Cover Crops and Soil Health Systems

Eileen Kladivko
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)

PURDUE UNIVERSITY

Corn silage land with and without a cereal rye cover crop

Tom Kaspar, Iowa

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?

PURDUE UNIVERSITY

Examples of larger projects in state and region

- Midwest Cover Crops Council

  www.mccc.msu.edu

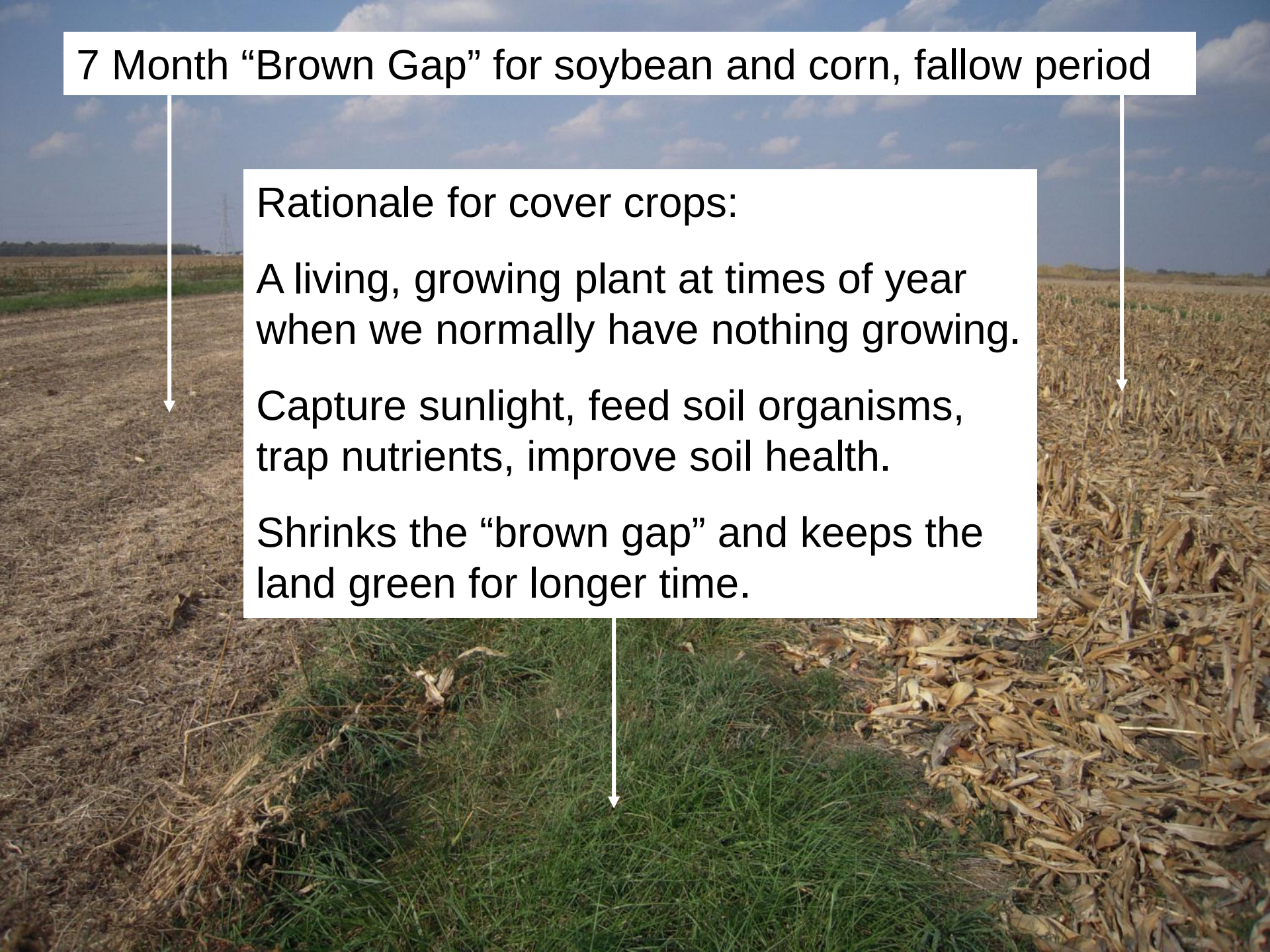
- Indiana Conservation Cropping Systems Initiative (CCSI)

  www.ccsin.org

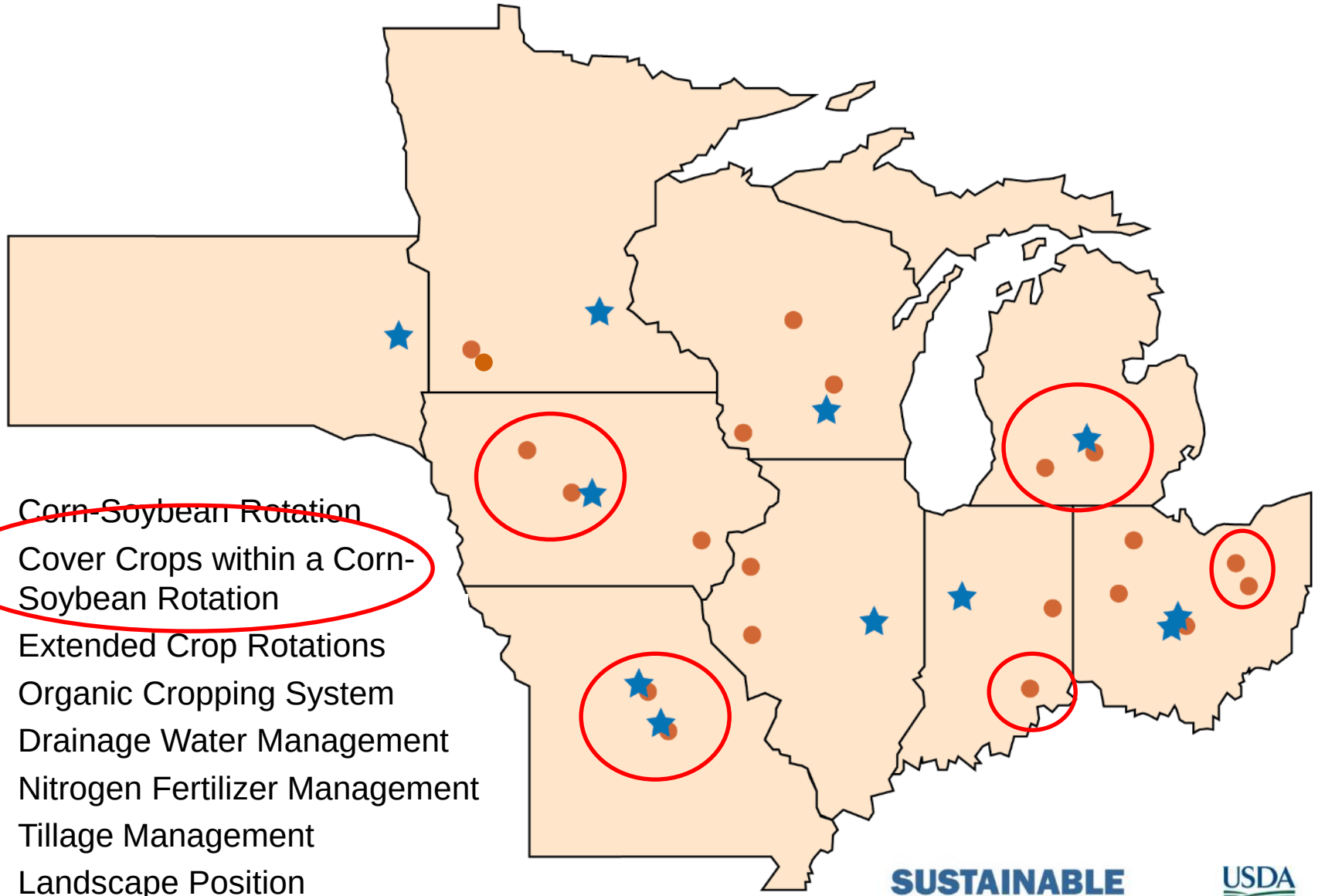
- Corn Systems and Climate CAP

  www.sustainablecorn.org

PURDUE
UNIVERSITY


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



- Corn-Soybean Rotation
- Cover Crops within a Corn-Soybean Rotation
- Extended Crop Rotations
- Organic Cropping System
- Drainage Water Management
- Nitrogen Fertilizer Management
- Tillage Management
- Landscape Position

SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

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

Cereal rye, SE Indiana

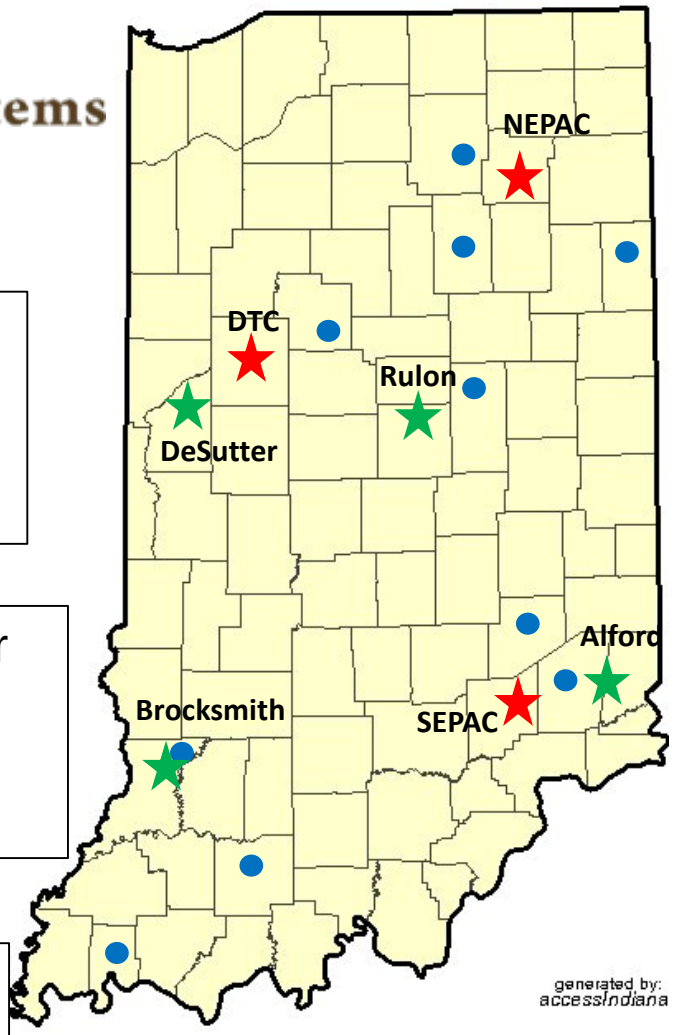
CCSI Conservation Innovation Grant (CIG) project

Conservation Cropping Systems Initiative

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



PURDUE UNIVERSITY

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 CO_2 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

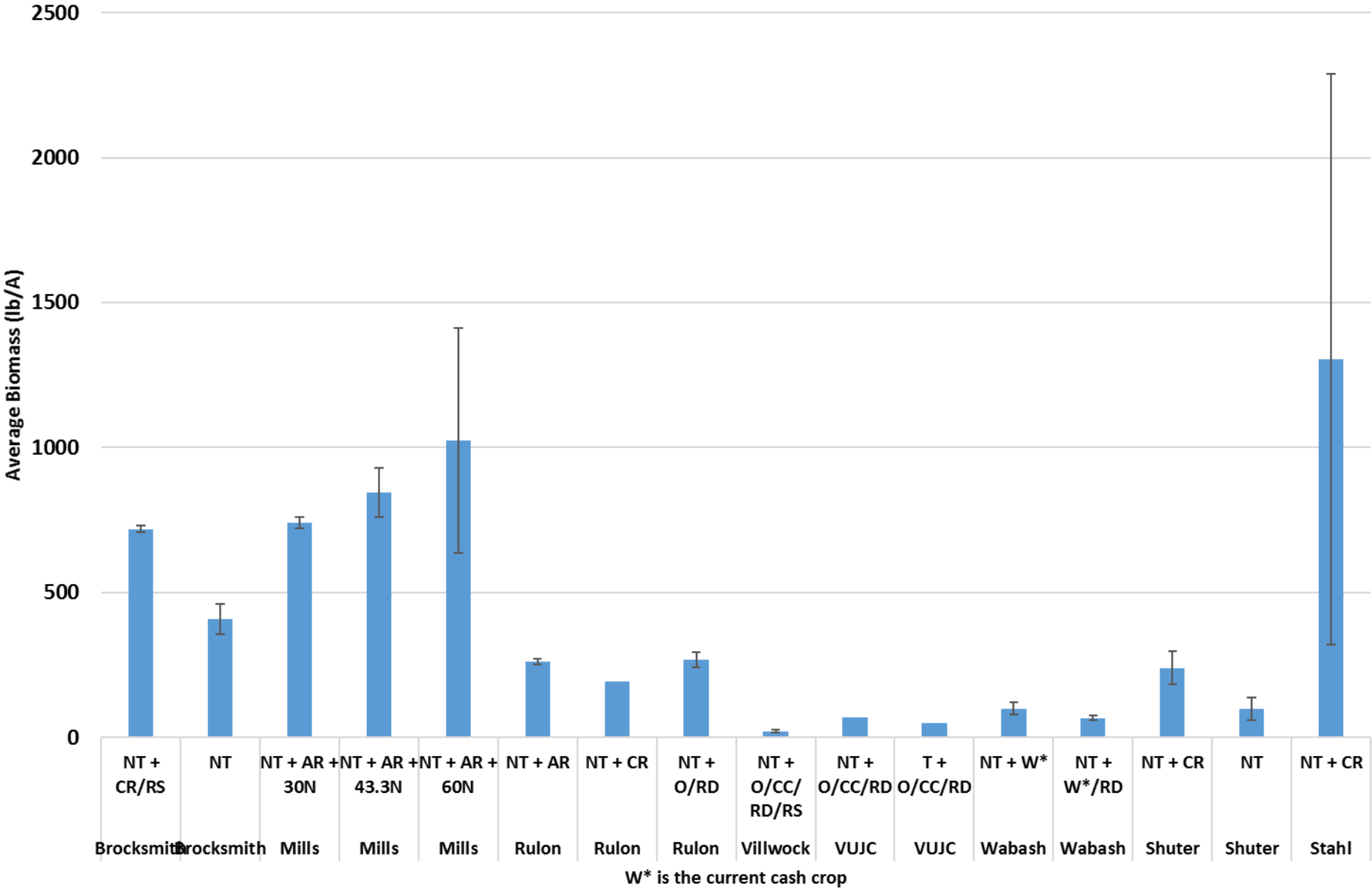
Amount of growth affects the magnitude of cover crop impacts on soil or cash crop!

~710 lb/A

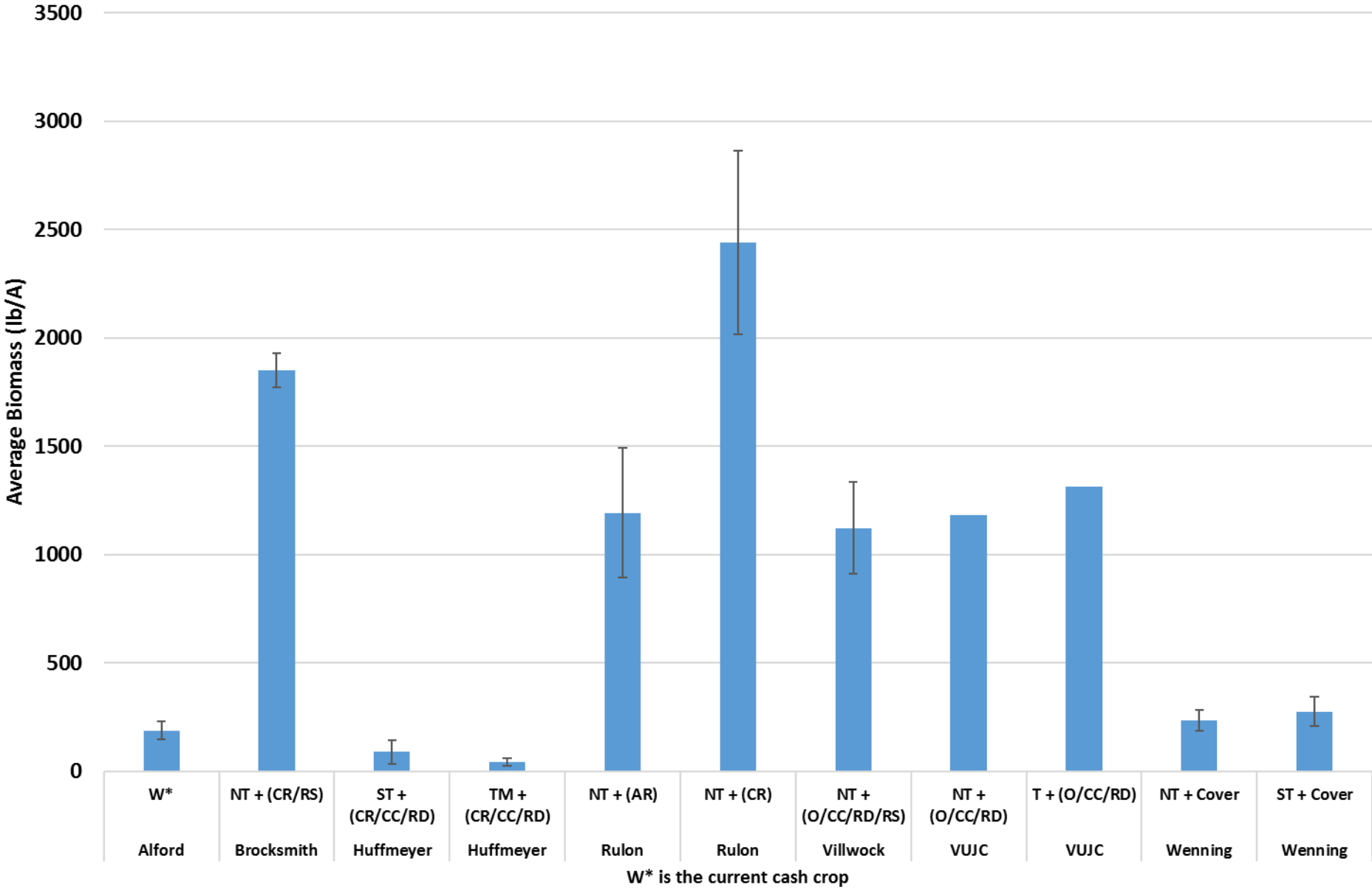
~2500 lb/A

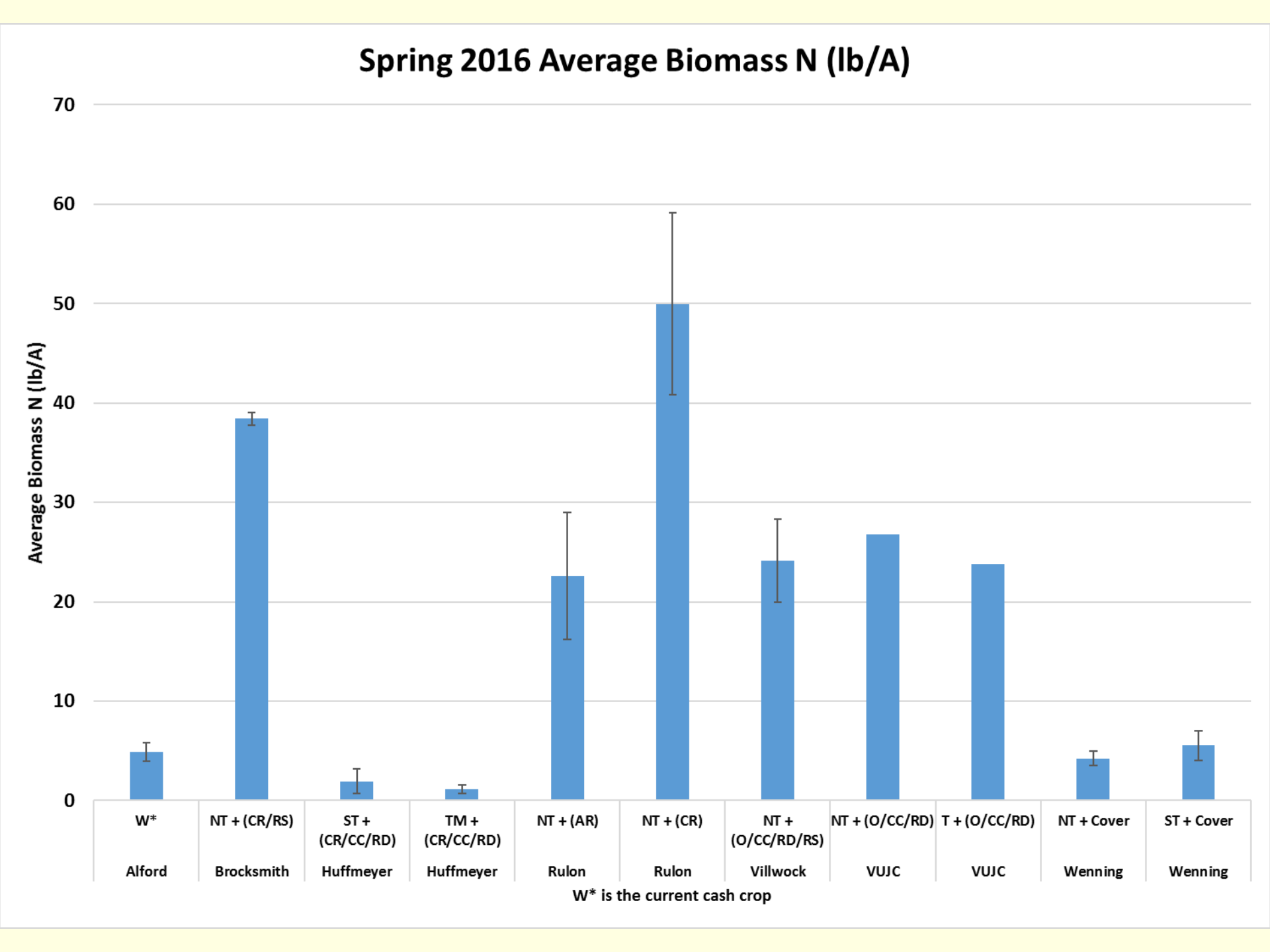
PURDUE
UNIVERSITY

Fall 2015 Average Biomass (lb/A)



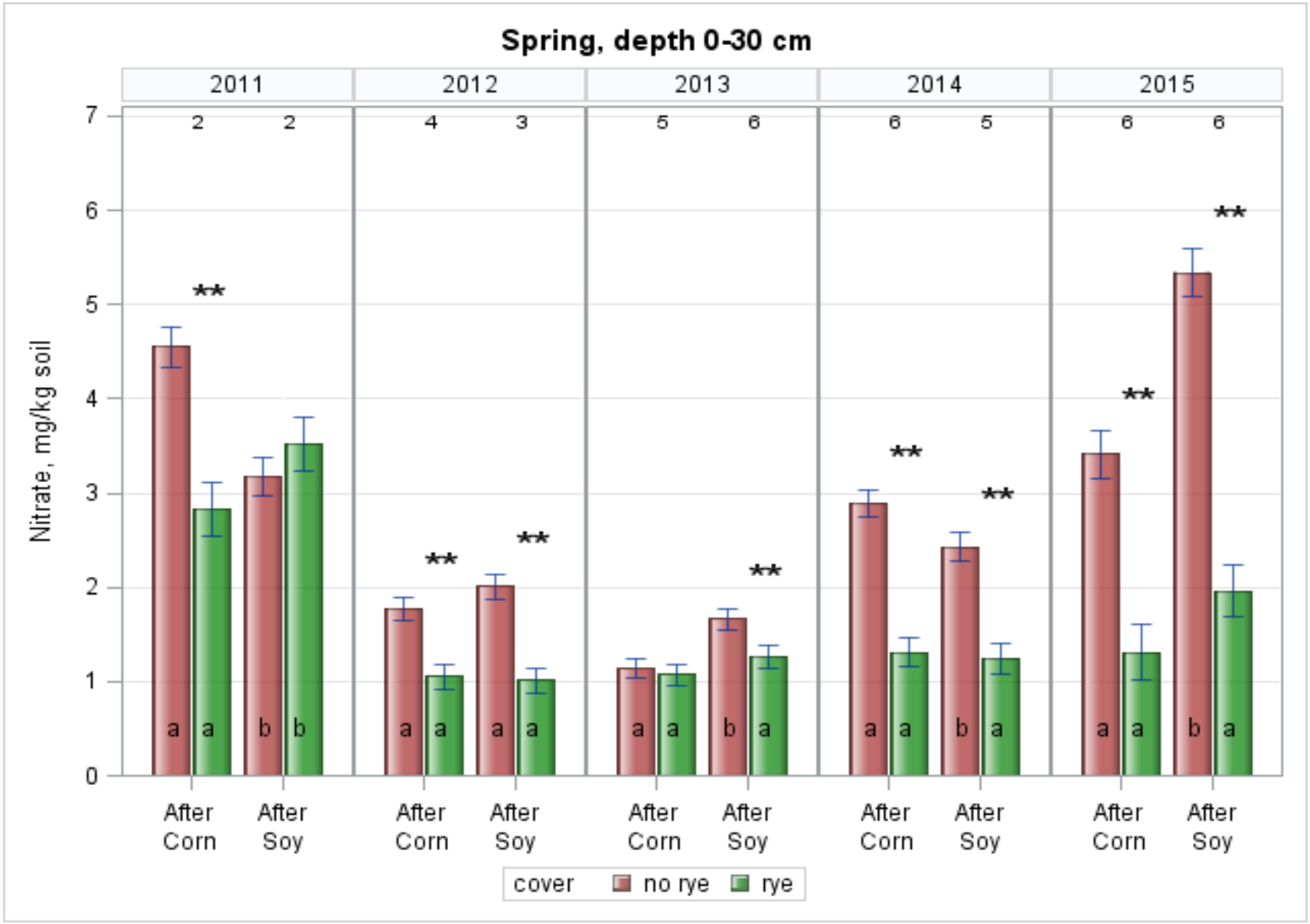
Spring 2016 Average Biomass (lb/A)




Spring 2016 Average Biomass N (lb/A)
Average Biomass N (lb/A)
70
60
50
40
30
20
10
0
W*
Alford
NT + (CR/RS)
Brocksmith
ST + (CR/CC/RD)
Huffmeyer
TM + (CR/CC/RD)
Huffmeyer
NT + (AR)
Rulon
NT + (CR)
Rulon
NT + (O/CC/RD/RS)
Villwock
NT + (O/CC/RD)
VUJC
T + (O/CC/RD)
VUJC
NT + Cover
Wenning
ST + Cover
Wenning
W* is the current cash crop

Findings so far

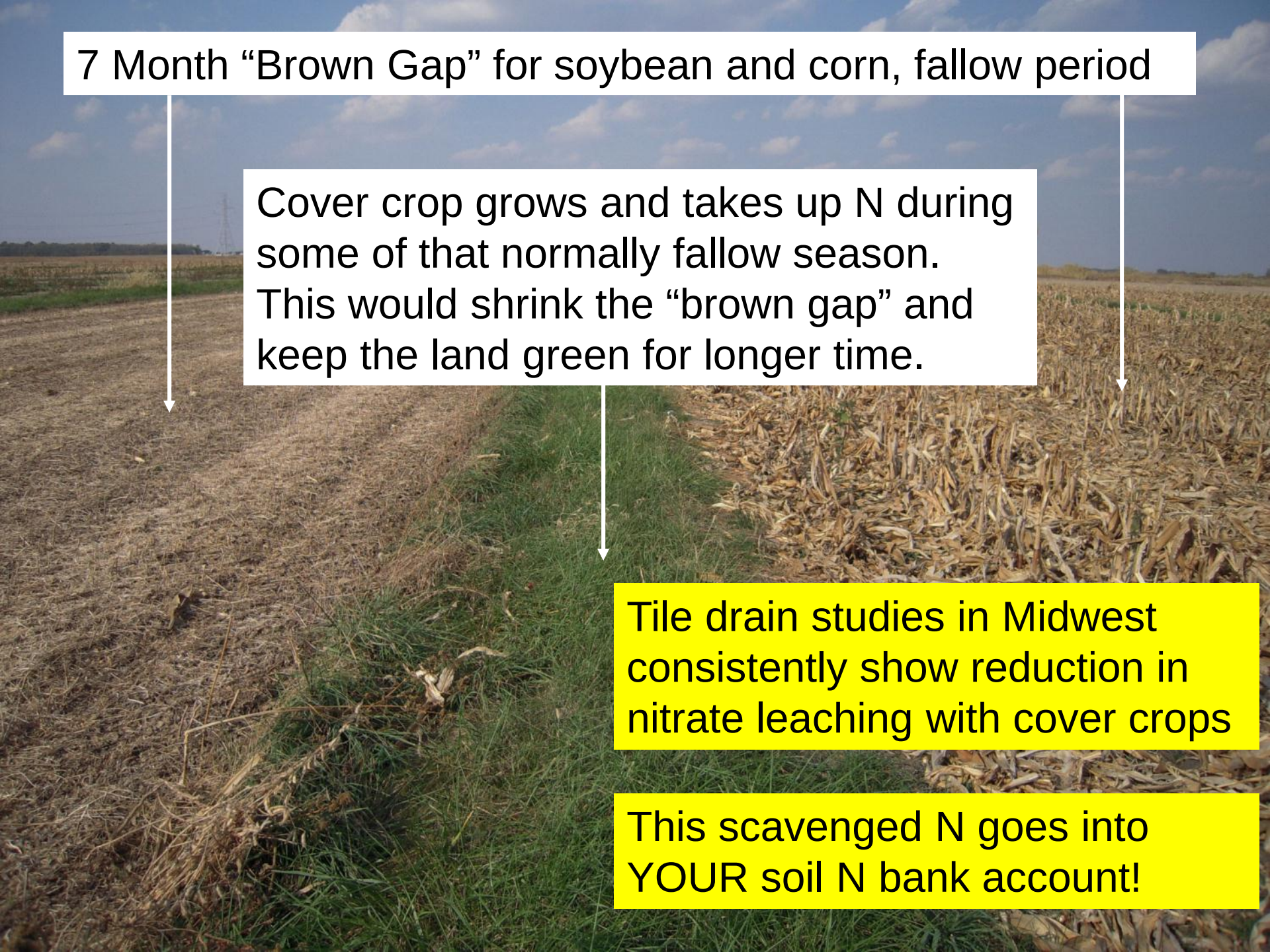
- Cover crop biomass varies greatly across sites and years, of course
- Soil nitrate in spring right before cover crop termination, is generally lower in cover crop plots than in controls (no cover crop). Cover crop has scavenged N from soil, protecting it against loss.



PURDUE UNIVERSITY

SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

USDA
United States Department of Agriculture
National Institute of Food and Agriculture


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!

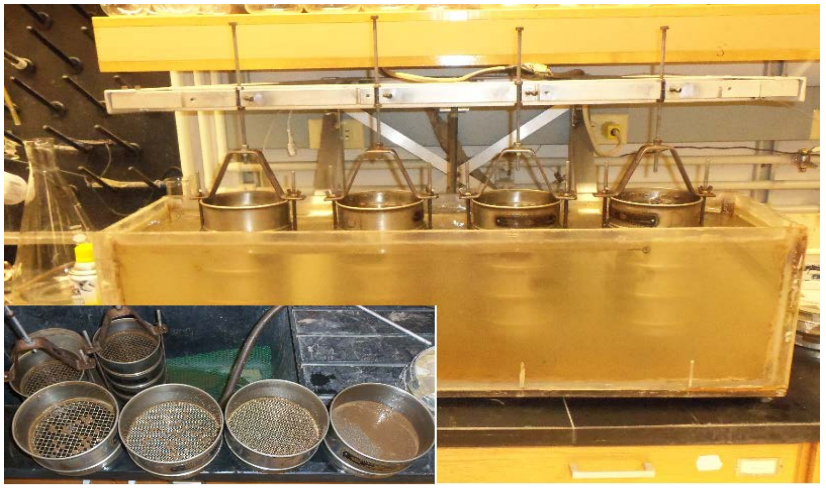
Findings so far

- 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.

PURDUE UNIVERSITY

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 (Θv) 0, -4.9, -9.8, and -33 kPa using intact cores
- -1500 kPa using a crushed <2mm sample



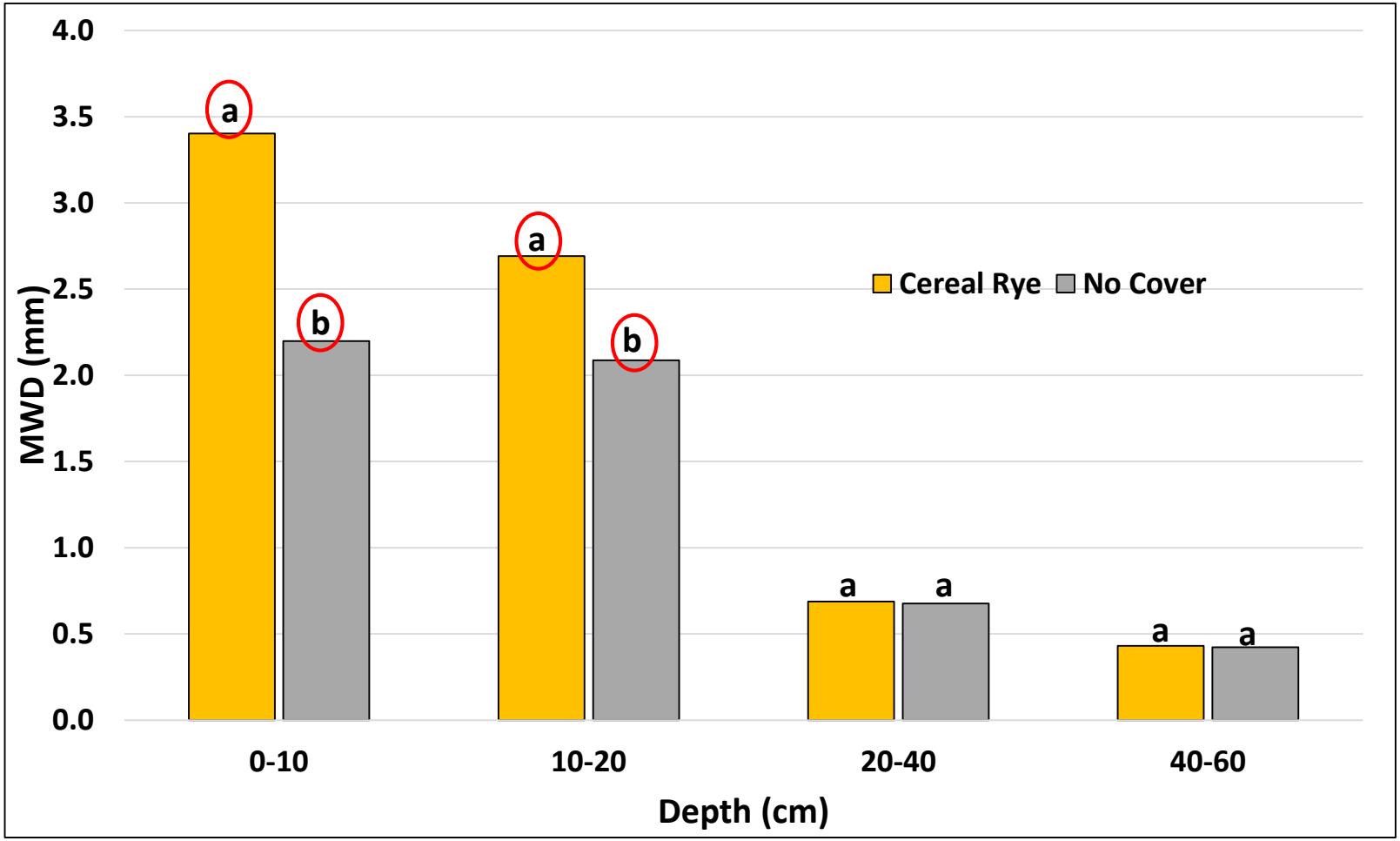
SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

PURDUE AGRICULTURE

Aggregate Stability

SEPAC 2015

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



Findings so far (cont.)

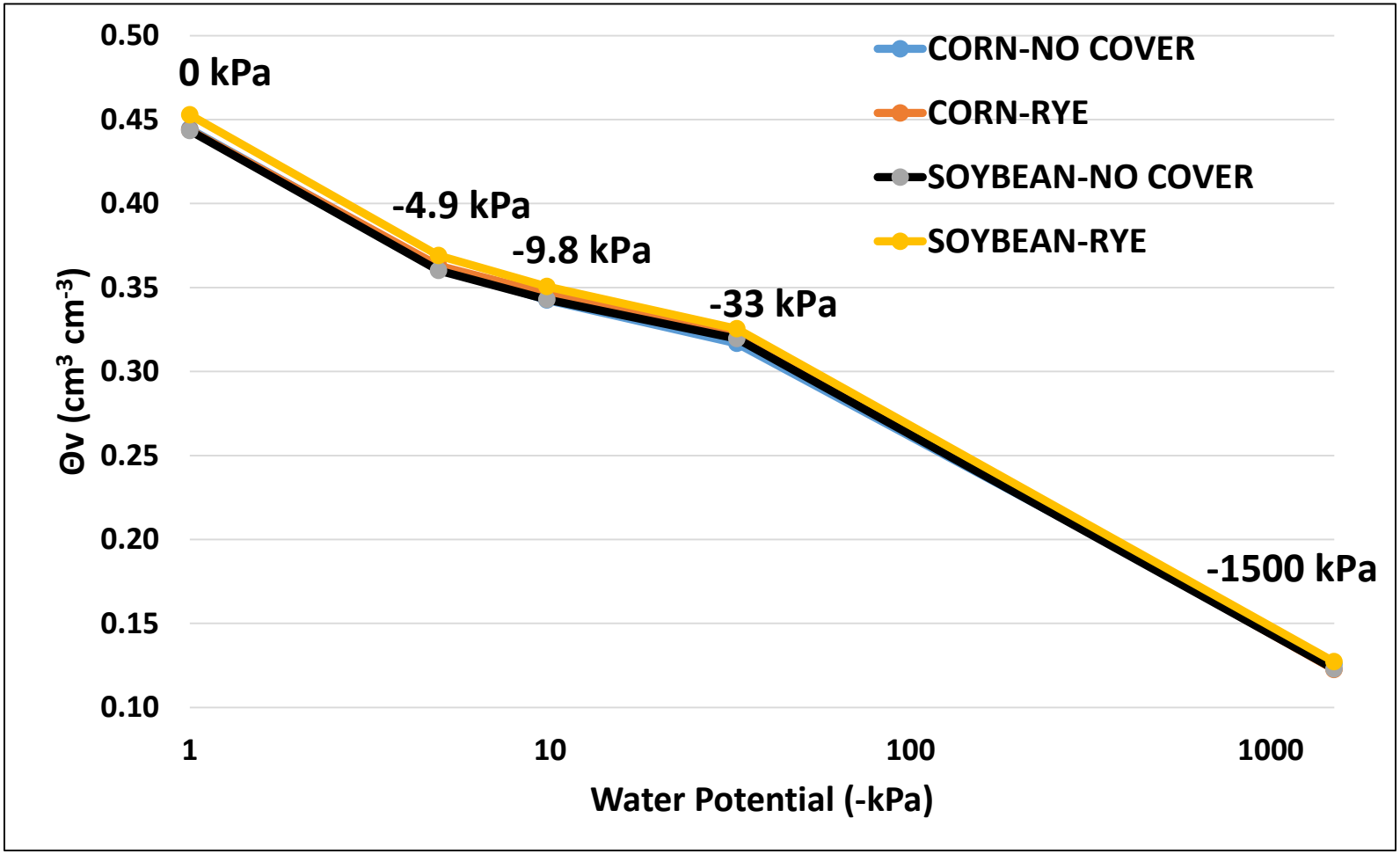
- No difference in bulk density and water retention curves (water holding capacity)
  (4 yr CSCAP; 2 yr CCSI project)

PURDUE UNIVERSITY

Water Retention

0-10cm, SEPAC 2015

Joe Rorick, M.S. Thesis

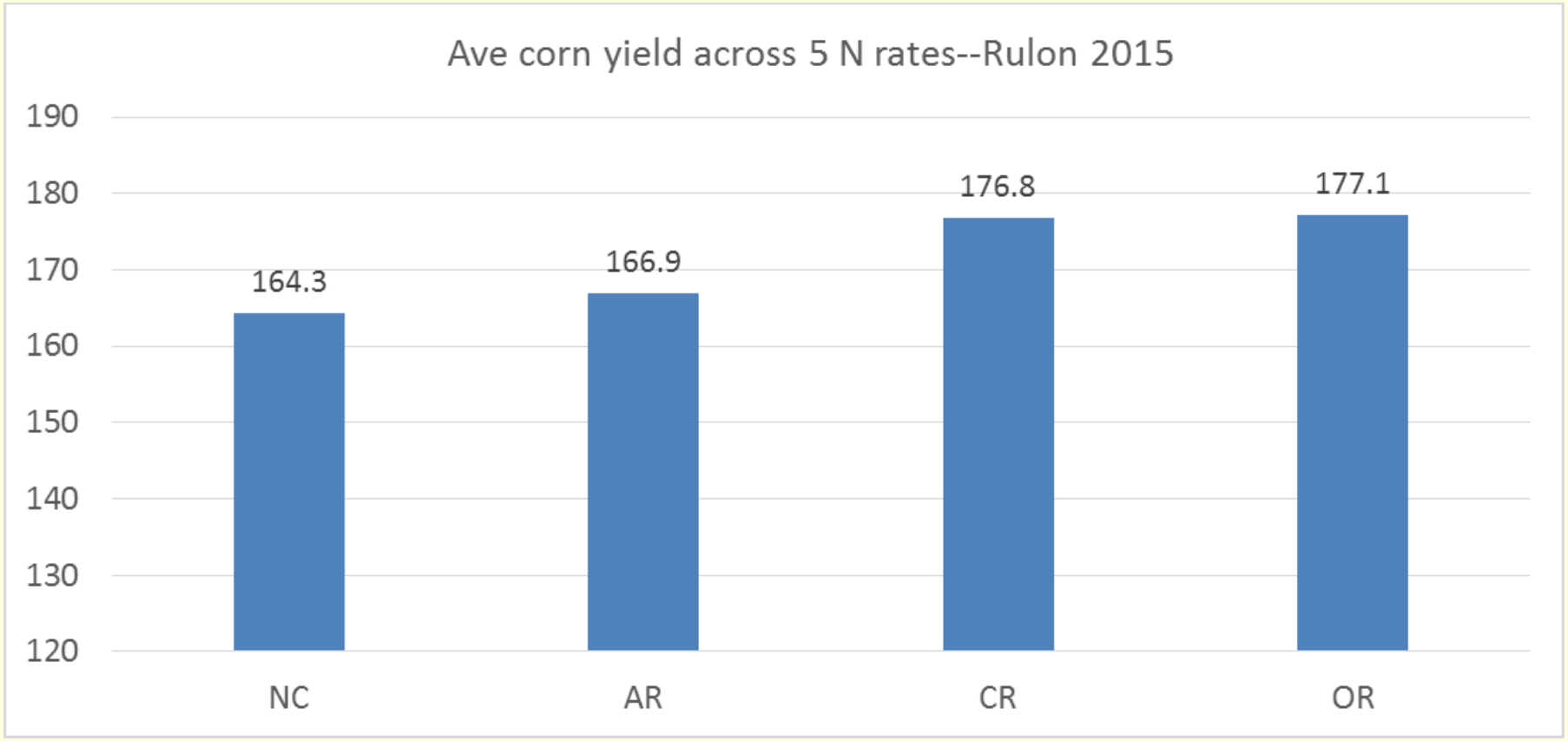


SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

PURDUE AGRICULTURE

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



PURDUE UNIVERSITY

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…….

PURDUE UNIVERSITY

WARD 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, Phospholipid Fatty Acid (PLFA) ng/g	1105.49
Functional Group Diversity Index	1.247

Total living microbial biomass

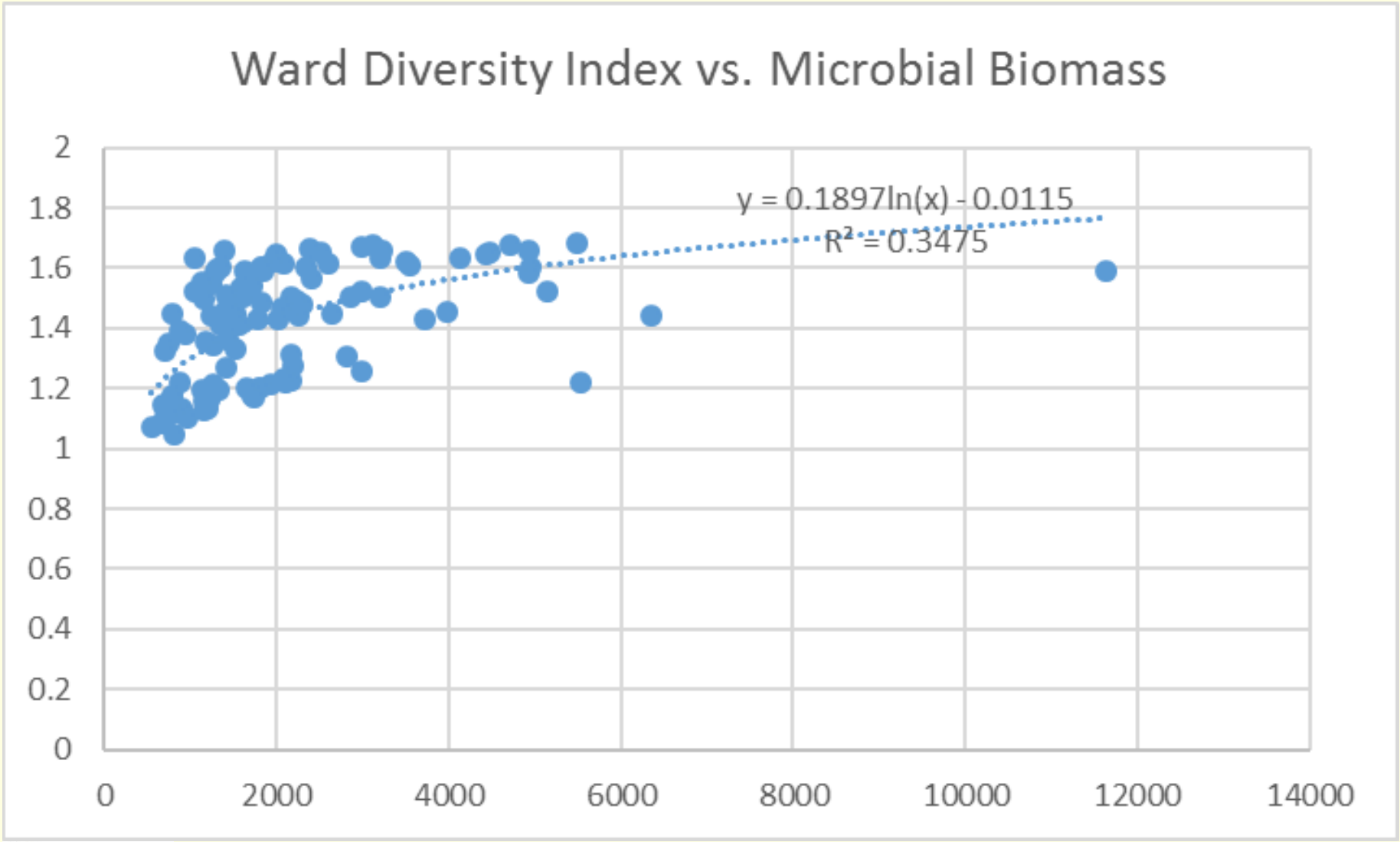
Diversity index

Functional Group Biomass & Diversity

Functional Group	Biomass, PLFA ng/g	% of Total Biomass
Total Bacteria	392.88	35.54
Gram (+)	312.41	28.26
Actinomycetes	88.87	8.04
Gram (-)	80.46	7.28
Rhizobia	0.00	0.00
Total Fungi	36.27	3.28
Arbuscular Mycorrhizal	19.03	1.72
Saprophytes	17.24	1.56
Protozoa	0.00	0.00
Undifferentiated	676.35	61.18

Different functional groups

Some correlation between diversity and microbial biomass



PURDUE UNIVERSITY

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 CO_2 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 Kladivko
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

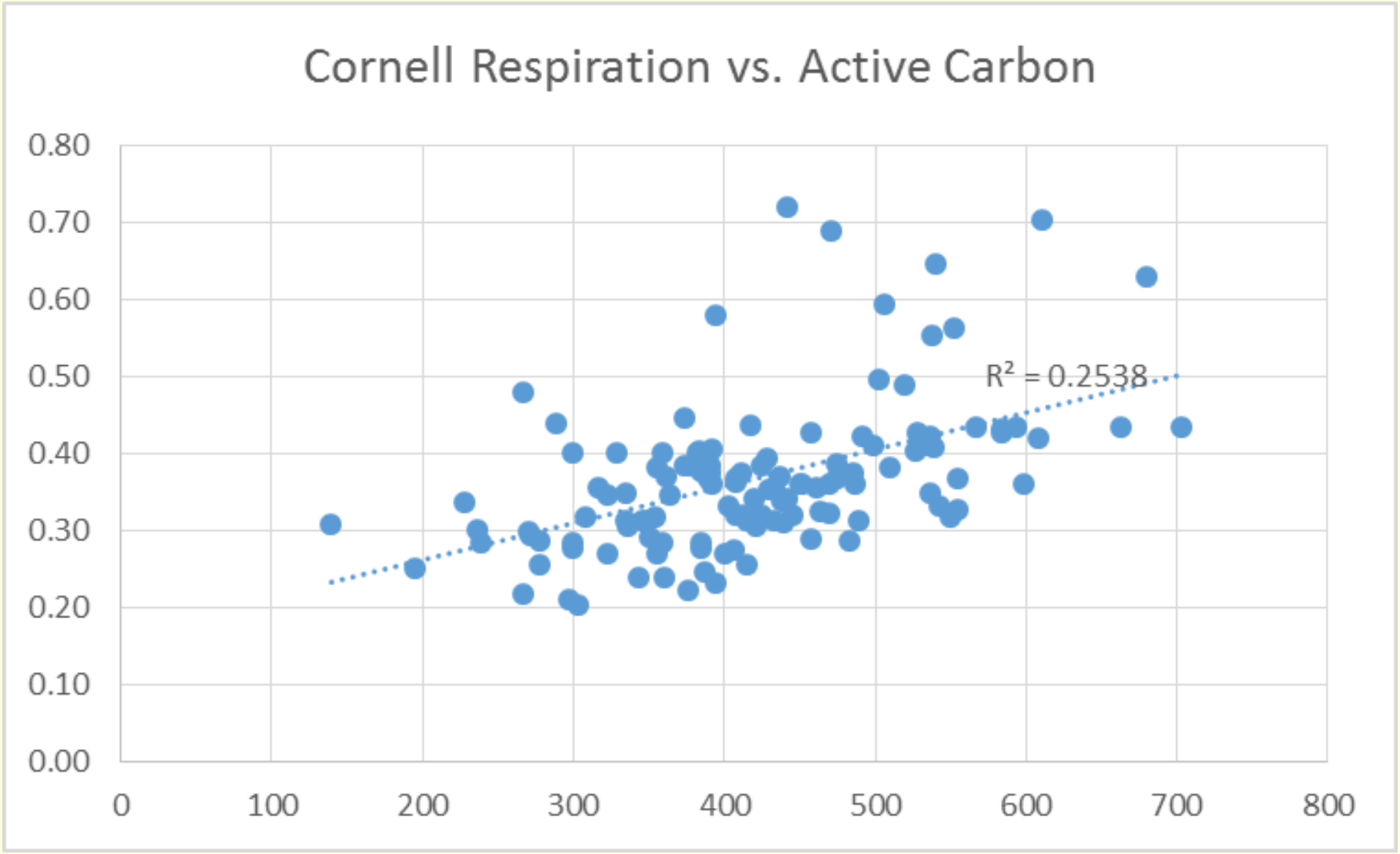
Measured Soil Textural Class: Silt Loam **Sand: 14%** **Silt: 70%** **Clay: 16%**

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

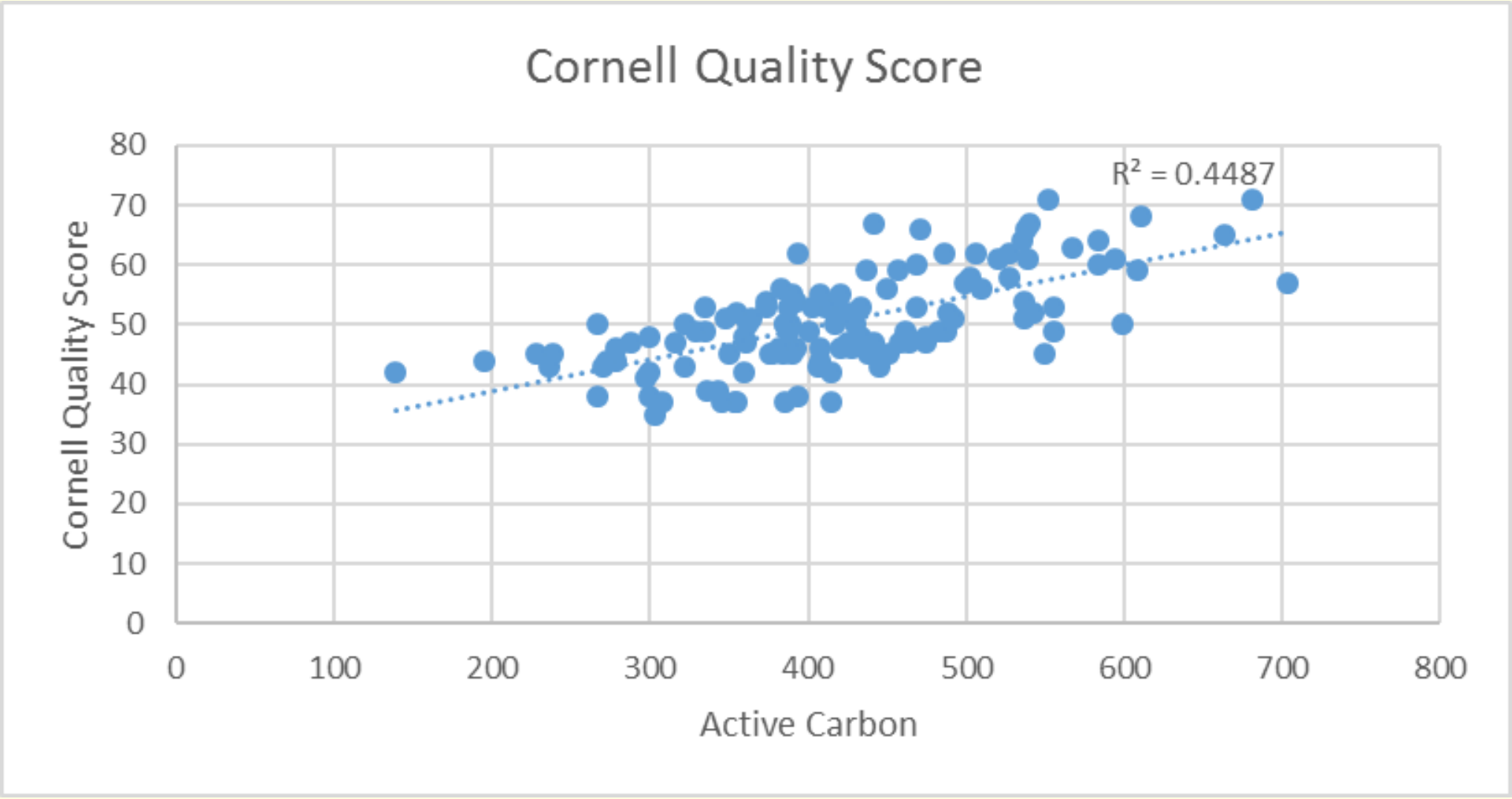
PURDUE UNIVERSITY

Respiration weakly correlated with active carbon



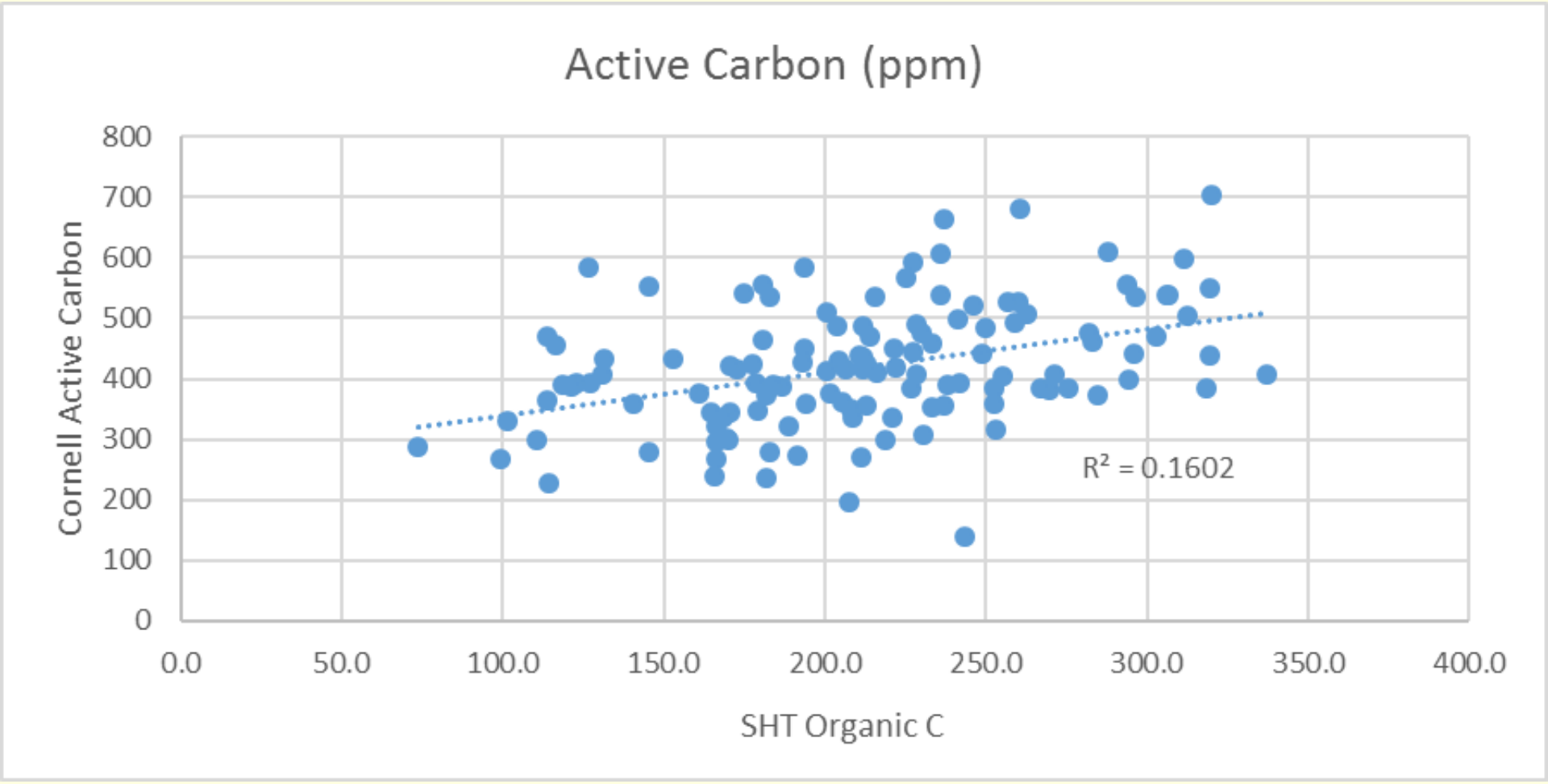
PURDUE UNIVERSITY

Overall quality score correlated with active carbon



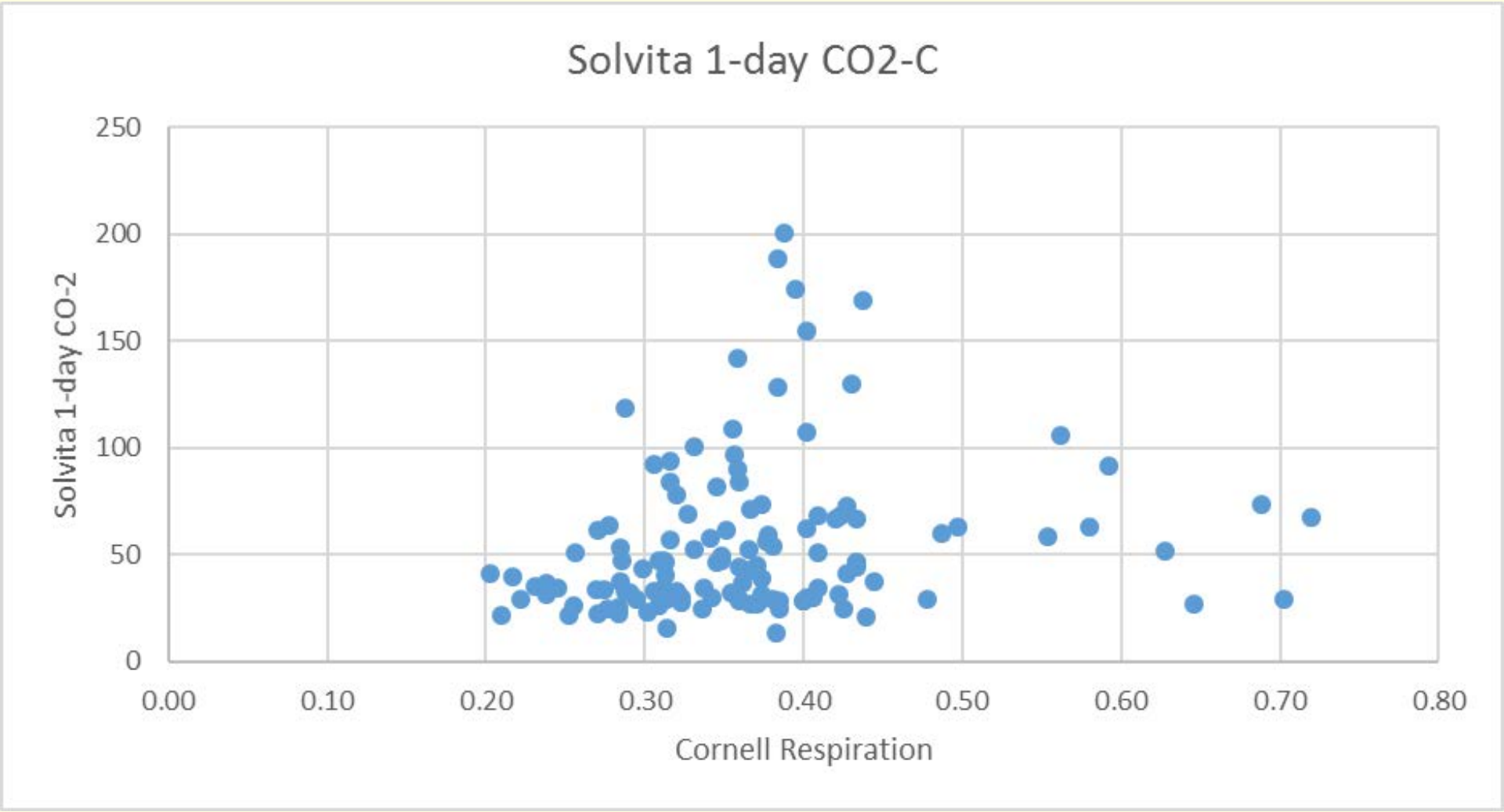
PURDUE UNIVERSITY

Cornell active carbon not correlated with SHT organic carbon



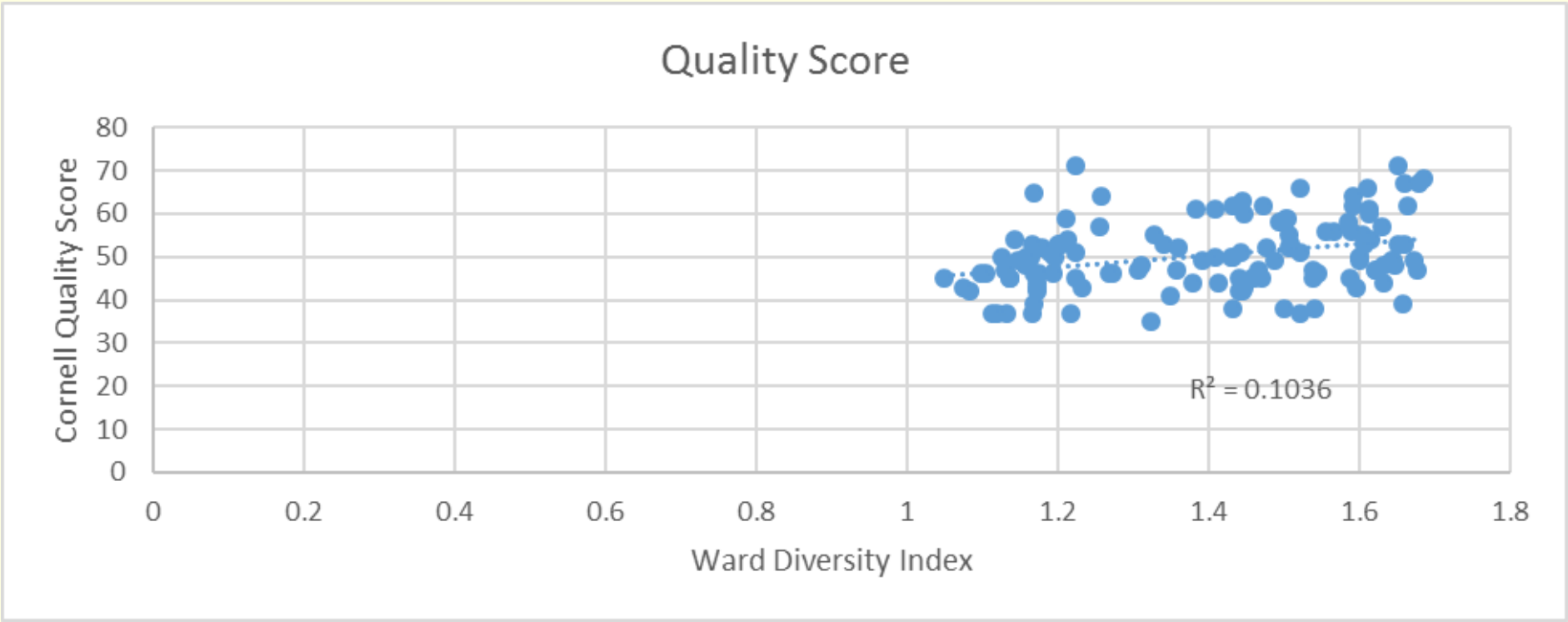
PURDUE UNIVERSITY

Two methods for respiration measurements not correlated



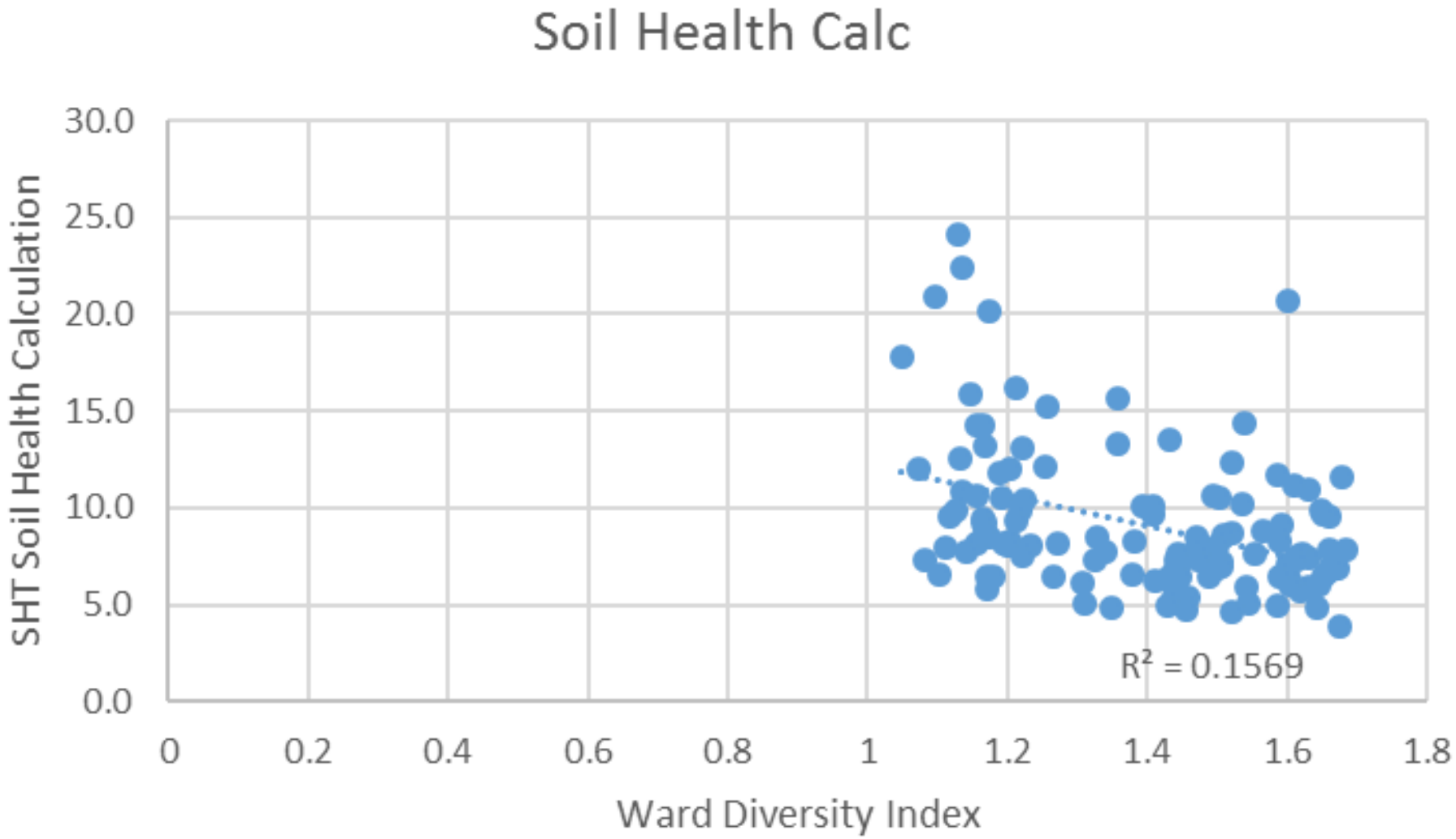
PURDUE UNIVERSITY

Cornell overall quality score not correlated to Ward diversity index

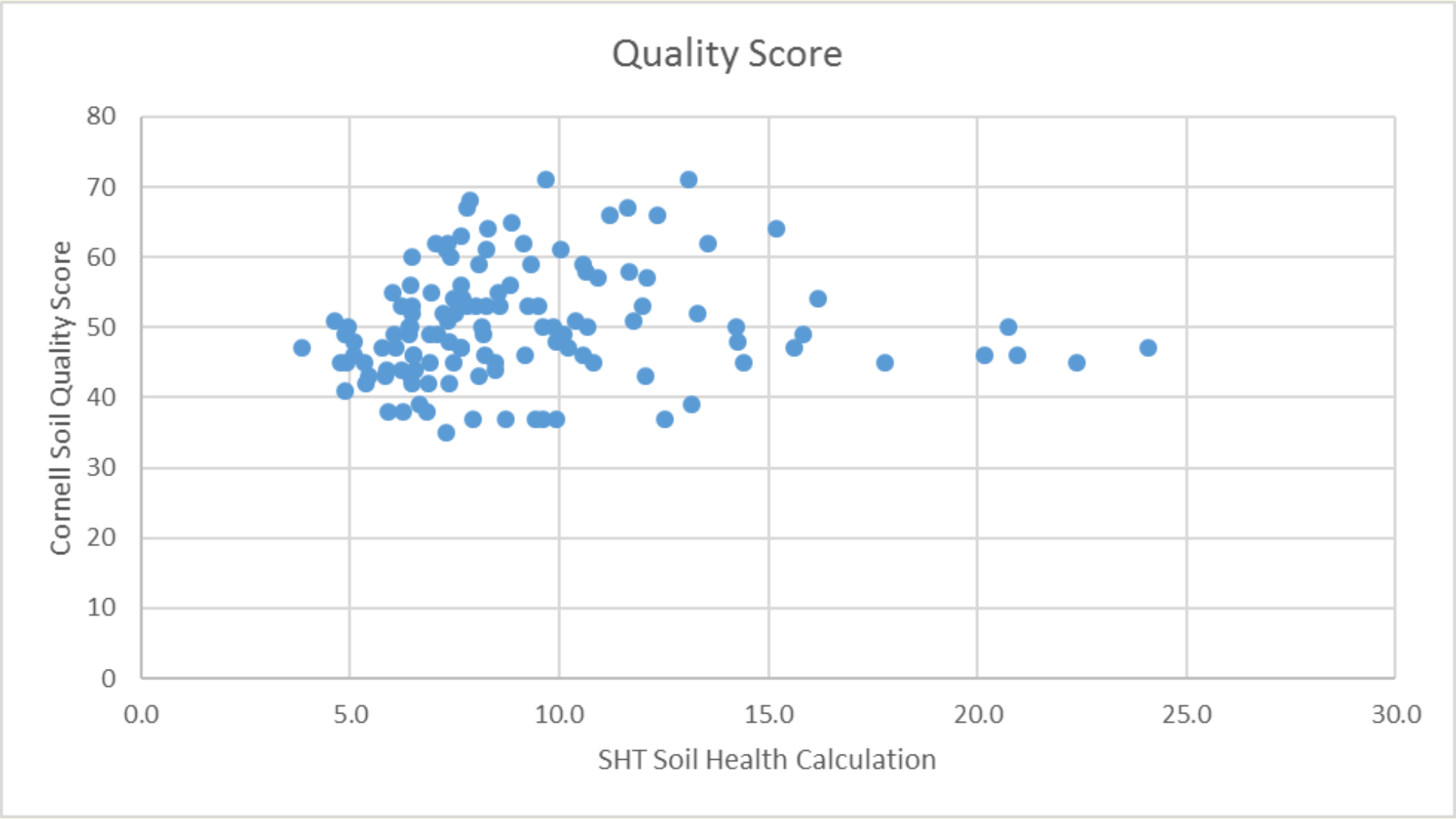


PURDUE UNIVERSITY

SHT soil health score not correlated to Ward diversity index



Cornell soil quality score not correlated with SHT soil health score

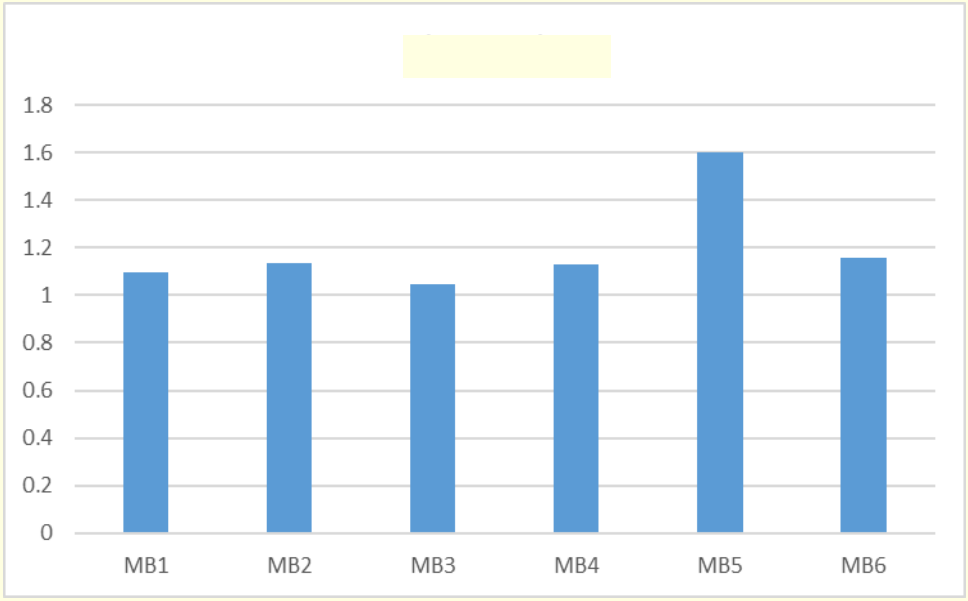


PURDUE UNIVERSITY

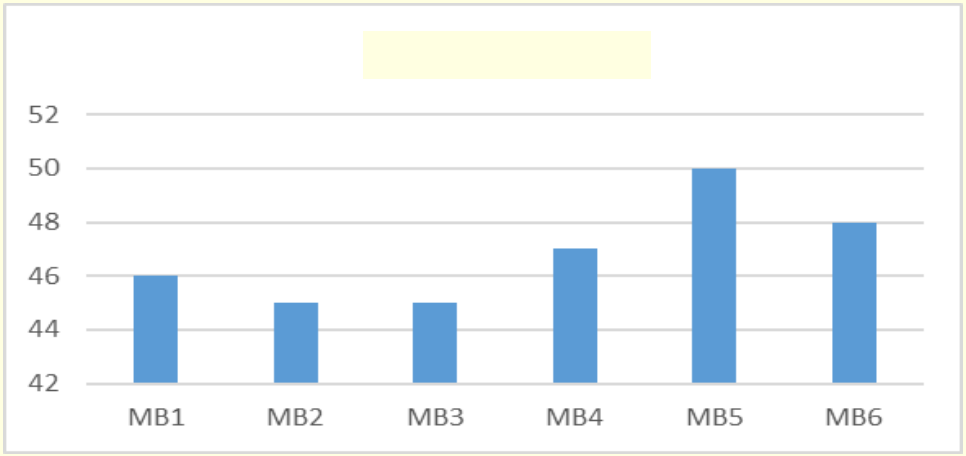
- So the three overall soil health scores (Ward diversity index, SHT soil health score, Cornell soil quality index) are not correlated with each other. Not surprising, because each test is measuring different things.
- Underscores that people need to know what they're most interested in assessing, before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

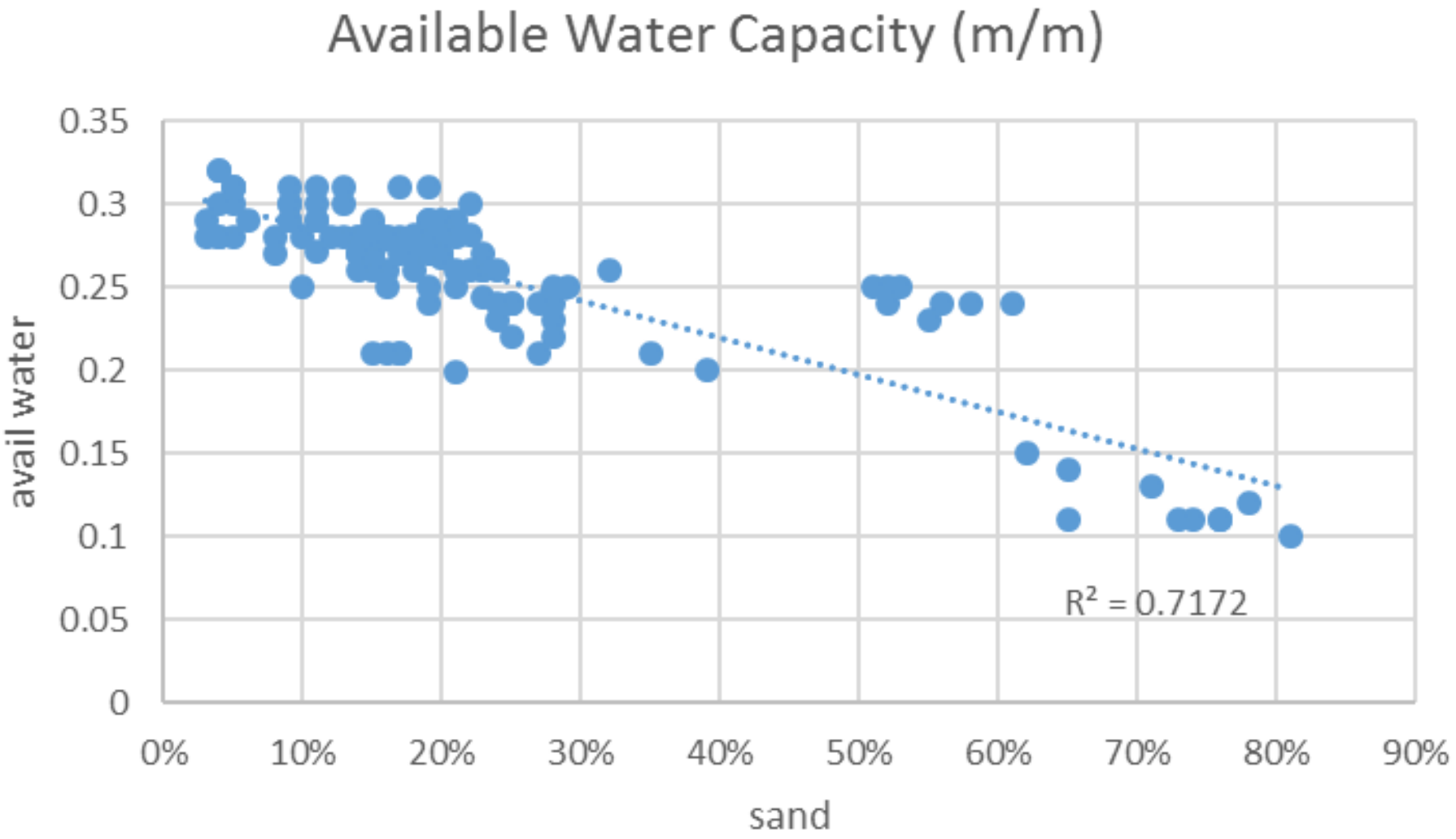


Cornell quality score, site MB



PURDUE UNIVERSITY

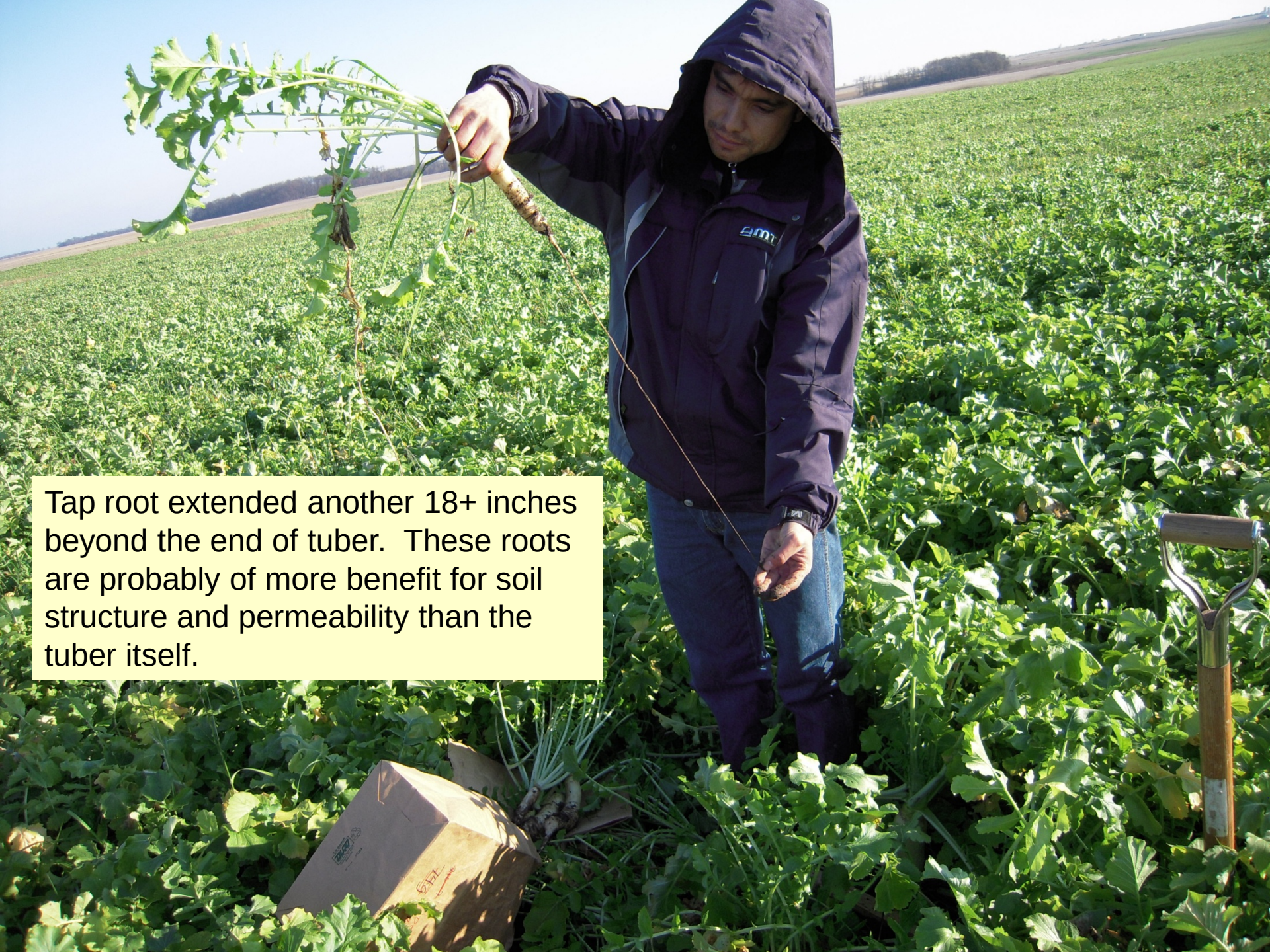
Available water capacity negatively correlated to sand



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?

PURDUE UNIVERSITY


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.


PURDUE
UNIVERSITY

Photo: Lee Schweitzer

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.

PURDUE UNIVERSITY

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

Economics of Conservation Series

Long-Term Payoffs: Diversit

Dan DeSutter - Attica, Indiana

Economics of Conservation Series

Conservation Cropping Systems Initiative

Cover Crops: Multiple Species Deliver Multiple Benefits

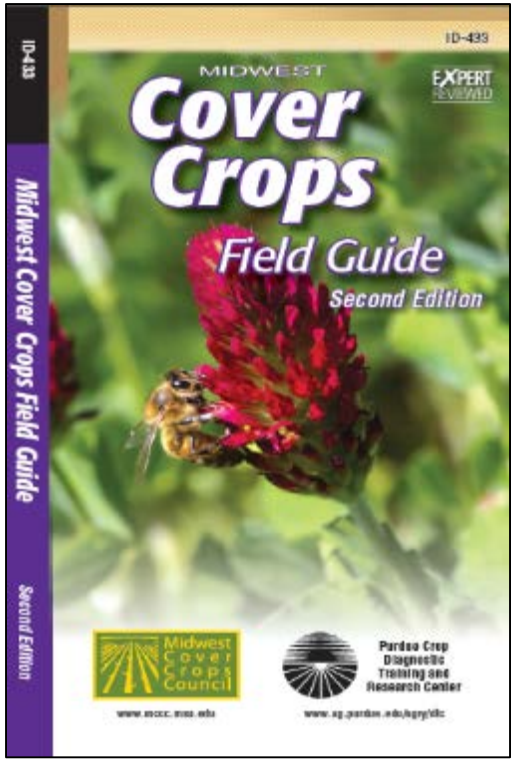
Jamie Scott - Pierceton, Indiana

Dollar Value

Better Soil

The Financial Challenge

Resources



2nd Edition now available!

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

www.mccc.msu.edu

Cover Crop Selector Tools
(link on left sidebar)

PURDUE UNIVERSITY