COVER CROPS AND SOIL HEALTH

MABA

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MSU Soil Fertility Extension

Today's goals

- Present cover crop management considerations
- Discuss single vs mixed species cover crop effects on
  - Nitrogen availability
  - Soil organic matter
  - Soil quality parameters
  - Following crop yield and protein
  - Economics

The Summerfallow Challenge

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

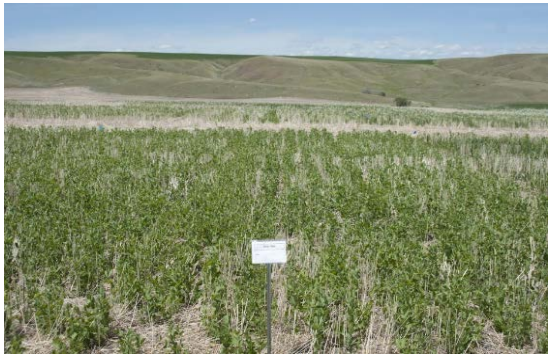


Photo: Steve Spence

What we have found with MT CC research trials

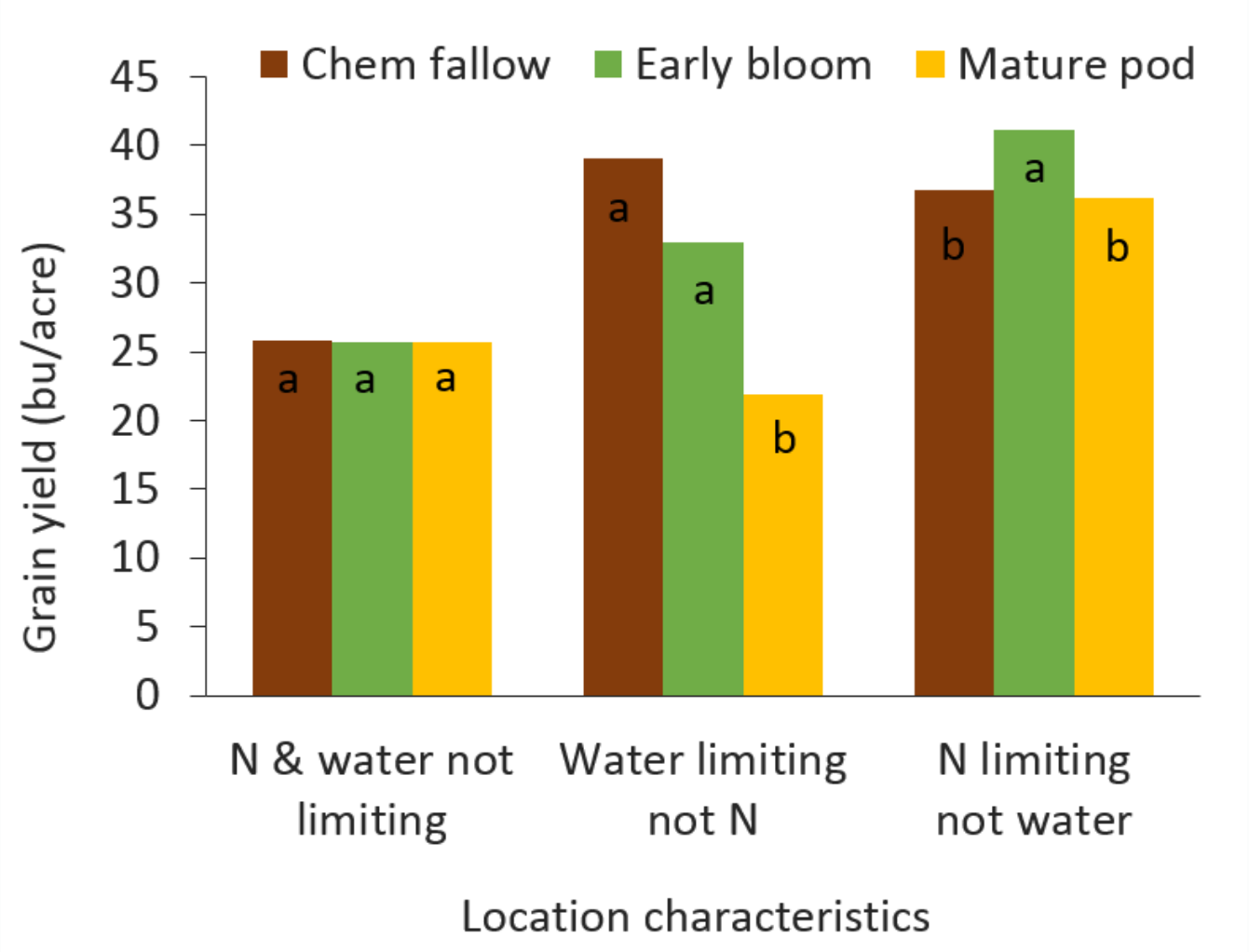
MSU single species cover crop research since 1999 has found higher grain yields and/or protein after cover crops when:

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?

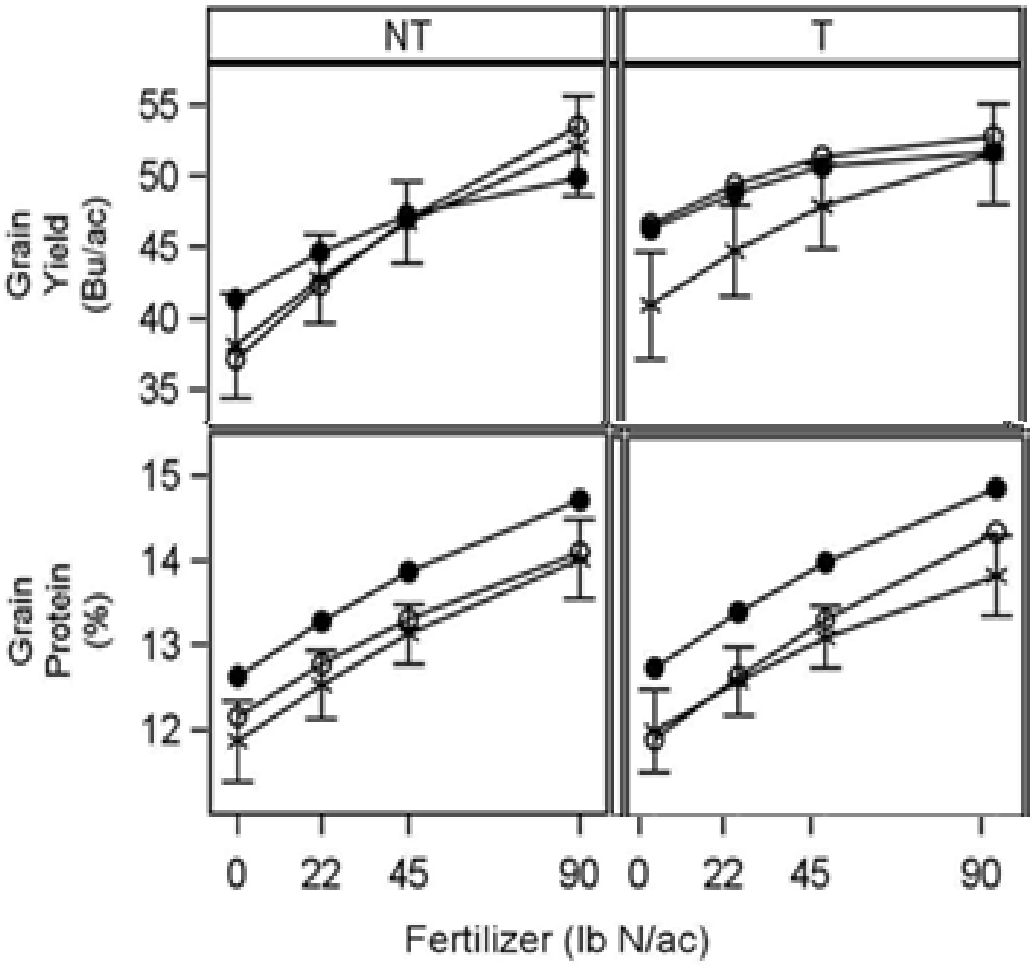
- More N fixed (1)
- More time for soil water to be recharged and N to become released from residue (1, 2, 3)
- Faster N release and fewer N losses (4)

Our MT studies confirmed early Saskatchewan studies that termination timing is key, when water is limiting



Haying cover crop at early bloom produced higher sp. wheat yields the following year than harvesting pea when water or N limiting (Miller et al 2006)

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



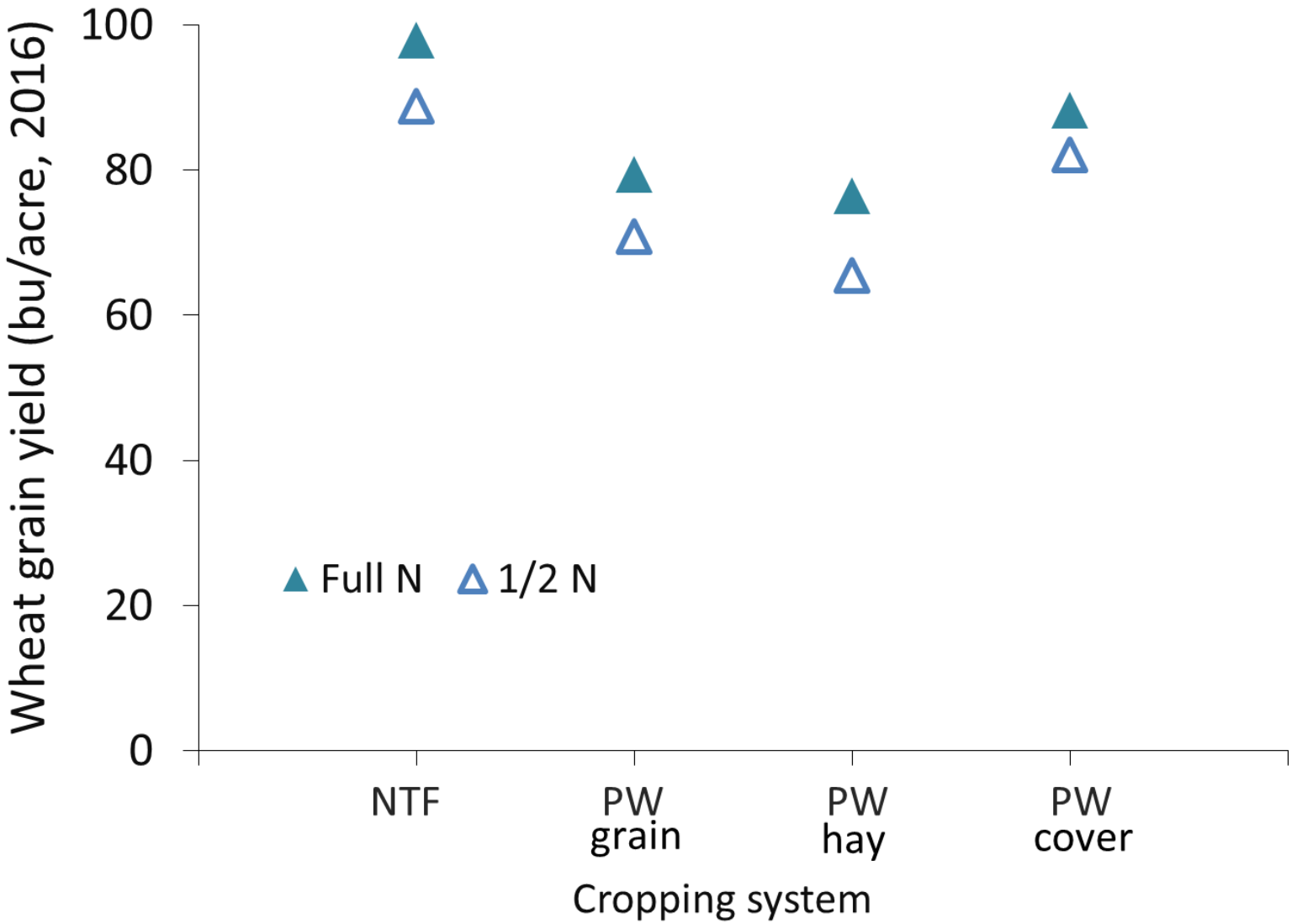
Take home:

- 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)

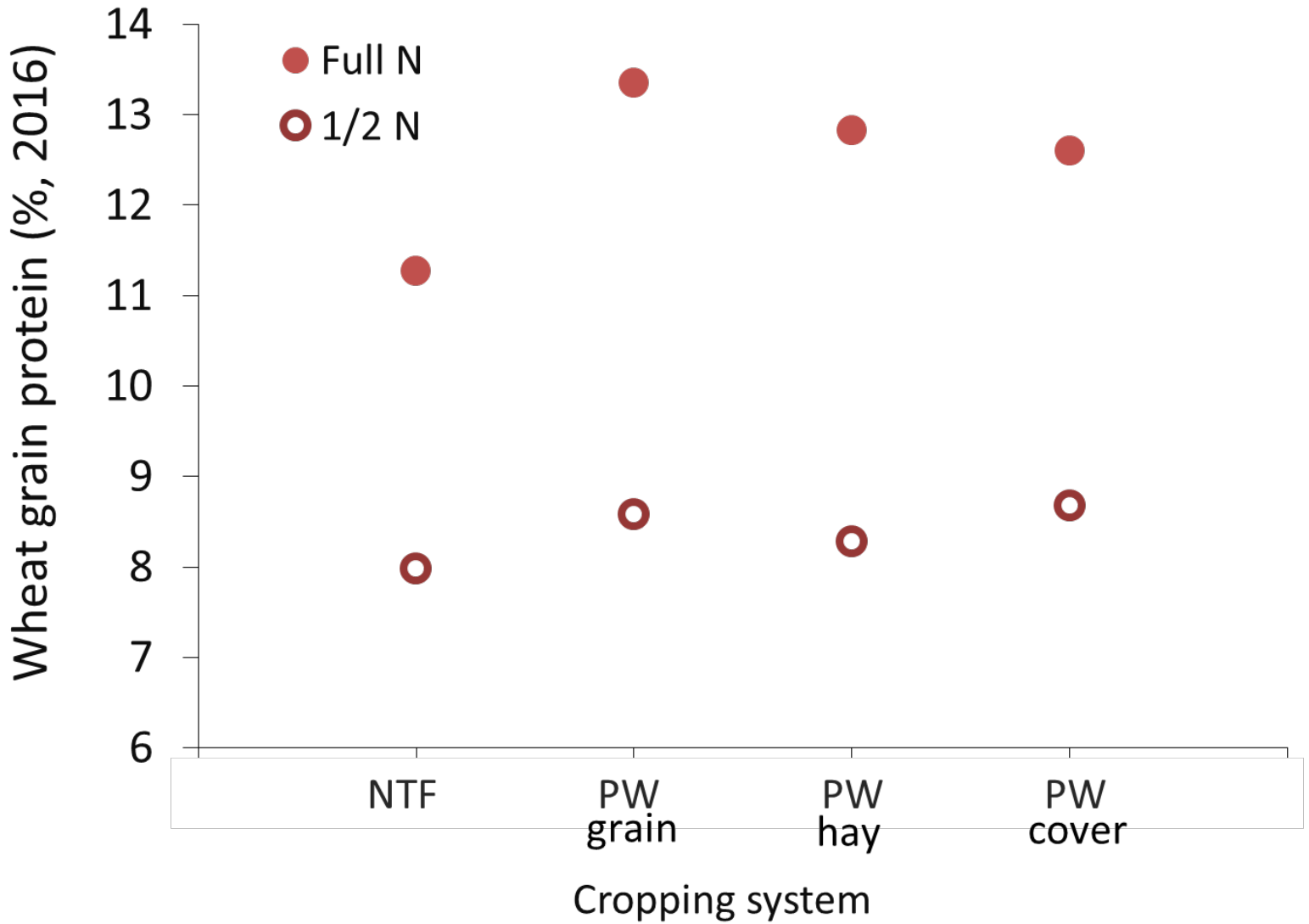
14-year Plot Study: east of Bozeman

- Long-term effects of no-till pea grain, forage, or cover crop-wheat vs. fallow-wheat
- ~16” annual precip on deep soils & ability to recharge soils
- Pea terminated at full pod
- 2 N rates: Full (3 lb available N/bu) and ½ N

14-Year Plot Study:
Winter wheat grain yield in 14th year



14-Year Plot Study: Grain protein in 14th year (2016)

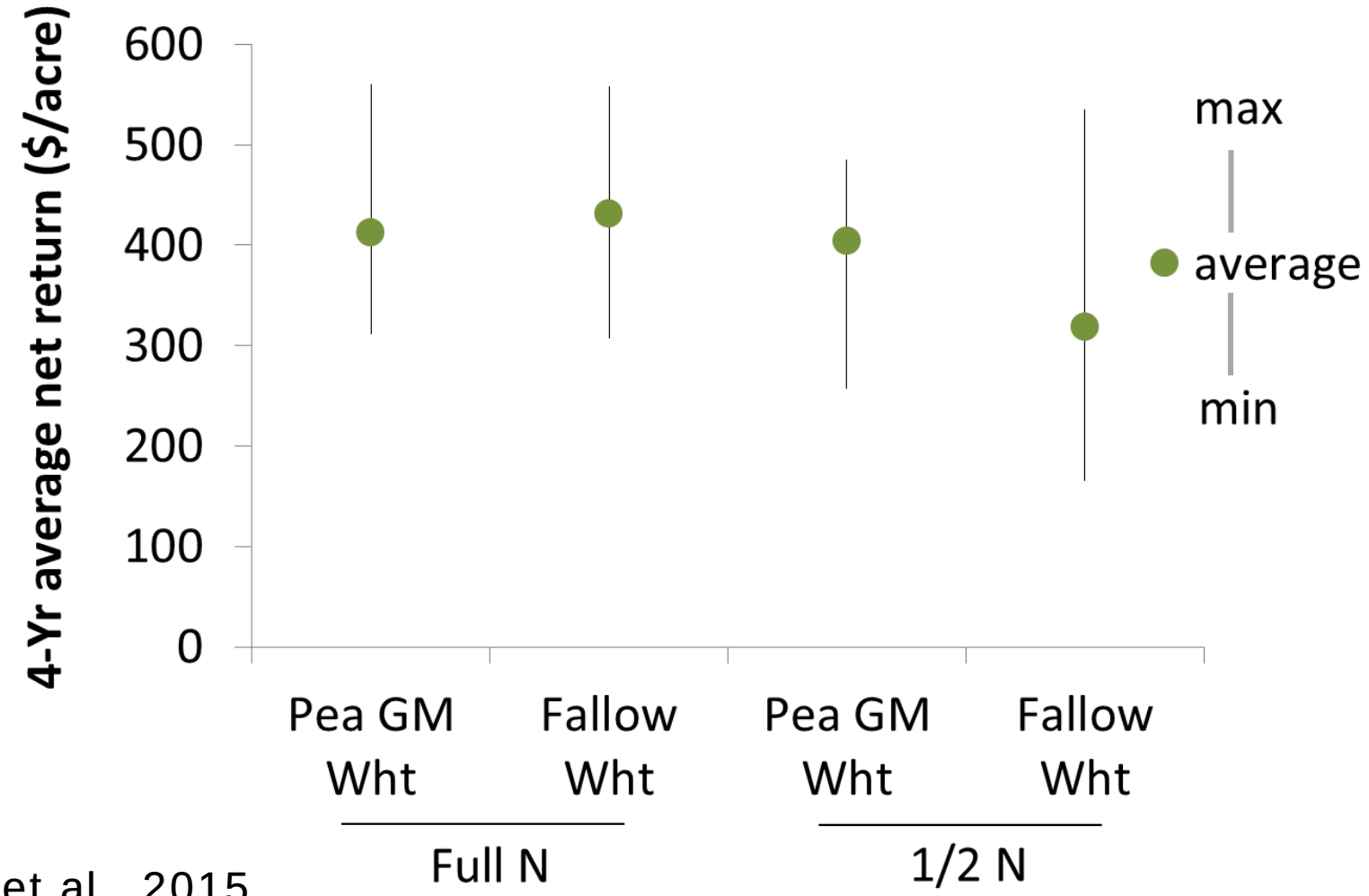


Questions?

On to economics of single species cover crops

Economics: 14-year Plot Study (**2009-2012**)

2010 was a wheat year, and had very wet spring

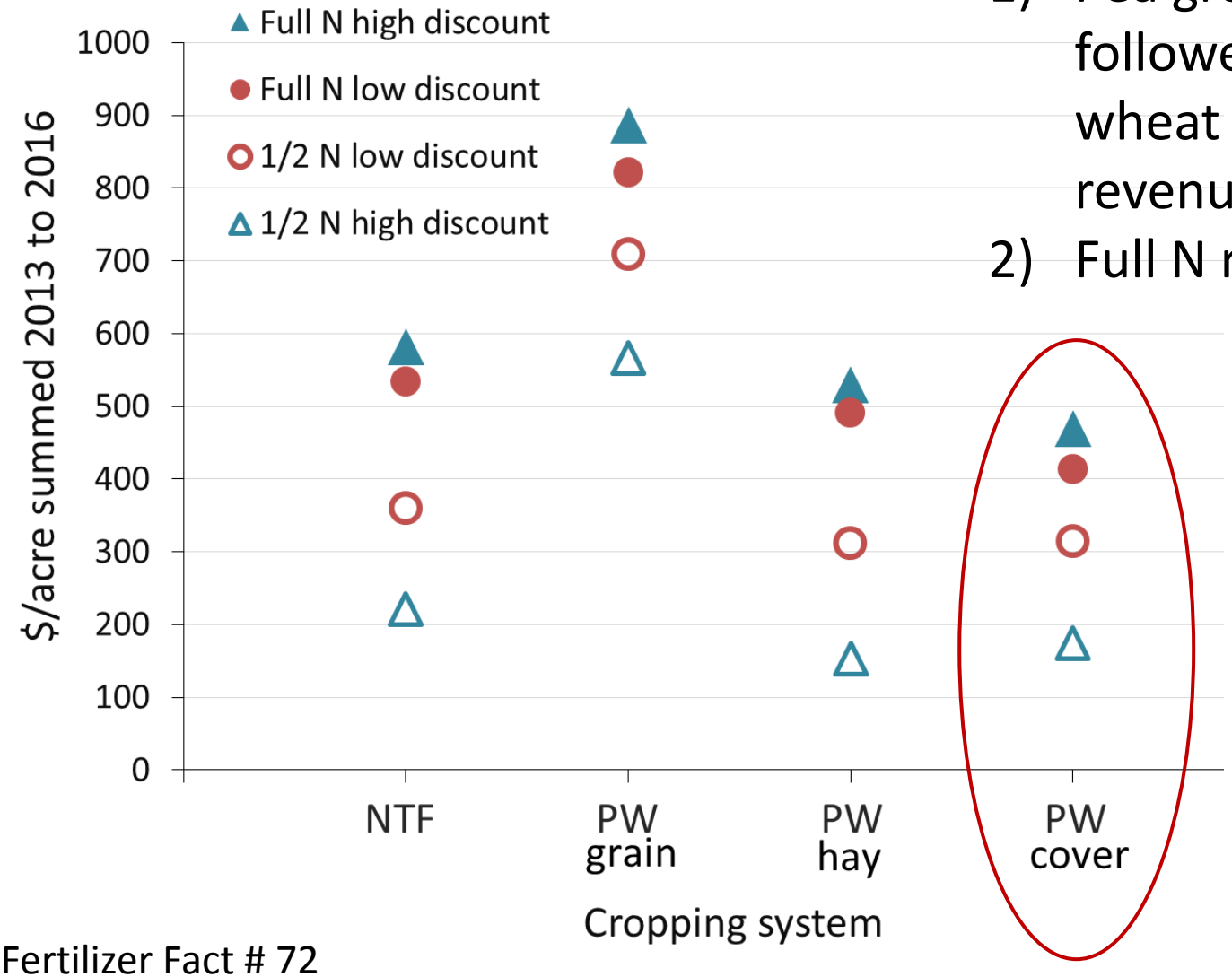


Miller et al., 2015

Economics: 14-year Plot Study (**2013-2016**) dry years

Take home:

1) Pea grown for grain followed by winter wheat was big net revenue winner.
2) Full N rate best choice

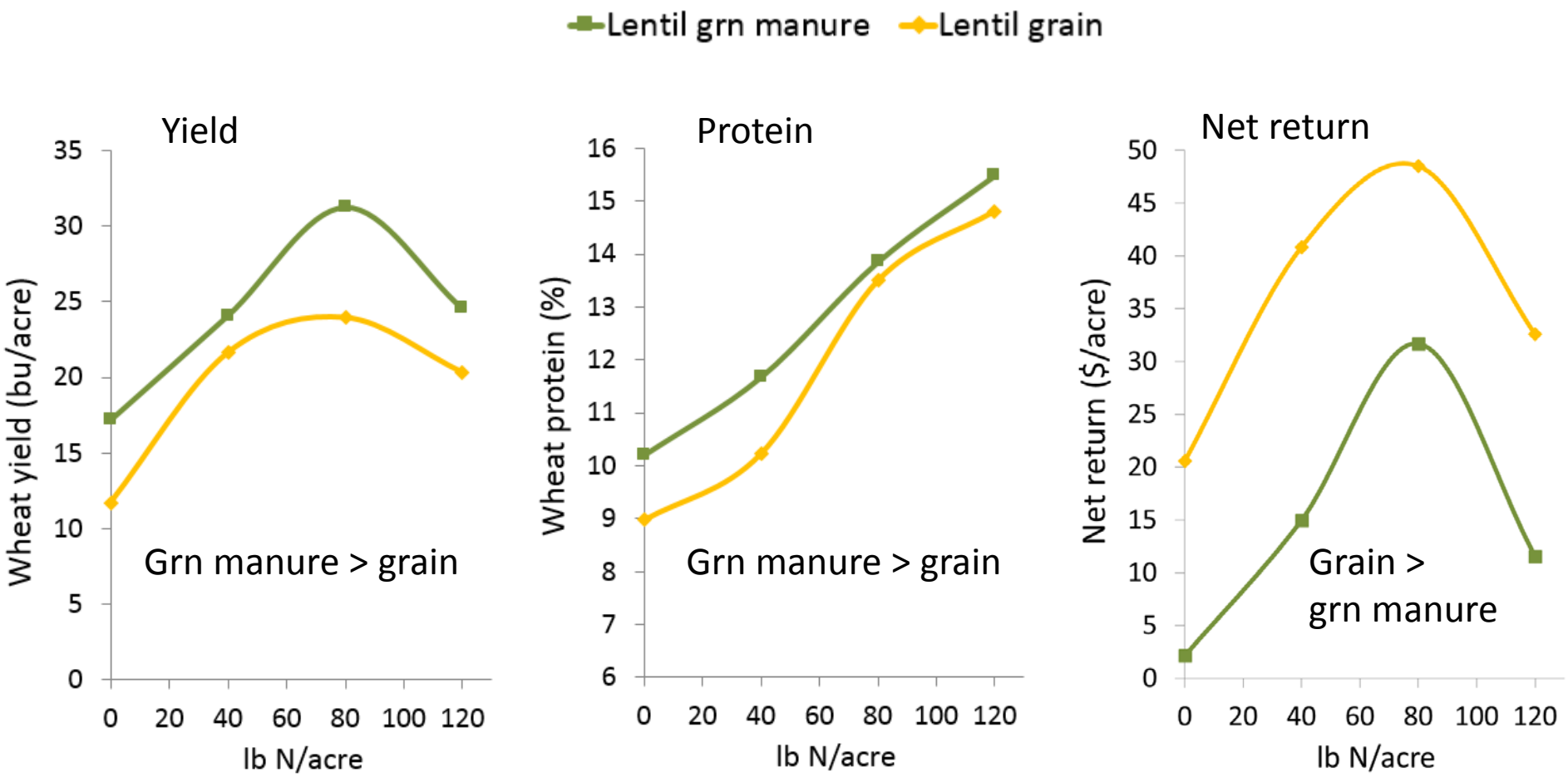


Fertilizer Fact # 72

14-year Plot Study: Take home messages

- Wheat grain yield and protein benefits take time
  - 3 - 4 CC cycles in high moisture years
  - 6 CC cycles with dry years
- Economic returns were more stable with cover crop (less dependent on N rate) and much higher with pea-grain than cover crop
- How do results compare in locations outside Gallatin Valley?

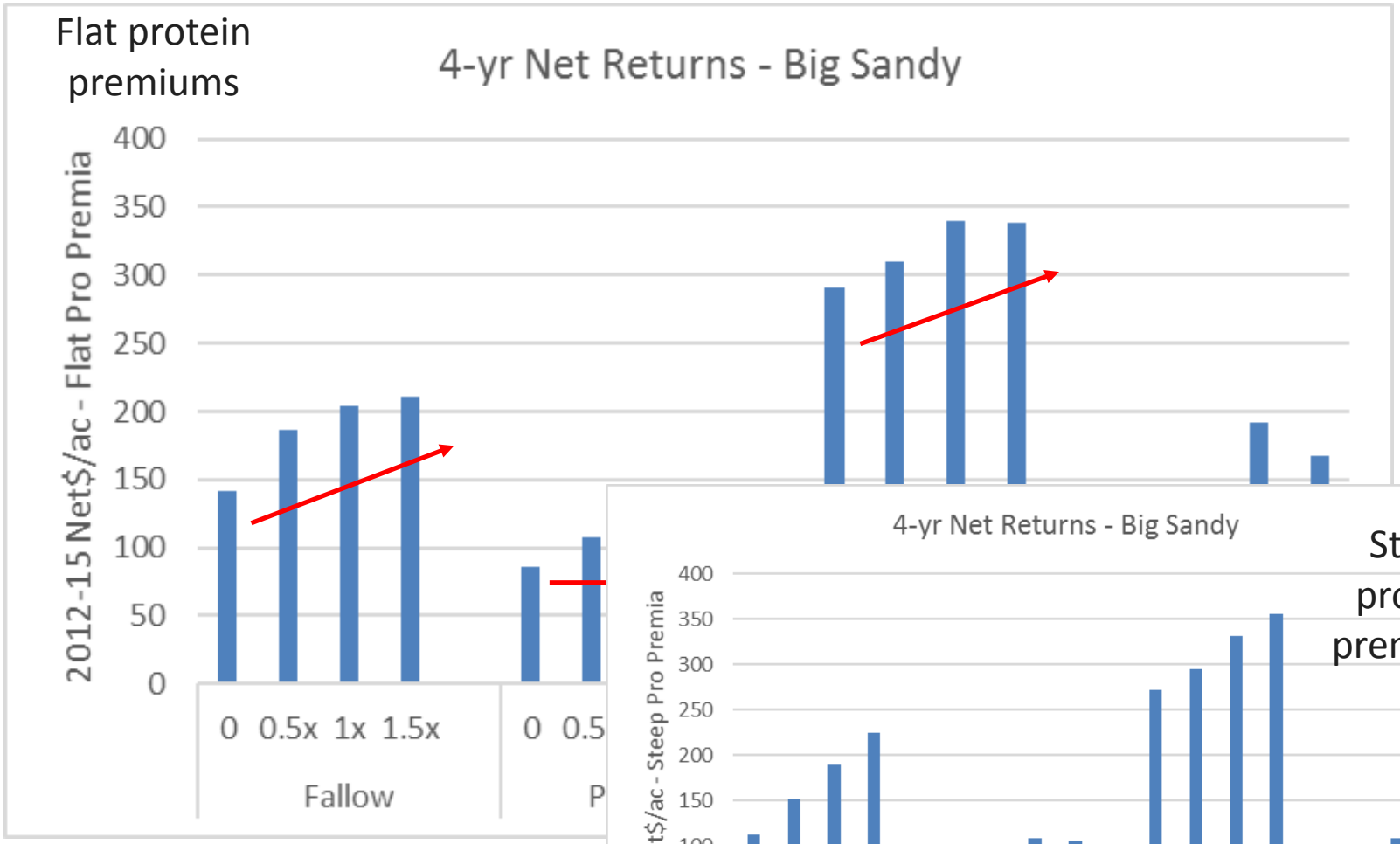
Average winter wheat yield, protein, annual net return after lentil green manure or grain (2005-2010)



Chen et al., 2012, Moccasin, MT, dryland, notill, shallow soil (18”), plot study

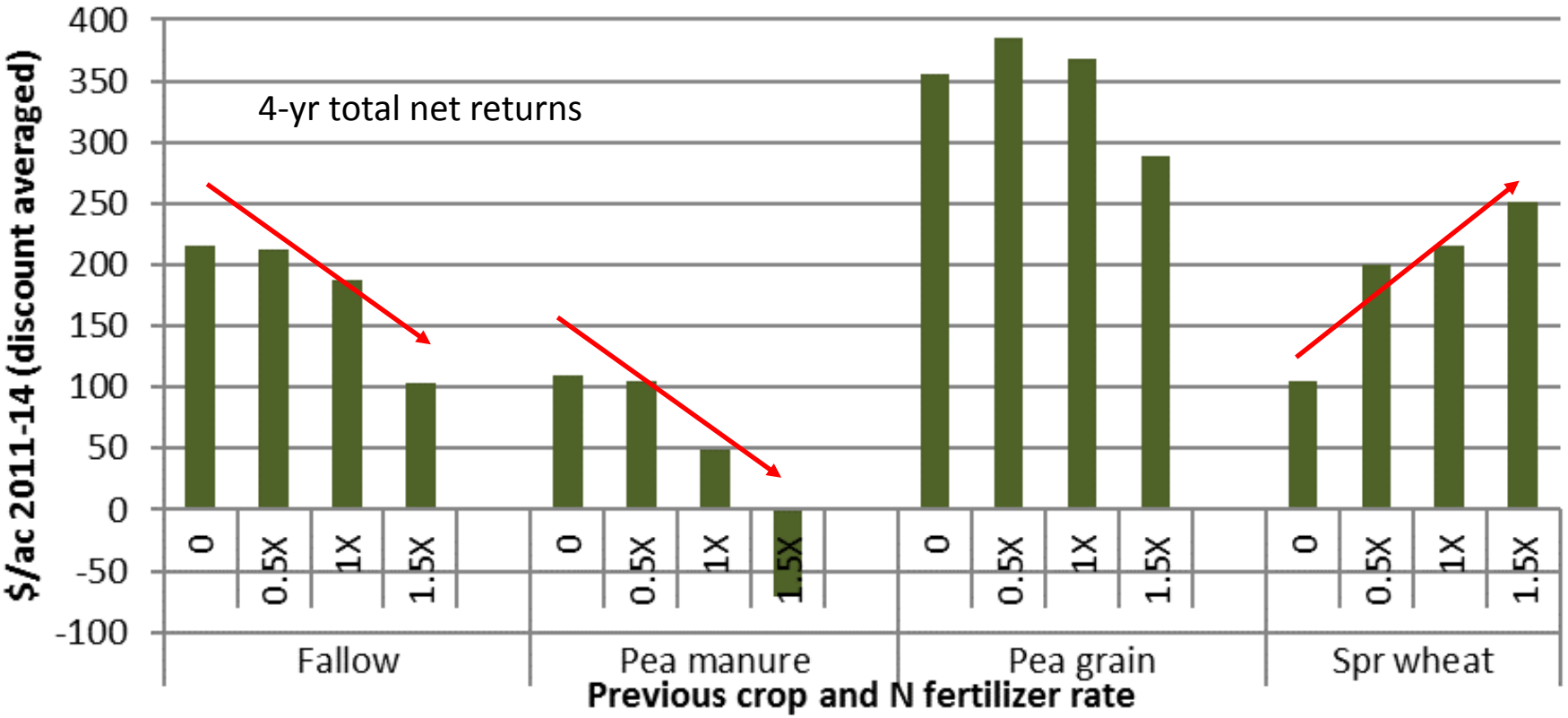
4-yr Net Returns – Big Sandy (Sandy Clay Loam, 1.4% OM)

Flat protein premiums



Miller and Jones unpub data

4-yr Net Returns – Dutton (Clay loam to Clay, 3% OM)



Average protein premiums

Take home: In short to long term studies, in different regions in Montana, pea - wheat returns far more profit than cover crop - wheat, when cover crop sprayed out.

Questions?

On to cover crops and soil health

Soil Quality vs Soil Health

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

- Texture
- pH
- Cation Exchange Capacity

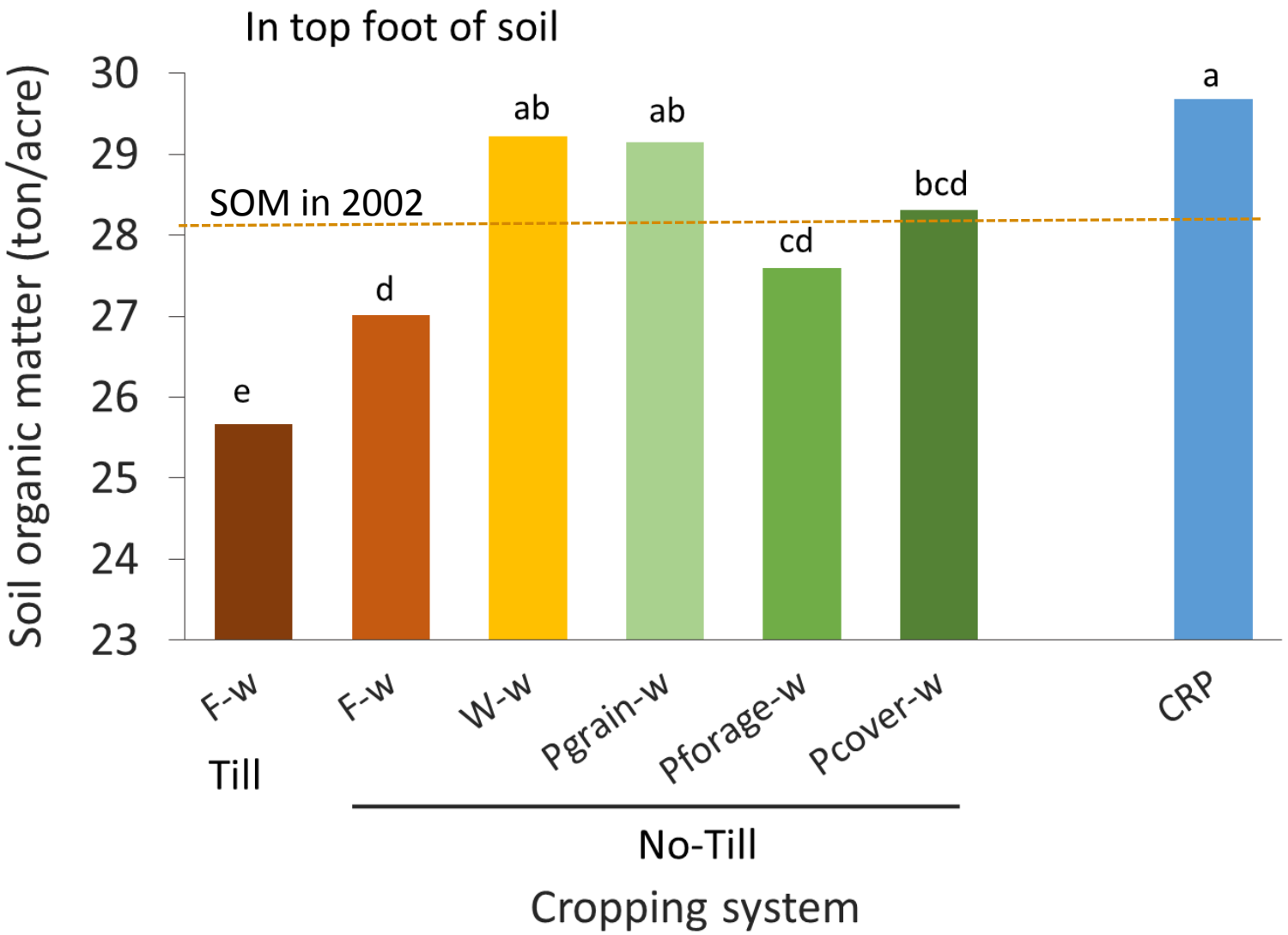
Soil Health = dynamic properties which may be subjective to measure

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

Which is more likely to be influenced by cover crops?

SOM often is included in both lists

SOM after 10 years of cropping systems (2012)



Engel, in press, MSU Post Farm

Cover Crop Cocktails Study

1. Does increased crop diversity improve soil health?
   - Microbial biomass
   - Soil enzyme activity
   - Soil temperature
   - Aggregate stability
   - Compaction
   - Soil water, nitrate, and Olsen P
   - Mycorrhizal colonization
   - Potentially mineralizable nitrogen
2. Does increased diversity increase subsequent grain yield?

Plant functional groups – planted individually and in groups

Nitrogen Fixers

Spring Pea

Lentil

Increase nitrogen

Add soil carbon

Fibrous Root

Oats

Proso millet

Reduce compaction, move nutrients upward

Rapid ground cover, high biomass, potential disease control

Tap Root

Purple top turnip

Safflower

Brassica

Daikon radish

Winter canola

Experimental Design

11 treatments

The big three

- Summer Fallow (SF)
- Pea-only Legume Green Manure (PEA)
- Cover Crop Mixture -8-spp/4-functional group (CCM)

Single functional group treatments (2-species)

- Nitrogen Fixers (NF)
- Fibrous Roots (FR)
- Taproots (TR)
- Brassicas (BC)

Three functional group treatments (6-species)

- FR, TR, BC
- NF, TR, BC
- NF, FR, BC
- NF, FR, TR

Cover Crop Biomass – depends on moisture

Photo: Steve Spence

Biomass is not strongly related to # of species

Photo: Meg Housman

Soil quality summary after second full rotation – among pea, 8 species mix, and fallow

	Amsterdam	Conrad	Dutton	Bozeman
Microbial Biomass	CC>fallow	NS	NS	NS
Microbial Enzymes (5)	CC>fallow	NS	NS	CC>fallow
PMN	CC>fallow	NS	NS	NS
Olsen P	NS	NS	na	na
Temp at 2”	CC<fallow	CC<fallow	--	--
Aggregate stability	NS	NS	na	na

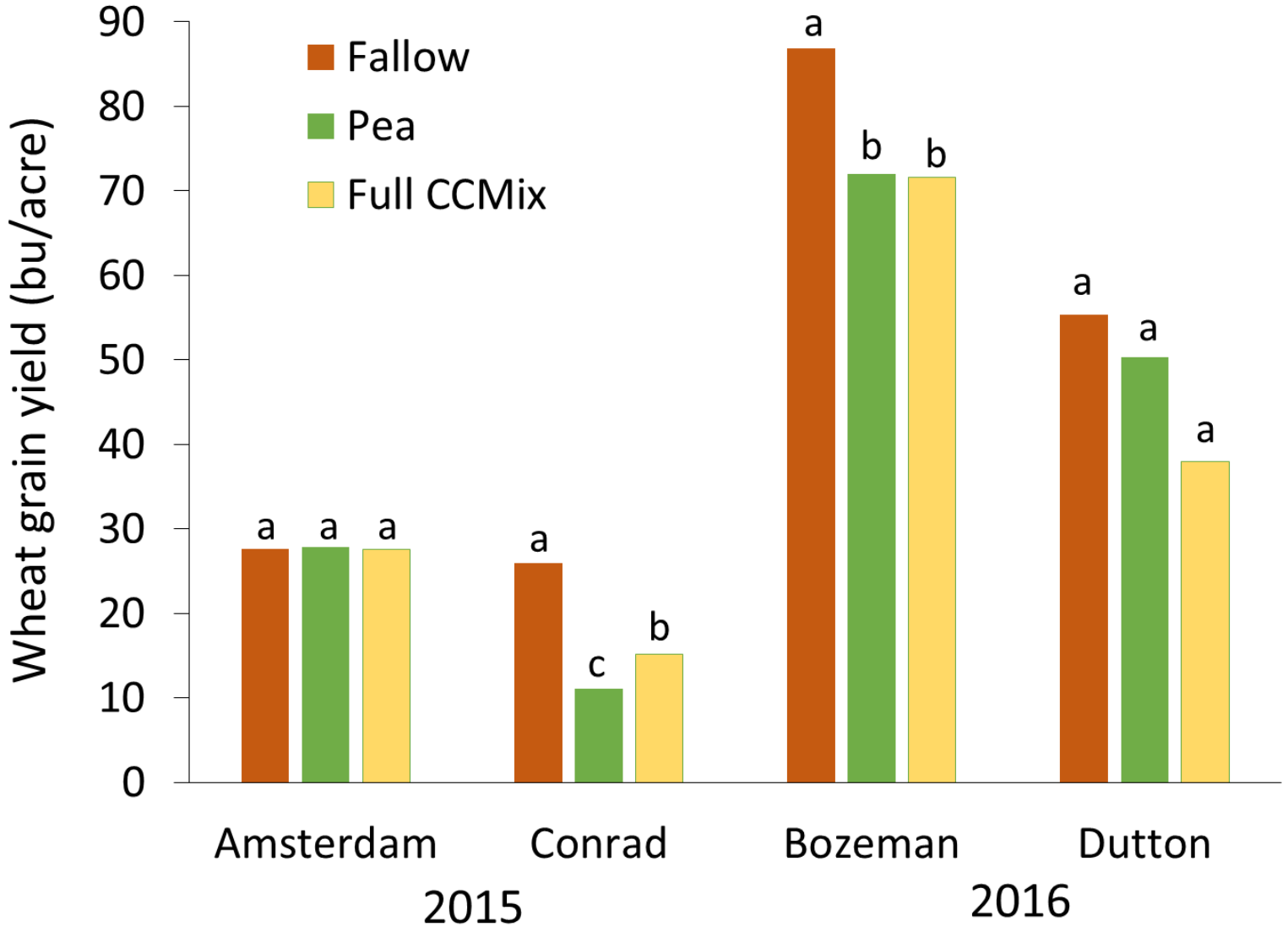
NS – no significant difference (95% confidence) among treatments, na – not available

The number of species in Ccrop mix did not matter much

Questions?

On to wheat yields after mixed species cover crops

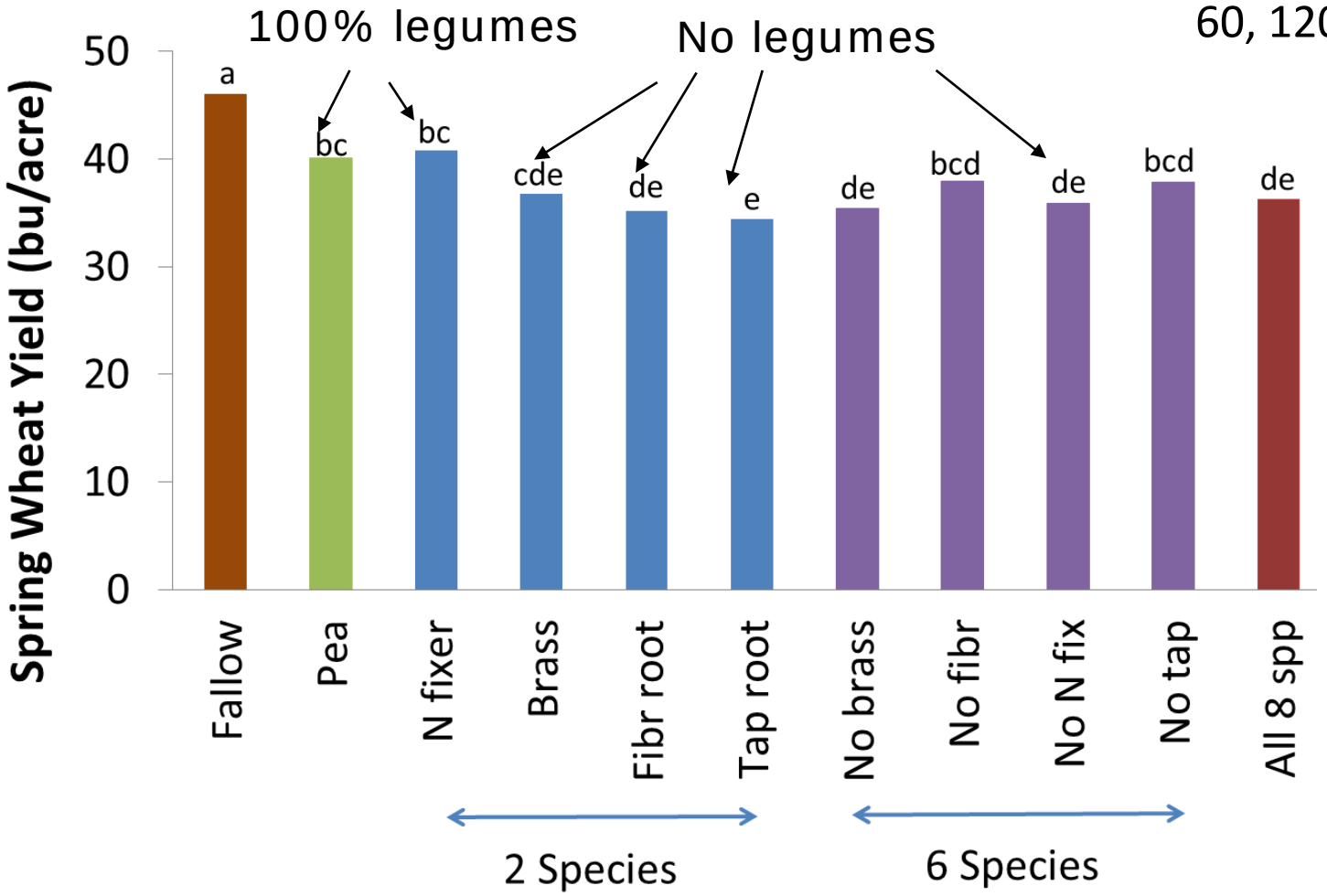
Wheat grain yield after 2 cycles



Miller, unpub. data

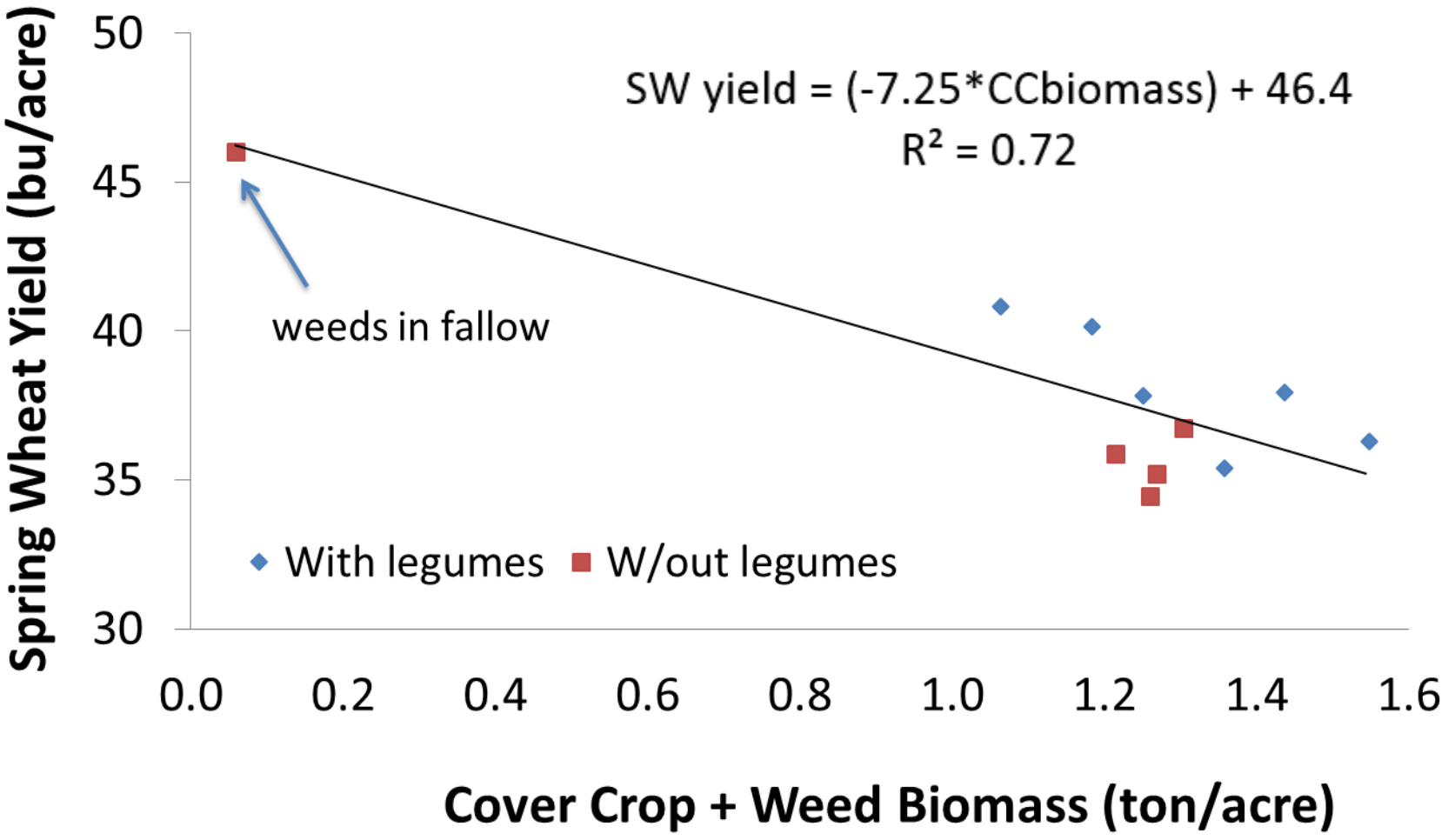
Effect of cover crop treatment on spring wheat grain yield at Dutton (2014)

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)

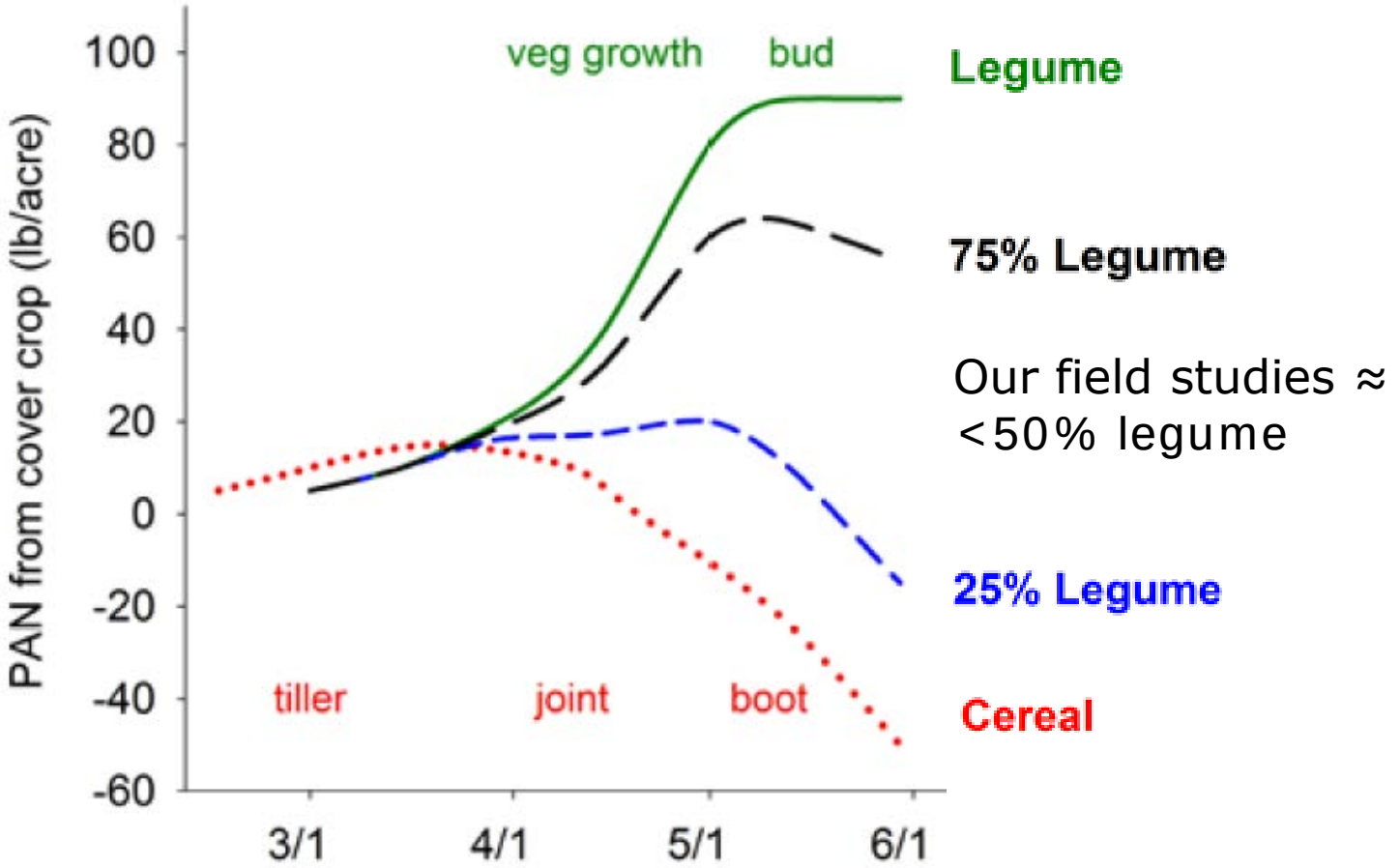


Housman, Tallman, et al.,
unpub data, Dutton

MSU Mixed Cover Crop Field Studies

- 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 (full pod or even later)** was likely cause of yield differences.
- Low N release because of low amount of legume likely caused difference with our plot studies.

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



Our field studies ≈ <50% legume

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

Willamette Valley, Oregon
Sullivan and Andrews, 2012

Summary

- Cover crops can't compete economically with pea grain-wheat
- It takes time to change soil quality
- Higher number of species in mix doesn't appear to consistently improve yield, protein, or soil quality. Good result – allows flexibility. Base selection on seed cost, biomass produced, specific soil health goals, etc.
- IF your client is growing cover crops, encourage early termination (by first pea bloom) and >50% legume in seed mix.


Thank you for funding the MSU studies:
WESTERN SARE
Sustainable Agriculture Research & Education
Montana Fertilizer Advisory Committee
QUESTIONS?
For additional information on soil fertility topics including information on cover crops, see http://landresources.montana.edu/soilfertility