Climate Change and Corn in the Corn Belt of the Midwest, USA

Richard Moore, Ohio State University
Dennis Todey, South Dakota State University

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

Today's Topics:

1. Corn
2. Climate Change—Dennis Todey
3. Climate Change and Corn—USDA Midwest Climate Hub
4. Corn Cap grant—Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems Coordinated Agricultural Project
5. Corn and Lake Erie

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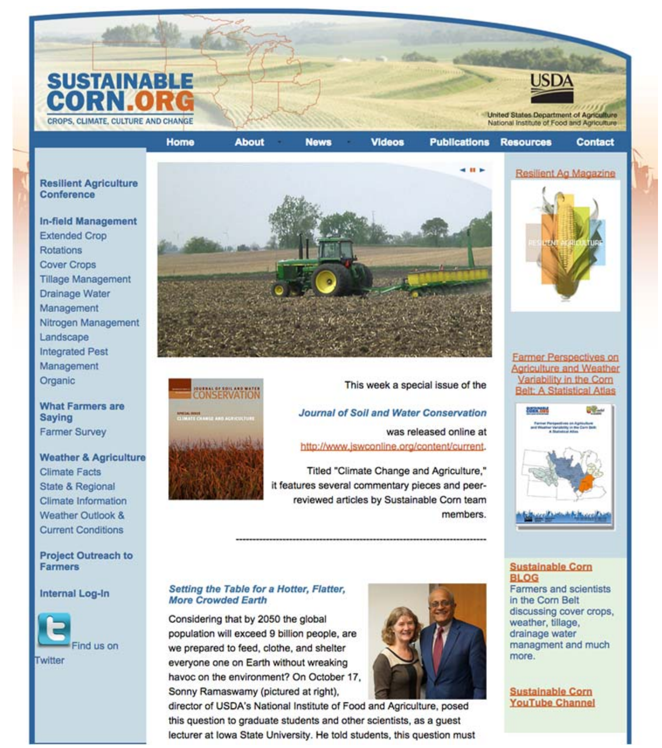
More Information on the Corn Cap grant is available from:

Special issue of the
Journal of Soil and Water
Conservation

November/December 2014; 69 (6)

Sustainablecorn.org



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CROPS, CLIMATE, CULTURE AND CHANGE

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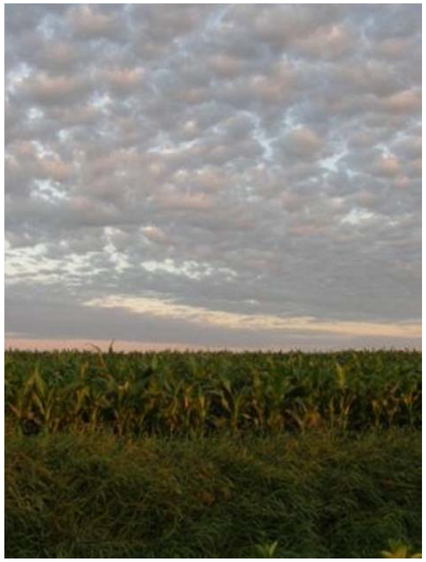
Importance of Corn

- Major cereal crop in the United States
- 75% of world caloric intake is from corn, rice, soybean and wheat
- 70% of U.S. corn crop produced in 9 CSCAP Midwest states



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Ohio Agricultural Crop Values (2012)

Crops - Planted, Harvested, Yield, Production, Price (MYA), Value of Production †

Commodity	Planted All Purpose Acres	Harvested Acres	Yield	Production	Price per Unit	Value of Production in Dollars
CORN						
CORN, GRAIN		3,650,000	123.00 BU / ACRE	448,950,000 BU	7.09 $ / BU	3,183,056,000
CORN, SILAGE		200,000	16.00 TONS / ACRE	3,200,000 TONS		
CORN	3,900,000					
SOYBEANS						
SOYBEANS	4,600,000	4,590,000	45.00 BU / ACRE	206,550,000 BU	14.60 $ / BU	3,015,630,000
HAY & HAYLAGE						
HAY & HAYLAGE		1,170,000	2.39 TONS / ACRE, DRY BASIS	2,791,000 TONS, DRY BASIS		537,185,000
HAY & HAYLAGE, ALFALFA	65,000	410,000	3.00 TONS / ACRE, DRY BASIS	1,232,000 TONS, DRY BASIS		
HAY						
HAY		1,100,000	2.12 TONS / ACRE	2,330,000 TONS	193.00 $ / TON	445,080,000
HAY, ALFALFA		350,000	2.80 TONS / ACRE	980,000 TONS	231.00 $ / TON	226,380,000
HAY, (EXCL ALFALFA)		750,000	1.80 TONS / ACRE	1,350,000 TONS	162.00 $ / TON	218,700,000
WHEAT						
WHEAT, WINTER	500,000	450,000	69.00 BU / ACRE	31,050,000 BU	7.94 $ / BU	246,537,000
WHEAT	500,000	450,000	69.00 BU / ACRE	31,050,000 BU	7.94 $ / BU	246,537,000
SWEET CORN						

Source: http://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=OHIO

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Crops of the Midwest

- Corn (53,000,000 acres)
- Soybean (44,000,000 acres)
- Wheat, alfalfa, asparagus, cabbage, carrots, cucumbers, onions, peas, bell peppers, potatoes, sweet corn, tobacco, tomatoes, watermelon
- Apples, blueberries, sweet cherries, tart cherries, peaches, plums, raspberries, strawberries
- Pastureland (16,000,000 acres used for grazing and forage)
- Market value of $188,860,000,000 in 2012

Source: Jerry Hatfield PPT presentation Nov. 2014

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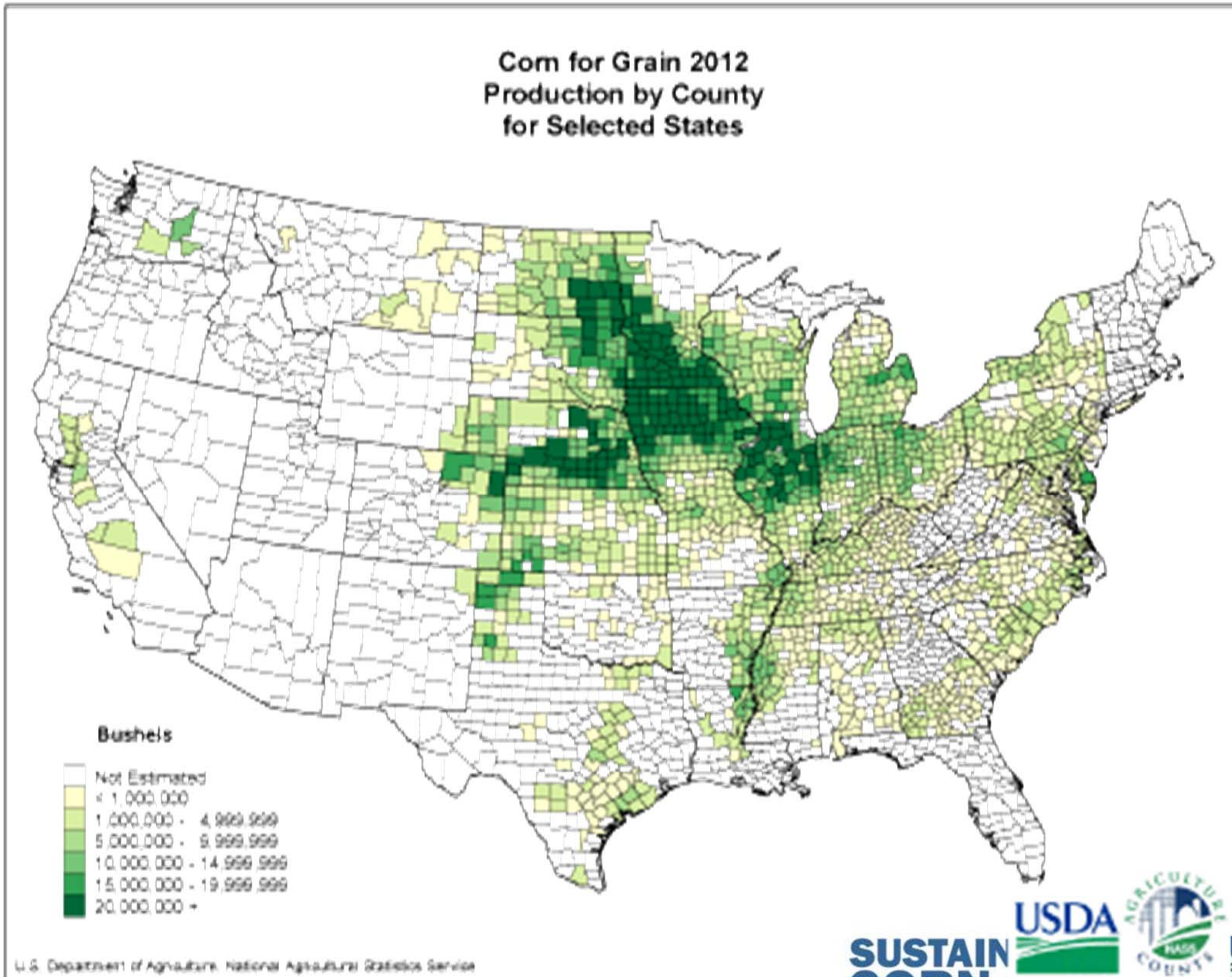
Ohio Corn Production (2012)



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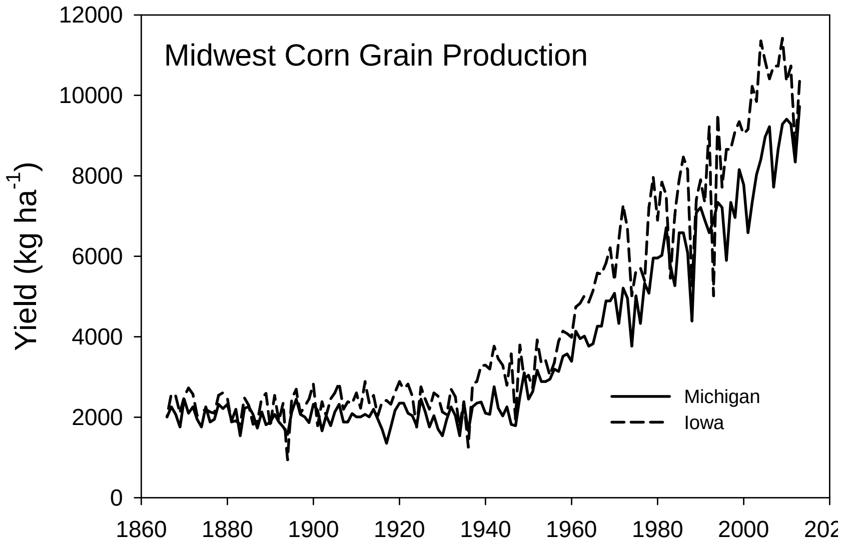
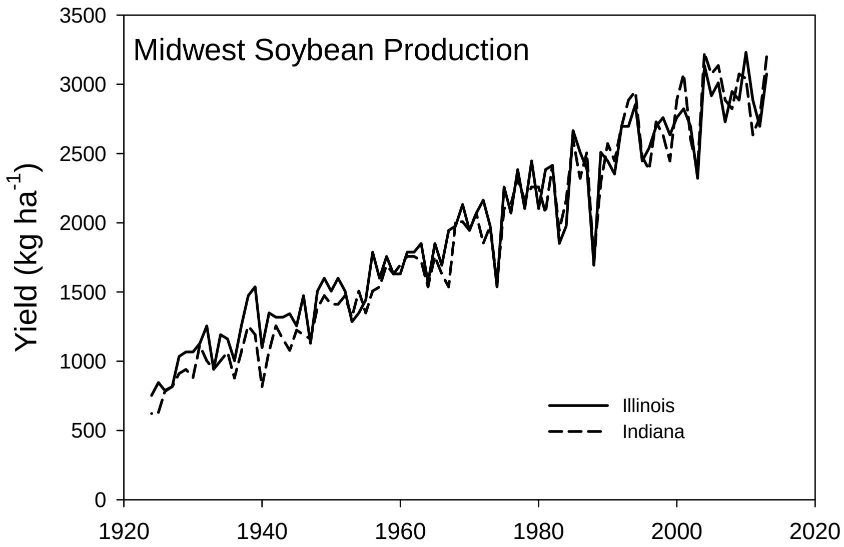
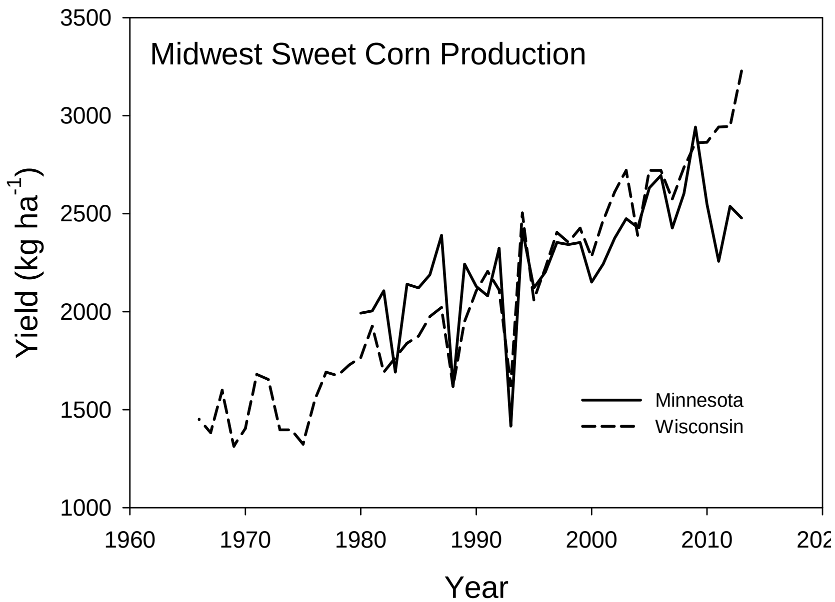
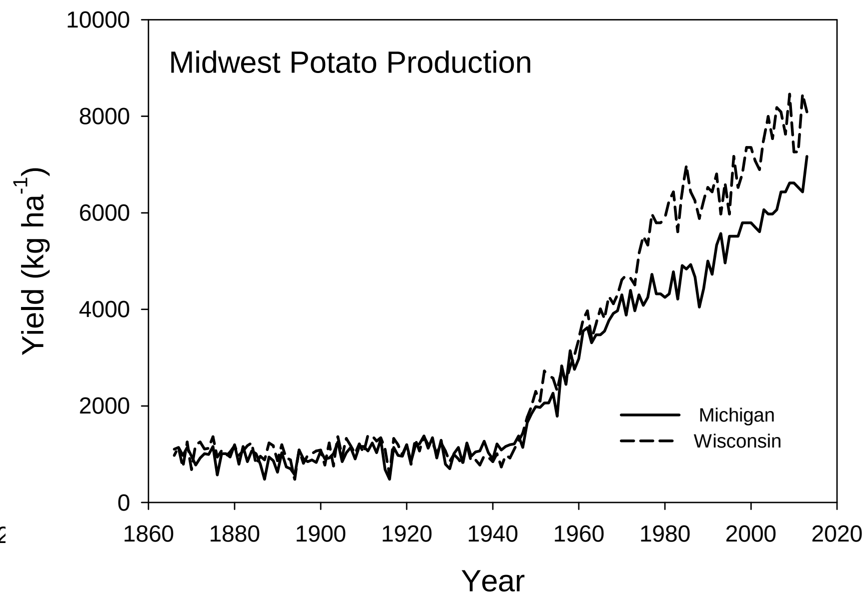
Current Agriculture in the Midwest









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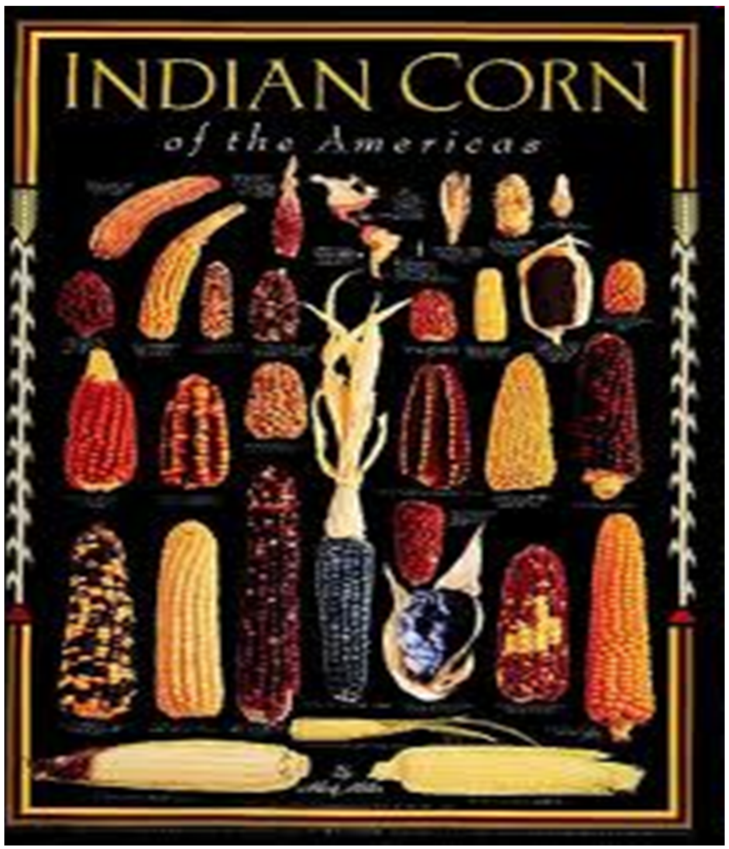
Domestication of Corn

- Corn, or maize *(Zea mays ssp. Mays),* was domesticated from a wild grass called teosinte over 6300 years ago in Mexico.



70-80 day corn varieties were common for the native Americans. Today 120 day corn is common.

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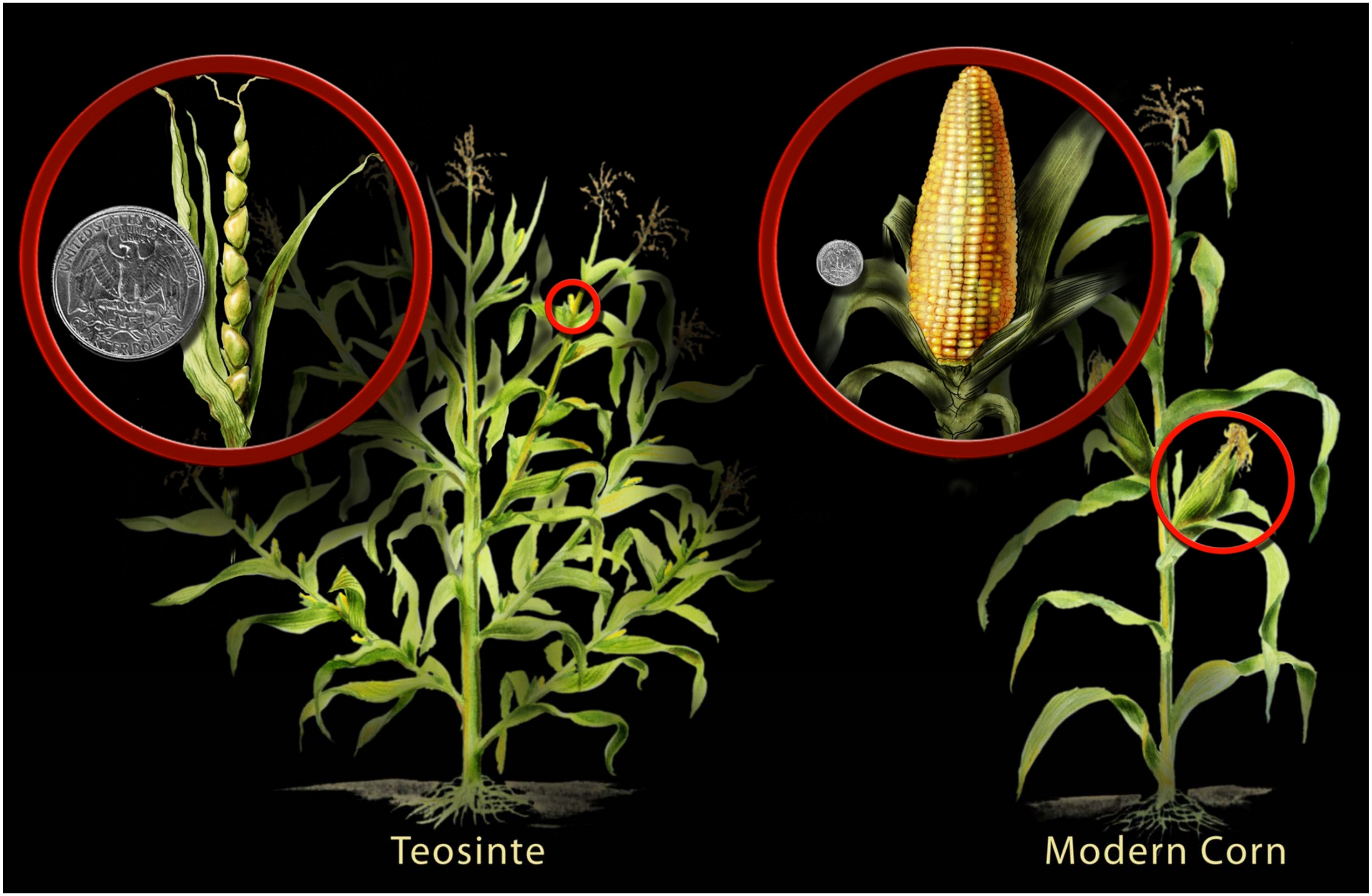
Teosinte
Modern Corn

USA GROWING STRATEGY
Rotation of Corn and Soybean Fields

Corn

Soybeans

No-till Soybeans after Corn

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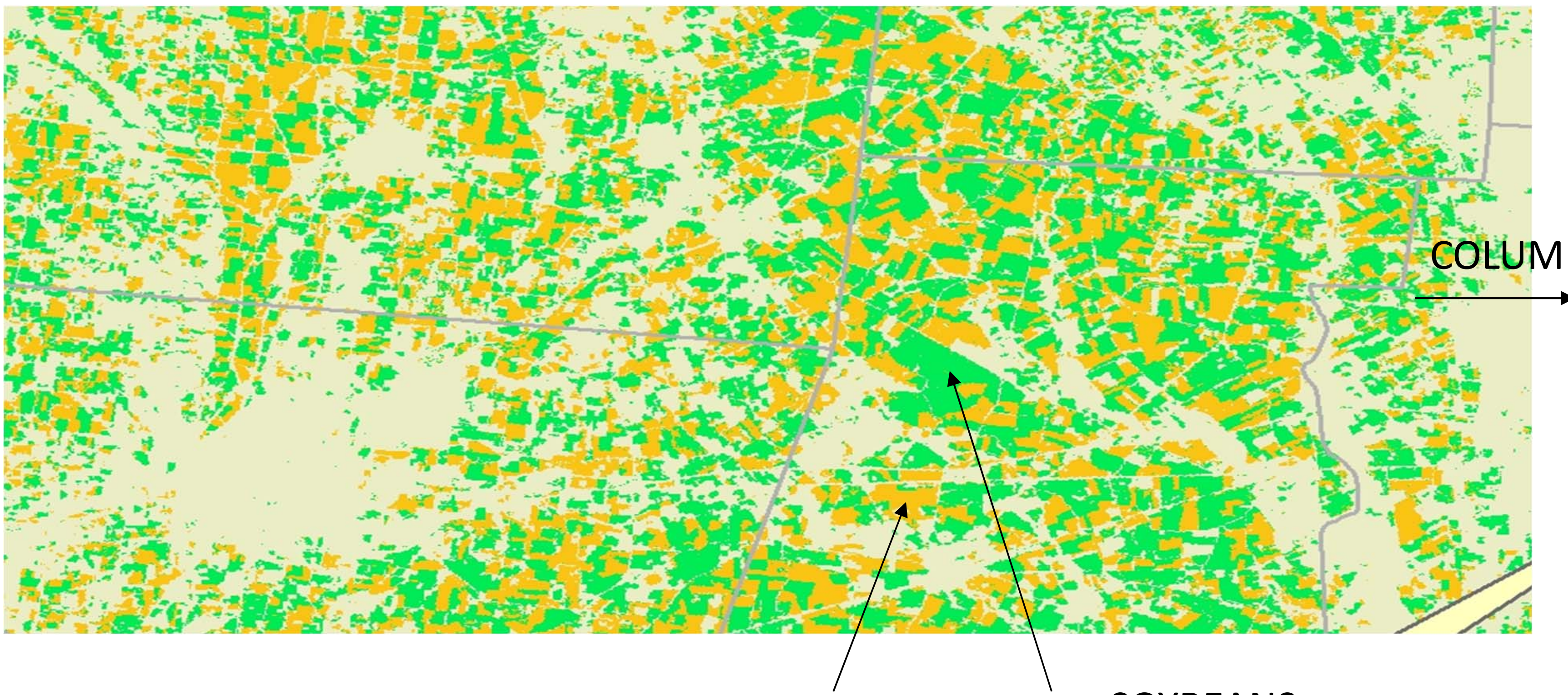
TYPICAL CORN SOYBEAN LANDSCAPE
BY PARCEL JUST WEST OF COLUMBUS, OHIO



Source: USDA 2012 land use maps

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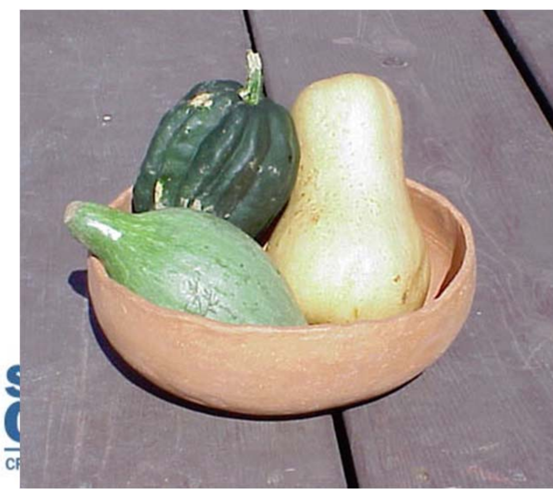
Native American Growing Strategy: THREE SISTERS

CORN

BEANS

SQUASH



“Cornstalk” and “Cornplanter”

- Chief Cornstalk of the Shawnees was born "Keigh-tugh-qua," meaning maize plant—and became leader of the northern confederacy of Indian tribes, composed of the Shawnees, Delawares, Mingoes, Wyandottes. He was defeated at Point Pleasant in 1774.

Cornplanter (right) was a Seneca tribal leader who supported the movement to adopt agriculture and small farms, while also emphasizing the need for moral and religious order among his people.

Credits: Moore and Long 2012 Stone Lab

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Climate Change and Impact for Agriculture

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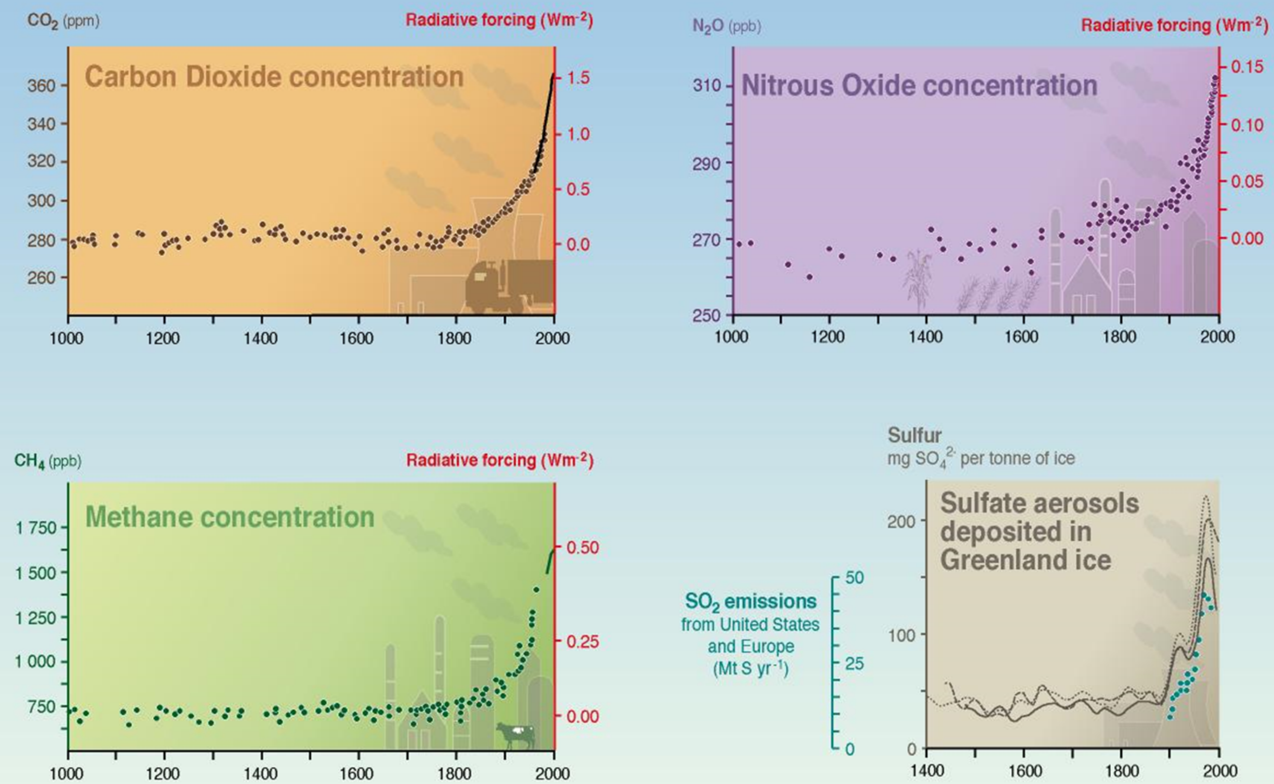
AMERICAN ASSOCIATION OF STATE CLIMATOLOGISTS

SOUTH DAKOTA Climate and Weather

Greenhouse gases

- Carbon dioxide (CO_2)
- Water (H_2O)
- Ozone (O_3)
- Methane (CH_4)
- Chloro-florocarbons (CFCs)
- Nitrous oxide (N_2O)

Indicators of the human influence on the atmosphere during the Industrial era



SYR - FIGURE 2-1
WG1 FIGURE SPM-2

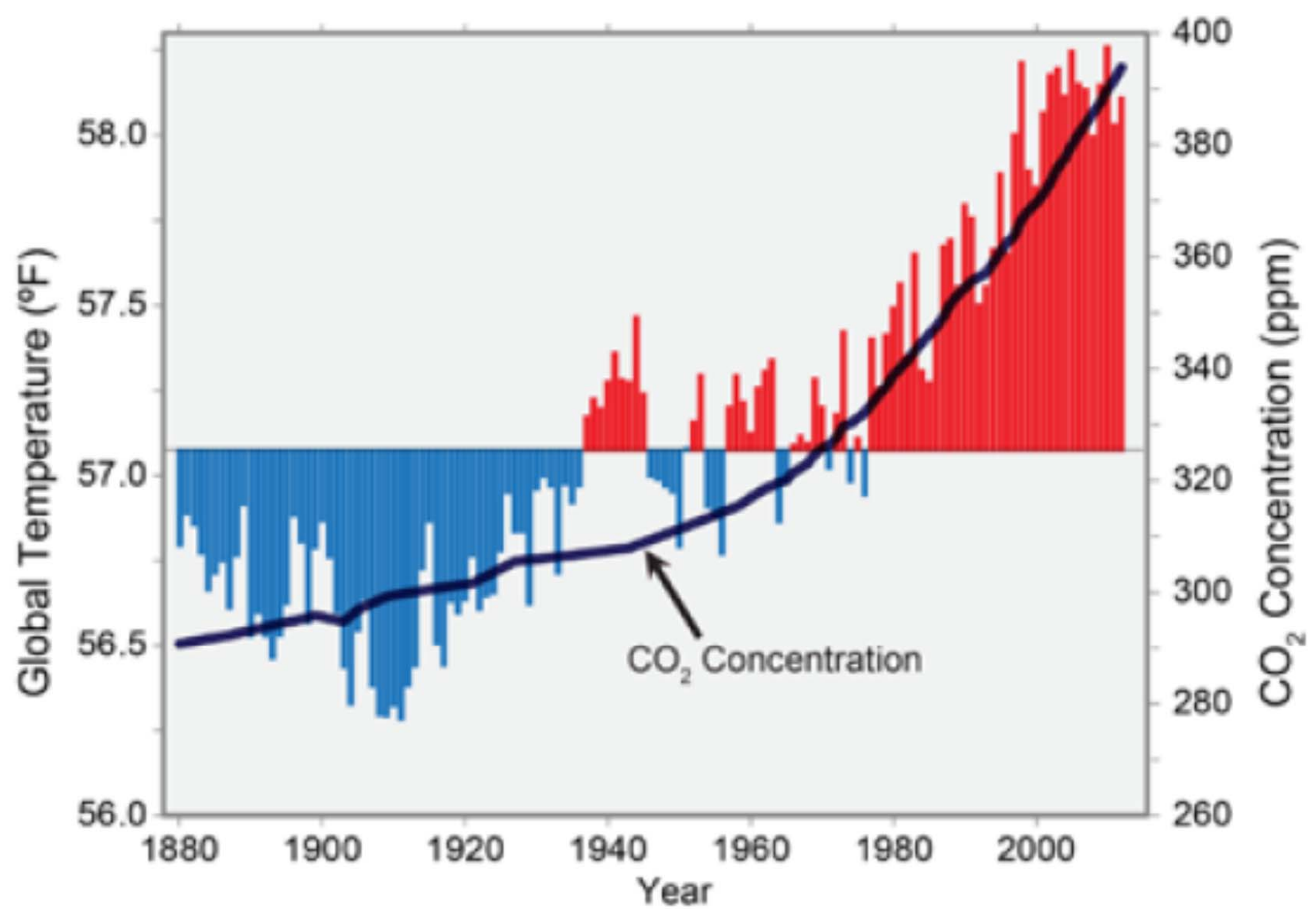
IPCC | INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

Derived from

- http://nca2014.globalchange.gov/

Global Temperature and Carbon Dioxide



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Separating Human and Natural Influences on Climate

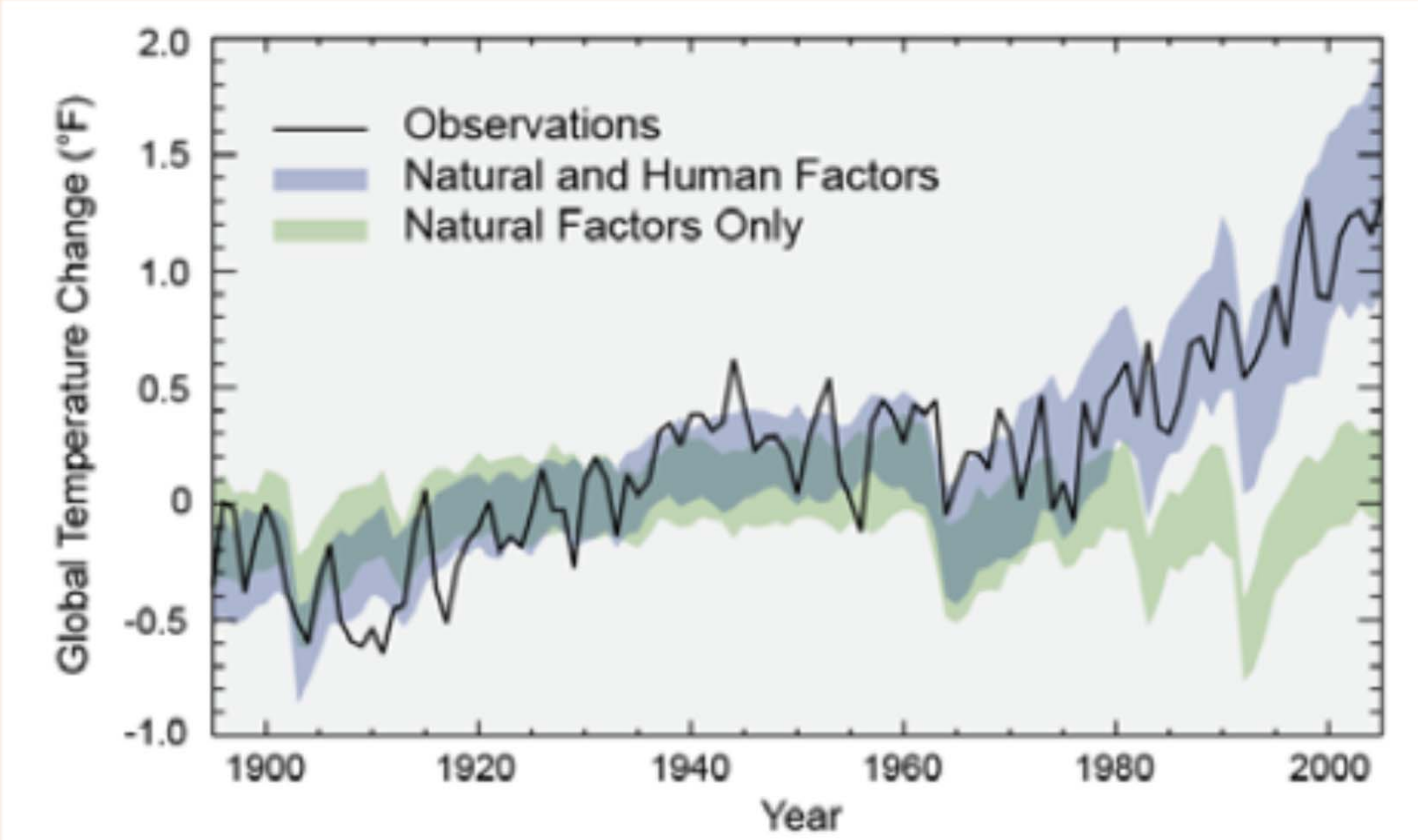
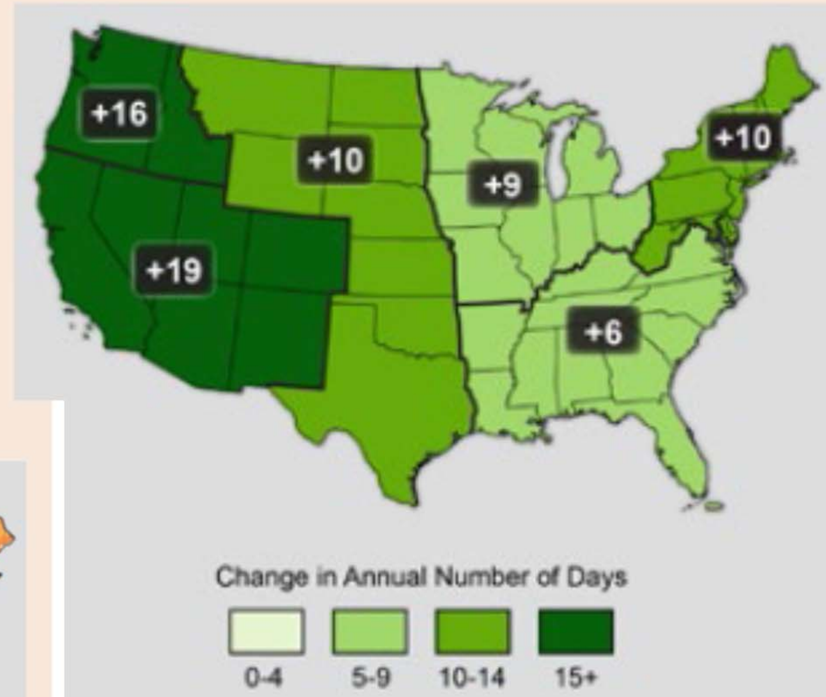


Figure 2.3. Observed global average changes (black line), model simulations using only changes in natural factors (solar and volcanic) in green, and model simulations with the addition of human-induced emissions (blue). Climate changes since 1950 cannot be explained by natural factors or variability, and can only be explained by human factors. (Figure source: adapted from Huber and Knutti[29]).

Observed Increase in Frost-Free Season Length



2.10. The frost-free season length, defined as the between the last occurrence of 32°F in the spring e first occurrence of 32°F in the fall, has increased in J.S. region during 1991-2012 relative to 1901-1960. ses in frost-free season length correspond to similar ses in growing season length. (Figure source: NOAA / CICS-NC).

Projected Changes in Frost-Free Season Length

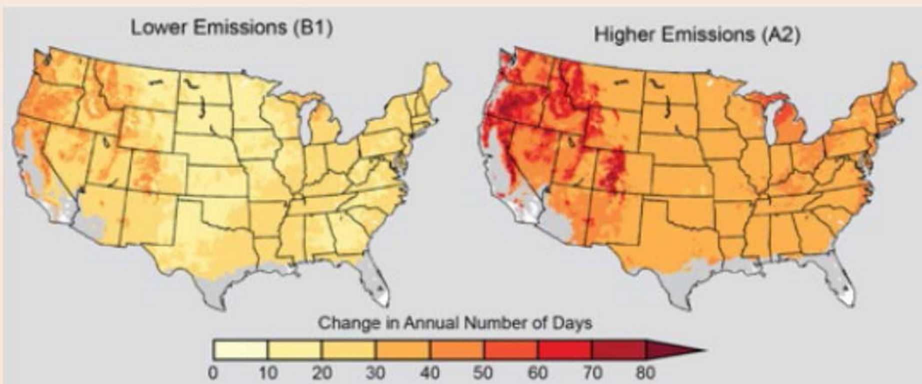


Figure 2.11. The maps show projected increases in frost-free season length for the last three decades of this century (2070-2099 as compared to 1971-2000) under two emissions scenarios, one in which heat-trapping gas emissions continue to grow (A2) and one in which emissions peak in 2050 (B1). Increases in the frost-free season correspond to similar increases in the growing season. White areas are projected to experience no freezes for 2070-2099, and gray areas are projected to experience more than 10 frost-free years during the same period. (Figure source: NOAA NCDC / CICS-NC).

Observed Change in Very Heavy Precipitation

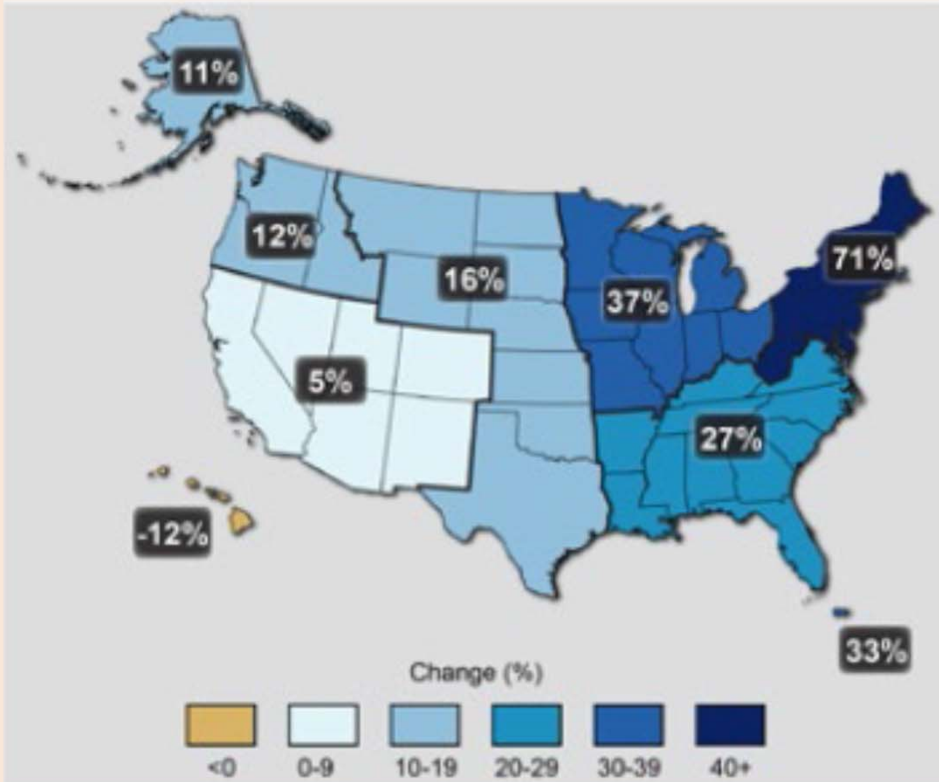


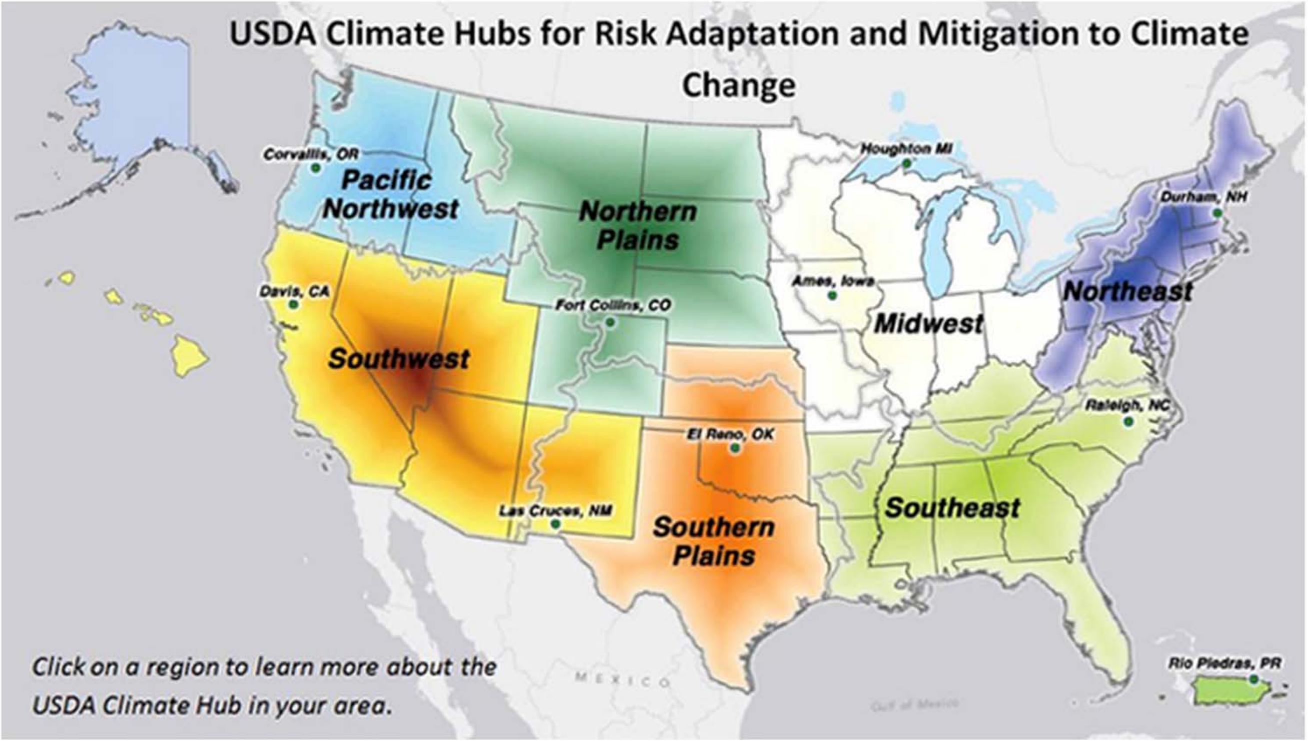
Figure 2.18. The map shows percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2012 for each region of the continental United States. These trends are larger than natural variations for the Northeast, Midwest, Puerto Rico, Southeast, Great Plains, and Alaska. The trends are not larger than natural variations for the Southwest, Hawai'i, and the Northwest. The changes shown in this figure are calculated from the beginning and end points of the trends for 1958 to 2012. (Figure source: updated from Karl et al. 2009[1]).

Trends in Flood Magnitude

Figure 2.21. Trend magnitude (triangle size) and direction (green = increasing trend, brown = decreasing trend) of annual flood magnitude from the 1920s through 2008. Local areas can be affected by land-use change (such as dams). Most significant are the increasing trend for floods in the Midwest and Northeast and the decreasing trend in the Southwest. (Figure source: Peterson et al. 2013[48]).

Climate Change and Corn

- USDA Midwest Regional Climate Hub (Jerry Hatfield)
- http://climatehubs.oce.usda.gov/
- http://climatehubs.oce.usda.gov/midwest-hub



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Impacts on Production

- Excessive precipitation in the spring, delaying planting and field operations
- Variable precipitation in the growing season causes the variation in production
- Extreme temperatures during the growing season affect plant growth and yield and livestock production
- Warm temperatures during the winter causes early flowering of perennials and risk of frost damage (2012 tart cherry in Michigan)
- Expanded ranges and intensity of insects and diseases

Source: Jerry Hatfield, USDA Midwest Climate Hub 2014

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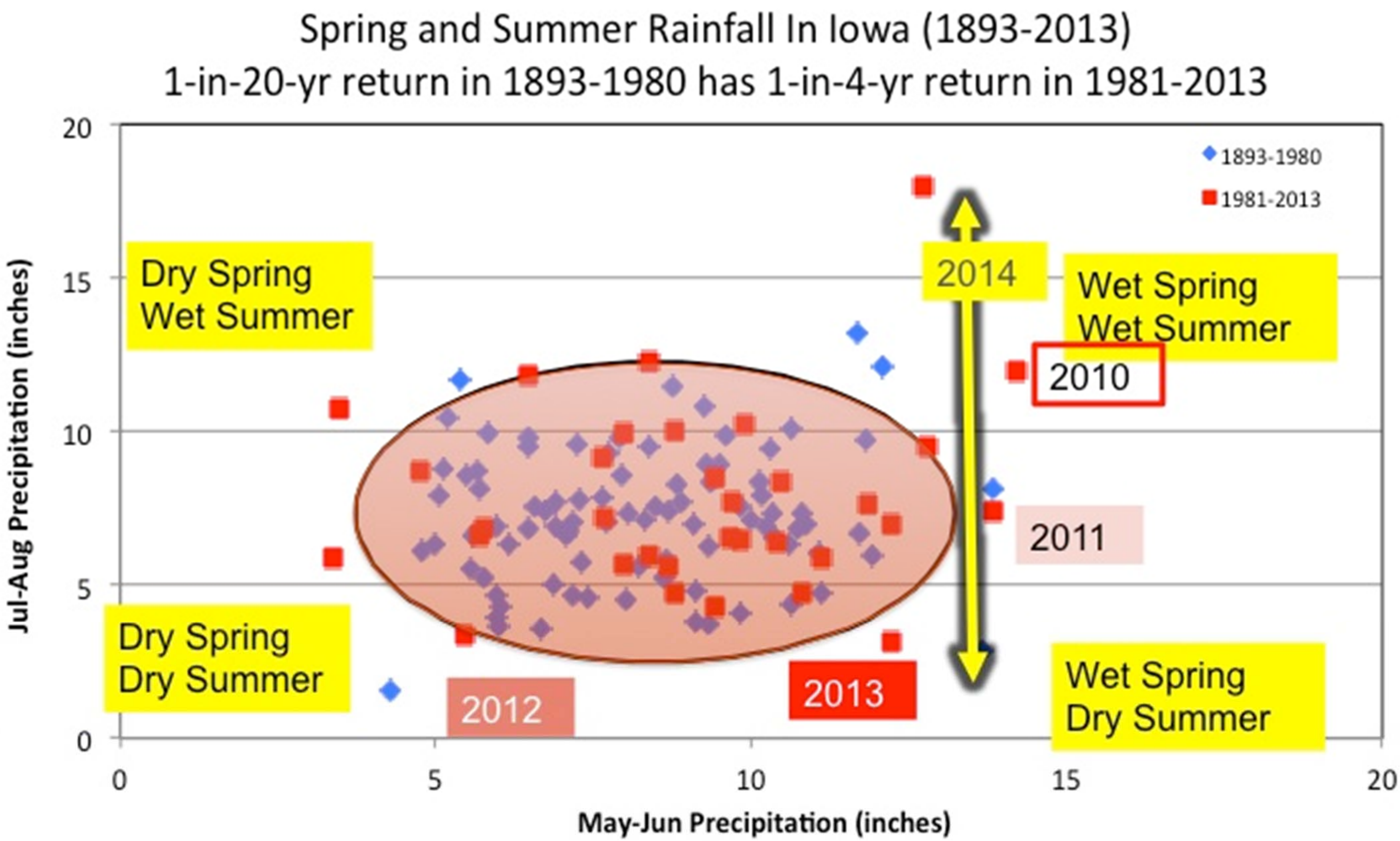
Weather Trend: Unusual combinations of spring and summer rainfall are occurring more often



Data Source: State of Iowa Climatologist

Erosion: How much is tolerable?

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SDSU South Dakota State University

WISCONSIN UNIVERSITY OF WISCONSIN–MADISON

IOWA STATE UNIVERSITY

MICHIGAN STATE UNIVERSITY

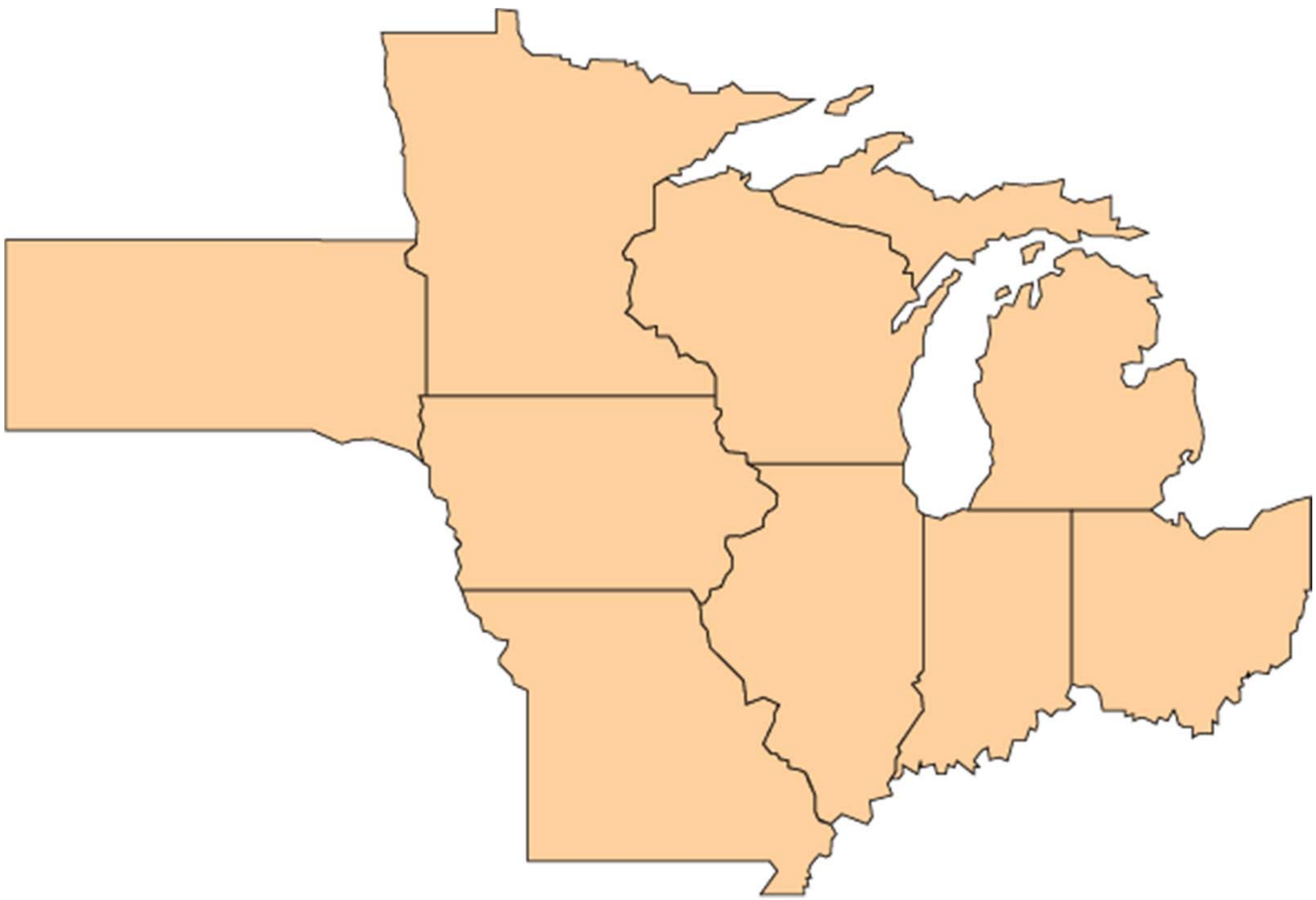
ILLINOIS

PURDUE UNIVERSITY

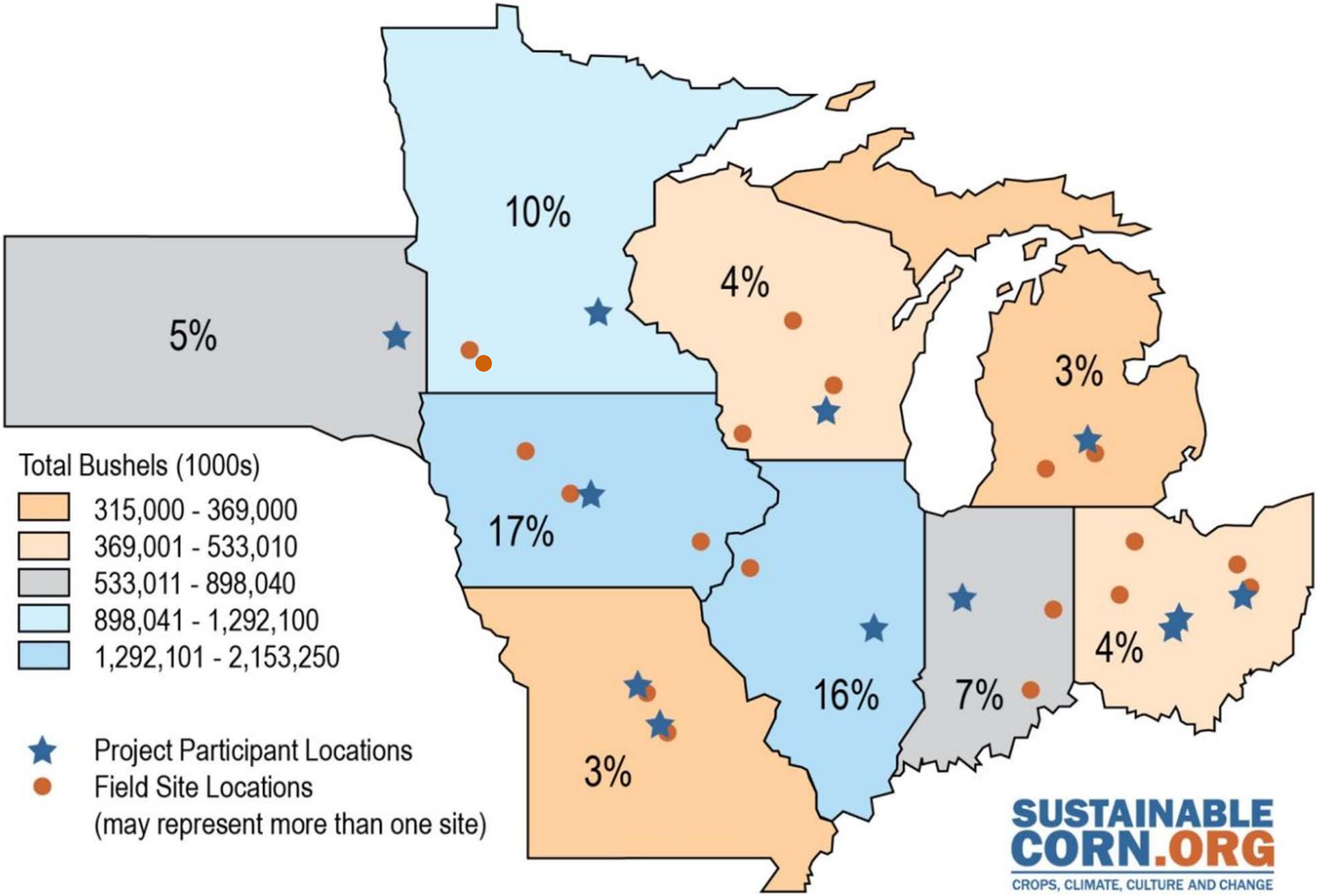
1866 LINCOLN University

THE OHIO STATE UNIVERSITY

USDA ARS Agricultural Research Service



Project Participants and Field Sites and 2010 Percent of U.S. Total Grain Harvest



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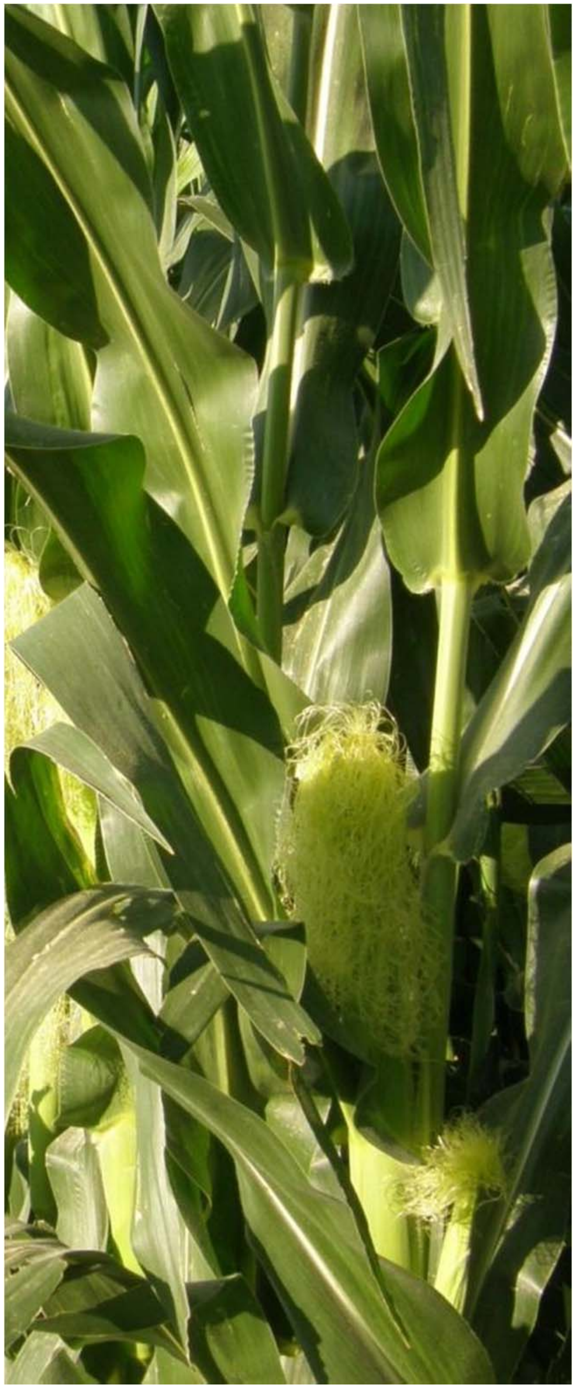

Agriculture and Climate

- Climate scientists agree that long-term weather patterns will continue to change; however, **there is great uncertainty and little research regarding how these global climate changes will impact local and regional cropping systems**.

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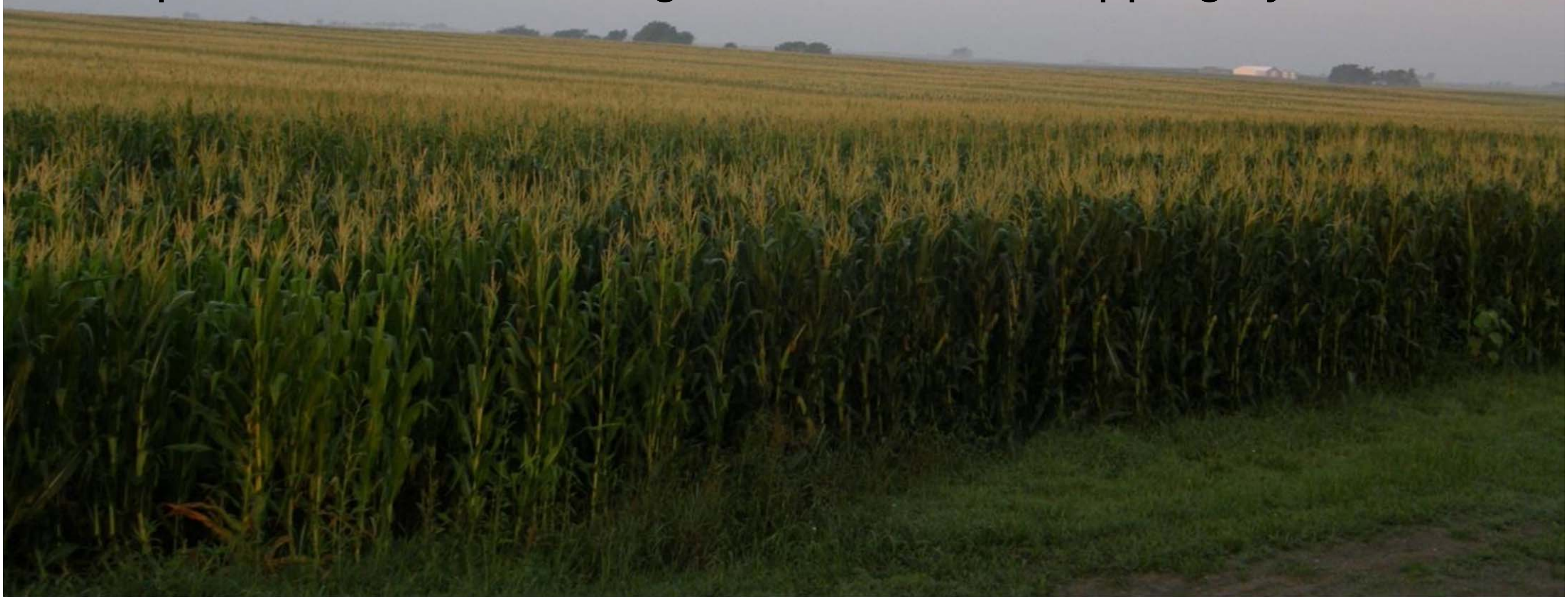
Climate and Agriculture in the Midwest

- Longer growing season - shifted frost dates
- Warmer winters
- Warmer nights
- More frequent severe precipitation events
- Greater annual stream flows
- Increased humidity within canopy

Climate & Corn-based Cropping Systems CAP Vision

- To create new science and educational opportunities as a transdisciplinary team
- To develop science-based knowledge that addresses climate mitigation and adaptation, informs policy development, and guides on-farm, watershed level and public decision making in corn-based cropping systems



Team's research, extension, and education goals directed to specifically:

CARBON

Retain more soil carbon resulting in improved soil quality and sustainability

NITROGEN

Limit the loss of nitrogen during seasonal peaks observed within Midwestern systems that have naturally rich soils and fertilizer applications

WATER

Stabilize soil and nutrients during periods of saturated and flooded conditions while improving water availability and efficiency for crop use during moisture stress conditions

SYSTEMS

Build system resilience by integrating productivity and environmental goals through field, farm, watershed and landscape level management in the face of changing climate

STAKEHOLDERS

Transfer knowledge and findings through science-driven, experiential learning opportunities to equip and educate farmers and teachers

The CSCAP Team

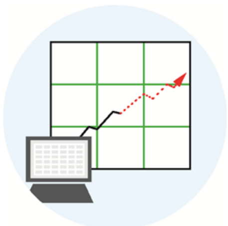
A transdisciplinary project integrates the knowledge of many specializations to make a quantum leap beyond disciplinary sciences to create new collaborative knowledge, leading to new understanding of difficult and complex problems.

- 140-person team of scientists, graduate students and topic-based specialists
- More than 19 disciplines
- 10 Land Grant Universities & USDA-ARS
- 35 field research sites in 8 states
- 20 dedicated extension educators
- 35 graduate students
- 20 advisory board members

Organized into Six Objectives

1. Develop standardized methodologies and perform baseline monitoring of carbon, nitrogen and water footprints at agricultural test sites across the Midwest.

2. Evaluate how crop management practices impact carbon, nitrogen and water footprints at test sites.

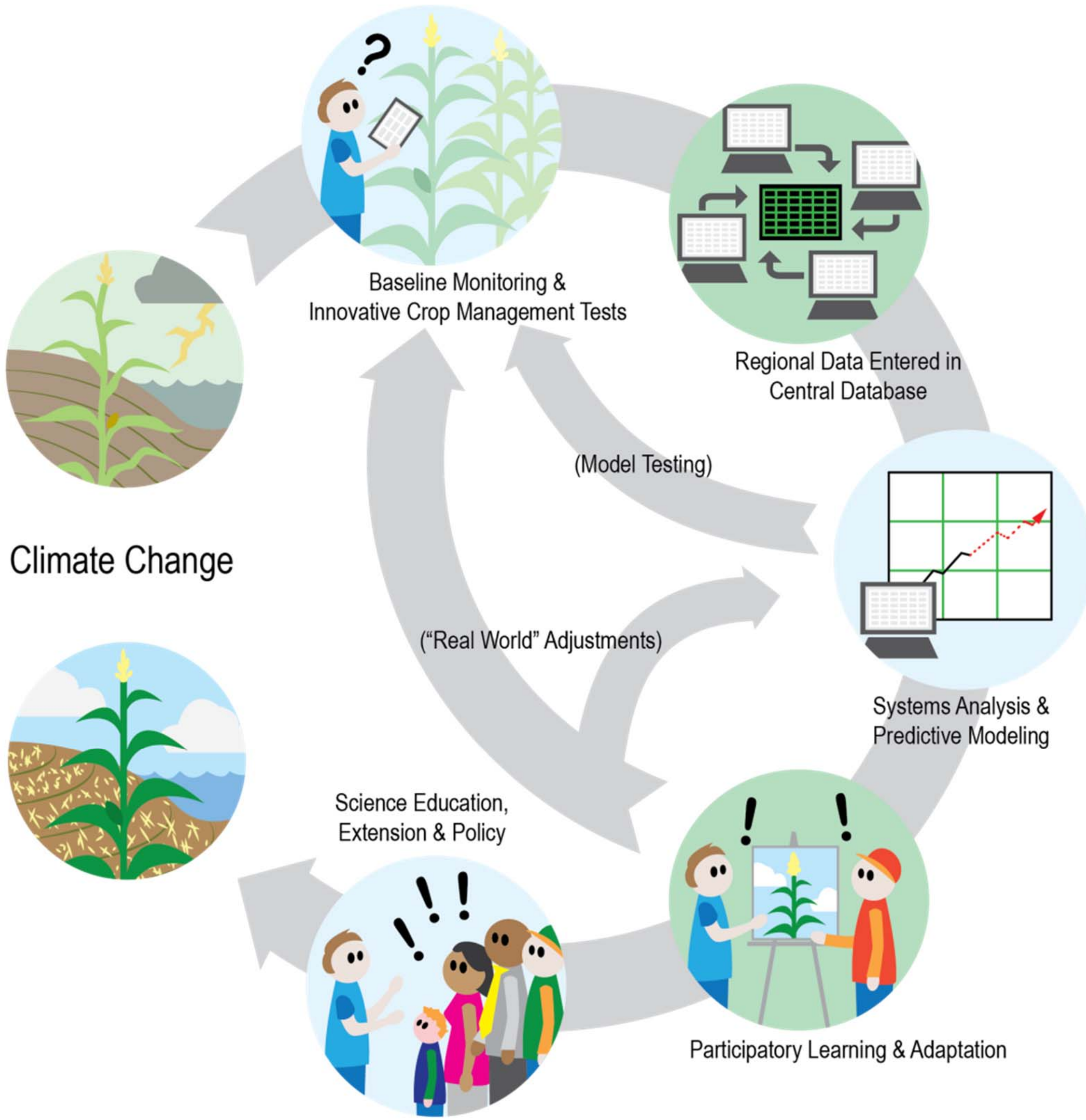


3. Apply models to research data and climate scenarios to identify impacts and outcomes that could affect the sustainability and economic vitality of corn-based cropping systems.

4. Gain knowledge of farmer beliefs and concerns about climate change, attitudes toward adaptive and mitigative strategies and practices, and decision support needs to inform the development of tools and practices that support long-term sustainability of crop production.

5. Promote extension, outreach and stakeholder learning and participation across all aspects of the program.

6. Train the next generation of scientists, develop science education curricula and promote learning opportunities for high school teachers.


Baseline Monitoring &
Innovative Crop Management Tests
Regional Data Entered in
Central Database
(Model Testing)
Climate Change
("Real World" Adjustments)
Systems Analysis &
Predictive Modeling
Science Education,
Extension & Policy
Participatory Learning & Adaptation

(1) Develop standardized methodologies and perform baseline monitoring of carbon, nitrogen and water footprints at agricultural test sites across the Midwest

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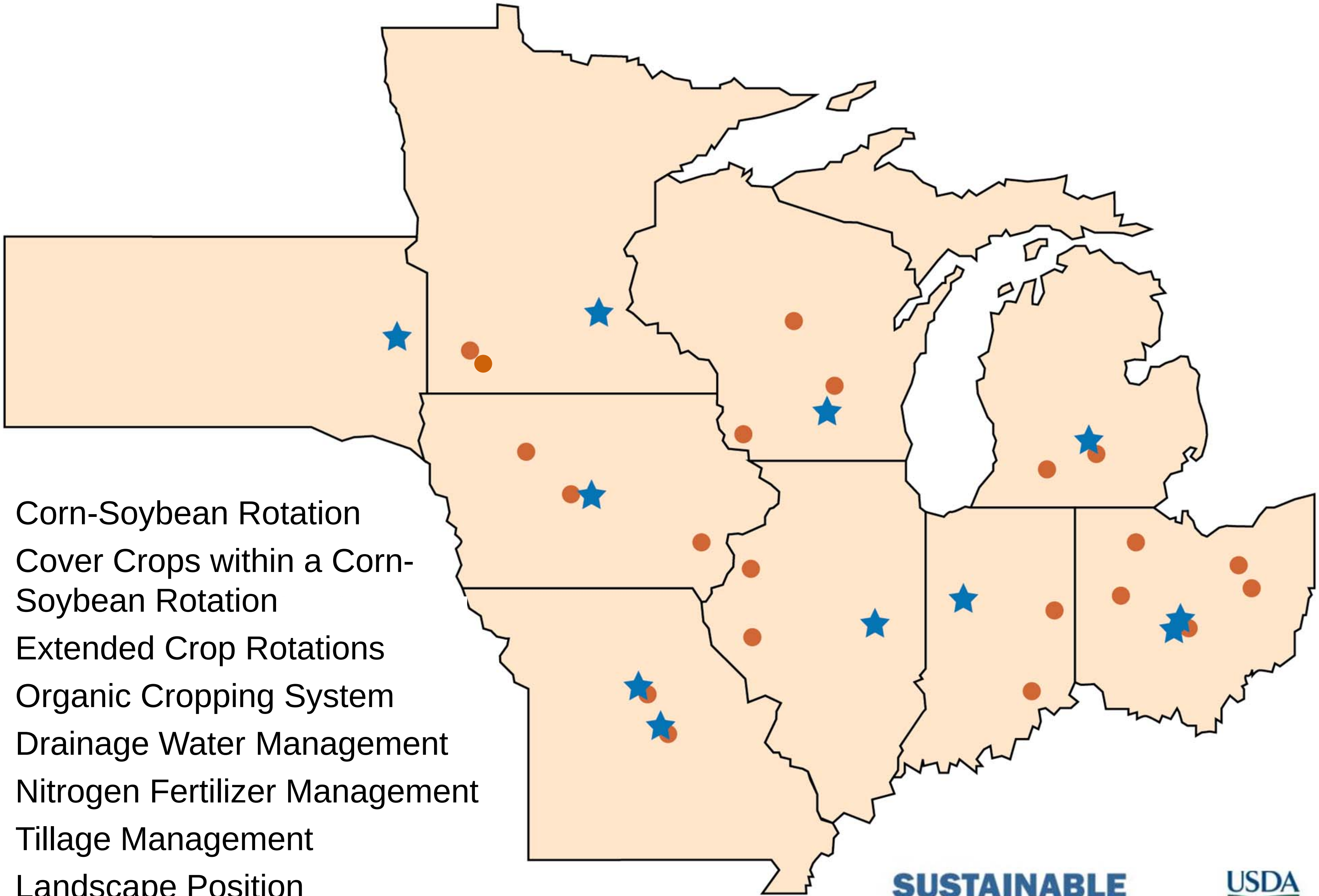
(2) Evaluate how crop management practices impact carbon, nitrogen and water footprints at test sites

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

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Measuring GHG—Rattan Lal

President Obama announced on June 2, 2014, that the US Environmental Protection Agency would cut carbon (C) emissions from the US power sector by up to 30% and soot and smog pollution by 25% by 2030 relative to 2005 levels (Kintisch 2014). There will also be an additional water demand of 40% by 2030, in which soil-water storage (e.g., green water) will play a crucial role (Rosegrant et al. 2002).

Source: Rattan Lal's article in the Special Issue of the Journal of Soil and Water Conservation Nov.-Dec 2014

Nsalambi Nkongolo, Lincoln University

Example of Objective 2 Reseach: Warren Dick—Ohio State University

Long-term No-till
Corn-Soybean Plots (OARDC, Wooster)

Waren Dick

Introduction

- **Methane (CH_4) is a potent greenhouse gas found at lower concentrations in the atmosphere than CO_2. However, methane's global warming potential is 23x greater that that of CO_2.**

- **Methanotrophs, or methane-oxidizing bacteria (MOB):**
  - are present in aerobic soils
  - oxidize methane and use it as sole source of carbon and energy
  - serve as the only known biological sink of atmospheric methane,
  - are divided into two main groups based on carbon assimilation pathway

- **Land-use practices (e.g. no-tillage) impact rates of methane oxidation in soil**

Hypothesis

Variation in methane-oxidation rates in soils under different land-use practices is indicative of methane-oxidizing bacterial diversity in those soils

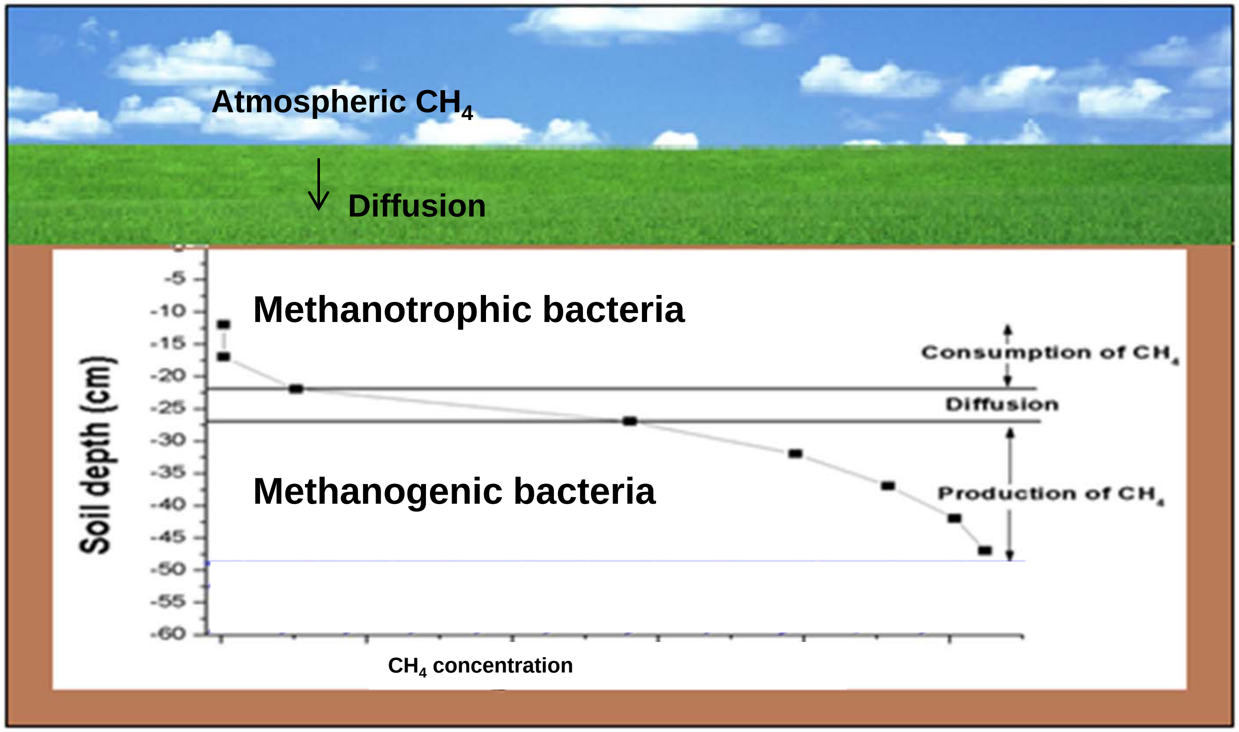

Figure 1. Scheme of methane consumption and emission in soil (Adapted from Wetlands Research, 2009)

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Conclusions

- **Long-term no-tillage soils have higher methane oxidation rates (Jacinthe et al., 2014) than tilled soils and are a sink for this greenhouse gas.**
- **Methane-oxidizing bacteria comprise less than 6% of the entire bacterial community.**
- **This work has identified those methane-oxidizing bacteria that we must manage to improve no-tillage soils as sinks for methane.**
- **The graduate student on this project has become skilled in bioinformatics to analyze large DNA databases. This is an important skill that is highly valued.**

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Drainage –USDA ARS (Norm Fausey)

In general, plots under no-till with subsurface drainage produced lower emissions compared to those under chisel till. Subsurface drainage lowered the emissions compared to those under no drainage. Results from this study concluded that subsurface drainage in poorly drained soils with long-term no-till practice can be beneficial for the environment by emitting lower GHG fluxes compared to tilled soils with no drainage.

Source: S.Kumar, T. Nakajima, A.Kodono, R. Lal, and N. Fausey 2014 Special Issue Journal of Soil and Water Conservation

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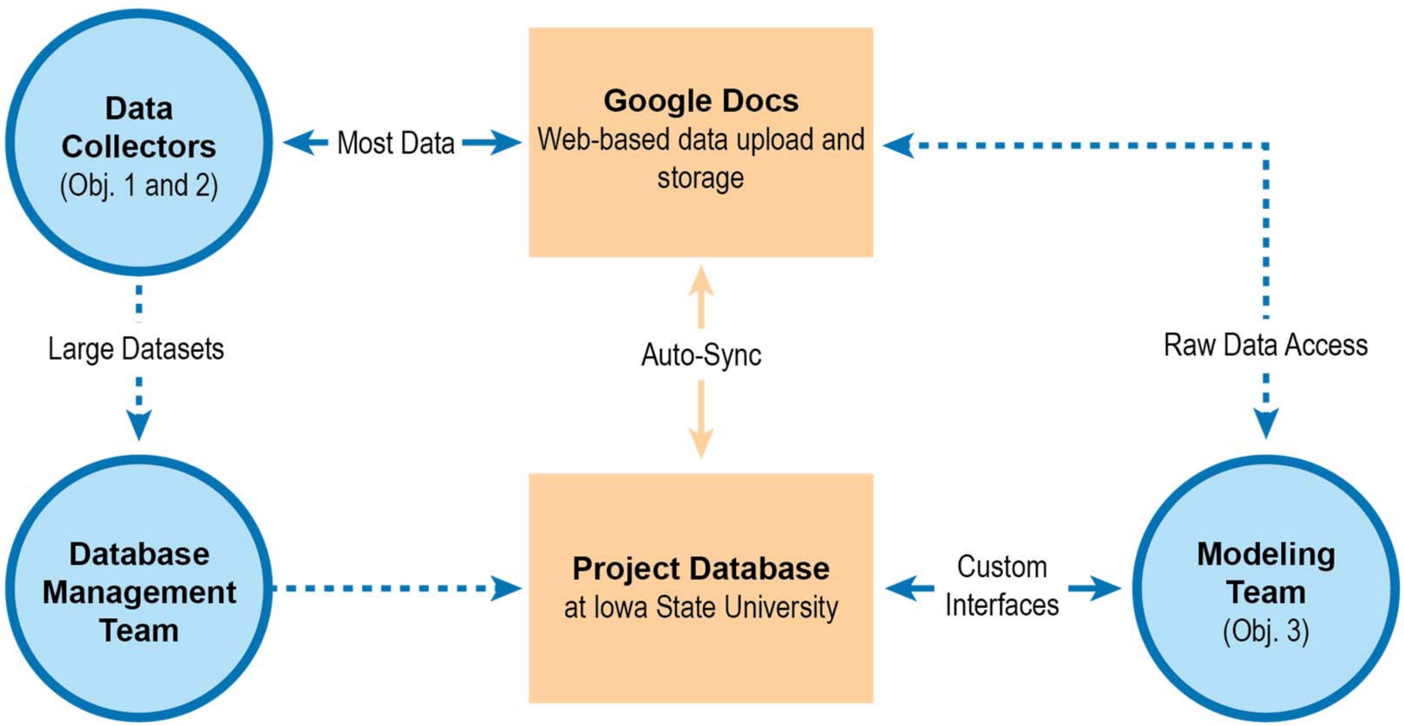
Central Database

- Field Research Trials
- Watershed Based Survey Data
- Farmer Interview Data



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(3) Systems Analysis & Predictive Modeling

- Apply models to research data and climate scenarios to identify impacts and outcomes that could affect the sustainability and economic vitality of corn-based cropping systems.

- Determine the optimal targeting of cover crops, drainage management, and other conservation practices within a corn-based cropping system for a variety of possible environmental goals and under most likely future climate scenario.

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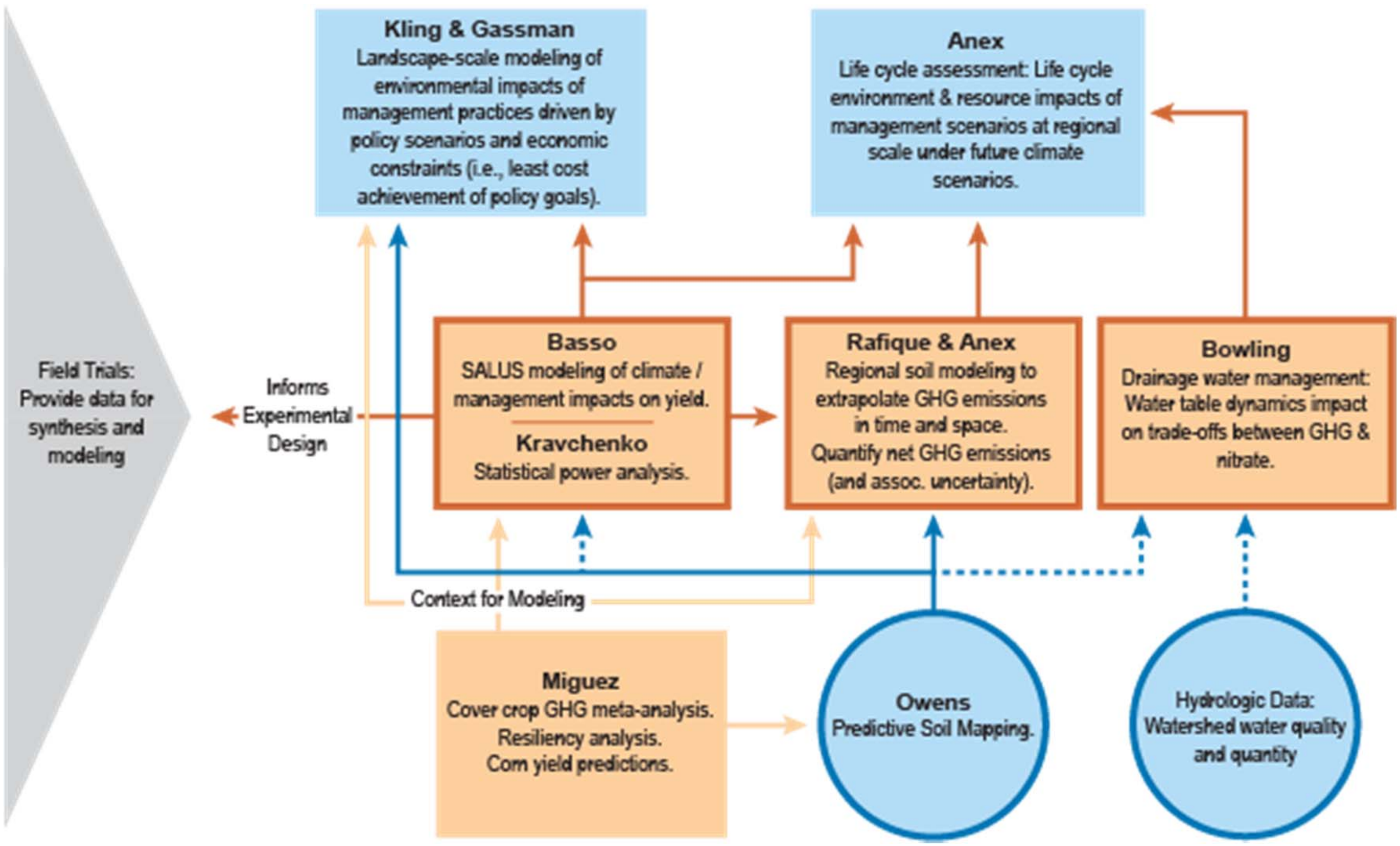
(3) Systems Analysis & Predictive Modeling



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(4) Social & Economic Research

- Gain knowledge of farmer beliefs and concerns about climate change, attitudes toward adaptative and mitigative strategies and practices, and decision support needs to inform the development of tools and practices that support long-term sustainability of crop production.
- Survey of nearly 20,000 farmers in top 22 corn-producing HUC6 watersheds in the upper Midwest.
- Co-produced by CSCAP and U2U project

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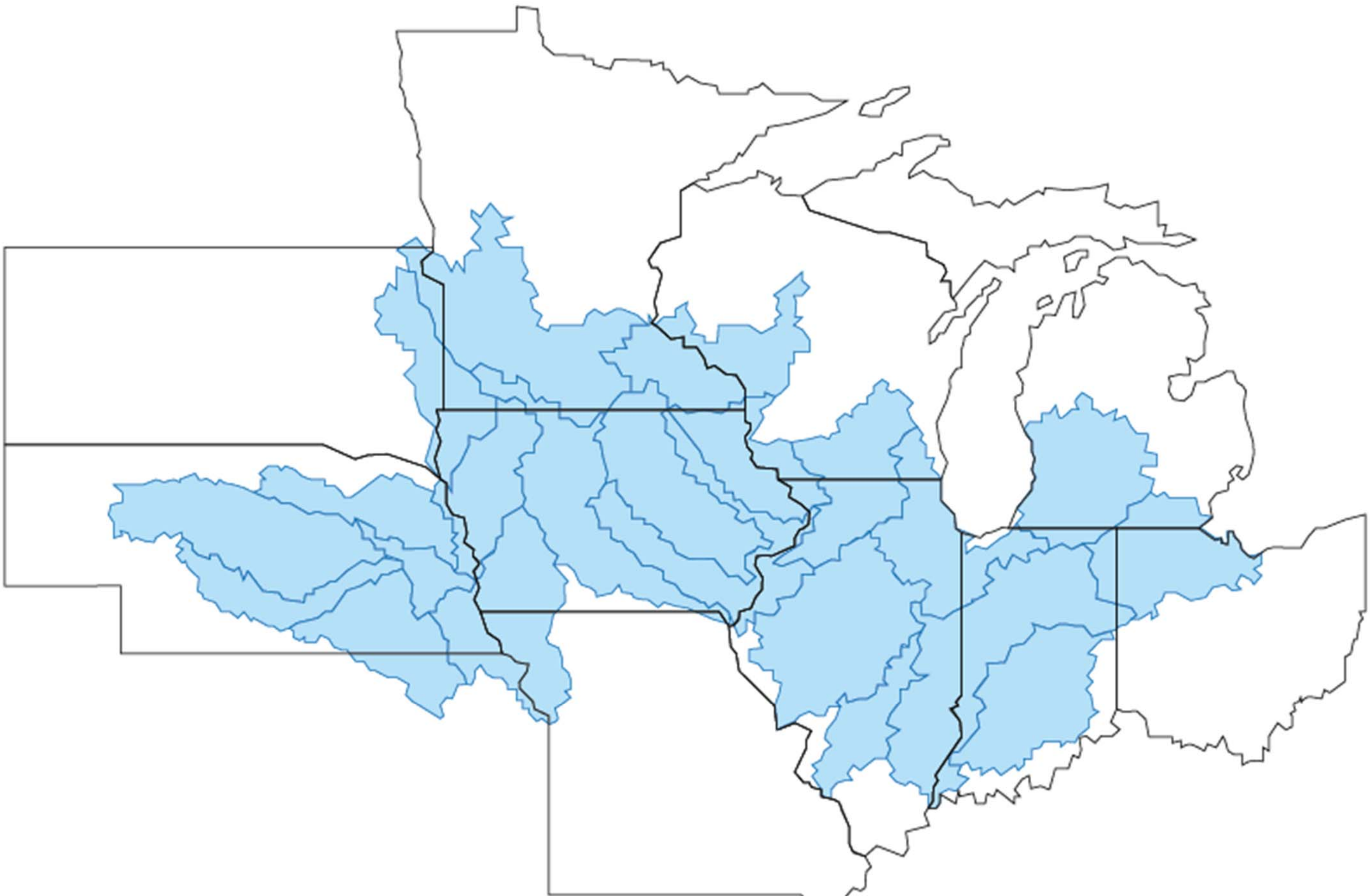
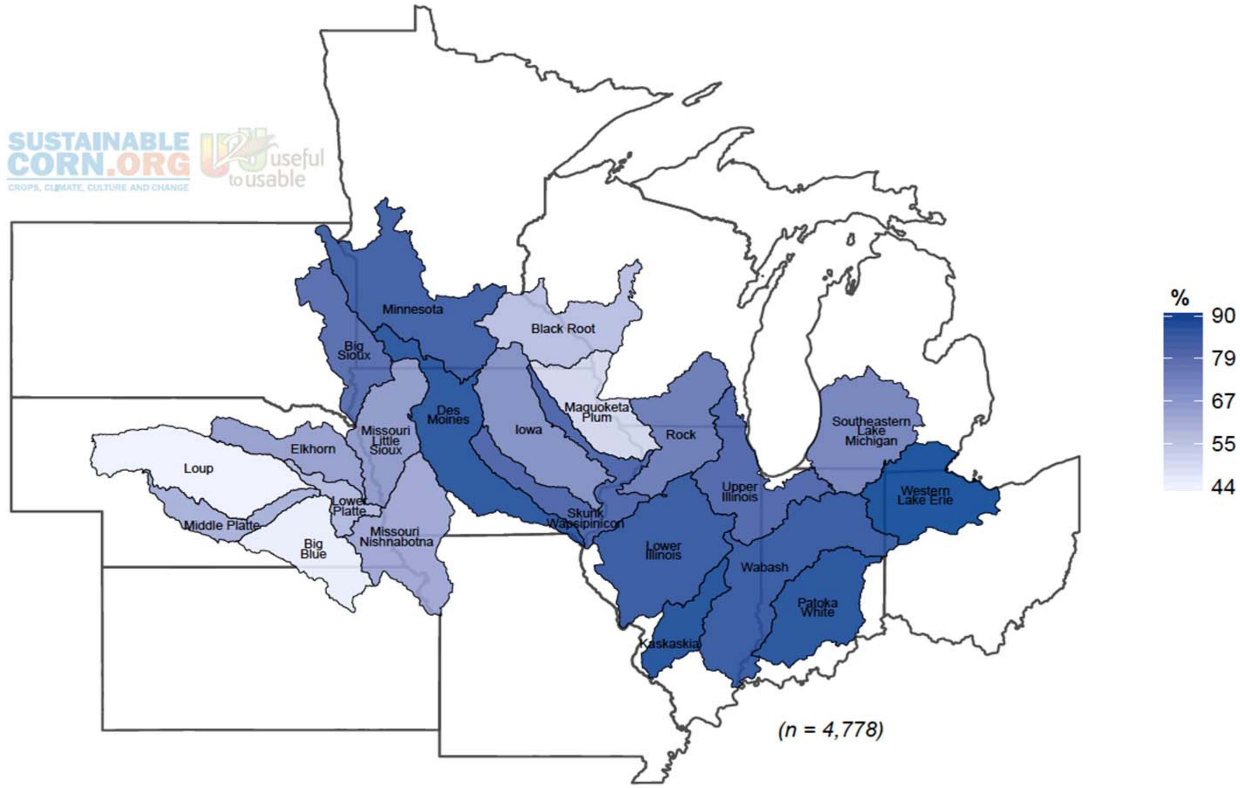


Corn Farmers' Attitudes about Climate Change--water



Map 32. Experienced significant problems with saturated soils or ponding over the past five years (2007–2011), percent.

Source: Loy, Adam, Jon Hobbs, J. Gordon Arbuckle Jr., Lois Wright Morton, Linda Stalker Prokopy, Tonya Haigh, Tricia Knoot, Cody Knutson, Amber Saylor Mase, Jean McGuire, John Tyndall, and Melissa Widhalm, 2013. Farmer Perspectives on Agriculture and Weather Variability in the Corn Belt: A Statistical Atlas. CSCAP 0153-2013. Ames, IA: Cropping Systems Coordinated Agricultural Project (CAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems.

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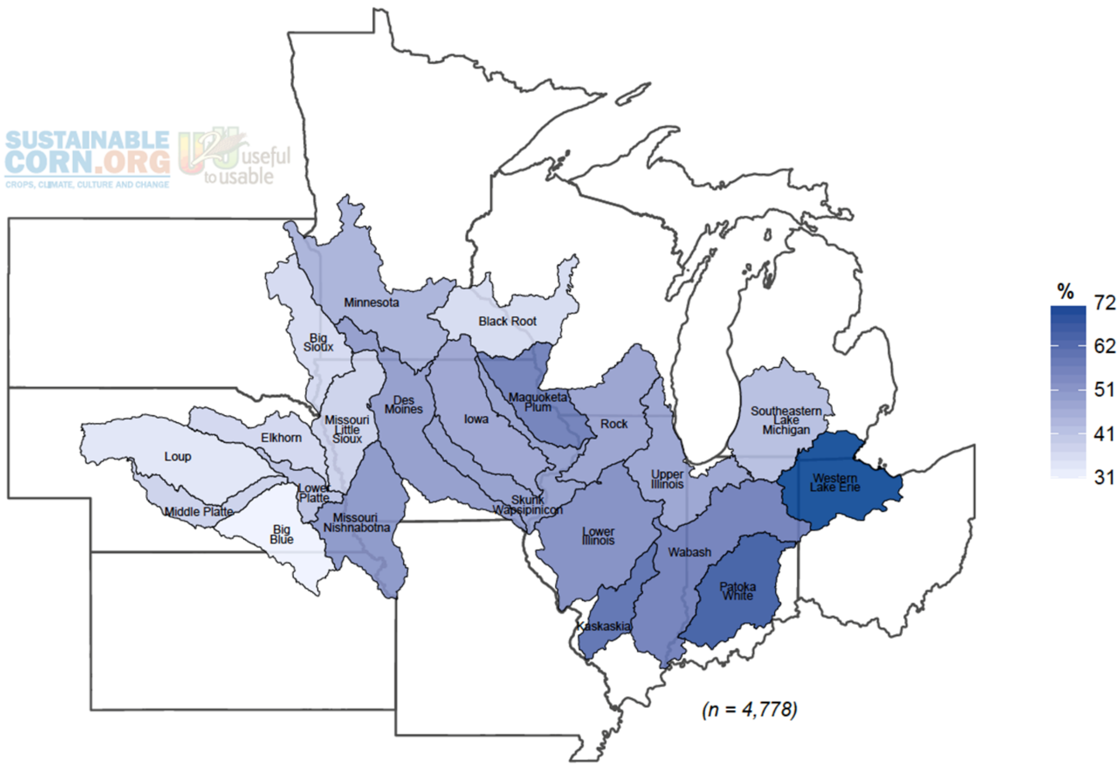
Corn Farmers' Attitudes about Climate Change--rain



Map 26. More frequent extreme rains (Q5F), percent concerned or very concerned.

Source: Loy, Adam, Jon Hobbs, J. Gordon Arbuckle Jr., Lois Wright Morton, Linda Stalker Prokopy, Tonya Haigh, Tricia Knoot, Cody Knutson, Amber Saylor Mase, Jean McGuire, John Tyndall, and Melissa Widhalm, 2013. Farmer Perspectives on Agriculture and Weather Variability in the Corn Belt: A Statistical Atlas. CSCAP 0153-2013. Ames, IA: Cropping Systems Coordinated Agricultural Project (CAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems.

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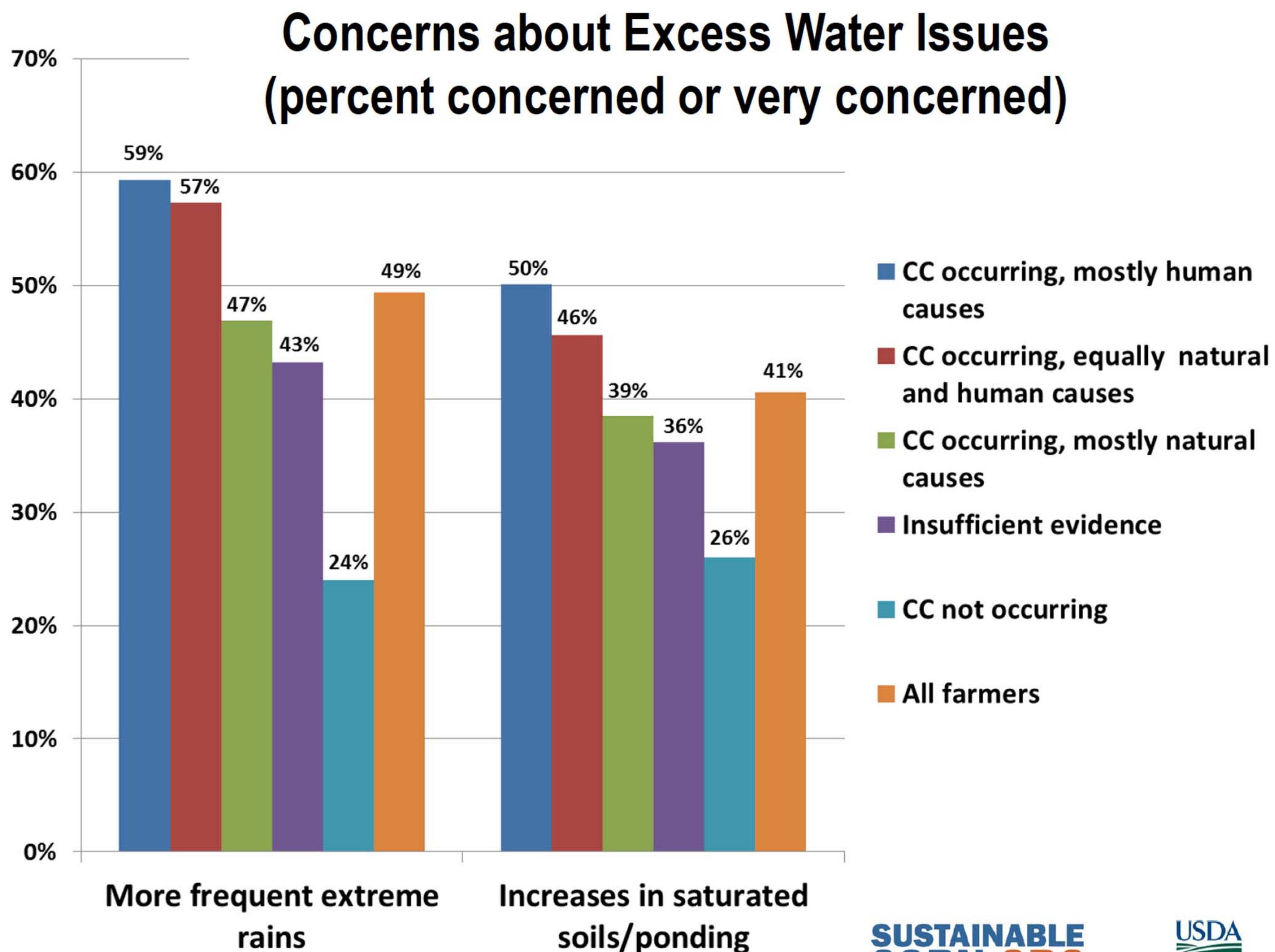

Source: J.Arbuckle ASA presentation October 24, 2012

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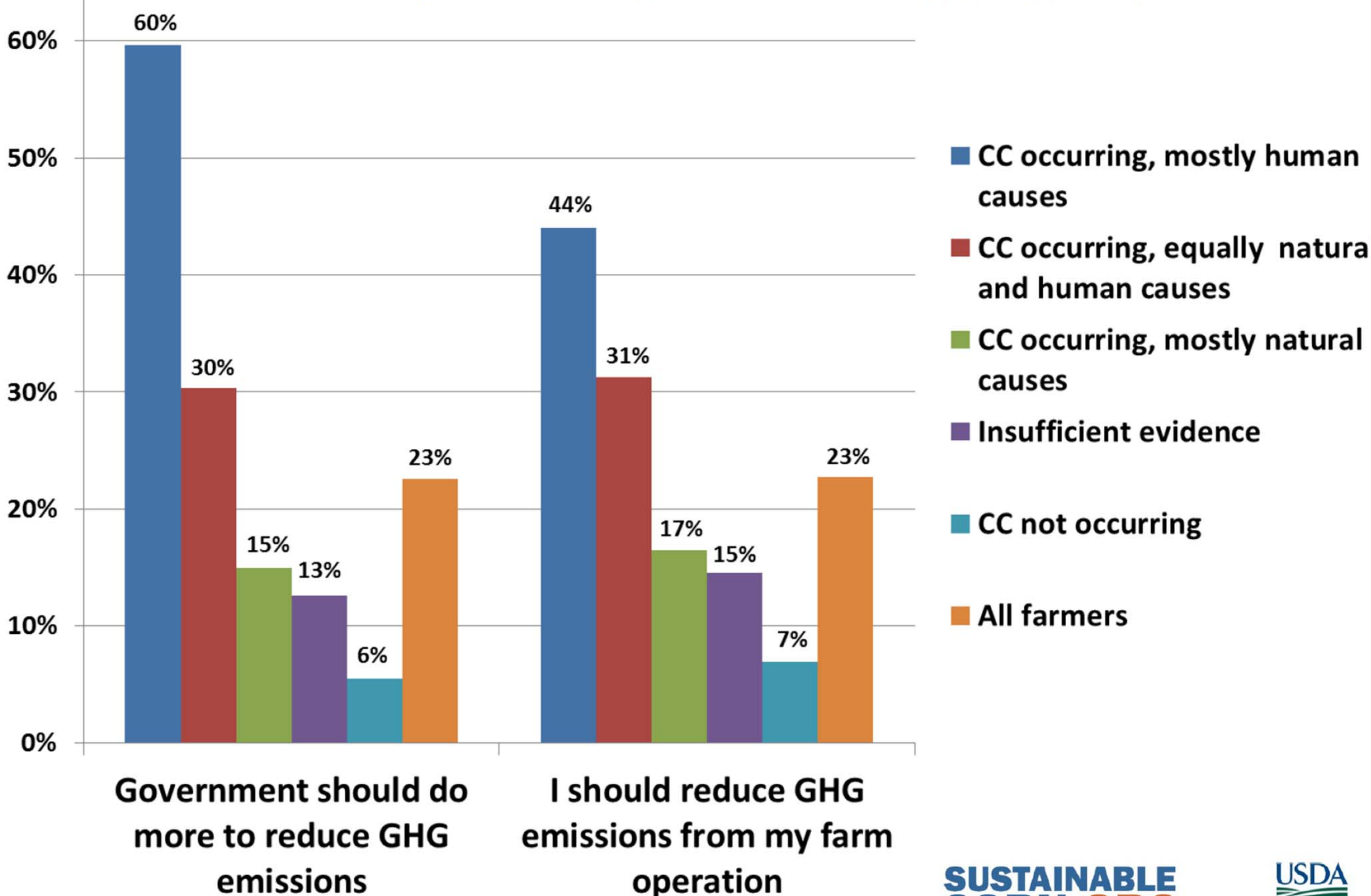
Support for Collective and Individual Mitigation (percent agree or strongly agree)



Source: J.Arbuckle ASA presentation October 24, 2012

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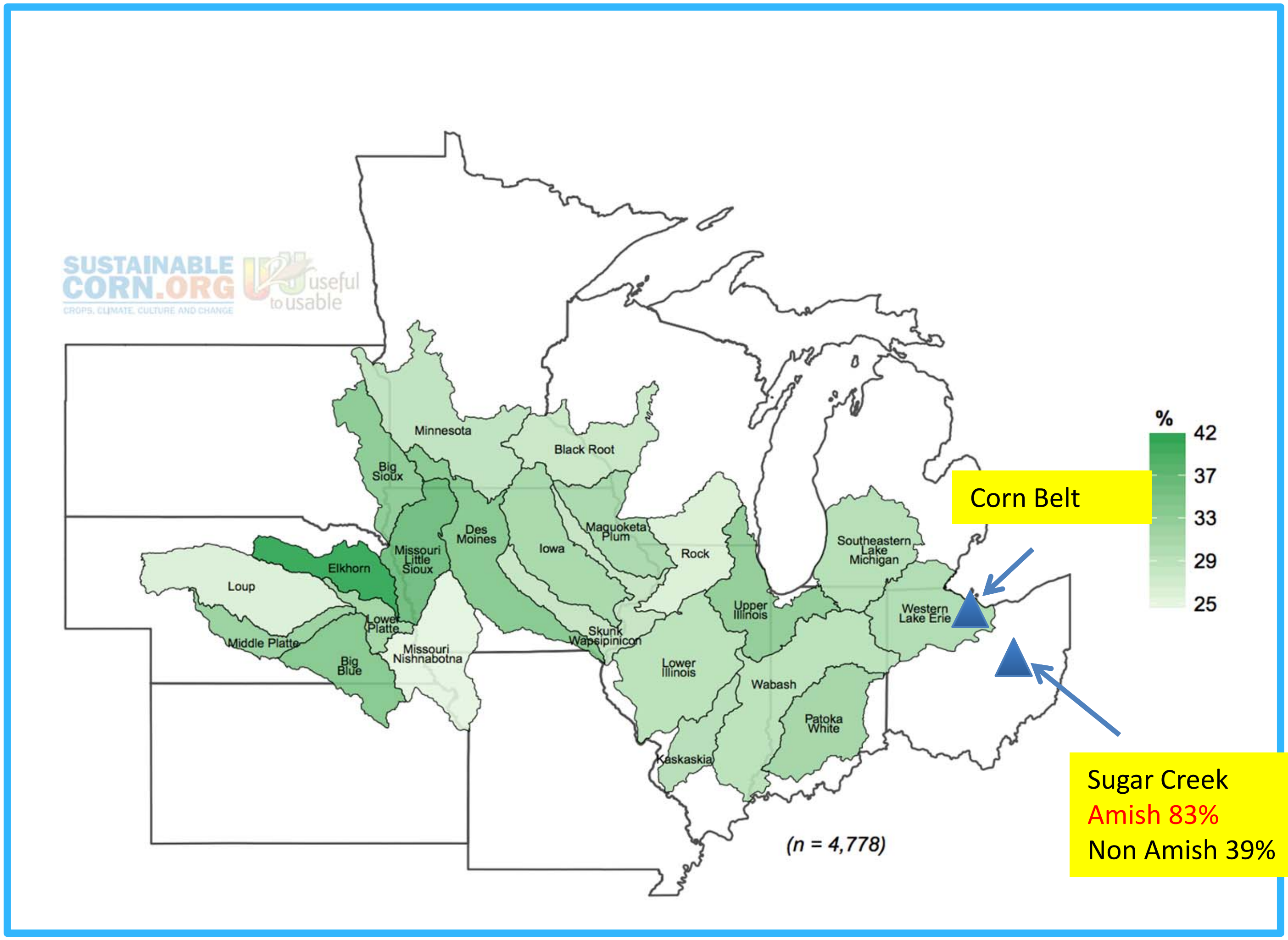
USA CORN BELT FARMERS ATTITUDES ABOUT CLIMATE CHANGE: "Insufficient Evidence to know with certainty whether climate change is occurring or not".



Source: Loy, Adam, Jon Hobbs, J. Gordon Arbuckle Jr., Lois Wright Morton, Linda Stalker Prokopy, Tonya Haigh, Tricia Knoot, Cody Knutson, Amber Saylor Mase, Jean McGuire, John Tyndall, and Melissa Widhalm, 2013. Farmer Perspectives on Agriculture and Weather Variability in the Corn Belt: A Statistical Atlas. CSCAP 0153-2013. Ames, IA: Cropping Systems Coordinated Agricultural Project (CAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems.

Farmers' Attitudes about Climate Change (2012)

	Corn Belt	SC Non Amish	SC Amish
Human	7.80%	14.29%	8.33%
Human Natural Combo	33.10%	4.76%	0.00%
Natural	24.60%	33.33%	8.33%
Insufficient Evidence	30.90%	33.33%	83.33%
Not Occurring	3.50%	0.00%	0.00%

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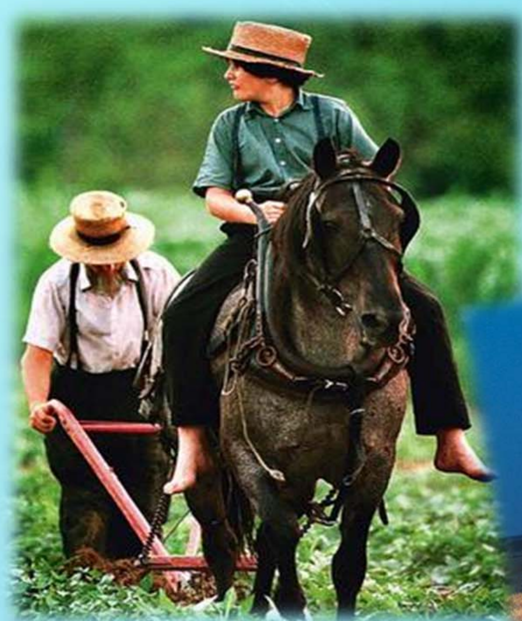
Summer Interns' Hypothesis:

Individuals, who chose "insufficient data" as an answer to the 2012 survey about agreeing or disagreeing about climate change, would have a wide range of specific reasons.

Source: http://www.dreamstime.com/royalty-free-stock-photo-rich-earth-image1400985

Source: http://farmon.com/pages/e-mag/ag-ovations/who-is-farmon-and-why-should-we-care-if-young-farmers-farm.aspx

The broad answers to these questions would be based on their own farming experience and that these reasons were based on their local experiences.



Source: http://www.brisbanetimes.com.au/news/united-states/a-peek-under-the-bonnets/2008/01/16/1200419875292.html

Source: http://www.pegtopfarm.co.uk/The-Farm-Today(792911).htm

Source: http://modernfarmer.com/2013/11/old-time-farm-kids/

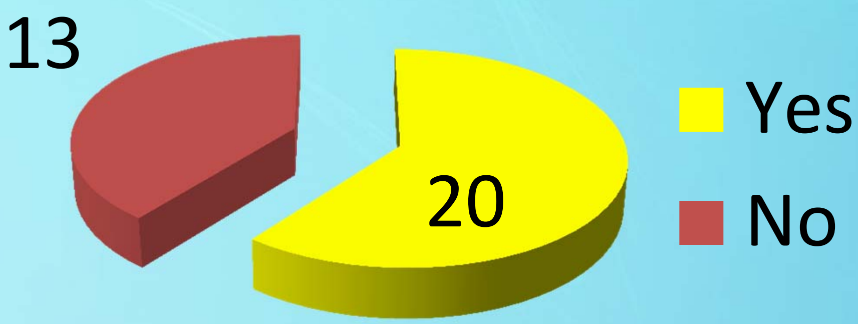
On Saturday, July 19, R. Moore’s intern team conducted surveys at a Family Farm Day event in Dundee. The remaining surveys were selected at random from about 3,000 farms in the Sugarcreek Watershed.

Unique Stories:

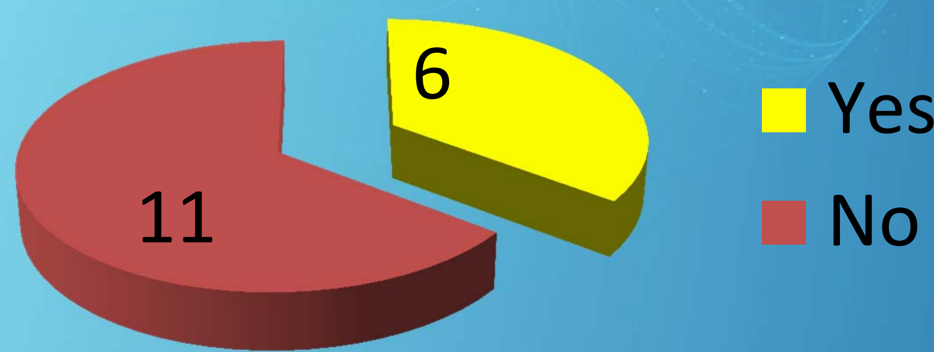
- Keeping Animals in the barn/feeding more
- Blocked up windows
- Thawed pipes with hair dryers
- Waited to plant
- Wrapping the barn/beehives in plastic/black cardboard/tarp
- Feed bags for insulation

Is flooding occurring more often?

Amish:



English:



One Amish female noted that though she does not believe flooding is occurring, she believes **climate change** is occurring.

(5) Extension: Promote extension, outreach and stakeholder learning and participation across all aspects of the program

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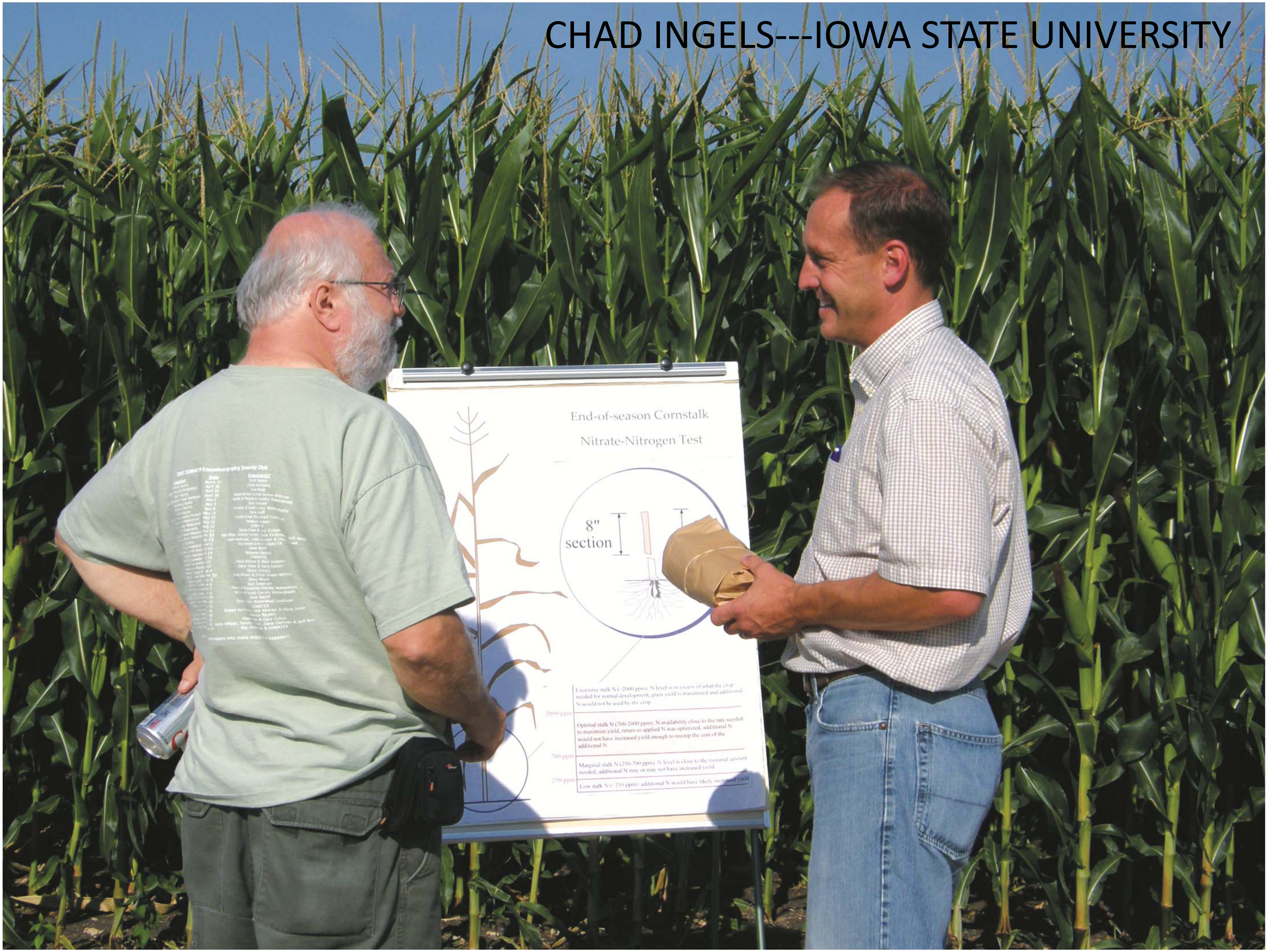
CHAD INGELS---IOWA STATE UNIVERSITY
End-of-season Cornstalk
Nitrate-Nitrogen Test
8"
section

(6) Education: Train the next generation of scientists, develop science education curricula & promote learning opportunities for HS teachers

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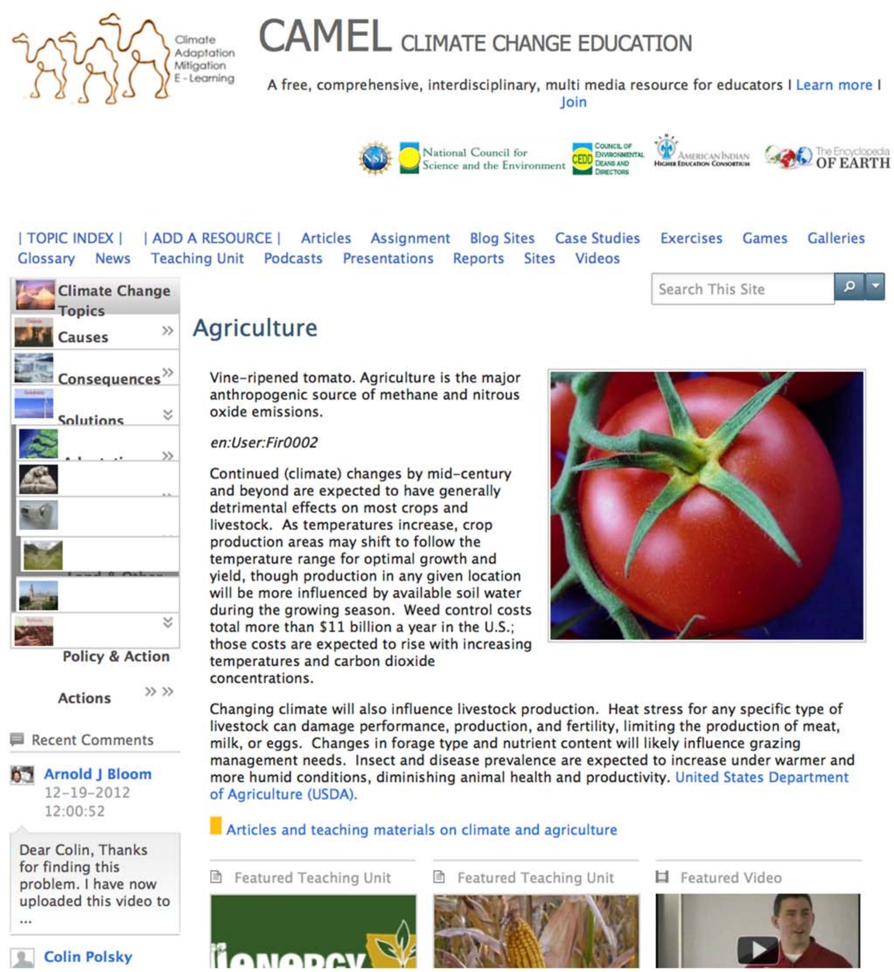
Stone Lab Course SENR 5194
Climate and Sustainability

Nitrates

Lake Erie Algal Bloom/hypoxia
in Sandusky Bay

National Council for Science and the Environment CAMEL Project



SPEED SCIENCE VIDEOS

http://www.camelclimatechange.org/


CSCAP GRADUATE STUDENTS

Undergraduate & Graduate Students: Climate Camps at Iowa State U. and Lincoln U.

Some factors to consider for Lake Erie Corn Farms

- **Rising temperature**
  - Increasing growing season lengths
- **Greater *variability* of temperature**
  - Higher night time lows
  - Extreme swings over short time periods
  - Periods of extreme heat, cold
  - Timing of frost events

Source: Dennis Todey

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Some factors to consider for Lake Erie Corn Farms

- Changes of precipitation *patterns*
  - Some places drier, others wetter
  - Decreased snowfall
- Greater *variability* of precipitation
  - More short, intense events
  - Shift of timing
- More severe weather events
  - Hail, storms, wind, etc.

Some factors to consider for Lake Erie Corn Farms

- Flexibility of production—more varieties, shorter season varieties, different crops
- Cover crops and less tillage=less GHG
- Build a resilient system to withstand the increased number and intensity of weather events

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THANK YOU