I. INTRODUCTION[1]

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GRACEnet is an acronym derived by contraction of the project's title, "***G***reenhouse Gas ***R***eduction through ***A***gricultural ***C***arbon ***E***nhancement ***net***work." GRACEnet represents a coordinated national effort that was established in 2005 by the Agricultural Research Service of USDA. As part of this effort guidelines were established to allow research collaborations across many locations and within different agro-ecosystems as appropriate to assess the role of agricultural management systems at local, regional, and national scale. Agricultural systems and their management are assessed for their ability to mitigate greenhouse gas (GHG) emissions through the enhancement of soil carbon sequestration and the reduction of agricultural greenhouse gas emissions into the atmosphere. Project planning was done by a highly qualified research team and includes their best efforts to describe the use improved approaches and best standardizing protocols, within the capabilities of current technology, for the collection of soil, plant, and gaseous samples so that valid comparisons can be made across many experiments, many locations, and many cropping and land use systems. The emphasis within the GRACEnet effort is to allow comparisons among common management scenarios at each location. Although the soils, crops and condition will be location specific, consistent methods and detailed record keeping will facilitate cross-location and cross-regional comparisons and ensure quality control.

GRACEnet OBJECTIVES/*Hypotheses*

1 Evaluate the soil C status and direction of change of soil C in existing typical and alternative agricultural systems. *Hypothesis: Soil and agronomic management practices can be developed that sequester more soil C than those currently and/or typically used.*

2 Determine net GHG emission (CO_2, CH_4 and N_2O) of current agricultural systems in existing typical and alternative agricultural systems. *Hypothesis: New agricultural systems can be developed that will decrease net GHG emission while increasing soil C storage.*

3 Determine the environmental effects (water, air and soil quality) of the new agricultural systems developed to reduce GHG emission and increase soil C

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storage. *Hypothesis: The development of agricultural systems that reduce GHG emission while increasing soil C storage will also improve water, air, and soil quality.*

Note: All participating units will address objective 1. Those units with the capacity to measure trace gases will also address objective 2. While those with the capacity to measure other environmental parameters will also address objective 3.

APPROACH: The GRACEnet experimental concept is based on **four** location-specific scenarios or treatments as follows:

1. Business as usual

What is the C accumulation rate under typical agricultural management practices?

These business as usual systems should be economically viable or at least used by the majority of producers that are able to continue in production agriculture in that area of the country. Each unit will determine the number of sub treatments it will research, since there may be many variations on typical practices within a geographic area.

2. Maximizing C sequestration rate

What has to be done to achieve the highest rate of soil carbon sequestration in that production system?

These treatments may be either economically feasible or technically feasible. The only constraint is that they remain in a agriculturally feasible production system. Each unit will determine the number of sub treatments it will research, since there will be many variations on practices to potentially maximize C sequestration.

3. Minimizing net GHG emission. This system differs from #2 because N_2O and/or CH_4 emission must also be considered.

How does this management scenario compare with #2? What is the sequestration rate and net GHG balance when all GHG emissions are considered?

Agriculture is the main source of N_2O and CH_4 to the atmosphere. Therefore, data will be collected by the units that have the capability and capacity to determine N_2O and/or CH_4 on the treatments under study in scenarios 1 and 2. Practices will be developed to decrease the emission of N_2O and CH_4. Each unit that addresses this scenario will determine the number of sub treatments it will research, since there will be many variations on practices to potentially maximize C sequestration.

4. Maximizing environmental benefits. Carbon sequestration may well become part of a larger conservation benefit package. Land managers and policy makers will be interested in tradeoffs among management options.

With careful management, how can soil C sequestration and GHG emission be *balanced with water quality, air quality, and soil quality goals?*

Units capable of evaluating environmental benefits and C sequestration will be encouraged both to study the individual issue or issues that they can address (water quality, air quality, or soil quality goals) and to collect data that may contribute information that is consistent with the needs of the 'larger conservation benefit package' that may be implemented by USDA or other action agencies.

Economically viable management practices that are typical of an area (business as usual scenario), including for major crop(s) or systems, tillage practice(s), and inputs provide a basis to evaluate the C status and direction of change of soil C stocks. Depending upon resources and in addition to scenarios 1 and 2, units will address scenarios 3 and/or 4 and will use the common protocols described in this document for soil sampling, plant measurements, trace gas sampling, micrometeorological measurements, and data management. Whenever feasible, reference soil, plant, and gas samples should be used and cross-compared with other laboratories for quality control and assurance purposes.

Contingencies – The goal of this project is to compare current and alternative farming systems with regard to soil C sequestration and net GHG emission. To adequately do so, there are three considerations: 1) sufficient time has to lapse for the treatments to be expressed and within the sensitivity of measurement methods, 2) it is also possible that meaningful differences do not actually exist, or 3) variability is too high to allow for determination of existing differences If some practices are found to be significantly better than others, additional research will be developed to: (i) develop a mechanistic understanding of the reasons for the success, and (ii) modify the successful practice to improve economic viability and increased effectiveness in reducing GHG emission. However, if real differences in management practices are not observed over a five-year period of time, this too, is valuable information.

PRODUCTS

The GRACEnet project has identified four products, which represent an integration of the objectives:

Product 1. **A national database of GHG flux and C storage.** All relevant project data from every network unit should be entered into a common data base for use by project scientists and others.

Product 2. Regional and national guidelines of management practices (in the form of decision aids) that reduce GHG intensity, applicable for use by producers, federal and state agencies, and C brokers. These guidelines will be produced in consultation with the USDA Global Change office and others to insure that they are in a format to meet their needs

Product 3. Development and evaluation of computer models created to assess management effects on net GHG emission. GRACEnet data will be used to evaluate the adequacy of IPCC constants and models such as CQESTR, Century, Daycent, and COMET.

Product 4. Summary papers for action agencies and policy makers, based on the current state of knowledge. The information generated by GRACEnet will be used to produce synthesis documents for action agencies such as NRCS, the USDA Global Change Program Office and other policy makers including those from regional, State, or local jurisdictions. These documents will address the feasibility of adopting the practices studied in GRACEnet and the amount of C sequestration and GHG reduction that is likely to result from their adoption as well as other issues of concern to them.

PROTOCOLS

To maximize the potential for both success at the project level and potential opportunities to compare as well as interpret across locations it is necessary to use standardizing protocols, within the capabilities of current technology, to collect soil, plant, and gaseous samples so that valid comparisons can be made across many experiments, many locations, and many cropping and land use systems. Although soils, crops and condition will be location specific, consistent methods and detailed record keeping will facilitate cross-location and cross-regional comparisons and ensure quality control as well as data sharing and interpretation. The GRACEnet protocols that are included in the subsequent chapter are:

Chapter 1. Guidelines for Site Description and Soil Sampling, Processing, Analysis, and Archiving (September 2010)

Chapter 2. Plant Sampling Guidelines (September 2010)

Chapter 3. Trace Gas Sampling Guidelines (April 2003)

Chapter 4. Micrometeorological Measurements (September 2010)

Chapter 5. Guidelines to Populate the GRACEnet Database Template (September 2010)

The above chapters are entered separately and can be downloaded separately from the GRACEnet website or all, including the introduction can be downloaded as a complete set.