SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

A partnership among 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;
USDA ARS – Columbus, Ohio; and USDA National Institute of Food and Agriculture (NIFA).

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.

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.

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.

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?