USDA-NIFA Climate & Corn-based Cropping Systems Coordinated Agricultural Project (CAP)

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2015 September 11 Global Research Alliance on Agricultural Greenhouse Gases

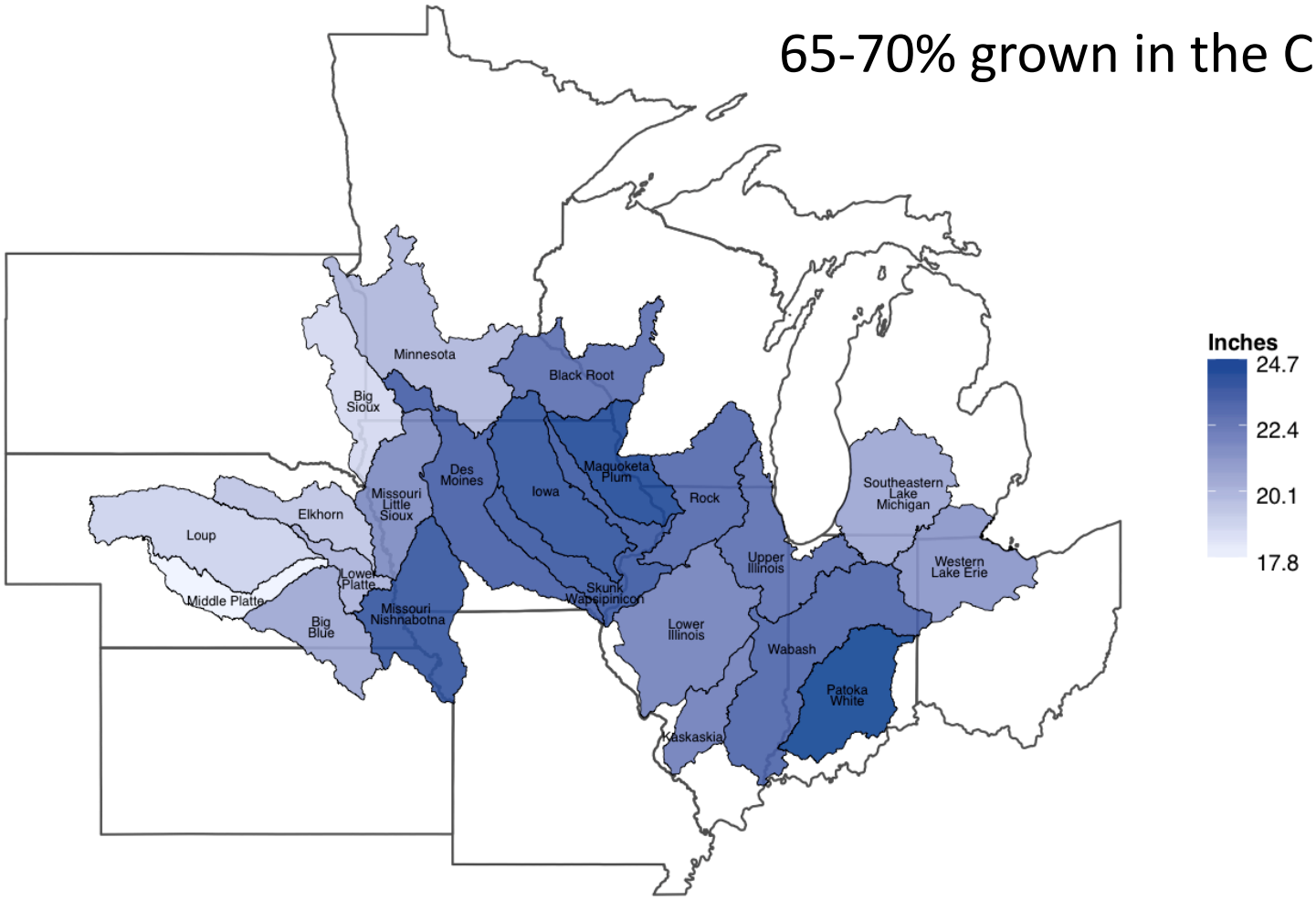
This research is part of a regional collaborative project supported by the USDA-NIFA, Award No. 2011-68002-30190:
Cropping Systems Coordinated Agricultural Project: Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems
Project Web site: sustainablecorn.org

Climate & weather disruptions to corn-based systems of production

~400,000 US farms grow corn; ¼ of all harvested crop acres

~$80 billion commodity US world leader in production

65-70% grown in the Corn belt



Corn belt median seasonal precipitation (April 1-Sept 30 1971-2011)

Agriculture & Weather Variability in the Corn belt: A Survey of Corn belt Farmers Statistical Atlas 2013
Arbuckle, Loy, Hobbs, Wright Morton, Tyndall

United States Department of Agriculture
National Institute of Food and Agriculture

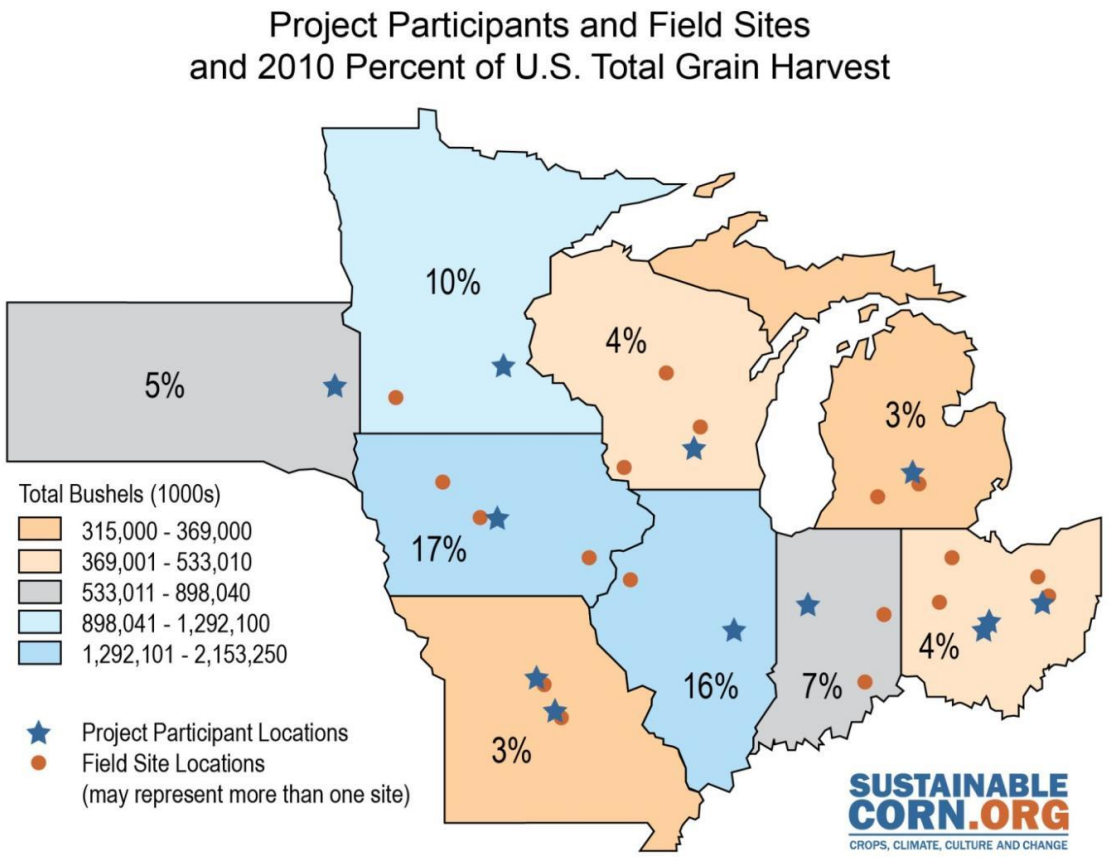
USDA-NIFA Climate Change, Mitigation & Adaptation in Corn-based Cropping Systems

Coordinated Agricultural Project (CAP)

36 research sites, field experiments
14 sites, GHG measurements

9 Upper Midwest states
10 Land Grant Universities
USDA-ARS
~140 faculty, graduate students, post docs, & technical staff

~200 farmers
Advisory board of industry, NGO, agencies, farmers & educators



The 11 institutions comprising the project team include the following Land Grant Universities and USDA Agricultural Research Service (ARS): Iowa State University, Lincoln University, Michigan State University, The Ohio State University, Purdue University, South Dakota State University, University of Illinois, University of Minnesota, University of Missouri, University of Wisconsin, and USDA-ARS Columbus, Ohio.

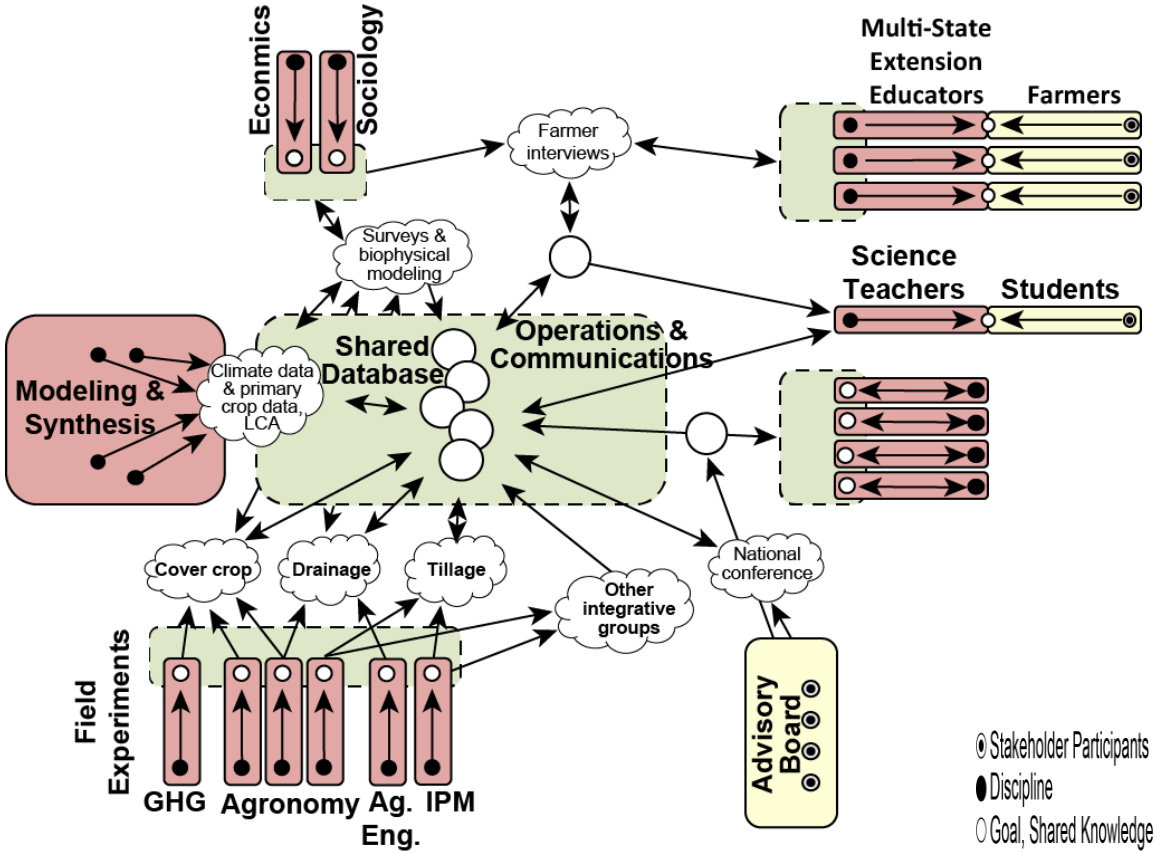
Multi-pronged agenda for sustainable agricultural systems

1. Institutional infrastructure; central data base
2. Field & landscape level trials
   (innovation & standardized protocols)
3. Sociology and economics (primary & secondary data)
4. Synthesis and integration of data; modeling climate & coupled human-natural systems
5. Feedback loops among scientists, farmers, industry, policy-makers, non-governmental organizations, and secondary science teachers

Transdisciplinary approach

Science creating new knowledge

Question formulation
Theory development
Data gathering
Data analyses
Interpretation findings
Applications

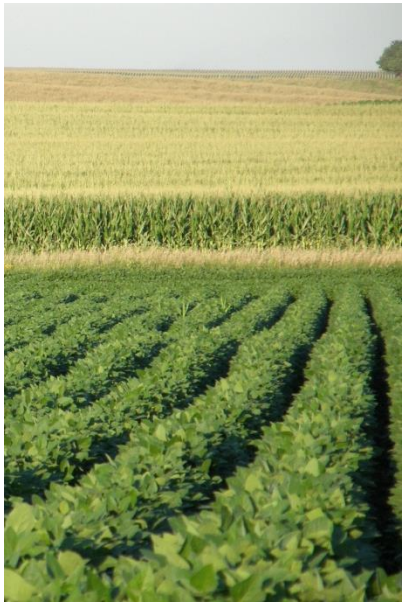


SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE


Apply our transdisciplinary approach
to better understand N, C, water, stakeholders; and
the relationships between and among their interlinked systems
associated with corn-based cropping systems under long term
changing weather conditions and localized climates
Interlinked systems

Some of the underlying BIG questions

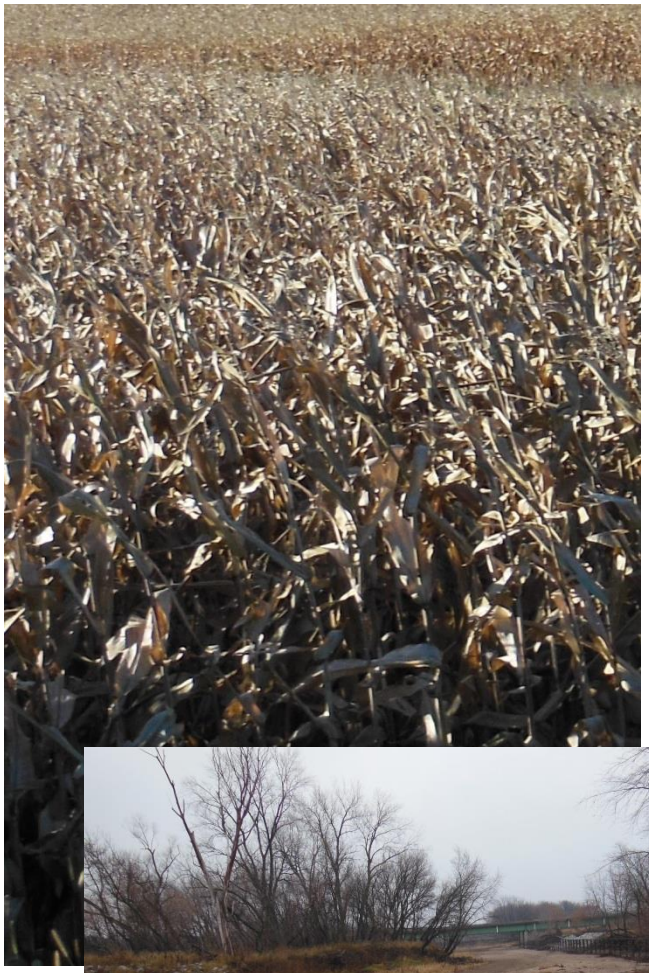
1. Why are some corn-based systems more productive and have lighter environmental footprints than others?
2. How much change can corn-based systems absorb and still retain integrity and core purposes—productivity and ecosystem services?
3. What are the characteristics of corn-based systems that offer increased capacity to adapt to changing and variable climates?
4. What characteristics reduce and limit capacity to adapt and mitigate climatic conditions?

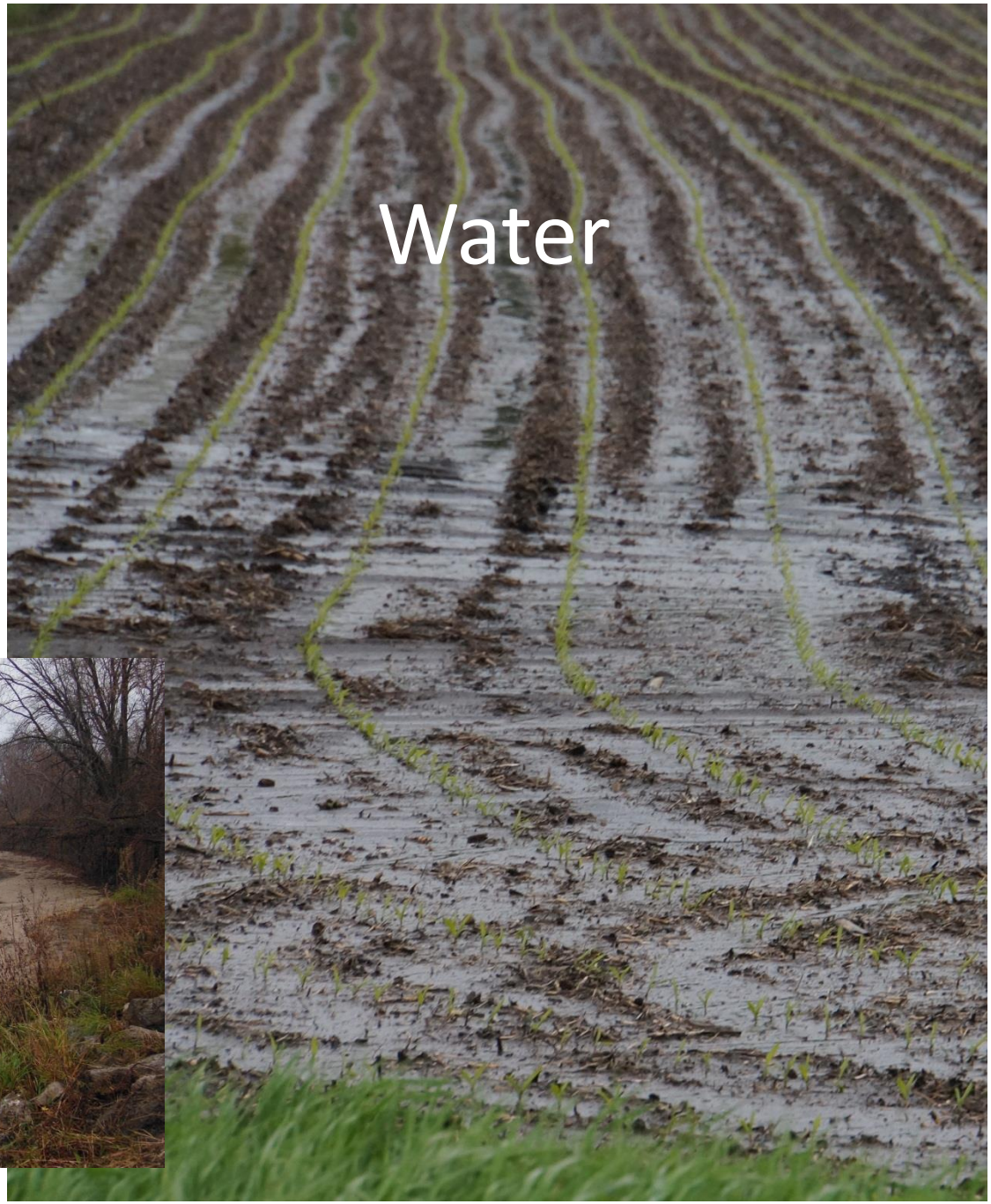


Resilience,
capacity to bounce back after a disruption

2013 May severe rain event


Platforms…
master variables in resilient
corn-based cropping systems



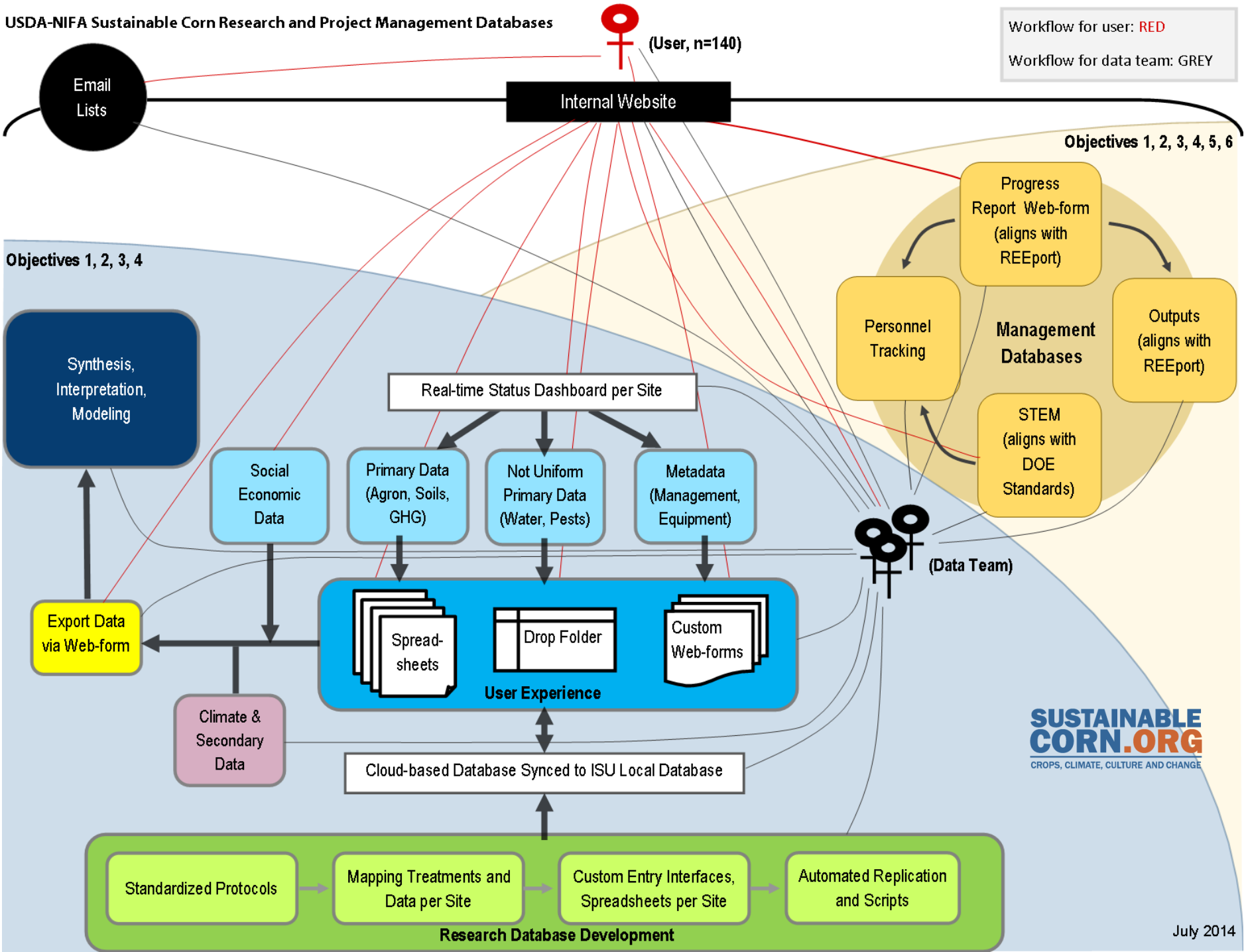

Water


Soil organic carbon

Nitrogen

Stakeholders

Systems


USDA-NIFA Sustainable Corn Research and Project Management Databases
(User, n=140)
Workflow for user: RED
Workflow for data team: GREY
Email Lists
Internal Website
Objectives 1, 2, 3, 4, 5, 6
Progress Report Web-form (aligns with REEport)
Personnel Tracking
Management Databases
Outputs (aligns with REEport)
STEM (aligns with DOE Standards)
Objectives 1, 2, 3, 4
Synthesis, Interpretation, Modeling
Real-time Status Dashboard per Site
Social Economic Data
Primary Data (Agron, Soils, GHG)
Not Uniform Primary Data (Water, Pests)
Metadata (Management, Equipment)
(Data Team)
Export Data via Web-form
Spread-sheets
Drop Folder
Custom Web-forms
User Experience
Climate & Secondary Data
Cloud-based Database Synced to ISU Local Database
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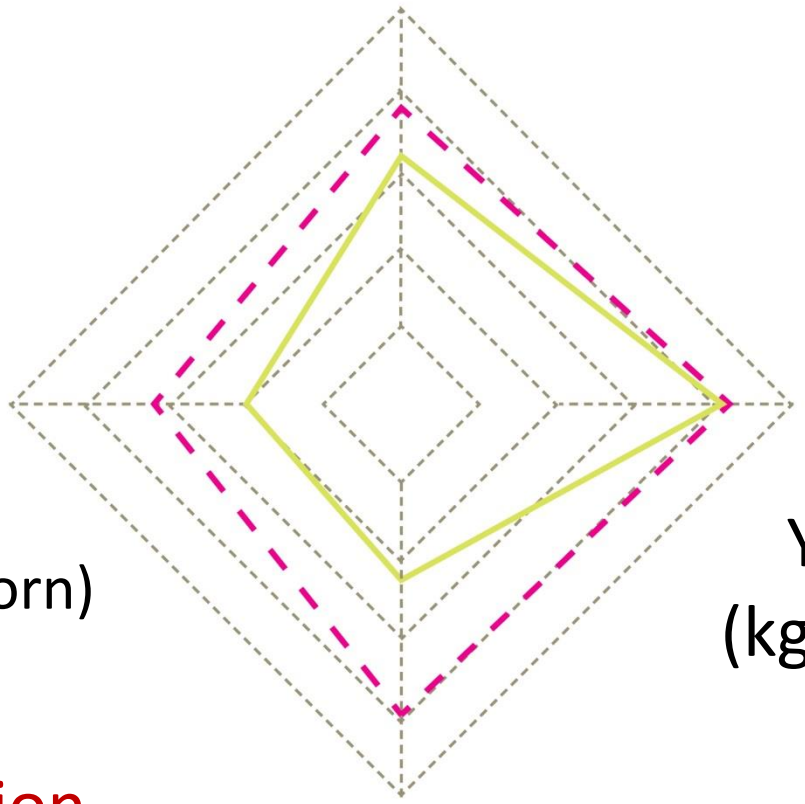
Standardized Protocols
Mapping Treatments and Data per Site
Custom Entry Interfaces, Spreadsheets per Site
Automated Replication and Scripts
Research Database Development
July 2014

Evaluation of potential adaptive actions

and mal-adaptive actions

Mitigation GHG

Benefits of variable rate N systems

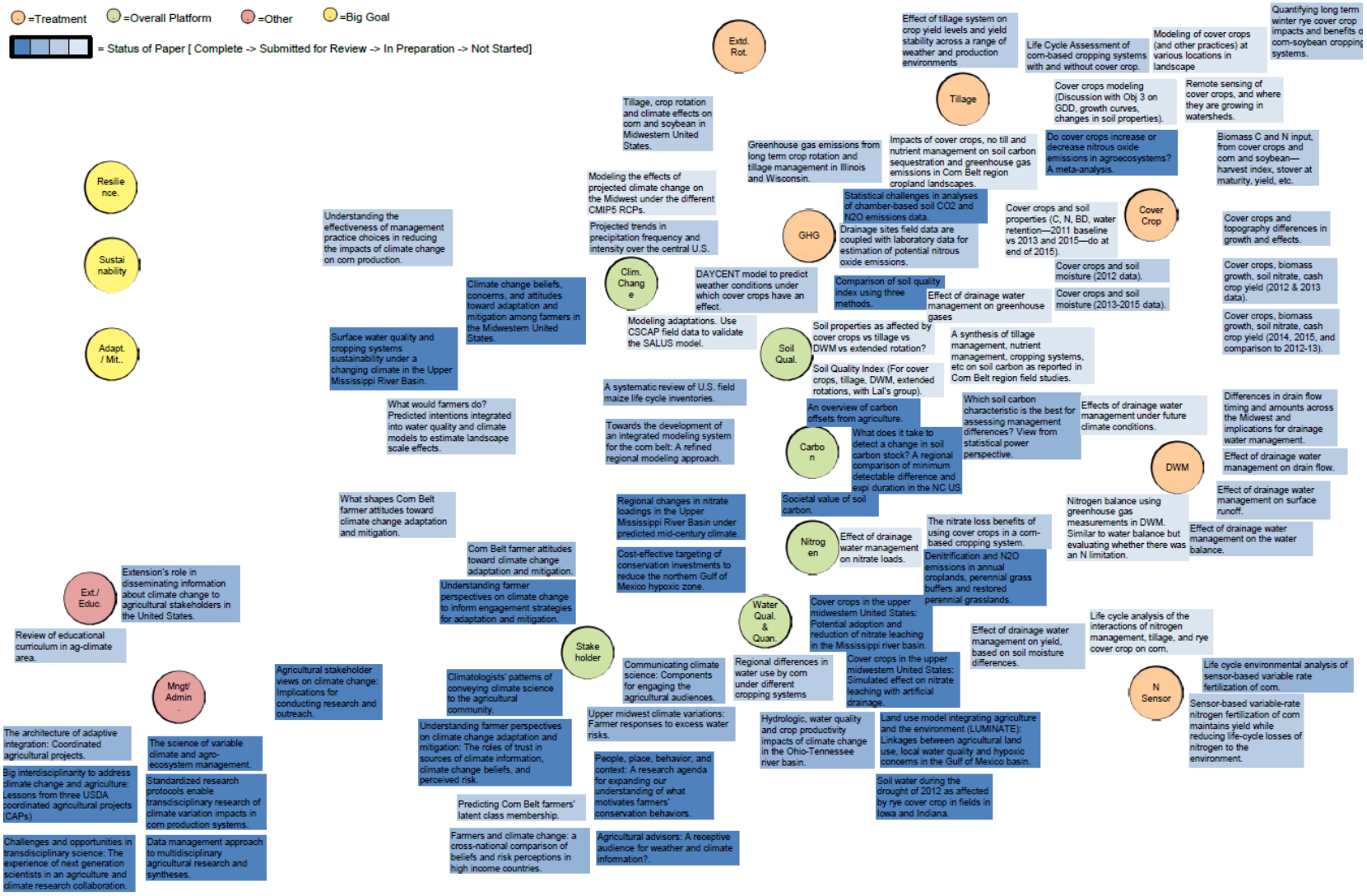


Red-fixed rate application

Green-variable rate

Synthesis & integration of science

203 papers; 82 are integrative in nature



Science to Recommendations

Information transfer and exchange dialogues with scientists, farmers, crop advisors, science teachers

Website www.sustainablecorn.org

Scientific audiences peer reviewed publications 208 +

J Soil and Water Conservation Special Climate issue 2014 Vol 69 (6)

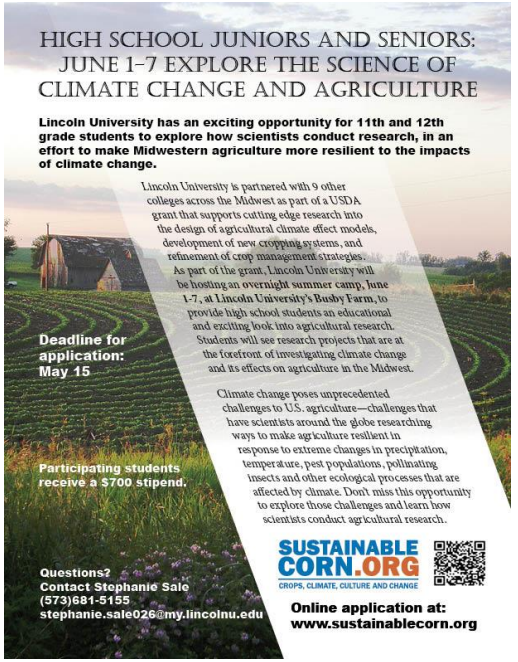
Non-scientific audiences Extension

18 Extension educators in 9 states
~160 Farmers
2014 National Conference on Resilient Agriculture for farmers & advisors
Youtube videos www.youtube.com/sustainablecorn
Fact sheets
Mass media
Twitter
Facebook
Field days
Demonstration plots

Education

- Training the next generation of scientists
- Promoting learning opportunities for high school teachers and students.

Summer camps 2012, 2013, 2014, 2015
Graduate student webinars
2015 graduate student DC trip to present project research



Greenhouse Gases in Corn-based Cropping Systems: Field Measurements and Modeling

Mike Castellano,
Associate Professor,
Department of Agronomy

Fernando Miguez,
Assistant Professor,
Department of Agronomy

GHG in corn based systems: Measurements and modeling
- Cover crops effects on yield, soil water and N_2O emissions

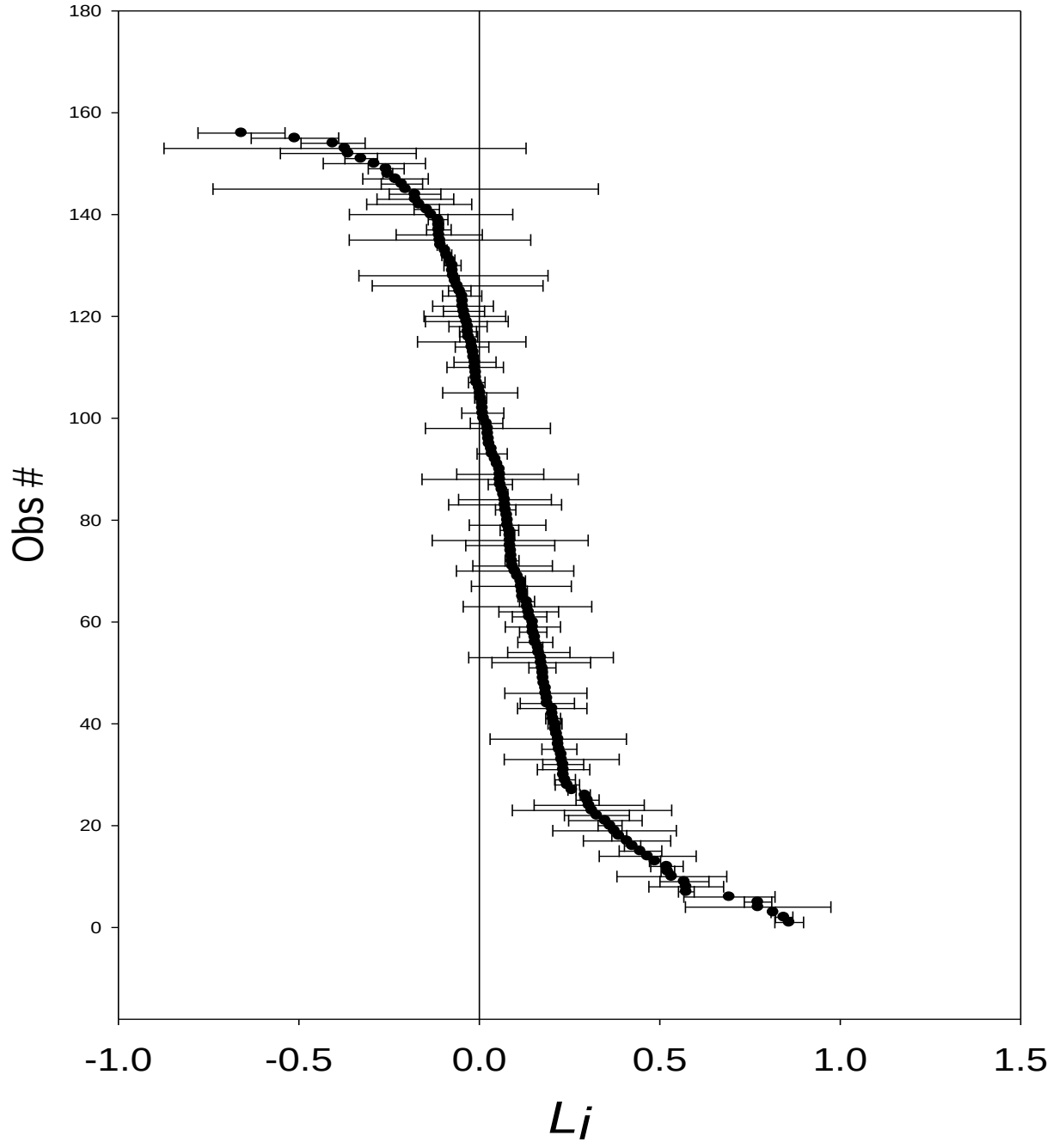
Fernando Miguez, Assistant Professor,
Department of Agronomy

Cover Crop effects on Corn-based systems

Indicator	Hypothesized Cover Crop Change: Improvement (+), Decline (-) or Neutral (+/-)	Indicator of Adaptation or Mitigation
Nitrous oxide emissions (N_2O)	+/-	Mitigation
Soil water	+	Adaptation
Soil erosion	+	Adaptation
Soil carbon	+	Adaptation and Mitigation
Cash crop yields	+/- moving to +	Adaptation

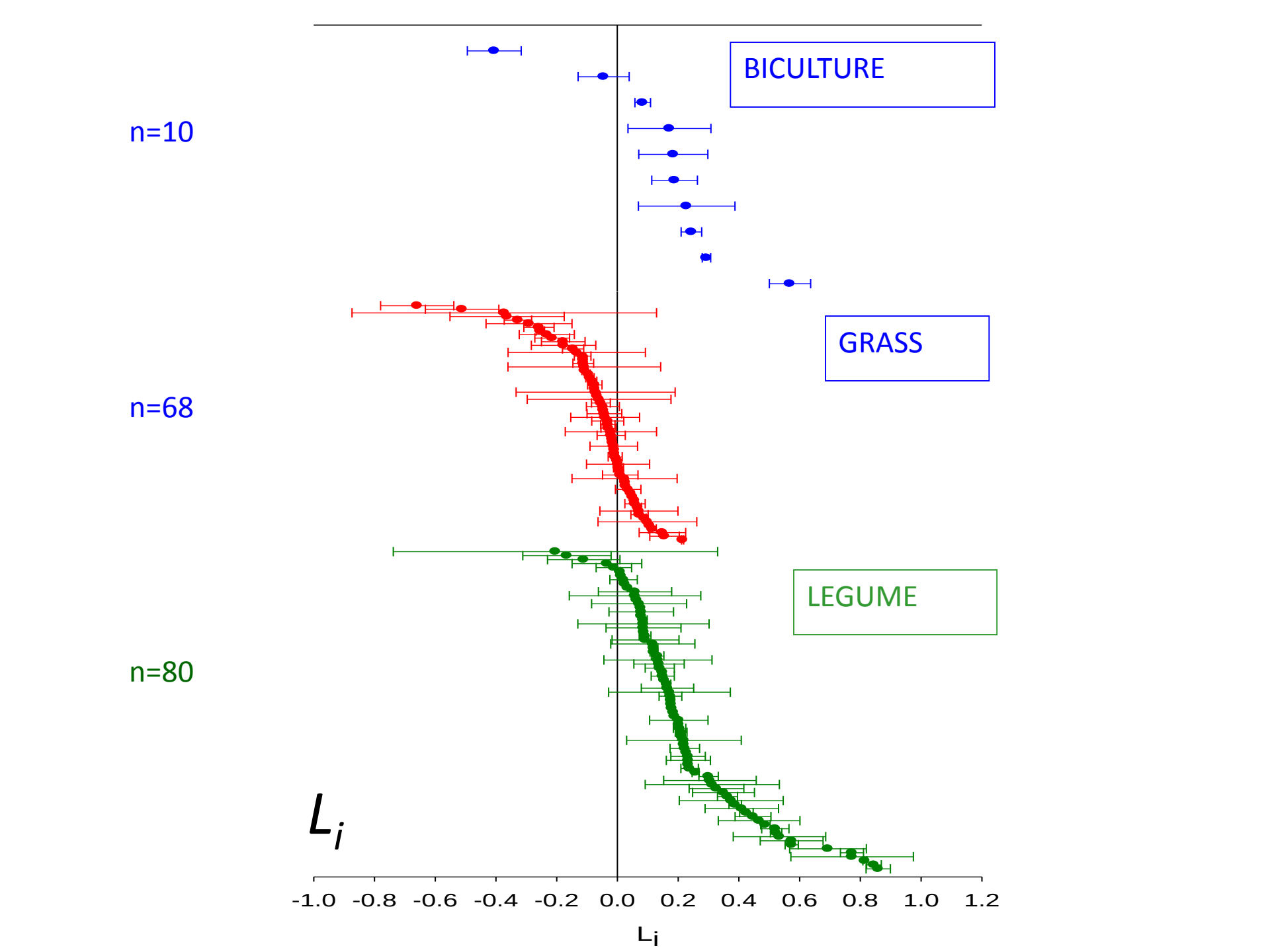
Indicator	Hypothesized Cover Crop Change: Improvement (+), Decline (-) or Neutral (+/-)	Indicator of Adaptation or Mitigation
Cash crop yields	**+/- moving to +**	**Adaptation**

Spring 2003 after killing rye

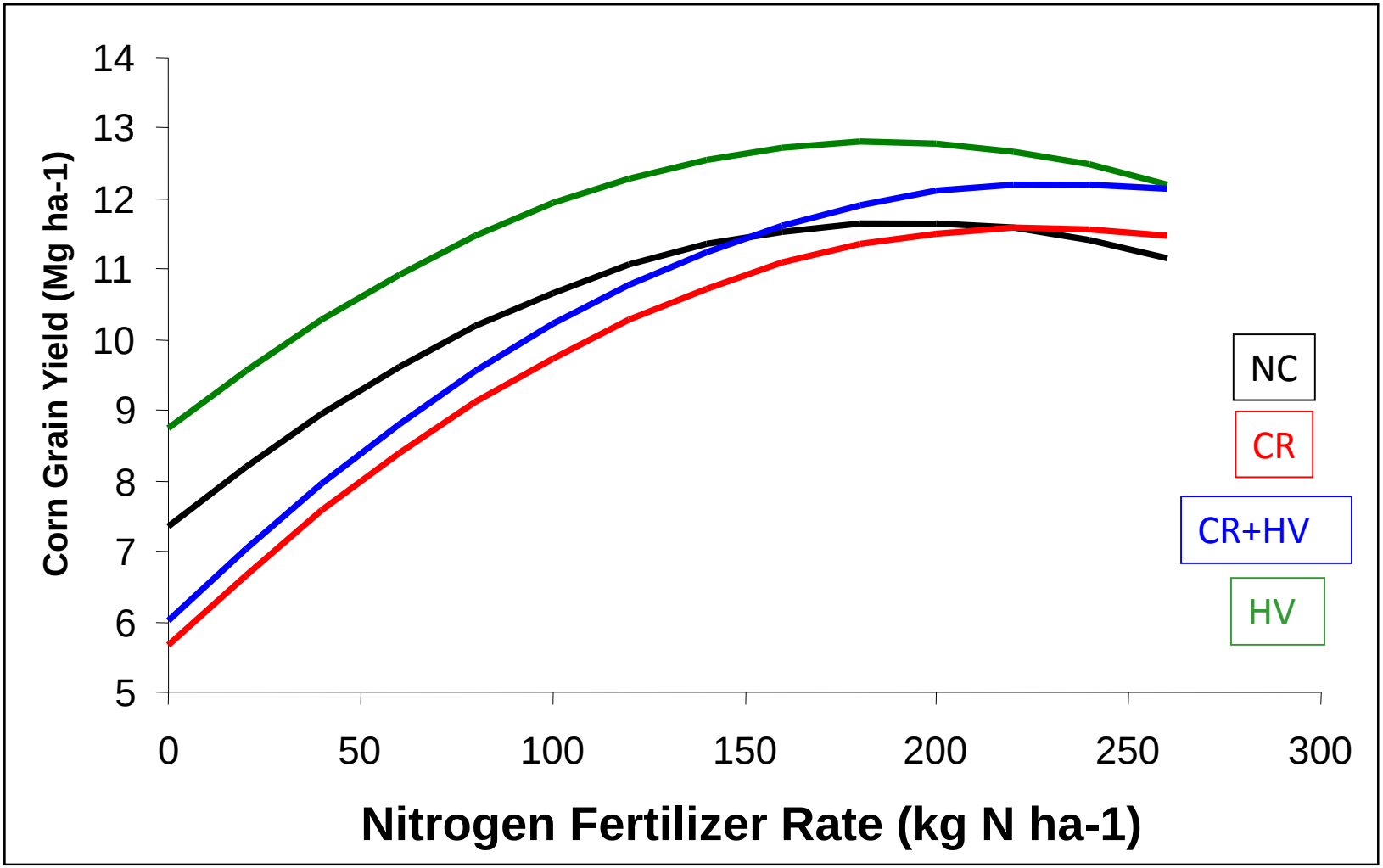


$$RR = \frac{Yield\ \ WCC}{Yield\ \ NC}$$

$$L_i = \ln(RR)$$


BICULTURE
GRASS
LEGUME
n=10
n=68
n=80
L_i
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0 1.2
L_i

Corn Grain Yield



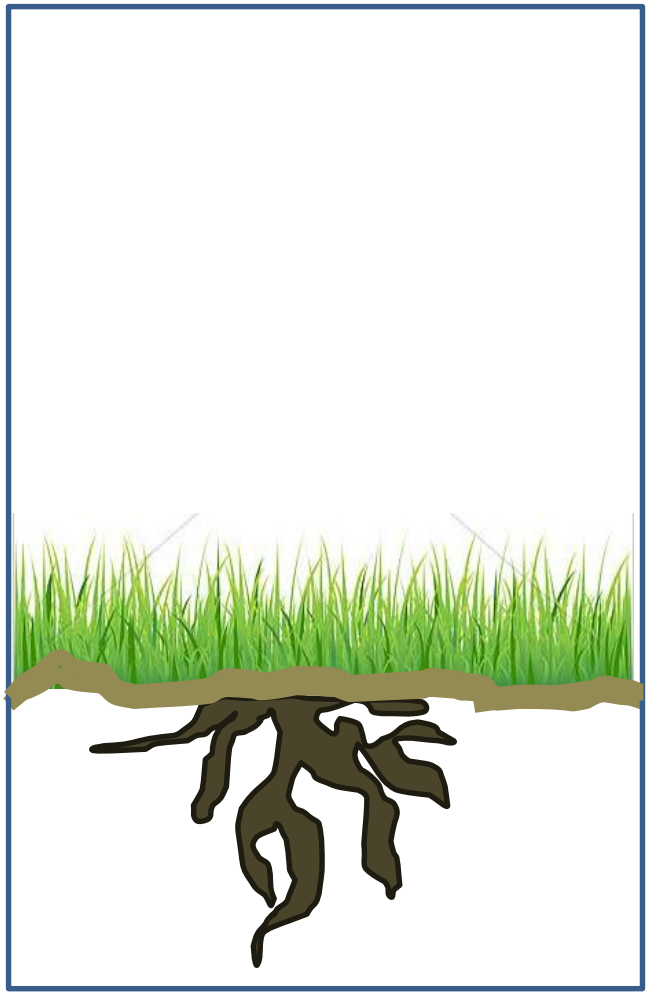
Indicator	Hypothesized Cover Crop Change: Improvement (+), Decline (-) or Neutral (+/-)	Indicator of Adaptation or Mitigation
Soil water	+	Adaptation

Indicator	Hypothesized Cover Crop Change: Improvement (+), Decline (-) or Neutral (+/-)	Indicator of Adaptation or Mitigation
Nitrous oxide emissions (N_2O)	+/-	Mitigation
Soil water	+	Adaptation

N_2O drivers

Mineral nitrogen	•C:N residue ratio •Type of cover crop •Tillage	•Incorporation of residue •N fertilizer rate
Reactive carbon	•Soil organic carbon •Tillage •Type of cover crop	•Incorporation of residue •Biomass input from cover crop
Soil water	•Biomass input from cover crop •Precipitation •Drainage	
Soil physical properties	•Bulk density •Soil texture	

Potential cover crop impacts on the water balance



Precipitation

Plant transpiration

Runoff

Soil Evaporation

Drainage

Soil Water Storage

Potential cover crop impacts on the water balance

Precipitation

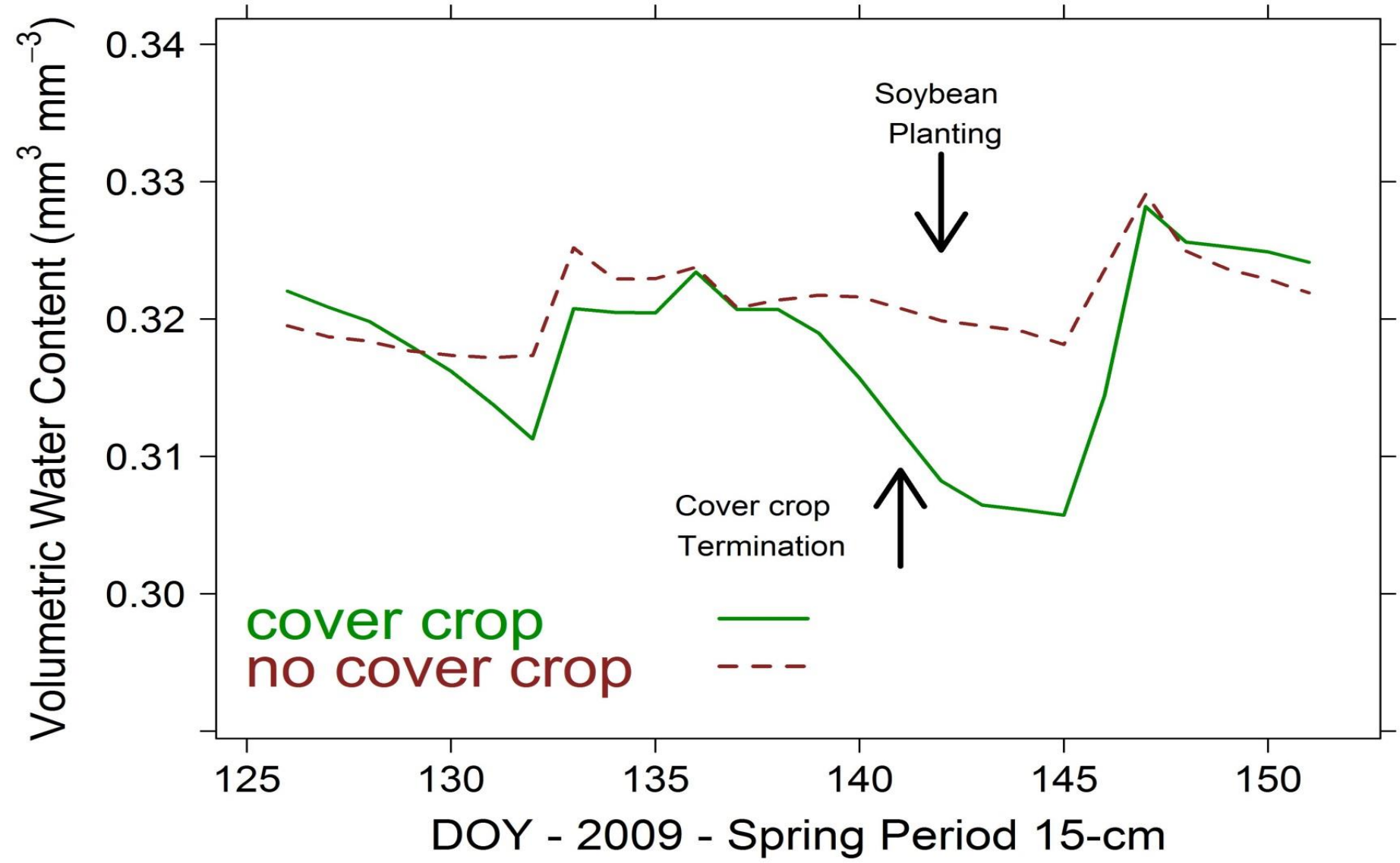
Runoff

Drainage

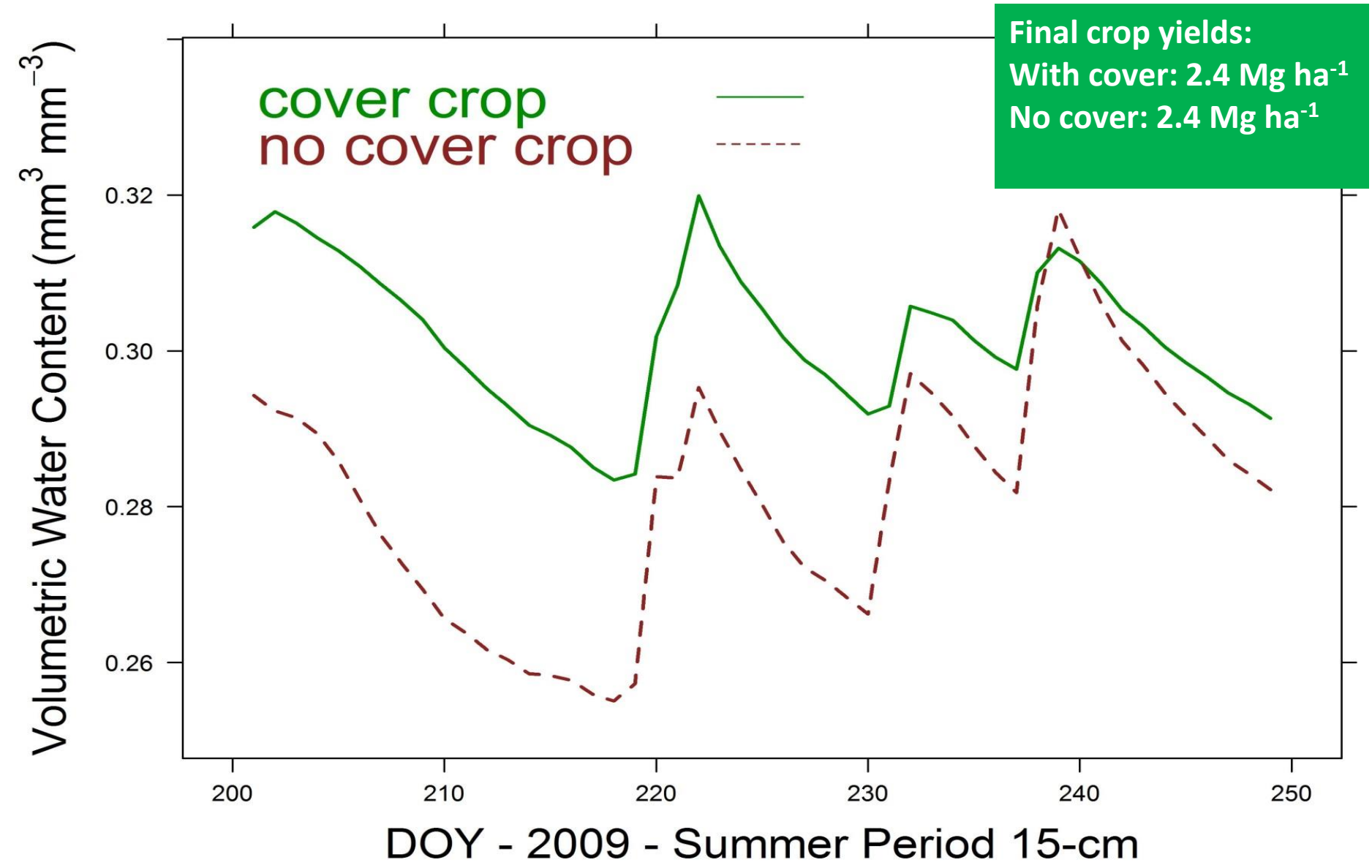
Plant transpiration

Soil Evaporation

Soil Water Storage



Basche et al. in prep. Soil water improvements with the long-term use of a winter rye cover crop

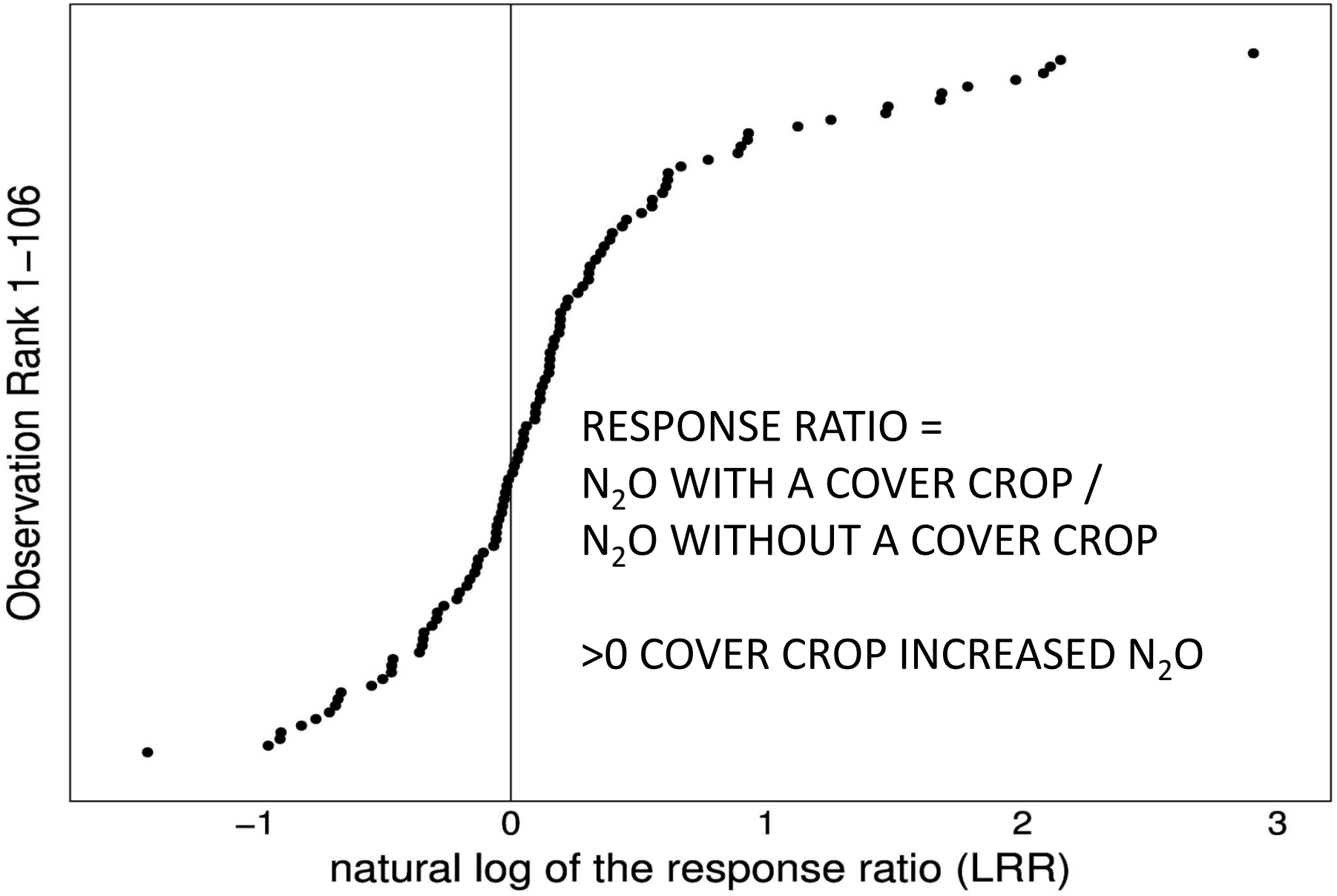


Final crop yields:
With cover: 2.4 Mg ha^{-1}
No cover: 2.4 Mg ha^{-1}

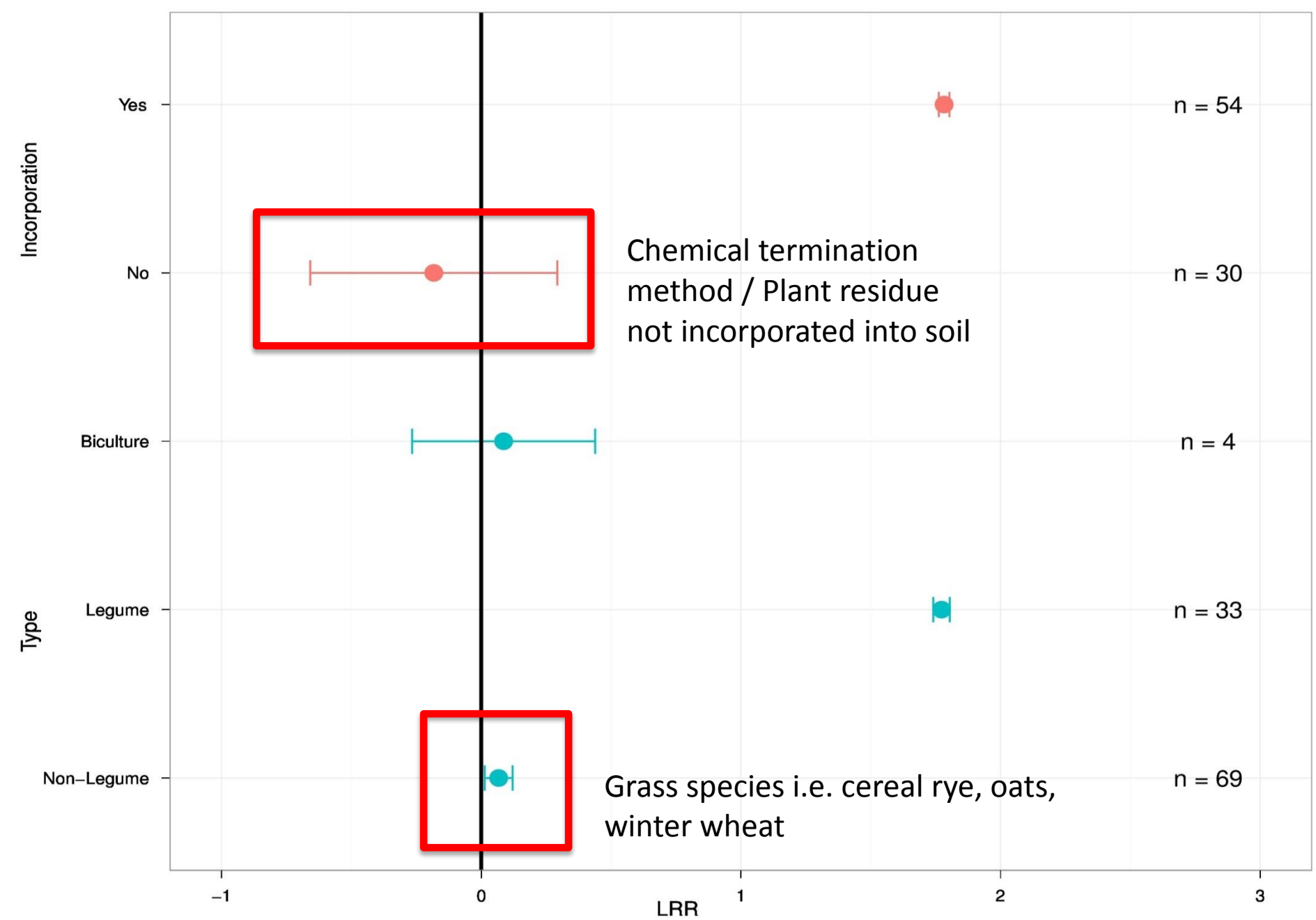
Basche et al. in prep. Soil water improvements with the long-term use of a winter rye cover crop

Indicator	Hypothesized Cover Crop Change: Improvement (+), Decline (-) or Neutral (+/-)	Indicator of Adaptation or Mitigation
Nitrous oxide emissions (N_2O)	+/-	Mitigation
Soil water	+	Adaptation

Do cover crops increase or decrease nitrous oxide emissions?

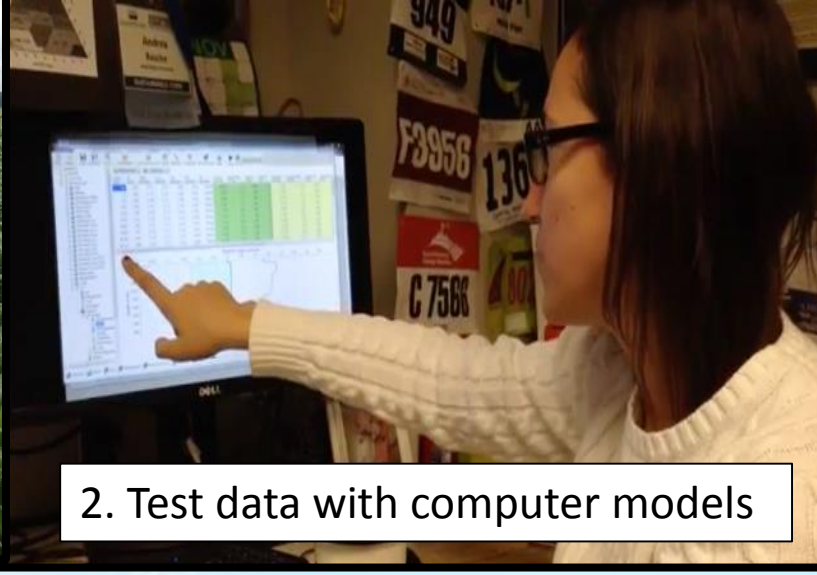


Basche , Miguez, Kaspar and Castellano. 2014. Do cover crops increase or decrease nitrous oxide emissions? A meta-analysis. Journal of Soil and Water Conservation.



Basche , Miguez, Kaspar and Castellano. 2014. Do cover crops increase or decrease nitrous oxide emissions? A meta-analysis. Journal of Soil and Water Conservation.

1. Collect crop and soil data



2. Test data with computer models

3. Goal: Extend understanding of long-term cover crop impacts, given expected climate trends

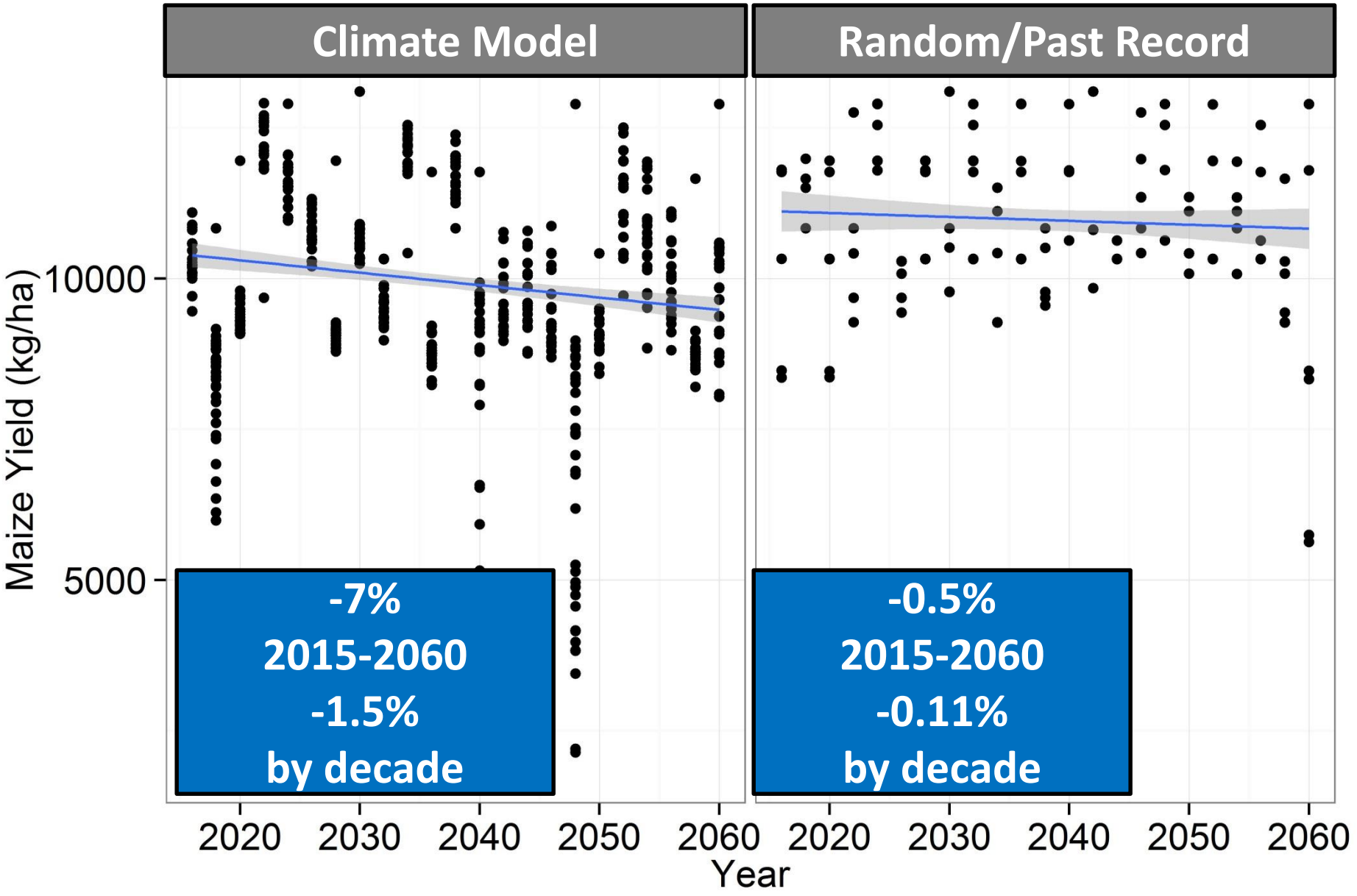
Cover Crop

No Cover Crop

What is the long-term (i.e. decades) effect of a winter rye cover crop on corn and soybean yields, in a changing climate?

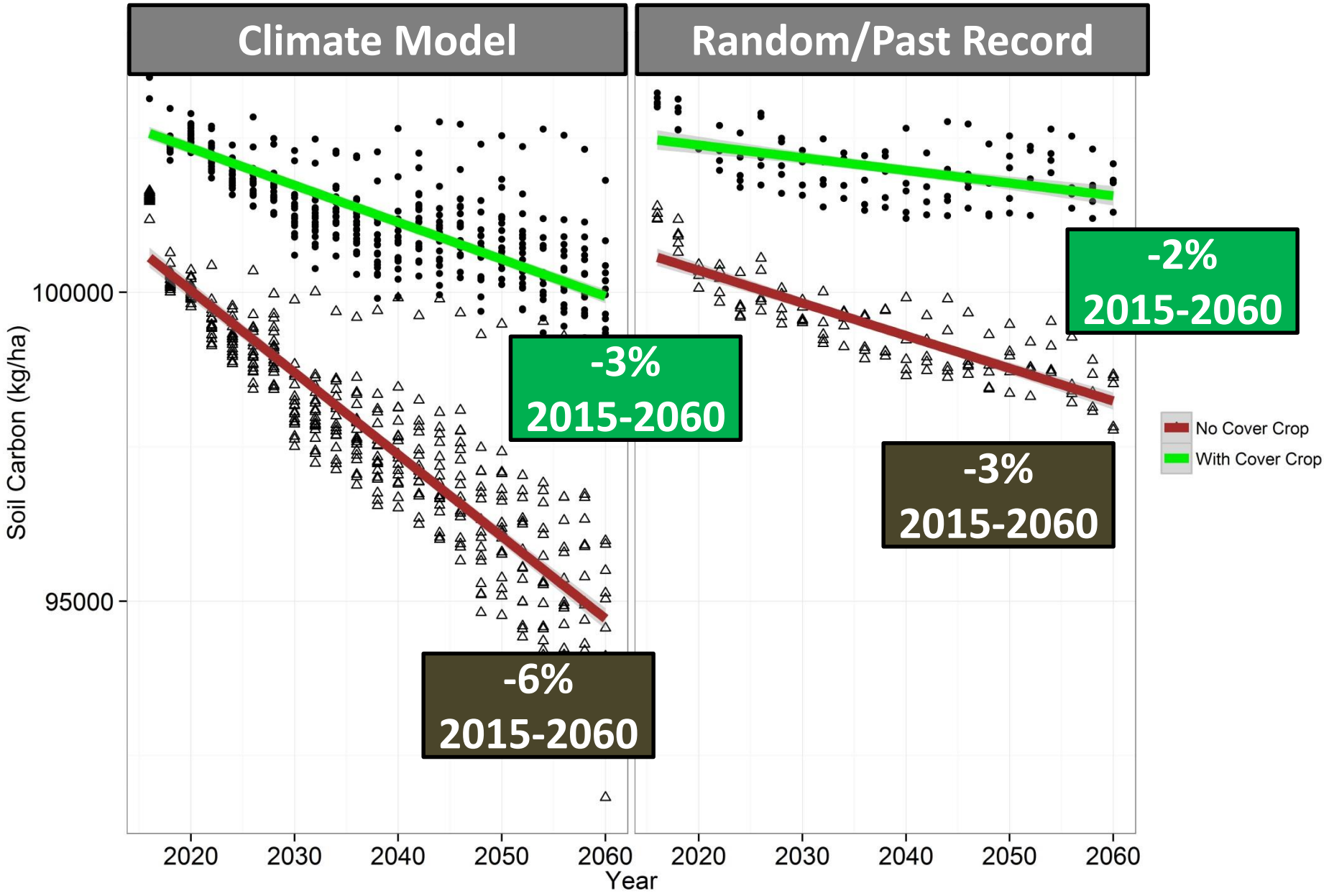
Indicator	Hypothesized Cover Crop Change: Improvement (+), Decline (-) or Neutral (+/-)	Indicator of Adaptation or Mitigation
Nitrous oxide emissions (N_2O)	+/-	Mitigation
Soil water	+	Adaptation
Soil erosion	+	Adaptation
Soil carbon	+	Adaptation and Mitigation
Cash crop yields	+/- moving to +	Adaptation

Indicator	Hypothesized Cover Crop Change: Improvement (+), Decline (-) or Neutral (+/-)	Indicator of Adaptation or Mitigation
Cash crop yields	**+/- moving to +**	**Adaptation**



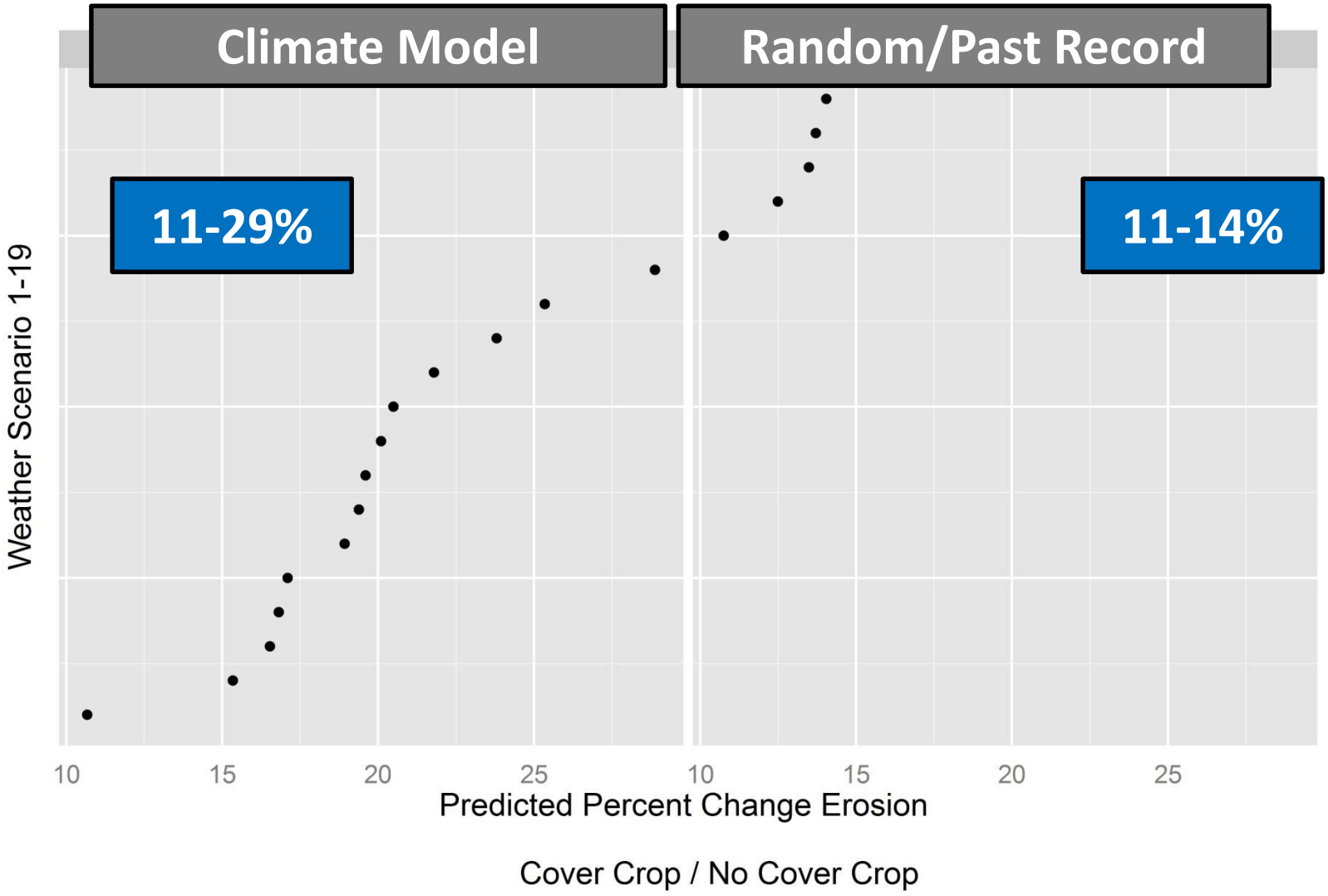
Basche et al. in review. Simulating long-term impacts of cover crops and climate change on crop production and environmental outcomes in the Midwestern United States

Indicator	Hypothesized Cover Crop Change: Improvement (+), Decline (-) or Neutral (+/-)	Indicator of Adaptation or Mitigation
Soil carbon	+	Adaptation and Mitigation

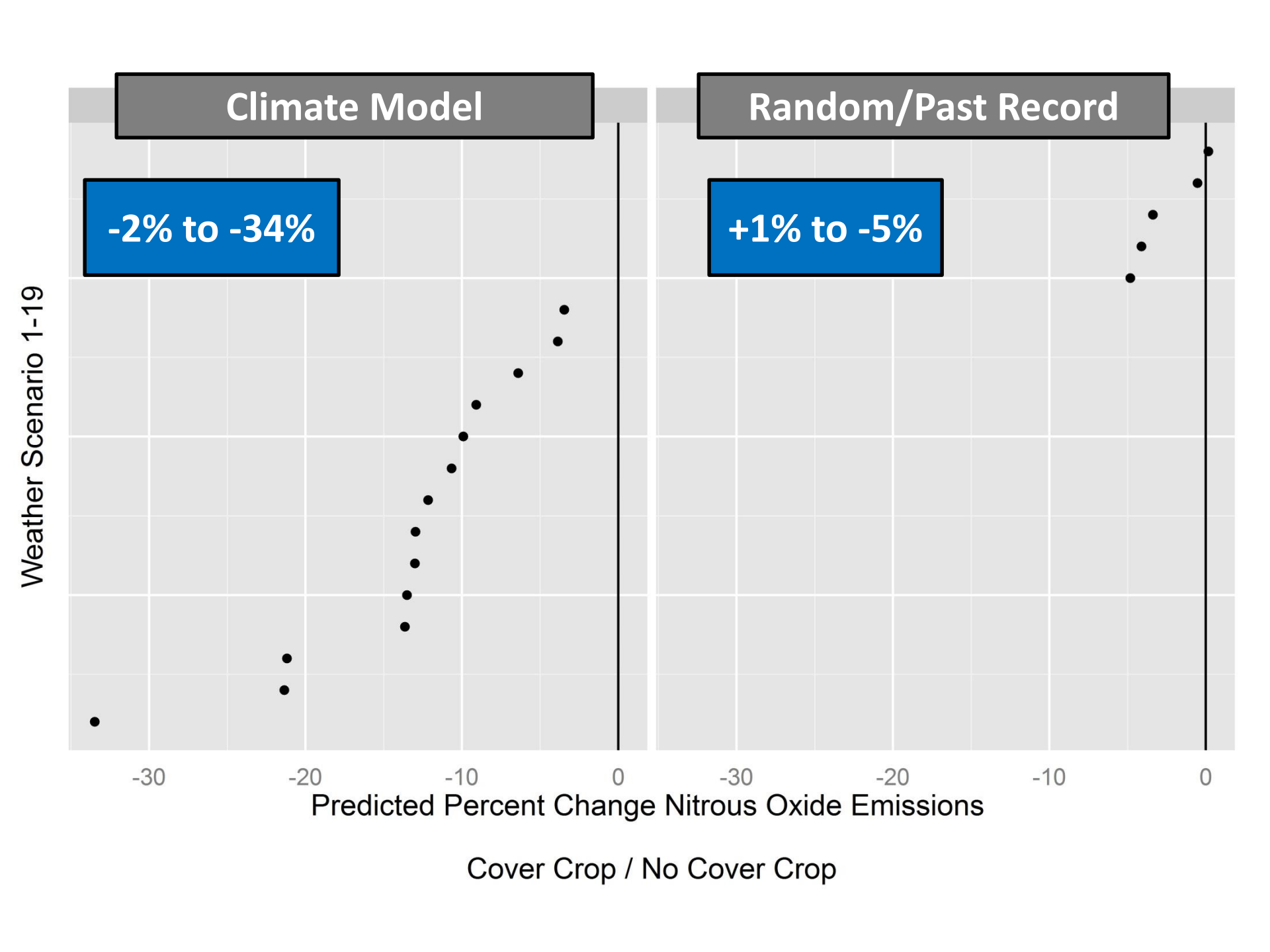


Basche et al. in review. Simulating long-term impacts of cover crops and climate change on crop production and environmental outcomes in the Midwestern United States

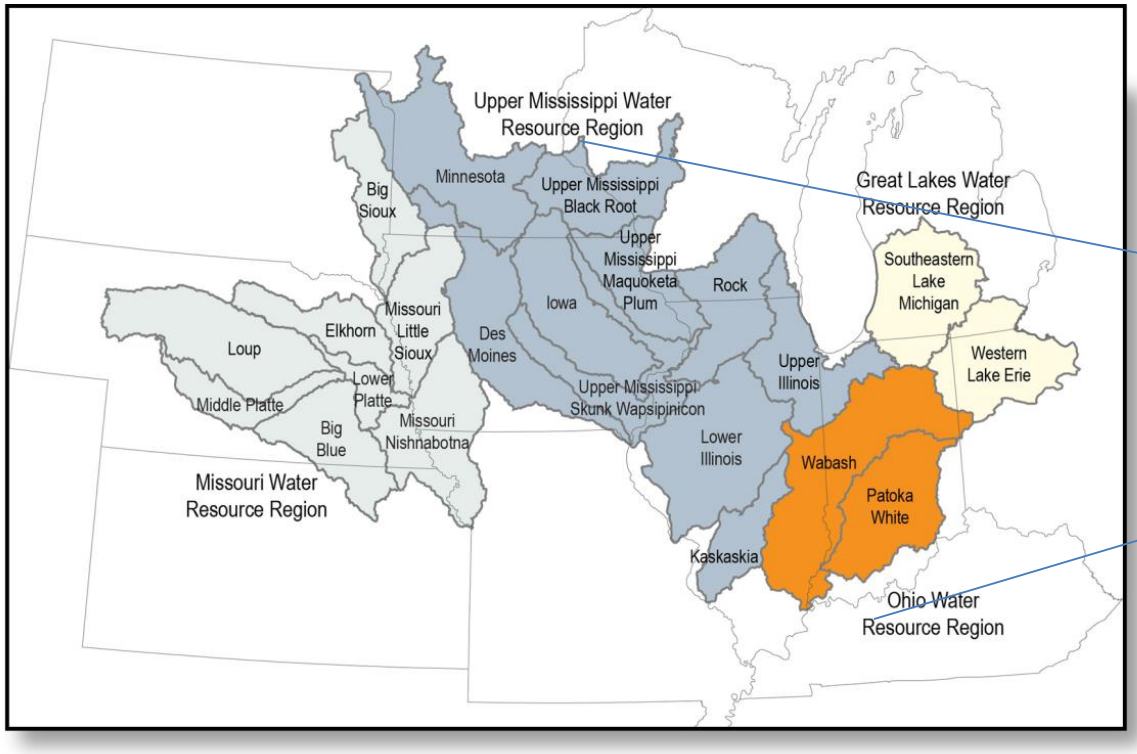
Indicator	Hypothesized Cover Crop Change: Improvement (+), Decline (-) or Neutral (+/-)	Indicator of Adaptation or Mitigation
Soil erosion	+	Adaptation


Climate Model
Random/Past Record
11-29%
11-14%
Weather Scenario 1-19
10
15
20
25
10
15
20
25
Predicted Percent Change Erosion
Cover Crop / No Cover Crop

Indicator	Hypothesized Cover Crop Change: Improvement (+), Decline (-) or Neutral (+/-)	Indicator of Adaptation or Mitigation
Nitrous oxide emissions (N_2O)	+/-	Mitigation


Climate Model
Random/Past Record
-2% to -34%
+1% to -5%
Weather Scenario 1-19
-30
-20
-10
0
-30
-20
-10
0
Predicted Percent Change Nitrous Oxide Emissions
Cover Crop / No Cover Crop

Cornbelt farmers' perceptions of climate change and GHG mitigation



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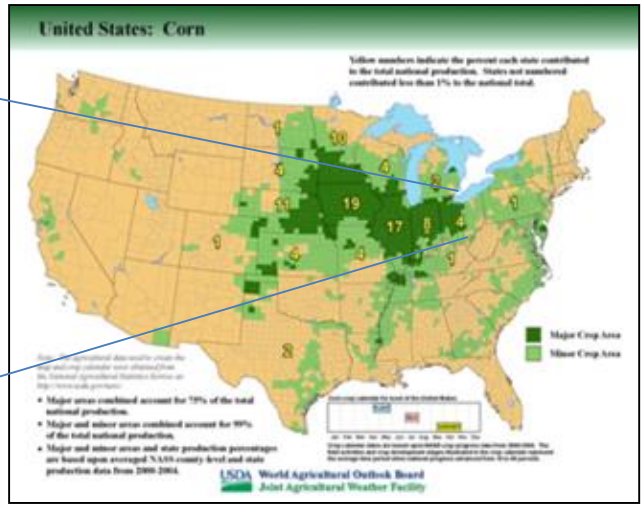
Useful to usable



Spring 2012 Survey of Corn Farmers in Upper Midwest

- Partnership with NIFA-funded Useful to Useable (U2U) project
- Sample stratified by 22 HUC6 watersheds representing ~60% of U.S. corn production
- 4,778 farmers: 26% response rate

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United States Department of Agriculture
National Institute of Food and Agriculture

"There is increasing discussion about climate change and its potential impacts. Please select the statement that best reflects your beliefs about climate change:" N=4,778 Cornbelt farmers (Spring 2012)

Climate change is occurring, and it is caused mostly by human activities	8%
Climate change is occurring, and it is caused equally by natural changes in the environment and human activities	33%
Climate change is occurring, and it is caused mostly by natural changes in the environment	25%
There is not sufficient evidence to know with certainty whether climate change is occurring or not	31%
Climate change is not occurring	4%

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Climate change is occurring, and it is caused mostly by human activities	8%
Climate change is occurring, and it is caused equally by natural changes in the environment and human activities	33%
Climate change is occurring, and it is caused mostly by natural changes in the environment	25%
There is not sufficient evidence to know with certainty whether climate change is occurring or not	31%
Climate change is not occurring	4%

Climate change is occurring	**66%**
➢ **Humans are at least partly responsible**	**41%**

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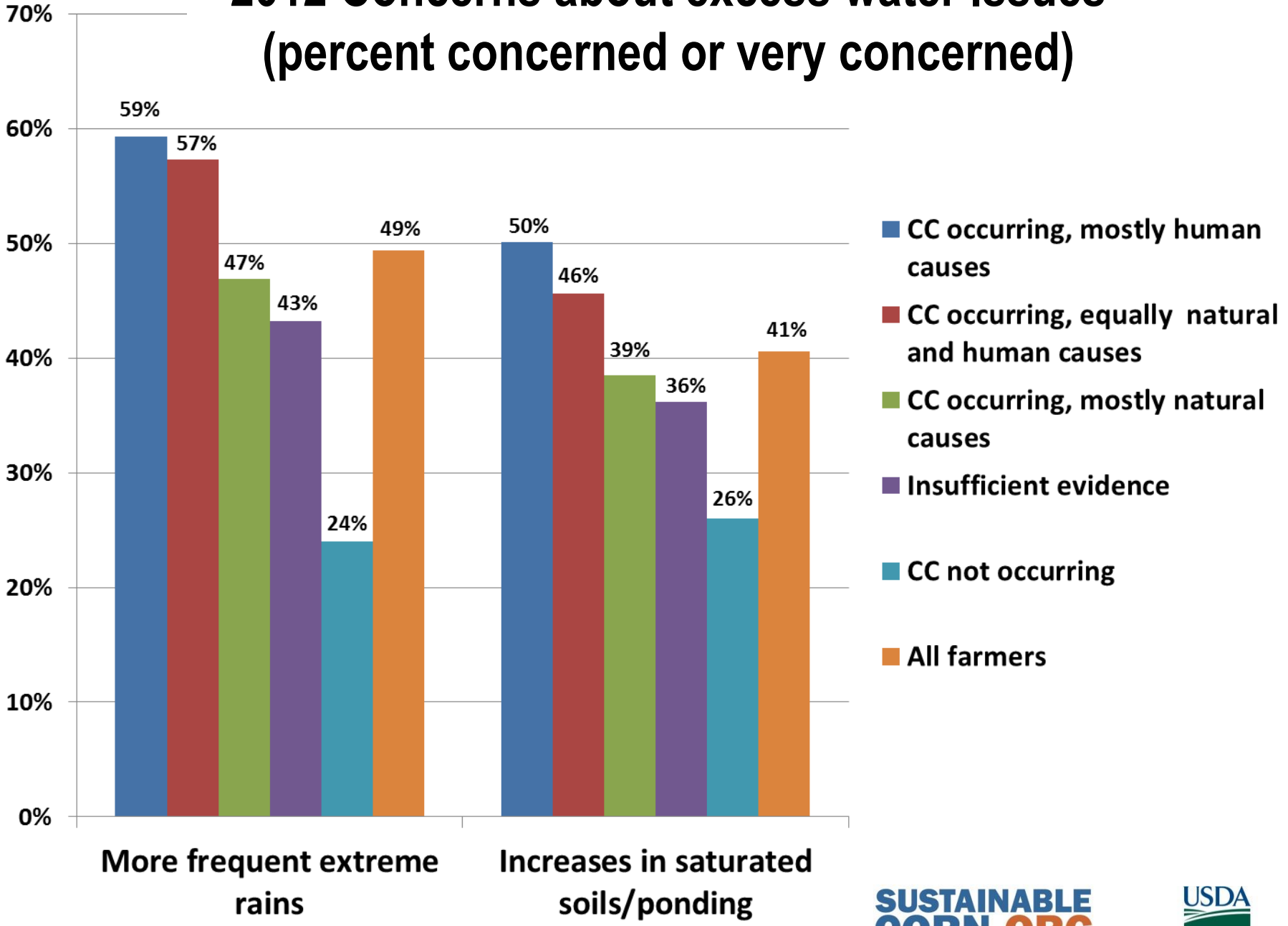
Climatologists' and farmers' beliefs about climate change

	Climatologists (N=19)	Farmers (N=4778)
a. Climate change is occurring, and it is caused mostly by natural changes in the environment	5%	25%
b. Climate change is occurring, and it is caused mostly by human activities	53%	8%
c. Climate change is occurring, and it is caused more or less equally by natural changes in the environment and human activities	37%	33%
d. Climate change is not occurring	0%	3.5%
e. There is not sufficient evidence to know with certainty whether climate change is occurring or not	5%	31%

2012 Concerns about excess water Issues (percent concerned or very concerned)



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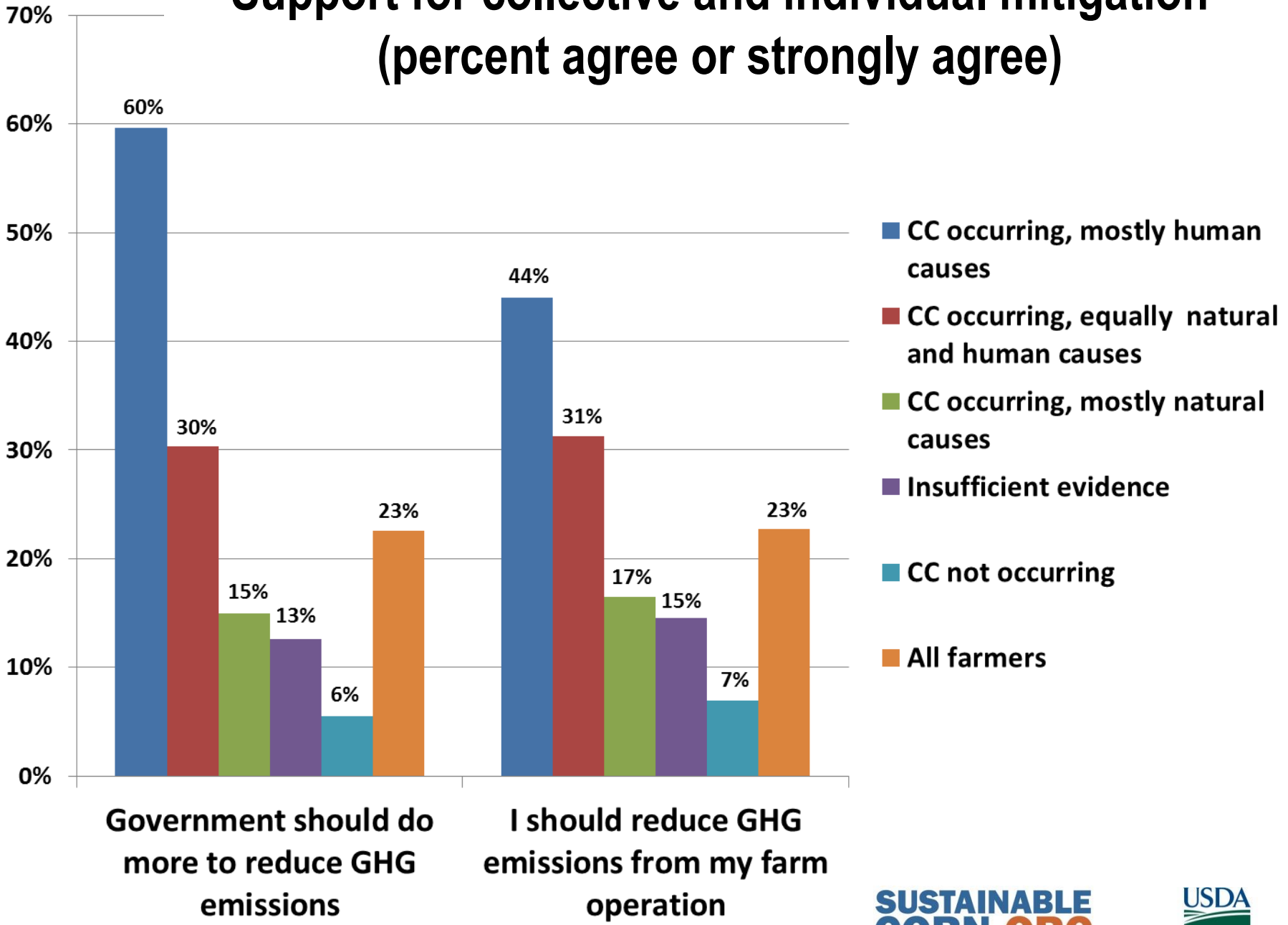
Support for collective and individual mitigation (percent agree or strongly agree)



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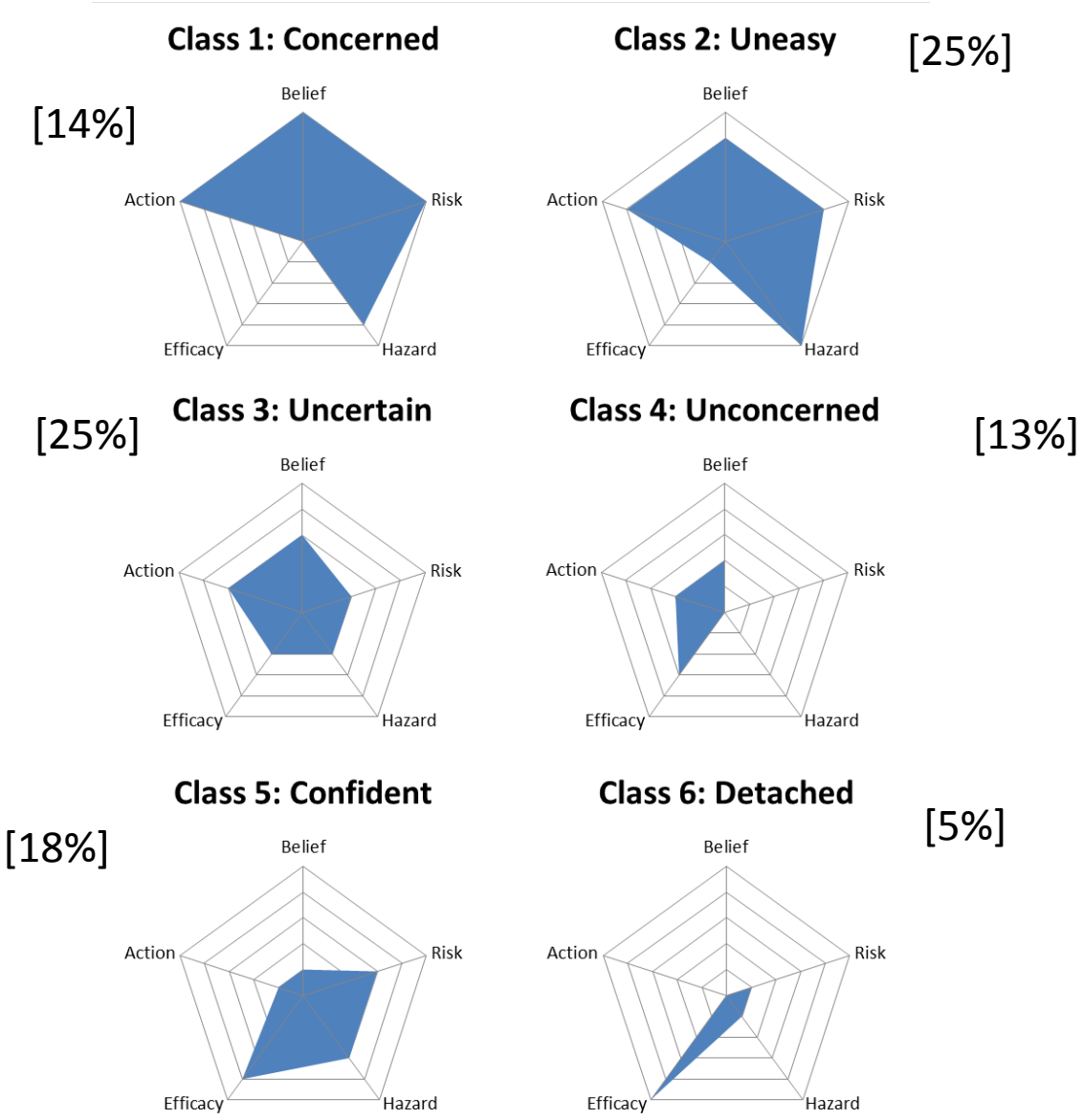
National Institute of Food and Agriculture

Understanding Cornbelt farmer perspectives on climate change to inform engagement strategies for adaptation and mitigation 2014 JSWC 69(6):505-516



Differences in how Midwest corn-based crop farmers think about responding to and acting on variable weather and climate conditions

Take-Home Points

- Many farmers are concerned about predicted climate change-related threats to Corn Belt agriculture
  - Risk perception varies greatly, associated with belief
- Many support individual-level adaptation
- Many also support institutional adaptive action, but more supportive of Extension than state and federal gov't
  - However, uncertainty and disbelief associated with lower support
- Most farmers do not believe that climate change is caused by human activity
  - Mitigation through GHG reduction is unpopular, except among farmers who believe that humans are main cause of climate change

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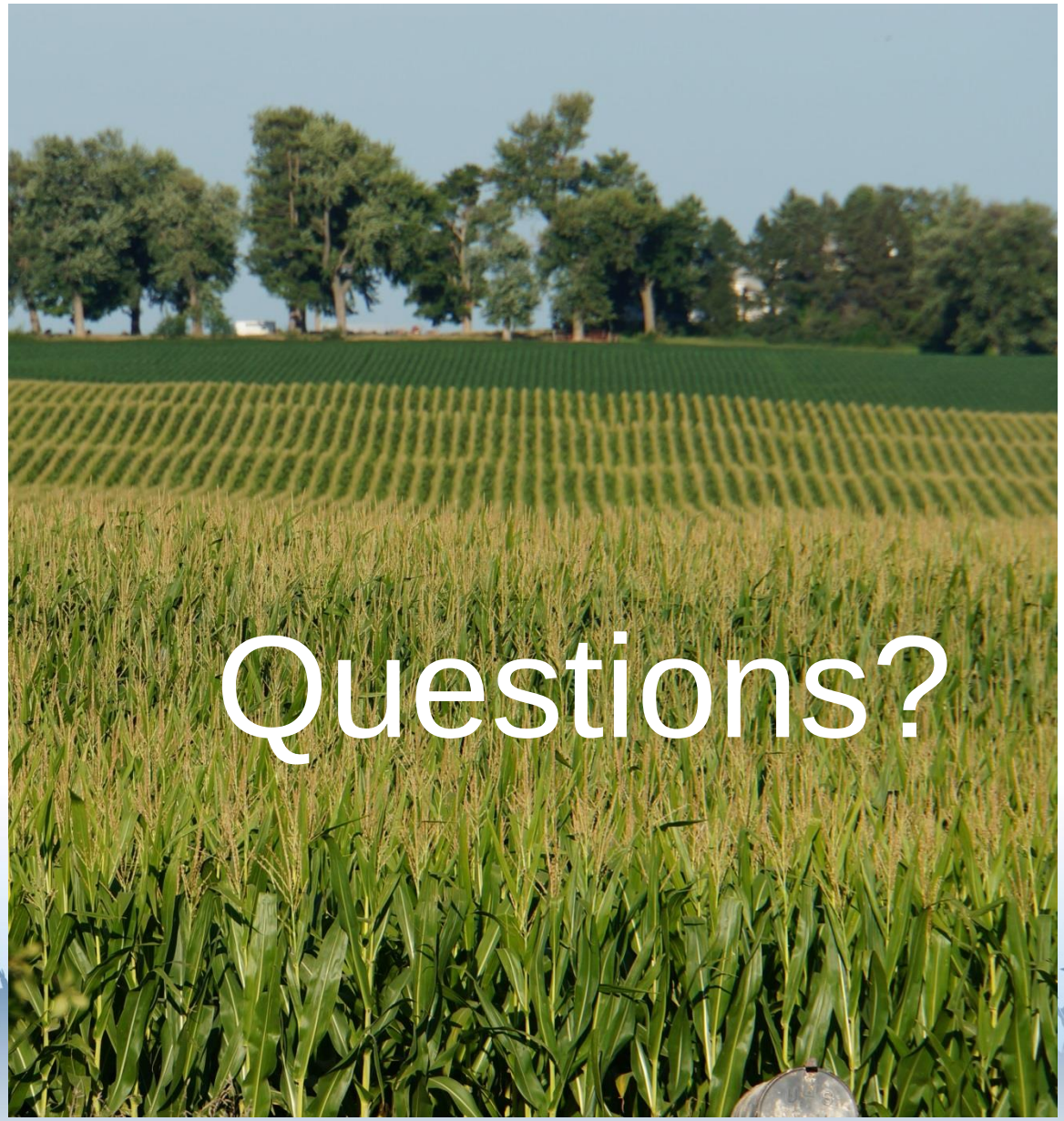
Website www.sustainablecorn.org

Blog www.AgriclimateConnection.org



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