

Cover Crops and Soil Health Systems

Eileen Kladviko

Agronomy Dept., Purdue University

(and a cast of hundreds across the state and region!)

Overall Goal

- Improve soil health!
 - Soil conservation, productivity
 - Crop productivity, resilience to climate variations
 - Water quality
 - Economics (profitability)

Corn silage land with and without a cereal rye cover crop



Soil Health Systems

- Groups of practices put together in coherent way
- Practices include cover crops, no-till, nutrient and pest mgmt., etc.
- Soil health focuses on integration of soil biology, fertility, and physical properties

Research Goals

- Document changes in soil health with different systems and practices
 - How much changed?
 - How fast?
 - How can we alter management to improve soil more and faster?
- How do we actually assess the changes? What measurements are useful?
- Impact of soil health changes on crop productivity? Water quality?

Examples of larger projects in state and region

- Midwest Cover Crops Council

www.mccc.msu.edu



- Indiana Conservation Cropping Systems Initiative (CCSI)

www.ccsin.org



- Corn Systems and Climate CAP

www.sustainablecorn.org



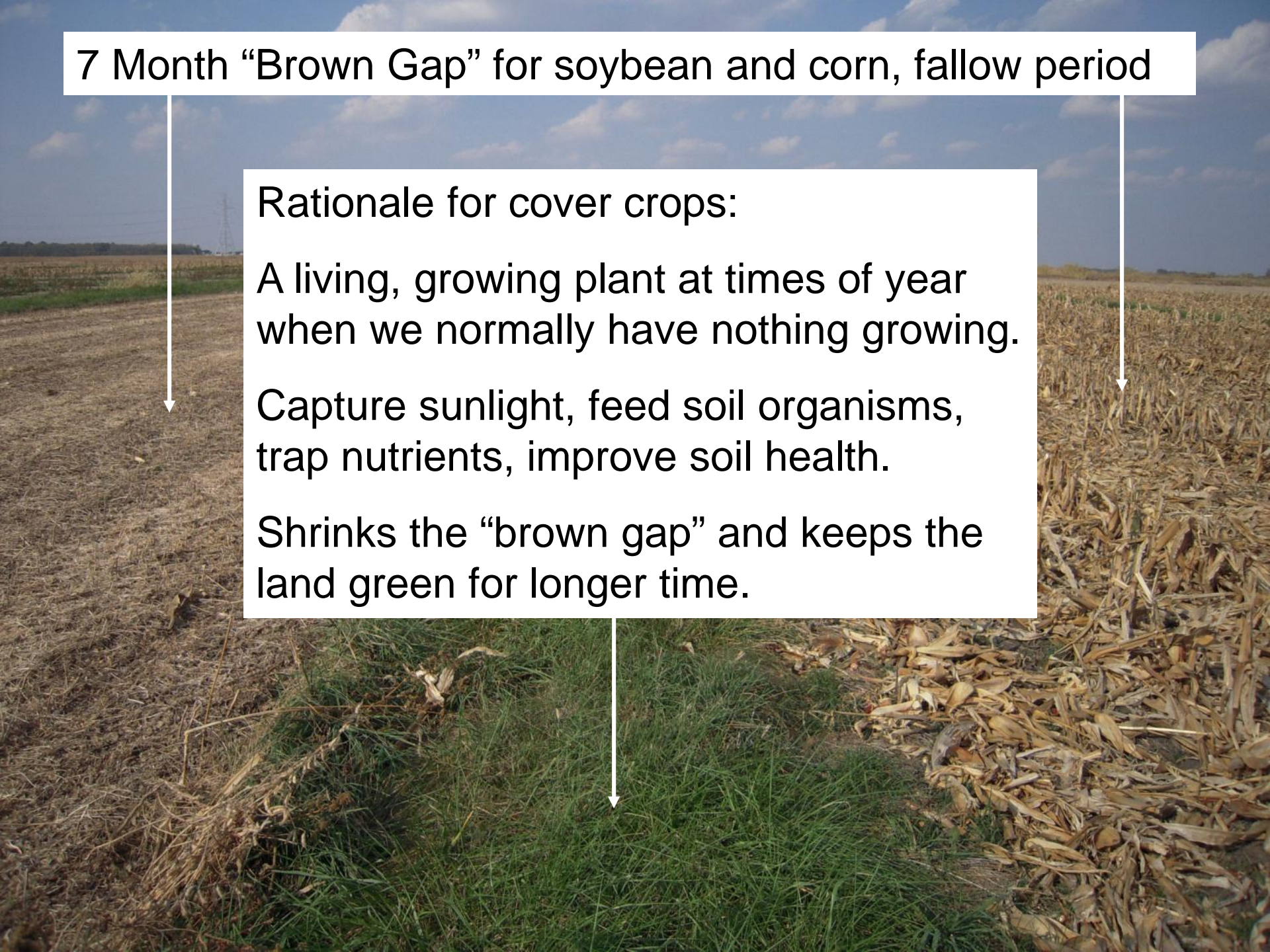
7 Month “Brown Gap” for soybean and corn, fallow period

Rationale for cover crops:

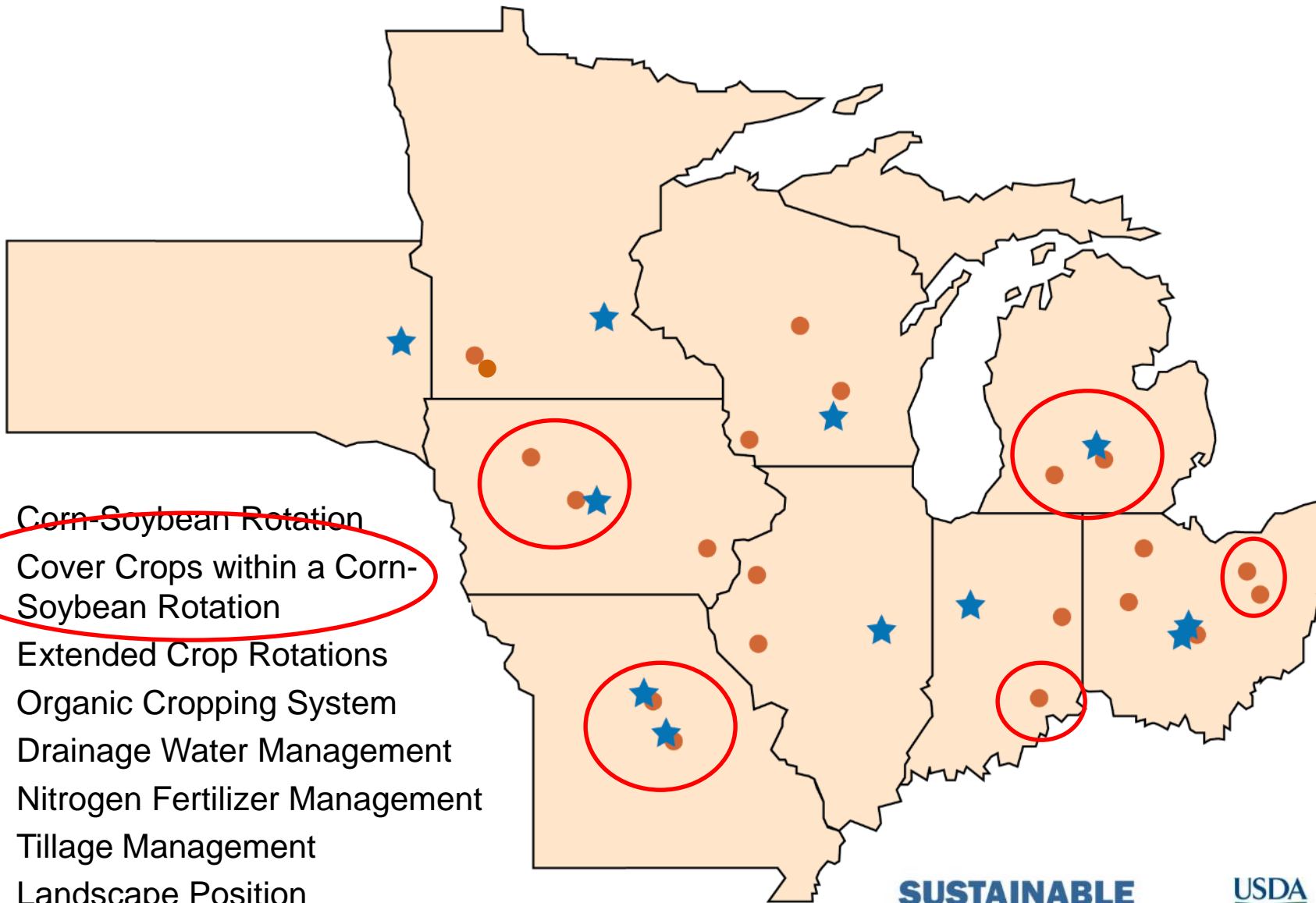
A living, growing plant at times of year when we normally have nothing growing.


Capture sunlight, feed soil organisms, trap nutrients, improve soil health.

Shrinks the “brown gap” and keeps the land green for longer time.



Field Research Network & Treatments



- 
- Cereal rye (*Secale cereale* L.) chosen because most winter-hardy and widely adaptable across the region

Cereal rye, SE Indiana

CCSI Conservation Innovation Grant (CIG) project

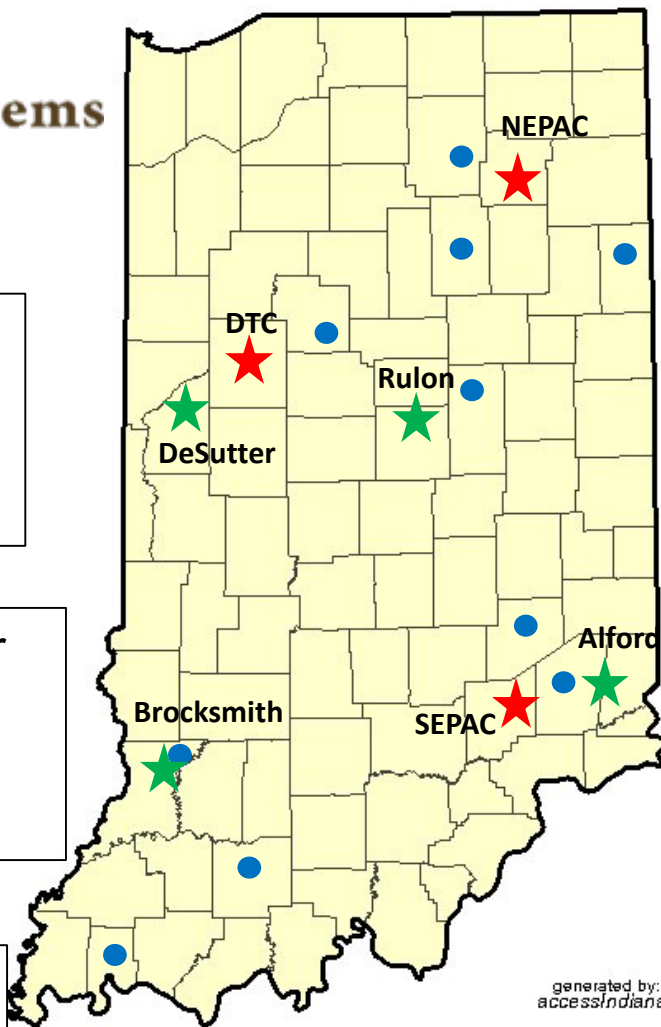


17 sites across IN

- 12 farmer sites
- 3 Purdue Ag Centers
- 2 others

- Most sites have cover vs. no cover strips
- Most sites are long-term no-till

Most covers are single species, but a few are mixes, esp. after wheat



Measurements made in CCSI project

- Cover crop—growth (biomass), N%, N content in biomass, fall and spring
- Soil
 - nitrate/ammonium-N(fall, spring, PSNT), std fertility (A&L), temp, moisture, four commercial soil health tests
 - Some sites w/ sensors for temp and moisture; aggregation, penetration, bulk density, water retention curve (water holding capacity)
- Cash crop—yield (corn also SPAD, stalk nitrate)

New soil biology/soil health tests

- PLFA (Phospholipid Fatty Acid)
 - Earthfort Soil Food Web
 - Solvita CO₂ burst / Soil Health Nutrient Tool
 - Cornell Soil Health test
-
- The first three are biological tests.
Interpretation of these are in their infancy, as there is no “standard” like w/ fertility test.
 - Cornell test includes bio, phys, and chem.

Findings so far

- Cover crop biomass varies greatly across sites and years, of course

Amount of growth affects the magnitude of cover crop impacts on soil or cash crop!

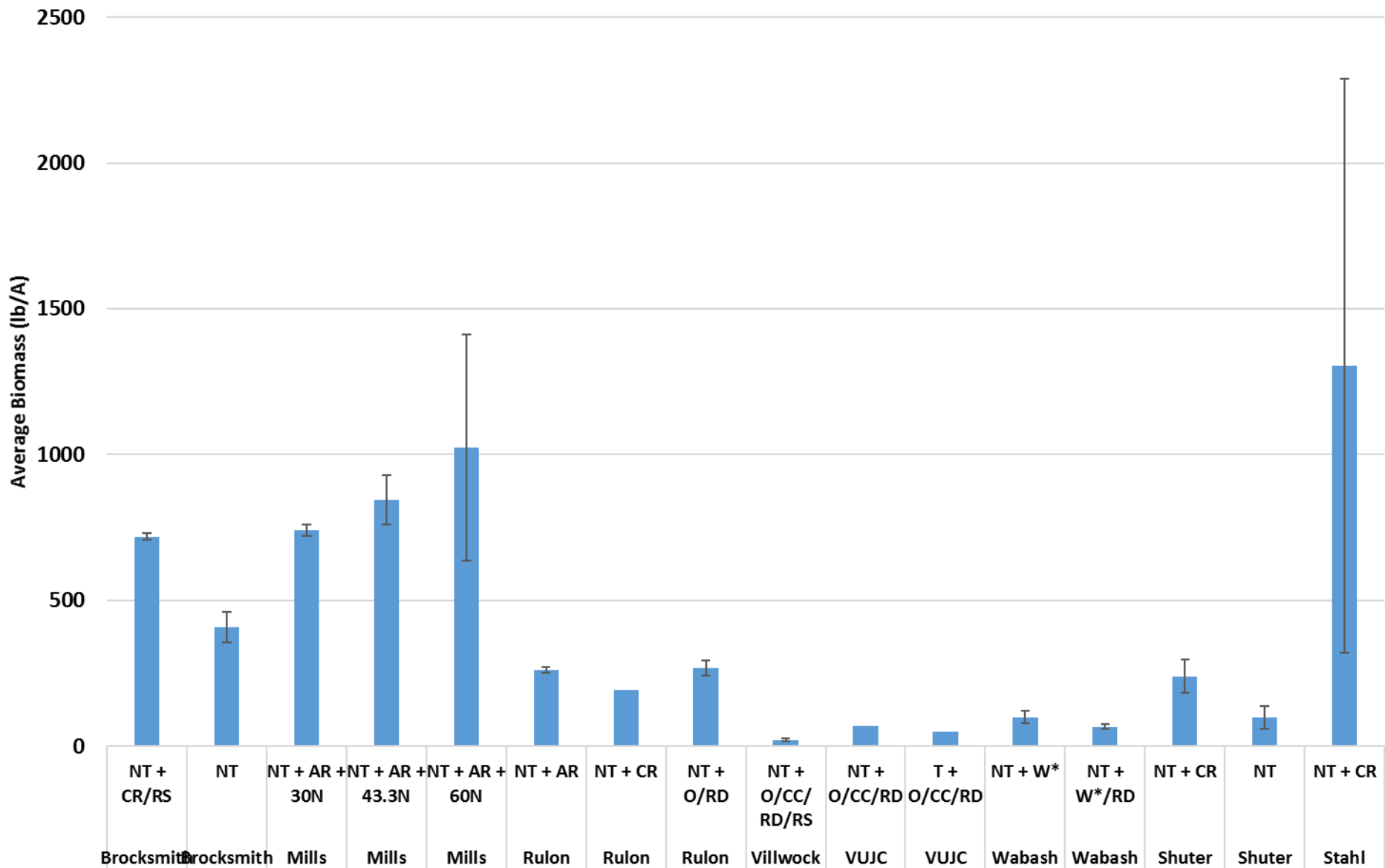


~710 lb/A



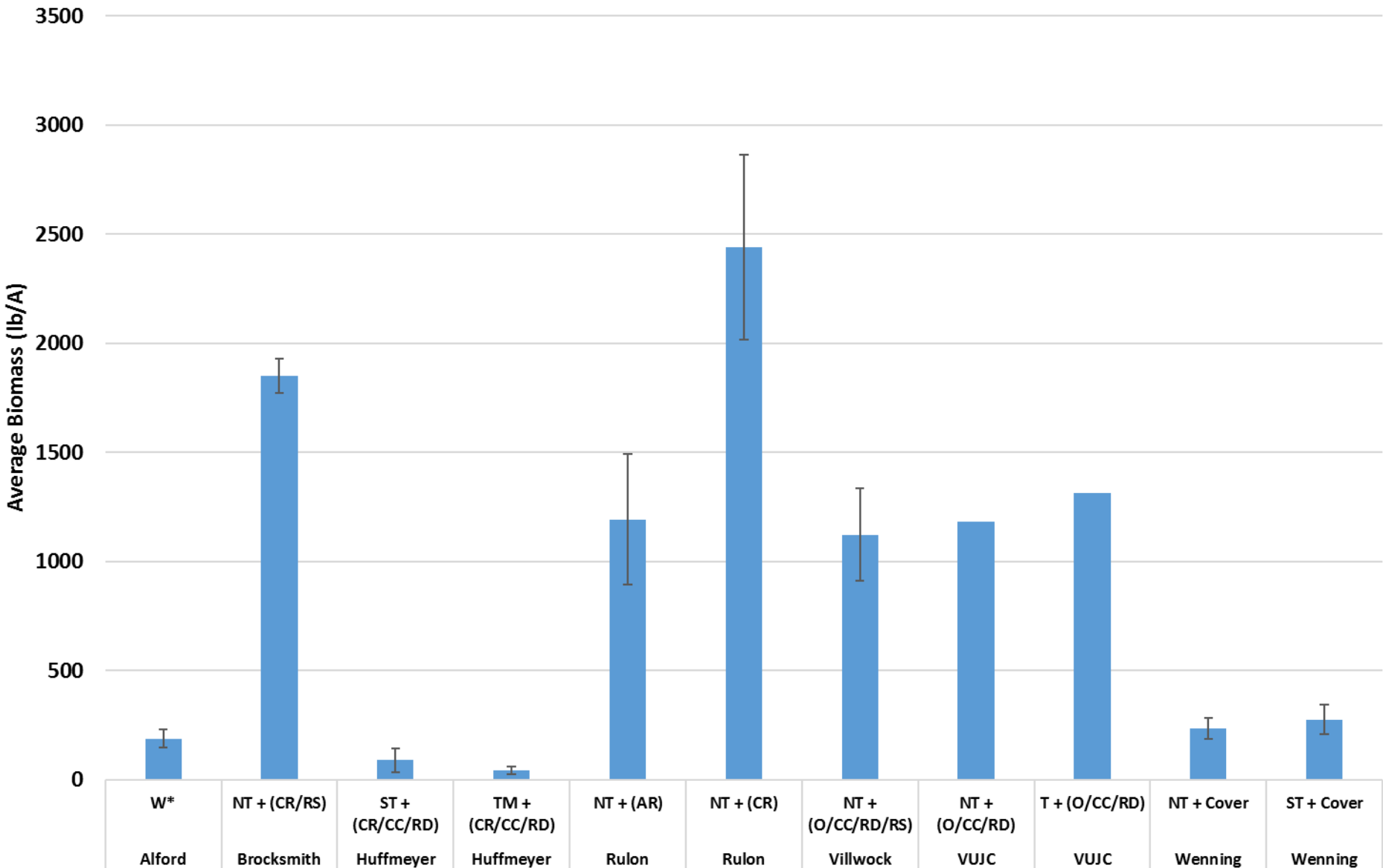
~2500 lb/A

Fall 2015 Average Biomass (lb/A)



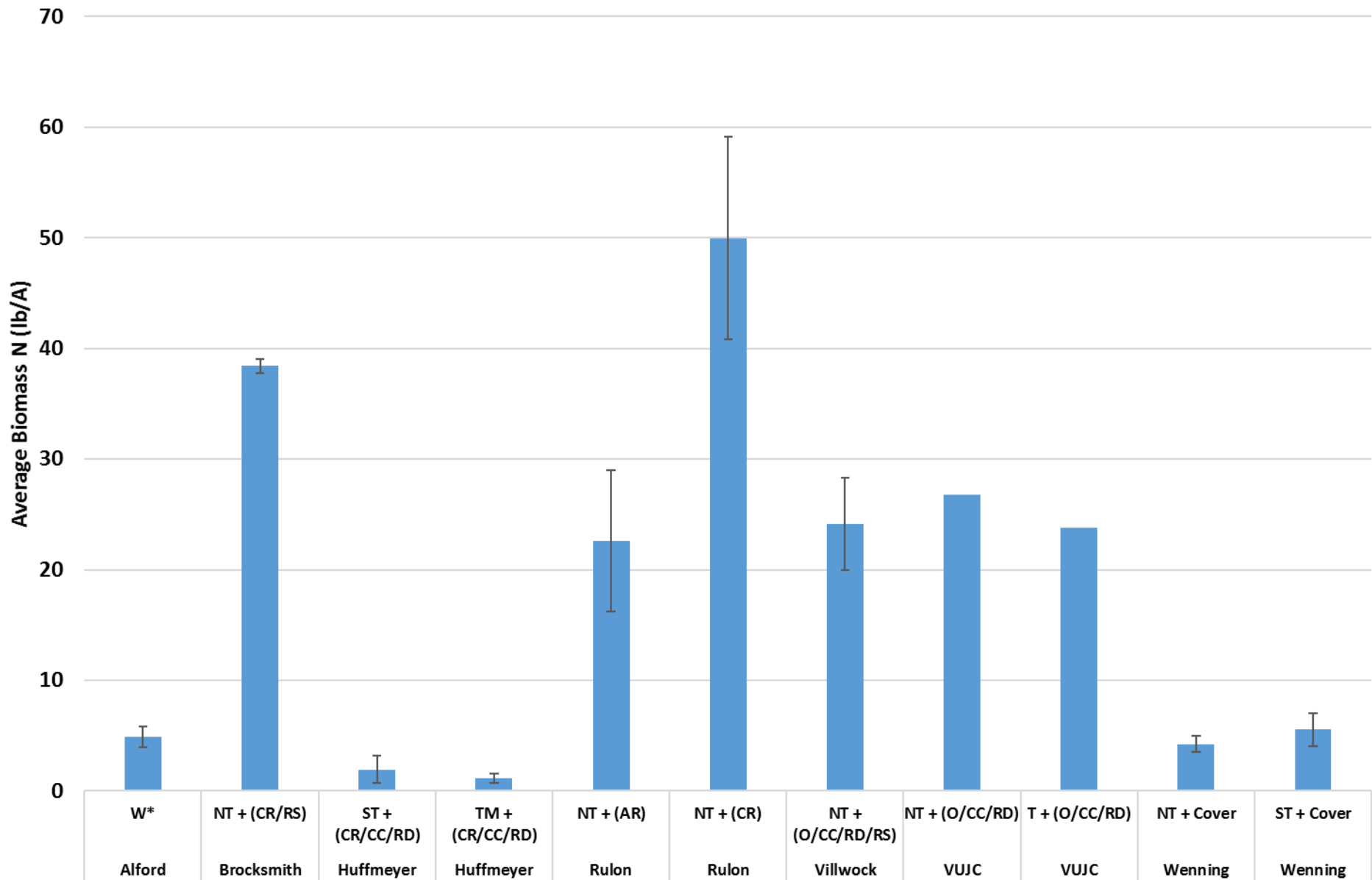
W* is the current cash crop

Spring 2016 Average Biomass (lb/A)



W* is the current cash crop

Spring 2016 Average Biomass N (lb/A)

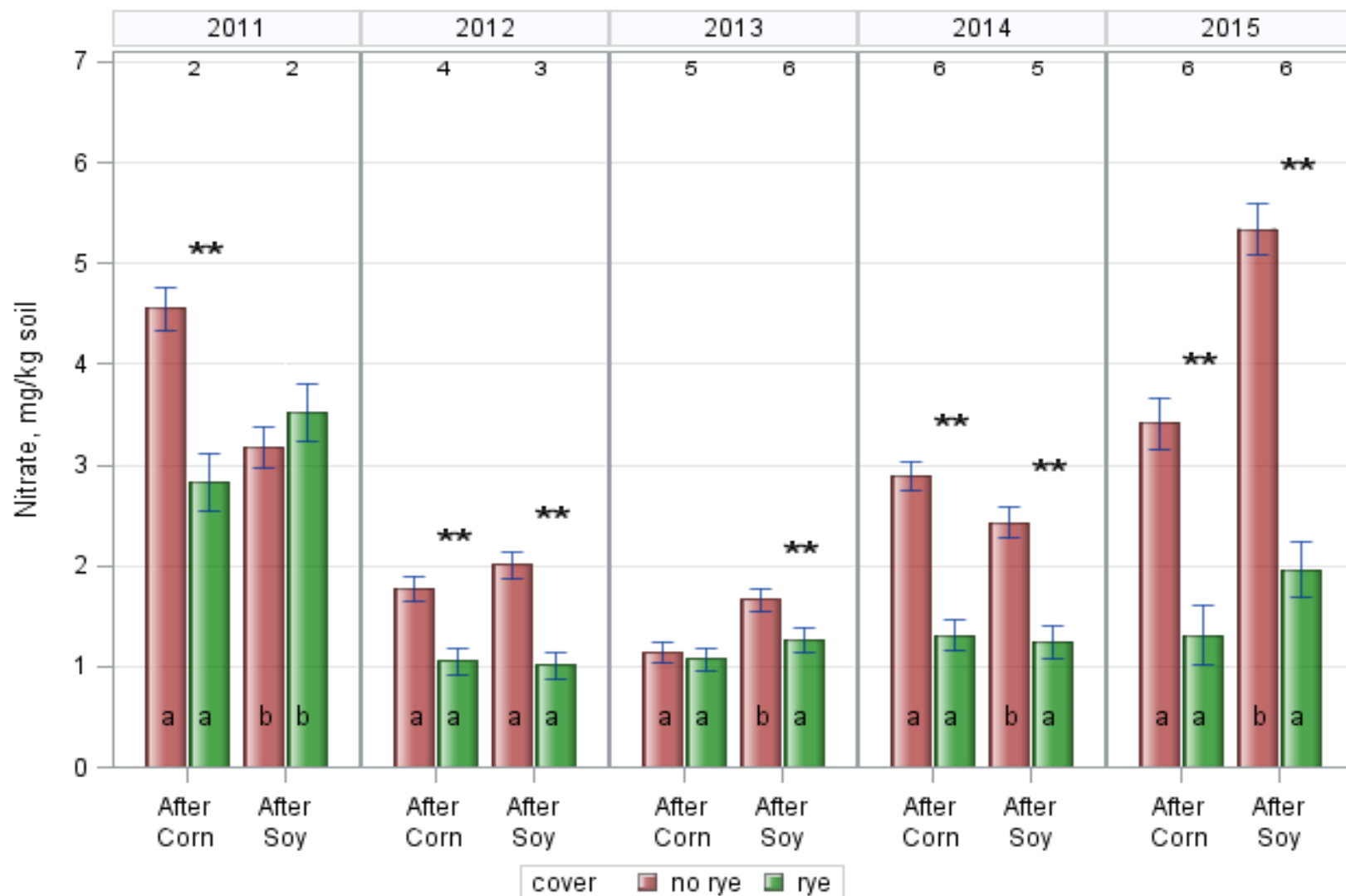


W* is the current cash crop

Findings so far

- Cover crop biomass varies greatly across sites and years, of course
- Soil nitrate in spring right before cover crop termination, is generally lower in cover crop plots than in controls (no cover crop). Cover crop has scavenged N from soil, protecting it against loss.

Spring, depth 0-30 cm



7 Month “Brown Gap” for soybean and corn, fallow period

Cover crop grows and takes up N during some of that normally fallow season. This would shrink the “brown gap” and keep the land green for longer time.

Tile drain studies in Midwest consistently show reduction in nitrate leaching with cover crops

This scavenged N goes into YOUR soil N bank account!

Findings so far

- Cover crop biomass varies greatly across sites and years, of course
- Soil nitrate in spring right before cover crop termination, is generally lower in cover crop plots than in controls (no cover crop). Cover crop has scavenged N from soil, protecting it against loss.
- Soil aggregation improved at some sites. We expect improvement at all sites, given time.

Lab Analysis

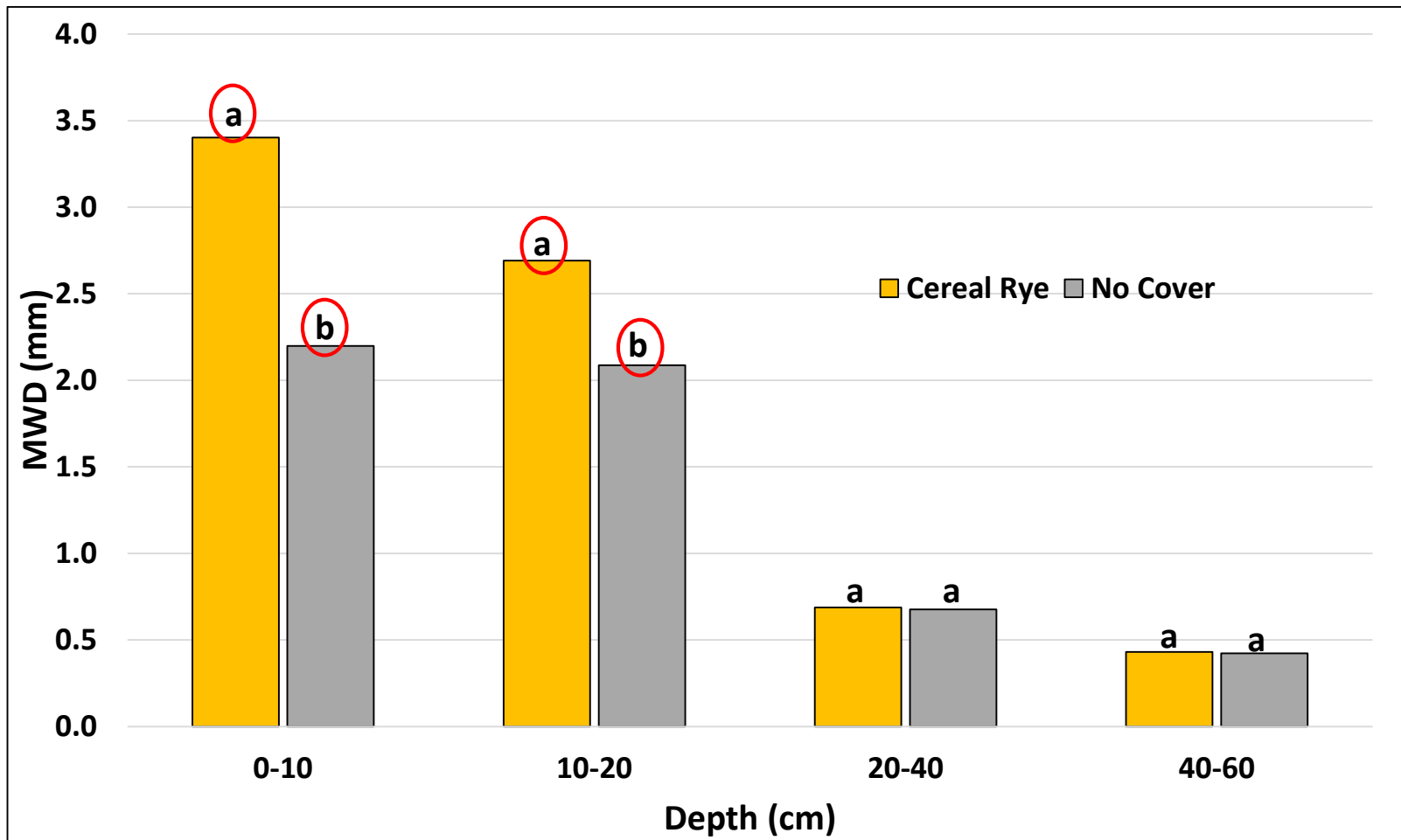
- Aggregate stability mean weight diameter (MWD) using the wet sieving method
- SOC and TN using the combustion method at IA State soil testing lab
- B.D. and Water Retention (Θ_v) 0, -4.9, -9.8, and -33 kPa using intact cores
- -1500 kPa using a crushed <2mm sample



Aggregate Stability

SEPAC 2015

J.D. Rorick, M.S. Thesis, 2016



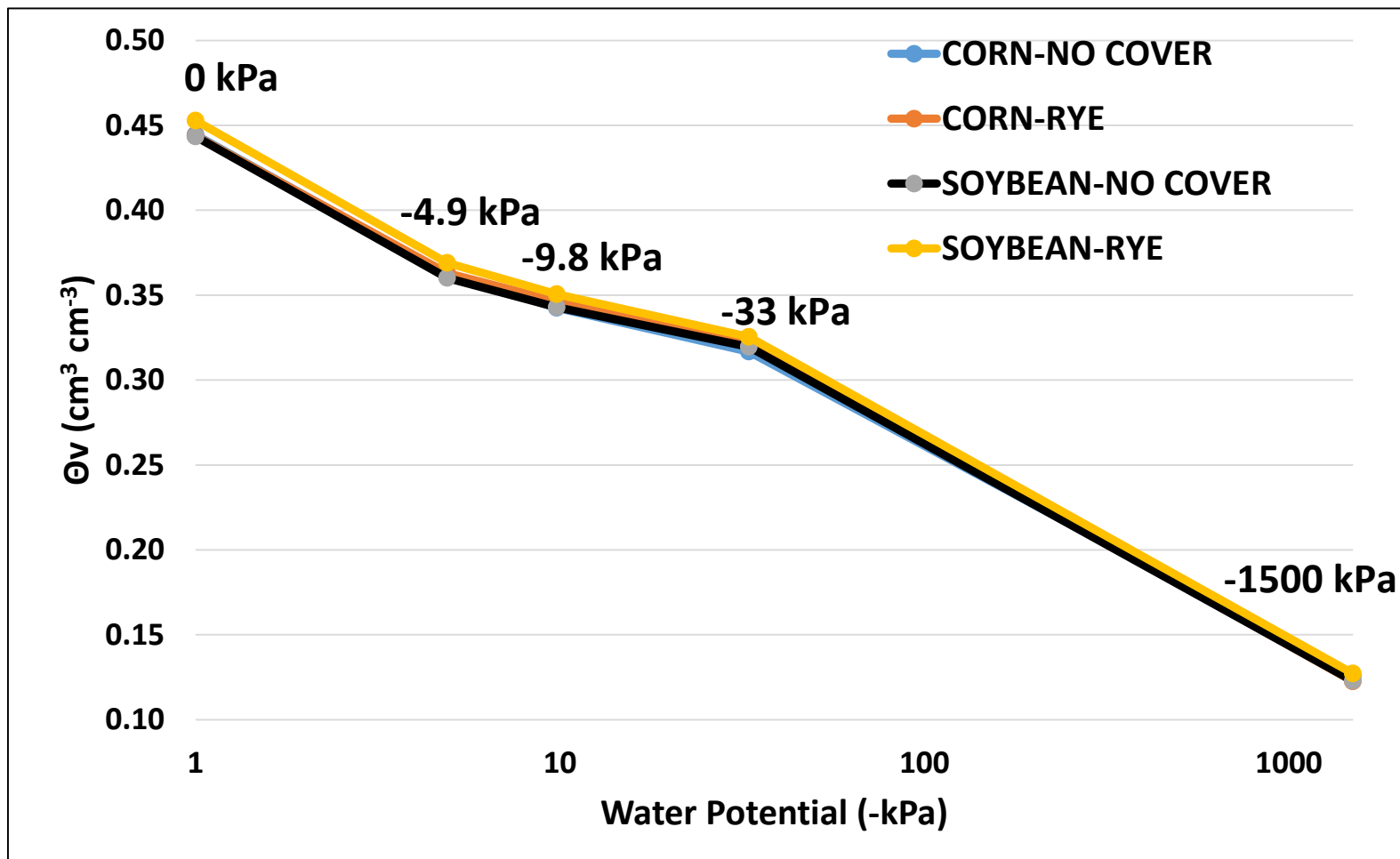
Findings so far (cont.)

- No difference in bulk density and water retention curves (water holding capacity) (4 yr CSCAP; 2 yr CCSI project)

Water Retention

0-10cm, SEPAC 2015

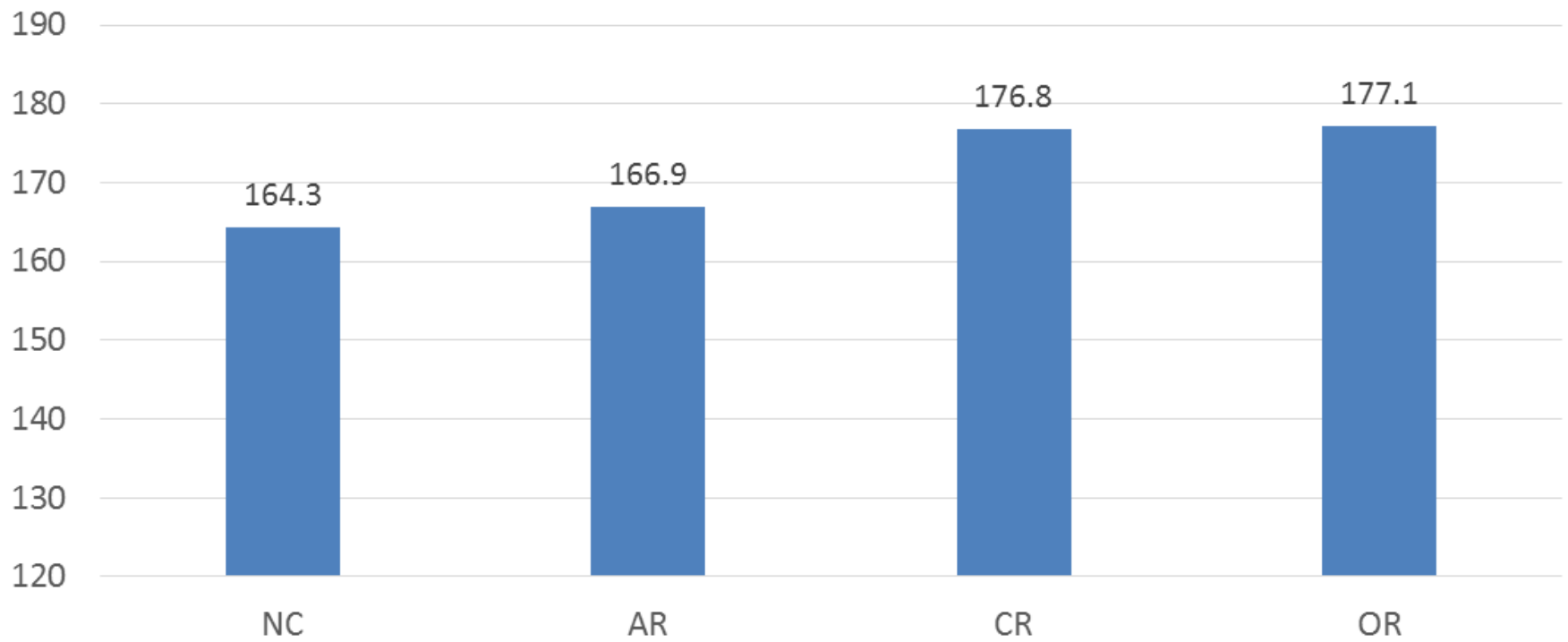
Joe Rorick, M.S. Thesis



Findings so far (cont.)

- Most site-years in CSCAP had no yield differences over 4 yrs, beans and corn
- Most site-years in CCSI-CIG also had no yield differences in first 2 years
- A few sites had greater yields

Ave corn yield across 5 N rates--Rulon 2015



Questions—Soil Health Tests

- Are there any relationships among the different tests, across the sites?
- Can some measures be predicted, or at least correlated, with other measures, preferably simpler or cheaper methods?
- Did commercial tests separate out the “new” treatment (usually cover crop) from the “current” treatment?

Findings so far (cont.)

(remember most CCSI sites only 2 yrs of cover!)

- Commercial soil health tests
 - Few consistent differences between cover and no cover
 - More differences across sites, soil types
 - Different tests not well correlated, even on measures where would expect good relationships
 - More work needed to determine usefulness!
(new post-doc starting Jan 2017 will further analyze)
 - But let's look at some examples.....



Laboratories, Inc.

Ag Testing - Consulting

Account No. : 51100

Biological Soil Analysis Report

IASWCD
225 S EAST ST STE 740
INDIANAPOLIS IN 46202

Invoice No. : 1133735
Date Received : 06/12/2013
Date Reported : 06/14/2013

Results For : IASWCD
Sample ID 1 : WABASH FARM
Sample ID 2 : WF-1
Lab No :226

Total living microbial biomass

Total Living Microbial Biomass, Phospholipid Fatty Acid (PLFA) ng/g 1105.49

Functional Group Diversity Index 1.247

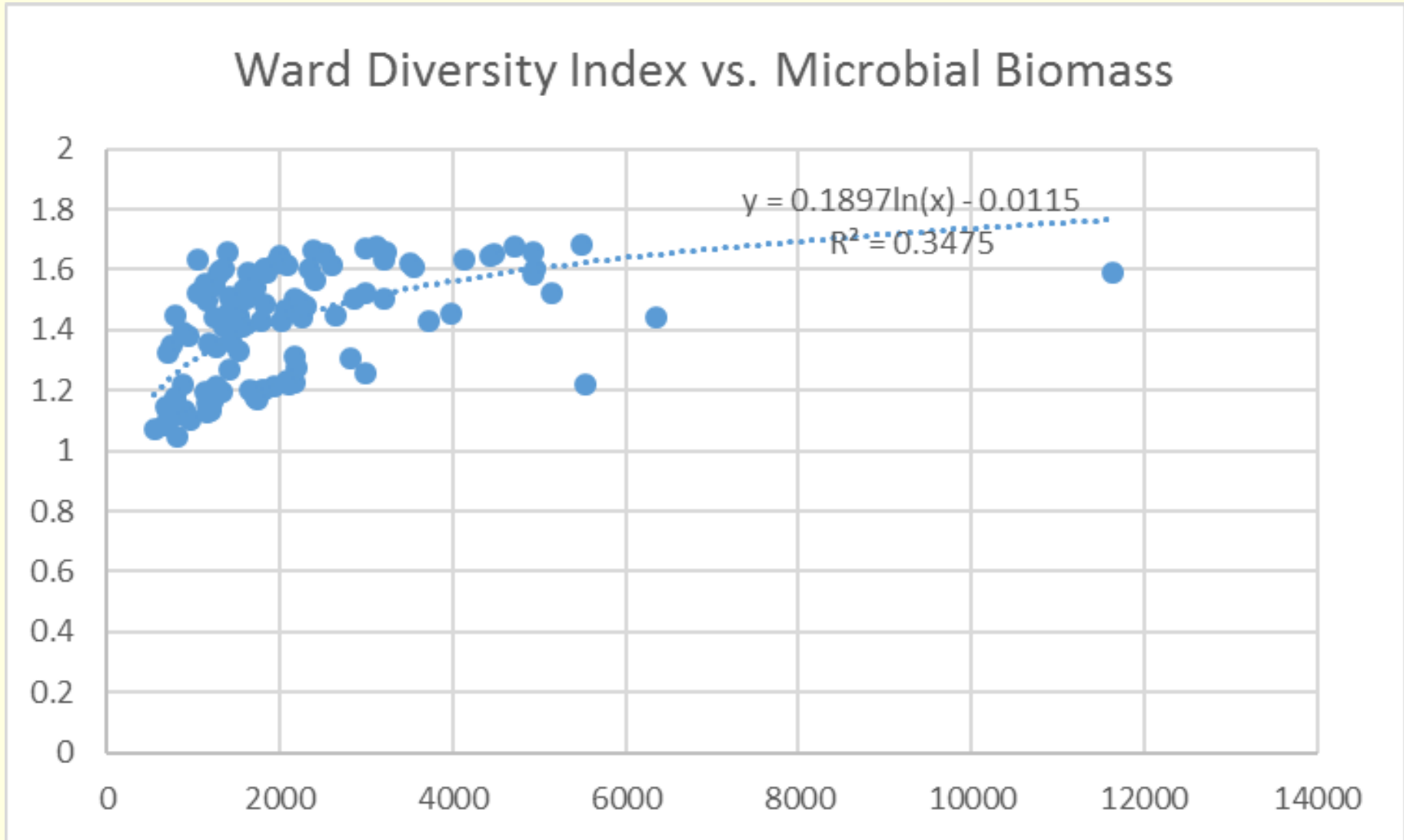
Diversity index

Functional Group Biomass & Diversity

Table with 3 columns: Functional Group, Biomass, PLFA ng/g, and % of Total Biomass. Rows include Total Bacteria, Gram (+), Actinomycetes, Gram (-), Rhizobia, Total Fungi, Arbuscular Mycorrhizal, Saprophytes, Protozoa, and Undifferentiated.

Different functional groups

Some correlation between diversity and microbial biomass



Ward Laboratories: Community Composition Ratios (Interpretations qualitative)

- Fungi : Bacteria

Our ave = 0.163

Scale	Rating
< 0.05	Very Poor
0.05+ - 0.1	Poor
0.1+ - 0.15	Slightly Below Average
0.15+ - 0.2	Average
0.2+ - 0.25	Slightly Above Average
0.25+ - 0.3	Good
0.3+ - 0.35	Very Good
> 0.35	Excellent

- Predator : Prey

Our ave = 0.022
Minimum = 0 (ie, all Prey)

Scale	Rating
< 0.002	Very Poor
0.002+ - 0.005	Poor
0.005+ - 0.008	Slightly Below Average
0.008+ - 0.01	Average
0.01+ - 0.013	Slightly Above Average
0.013+ - 0.016	Good
0.016+ - 0.02	Very Good
> 0.02	Excellent

Solvita CO₂ burst and Soil Health Tool (SHT)

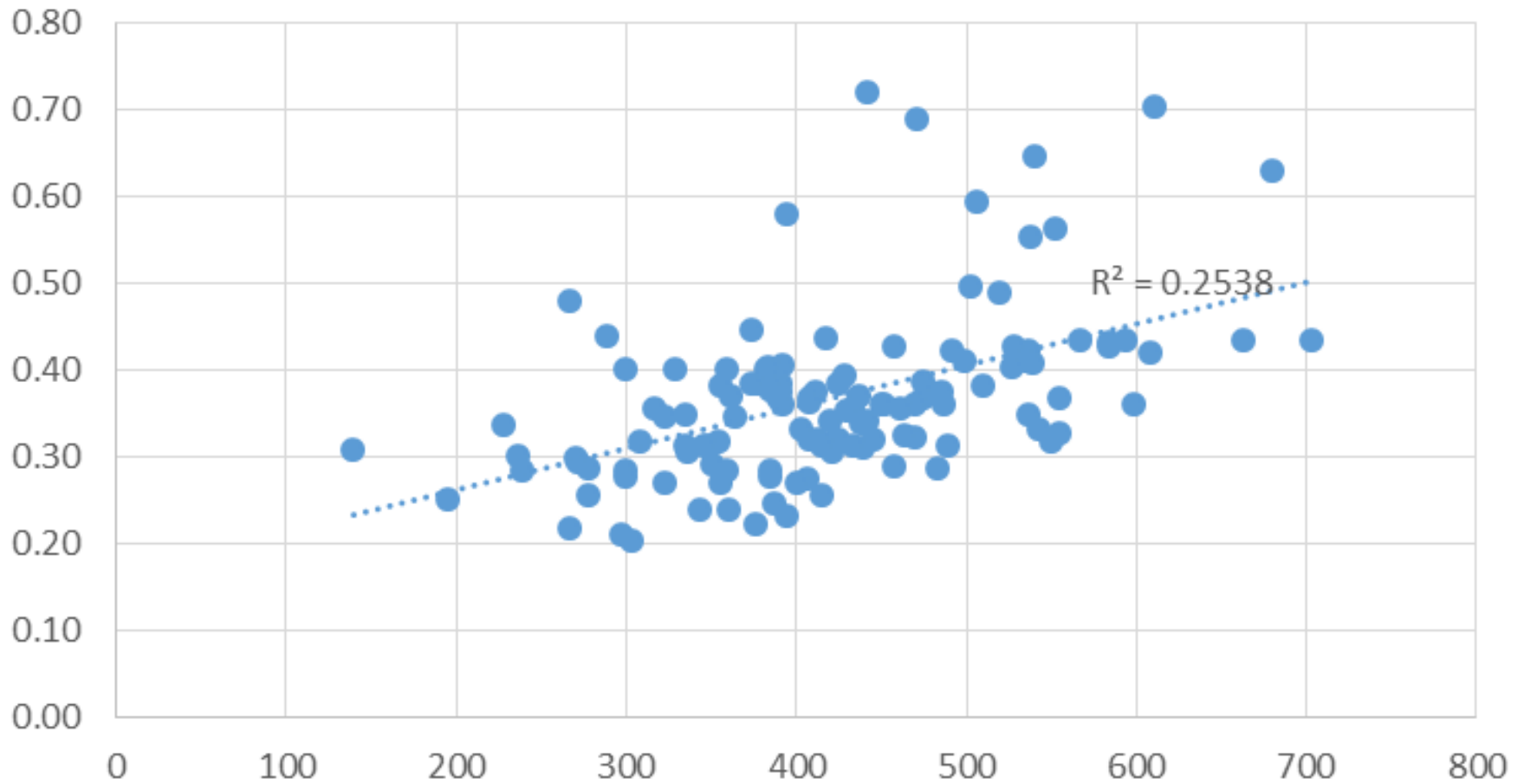
- Measures flush of microbial activity after drying and rewetting a soil sample
- Relates to microbial biomass present at time of sampling
- Another test extracts water-soluble C and N, which are immediately available to organisms
- Again, the test is a “snapshot”
- Sampling protocol less sensitive, since samples will be dried anyway

(2015 format
of results)

Cornell Soil Health Assessment				
Eileen Kladvko Lily Hall 915 State Stree W. Lafayette, IN, 47907 Agricultural Service Provider: None IASWCD jennifer-boyle@iaswcd.org		Sample ID: Mm_854 Field/Treatment: SEPAC 205 Tillage: Crops Crown: COG, SOY Date Sampled: 5/28/2015 Given Soil Type: No Soil Type Given Given Soil Texture: No Soil Texture Given Coordinates: Coordinates Not Provided		
Measured Soil Textural Class: Silt Loam		Sand: 14% Silt: 70% Clay: 16%		
Test Results				
	Indicator	Value	Rating	Constraint
Physical	Available Water Capacity	0.28	99	
	Surface Hardness			Not Rated: No Field Penetrometer Readings Submitted
	Subsurface Hardness			Not Rated: No Field Penetrometer Readings Submitted
Biological	Aggregate Stability	19.1	18	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
	Organic Matter	2.2	16	Nutrient and Energy Storage, Ion Exchange, C Sequestration, Water Retention
	ACE Soil Protein Index	4.0	21	Organic Matter Quality, Organic N Storage, N Mineralization
	Respiration	0.32	16	Soil Microbial Abundance and Activity
	Active Carbon	464	29	Energy Source for Soil Biota
Chemical	pH	5.4	0	Low pH: Toxicity, Nutrient Availability
	Phosphorus	2.5	72	
	Potassium	152.5	100	
	Minor Elements Mg: 180 Fe: 1.8 Mn: 17.8 Zn: 0.3		100	
Overall Quality Score		47	Low	

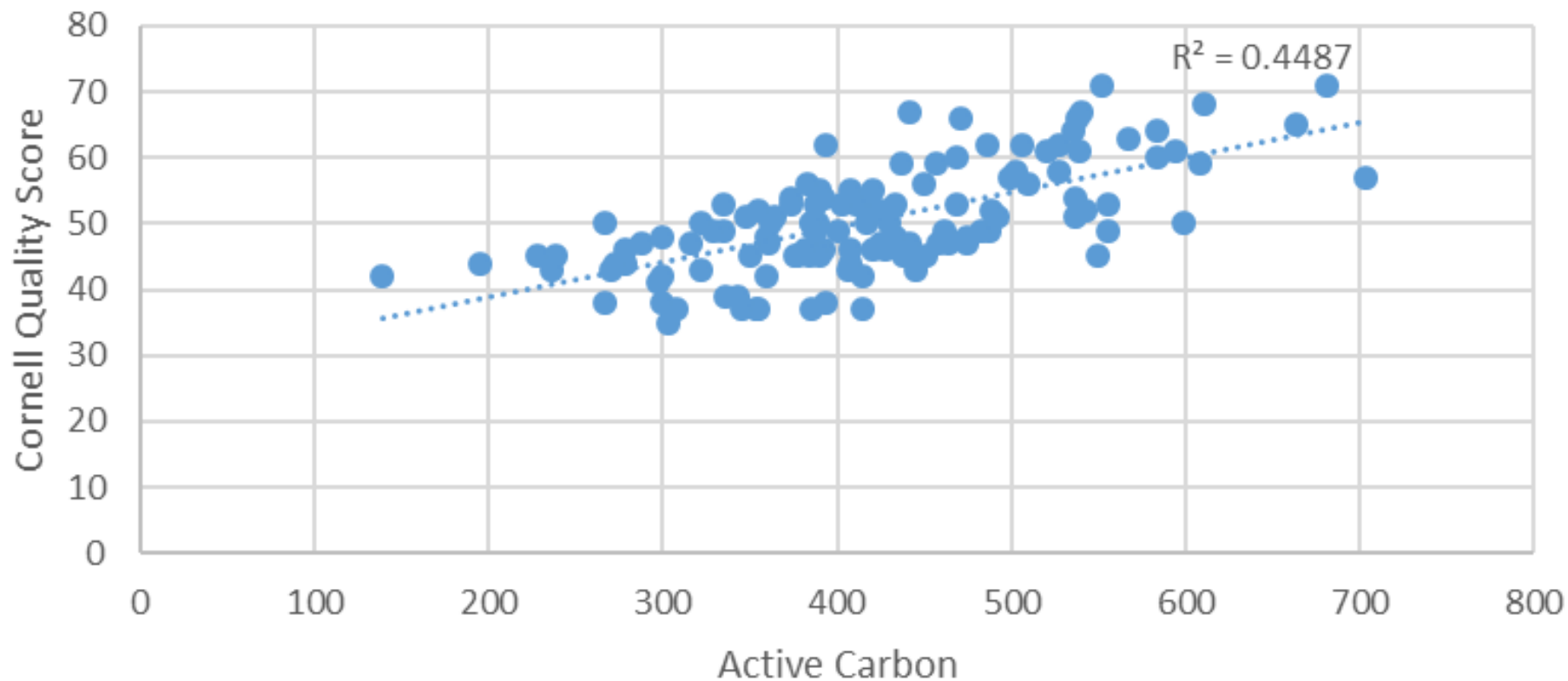
Respiration weakly correlated with active carbon

Cornell Respiration vs. Active Carbon

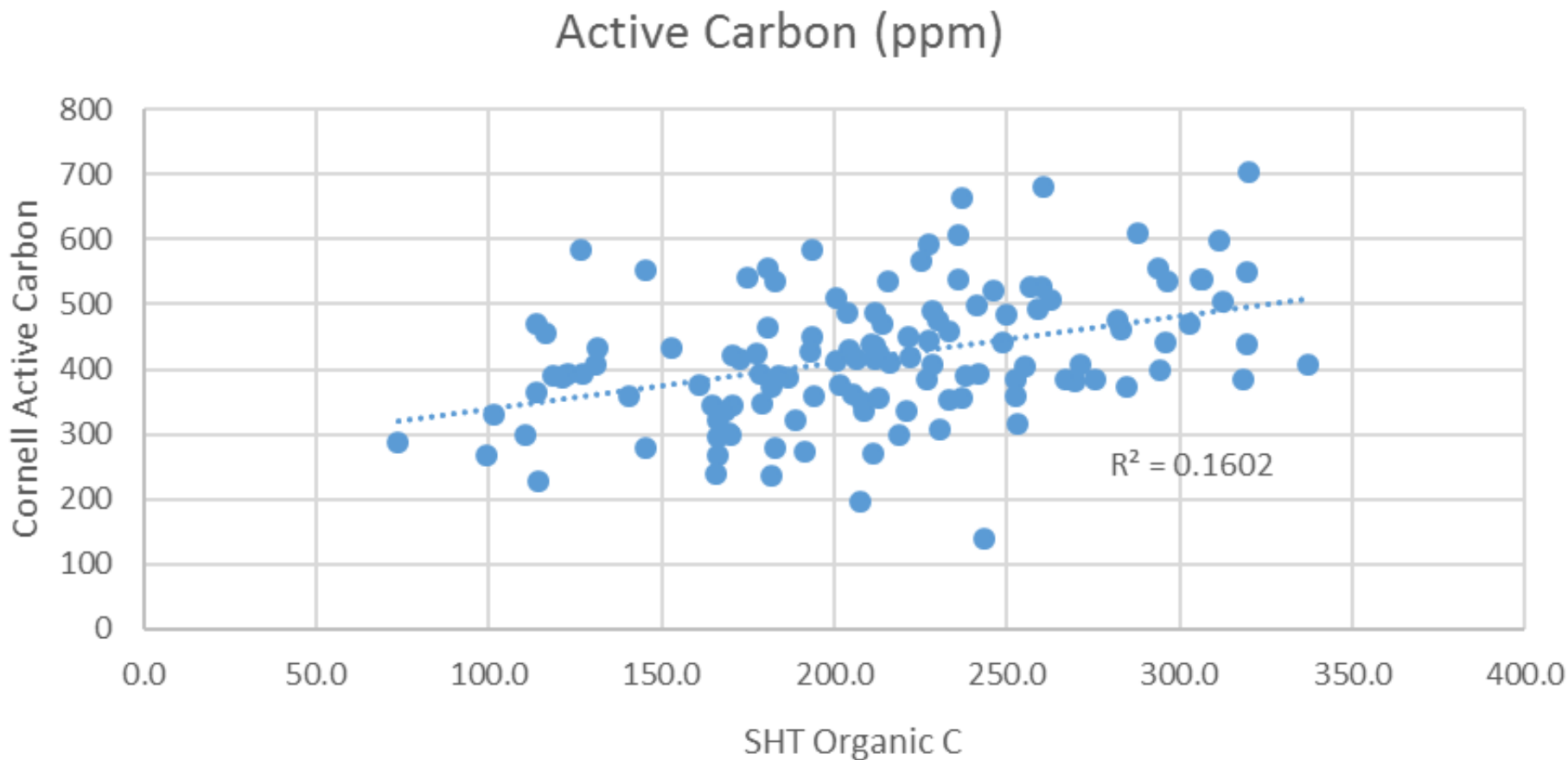


Overall quality score correlated with active carbon

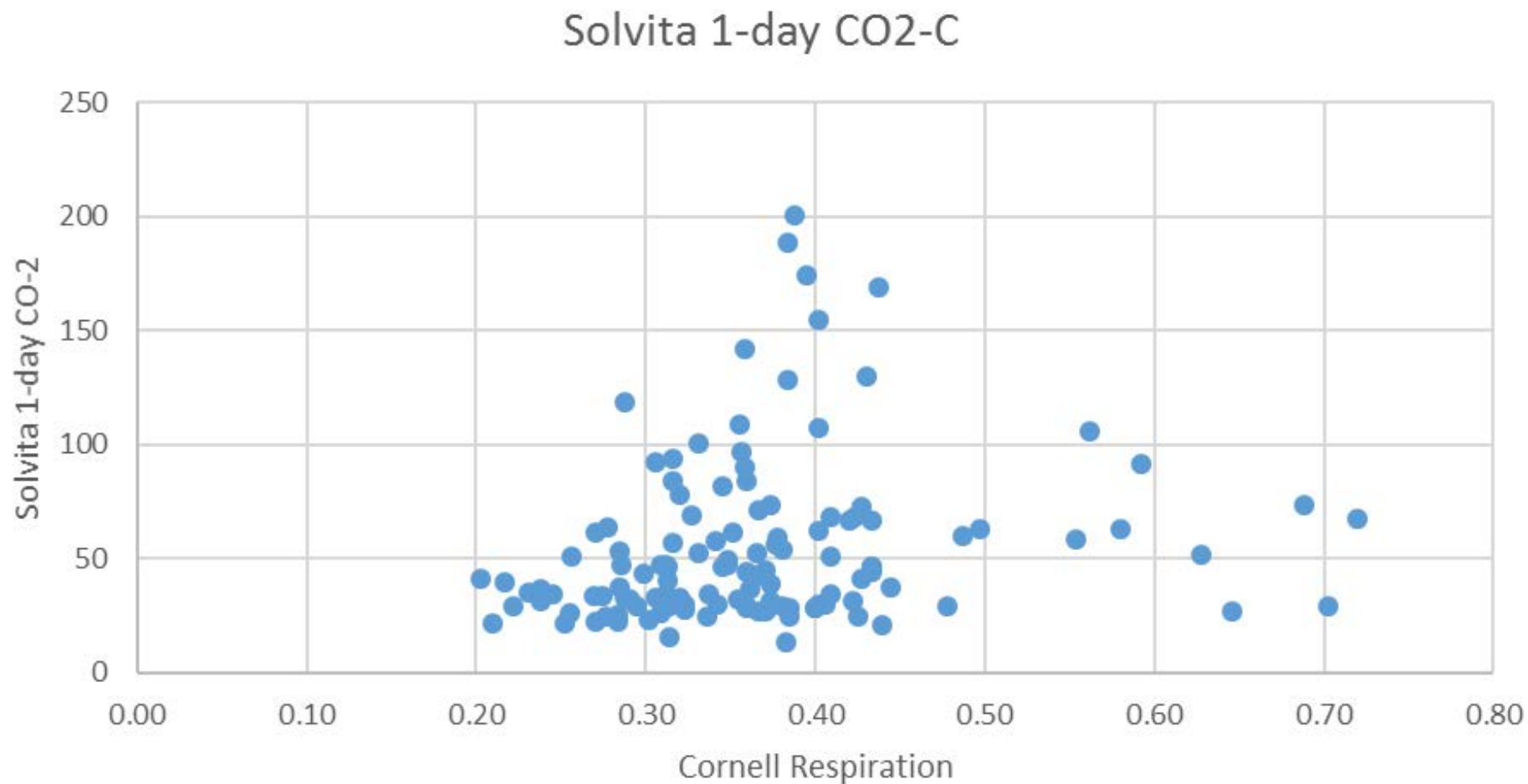
Cornell Quality Score



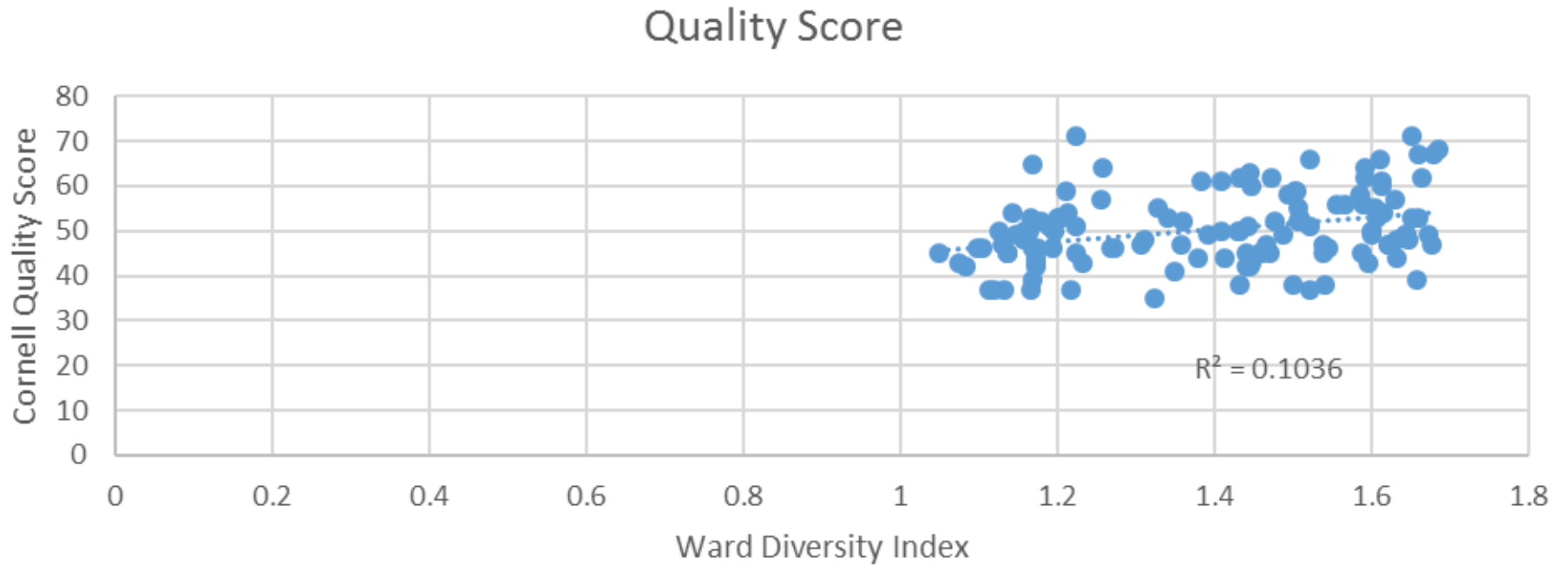
Cornell active carbon not correlated with SHT organic carbon



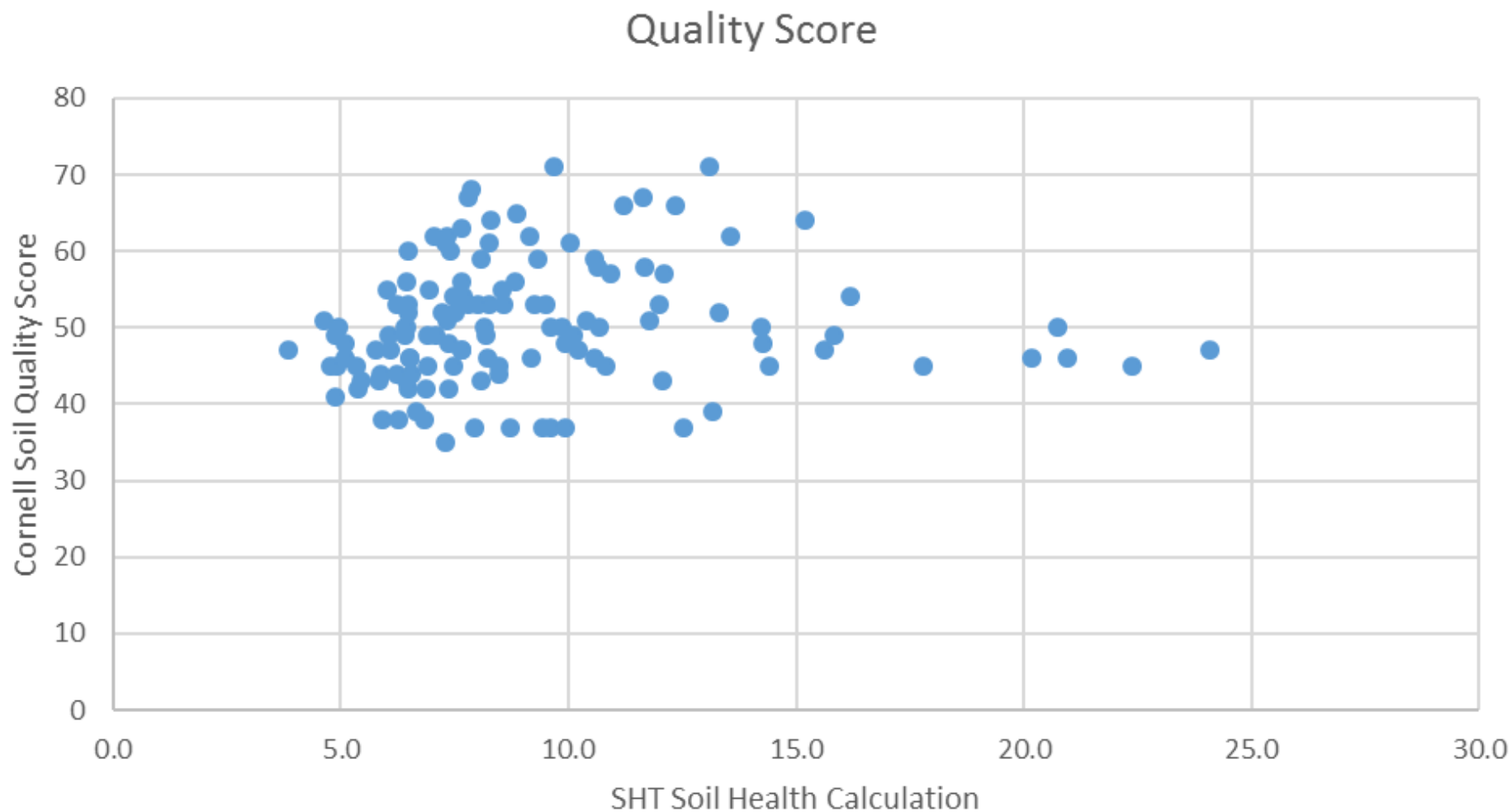
Two methods for respiration measurements not correlated



Cornell overall quality score not correlated to Ward diversity index



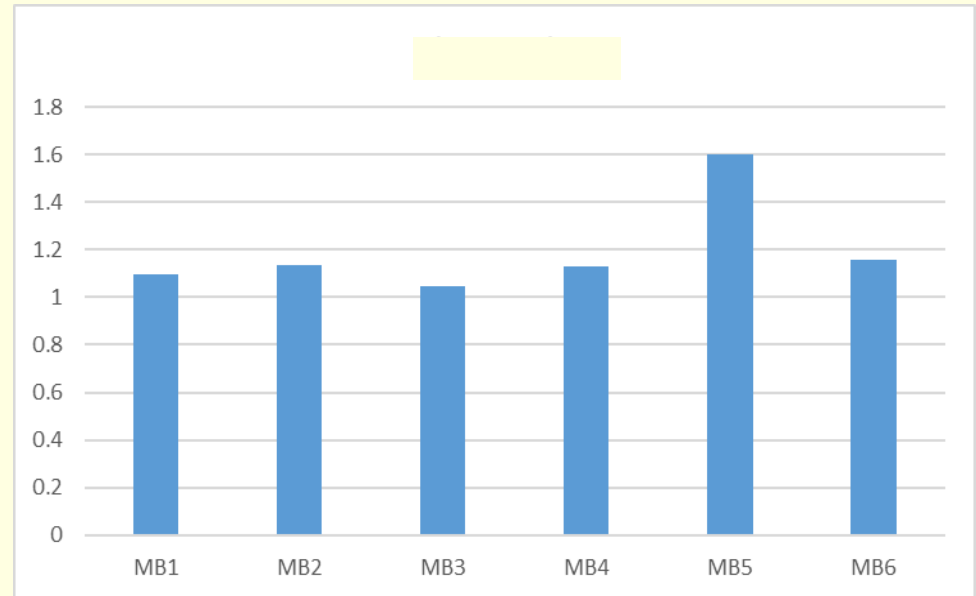
Cornell soil quality score not correlated with SHT soil health score



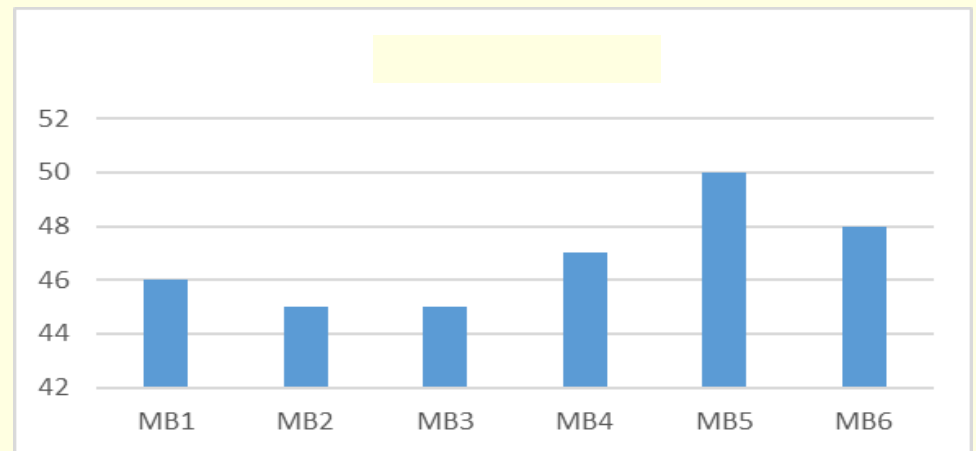
-
- So the three overall soil health scores (Ward diversity index, SHT soil health score, Cornell soil quality index) are not correlated with each other. Not surprising, because each test is measuring different things.
 - Underscores that people need to know what they're most interested in assessing, before choosing one test over another.

- No apparent consistency in being able to distinguish the alternating treatments of cover vs no cover (one example).
- Further analysis will go deeper into these results across all sites.

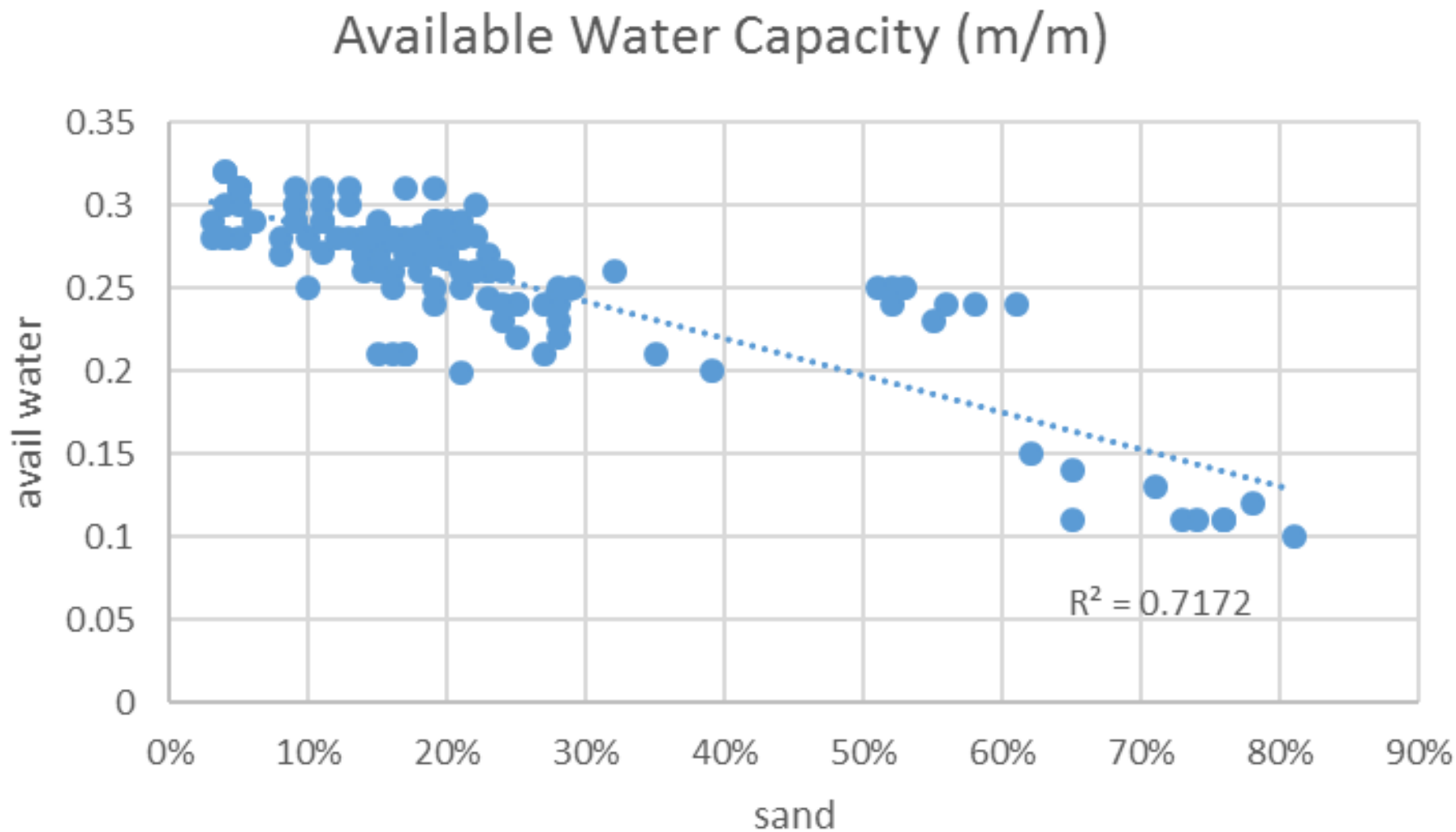
Ward diversity index, site MB



Cornell quality score, site MB

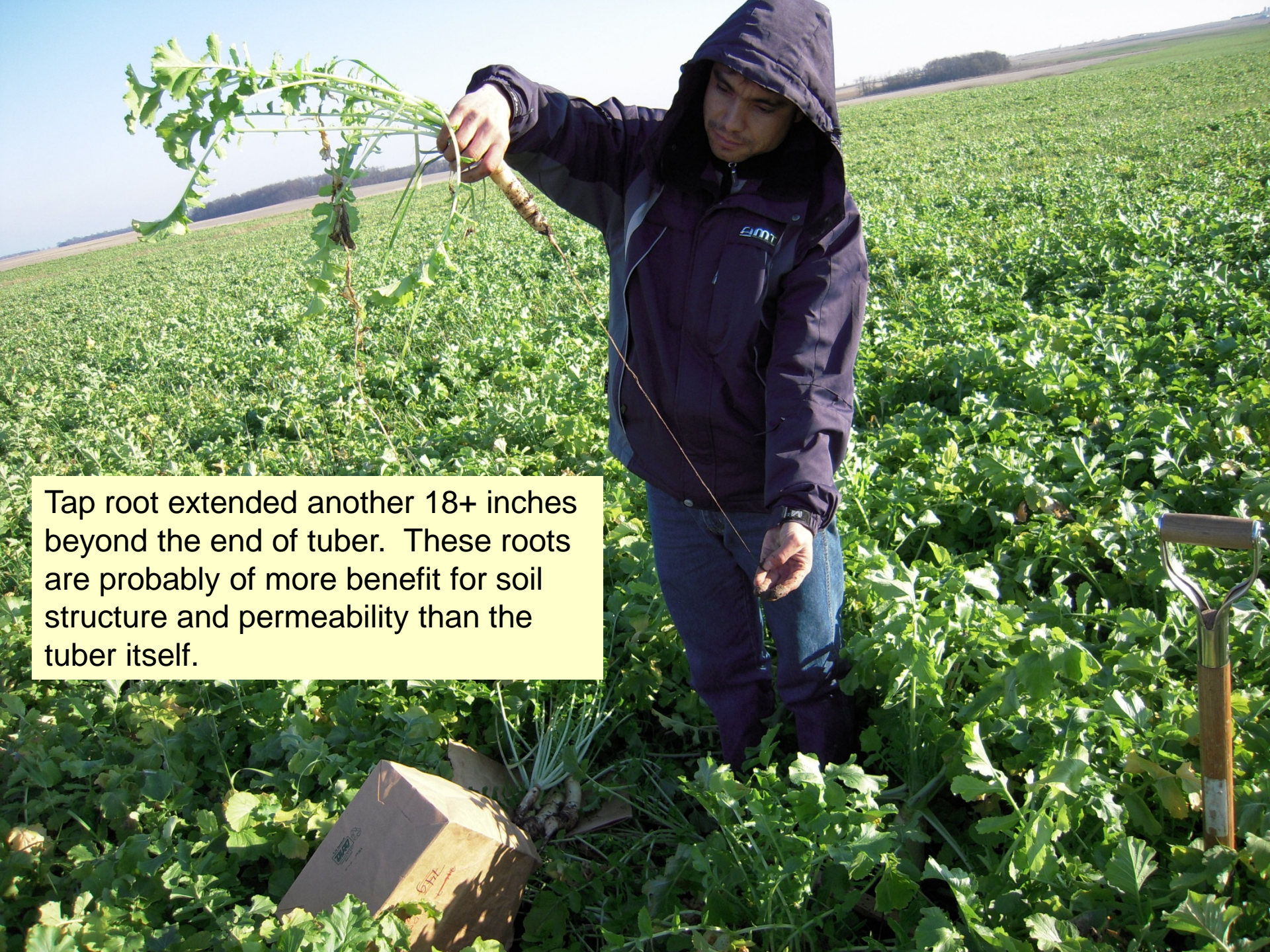


Available water capacity negatively correlated to sand



Challenges, future needs

- Longer time in the soil health system
- Start with conventional system and measure changes over time
- Further development of calibrations and interpretations of commercial soil health tests
- How assess other attributes we observe but are too difficult to “measure”? How assign a “score” or “importance” value?



Tap root extended another 18+ inches beyond the end of tuber. These roots are probably of more benefit for soil structure and permeability than the tuber itself.





Economics of Soil Health—Cover Crops and No-Till

- Case studies from Indiana farmers as part of CCSI-Conservation Innovation Grant
- Eight case studies published on CCSI website
- Go to www.ccsin.org; click on Economics of Soil Health tab
- Evaluations by farmers with added input from Dr. Wally Tyner and grad student Myriam Bounaffaa, Purdue Ag.Econ.

Long-Term Payoffs: Diversification

Dan DeSutter - Attica, Indiana

Over the past 20 years, Dan DeSutter of Attica, Indiana, has built a national reputation as a proponent of no-till, cover crops and healthy soils, putting his expertise in a financial analysis and conservation on his family's farm.

Cover Crops: Multiple Species Deliver Multiple Benefits

Jamie Scott - Pierceton, Indiana

Jamie Scott knows first-hand the importance of tracking the effects of conservation practices on the farm.

"We've 19 years into our no-till system, but we aren't taking good notes," admits the northeast Indiana farmer, who farms about 2,000 acres of corn, soybeans, wheat and cover crop need with his family. He is determined to do a better job of documenting the impact of cover crops on his operation.

Scott is a huge proponent not only of cover crops, but of diverse "cocktail" mixes of cover crop species, which impact soil health in several ways.

Better Soil

"When you walk across the plots, you feel the difference," Scott says. "We had a visitor recently and when the cocktail mix was, the guy said, 'this is like walking with a dog carpet with a thick pad under it.' Where the single species was, he said, 'this is like Astroturf carpet.' On the bare ground, he said, 'this is like concrete.'"

Digging into the field gives even greater perspectives. "It's amazing how much it changes the soil—how rich it looks, the darkness of the soil," Scott points out. "People 'you've got good soil here.' But you could also go to

The Financial Challenge

Jamie Scott recognizes that it's not easy to track the field effects of rotations and cover crops over long periods, or to pinpoint the economic value of some of the most important benefits of cover crops.

"There are certain things that are hard to put a dollar value on," he says. "Organic matter is one of those."

Scott says cover crops have helped build organic matter levels in his fields.

"With a corn/bean rotation, even no-till, we were struggling to build organic matter," he says. "With cover crops, we were starting to move up. And when we started adding wheat and a cocktail mix, we went going from a two-percent level to a three-percent level."

Studies have attributed the nitrogen value of adding 1% soil organic matter at \$15.70 to \$40.00 per acre per year. Graduate student Joshua Latour, working under Purdue University agricultural economist Wallace Tyner, found that one-species cover crops increase soil organic matter by 54 to 379 pounds per acre each year. He also determined that cover crops can reduce off-field nitrogen movement by four to 23 pounds per acre per year—which adds up if it helps farmers keep that N in the root zone for the next crop—depending on cash crop, soil type, and tillage regimen.



the year to come. "The biggest payoffs for what we're doing," he says. "They don't show up in one year or two years. We manage for that. If there's a short term that's great. But we know there's long term value."



Dollar Value

"I think there's a benefit from having soil—it's going to increase biological activity, good thing," DeSutter points out. "How figure on that? I don't know."

Of course, he's not alone. One of the goals of CCSI was to try to put dollars in soil health. It's difficult work—a mix of the value of cover crops by graduate s

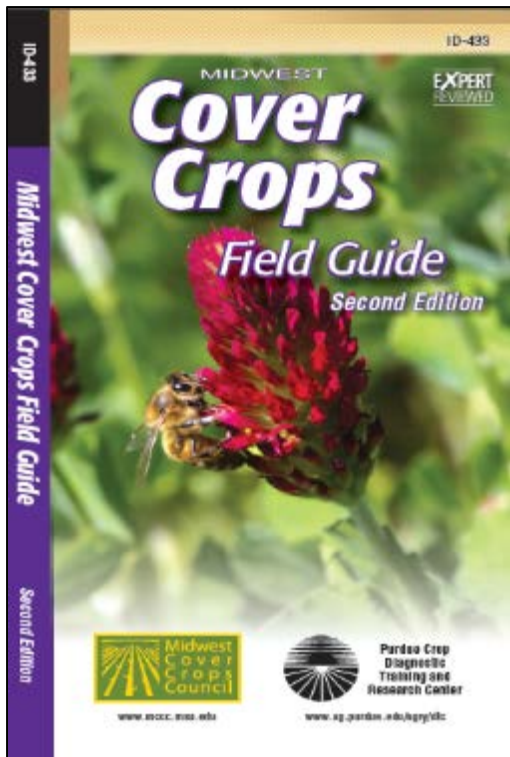
in the Conservation Cropping Systems Initiative, a partnership of a wide range of universities and organizations in the state carrying out farm-scale agronomic and economic research on soil health.

Through CCSI, Scott conducted three trials—comparing wheat grown without a cover crop, a single-species cover crop of annual ryegrass, and a cover crop cocktail mix—each replicated four times. Each of the 12 strips on his trial field was 40 feet wide and 1,000 feet long to minimize the effects of varying soil types ("we have a bit of everything," he says).



Economics of Conservation Series
Conservation Cropping Systems Initiative
www.ccsin.org

Resources



2nd Edition now available!

Purdue Extension Education Store
 1-888-EXT-INFO
www.the-education-store.com

PURDUE EXTENSION LOCAL FACES
COUNTLESS CONNECTIONS

AY-353-W
EXPERT REVIEWED

MANAGING COVER CROPS

An Introduction to Integrating Cover Crops Into a Corn-Soybean Rotation

Authors: Eileen Kladivko, Robert Nielsen, Shaun Casteel, Keith Johnson, and James Camberato, Purdue Department of Agronomy; Christian Krupke, Purdue Department of Entomology; William Johnson, Bryan Young, and Kersten Wise, Purdue Department of Botany & Plant Pathology

Illinois	Indiana	Iowa	Kansas	Michigan	Minnesota	Missouri
Nebraska	North Dakota	Ohio	Ontario	South Dakota	Wisconsin	

Home

Cover Crop Resources

- Cover crop species
- Cover crop selector tools
- Innovator profiles
- Extension material
- Publications
- Multimedia

WHAT ARE COVER CROPS?

Cover crops are plants seeded into agricultural fields, either within or outside of the regular growing season, with the primary purpose of improving or maintaining ecosystem quality.

The goal of the *Midwest Cover Crops Council* (MCCC) is to facilitate widespread adoption of cover crops throughout the Midwest, to improve ecological, economic, and social sustainability.

WHAT DO COVER CROPS DO FOR THE ENVIRONMENT?

- Enhance biodiversity

➔ NEWS ➔

Check out the agenda and register for the [2016 MCCC meeting Feb. 23-24, Madison, WI](#)

New MCCC publication: [Integrating Cover Crops in Soybean Rotations](#)

www.mccc.msu.edu

Cover Crop Selector Tools
(link on left sidebar)