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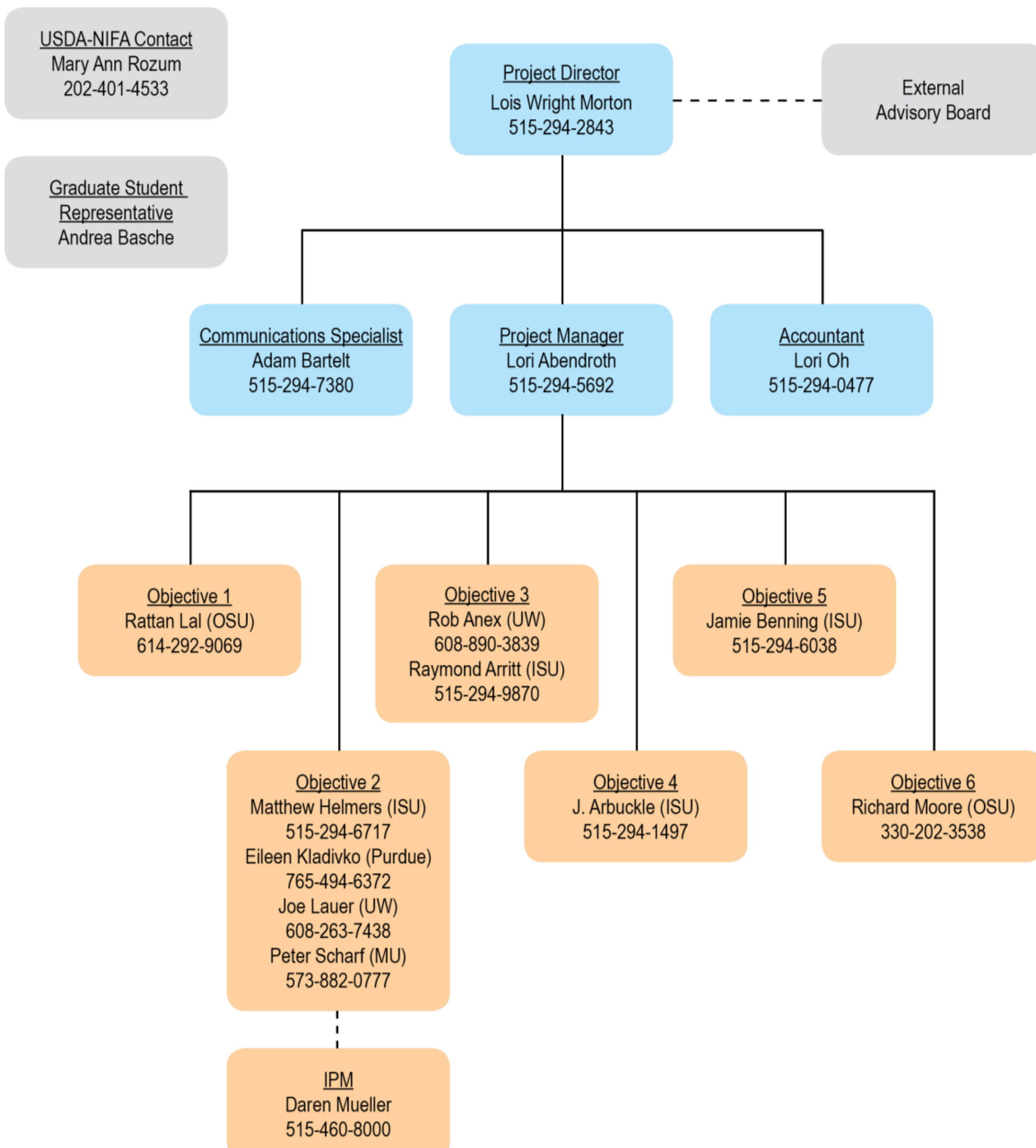
Cropping Systems Coordinated Agricultural Project (CSCAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems

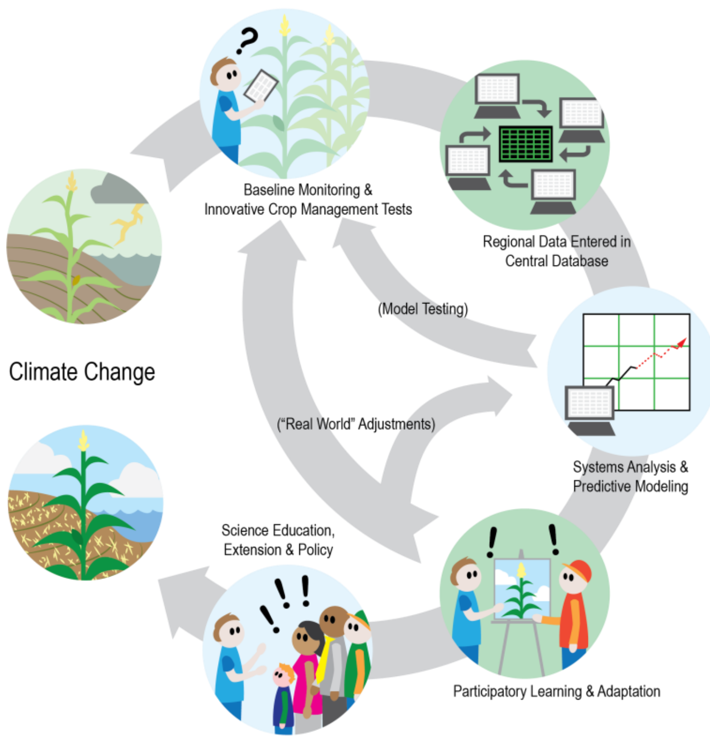
Semi-Annual Meeting: CSCAP Advisory Board & Leadership Team

March 9, 2012



CSCAP Research Directive:
Topic Areas, Research Questions, and Hypotheses

Topic Area, *Leader(s),* Page #



Research Questions:

- Help investigators avoid distractions, diversions and the "all-about" project by working toward supporting a specific, arguable thesis.

Hypotheses:

- Give insight into the proposed research question
- Are measurable and testable
- Are developed directly from the prior science & experiences of the researcher
- Should be concise
- Have a well-founded rationale

OBJECTIVES 1 & 2

Topic Area: Tillage System, Extended Rotations, Cover Crops, Nitrogen Sensing, Controlled Drainage, Greenhouse Gases, and Integrated Pest Management

Project Investigators: Lal, Kladivko, Helmers, Lauer, Scharf, Mueller, Bowling, Castellano, Cruse, Davis, Dick, Fausey, Frankenberger, Gassmann, Kravchenko, Nafziger, Nkongolo, O'Neal, Sawyer, Strock, Villamil, Dunbar (Graduate Student), Han (Graduate Student), and Zaworski (Graduate Student)

AS PER PROPOSAL: *Develop standardized methodologies for estimating C, N, and water footprints of corn production in the region and perform baseline monitoring in eight states to evaluate the impacts of a suite of crop management practices, including no-till, extended crop rotations, drainage water management, cover crops, and canopy N-sensors.*

SYNOPSIS: Management practices used in corn production systems influence carbon, nitrogen, and water processes in the soil. These processes can have a range of impacts on the greenhouse gas footprint and overall nitrogen, carbon, and water footprint of corn production and on the resilience of corn production systems to climate change. The research questions below attempt to capture what we believe to be the most important of these impacts. These questions will guide our joint efforts to study corn production in the context of climate change.

RQ 1. How do tillage management systems impact the greenhouse gas footprint of corn production systems?

Hypothesis: Reducing tillage will reduce the proportion of crop residue that is oxidized to CO_2, increase the proportion that ends up in soil organic matter, and reduce the greenhouse gas footprint of corn production.

RQ 2. How do extended rotations impact the greenhouse gas footprint of corn production systems?

Hypothesis 2a: Nitrous oxide emissions can be decreased and methane sinks can be enhanced by using extended crop rotations due to lower nitrogen fertilizer use in other crops in the rotation.

Hypothesis 2b: Soil organic carbon storage can be increased by using extended crop rotations due to longer growing seasons and greater rooting associated with perennial crops in the rotation.

RQ 3. How do winter cover crops impact the greenhouse gas footprint of corn production systems?

Hypothesis 3a: Winter cover crops will trap CO_2 from the air, increase organic carbon in soil, and reduce the greenhouse gas footprint of corn production systems.

Hypothesis 3b: Landscape position will influence the impact of winter cover crops on greenhouse gas footprint by influencing cover crop biomass and the proportion of this biomass that is ultimately oxidized back to CO_2.

Hypothesis 3c: Cover crops will reduce overall nitrate export to the stream, thus reducing off-site production of nitrous oxide.

Hypothesis 3d: Winter rye cover crop reduces corn nitrogen fertilization rate requirement over the long term, thus reducing the greenhouse gas footprint of corn production systems.

RQ 4. How does sensor-based nitrogen (N) fertilizer management impact the greenhouse gas footprint of corn production systems?

Hypothesis 4a: Sensor-based N fertilizer management can reduce total N fertilizer use while maintaining corn yields, thus reducing CO_2 release during fertilizer manufacture and reducing the greenhouse gas footprint of corn production systems.
Hypothesis 4b: Sensor-based N fertilizer management can reduce nitrous oxide emissions (and greenhouse gas footprint) by reducing the occurrence of N supply in excess of crop needs and by reducing the time window during which nitrous oxide can form.

RQ 5. How do cover cropping, tillage, and sensor-based N management interact in their impacts on the greenhouse gas footprint of corn production systems?

Hypothesis 5a: Cover cropping, tillage, and N management will interact in their effect on greenhouse gas footprint. Increased soil carbon from cover cropping and reduced tillage will increase soil moisture retention, increasing risk of nitrous oxide emissions and increasing the benefit due to sensor-based N management.
Hypothesis 5b: Greenhouse gas footprint effects and cost-benefit ratios will be different for these three approaches; understanding these differences can improve policy.

RQ 6. How does drainage impact the greenhouse gas footprint of corn production systems?

Hypothesis: Drainage compared to no drainage reduces nitrous oxide emissions, thus reducing the greenhouse gas footprint of corn production.

RQ 7. How does drainage water management impact the greenhouse gas footprint of corn production systems?

Hypothesis 7a: Drainage water management compared to conventional drainage will not differ relative to nitrous oxide emissions within the field.
Hypothesis 7b: Drainage water management compared to conventional drainage will reduce overall nitrate export to the stream, thus reducing off-site production of nitrous oxide.

RQ 8. How does sensor-based N management affect the resiliency of corn production to changing climate?

Hypothesis: Sensor-based nitrogen applications both avoid and compensate for nitrogen losses that occur with standard N management in wet years, increasing yield by more reliably supplying N.

RQ 9. How does tillage affect the resiliency of corn production to changing climate through alterations in carbon, nitrogen, and water in the soil?

Hypothesis: No-tillage compared to tillage improves soil quality by increasing soil carbon, soil aggregation, and soil water infiltration, thus reducing year-to-year variability in yield.

RQ 10. How do extended rotations affect resiliency of corn production through alterations in carbon, nitrogen, and water in the soil?

Hypothesis: Extended rotations will improve soil quality by increasing soil carbon, soil aggregation, and soil water infiltration, thus reducing year-to-year variability in yield.

RQ 11. How does drainage affect the resiliency of corn production through alterations in carbon, nitrogen, and water in the soil?

Hypothesis: Drainage compared to no drainage reduces yield variability, increases overall productivity, and improves the nitrogen and water use efficiency in corn-soybean productions systems.

RQ 12. How does drainage water management affect the resiliency of corn production through alterations in carbon, nitrogen, and water in the soil?

Hypothesis 12a: Drainage water management compared to conventional drainage reduces yield variability, increases overall productivity, and improves the nitrogen and water use efficiency in corn-soybean productions systems.
Hypothesis 12b: Drainage water management compared to conventional drainage will reduce overall nitrate export to the stream.
Hypothesis 12c: Drainage water management compared to conventional drainage will increase soil water storage.

RQ 13. How do winter cover crops affect the resiliency of corn production through alterations in carbon, nitrogen, and water in the soil?

Hypothesis 13a: Cover crops improve soil quality by increasing soil carbon, soil aggregation, and soil water infiltration, thus reducing year-to-year variability in yield.
Hypothesis 13b: Cover crops reduce nitrate leaching by taking up residual soil nitrate.
Hypothesis 13c: Cover crops conserve soil water, thus reducing year-to-year variability in yield.
Hypothesis 13d: Effect of cover crops on yield resiliency of corn production systems to weather stresses will vary as a function of diverse terrain.

RQ 14. Will corn and soybean diseases be affected by climate and management practices evaluated in the CS-Corn project?

Hypothesis 14a: Increased rain events will increase incidence and severity of foliar diseases of corn and soybean.
Hypothesis 14b: Management practices such as extended rotations, tillage and cover crops will affect foliar disease incidence and severity.
Hypothesis 14c: Extreme climate (i.e. drought or even temperature extremes) will cause higher incidence and severity of stalk rots or corn prior to harvest.

RQ 15. How do weeds affect greenhouse gas emission measurements? (Davis graduate student)

Hypothesis 15a: Effect of early season weed competition in corn and soybean will affect GHG emissions.
Hypothesis 15b: Dying weeds will affect GHG emission after post-emergence herbicide applications.

RQ 16. Will seed treatments help soybean production be more resilient to climatic fluctuations? (Zaworski)

Hypothesis 16a: L1940-A seed treatment will protect soybean seedlings against SDS.
Hypothesis 16b: L1940-A seed treatment efficacy will be affected soybean cyst nematode (SCN).
Hypothesis 16c: L1940-A seed treatment will help protect soybean seedlings against SCN.

RQ 17. Will production practices such as Drainage Water Management (DWM) and cover crops increase root rot diseases of soybean? (Han)

Hypothesis 17a: Fields with DWM tiling will have more root rot diseases.
Hypothesis 17b: Root rot severity will be affected by the moisture content of soils.
Hypothesis 17c: Root rot severity will be affected by the use of cover cropping strategies.

RQ 18. How does the cultural practice of cover cropping affect arthropods? (Dunbar)

Hypothesis: Pest pressure will decrease in the presence of the rye cover crop while beneficial arthropods will increase in diversity.

RQ 19. How does the cultural practice of crop rotation affect pests? (Dunbar)

Hypothesis: Incidence and severity of plant diseases will decreases with increasing number of crops rotated. Both rotation-resistant rootworm variants will be rare, but more variant north corn rootworms will be observed.

RQ 20. How does variation in climate across a broad geographical area affect pest management inputs and key pests? (Dunbar)

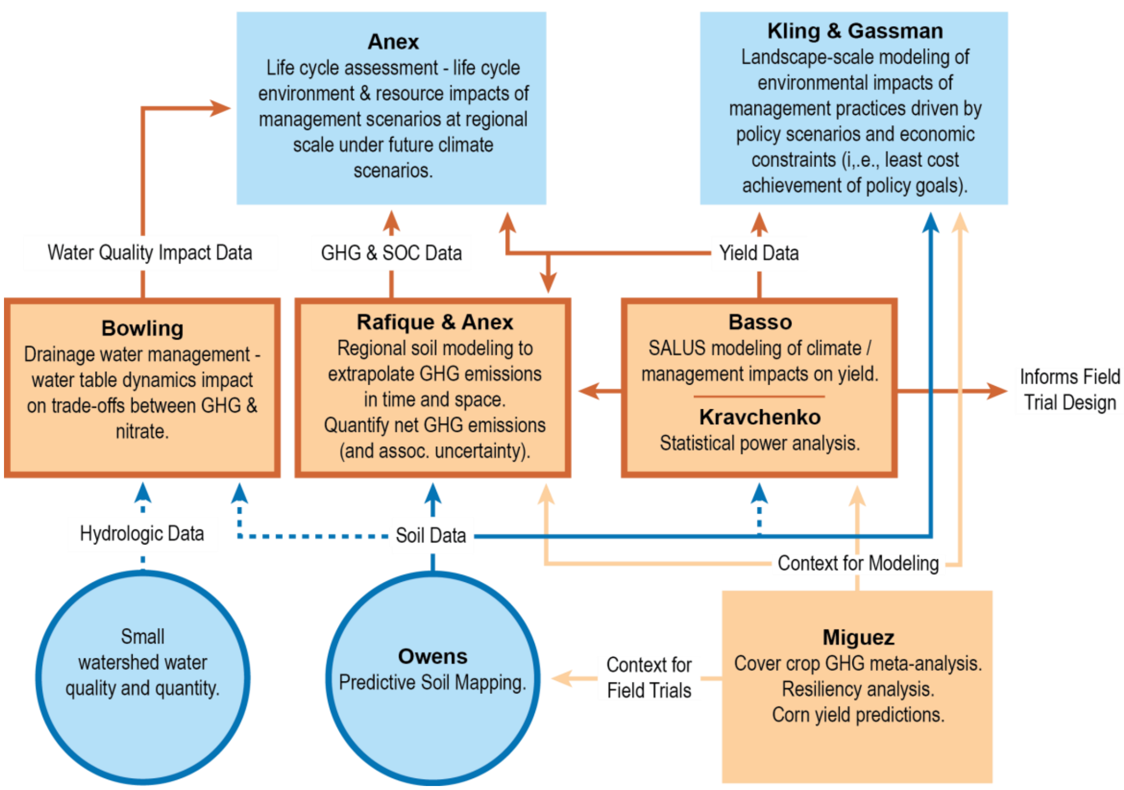
Hypothesis: Pest management inputs and key pests abundances at any one CSCAP site will be more similar to CSCAP sites located closer than those located further away. Pest management inputs will reflect local pest pressure.

OBJECTIVE 3

Topic Area: Systems Analysis and Predictive Modeling

AS PER PROPOSAL: *Apply climate information to physical models to synthesize results from field tests and extend them to predict responses to climate and economic scenarios*. *We will combine process models, historical data, and climate projections with data from Objectives 1 and 2 to calibrate biophysical models at ever-larger scales: field, farm, and landscape. These models will be used to perform "what if" experiments about observed climate variability and projected climate change. Finally, we will develop a landscape-scale modeling system that integrates economic land use models with detailed biophysical models and projections from climate models. This modeling framework will be used to determine the optimal targeting of cover crops, drainage management, and other conservation practices within a corn-based cropping system under a variety of possible environmental goals.*

SYNOPSIS: The overall project vision is to create a region-wide coordinated functional network 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 systems. The proposal is not specific regarding the research questions that drive the overall project, but is clear that the research is centered on systems-level research at multiple scales that informs decision-making and policy. The results of the field experiments are to be extrapolated in both time and space to inform questions about mitigation and adaption of climate change within the corn-based cropping systems of the Midwest U.S.



Objective 3 Connections. Questions and hypotheses are organized by lead researcher due to the specific analysis and modeling capabilities per research team with communication and feed-in mechanisms in place between researchers.

PREDICTIVE SOIL MODELING: LEAD – OWENS

The USDA-NRCS Soil Survey contains a wealth of spatial soil information for the entire US. Originally available only in paper maps, digitized soil maps have statewide and national coverage since 2005. Although soil scientists know that soils vary in a continuum across the landscape, the digitized soil survey portrays soils as: (1) having uniform properties within a soil mapping unit or polygon but with abrupt changes at polygon boundaries, (2) changing at political boundaries and (3) unnatural abrupt changes which do not truly characterize the soil landscape. Soil surveys deliver data and describe morphologic differences in soils, but information on functional similarities is difficult or impossible to obtain; therefore, in the current format, the soil survey only transfers data, not information. The research conducted at Purdue will focus on disaggregating traditional soil survey data and re-aggregating it in new ways to group common soil properties which relate to ecosystem function. Methods will also be explored to develop innovative applications of soil survey data which relate to corn based agricultural systems.

Task 1. Identify presently available soil datasets and maps at various scales.

Task 2. Provide region wide gridded maps, from existing datasets, at 10 and 30 meter resolution for various soil properties (available water, carbon, soil depth, etc.).

Task 3. Develop baseline soil property maps at fields where CAP projects are currently being conducted.

Task 4. Provide improved quantitative estimates of soil properties at a regional scale for model input and projections.

Task 5. Develop methods for upscaling field property measurements to provide soil data for regional scale models.

Hypothesis 1: Soil properties control ecosystem functions such as yield, carbon storage potential and greenhouse gas emissions at multiple scales.

Hypothesis 2: Soil data and topographic information is currently available to provide accurate soil predictions that may be scaled to provide predictions at the farm to regional scales.

RESILIENCY AND META-ANALYSIS: LEAD – MIGUEZ

Determine the impact of cover crops on greenhouse gas emissions in corn-based cropping systems through a comparative literature review of nitrous oxide emissions in systems with and without cover crops. We will also evaluate the role of management practices in improving agroecosystem resilience to intense precipitations events on field scale through data analysis focused on the 2010 floods in central Iowa.

See Appendix; page 18, for specific goals, modeling efforts and progress to-date.

RQ 1. How do cover crops influence greenhouse gas emissions of agroecosystems?
Hypothesis: The impact of cover crops on greenhouse gas emissions will not necessarily be a net negative: it will be dependent upon several management and environmental variables, including variety (grass versus legume), tillage regime, fertilizer application/rate, precipitation and soil type.

RQ 2. How do cover crops influence the overall global warming potential of an agroecosystem?

Hypothesis: Cover crops may add SOC storage capacity to the soil. They may increase or decrease nitrous oxide emissions depending upon the variables listed in RQ 1. Many studies do not measure more than nitrous oxide so the impact will be better measured by CSCAP field experiments.

RQ 3. What are the biophysical mechanisms underlying gas flux changes in cover crop systems?

Hypothesis: Leguminous cover crop systems take up N while alive but release N during decomposition. The same is true for carbon and cover crops. Live plants may fix C in the short term but during decomposition it may be released. Root respiration may also be a net source of carbon dioxide emissions.

RQ 4. What other environmental trade-offs (e.g. reduction in nitrate losses) should be considered in agroecosystems if cover crops increase GHG flux?

Hypothesis: Depending upon cover crop varieties and field conditions, cover crops have the potential in corn systems to lead to: Improved soil organic matter, improved soil moisture, reduction of erosion losses, reductions in nitrate losses, and improvement in crop yields.

RQ 5. Does increased diversity (cover crops, extended rotations) improve agricultural indicators in response to intense precipitation events?

Hypothesis: Increased diversity will improve some agricultural indicators following intense precipitation events.

RQ 6. Does increased diversity improve: yield stability, soil erosion losses, soil organic carbon, and pest pressure?

Hypothesis: Increased diversity will improve some of the above indicators when appropriately compared to less diverse fields.

RQ 7. How are these indicators (yield stability, erosion, SOC, pest pressure) related to climate resilience?

Hypothesis: Maintaining the natural resource base (limiting soil erosion losses, maintaining organic matter in the soil) is essential to ensuring that Midwest corn cropping systems remain productive in years of extreme precipitation events. Further, yield stability ensures that from an economic point of view, land managers are better able to reduce major losses.

YIELD IMPACTS OF CLIMATE CHANGE: LEADS – BASSO & KRAVCHENKO

Our goal is to simulate and predict the impact of climate on yield and the local environmental impacts of corn-based cropping systems in the Midwest USA using the SALUS model (Basso et al., 2010; Senthilkumar et al., 2009; Basso et al., 2007). Specifically, the MSU modeling team (Basso Co-PI) will be examining the consequences of temperature, precipitation, and CO_2 changes on irrigated and rain fed corn-soybean rotations in the Midwest USA along with nutrient losses managed with no tillage and conventional tillage.

See Appendix; page 17, for specific goals, modeling efforts and progress to-date.

No research questions or hypotheses explicitly stated for Basso.

SOIL CARBON & GHG MODELING: LEADS – RAFIQUE & ANEX

RQ 1. What will be the net reduction in GHG fluxes due to the use of cover crop, extended rotation, and drainage water management treatments in corn based cropping system under projected future climates?

RQ 2. What are the potential of cover crop, extended rotation and drainage water management treatments in sequestering more soil C in corn based cropping system under projected future climates?

RQ 3. What is the minimum time required to observe the effects of cover crop, extended rotation and drainage water management on soil carbon changes?

RQ 4. How can the DayCent model be calibrated for the extreme weather conditions and dry/wet periods?

RQ 5. How do the potential of cover crop, extended rotation and drainage water management treatments vary over time and space in reducing GHG fluxes from the corn based cropping system of the Midwest?

RQ 6. Was is the potential of the use of cover crop, extended rotation and drainage water management treatments over time and space in sequestering soil C in the corn-based cropping systems of the Midwest USA?

FIELD-SCALE HYDROLOGIC MODELING: LEAD – BOWLING

The field scale hydrologic modeling for Task 1 will utilize both the DRAINMOD model and the Variable Infiltration Capacity (VIC) model, for which Bowling has recently developed a subsurface drainage algorithm. This will continue evaluation and verification of the macro scale VIC modeling approach. This effort will utilize directly the field data being collected at Purdue as part of this project. Bowling will also be involved with integrative modeling across the other DWM field sites. For Tasks 2 and 3, the regional-scale modeling will utilize the VIC model. This will require information regarding land use type, soil physical properties, soil drainage recommendations, digital elevation data and gridded daily weather data (precip, tmin, tmax, and wind speed) for all of the states included in the CSCAP project.

Small watershed water quality and quantity data will be provided primarily by the CSCAP site located at Coshocton, OH. Site-specific information is found in the Appendix, page 20.

RQ 1. What is the sensitivity of water conservation and nitrate load reduction due to drainage water management (DWM) under observed and projected climate variability at the Davis Purdue Agricultural Center?

RQ 2. What is the potential for water conservation and nitrate load reduction with DWM under projected climate conditions across the entire CSCAP region?

RQ 3. What are the trade-offs between nitrate load reduction (due to reduced subsurface drainage) and greenhouse gas emissions (due to reducing soil conditions) in the subsurface drained agricultural lands of the US Corn Belt?

LIFE CYCLE ASSESSMENT: LEAD – ANEX

RQ 1. What are the life-cycle environmental and resource impacts of the alternative corn management systems under projected future climates?

RQ 2. How should emissions/absorption of GHG that occur at different times be accounted for in assessing life cycle GWP?

RQ 3. How do the net-energy, GWP, and eutrophication potential of corn grain based ethanol and gasoline compare for the corn management systems under consideration?

RQ 4. What are the largest sources of GHG emissions, eutrophication potential, etc. over the full life cycle for the corn production systems under consideration?

RQ 5. What trade-offs are inherent among the studied management systems in impact categories such as GWP and eutrophication potential?

RQ 6. To what life cycle model assumptions are the net-energy, GWP, etc. of the corn production systems most sensitive?

RQ 7. How do life cycle impacts of the corn management systems under study vary with geographic location and time (under projected future climates)?

LANDSCAPE-SCALE ECONOMIC AND POLICY ANALYSIS: LEADS – KLING & GASSMAN

Our research questions will focus on the optimal placement of conservation practices and cropping systems (e.g., cover crops) to achieve environmental goals.

RQ 1. What is the least cost placement of cover crops and drainage management to achieve nutrient reduction goals in individual watersheds in the UMRB and in the entire watershed?

RQ 2. How quickly does the cost rise as the nutrient reduction goals increase?

RQ 3. What are the GHG effects of the cover crop and drainage management strategies?

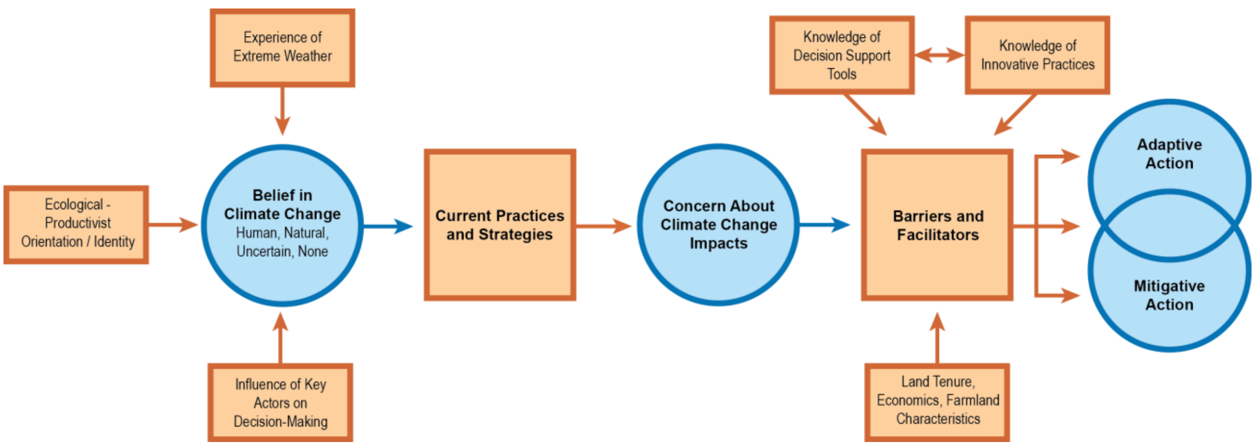
RQ 4. How does the optimal placement and cost change when crop prices increase? How do they change if/when there is a substantive market for corn stover?

OBJECTIVES 4 & 5

Topic Area: Social-economic and Extension

AS PER PROPOSAL: *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 and adoption of tools and practices that support long-term sustainability of crop production. Contribute to feedback loops between social science research, biophysical field research, monitoring, and modeling of agricultural production systems.*

SYNOPSIS: These objectives focus on farmer capacity and willingness to adopt management practices and strategies that lead to long-term sustainability and productivity of corn-based cropping systems under variable weather and long-term climate changes. Objective 4 will collect and analyze data on Midwestern farmers' beliefs and concerns about climate change, current management strategies, awareness and use of decision tools and innovative practices, and the relationships between these variables and farmer willingness and capacity to pursue adaptive and mitigative actions. Findings from objective 4 will inform the development of extension programming, tools for farmer decision-making, and education curricula under Objectives 5 and 6. Findings will also inform a feedback loop to the field trials and modeling objectives and science-based policies. These objectives will be attained in close partnership with the standard CAP grant "Useful to Useable (U2U)."



See Appendix, pages 20-21 for survey question categories from the CSCAP-U2U Survey and variables that will be merged into our data set from the Census of Agriculture.

RESEARCH QUESTIONS AND HYPOTHESES SPECIFIC TO CSCAP

Project Investigators: Arbuckle, Benning, Tyndall, Wright Morton, Knoot

RQ 1. To what degree do farmers perceive climate change as a threat to their livelihoods, and how do those attitudes impact their willingness to adopt or otherwise support *adaptation* strategies and practices?

Hypothesis 1a: Belief in climate change and concern about its impacts will be associated with willingness to adopt adaptive strategies and practices.

Hypothesis 1b: Recent experience of extreme weather and its impacts will be associated with willingness to adopt adaptive strategies and practices.

Hypothesis 1c: Confidence in current risk-management and resilience-enhancing practices and strategies will mediate willingness to adopt further adaptive management.

RQ 2. To what degree do farmers implicate human activities as drivers of climate change, and how do those beliefs impact their willingness to adopt or otherwise support *mitigation* strategies?

Hypothesis: Beliefs about the causes of climate change (e.g., human vs. natural) will influence willingness to adopt or support mitigation strategies and practices.

RQ 3. What weather-related decision tools do farmers employ, and how is use related to climate change preparedness/adaptive management?

Hypothesis: Farmer use of weather-related decision tools will be associated with use of resilience-enhancing strategies and practices.

RQ 4. What other human dimensions factors (e.g., institutional, economic, or cultural influences, knowledge of practices/strategies) act as barriers to or facilitators of more resilient corn-based systems?

Hypothesis 4a: Farmer location on a cultural identity/orientation continuum between stewardship and productivism will determine willingness to adopt or support different types of adaptive strategies and practices (e.g., in-field productivity maintenance vs. edge-of-field water quality protection).

Hypothesis 4b: Farmer knowledge of innovative adaptive and mitigative practices and strategies will mediate their use.

Hypothesis 4c: Relative importance of key conservation and productivist actors in agricultural social networks will mediate attitudes toward adaptation and mitigation.

Hypothesis 4d: Land tenure arrangements will impact farmers' willingness and perceived ability to adopt adaptive and mitigative practices and strategies.

RQ 5. How do climatological, meteorological, and biophysical factors shape farmer behavior toward climate change and potential adaptive and mitigative actions?

Hypothesis 5a: Perceptions of climate change risk will vary with experience with climatological and meteorological conditions (i.e., extreme weather).

Hypothesis 5b: Perceptions of climate change risk will vary with biophysical factors (i.e., farmland characteristics, presence of waterways).

RQ 6. How do farmers accommodate climate change in their decision making processes, and what tools and materials should be developed to help them establish more resilient systems? *(To be explored through in-depth I-Farm interviews.)*

RQ 7. To what extent do farmer-led discussion groups in combination with the use of performance-based measures facilitate improvements in soil condition and reductions in soil and nutrient loss to proximate water bodies in corn-based cropping systems?

Hypothesis 5a: Farmer led group interactions and relationships increase learning and understanding of climate impacts on their cropping systems and their watershed.

Hypothesis 5b: Farmer led groups utilizing the performance-based management process (IFARM, stalk N tests, SCI) will be more likely to identify and use risk assessment strategies at the farm and watershed levels to adapt to changing climate conditions than farmers not engaged in the group process or exposed to performance-based tools.

RESEARCH QUESTIONS AND HYPOTHESES SHARED WITH U2U

Project Investigators: Wright Morton, McGuire (Graduate Student), Wilke (Graduate Student)

RQ 8. To what extent is there a disconnect between scientific climate change information and subsequent response from farmers in developing agriculture risk management portfolios? What are the sources of these disconnects?

RQ 9. How do scientific groups, such as climatologists, perceive long-term risks and benefits associated with climate change, and how does this differ from "layperson" or farmer groups? How does this contrast with perceptions of change anticipated in the next 2 or 5 years?

RQ 10. What are sources of these differences in perception regarding the issue of climate change between these two groups?

RQ 11. How does a farmer's individual identity influence farm management decisions under variable weather conditions?

Hypothesis: The more dominant a farmer's conservationist identity is within his/her individual identity, the more likely he/she will adopt practices that reduce the negative impact of severe weather events.

RQ 12. How does a farmer's social identity influence farm management decisions under variable weather conditions?

Hypothesis 12a: The more dominant a farmer's conservationist identity is within his/her social identity, the more likely he/she will adopt practices that manage for both profitability and minimization of environmental impact when adapting to OR mitigating for climate change.
Hypothesis 12b: The more dominant a farmer's conservationist identity is within his/her social identity, the more likely he/she will adopt practices that adapt to or mitigate for the impact of drought.
Hypothesis 12c: The more dominant a farmer's conservationist identity is within his/her social identity, the more likely he/she will adopt practices that adapt to or mitigate for the impact of extreme weather events (soil erosion and nutrient loss).
Hypothesis 12d: The more dominant a farmer's conservationist identity is within his/her social identity, the more likely he/she will adopt practices that put long-term conservation of farm resources before short-term profits when adapting or mitigating for climate change.

RQ 13: How does a farmer's role identity influence farm management decisions under variable weather conditions?

Hypothesis: The more dominant a farmer's conservationist identity is within his/her role identity, the more likely he/she will adopt practices that reduce the negative impact of severe weather events on productivity and conservation practices.

OBJECTIVE 6

Topic Area: Education

Project Investigators: Moore, Lekies, Hintz

AS PER PROPOSAL: *Integrate education across all aspects of the CSCAP with focus on place-based education and outreach programs.*

SYNOPSIS: Our hypothesis is those place-based educational opportunities that incorporate inquiry and interactive (constructivist) learning strategies are effective for increasing student understanding and performance in traditional academic subjects (e.g., STEM) as well as fostering awareness of environmental issues.

RQ 1. Will the target audience of 9-12 high school students increase their content knowledge and understanding using the Grade Band 9-12 Educational "Climate Discovery" Modules developed by the project?

Hypothesis 1a: We hypothesis that students will increase their content knowledge and environmental awareness by using the Grade Band 9-12 Educational "Climate Discovery" Modules developed by the project.

Hypothesis 1b: Students' knowledge and awareness development of environmental issues surrounding sustainable agriculture including phenology, food production, watershed ecology, water footprints, and career awareness will be evaluated using pre and post testing and surveys.

RQ 2. Will teachers increase their content knowledge and awareness of environmental issues by participating in teacher training/classes developed by the project and/or using the Grade Band 9-12 Educational "Climate Discovery" Modules developed by the project?

Hypothesis 2a: We hypothesize that teachers will increase their content knowledge and awareness and will include environmental topics to a greater extent because of their participation in the teacher training/classes developed by the project and/or using the Grade Band 9-12 Educational "Climate Discovery" Modules developed by the project.

Hypothesis 2b: The quality and usefulness of teacher training and curriculum resources of teachers will be evaluated through evaluation forms, observations, and surveys or retrospective pre/posttests.

RQ 3. Will undergraduates/graduate students increase their content knowledge and awareness of environmental issues by participating in short courses developed by the project?

Hypothesis 3a: We hypothesize that undergraduates/graduate students will increase their content knowledge and awareness of environmental issues by participating in short courses developed by the project.

Hypothesis 3b: The quality and usefulness of the short courses will be evaluated through evaluation forms and surveys or retrospective pre/posttests.

RQ 4. Will undergraduates participating in research internships increase their content knowledge and awareness of environmental issues and awareness of careers in the field?

Hypothesis 4a: We hypothesize that undergraduates participating in research internships will increase their content knowledge and awareness of environmental issues and awareness of careers in the field.

Hypothesis 4b: The quality and usefulness of undergraduate research internships will be evaluated through evaluation forms, observations, and surveys.

RQ 5. How successful has the implementation of the overall project been in meeting its targeted goals of educational outreach?

Hypothesis 5a: We hypothesize that the project will be successful in meeting its targeted goals.

Hypothesis 5b: The success of the implementation will be evaluated by analyzing the numbers and types of participants, overall changes in environmental knowledge and awareness as determined by the survey results, and review of implemented activities and milestones.

APPENDIX

OBJECTIVES 1 & 2

No additional materials

OBJECTIVE 3

BASSO & KRAVCHENKO

Our effort is to simulate and predict the impact of climate on yield and environment of corn-based cropping systems in the Midwest USA using the SALUS model (Basso et al., 2010; Senthilkumar et al., 2009; Basso et al., 2007). Specifically, the MSU modeling team (Basso Co-PI) will be examining the consequences of temperature, precipitation, and CO2 changes on irrigated and rain fed corn-soybean rotations in Midwest USA along with soil carbon and nutrient losses managed with no tillage and conventional tillage. Furthermore, SALUS will identify the best adaptation and mitigation strategies for maintaining a sustainable corn-based system production in the medium and long term for the Midwest USA by providing critical information on changing supply and demand for water resources, and elucidate interactive effects of climate on yield and GHG emissions. A simple SALUS web-based system for farmers is also available to easily assess the impact of a management strategy on yield, nitrate leaching, N2O emissions for corn-based cropping system. SALUS Simple Web is available for use at www.salusmodel.net

Co-PI Bruno Basso participated in the work of the Objective 3 team development on the data need for model applications within the project. More specifically, the MSU team (Bruno Basso and Sasha Kravchenko) worked closely with Dr. Jeff Andresen (MSU and member of the Useful to Usable CAP project) to develop the climate projections for Michigan. Daily downscaled climate data have been developed using different Global Circulation Models (GCM) and emissions scenarios. Next step includes the application of the System Approach for Land Use Sustainability (SALUS) model for predicting the impact of climate on yield and environment of corn-based cropping systems for the Michigan site. We will be examining the consequences of temperature, precipitation, and CO2 changes on irrigated and rain fed corn-soybean rotations in Michigan along with soil carbon and nutrient losses managed with no tillage and conventional tillage.

During this period SALUS algorithms have improved with additional testing with measured dataset from Mexico, Argentina and Russia.

The modeling team at Michigan State University (Dr. Basso and Mr. Munoz) has been working on modeling the impact of cover crop and maize yield at various landscape positions. During the last three months, Dr. Basso worked closely with Mr. Munoz on setting up the proper files to execute SALUS at different landscape positions for maize and for cover crop. The parameterization of SALUS was necessary to include the landscape effects on the soil water balance (infiltration, ponding capacity, soil water redistribution, and root water uptake).

Moreover, Dr. Basso has been involved in various meeting with Dr. Rob Anex (Univ. Wisconsin) and with Dr. Ray Arritt (Iowa State Univ.) to address the important issue of future climate scenarios selection. Dr. Basso in collaboration with Dr. Andresen and Dr. Winkler (Climatology-Michigan State University) evaluated the possibility of using the future climate scenarios developed by Dr. Winkler's team. This initial plan has been modified as results of the meeting s between Dr. Arritt, Dr. Anex and Dr. Basso.

Dr. Arritt suggested that alternatives to these climate scenarios were necessary due to the old approach adopted in the development of these climate scenarios. They are derived from GCM output prepared for the IPCC Third Assessment Report. Thus, new challenges arose concerning the future climate scenarios selections. Dr. Arritt, Dr. Basso and Dr. Anex will continue to work closely to identify the best future climate scenarios to be adopted in the projects for modeling the impact of climate change and climate variability on maize yield using SALUS model and on greenhouse gas emissions using DayCent.

The knowledge on effects of landscape positions and cover crops on maize yield and long term sustainability of maize production through the integration of measured and simulated data using SALUS will provide fundamentals insights towards the path of sustainability of maize production systems.

MIGUEZ

The overall goal of this research will be to better define the management strategies that enhance resilience in Midwest corn cropping systems. Improving this understanding will allow such systems to remain productive and sustained through the increased environmental disturbances projected as climate patterns change. Management practices within these systems - cover crops, extended rotations and tillage, for example - will lead to differences in field-level ecosystem services such as yield stability and continued delivery of clean air and clean water. Indicators hypothesized to govern such ecosystem services include soil fertility, soil erosion, water conservation as well as plant functional diversity. Such management practices also contribute to mitigation of other harmful environmental impacts, including greenhouse gas emissions. Thus, this research will strengthen the links between Midwest agricultural practices and their impact on climate change mitigation and adaptation.

	Objective	Method
1	Impact of cover crops on greenhouse gas emissions in corn cropping systems	Comparative literature review of nitrous oxide emissions in cover cropped and non-cover cropped systems
2	Evaluate the role of management practices in improving agroecosystem resilience to intense precipitation events on field scale	Data analysis focused on the 2010 floods in Central Iowa. Synthesis of historical information, field data, and farmer surveys to determine indicators impacting resilience.

<u>Objective #1: Meta analysis of cover crops, greenhouse gas emissions and soil carbon</u>

There are many well researched ecological benefits to incorporating cover crops into corn cropping systems, such as their potential to decrease soil erosion, reduce nitrate leaching, provide moisture control and increase soil organic matter and nitrogen inputs (Parr et al. 2011). These are ecosystem services that we hypothesize are related to climate resilience. Some of these benefits, however, may have unintended consequences for other elements of an agroecosystem given the coupling of nutrient cycles, notably C and N. Some field research does point toward an increase in nitrous oxide emissions in cropping systems where cover crops are present. This work, however, is limited and comes from various sites utilizing a range of cover crops and different measurement techniques. Through a literature review of corn systems with cover crops, our goal is to establish an enhanced understanding of the full global warming potential of these systems.

Preliminary analysis points to the type of cover crop having an important role in both nitrogen depositions in soil and nitrous oxide emissions. In a Brazilian study looking at six different cover crop regimes in corn systems, Gomes et al. (2009) found that the residues of legume cover crops, which have low C:N and lignin:N ratios, stimulated microbial activity via increasing the rate of N mineralization. This supplies more NH_4^+ and NO_3^-, substrates for nitrous oxide production. This study also proposed that the choice of cover crop was more closely related to nitrous oxide emissions as compared to environmental variables such as soil temperature and water filled pore space. Further, Pelster et al. (2011) found that the more predominant factor influencing nitrous oxide emissions in maize soybean rotation with till and no till treatments was fertilizer application. Thus, N input is important in regulating nitrous oxide emission and therefore the reasoning that legume cover cropping systems increase nitrous oxide emissions is consistent with this. However, it is not consistently observed in the papers analyzed thus far.

Further, a meta-analysis comparing no-till versus conventional tillage and greenhouse gas emissions found that the conversion to no-till in the short term (<5 years) led to an increase in gas flux in humid climates (Six et al. 2004). Decreases in emissions for the no-till systems required longer term adoption (>10 years). Although preliminary analysis indicates that tillage treatments play less of a role in regulating greenhouse gas emissions when compared to other treatments that the CSCAP will analyze, this temporal trend could be important to note given the five year time period of the study. The continued evaluation of cover crop systems will further enhance an understanding of the drivers behind greenhouse gas emissions, particularly when contrasted with the results of this meta-analysis.

<u>Objective #2: An analysis of the 2010 flood impact in Central Iowa</u>

The summer of 2010 brought a deluge of rainfall to several counties in Central Iowa. The Ames weather station in Story County, for example, received 285 mm of precipitation in the month of August alone, almost three times greater than the long term average for the month of August. The Skunk River crested above record levels in some spots and came close to other record highs in others, activating a “Code Red Alert” and evacuating many town residents. To my knowledge there has been no thorough investigation of the full ecological impact of this event, including the impact on crop yields and soil losses. Undoubtedly an event of this magnitude would have an effect on the row crop dominated landscape in central Iowa. Therefore, this part of the study will aim to analyze on a field level any indicators that may have contributed to greater losses. Was there a difference in yield response between fields with differing crops and management strategies? Did the effects linger into the 2011 planting and harvest? What are the perceived future climate threats for land managers? What management strategies do farmers believe prepared them for the flood, for better or worse?

We applied for a SARE Graduate Student Grant to provide additional funds to conduct farmer interviews that will help us answer some of these socioeconomic questions as well as to collect potential yield data. Through collaboration with partners and networks of farmers we will recruit up to thirty farmers with fields damaged in the 2010 floods. The goal of the survey is to provide information to inform user-driven science on farmer concerns regarding management practices, climate change, current risk management strategies and perceived and real vulnerabilities resulting from the flood. These results could be presented at an upcoming CSCAP conference to create better user driven needs based scientific outcomes. This study would allow us to collaborate with the Objective #4 team's work. A secondary role of the interviews will be to assess the feasibility of incorporating participant generated yield data in a future spatial analysis. Using information from the USDA's Crop Data Layer (a high resolution - 30m to 56m - satellite imagery product) and the NASA TRMM rainfall product, a map can be produced for the region in Central Iowa impacted by the floods. Theoretically, this information will be spatially combined with crop and yield data from corresponding interviews and a "diversity" index derived based on the cropping systems present on the landscape. This would allow us to assess the relationships of yield stability and cropping rotations. Developing a reliable index will depend upon the quality of data supplied by survey participants, and thus depending upon whether we conduct surveys will determine if we proceed with this project.

KLING & GASSMAN

Objective: To provide empirical estimates of the greenhouse gas reductions and associated ecosystem services from the optimal landscape placement of conservation actions within corn-based cropping systems.

and/or

To study the design of carbon offset markets and other federal policies with respect to their ability to achieve greenhouse gas reductions and related ecosystem services cost-effectively.

Project Description: In this project, we will develop a landscape scale modeling system integrating economic land use models with detailed biophysical models and regional climate models. This modeling framework will be used to determine the optimal targeting of cover crops, drainage management, and other conservation practices within a corn based cropping system under a variety of possible environmental goals.

To accomplish this, our research team will take advantage of an extensive and tested existing modeling framework which we will adapt to incorporate new parameters and routines based on the field research other members of the team generate. Our current modeling framework, the UMRB-SWAT modeling system developed at the *Center for Agricultural and Rural Development* Iowa State University, covers the Upper Mississippi River Basin (UMRB), a large and agriculturally important watershed in the central U.S and is built around the Soil and Water Assessment Tool (SWAT) model (Arnold et al. 1998; Gassman et al. 2007) and the Environmental Policy Integrated Climate (EPIC) field-scale model (Izaurralde et al., 2006). The UMRB is an ideal region for a large targeting study of agricultural conservation funds given its poor local water quality, the magnitude of its nutrients contributions to the Gulf of Mexico, and the large untapped potential for GHG gains from its agricultural sector.

SWAT integrates local weather variables, soil properties, topography, land cover and land management scenarios and has the capability of simulating the long-term effects of environmental changes. It is a physical process based, distributed parameter, continuous time scale model which can simulate the processes of water flow, sediment erosion and transport, nutrient cycling and transport, and variation in land use and climate. SWAT can also identify critical sub-watersheds for soil conservation and nutrient management and is thus an ideal model for targeting of optimal placement of conservation practices.

The modeling system work is also capable of simulating soil carbon dynamics as affected by cropping systems and tillage practices using EPIC. The latest versions of EPIC contain soil carbon cycling routines based on the approach used in the Century model (Kelley et al. 1997) to simulate soil organic carbon dynamics and estimate carbon storage for different land management practices.

The UMRB-SWAT modeling system incorporates GIS capability, survey and laboratory input databases including topography, land cover, land management practices, weather, point sources, reservoirs, wetlands, streamflow and water quality variables, and economic costs of establishing land management practices (Gassman et al. 2006). This integrated modeling system will simulate different land management practices, land use land cover changes, and/or potential future climate change to evaluate the impacts of these changes on greenhouse gases, sediment, and water quality. This capacity has been previously successfully applied to examine UMRB land use and land management scenarios (Kling et al. 2006, Secchi et al. 2009, Rabotyagov et al. 2009) and climate change scenarios (Takle et al. 2006, 2009, Lu et al. 2009). We will also take advantage of our team's experience with using evolutionary algorithms

(Rabotyagov et al. 2010), a powerful analytical tool that can identify the least cost placement of conservation practices to achieve multiple environmental endpoints in complex systems.

BOWLING

Background: In general, I utilize in-situ and remotely sensed observations, hydrologic models and hydroinformatics to investigate the hydrologic consequences of environmental change, including climate variability, land use change and agricultural management practices.

I am involved in the on-going development of two models, the Distributed Hydrology-Soil-vegetation Model (watershed scale) and the Variable Infiltration Capacity (VIC) land surface scheme, including the use of down-scaled and quantile-based bias-corrected regional and global climate model output for investigating the hydrologic response to projected climate.

Coshocton – possible studies to contribute to Objectives related to determining effects of climate change in models:

- Scaling from small watersheds to larger watersheds
  - Models used must be able to model scaling from small watersheds
  - Coshocton data can be used to quantify this effect
  - Coshocton data can be used for modeling from the small to large scales.
- Determining effects of CC on different components of the hydrological cycle at the small scale
  - Effects of CC on times between storms and changes in different part of the US
  - Effects of CC on small watershed runoff
  - Effects of CC on small watershed water quality
  - Effects of CC on air temperature
  - Effects of CC on ground-water recharge
  - Effects of CC on soil water
  - Effects of CC on soil temperature
- Providing data on soil carbon under different management practices
- Providing runoff data for small watershed modeling

OBJECTIVE 4

Survey question categories; CSCAP-U2U Survey and Census of Agriculture

Adaptation and mitigation
Do farmers support private and public adaptive and mitigative actions? (Q20)
What resilience strategies would farmers consider if climate change predictions occur? (Q16)

Vulnerability and resilience: Beliefs and concerns
Have farmers experienced weather-related impacts (drought, ponding, flooding)? (Q1-4, 21)
Do farmers believe that climate change is occurring? (Q18)
If so, to what do they attribute it? (Q18)
Are farmers concerned about predicted impacts of climate change (i.e., more flooding, disease)? (Q5)
What resilience strategies do farmers currently have in place? (Q6, 7, 15)
Confidence in ability of practices and strategies to cope with predicted changes? (Q17, 19, 21)

Decision support
When do farmers typically make crop and soil management decisions? (Q9)
When do farmers typically carry out key crop and soil management practices (i.e., chemical application, tillage)? (Q8)
What weather-related decision support tools do farmers use? (Q10-12)
Who do farmers look to for decisions about agricultural practices and strategies? (Q25)

Identity
To what degree do farmers view themselves as innovators and opinion leaders? (Q22)
What characterizes a “good farmer”? (Q23)

Key variables to be incorporated from the Census of Agriculture
All land owned (0043)
All land rented or leased from others (0044)
Principal County name (0055)
Cropland acres (0787-1062)
Pasture acres (0796-0788)
Other acres (0795-0797)
Irrigation (0680-0681)
CRP (0683-0685)
Crop insurance insured acres (1067)
Field crops produced (acres harvested, quantity harvested, acres irrigated)
Grain storage capacity
Hay and forage crops produced (acres harvested, quantity harvested, acres irrigated)
Livestock produced
Production under contract
Gross farm income (1347)
Government program payments
Production expenses
Value of land, buildings, machinery, and equipment
Operate within an American Indian reservation
Internet access
Sales of value added products
Type of organization (family farm, LLC, etc.)

OBJECTIVE 5

No additional information

OBJECTIVE 6

No additional information