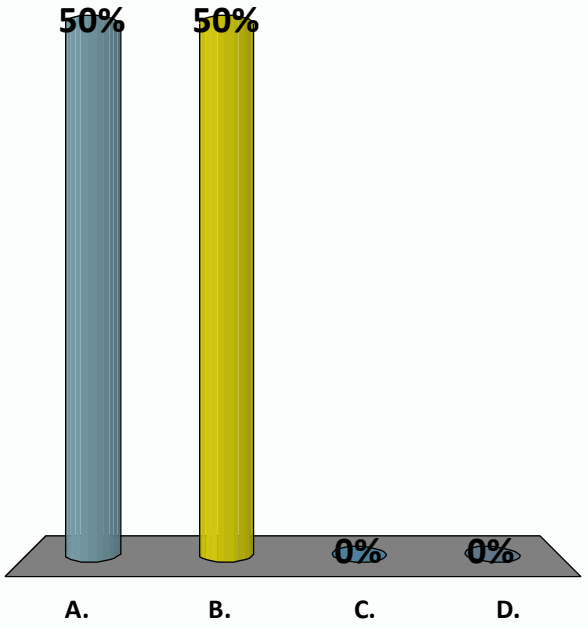
Dept. Land Resources & Environmental Sciences

MONTANA STATE UNIVERSITY

MSU Soil Fertility Extension

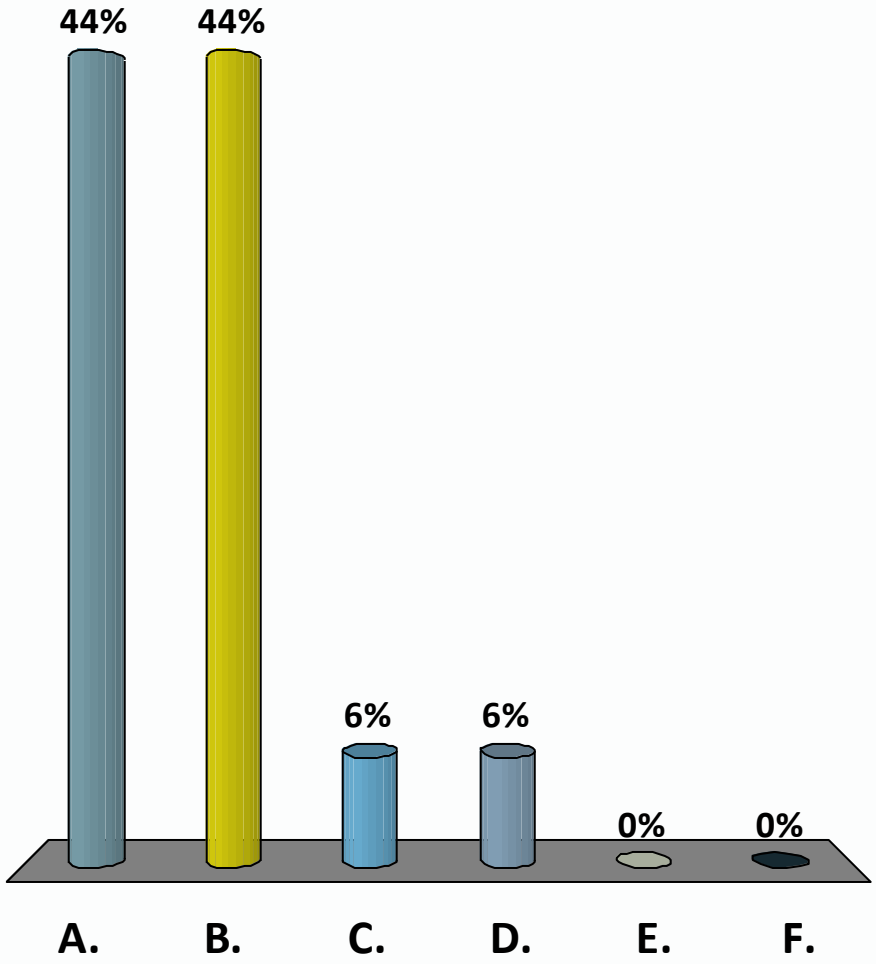
Cover crops:

A. Teach us how to use clickers
B. Can keep you warm at night
C. Build strong worms
D. Are yummy if you are a cow



What brings you to the workshop today?

A. Farm management (mainly cash crops on 100+ acres)
B. Ranch management (mainly livestock on 100+ acres)
C. Small acreage farm/ranch management (<100 ac)
D. Job with state or federal government
E. Job as crop adviser
F. Interested citizen



Today's goals

- Present potential benefits of cover crops
- Discuss cover crop effects on
  - Nitrogen
  - Soil organic matter
  - Temperature, aggregate stability, microbial activity
  - Following crop yield and protein
  - Economics
- Present management considerations with cover crops

The Summerfallow Challenge


Photo: Susan Tallman

PROS:
Soil moisture recharge
N benefit

CONS:
Loss of organic matter
Increased
- soil erosion
- saline seeps
- N leaching

Decreased
- soil structure
- water holding capacity
- soil biological activity


Photo: Susan Tallman

Alternatives?

- No-Till
- Cover crops

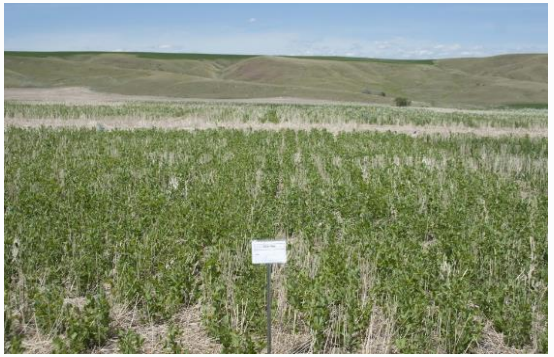
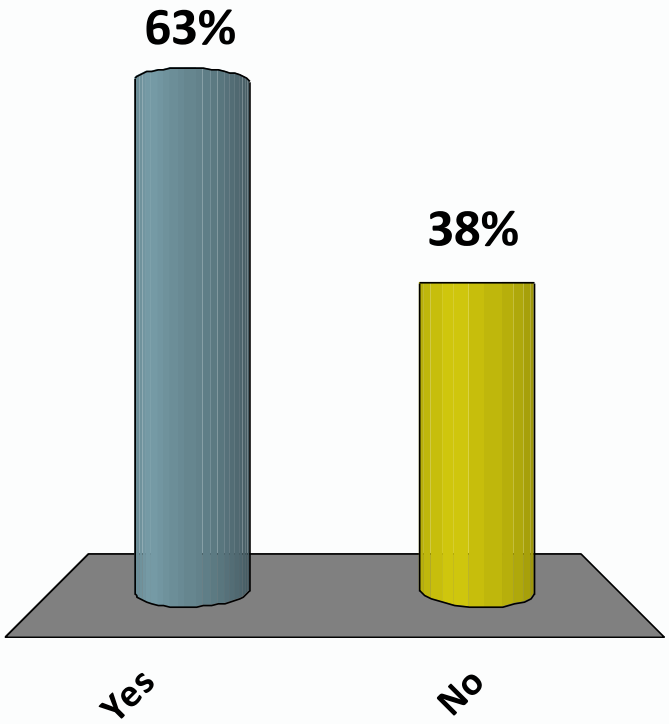


Photo: Steve Spence

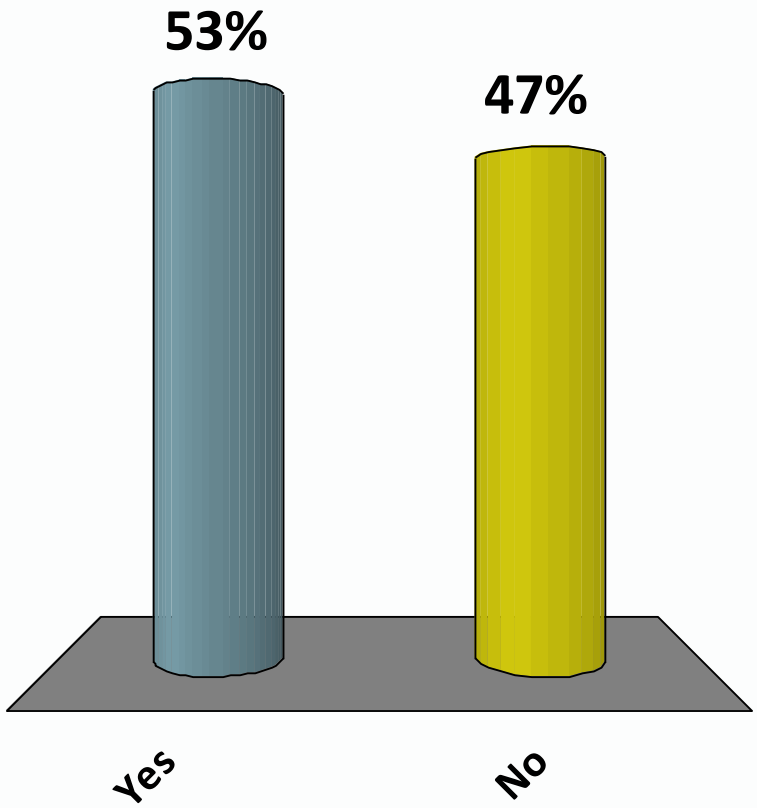
Do you, or have you grown cover crops, or advise people who grow cover crops?

A. Yes
B. No



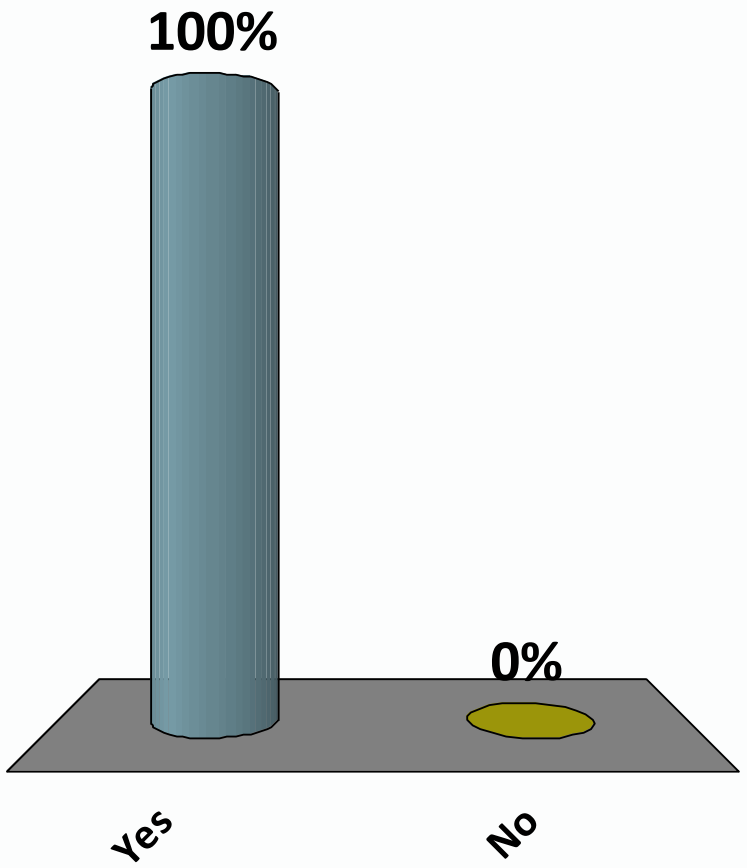
Have you heard of MSU's cover crop studies?

A. Yes
B. No



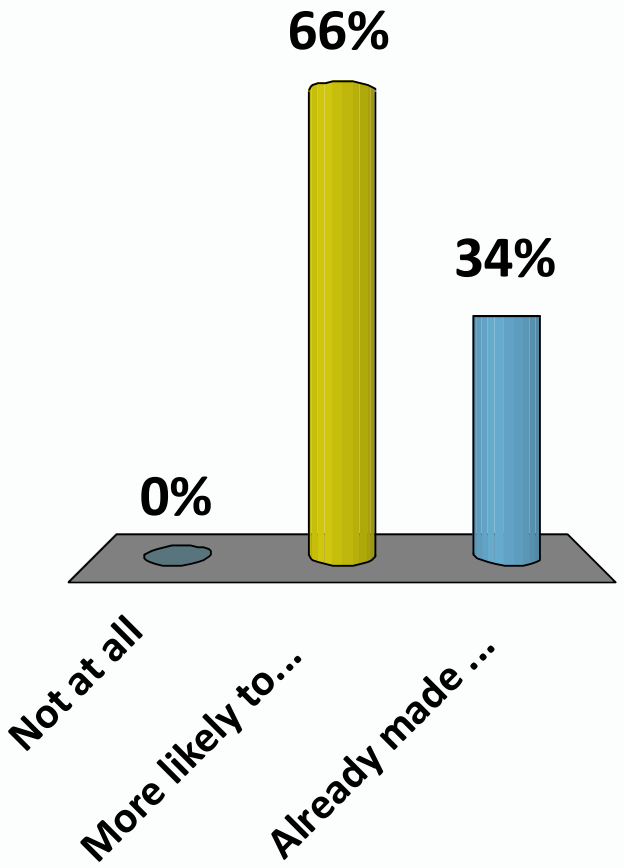
If you've heard of our studies, have they changed your understanding of cover crops?

A. Yes
B. No



If you've heard of MSU's cover crop studies, how has your management changed, if at all?

A. Not at all
B. More likely to make a change
C. Already made a change

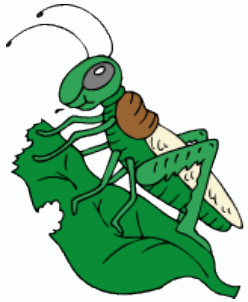


Benefits and challenges of cover crops

Equipment

Biomass

TIME



Management challenges

N, P, K, S

Soil Quality vs Soil Health

Soil Quality = properties that change little, if at all, with land use management practices

- Texture
- pH
- Cation Exchange Capacity

Which is more likely to be influenced by cover crops?

Soil Health = dynamic properties which may be subjective to measure

- Aggregation
- Microbial activity
- Tilth
- Nutrient availability
- Water holding capacity
- Compaction

What we have found with MT research trials

MSU single species cover crop research since 1999 has found higher grain yields and/or protein after cover crops when:

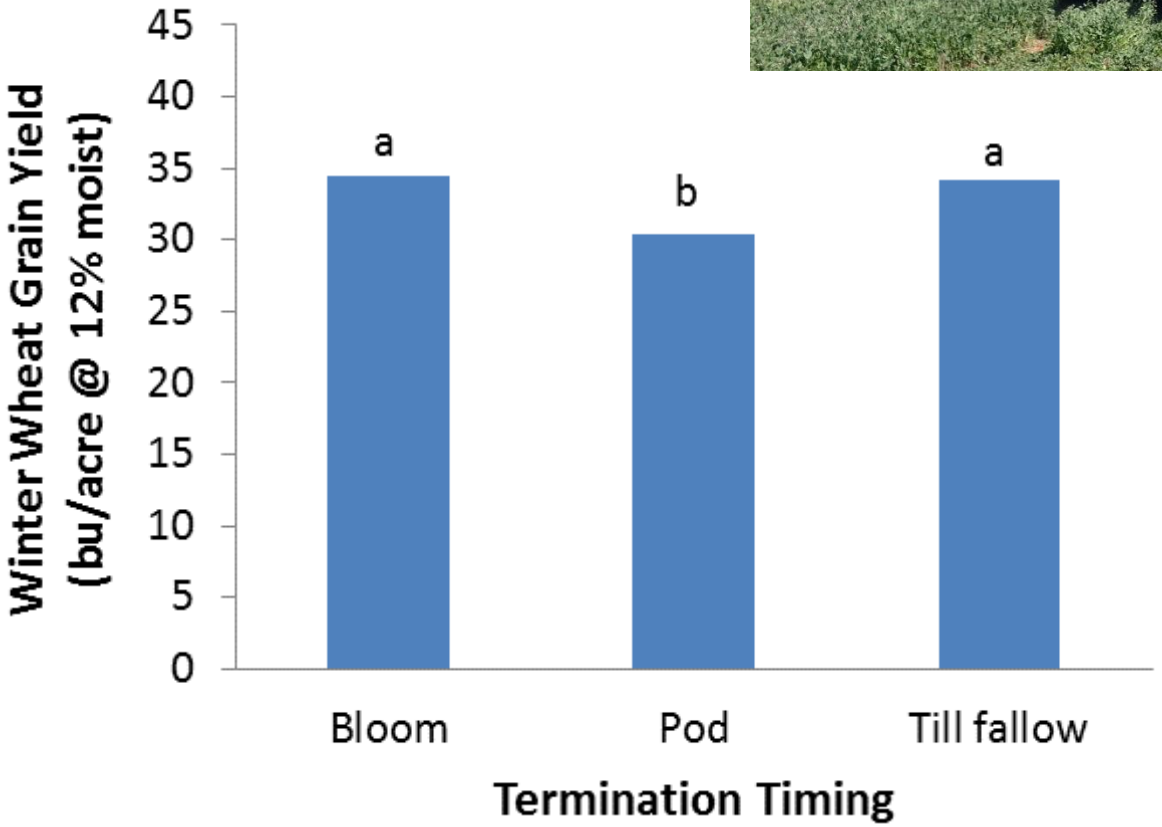
1. Seeding winter legumes (vs spring legumes)
2. Seeding spring cover crops early (vs late)
3. Terminating at first bloom (vs pod)
4. Tilling cover crop (vs spraying)

Why?

- More N fixed (1)
- More time for soil water to be recharged and N to become released from residue (1, 2, 3)
- Faster N release and fewer N losses (4)

Our MT studies confirmed early Saskatchewan studies that termination timing is key

WHY?



Terminating legume cover crop at early bloom produced higher organic wheat yields the following year than terminating at flat pod in 2006-2007

(Miller et al. 2011)

Similar results for advantage of bloom over pod in conventional systems

Plot Study No-till and Till: Design

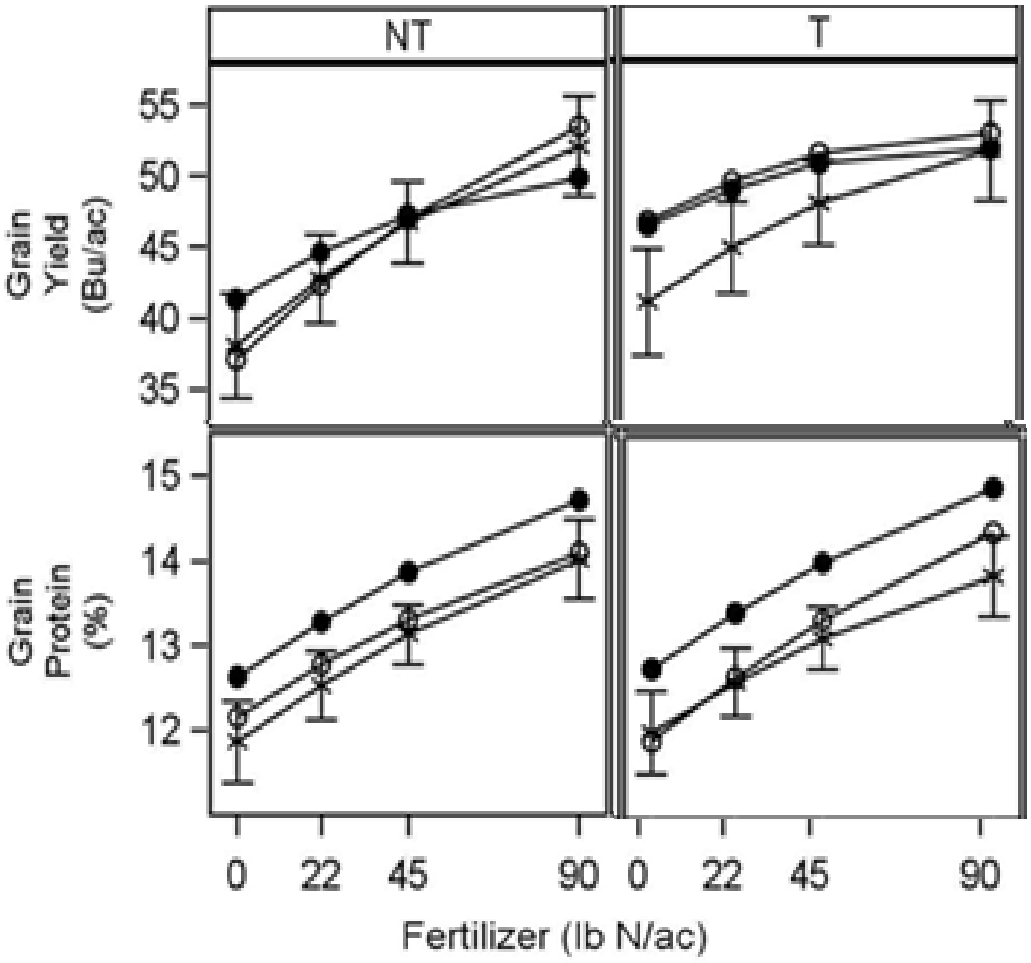
3 Crop Treatments X **Tillage Treatments**

- Spring Pea Manure
- Spring Lentil Manure
- Fallow

- No-Till (NT)
- Till (T)

- Green manures terminated at first flower
- Spring wheat planted at 4 N rates following year
- Gallatin Valley, ~14 inch annual precip.

Effect of lentil and pea cover crop on spring wheat yield & protein



Take home:

- Early-terminated spring cover crop did not hurt wheat yield or protein.
- Pea cover crop only increased yield at low N rates when tilled.
- Pea increased grain protein at all N rates and both NT and T.
- Lentil cover crop did not benefit yield or protein (likely N contribution too low)

Questions?

Cover Crop Cocktails Plot Study

1. Compare crop and soil response to fallow, single species pea CC, and multi-species mixtures
   - Cover crop and wheat: Biomass, biomass quality, yield
   - Soil:
     - Microbial biomass
     - Soil enzyme activity
     - Soil temperature
     - Aggregate stability
     - Compaction
     - Soil water, nitrate, and Olsen P
     - Mycorrhizal colonization
     - Potentially mineralizable nitrogen
2. Determine the specific effects of 4 plant functional groups
3. 2 sites in Triangle, 2 in Gallatin Valley

Plant functional groups – planted individually and in groups

Nitrogen Fixers

Spring Pea
Common Vetch
Lentil

→ *Increase nitrogen*

→ *Add soil carbon*

Fibrous Root

Oats
Italian ryegrass
Proso millet

→ *Reduce compaction, move nutrients upward*

→ *Potential disease control*

Tap Root

Purple top turnip
Safflower

Brassica

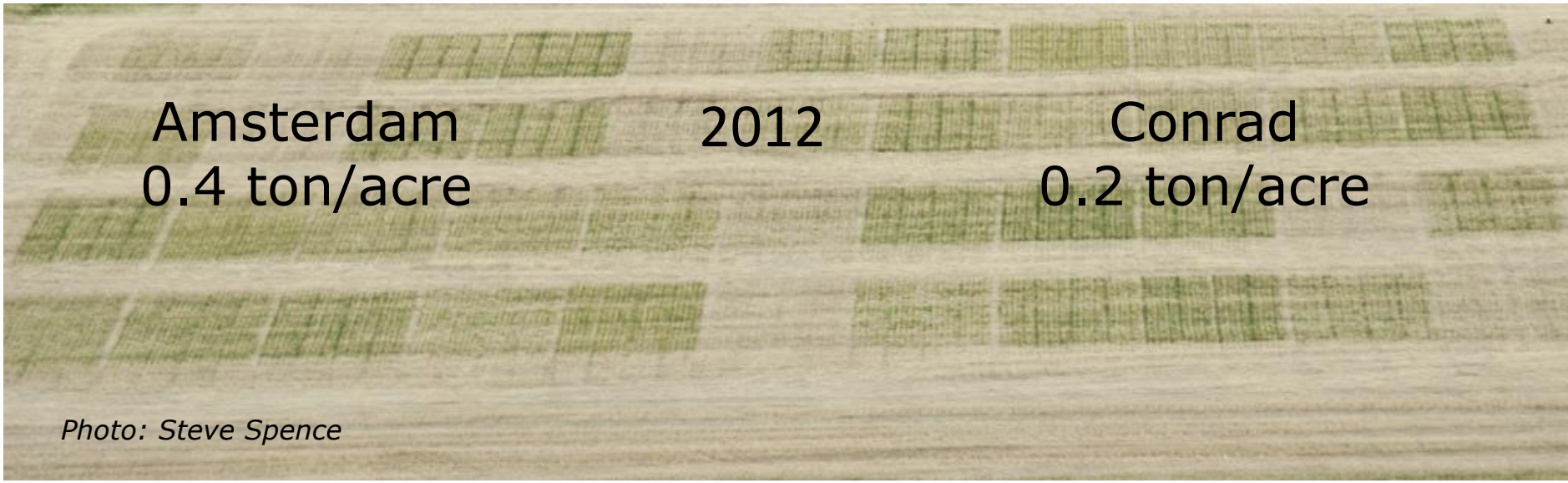
Daikon radish
Winter canola
Camelina

Lessons learned about plantings

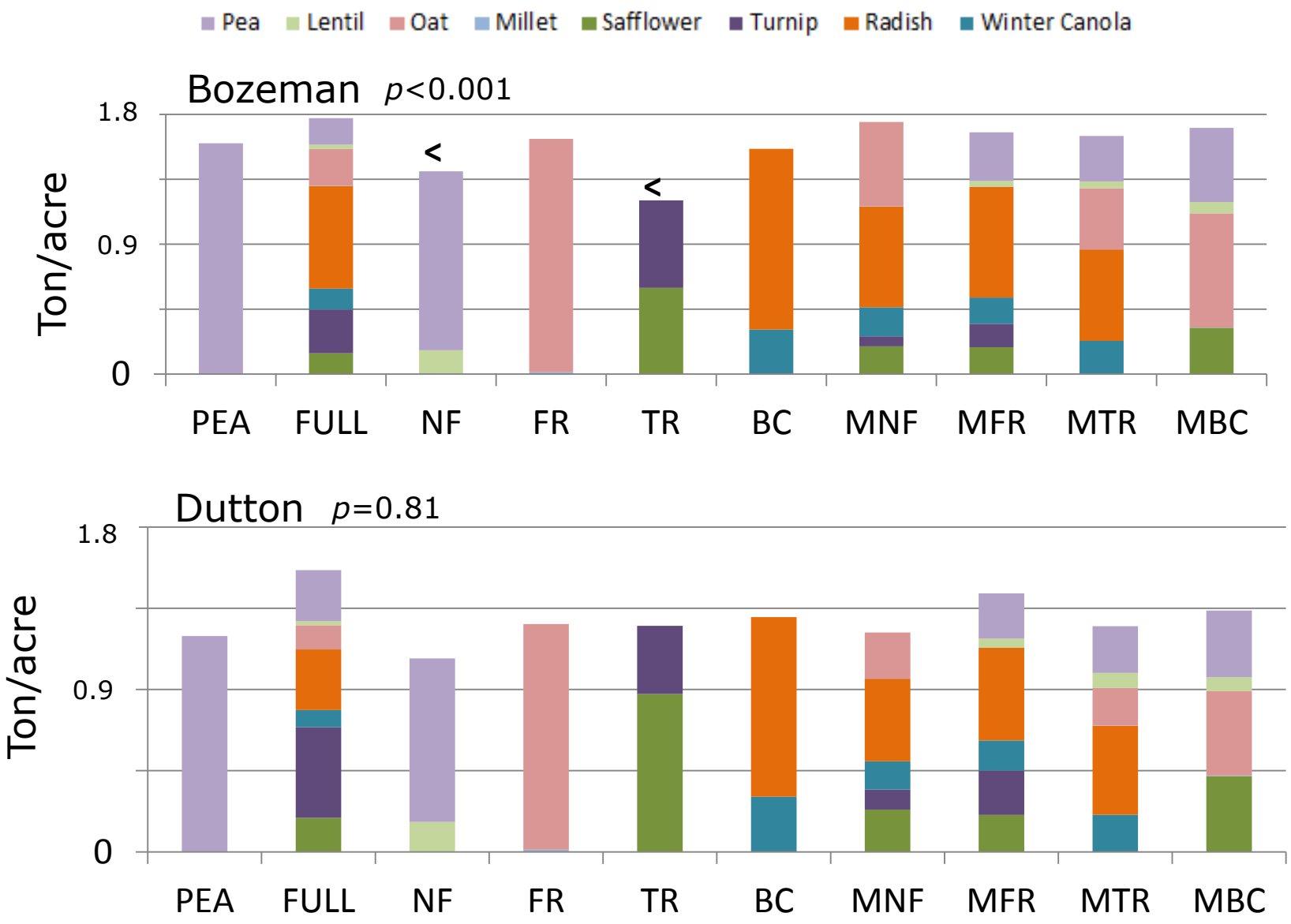
Photo: Susan Tallman

- Early weed control essential
- Common vetch difficult to terminate w/ glyphosate
- Camelina, Italian ryegrass, and lentil not competitive
- Radish bolts in late spring
- Millet not competitive in mid-spring mix
- Possible biological control benefits of wheat-stem sawfly with oat and radish

Cover Crop Biomass – depends on moisture

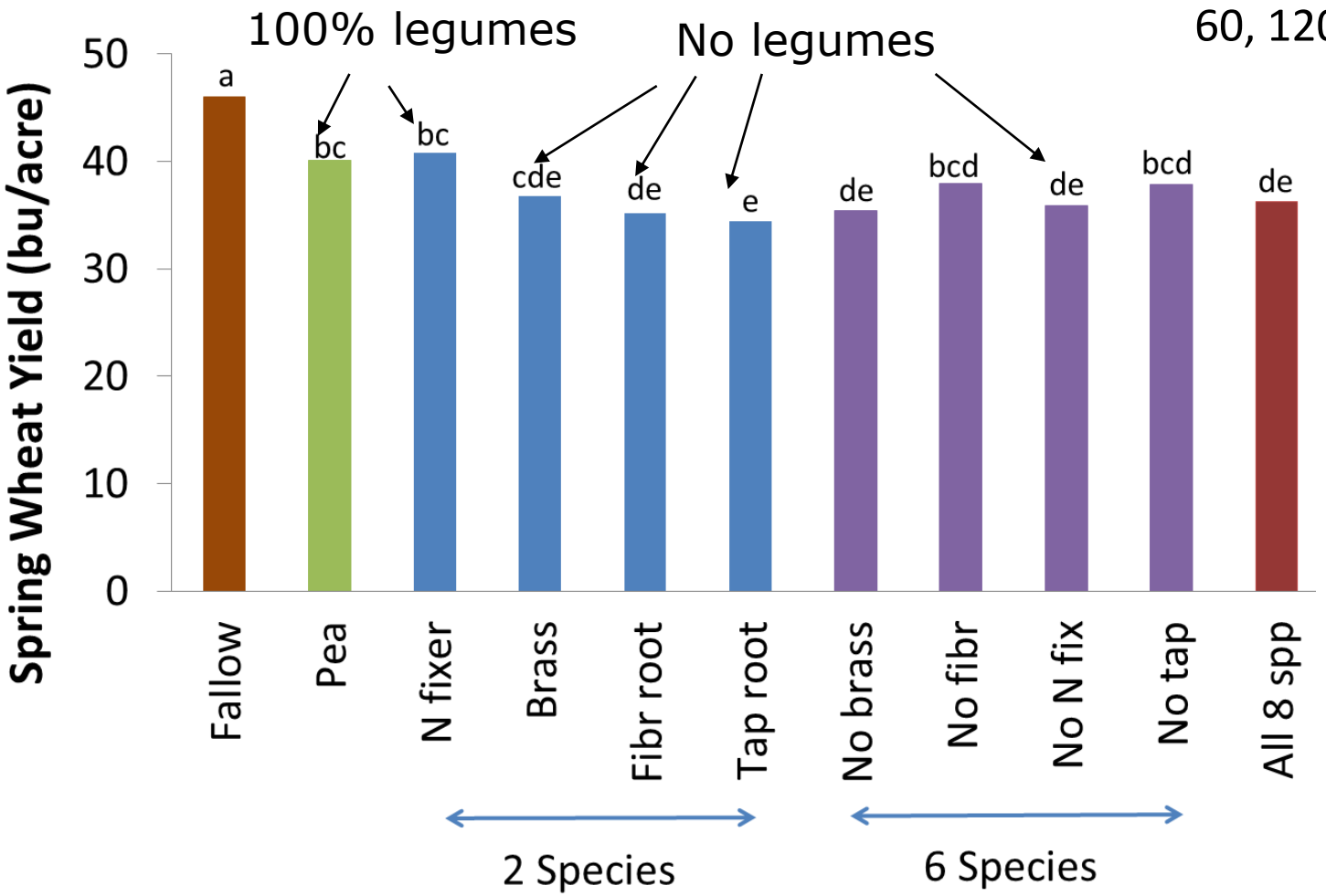


2013 Cover Crop Biomass – wet year



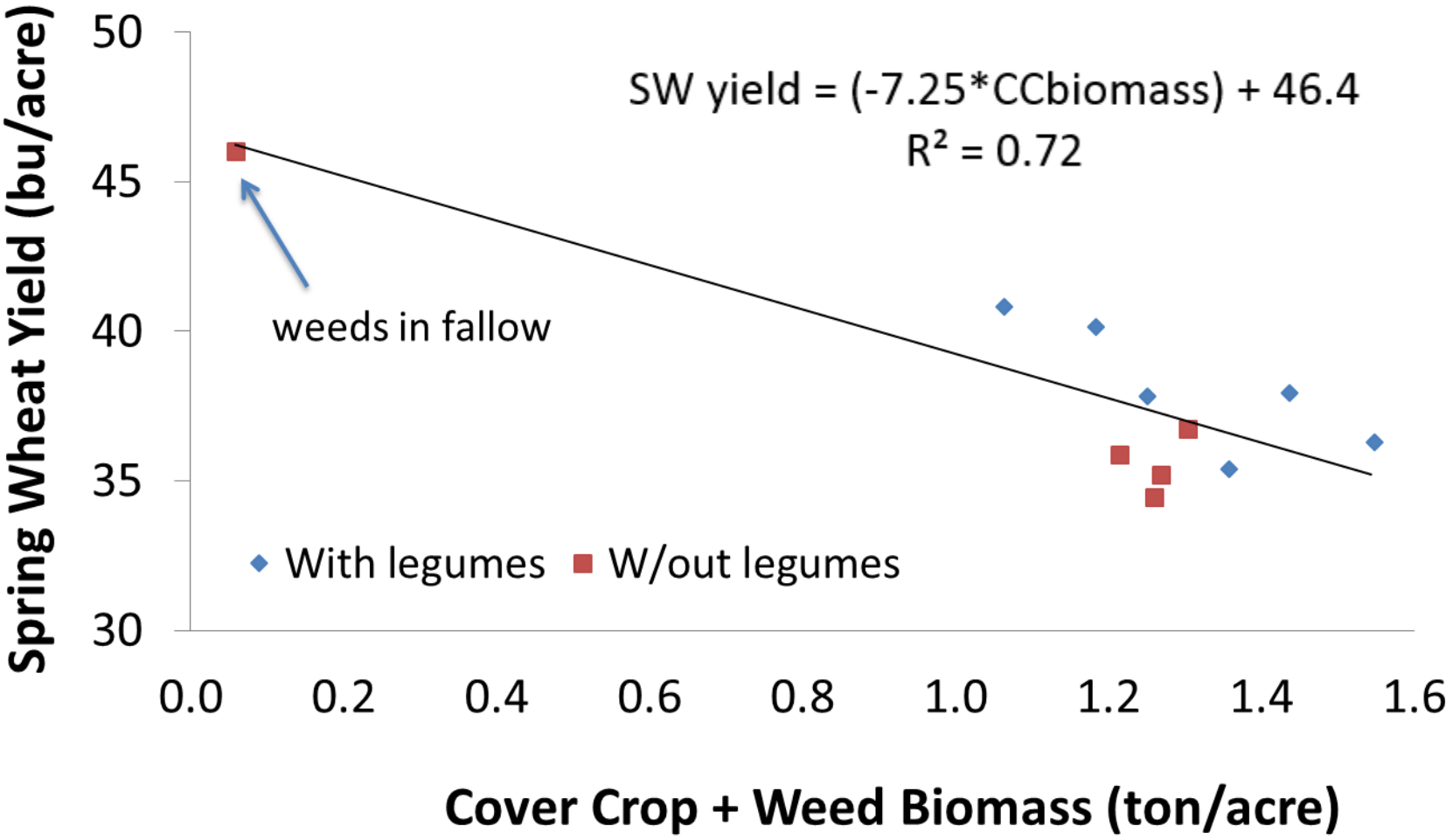
Effect of cover crop treatment on spring wheat grain yield at Dutton (2014)

Averaged over 0, 60, 120 lb N/acre



Housman et al., unpub. data, Dutton

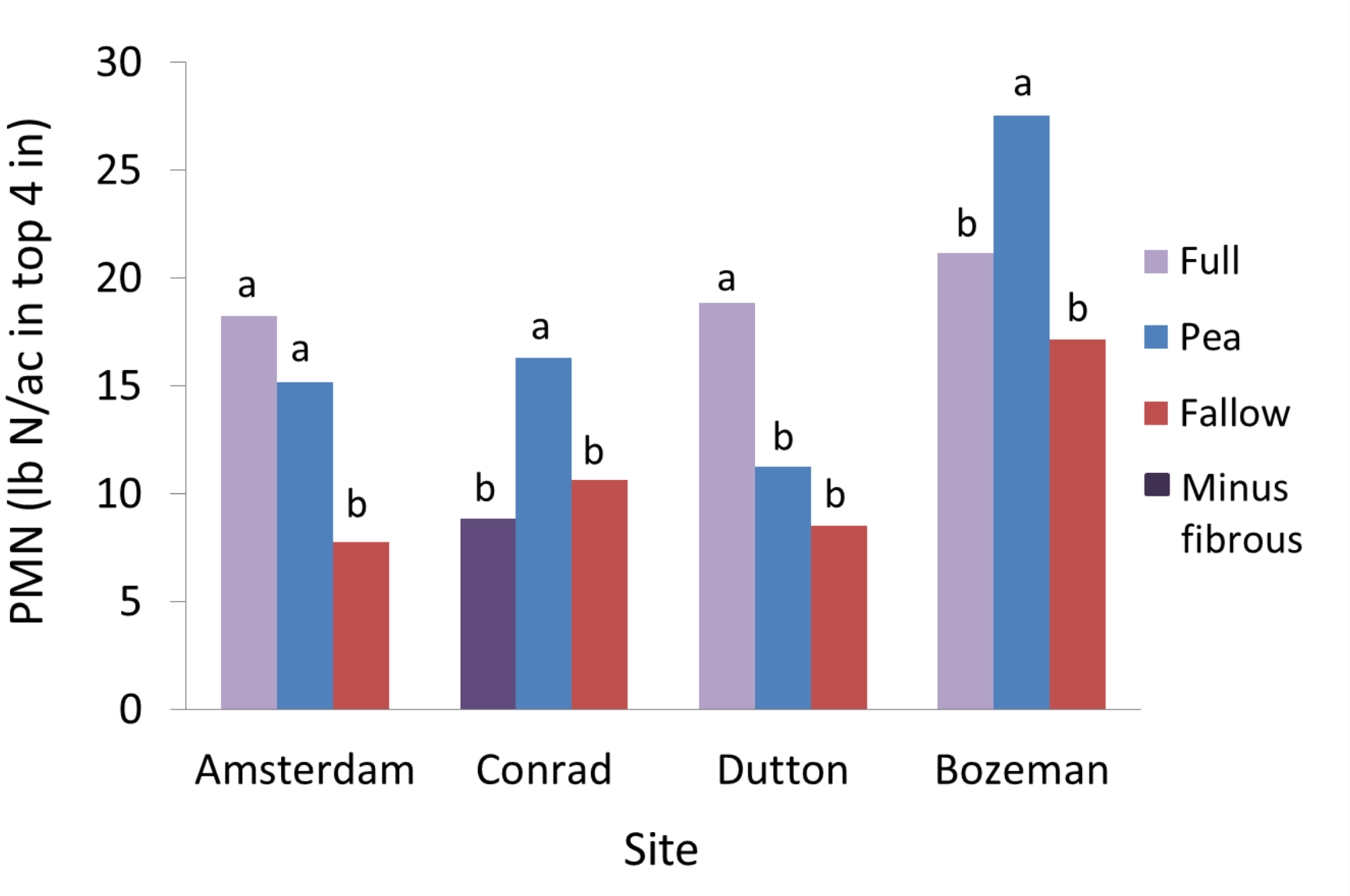
Spring wheat yield at Dutton vs previous year total biomass (cc + weed)



Housman, Tallman, et al., unpub data, Dutton

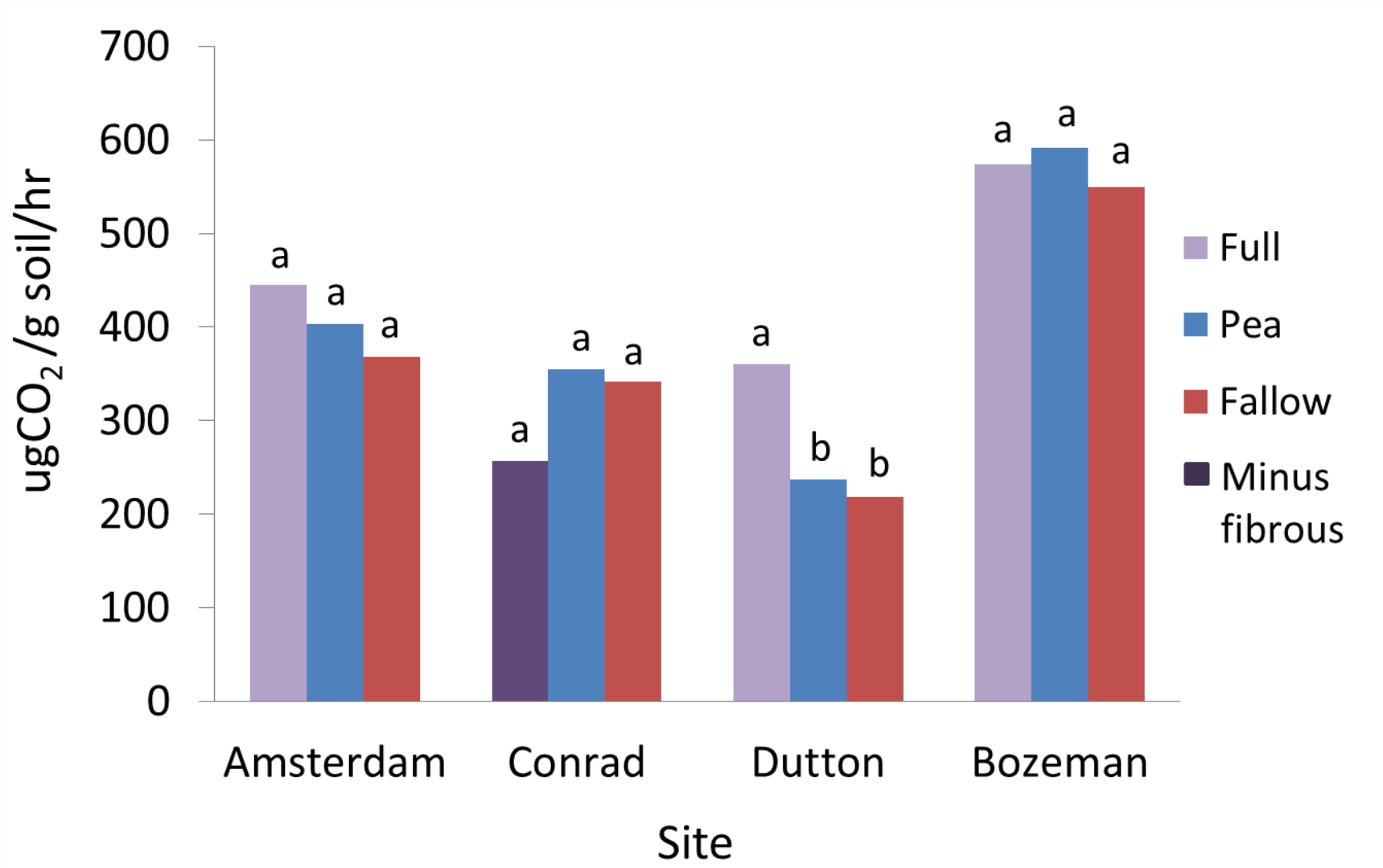
What about soil health?

Potentially Mineralizable Nitrogen – 1st year



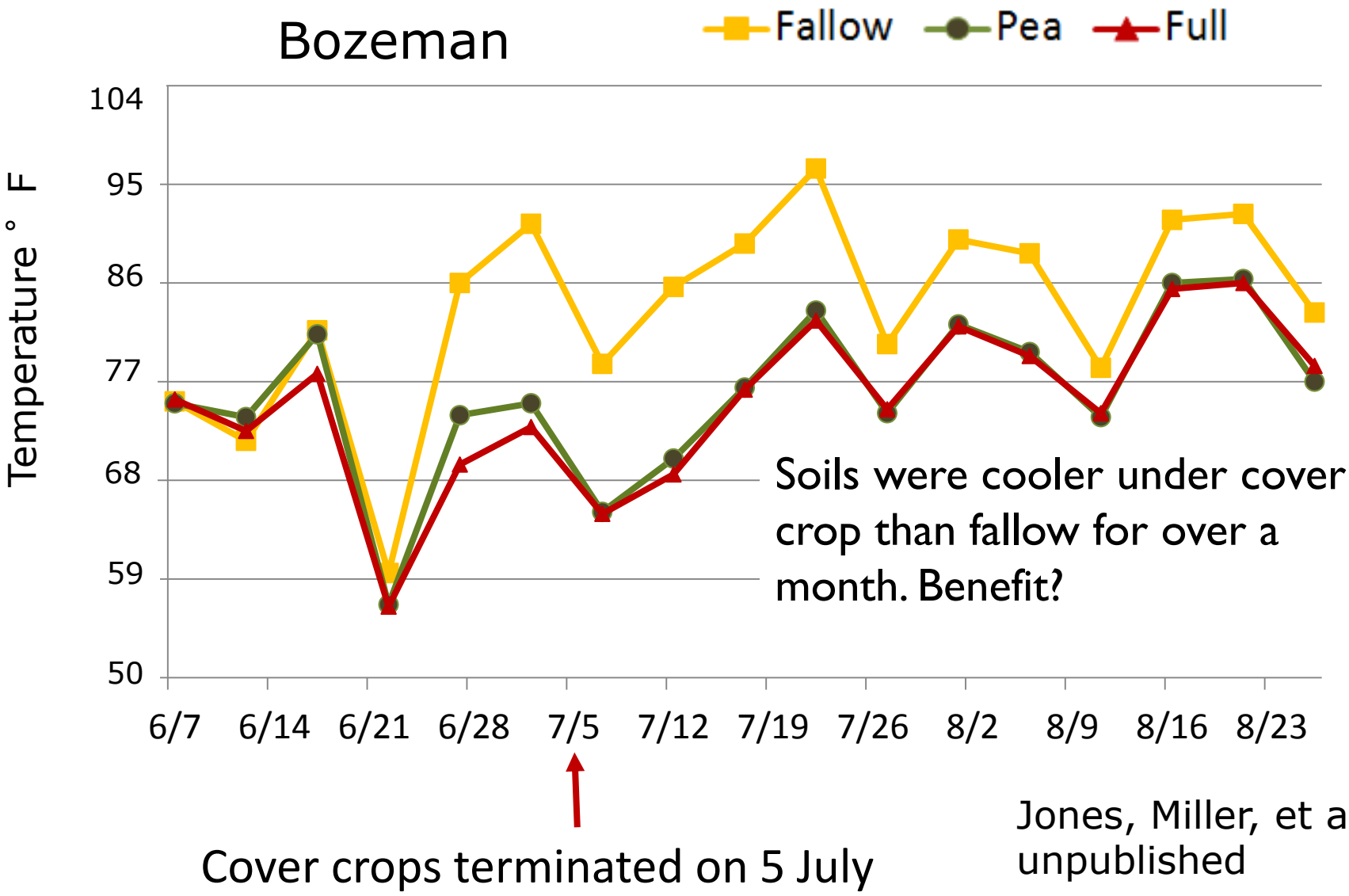
Tallman, Housman, et al., unpub data

Microbial Biomass – 1st year



Tallman, Housman, et al., unpub data

Soil temperature at 2” deep much higher under fallow than cover crops (but no differences between pea and full)



Summary after FIRST full rotation

	Amsterdam	Conrad	Dutton	Bozeman
CC Biomass	ns	ns	ns	ns
Biomass C:N	8 spec>Pea	ns	8 spec>Pea	ns
Microbial Biomass	ns	ns	CC>fallow	CC>fallow
PMN	CC>fallow	Pea>6 spec	CC>fallow	ns
Olsen P	ns	ns	ns	ns
Temp at 2”	--	--	CC<fallow	CC<fallow
Aggregate stability	ns	ns	ns	ns

ns – no significant difference (95% confidence) among any treatments (meaning pea vs 8 spec OR fallow vs cover crops)

Summary after SECOND full rotation

	Amsterdam	Conrad
Cover crop biomass	6 spp. > 2 spp.	ns
Microbial Biomass	CC>fallow	ns
Microbial Enzymes (5)	CC>fallow	ns
PMN	CC>fallow	ns
Olsen P	ns	ns
Temp at 2”	CC<fallow	CC<fallow
Aggregate stability	ns	ns

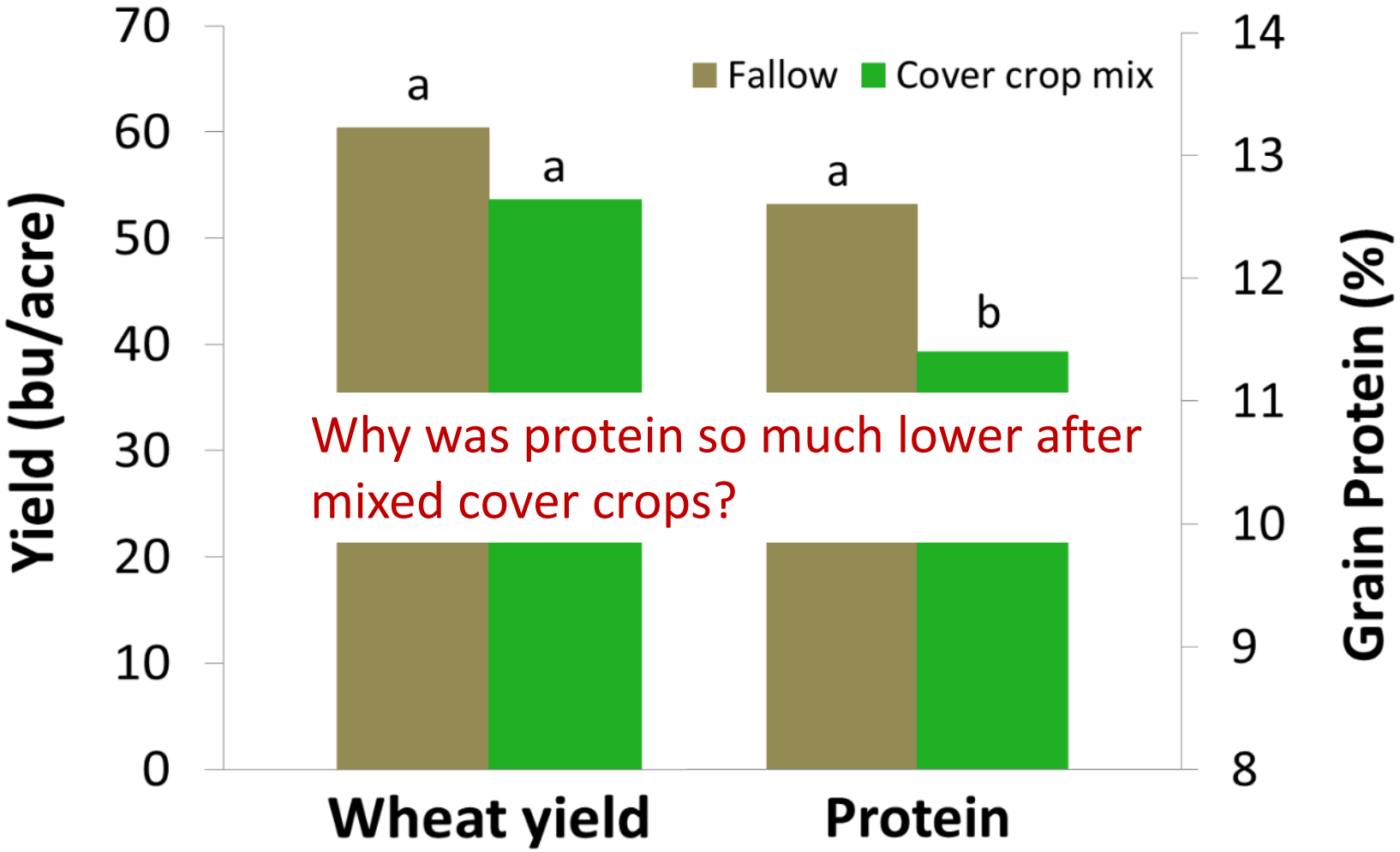
ns – no significant difference (95% confidence) among any treatments (meaning pea vs 8 spec OR fallow vs cover crops)

Cover Crop Cocktails Plot Study: Take home messages on yield and soil quality

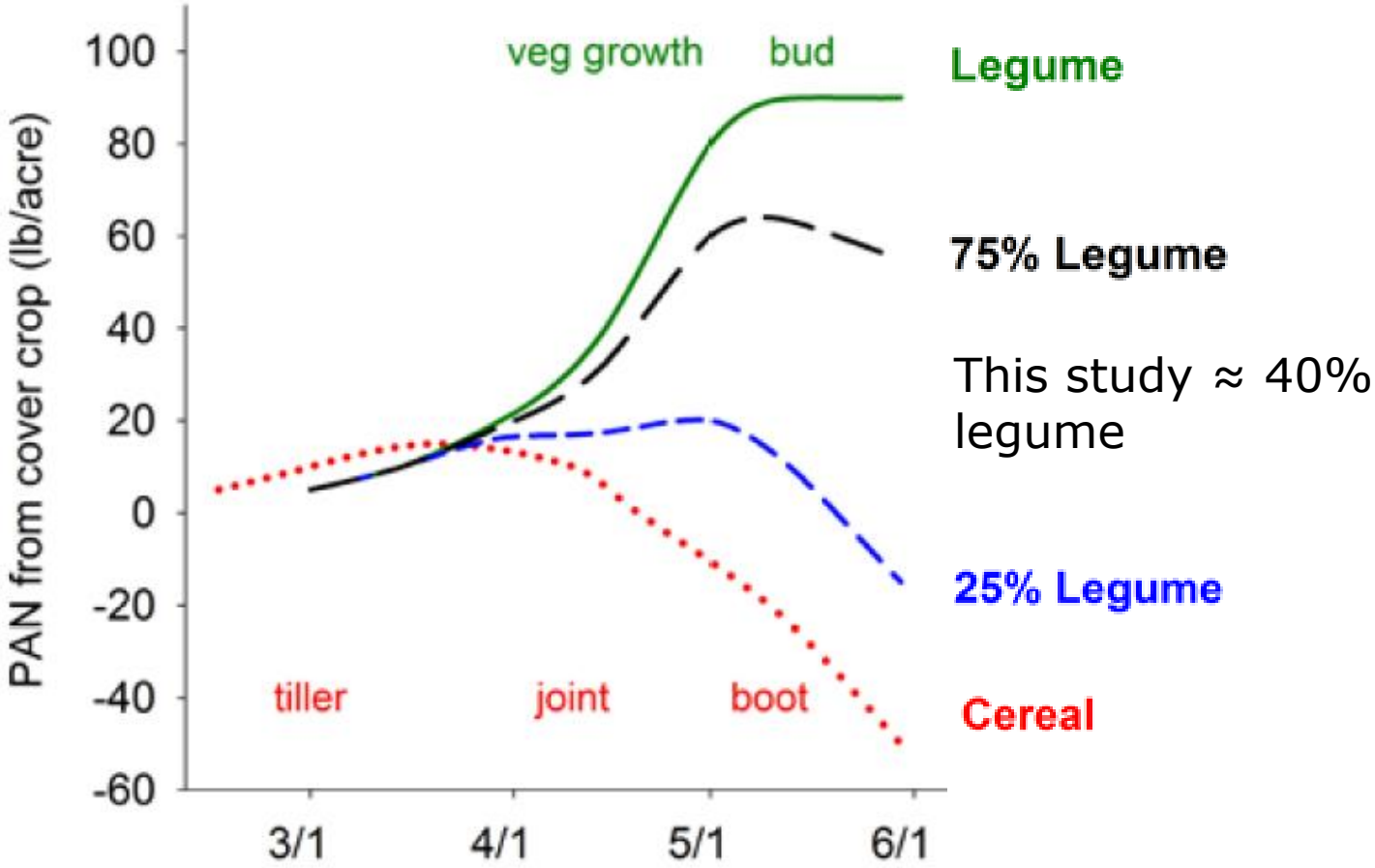
- After one cycle, spring wheat grain yields higher after pea and N fixers than most other mixes.
- Higher cover crop biomass correlated with lower spring wheat yield, likely b/c of more water and N use.
- Relatively few soil health differences between pea and 8-species mix after one cycle; not unexpected.
- After two cycles, no soil health differences between pea and 8-species mix, but CCs increased microbial activity.

Questions?

Cover Crop Cocktails Farm Study: Spring wheat yield after mixed CC, Gallatin Valley



Percent legume and termination timing affects plant available N (PAN)

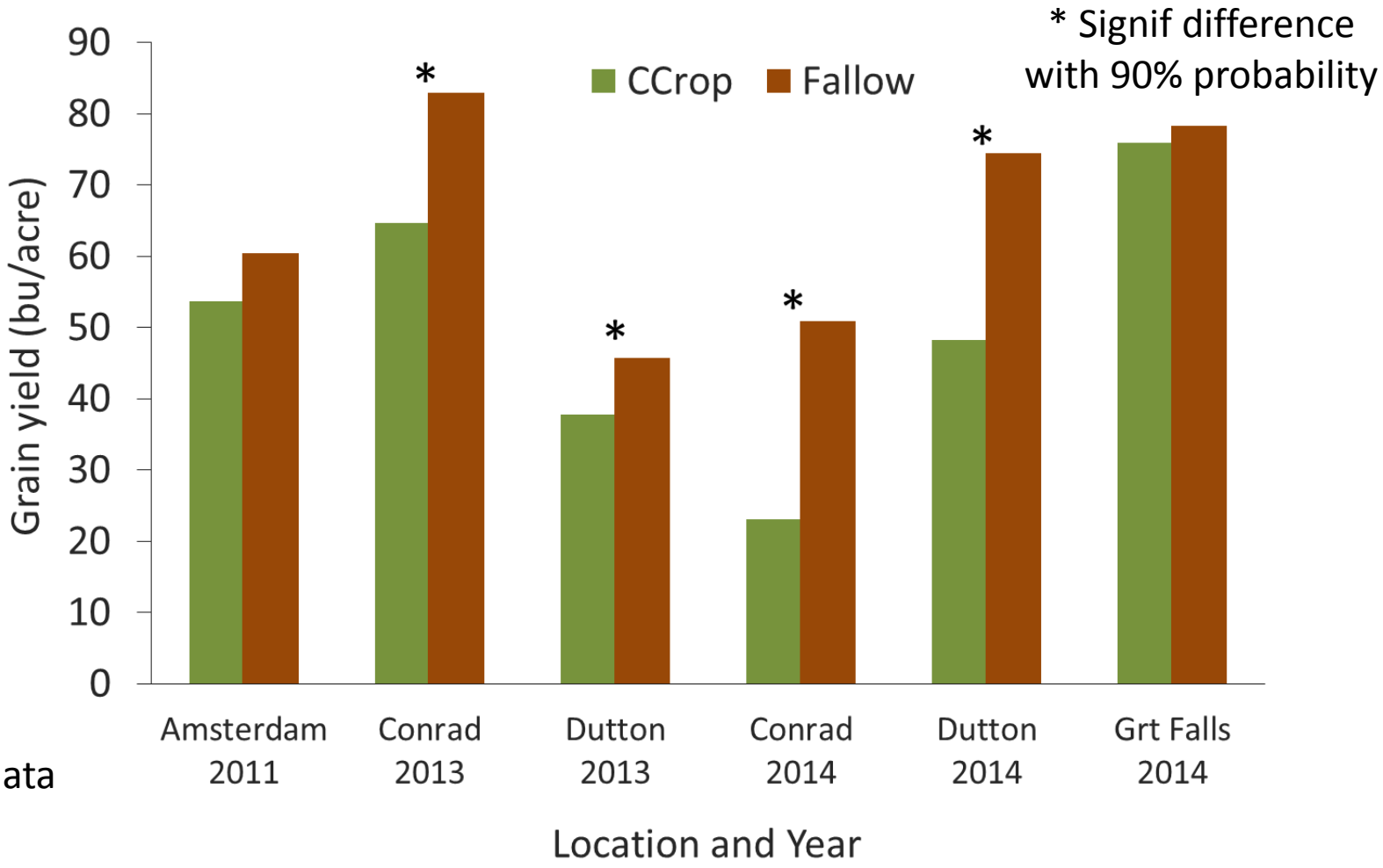


This study ≈ 40% legume

Take home: Legume % less than 50 can result in low available N esp if terminated late

Willamette Valley, Oregon
Sullivan and Andrews, 2012

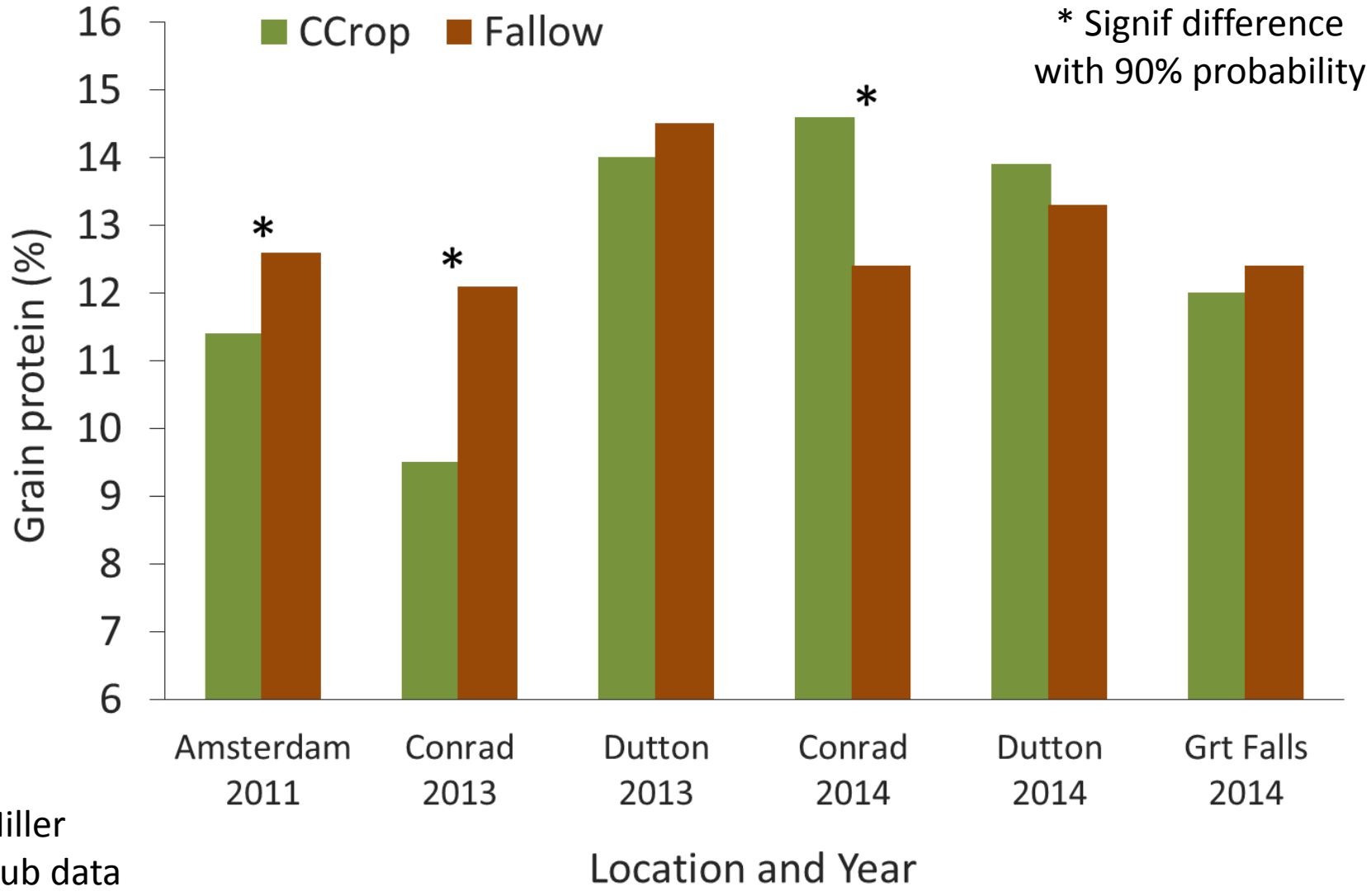
Cover Crop Cocktail Farm Study: 1 rotation of mixed CC reduced grain yield in 4 of 6 production years



P. Miller unpub data

Yield less after mixed cover crops on farmers' fields, likely due to late termination and high water & N use by CCrop

Cover Crop Cocktail Farm Study: 1 rotation of mixed CC produced varied grain protein results



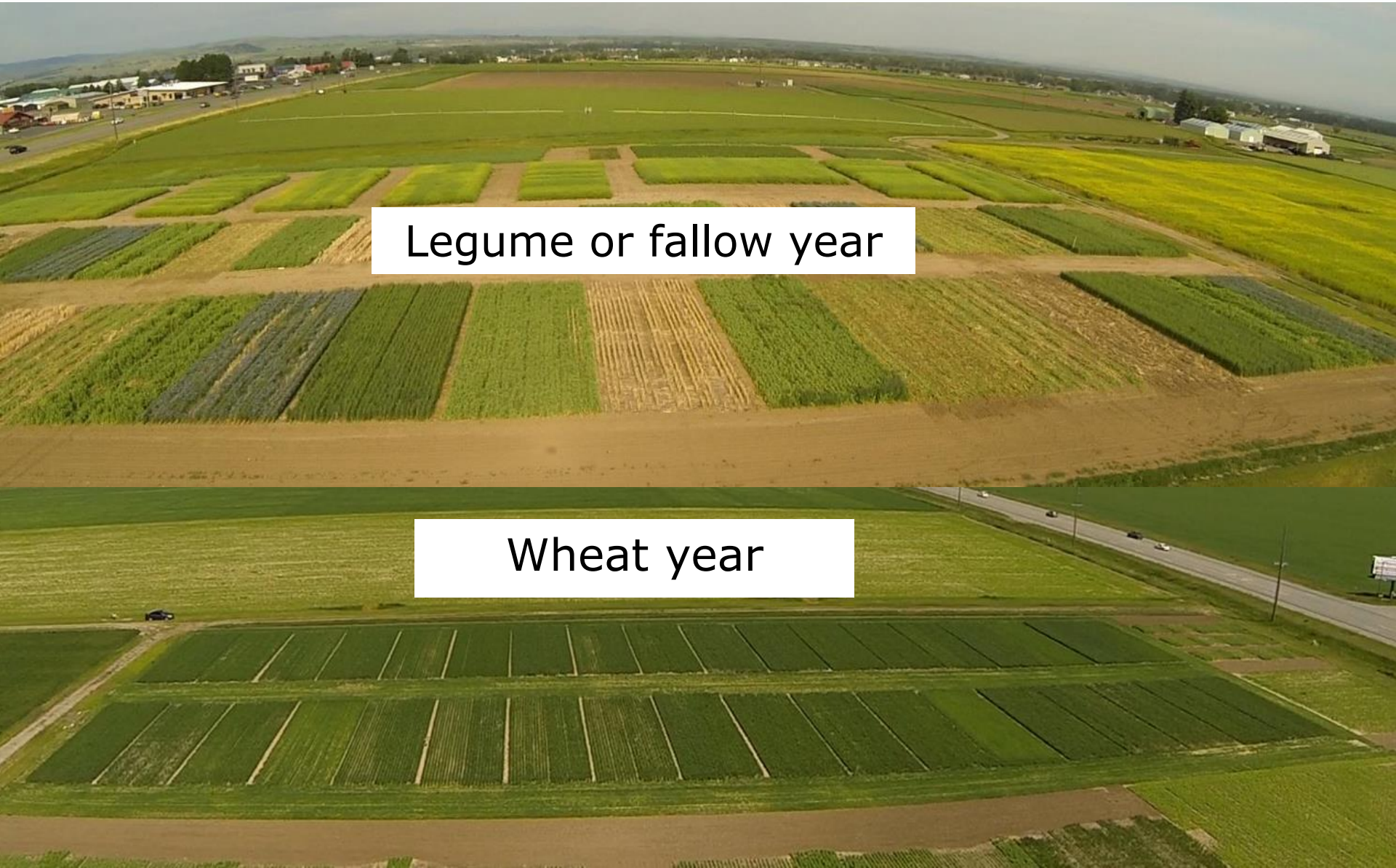
P. Miller unpub data

Cover Crop Cocktails Farm Study: Take home messages on yield and protein

- Spring wheat grain yield was lower after CC than fallow in four of six field-scale studies, and protein results were mixed.
- High water use from late termination was likely cause of yield differences.
- Low N availability from late termination & low legume % was likely cause of protein differences.

Questions or Comments?

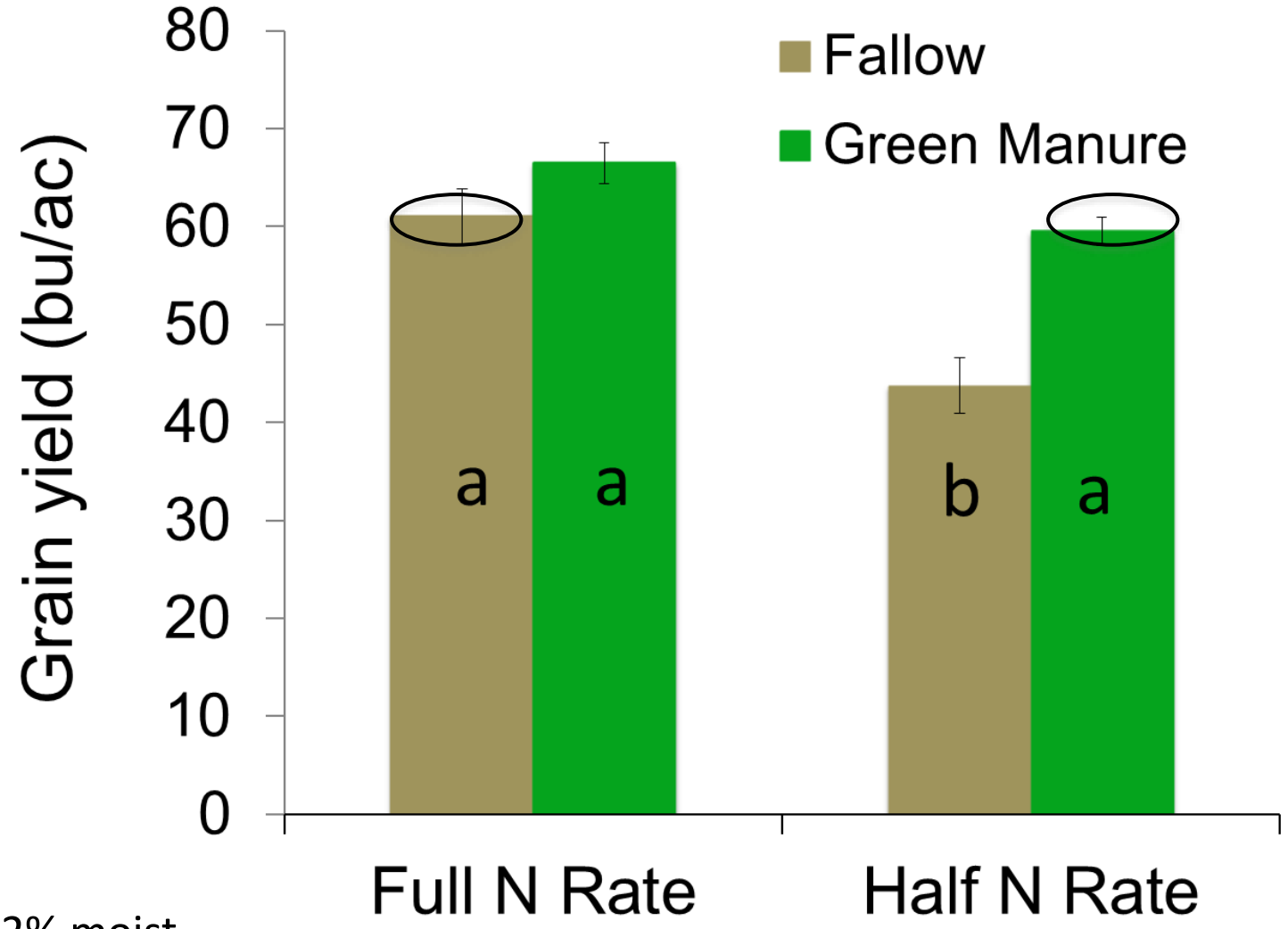
Not a stellar outlook for cover crops in short term, what about long term? 8-year plot study



8-year Plot Study

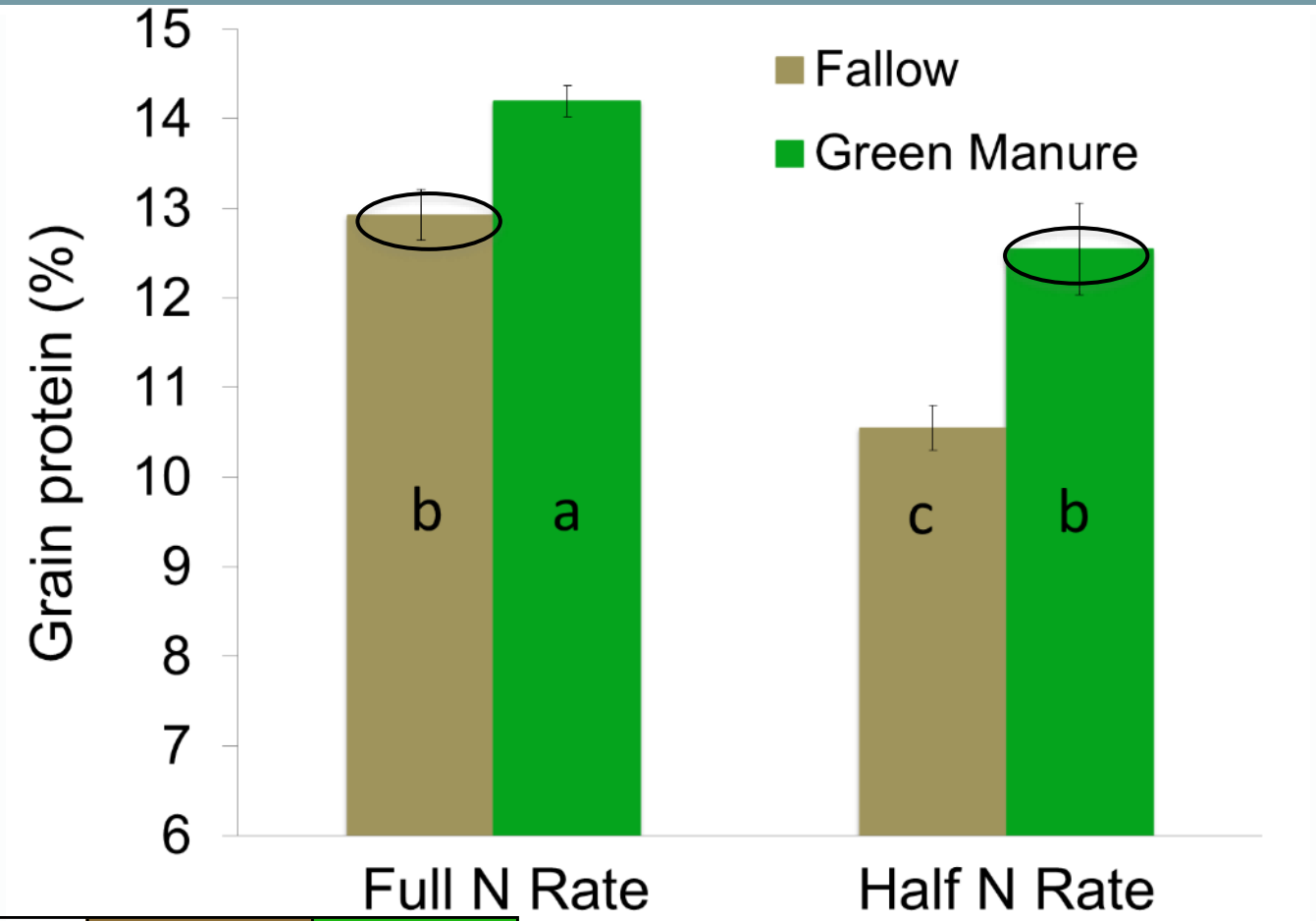
- Long-term effects of no-till pea forage/legume cover crop-wheat vs. fallow-wheat
- ~16” annual precip on deep soils & ability to recharge soils
- Pea forage grown in 2003, 05, 07 and pea CC grown in 2009, terminated at full pod
- Spring or winter wheat planted in even years. 2010 was wettest of wheat years, 2012 record drought.
- 2 N rates: Full (3 lb available N/bu) and ½ N
- *NO differences in wheat yield following CC and following fallow in 2004, 2006, 2008, and 2012, and large benefit of CC in 2010*

8 Year Plot Study: Grain yield in 8th year (2010)



@ 12% moist

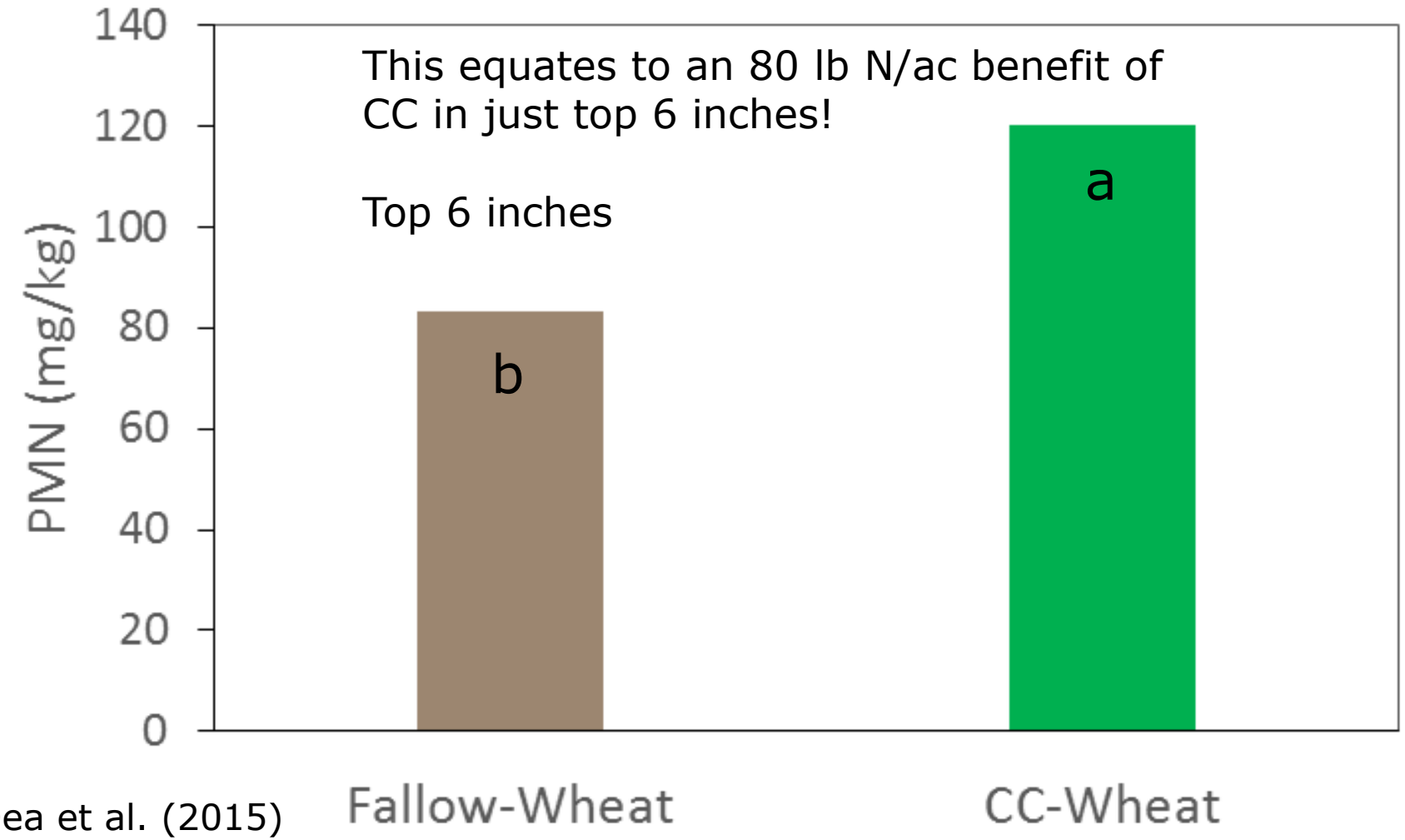
8 Year Plot Study: Grain protein in 8th year



* N fertilizer rates	*Fallow-Wheat*	*LGM-Wheat*
Full N rate (lbs/ac)	124.00	83.00
Half N rate (lbs/ac)	39.00	0.00

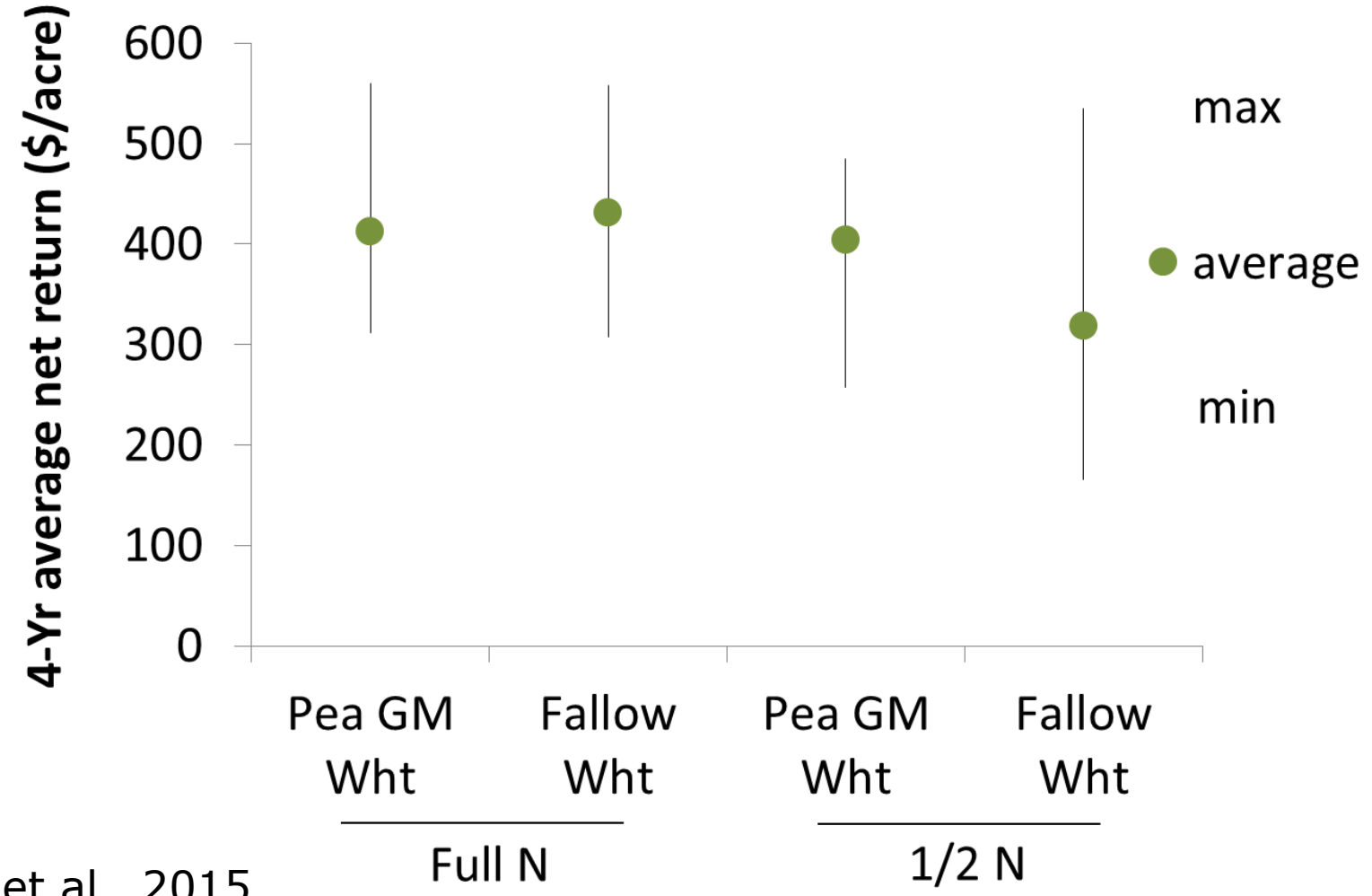
Pea cover crop after 4 CC-wheat rotations saved **124 lb N/ac** compared to fallow.

Potentially mineralizable N (PMN)
Cover crop-wheat vs fallow-wheat (April of 8th yr)



O'Dea et al. (2015)

Economics: 8-year Plot Study (2009-2012)



Miller et al., 2015

8-year Plot Study: Take home messages

- In the first 3 cycles, wheat grain yield was not higher after legume than after fallow.
- After 4 two-year cycles, wheat grain yield and protein were higher after legume CC than after fallow.
- Higher than normal precipitation in 2010 likely 1) increased release of available N from an increased organic N pool, and 2) made N limiting to growth.
- Over 100 lb N/ac was saved in 2010 following legume cover crop compared to fallow!
- Economic returns were more stable with cover crop (less dependent on N rate)

Questions?

N credit from pulse/legumes

- N Credit = The amount of fertilizer N to back off from a standard recommendation (e.g, lb N/bu of yield goal) when previous crop is a legume, *based on spring soil sampling*.
- Adjust yield goal – will be lower after legumes than fallow due to water use, but higher than after small grain

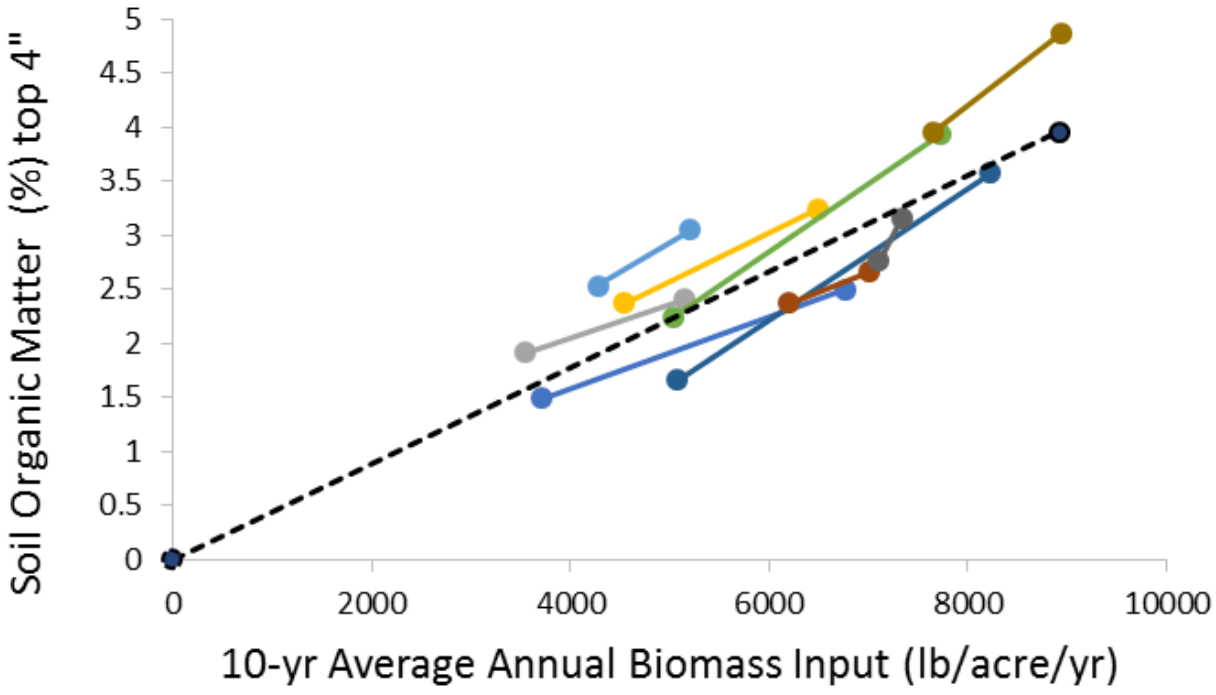
Estimated N credit from pulse/legume

- Legume cover crop grown once:
  20-30 lb N/ac (higher if moist)
- Legume cover crop grown 3 or more times:
  30-50 lb N/ac
- If fall soil test (rather than spring), increase all of above by 10 lb N/ac (due to overwinter N mineralization)

Example N rate calculation (based on Big Sandy study results)

	Fallow	Grain pulse grown 1x	Legume cover crop grown 1x
WW yield goal (bu/ac)	45	35	45
Spring soil N (lb/ac)	80	55	65
Total soil N recommended (bu/ac x 2.6 lb/bu)	45 x 2.6 = 117	35 x 2.6 = 91	45 x 2.6 = 117
N credit (lb/ac)	0	10	25
Fertilizer N (lb/ac)	117-80-0=**47**	91-55-10=**26**	117-65-25=**27**

SOM input = a function of biomass input



- Residue decomposition rate varies with climate, tillage, soil type, etc.
- Potential SOM input depends on biomass produced regardless of soil and site conditions

Fisher et al., 2007, Australia irrigated systems

Decomposition of plant residue to SOM

Wet year and climate

Bozeman, 2013
3300 lb/acre

+

Dry year and climate

Conrad, 2012, 360 lb/acre

CO_2

1650
lb/acre

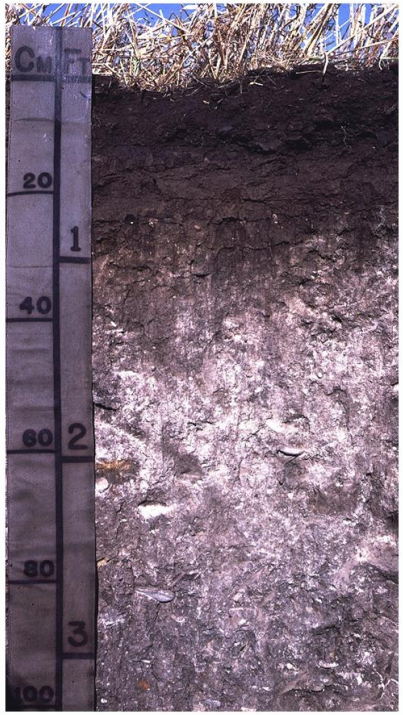
50%

Soil
Organic
Matter

180
lb/acre

SOM addition to soil

2% SOM in top 6”
40,000 lb SOM/acre



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Wet year and climate

1650 lb SOM/acre

$\frac{1650}{40{,}000} = 0.04$ ⟶ 2.08% SOM

After 3 cycles = 2.24%

Dry year and climate

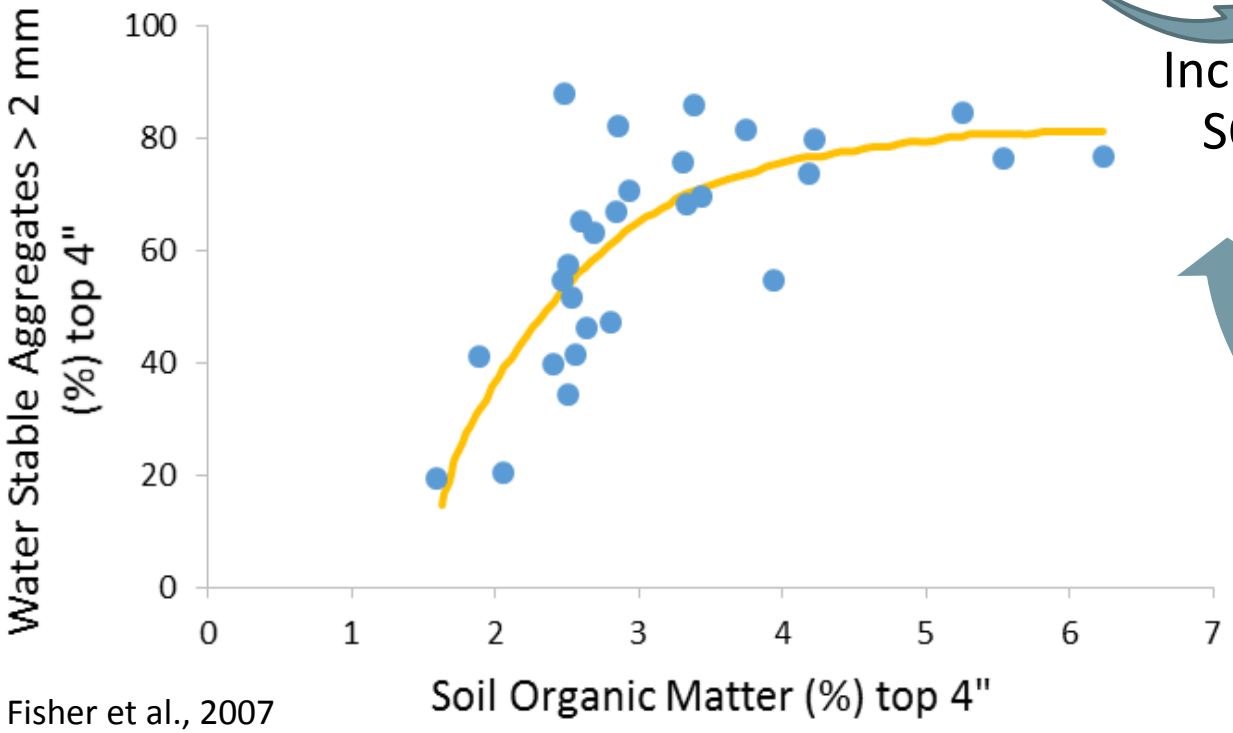
180 lb SOM/acre

$\frac{180}{40{,}000} = 0.0045$ ⟶ 2.01% SOM

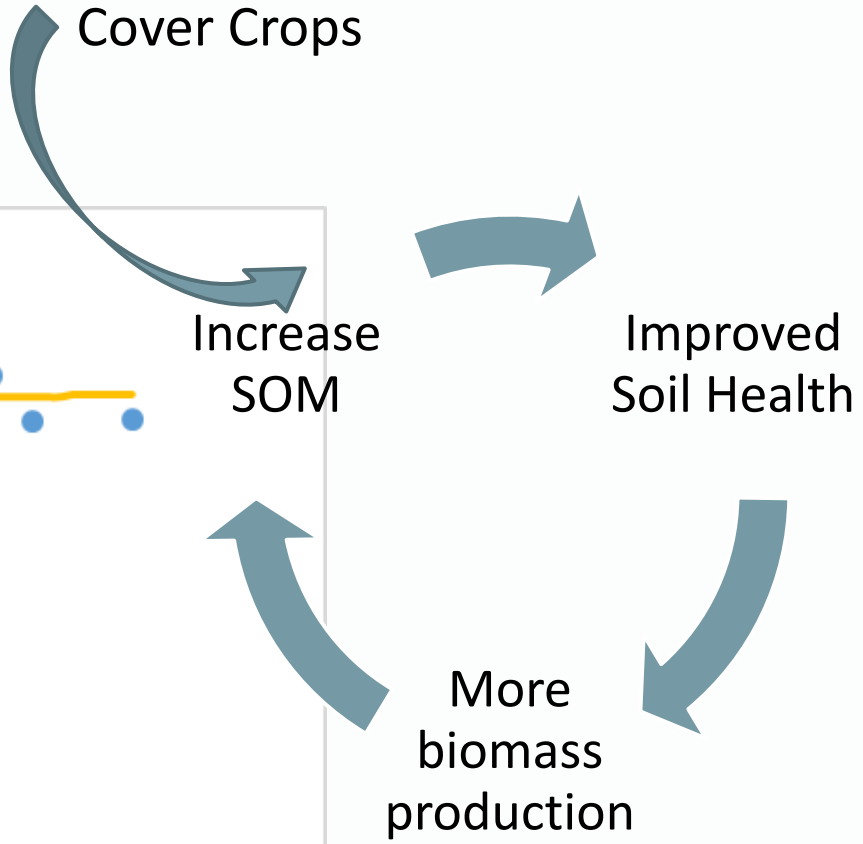
So why try?

The journey of a thousand miles *begins with one step*. ... *Martin Luther King*, Jr.

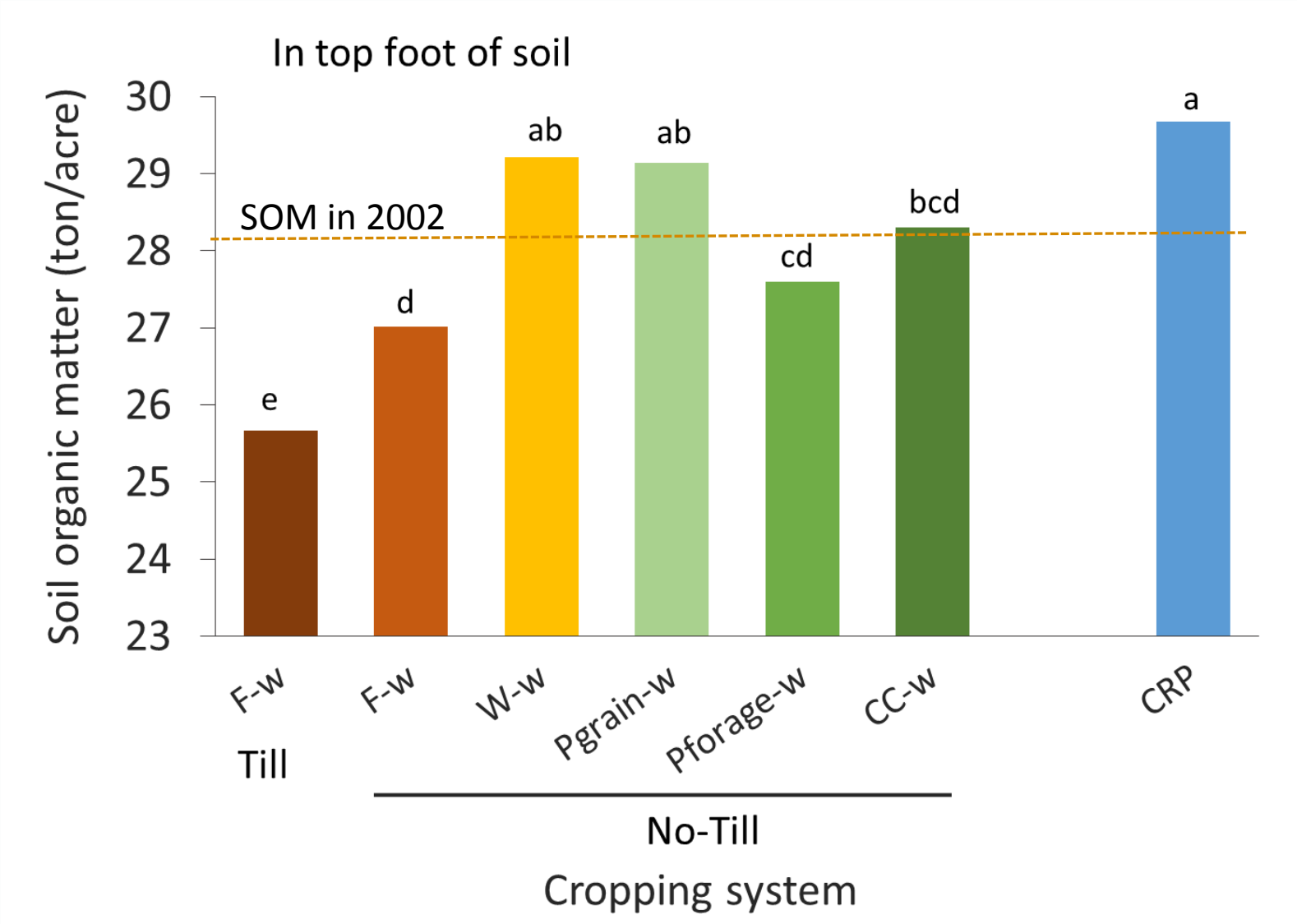
Small increases in SOM lead to potentially large improvement in soil structure.



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

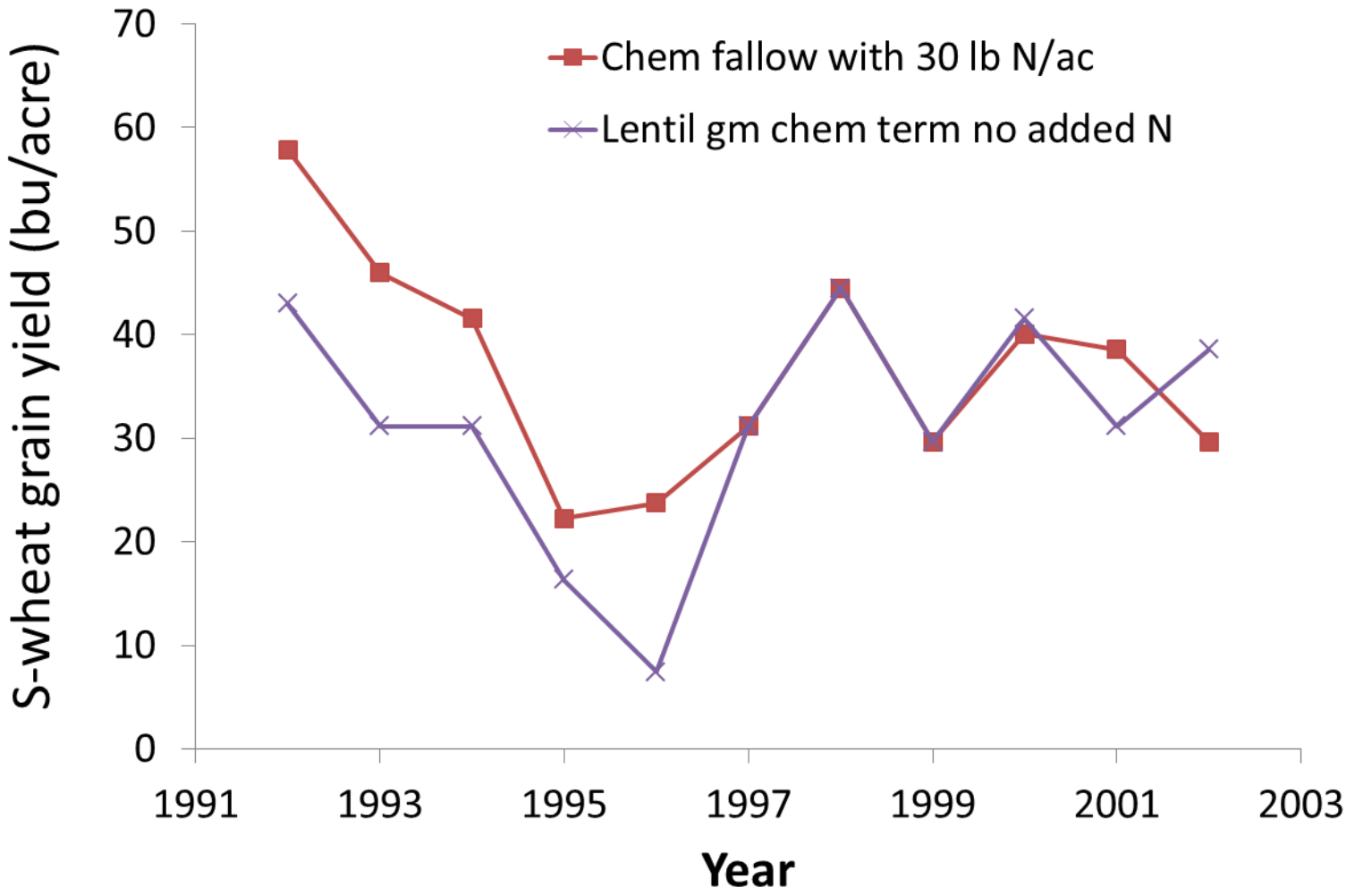


SOM after 10 years cropping systems (2012)



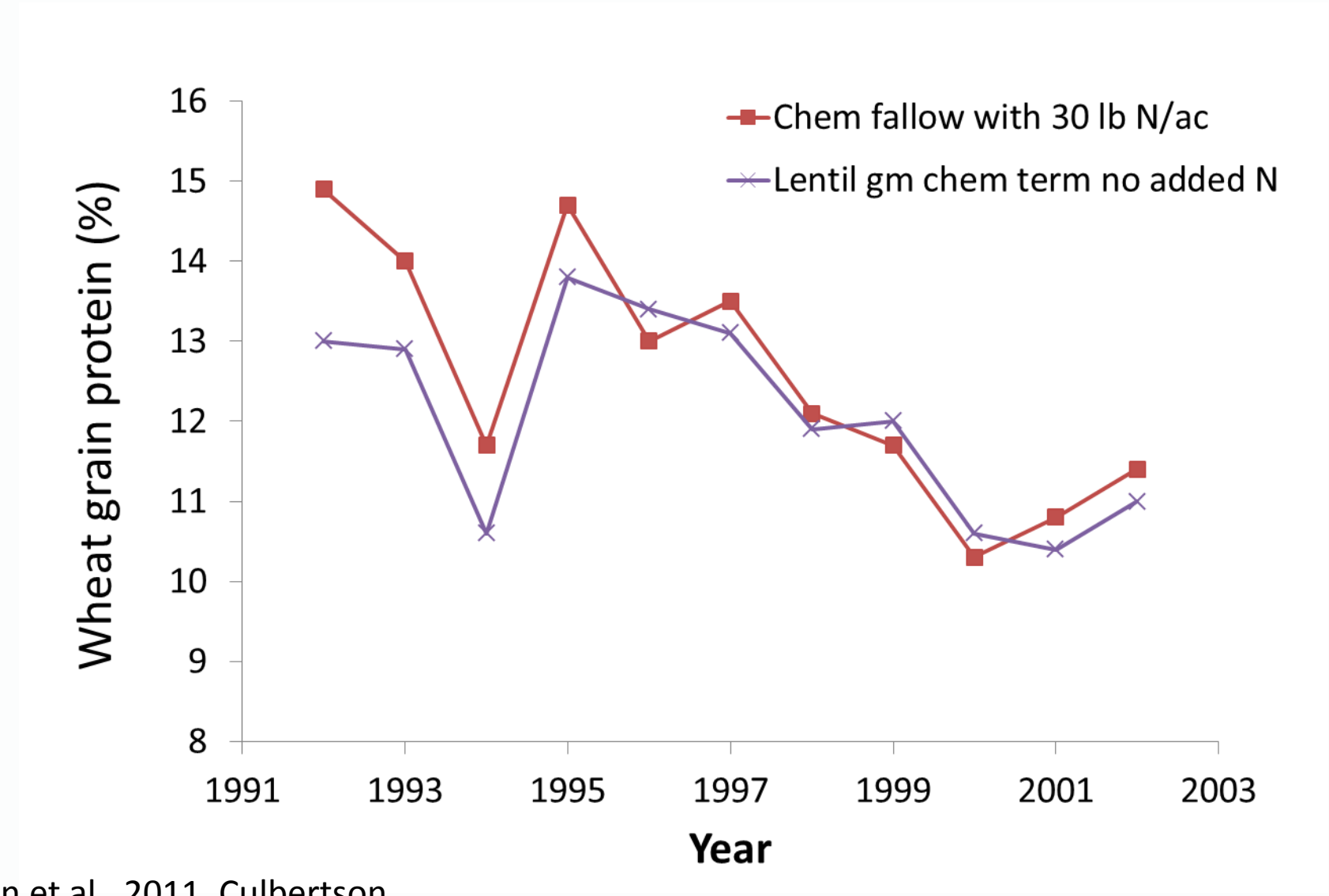
Engel, unpub data, MSU Post Farm

Legume cover crops: They take time to influence subsequent wheat yield



Allen et al., 2011, Culbertson

Pulse/legume rotations benefit protein before yields



Allen et al., 2011, Culbertson

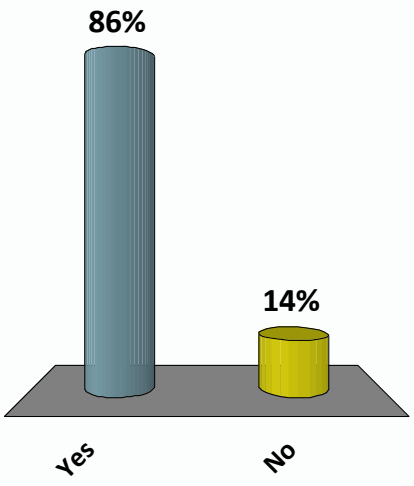
Questions?

Economic options

Do you, or would you, graze cover crops?

A. Yes

B. No



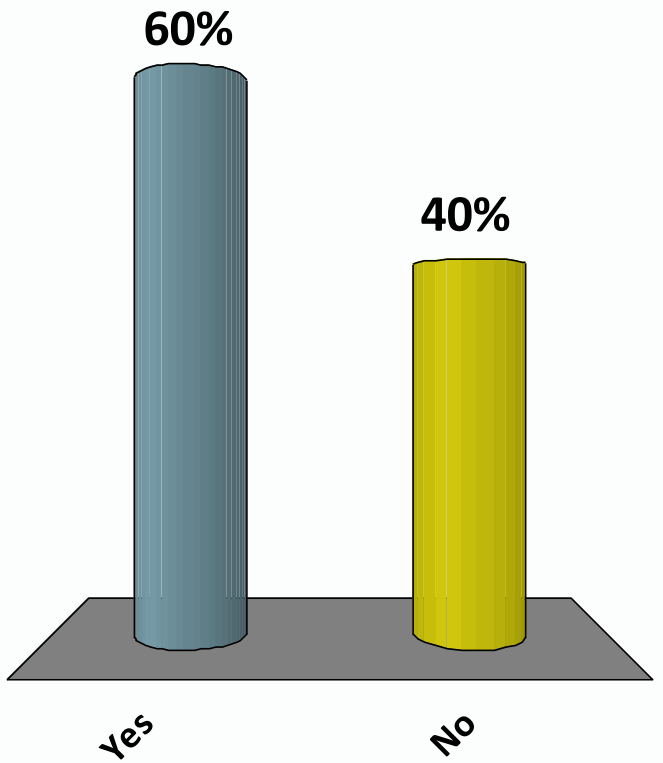
- Grazing may provide more immediate economic return and increase the rate of change in soil health. Currently under study at MSU-Northern.
- NRCS provides incentives for growing cover crops

Conclusions

- In short term (1 CC-cycle studies), grain yield and protein are generally equal or less than after fallow.
- Early termination (by ~ first pea bloom) is key to preventing yield and protein losses.
- In short term studies, there does not appear to be yield or soil quality advantages of multiple species mixes over pea.
- In long term (4+ cycles), yield, protein, and net revenue can be higher after cover crops than fallow, especially at low N rates, likely from more available N.
- Cover crops provide resilience to uncontrollable factors such as weather and markets
- Cover crop value to soil health, subsequent crops, and possibly land value is expected to increase over time.

Is your management, or management recommendations, likely to change, based on what we have presented today?

A. Yes
B. No



Acknowledgments

- USDA – AFRI
- USDA – WSARE
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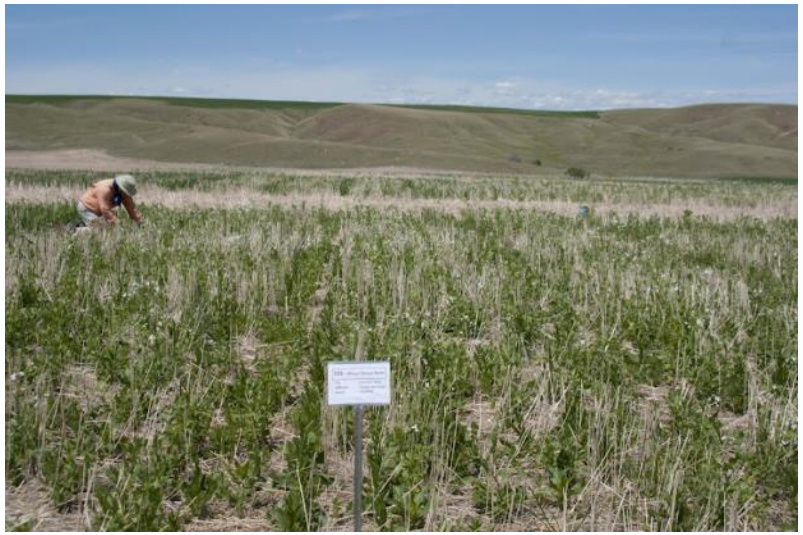
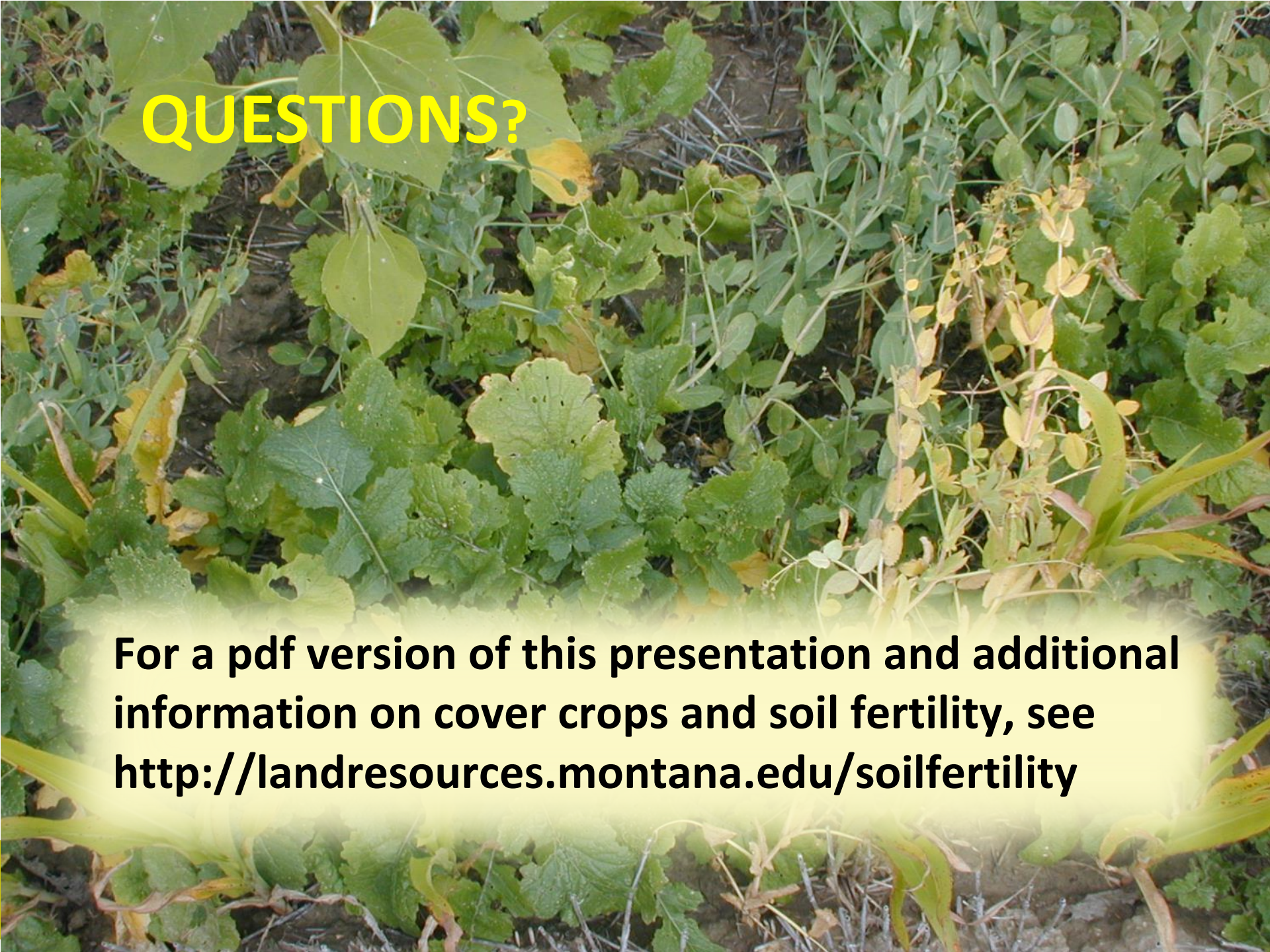
- Montana Fertilizer Advisory Committee
- Montana Wheat and Barley Committee
- Numerous landowners
- Ann McCauley
- Jeff Holmes
- Anton Bekkerman
- Mac Burgess




QUESTIONS?
For a pdf version of this presentation and additional information on cover crops and soil fertility, see http://landresources.montana.edu/soilfertility