Climate Friendly Farming™ Project
Modeling Carbon Sequestration and Greenhouse Gas Emissions

Year One Report

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Introduction

Modeling activities are included in the scope of work of the three farming systems identified for the Climate Friendly Farming™ Project: Dryland, Irrigated, and Dairy systems. Active participation in the monitoring and experimental work designed to characterize and project carbon sequestration and greenhouse emissions in these systems has been an important component of the activities of the modeling team during this first year of the project. This information is vital to establish baseline conditions, provide data for the development and evaluation of sub-models, and provide points of verification for long-term assessment of system responses to changes in agricultural practices.

The current personnel of the modeling team includes Roger Nelson (Scientific Programmer), Dr. Armen Kemanian (Dryland and Irrigated Systems Modeling), and Dr. Bincheng Zhao (Dairy Systems Modeling). Dr. Claudio Stöckle is providing overall leadership to this work, with significant cooperation from Dr. David Huggins (Dryland Systems), Dr. Shulin Chen (Dairy Systems), and Dr. Harold Collins (Irrigated Systems).

Overall Goal

Establish the long-term equilibrium values and rate of changes of soil carbon storage and N_xO, CH_4 and CO_2 emissions of current/conventional and future/improved dryland, irrigated, and dairy farming systems.

Specific Objectives

1) Improve and parameterize cropping systems simulation models.
2) Calibrate and evaluate models using biological and environmental data from the different farming systems.
3) Apply the models to help in the interpretation of carbon, nitrogen, and water management balance components observed on the different farming systems/management schemes implemented in the field.
4) Apply the models to evaluate the long-term (50 years) evolution of carbon, nitrogen, and water balance components in each system and different management schemes.

Planned Tasks by Objective

Improve and parameterize cropping systems simulation models

Task 1. Develop and evaluate soil carbon and nitrogen cycling models.

Task 2. Conduct literature review and controlled experiments as needed to determine decomposition rate constants and moisture and temperature responses for the different model pools and crops included in the farming systems.

Task 3. Develop models and characterize organic residue physical properties of interest for the simulation of energy and water balances (e.g., radiation interception, water holding capacity).

Task 4. Conduct field experiments to determine crop water use and transpiration-use efficiency for the different crops included in the farming systems. Evaluate transferability of these parameters for climate change and carbon-dioxide elevation scenarios.

Calibrate and evaluate models using biological and environmental data from the different farming systems

Task 1. Characterize seasonal patterns of greenhouse gas emissions for the different farming systems.

Task 2. Characterize the seasonal and multi-seasonal patterns of standing and flat crop residue decay.

Task 3. Compare simulations and field data of crop growth, water and nitrogen use, residue fate, carbon storage, and greenhouse gas emissions for the different farming systems.

Apply the models to help in the interpretation of carbon, nitrogen, and water management balance components observed on the different farming systems/management schemes implemented in the field

Task 1. Apply the model to evaluate and interpret the magnitude of the balance components for the different farming systems. Include as much existing data as possible (e.g., 5 years of data at the WSU Cunnigham farm).

Task 2. Assess and interpret the effect of changes to cropping systems and management schemes on carbon storage and greenhouse gas emissions patterns.

Apply the models to evaluate the long-term (50 years) evolution of carbon, nitrogen, and water balance components in each system and different management schemes

Task 1. Collect a database of soil, climate, cultivation history and other properties of the monitoring sites identified for each farming system.

Task 2. Generate long-term daily weather data for two contrasting climate change scenarios.

Task 3. Perform long-term simulations for each farming system, cropping system/management, climate change scenarios, and two CO_2 elevation scenarios.

Progress Report (organized by milestone)

<u>Develop conceptual models for GHG cycles</u>

A thorough literature review of soil carbon and nitrogen processes and conceptual models was conducted. A conceptual framework for the carbon sub-model of the overall cropping systems model was developed, and a prototype program was coded for testing. Both carbon dioxide and nitrous oxide emissions are explicitly modeled. The corresponding subroutine was incorporated into a cropping system model, which is operational as a prototype coded in Visual Basic running in MS Excel. Preliminary testing suggested the need for additional refinements of the model, which will be implemented early in 2005. Ultimately, the carbon and nitrogen cycle sub-models and corresponding GHG emission routines will be incorporated into CropSyst, a fully operational multi-crop, multi-management cropping system model that runs as a stand-alone program for MS Windows-based computers.

<u>Finalize data collection protocol for model verification</u>

During this first year, the modeling team was involved in setting up field monitoring experiments for Dryland (Dr. Kemanian) and Dairy Systems (Dr. Zhao). Close coordination with Dr. Harold Collins (Irrigated Systems) also took place to provide reasonable uniformity of procedures across the different farming systems. The data collected in this and future growing seasons will provide a base for the verification of several sub-model components included in CropSyst.

Create experimental database for systems

Based on existing data collected previously by team members and a thorough literature review, a document evaluating and interpreting historical patterns of carbon storage and nitrous oxides emissions for various cropping systems in the dryland cultivated areas of the Pacific Northwest was prepared. This information was re-analyzed to aid in the design of the soil carbon and nitrogen conceptual model, to parameterize the model with field data, and to propose new experimental procedures in the context of the project. In addition, this information provides an important baseline for the project. Similar baseline reviews were prepared for the other two farming systems included in this project.

Experiments to characterize growth and water use of irrigated field corn and potato and determine model parameters were planned, instrumented, and completed this year. A graduate student and a post-doctoral research associate funded with sources complementing the core PGAFF funds were used for this purpose. Operational funding provided by another source was $50,000 in year 2004. Potato is the most important irrigated crop in the region. The modeling of growth of potato plants, resource use, and tuber yield is significantly more complex than modeling grain crops. A potato model was developed and preliminary testing with field data was completed during this year.

An experiment to evaluate the cropping systems model capabilities to estimate daily/hourly changes in the soil profile (divided in 10-cm soil layers) water content, water potential, and temperature for fallow plots at Lind, WA was conducted from April to December 2004. The model appears adequate to simulate these soil physical factors that are very important in determining residue decomposition, organic matter transformation, and overall microbial mediation in the carbon and nitrogen cycle affecting CO_2 and N_2O emissions. A graduate student funded with sources complementing the core PGAFF funds participated in this activity. Operational funding provided by another source was $55,000 in year 2004.