CLIMATE FRIENDLY FARMING:

ESTABLISHING A TRANS-DISCIPLINARY FRAMEWORK FOR AGRICULTURE AND CLIMATE CHANGE SCIENCE IN THE PACIFIC NORTHWEST

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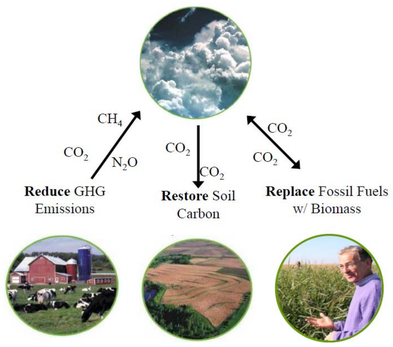
Why a trans-disciplinary, integrated Project?

Rationale and Justification:
Why this wasn't just "another ag science study"
Agriculture and climate are fundamentally linked. Agricultural management contributes greenhouse gas emissions to the atmosphere, cycles and stores carbon and nitrogen in soils and biomass, uses substantially amounts of carbon-based fuels, and could potentially be a substantive source of renewable energy. Furthermore, the evolution of modern agricultural systems is fundamentally tied to stable and predictable climatic patterns. Addressing the complex nexus of agriculture and climate change requires scientific approaches that are both *trans-disciplinary* and *actionable* and that lead to changes in how the agricultural industry operates.

The Project in a nutshell:
The Climate Friendly Farming (CFF) Project was established in 2003 with a $3.75m grant from the Paul G. Allen Family Foundation. The purpose was to conduct integrated research and extension programs that would contribute to mitigation of agricultural Greenhouse Gas (GHG) emissions and improve agricultural resiliency to climate change in the Pacific Northwest (PNW).



Specific objectives of the Project were: 1) assess the potential impact of climate change on PNW cropping systems; 2) assess the GHG contributions of PNW agricultural systems; 3) design agricultural systems that reduce GHG emissions and are more resilient to climate change; 4) develop and deploy technologies that reduce GHG emissions and increase soil carbon storage; 5) develop and deploy biomass-derived energy and co-product technologies; and 6) provide technical support for comprehensive PNW climate policy for agriculture. The original scope was completed in 2010.

The CFF Team and our Collaborators:
The core CFF Team included 9 co-PI's and 3 Project Staff (listed authors above) and more than 2 dozen graduate students, post-doctoral researchers, and field / lab technicians. Disciplines represented included biological systems engineering, soil science, horticulture, environmental science, economics, and extension. The CFF Team received several honors and awards, including USDA NIFA's Partnership Award for Innovative Program Models.

The Team collaborated with dozens of additional scientists on complimentary research projects, and had more than two dozen active partnerships with industry, agency and environmental organizations.

What were the Project Outcomes?

Highlights of Integrative Scientific findings:
- Reducing emissions associated with manure management using an anaerobic digestion technology platform is the single largest strategy for reducing agricultural GHG emissions in the PNW. Commercially viable technology could readily reduce 3-6 $MMTCO_2e$ annually in the PNW.
- Co-digestion of food processing waste with dairy manure improves both the technical and economic performance of anaerobic digestion, making AD technology economically feasible under many commercial conditions.
- The most important factors in determining soil carbon sequestration are initial organic matter and organic inputs.
- Conservation tillage coupled with improved cropping systems can provide a modest, near-term GHG mitigation strategy in the region (~0.3 MMTCO2e annually), but is likely important for improving cropping system resiliency under changing climatic conditions.
- Recovery and application of carbon and nutrient residuals from organic wastes is the single most significant strategy for increasing soil carbon.
- The use of nitrogen fertilizers is a major source of *direct* and *indirect* GHG emissions, outweighing the annual carbon sequestration potential of most cropping systems in our region on a life-cycle basis. Given the need for nitrogen inputs, improving Nitrogen Use Efficiency (NUE) is key for reducing agriculture-related GHG emissions.
- Measurements of N2O emissions from the N fertilizer-intensive potato production system in the region are significantly lower than expected based on IPCC estimates, likely due to fertigation technology.
- Deployment of precision nitrogen management technology can improve NUE in dryland grain-based cropping systems, reducing nitrogen-related GHG emissions and saving farmers money.
- Management decisions directed at increasing soil carbon sequestration may have consequent effects, positive or negative, on *direct* and / or *indirect* nitrogen related GHG emissions. Incentives to encourage C sequestration should account for these changes.

Outputs and Tools Developed or Enhanced:
The Project produced more than 50 journal publications, dozens of technical and trade publications, 3 patents and 1 additional unpatented Invention Disclosure, 1 software license package, and a comprehensive final report (27 chapters plus summary) on the findings from the Project. In addition, multiple tools / models have been developed or improved to provide decision support for farm and technology management, including:
- CropSyst, a cropping systems simulation model enhanced to evaluate C and N dynamics (Stöckle et al., 1994, 2003);
- C-Farm, a simplified excel-based C sequestration tool appropriate for working directly with industry, policy-makers and extension personnel (Kemanian and Stöckle, 2010);
- Linked Excel farm-level budgets that show the economic impact of reduced tillage and possible carbon credits;
- General Integrated Solid Waste Co-digestion (GISCOD) model, a tool designed to provide performance expectations for digestion of mixed organic wastes (Zaher et al., 2009); and

What has resulted from CFF Outcomes?

Community Impacts:
- 15 commercial farm-based AD projects are now operating in the PNW (3 additional under construction), processing 4,750 tons / day of organic wastes (60,000 Wet Cow Equivalents, 161 tons / day food waste) representing 18.6 MW electrical capacity installed, mitigating nearly 850,000 tons of CO_2e annually and representing an estimated $91 million in capital invested.
- A viable replacement for peat moss as a horticultural–grade, soil-less media was developed from digested dairy manure solids. Peat moss is primarily harvested from peat bogs, which are an important carbon sink. The US peat market consumes approximately 80 million metric tons annually.
- Technologies have been developed that enable recovery of up to 70% of nitrogen and phosphorous from anaerobically digested manure and food processing waste, representing the potential for providing 20% and 27% of the state's total agricultural demand for nitrogen and phosphorous fertilizer, respectively, if the technology is applied to the largest 135 dairies in the state. Commercial scale nutrient recovery plants are being constructed on two dairies in the state.
- A suite of Precision Nitrogen Management technologies has been evaluated on-station and on-farm with two commercial collaborators, resulting in up to 20% reductions in total nitrogen fertilizer application without yield or quality penalties.
- The project team and collaborators have fostered development of numerous policy mechanisms in the state and region for GHG mitigation, anaerobic digestion development, and biofuel/bioenergy policy. Examples include legislation and agency rules addressing the potential for agricultural GHG emission reduction, permitting for anaerobic digestion facilities, the use of manure and organic wastes for renewable energy, and a variety of policies related to biofuels.

Basis for new and continued Projects:
CFF Provided the basis for dozens of new and continued projects totalling more than $50m in grant awards through research findings, enhanced analytical tools, collaborations developed with other scientists, and reputation and partnerships with the broader community. A snapshot of major trans-disciplinary / integrated projects that CFF contributed to include:
- OFFOOT – Organic Farming Footprints (USDA OREI)
- Columbia River Supply & Demand Forecast (WA Ecology)
- REACCH – PNW Wheat Climate CAP (USDA NIFA)
- SCF – Site-Specific Climate Friendly Farming (USDA NIFA)
- BioEarth – PNW Regional Earth Systems Model (USDA NIFA)
- AD Systems Integration (USDA NIFA)
- AIRTRAP Nutrient Recovery System (USDA NRCS)

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