Consortium for Agricultural Soils Mitigation of Greenhouse Gases (CASMGS)

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Since the late 1800s, carbon dioxide (CO_2) levels in the atmosphere have risen from 260 parts per million (ppm) to greater than 370 ppm (IPPC, 1995). Most of the recent increase in CO_2 has been attributed to combustion of fossil fuels for energy and transportation, but changes in agricultural land use also contribute to CO_2 levels. Important agricultural land use changes include combustion of biomass through forest clearing, oxidation of soil organic carbon (SOC) through cultivation of cropland, and loss of SOC through soil erosion.

Carbon dioxide is one of three greenhouse gases (GHGs) related to agricultural land use which potentially impact climate. Other important GHGs that are impacted significantly by agriculture include nitrous oxide (N_2O) and methane (CH_4). Research to date has indicated that agricultural land use options can play an important role in mitigating the increase in each of these GHGs. Carbon dioxide can be sequestered in agricultural soils through changes in farming practices, reforestation efforts, and the use of biofuels. Nitrous oxide emissions can be reduced by changes in agricultural input use. Methane emissions can be reduced by changes in animal feeding systems and animal waste treatment. Land use systems are complex, however, and a full accounting must be taken of the energy used in the inputs of different agricultural land use systems and the limits inherent in agricultural soils and systems to mitigate GHGs. Much additional research is needed to increase public and private confidence in the ultimate net effect of changes in agricultural practices on GHGs. The effects of changes in agricultural land use on GHG mitigation must be more accurately estimated both in terms of permanence in time (short-term, medium-term, and long-term effects) and landscape (local, regional, national, and global scales).

The Consortium for Agricultural Soils Mitigation of Greenhouse Gases (CASMGS) is a coalition of scientists from 10 institutions in the U.S. to provide a highly coordinated, comprehensive, and efficient study of how agricultural soils can be managed to increase soil carbon (C) sequestration and reduce greenhouse gas (GHG) emissions. CASMGS scientists are also examining how policies designed to encourage C sequestration and reduce GHG emissions can be assessed, and how results can be quantified and verified.

To address the issue of agricultural soil mitigation of GHGs, a comprehensive roadmap is required to guide the project. The flow of research must go from (1) basic mechanisms of C storage and GHG flux, to (2) the effect of different Best Management Practices (BMPs) on GHG storage and loss, to (3) extrapolating the effect of BMPs on GHG mitigation over a local, regional, and national scale through use of models, to (4) the precise means of measuring and monitoring changes in C levels in the soil and GHG flux in agroecosystems. Finally, the results must be communicated to policymakers, regulators, and the public. To accomplish this, the Executive Committee of CASMGS has established five tasks areas.

The five tasks are:

1) Develop a better understanding of the basic processes of soil C sequestration and GHG emissions;
2) Evaluate BMPs to increase C sequestration and reduce net GHG emissions from soils;
3) Utilize computer models and databases to predict and assess C sequestration and GHG emissions;

4) Develop tools for measuring and monitoring soil C sequestration rates and GHG emissions; and
5) Communicate C sequestration and GHG reduction information to policymakers, and the agricultural and energy industry.

A more detailed description of the research projects in each task follows.

TASK 1: BASIC PROCESSES OF SOIL C SEQUESTRATION AND GHG EMISSIONS

The overall goal for Task 1 is to develop a basic understanding of biophysical and biochemical processes that control soil C dynamics and GHG emissions in agricultural soils of the U.S. Efforts in Task 1 are targeted to quantify the fundamental processes and mechanisms that underlie the capacity of soil to retain carbon. This research is designed to result in a mechanistic understanding of the processes, which will make assessments of C sequestration and GHG mitigation in agricultural ecosystems more accurate. The results also will allow us to manipulate the plant-soil system to achieve the greatest possible level of carbon accumulation while simultaneously minimizing adverse effects of GHG emissions.

Subtask 1. Subtask 1 research projects are designed to help understand the influence of land management strategies (e.g., grazing, crop rotation, irrigation) on plant primary production and the transformation of these materials into SOC. Additional studies are planned to enhance our understanding of the effects of shifts in litter quality (due to changes in species composition or substrate quality) on subsequent soil C sequestration.

Research involves both crop-based and grassland systems. In the crop-based systems, objectives include determining the influence of crop rotations and irrigation on primary production and understanding the effects of litter quality on subsequent protection of SOC. For managed, non-irrigated grassland systems, the objectives include determining the effects of grazing management and woody plant invasion on primary production and soil C inputs.

Subtask 2. The primary goal of Subtask 2 is to elucidate the biological, chemical, and physical mechanisms controlling the long-term storage of C in agricultural soils. Specific objectives are to:

- Investigate the role of soil structure (aggregation) on the sequestration of SOC.
- Determine the location of plant and microbial-derived soil organic matter (SOM) constituents within soil aggregates.
- Determine the relationships between clay mineralogy and the stabilization of SOM.
- Quantify rates of turnover of specific biomolecules characteristic of plant and microbial origin within SOC and characterize the rate-limiting steps in the C stabilization process.
- Determine growth yield efficiency and substrate partitioning and relate them to field determined C sequestration under different cropping/tillage systems.
- Investigate how microbial community structure, diversity, and activity influence C turnover and stabilization.

Subtask 3. The overall goal of Subtask 3 is to develop a better understanding of the factors controlling losses of carbon from agricultural soils to infiltrating water. Dissolved C losses (inorganic and organic) via leaching and infiltration have generally been ignored in soil C balances even though these can be important terms. This research is investigating the basic processes and mechanisms that control fluxes of inorganic and organic C from agricultural soils via infiltrating waters.

TASK 2: BEST MANAGEMENT PRACTICES

This task focuses on the physical and economic potential of various BMPs for sequestering C and reducing the rate of enrichment of GHG concentrations in the atmosphere. In evaluating BMPs, it is important to understand not only the physical potential for adoption of these practices, but also the economic viability of the practices. Thus, this research includes both economic modeling and physical measurements.

Analysis of BMPs for agricultural soils mitigation of GHGs is not as straightforward as simply measuring the C sequestration resulting from different management practices. To meet the objective of this project, a full accounting of reductions in C equivalent emissions is included in both the technical and economic feasibility research. For example, C sequestration from adoption of low-till practices may be possible only with the increased emission of other GHGs. Focusing only on C reductions of land-use changes would overstate the value of such changes in terms of the potential to reduce GHGs. A comprehensive (full cost accounting) of alternative BMPs must incorporate all such effects.

The co-benefits and co-costs (also commonly referred to as "hidden C benefits/costs") of BMPs also need to be explicitly considered. There is a substantial agreement that the adoption of practices to sequester soil C will also yield additional "co-benefits" in the form of reduced soil erosion, improved water quality, reduction in emission of other GHGs, provision of wildlife habitat, etc. Likewise, there may be "co-costs" in the form of expanded pesticide use, irrigation water use, and effects on other GHGs. It is critical to understand the broader benefits and costs of promoting these alternative management systems, including other environmental and sustainability features before we can determine which of these various BMPs are truly socially efficient.

CASMGS researchers are developing a suite of deliverables regarding BMPs for agricultural soils mitigation of GHGs. These deliverables are:

- Estimates of the rate of soil carbon sequestration for the most important and potentially applicable BMPs. Both the physical potential and economic potential of these systems is being studied. The list of BMPs and systems that is being considered fall into the three categories discussed above and are listed in Table 1.

Table 1: List of BMPs under study.

Land Management	**Perennial Ecosystems**	**Irrigation and Water Management**
Conservation tillage	Agroforestry	Irrigation management
Cropping intensity	Riparian zones and buffers	Water management
Nutrient management and precision farming	Prairie restoration	Soil restoration, saline soil reclamation
	Wetlands restoration	
	Grazing intensity and fires on prairies	

- Full C-cost accounting for the systems with the best information. Full C-cost accounting includes addressing the C emissions associated with different energy requirements of alternative cropping systems, the C equivalent of other GHGs that may be affected by the adoption of a particular practice, and the degree to which C gains from sequestering activities are permanent.

- Generation of a common data bank. Soil C data generated in all measurements undertaken in this task will be provided to a single soil C data bank. The data bank will be organized around common agro-ecoregions.

- Provide data on ancillary physical benefits to on-farm productivity. Although there are believed to be benefits to farm productivity associated with practices the sequester C, there is a need to provide detailed quantification of the physical, chemical, and biological benefits of these practices for soil productivity.

- Estimate the co-benefits and co-costs of C sequestering activities.

Data on the effect of different agricultural land management practices on crop and residue yields, soil C and N measurements, and other ancillary effects (such as erosion rates, runoff water quality, and others) are being collected from dryland and irrigated cropland experiments in Colorado, Kansas, Texas, and Montana, and rangeland in Colorado, Kansas, and Texas. Information concerning field management operations, and fertilizer and chemical application timing and rates for each particular cropping/tillage system are currently being assembled. Preliminary enterprise budgets for each cropping and tillage system are being constructed. The energy balance analysis to calculate CO_2 emissions levels from the inputs used in production of the crops is beginning. CO_2 releases associated with the consumption of the various forms of energy (diesel fuel, natural gas, propane, electricity, etc.) in the production of machinery, and fertilizers and chemicals of each cropping system are also being estimated.

TASK 3: PREDICTION AND ASSESSMENT THROUGH MODELS

One of the primary missions of CASMGS is to develop and apply prediction and assessment technologies at local, regional and national scales. The goals of Task 3 include:

- To improve and test existing biophysical models for predicting soil C and GHG fluxes and economic models for predicting the consequences of land use and management choices, at a variety of scales.

- To develop quantification systems which meld field measurements, remote sensing, and spatial data with models for improved predictions of soil C accumulation and GHG fluxes.

- To develop improved and more consistent databases for application across different modeling platforms.

- To provide assessments of GHG mitigation practices and policy scenarios using integrated ecosystem and economic models, at local, regional, and national scales.

There are eight subtasks within Task 3. Subtasks 1-4 deal primarily with biophysical modeling (i.e. soil C changes and GHG fluxes as a function of climate, soils and management). Subtasks 5-8 deal with economic modeling and integrated policy assessments.

Subtasks addressing primarily biophysical modeling include:

1) Refinement and validation of biophysical models;
2) Field-scale prediction and assessment;
3) Regional prediction and assessment; and
4) National-scale prediction and soil C and GHG inventories.

Subtasks relating to the economic modeling and integrated policy assessments include:

5) Integration of economic and biophysical models;
6) Model comparisons and databases for integrated assessment models;

7) Integrated assessments of GHG mitigation at field and farm scale; and
8) Integrated assessments of GHG mitigation at the regional and national levels.

Subtask 1. Refinement and Validation of Biophysical Models. Efforts in this subtask concentrate on refinements to existing models of soil C and GHG emissions, compilation of experimental data for model validation, and software development to facilitate simulation and data analysis. Examples of Subtask 1 research projects:

- Revised version of EPIC. Investigators are transforming the EPIC model into a comprehensive tool for simulating SOC dynamics and non-CO_2 gas fluxes in agricultural systems.

- Improved maize/soil C model. CASMGS investigators are revising an improved maize growth model (HYBRID-MAIZE) and coupling the model to a soil process–based model.

- Development of validation/analysis database. An Access database of data and meta-data for experiments documenting soil C changes in response to land use and management practices has been developed. The investigators are merging similar databases assembled by the DOE/CSiTE (Carbon Sequestration in Terrestrial Ecosystems) group into the database.

- Development/adaptation of data/modeling/visualization platform. CASMGS investigators have developed a Modeling Applications Integrative Framework (MASIF) to process the large amounts of spatial-temporal outputs from regional scale simulation experiments.

Subtask 2. Field-scale Prediction and Assessment. Efforts to mitigate GHGs through managing agricultural soils, whether as a result of government programs or through private markets, requires reliable methods for project and field level quantification. Examples of Subtask 2 research projects:

- Spatial modeling of soil C distribution by environmental correlation. CASMGS investigators are mapping and taking inventory of soil C using geospatial tools, relating soil attributes with high-resolution environmental data, including terrain attributes derived from digital elevation models.

- Testing and parameterization of CSTORE Decision Support System. CASMGS investigators have recently developed a simplified soil C model (CSTORE) for use by field personnel, crop consultants, etc. to assess alternative strategies for C sequestration.

Subtask 3. Regional-Scale Prediction and Assessment. To assess soil C sequestration and GHG emissions at larger scales requires integration of more complex and spatially explicit data sets with dynamic simulation models. CASMGS investigators have chosen the North Central region of the U.S., a 12-state area comprised of North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, and Ohio, as a focal area for much of the research. Examples of Subtask 3 research projects:

- Development of generalized geospatial databases for the North Central region and the U.S. To support the North Central regional and national-level analysis work, a common set of data required by the biophysical models is being compiled and analyzed.

- Testing and evaluation of DAYCENT/CENTURY and EPIC in the North Central region. Data from long-term experimental sites located within the North Central region are being used for model evaluation for both CENTURY and DAYCENT. DAYCENT is a new, daily time step version of CENTURY that includes routines for simulating N_2O and CH_4 fluxes from soils – the model has been tested for a limited number of field sites but has not yet been used for large-scale regional simulations.

- Evaluation of climate/management interactions on C balance of maize-based systems in North Central region. CASMGS investigators are evaluating the difference in simulated C balances

throughout the North Central Region using the standard CENTURY model as compared with an approach that links the models HYBRID-MAIZE and CENTURY.

- Integrating remote sensing data as drivers for biophysical models in the North Central region. CASMGS investigators are enhancing the accuracy of regional simulations of C sequestration through the integration of remote sensing derived variables into crop simulation models.

Subtask 4. National-Scale Prediction and Inventories. Quantification and assessment capabilities at the national level are needed to provide information to the U.S. Government for GHG reporting as a component of international treaty obligations (e.g. UN Framework Convention on Climate Change). In addition, national level estimates from biophysical models are needed to provide inputs to the integrated economic-environmental modeling required for rigorous policy assessment. Examples of Subtask 4 research projects include:

- National CO_2 emission/C sink inventories. CASMGS research has provided estimates for net C emissions from U.S. agricultural soils using the IPCC national inventory approach and the CENTURY ecosystem model. Project efforts will further develop national inventory approaches using both the IPCC methodology and CENTURY approaches.

- National level assessments using EPIC. Current and alternative management practices are being modeled at national scales.

Subtask 5. Integration of Economic and Biophysical Models. CASMGS researchers are producing and revising an integrated ecosystem-economic analyses of potential policy and/or market incentives for C sequestration and GHG emission reductions. Examples of Subtask 5 research projects include:

- Soil C and GHG emissions as inputs to regional and national economic models. Research will continue to develop and apply simulation-based methodologies for analysis of mitigation strategies. For the North Central regional and national assessments, simulation model outputs derived from a consistent set of soil, climate, and management factors, for both CENTURY and the EPIC model, are being used to derive 'to-from' matrices of soil C change (and potentially estimates of N_2O flux).

- Develop tightly-coupled linkages between biophysical and economic models and evaluate the implications for soil C sequestration cost. This research involves linking processes in the CENTURY model with land use and input use decisions in the field/farm scale econometric process model developed at Montana State University, so that feedbacks between ecosystem and economic processes are better represented.

- Adapt the Tradeoff Analysis Model software to work with CENTURY, EPIC, and economic production models being used in CASMGS policy assessments. CASMGS investigators have produced model integration software known as the Tradeoff Analysis Model.

- Modifications to Resource and Agricultural Policy System (RAPS) for carbon policy analysis and for integration with CENTURY and the CASMGS-modified version of EPIC. The economic analysis and model to predict production, cost, and income changes for agriculture are being based on a system of integrated models designed to estimate the economic and environmental effects of agricultural and environmental policies at both disaggregate and aggregate levels.

Subtask 6. Model Comparisons and Databases for Integrated Assessment Models. Key to the successful integration of economic and biophysical models is compatibility of models and parsimony in the data requirements. Examples of Subtask 6 research projects include:

- Comparison of modeling approaches. Alternative economic modeling approaches are being used in the CASMGS analytical work. These vary from detailed producer-level studies, through national and global approaches.

- Development of guidelines for minimum economic data sets for integrated assessment models. CASMGS investigators are summarizing and comparing the data needs for field/farm-scale, regional, and national assessment models for C sequestration, drawing upon the minimum data sets needed for the existing integrated assessment models at the different spatial scales.

Subtask 7. Integrated Assessments of GHG Mitigation at Field- and Farm-Scale. Research on the impacts of soil C sequestration policies at the field- and farm-scale provides a detailed analysis of how the impacts of these polices may vary spatially. Examples of Subtask 7 research projects include:

- Estimate and validate the amount of soil C and the effect of management changes. The economic models in the RAPS modeling system are being combined with the physical process models CENTURY and EPIC to estimate the impact of field-level management decisions (tillage, cropping, residue management, etc.) on soil C stocks and changes in stocks per unit land area.

- Integrated economic assessment of soil C costs and changes in GHG in the Northern and Central Great Plains. Integrated assessments of the costs of changing production practices to sequester additional soil C (and the net impacts on other GHGs) are being done using field-level economic and environmental data for two important agricultural areas: the northern Great Plains and the Central Plains.

- Testing and parameterization of the Economic Component for CSTORE Decision Support System. A simplified soil C model (CSTORE) intended for use by field personnel and based on the soil C components of CENTURY is being linked to a farm-level economic/financial decision model.

Subtask 8. Regional and National Level Integrated Models and Policy Assessment. The North Central regional and national assessments incorporate both CO_2 and other GHGs, as well as co-benefits and co-costs of soil C policies. Examples of Subtask 8 research projects include:

- Regional estimates of costs, income, and production changes of alternative policies. This effort largely involves (1) the regional economic model RAPS from Iowa State University, which is being linked with the new version of EPIC and CENTURY, and (2) scaling-up the existing econometric-process model for the Northern Great Plains to operate with county and regional level data for the Central U.S.

- Forecast agricultural land use and link to regional simulation models. This activity addresses the potential change in C sequestration as a result of transformation of agricultural land to suburban and urban development.

- National level policy analysis. The goal is to integrate results from CENTURY and EPIC with economic models to generate information on the relative attractiveness of various management practices on a national basis.

- Develop estimates of leakage, permanence, transactions costs, and rest-of-world reaction effects on price and market activity relative to soil C policies in the U.S.

- Estimate the co-effects of mitigation policies. To provide estimates of co-benefits and co-costs of various C and GHG policies at field, farm, and regional scales, CASMGS investigators are using the RAPS model to estimate C sequestration, other GHG emissions, and additional environmental consequences of mitigation practices, including soil erosion, nitrogen, and phosphorus runoff, as predicted by CENTURY and EPIC.

TASK 4: MEASURING AND MONITORING

The overall objective of Task 4 is to develop methodologies to measure and monitor changes in soil C and GHG emissions that result from changes in land use and management. The development of scientifically sound, practical, and economical mechanisms to estimate changes in soil C storage and GHG fluxes is crucial to the success of any GHG mitigation plan.

Traditionally, changes in SOC induced by management have been measured in long-term experiments by soil sampling and laboratory determinations. These data have been instrumental in the development of models able to predict SOC changes that result from various climate-soil-management combinations. The most effective verification plan will likely use some combination of direct measurement and modeling. Likewise, changes in the non-CO_2 GHG fluxes will likely also be best assessed using a combination of direct measurement and modeling. Monitoring compliance with contracts is also critical for the implementation of mitigation contracts.

Task 4 is divided into four subtasks.

Subtask 1. Estimating SOC at Multiple Scales. CASMGS researchers are identifying the most cost-effective techniques and spatial scale to estimate the amount of SOC at the beginning of a contract period between a land owner/manager and a carbon buyer. The overall objective of this subtask is to identify optimal spatial scales on which carbon contracts can be designed.

CASMGS investigators are comparing the spatial heterogeneity of SOC and the cost of its assessment at six spatial scales: benchmark plots, detailed field scale, the soil-survey scale, whole-farm scale, rangeland scale, and county scale. Examples of Subtask 1 research projects include:

- Fine, field-scale odeling of variability in SOC estimates. Research is being conducted at three production fields in Nebraska: (1) irrigated continuous maize, (2) irrigated maize-soybean, and (3) a rainfed maize-soybean rotation. Different geostatistical procedures and sequences of incorporating auxiliary information for spatial estimation of whole-field SOC stocks are being compared.

- Soil survey-scale estimates of organic matter distribution.

- Whole-farm estimates of SOC. CASMGS researchers are working with three to five farms in Ohio to create a SOM baseline for each farm. Data obtained for each land use of the farm include: SOC levels, history of land use, history of fertilizer applications, and tillage history. Baseline data for SOM and land use that are collected in Year 1 serve as the reference point for past effects on SOC levels and for all future data collected.

- SOM in rangelands. CASMGS investigators are including vegetation type and aerial extent in a stratified soil-sampling scheme.

Subtask 2. Measuring Fluxes of GHGs. The focus of Subtask 2 is the measurement and analysis of relevant fluxes (CO_2, N_2O, and CH_4) in key agricultural and grassland ecosystems in the region. The overall objective is to conduct field experiments to determine the impacts of selected climate-soil-management combinations on net fluxes of CO_2, N_2O, and CH_4. Measurements are being taken at a variety of sites in Colorado, Kansas, Michigan, and Nebraska.

The goals and objectives include:

- Gather information using flux measurements on how management practices impact soil C

sequestration and GHG emissions.

- Develop practical procedures and capabilities for measuring SOC storage and GHG exchange at the field scale using flux measurements (including N_2O and CH_4).

- Provide data that can be used to improve, parameterize, and test existing models of CO_2, N_2O, and CH_4 fluxes to allow measurements to be extrapolated to different management scenarios and larger spatial scales.

Subtask 3. Methods to Extrapolate Measurements and Model Predictions of SOC Changes and GHG Fluxes from Sites to Regional Scales. Changes in management and land use that include C sequestration as an objective may affect many other processes, such as non-CO_2 gas flux, erosion, crop production, etc. The spatial variability of soil properties and conditions found in many fields may also influence how much C can be sequestered under a given climate-management combination. Thus, improved understanding of landscape controls on C sequestration, N_2O flux, and other processes is essential for producing accurate regional estimates of these phenomena.

Goals and objectives of this subtask include:

- Gain a predictive understanding of the complex relationships (climate, soils, topography, management) government C sequestration and related processes.

- Develop a methodology for scaling GHG fluxes from fields to regions.

- Contribute toward the development of an integrated methodology for predicting soil C sequestration and GHG fluxes based on the best and practical use of soil sampling, databases, simulation models and remote sensing.

To achieve these objectives, CASMGS investigators are using the CENTURY and EPIC models, together with their derived versions known as DAYCENT and APEX.

Subtask 4. Economic and Social Dimensions of C Sequestration. The overall objective of this task is to develop mechanisms to estimate and verify changes in soil C and GHG emissions that are needed to implement contracts to sequester soil C through government policies or private markets. Examples of Subtask 4 research projects include:

- Review the types of policy mechanisms and their suitability for soil C sequestration.

- Use the integrated modeling approach to predict changes in SOC storage and GHG fluxes based on soil sampling, databases, and coupled ecosystem and econometric-process simulation models.

- Investigate methods for monitoring changes in land use and other management practices associated with BMPs, and assess their costs.

- Conduct comparative case study analysis, using interviews, focus groups, and surveys to assess the factors affecting farmers' willingness to change behavior in light of policy mechanisms such as sequestration contracts.

TASK 5: OUTREACH PROGRAMS

Information from Tasks 1 – 4 is being formatted and disseminated to clientele. The desired outcome is to have audiences understand:

- The potential of agricultural soils to serve as a sink for atmospheric CO_2.
- Management options and new technologies that can increase soil C and affect the C cycle.
- Potential on-farm benefits and costs of adopting alternative practices or technologies.
- Benefits and risks of entering into contracts with government or private entities for C sequestration.

The two target audiences during this initial phase are: (1) those involved in the development of governmental policy and programs, and (2) the members of the energy production and distribution complex. State and federal agencies and university personnel represent an ancillary audience. The information and delivery mechanism is tailored to fit the clientele using printed material, the media, the internet, and oral presentations.

Subtask 1. Multi-media Education, Materials, and Training. One of the fundamental vehicles for CASMGS outreach involves the preparation of documents, training modules, and computer presentations, among other items. Outreach specialists are working in close collaboration with CASMGS scientists involved in different tasks to develop multimedia information materials for different audiences to be shared among different states. They are developing a common set of extension publications, training modules, and computer presentations about basics of the C cycle, GHG mitigation options, BMPs, and potential agronomic, economic, and global benefits of soil C sequestration management. More specific materials are being produced for each geographical region, but following joint templates.

A key component of the outreach plan for the CASMGS program is the development of discrete training modules. The goal of these modules is to deliver comprehensive education packages to individuals or groups that are anticipated to be instrumental in effecting changes in farm management practices and/or related farm management policy.

Subtask 2. Decision Support Systems. Decision support systems (DSS) consist of: (1) procedures for accessing or collecting relevant information about the decision-maker's situation, (2) an algorithm for processing that information, and (3) some output arrangements that make the results of the information processing useful by the decision maker. CASMGS investigators are working to develop, validate, and implement the interface arrangements (materials, procedures) that will make the decision support algorithms useful by the targeted group of decision-makers (emitters, mitigators, program directors, outreach personnel).

Subtask 3. Website and Newsletter Development and Maintenance. Research produced by CASMGS will address important questions regarding the impacts of agricultural management on soil C and GHG mitigation efforts. While much of the outreach to communicate these research results to non-scientists can be accomplished by producing traditional printed documents and distributed multimedia material, electronic communication over the internet and a CASMGS web site provides a means for broad and rapid dissemination of our research and outreach to a diverse audience.

Some of the individual states within CASMGS maintain their own web sites. The main national CASMGS web site is: www.casmgs.colostate.edu

Two electronic newsletters help communicate CASMGS information and research results. One is an internal newsletter written specifically for CASMGS scientists to keep the group updated. The other is an external newsletter to provide information on CASMGS research and general information on C sequestration and GHG mitigation to policymakers, governmental agencies, other researchers, farm organizations, the media, energy companies, and the general public.

Subtask 4. Forums. One component of the outreach effort will be a series of three regional forums. The forums will be coordinated by Pacific Northwest National Laboratory (PNNL) and will be held at Kansas State University, Texas A&M University, and Purdue University.

Forum 1. Measurement, Monitoring and Verification of Soil Carbon Sequestration. Kansas State University. Fall 2003.

Forum 2. Role of the Utility and Fossil Energy Industries. Texas A&M University. Winter/Spring 2004.

Forum 3. Best Management Practices and Carbon Sequestration. Purdue University. Spring 2004.

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