Consortium for Agricultural Soils Mitigation of Greenhouse Gases (CASMGS)
Progress Report: November 2003

The Consortium for Agricultural Soils Mitigation of Greenhouse Gases (CASMGS) is a coalition of scientists from land grant universities and a government laboratory in the U.S. The purpose of CASMGS is to study how agricultural soils can be managed to increase soil carbon (C) sequestration and reduce greenhouse gas (GHG) emissions. Scientists are also examining the economics of agricultural soil C sequestration and the effect of government policies on the adoption of C sequestration practices. The research and communication activities are divided into five tasks.

Task 1 – Basic processes of soil C sequestration and GHG emissions

A. Discover how to increase plant carbon inputs and increase stabilization in soil resulting in increase soil C levels:

- Research at Kansas State University has discovered differences among grain sorghum hybrids in the quality of the plant carbon. Hybrids of grain sorghum with higher lignin contents could increase long-term soil organic carbon (SOC) levels. Hybrids with higher lignin contents also have resistance to lodging, thus improving harvest.
- K-State research has also found that changing grazing rates on grasslands to recommended levels increases forage productivity and belowground root production. Work is underway to determine the effect on soil C levels.
- Research at Montana State University is evaluating changes in soil carbon under three no-till cropping systems (wheat-fallow, continuous wheat, and pulse-wheat).
- Research at Texas A&M University has found that SOC storage in grasslands of the Rio Grande Plains of southern Texas is increased by the conversion of those grasslands into highly productive woodlands.

B. Examine ways to increase the long-term stability of SOC:

- Research at Colorado State University, Kansas State University, Ohio State University, Pacific Northwest National Laboratory, Purdue University, and the University of New Hampshire are studying factors important for converting plant and microbial materials into soil aggregates and stable humus, which improves the long-term stability of SOC. Formation and maintenance of soil aggregates are important in conserving carbon in the soil.
- Research at Michigan State University has found that frequent wetting and drying of large soil aggregates near the soil surface results in longer-term soil C sequestration. Wetting and drying cycles promote formation of carbonates in the small pores within the large soil aggregates.
- The Ohio State University researchers are finding that the type of clay, soil pH, and other factors may play a role in how readily SOC attaches to clay particles.

C. Understand how C can be lost from agricultural soils:

- Michigan State University researchers have found that lime applications help stabilize SOC.
- Research at Purdue University is determining how SOC can be lost through the action of water movement through soils and across soil surfaces into rivers and streams. Surface runoff from storm events can remove organic materials from the soil into surface waters.

Task 2 – Best Management Practices (BMPs)

A. Physical potential of BMPs:

- Rates of soil C sequestration have been collected from experimental sites in Colorado, Kansas, Ohio, and Texas. Research has evaluated the effects of tillage, cropping intensity, use of forages and cover crops, nitrogen (N) fertilization, and manure application. In general, C sequestration is greatest with BMPs such as no-till, continuous cropping systems (including elimination of fallow or use of cover crops), selection of forage and grain crops that have higher leaf-to-grain ratios, adequate N fertilization, and manure application. Carbon sequestration rates under no-till generally have been between 0.2 and 0.7 metric tons C per ha per year (0.1 tons C/acre/year).
- *A*nalyses of erosion-induced transport of carbon conducted at the Ohio State University has shown that emissions are greatly increased at the depositional sites and a considerable part of the C transported by runoff is emitted into the atmosphere is CO_2. Thus soil conservation reduces the risks of erosion-induced emissions.

B. Economic potential of BMPs:

- Several institutions are studying the costs of increasing C sequestration through changes in tillage practices, cropping systems, soil conservation, or adoption of new technologies. The co-benefits of the adoption of these practices (such as improved water quality, reduced soil erosion, reduced emission of other GHGs, increased wildlife habitat) are also being evaluated.

- Researchers at Montana State University have developed a survey instrument to collect data on the costs and co-benefits of BMPs that sequester carbon. In conjunction with Kansas State University researchers, a consistent framework for using full GHG accounting has been developed. This framework will account not only for the amount of C being sequestered by a certain management practice, but the effect that practice has on emissions of other GHGs and environmental quality.
- Researchers at Colorado State University have collected county crop yield data and merged that with costs and returns data to estimate the change in net returns associated with conservation tillage, increasing cropping intensity, and planting grass on highly erodible land. Work on assessing the effect of debt structure on willingness to adopt new technologies is underway.
- At Kansas State University, researchers have computed the net returns to land and management for a variety of cropping systems and combined it with yields, inputs, field operations, and C sequestration rates to estimate the value of carbon credits needed to get producers to adopt less profitable BMPs for carbon sequestration.
- Researchers at The Ohio State University have assembled crop budgets for Ohio, Indiana, and Illinois to find out the costs of sequestering carbon in agricultural soils under various payment schemes.
- Iowa State University researchers are measuring the value of accurate field-scale carbon measurement technology, the value of targeting the adoption of conservation tillage to high carbon sequestration areas, the carbon sequestration potential and co-benefits associated with the Conservation Reserve Program, and other factors.

Task 3 – Utilizing computer models to estimate C sequestration and GHG fluxes on local, regional, and national scales

A. Models to predict physical soil C changes and GHG fluxes.

- At Colorado State University, University of Nebraska, Pacific Northwest National Laboratory, and Texas A&M University, work has progressed on improving existing computer models (DAYCENT, EPIC, HYBRID-MAIZE) and validating the models against a comprehensive database of field experiments. Existing models underestimated C input to soil in corn cropping systems. The new HYBRID-MAIZE model improved estimates of plant C input resulting in a 36-42 % increase in the predicted annual rate of C sequestration.
- A database of more than 1,200 studies has been compiled on a variety of soil factors and GHG measurements to be used to improve and verify models. This database has been used for national and global-level studies of soil C storage that have been published in scientific journals and submitted to the EPA, USDA, and the Intergovernmental Panel on Climate Change.
- Colorado State University, Montana State University, and Purdue University are evaluating a computer program called C-STORE to allow producers, natural resources managers, and agribusiness predict the amount of carbon stored in their farm fields, based on a variety of possible farm management scenarios.
- Colorado State University, Michigan State University and University of Nebraska are implementing a Modeling Applications Integrative Framework (MASIF) to process large amounts of information from regional-scale simulation experiments.
- Colorado State University, Iowa State University, Pacific Northwest National Laboratory, and Texas A&M University have participated in a new version of the U.S. Inventory for Agricultural Soil Organic Carbon for the USDA and EPA dealing with National Greenhouse Gas Emissions and Sinks. Two models, CENTURY and EPIC, are being used and tested to assess current levels of SOC nationally and potential increases or decreases in SOC levels resulting from changes in management practices. Preliminary results of simulated SOC change and rates have been obtained for Alabama, North Dakota, Iowa, Nebraska, and Oklahoma.

B. Integrated economic-ecosystem modeling.

- Colorado State University, Montana State University, Texas A&M University, and Iowa State University are refining existing integrated economic-ecosystem models for use in economic and policy assessment.
- Colorado State University, Iowa State University and Montana State University are determining the impacts of soil C sequestration policies at the field- and farm-scale on other areas of the country. The effects of policies that target specific climate-friendly practices (such as reduced tillage) are being compared with policies that target performance (such as direct payments for C sequestration).
- Work is progressing on developing an on-farm decision support system to evaluate the economics of practices that increase soil C storage on the farm.
- Iowa State University, Montana State University and Texas A&M University are conducting regional-level policy assessments for the North Central region of the U.S. Research is underway on the regional and national effects of soil carbon policies on BMP adoption, other GHGs emissions or reductions, and the co-benefits and co-costs. The effect of alternative policies on costs, income, and production changes is being estimated.

Task 4 – Developing tools for measurement and monitoring

A. Estimating SOC levels:

- At Iowa State University, Kansas State University, Ohio State University, Texas A&M University and University of Nebraska, researchers are evaluating the variability of SOC measurements to make recommendations on the numbers of samples required for reliable estimates. Soil C estimates are consistent if elevation and electrical conductivity are taken into account during soil sampling.
- At The Ohio State University, researchers have found good correlation of SOC levels between direct laboratory measurement and Near Infrared Reflectance (NIR). NIR may provide a more rapid and economical way to assess SOC levels. Research at Texas A&M University and Kansas State University are evaluating NIR to estimate SOC levels in rangelands.

B. Measuring GHG changes within agricultural and grassland ecosystems:

- In Colorado, researchers are correlating changes in SOC levels with daily changes in the greenhouse gases nitrous oxide (N_2O) and methane (CH_4) to provide a comprehensive picture of how no-till and intensive-cropping management systems affect the total net GHG balance.
- Kansas State University researchers have built special automated chambers to continuously measure CO_2 levels from soil respiration in grasslands. The chamber systems are being used to study the impact of grazing intensity on carbon sequestration.
- At Michigan State University, researchers are measuring changes in CO_2, N_2O, and CH_4 in cropping systems, comparing conventional farming practices with potential BMP practices for carbon sequestration.
- At the University of Nebraska, researchers are examining changes in CO_2 emissions between irrigated and rainfed corn cropping systems.

C. Using local measurements to make regional estimates:

- Colorado State University researchers have used the DAYCENT computer model to compare estimates of N_2O emissions to actual measurements of N_2O emissions from experimental plots. The correlation has been reasonably good. If the computer model can be shown to be reasonably accurate, N_2O emissions from agricultural soils can be estimated with confidence.
- Research at Texas A&M University and the Pacific Northwest National Laboratory has correlated physical N_2O measurements with computer models. They also have found a good correlation, adding to the promise of using computer models to assess N_2O emissions from agricultural soils on regional and national scales.

D. Economic and social dimensions of C sequestration:

- At Montana State University, researchers are examining how the design of soil C credit contracts for market trading may affect the acceptance of the contract by agricultural producers. The researchers are also looking at the tradeoff between the costs and accuracy of SOC measurements.
- Ohio State University researchers have developed a farmer survey questionnaire that will be used to estimate the likely distribution of voluntary soil C sequestration contracts across the Midwest region.

Task 5 – Outreach

A. Multi-media education materials and training:

- The Eastern Cornbelt outreach specialist for CASMGS has developed three publications on C sequestration aimed at producers, Extension staff, and USDA-NRCS field staff.
- The Western Cornbelt outreach specialist for CASMGS held a field day in August, 2003 on C sequestration in irrigated and dryland agriculture in Nebraska.
- The Great Plains outreach specialist for CASMGS has produced several "MontGuides" on C sequestration based on articles from Kansas State University. The MontGuides are for distribution to farmers and ranchers.
- Kansas State University has developed two written publications on soil C, and several articles on its web site.
- Michigan State University is preparing an Extension bulletin on C and N management guidelines, with specific consideration for C sequestration and GHG mitigation.
- In addition, numerous presentations have been give by CASMGS researchers to popular, policy, and scientific groups, including the Council of Economic Advisors, U.S. Department of State, Congressional staff, the DOE Sequestration conference, the USDA Sequestration conference, and others.

B. *Decision Support Systems:*

- Montana State University specialists are developing an on-farm Decision Support System that will allow producers to analyze the economics of switching to practices that sequester more C on their own farms. Another farm-level Decision Support System, called the CarbOn Management Evaluation Tool (COMET), has been developed and tested in Indiana. COMET has been distributed to USDA-NRCS and Conservation Technology Information Center staff for feedback in order to develop a user's guide.

C. Website and newsletter development and maintenance:

- A CASMGS website has been developed. The URL is: http://www.casmgs.colostate.edu.
- An internal newsletter for CASMGS cooperators has been developed at Texas A&M University. Texas A&M University has also begun development of a practical web site defining the economic and policy issues of C sequestration and GHG mitigation. The site is at: http://agecon.tamu.edu/faculty/mccarl/acsmain.htm.
- Kansas State University also has a website on soil organic C at: www.oznet.ksu.edu/ctec. Two electronic newsletters have are being produced at Kansas State University. One of the newsletters is designed to communicate CASMGS research project updates and general information on soil C sequestration and GHG mitigation to policymakers, industry, producer groups, scientists, and others. One issue of this newsletter has been sent, and a monthly schedule will begin in winter, 2003. Back issues can be accessed at http://ageco.tamu.edu/faculty/tbutt/extletter.htm. The other newsletter is more specific to Kansas and how C sequestration research and policies impact this immediate area. This newsletter has been issued to policymakers, industry, producer groups, Kansas State University specialists, USDA-NRCS personnel, and others about twice a month since the summer of 2002. Back issues can be accessed at http://www.oznet.ksu.edu/ctec.

D. Forums:

- The CASMGS Carbon Measurement and Monitoring Forum was held October 15-17 in Manhattan, Kansas, hosted by Kansas State University. More than 125 scientists, policymakers, industry representatives, and producer representatives from 25 states and 3 foreign countries attended. Speakers also included representatives from the U.S. Department of State, USDA, NASA, and carbon sequestration consortiums in Australia, Canada, and New Zealand. The presentations made at the Forum can be found on the web at: http://www.oznet.ksu.edu/ctec/Fall_Forum.htm.
- A second CASMGS Forum is scheduled for January 20-22, 2004 in College Station, Texas, hosted by Texas A&M University. The topic of this Forum is "Partnering Agriculture and Energy." A third Forum will be held, hosted by Purdue University. This Forum will discuss Best Management Practices for carbon sequestration.

International

CASMGS had formalized agreements through the US State Department to collaborate with other carbon sequestration consortia in Canada, Australia, and New Zealand. Representatives have met and are developing work plans on N_2O emissions, soil C measurement technologies, and modeling. Representatives from those countries participated in the CASMGS Carbon Measurement and Monitoring Forum held in Manhattan, Kansas. Representatives from the US have attended three workshops in Canada, an all scientist meetings in Australia, and a joint Australia-New Zealand workshop on non-CO_2 greenhouse gases. Other outreach activities are occurring with individual scientists in other countries.

CASMGS consortium of expert scientists from **Colorado State University, Iowa State University, Kansas State University, Michigan State University, Montana State University, The Ohio State University, Purdue University, Texas A&M University System, University of Nebraska, and Battelle-Pacific Northwest National Laboratory**, in conjunction with research groups within the USDA's Agricultural Research Service, Economic Research Service and Natural Resource Conservation Service.

For further information visit the website: http://www.casmgs.colostate.edu or contact:

Charles W. Rice, Director
2004 Throckmorton Plant Sciences Center
Department of Agronomy
Kansas State University
Manhattan, Kansas 66506-5501
Phone 785-532-7217 Fax: 785-532-6094 Email: **cwrice@ksu.edu**