



Climate Friendly Farming™ Research and Demonstration Project

Executive Summary

Center for Sustaining Agriculture & Natural Resources
Washington State University

Annual Progress Report to the Paul G. Allen Family Foundation

November 2003 – January 2005

Summary

The Climate Friendly Farming™ Project has been successfully established at Washington State University. The Project has received top billing from WSU's College of Agriculture, Human and Natural Resource Sciences (CAHNRS) on several occasions this year, including being the feature program represented in *WSU Connections*, the CAHNRS annual alumni magazine. In addition, the Project was nominated by CAHNRS and WSU Extension and subsequently selected by the National Association of State Universities and Land Grant Colleges (NASULGC) as a featured exhibit at the 2005 Food and Agricultural Science and Education Exhibition and Capital Hill Reception in Washington D.C. on March 1, 2005. More than 800 people, including nearly 40 members of Congress attended this event in 2004.

Key milestones completed in year one include: completed construction of a commercial anaerobic digester in partnership with a private dairy farm, completion of an initial adoption study of dryland conservation practices, baseline evaluation of cropping system performance, development of conceptual models for GHG cycles in farming systems, additional new funding secured totaling \$1,262,920 (over \$200,000 of which supplemented funding for the core scope of work in year 1), and various outreach efforts including popular articles, field days, website and presentations. The component reports posted to a password-protected reporting page on our website highlight first year progress toward the milestones (posted by January 31).

Several of the research leads have stressed that the Climate Friendly Farming Project is their first priority. Many of them have devoted a significant percentage of their personal research time and have leveraged much or all of their own program resources toward the project.

The Project has already created quite a stir in the public arena – remarkable for an agricultural research project that is just underway. More than 1200 people (producers, industry, agency personnel, media, community members, politicians, etc.) have learned about the project through formal presentations and poster displays. Popular articles about the Project (all by invitation) have reached a circulation of more than 20,000 people, and have prompted inquiries from literally every region of the US and several other countries. The Project has become a lightning rod of conversation and collaboration among players in the emerging bioenergy industry in the Pacific Northwest. The organizers of the 5th annual Northwest

Renewable Energy Festival in Walla Walla claimed that the Climate Friendly Farming™ display and presentations were the highlights of this year's festival. Two participants in our presentation at the Spokane Ag Expo Farm Forum told us that the Climate Friendly Farming™ presentation should have been the keynote address for the whole Expo. Producers, industry and community members are excited to learn about agricultural research that is shifting agriculture from an environmental liability to an environmental asset. A recent example demonstrating the potential of market-place incentives for climate friendly farming was reported by MSNBC.com (January 3, 2004, "Trade in global warming credits includes pigs). TransAlta and Tokyo Electric Power Co. (Canadian and Japanese utilities respectively) purchased the carbon credit from a Chilean hog producer who installed a digester to capture methane from the hog manure.

What is Grantee's progress toward achieving the Project milestones described in Appendix A?

We have achieved all of the year 1 milestones and have even achieved several outyear milestones. The one area we did not achieve as much progress as we had planned was the baseline evaluation and monitoring of GHG emissions. The dairy monitoring was delayed by the opportunity to secure a contract for a commercial digester. The questions about N₂O monitoring methodology, which surfaced early in the irrigated component, delayed implementation of the common protocol across cropping systems pending the development of a more reliable sampling method (see unexpected barrier / opportunity #3 below for more discussion). Monitoring sites for all systems were established and extensive environmental data was collected, but collection of trace gas data was limited in the first year. We envision that the ongoing monitoring over the next two years will continue to develop the baseline evaluation. See Appendix 1 for the milestones and component reports on the password protected page on our website for details.

Have there been any unexpected barriers or opportunities that have led to changes in the Project thus far?

1. The opportunity to partner with a private dairy farmer for the construction of a commercial anaerobic digester arose early in 2004. The Vander Haak Dairy, LLC. received a federal cost-share grant from USDA's Rural Development Program to partially offset the costs of building an anaerobic digester. A contractual research agreement was reached between WSU and the Vander Haak Dairy to allow WSU research and extension personnel access to the Vander Haak digester to conduct research, demonstration and outreach activities related to anaerobic digestion committed in the Climate Friendly Farming grant. Construction was completed in late October and the Vander Haak digester began producing electricity with biogas in November of 2004. This partnership opportunity advances the timetable for several elements in the dairy component of the Climate Friendly Farming Project, creates the potential for demonstration and outreach to the dairy farming industry earlier in the project, and ultimately increases the profile of our research and outreach efforts related to anaerobic digestion with dairy producers, bioenergy advocates and anaerobic digestion technology providers. A consequence of this opportunity is the limited amount of input that our research team has on the design of the anaerobic digester. The Vander Haak's selected the GHD design, based on proven reliability of the system as well as the service contract provided by GHD's sublicense holder (Andgar Corporation of Ferndale, WA). We were able to enter this partnership for less than the planned amount for a commercial digester cost-share, and have reserved the remainder of this cost-share to put toward the development of a significantly larger pilot-scale version of our novel anaerobic digester concept. A second consequence of this opportunity is that we exercised caution in deploying environmental and GHG field monitoring equipment on Whatcom County dairies to ensure that nothing jeopardized the execution of the digester research agreement. Monitoring equipment was deployed on the WSU Knott Dairy first, and limited equipment was deployed late in the year in Whatcom County. Additional equipment will need to be deployed in Whatcom early in the spring before field work begins. A third consequence of this opportunity is that it provided the physical platform and cash match necessary for our successful Conservation Innovation Grant proposal to

USDA's Natural Resource Conservation Service for research and demonstration of high-quality fiber, nutrient extraction, and process improvements for anaerobic digestion – funding necessary for meeting our committed scope of work. We are still pursuing the strategy and necessary resources to commercialize our novel anaerobic digester system by year 5 of the Project.

2. WSU filed a provisional patent application on December 27, 2004 for both Shulin Chen's novel anaerobic digestion concept and Craig MacConnell's post-digestion fiber treatment process. There are already inquiries about licensing the post-digestion fiber treatment process.
3. A significant development related to monitoring of greenhouse gas emissions from irrigated agricultural systems was discovered during first year monitoring efforts and has contributed to the development and refinement of trace gas monitoring protocols. Preliminary measurements from the sampling stations indicated noisy data resulting from the timing of chamber deployment and sample collection interval. The original sampling intervals used were based on values derived from the current literature on trace gas flux measurements and was found to be inappropriate for the irrigated soils of the Columbia Basin. Therefore, we developed new methodologies to identify sampling intervals of the gas flux measurement and also timing of chamber deployment after irrigation. This could prove to be a key scientific contribution for measuring nitrous oxide emissions from irrigated, sandy soils.
4. During this first year, our belief that bioenergy (e.g. power, fuels, and products) is an important part of Climate Friendly Farming has been reaffirmed. The emphasis on bioenergy in our initial concept paper to Vulcan was removed during the proposal development process in our attempt to craft a focused project. We now see the concept of Climate Friendly Farming as having three important legs - reduce emissions of greenhouse gases (GHG) from agriculture (CO_2 , CH_4 , and N_2O); increase sequestration of C by farming systems; and produce bioenergy as a GHG-neutral alternative. Bioenergy technologies have a two-fold impact on greenhouse gas emissions: 1) they offset the use of fossil fuel energy sources and 2) these technologies and practices improve the function of "climate friendly" farming systems (i.e., oilseed crops as rotation crops, etc.). In addition, there is an emerging bioenergy industry in the region which could be effectively utilized to facilitate the adoption of climate friendly practices by producers. Discussions about bioenergy with the Center for Clean Air Policy and recently published reports from the Consortium on Agricultural Soils Mitigation of Greenhouse Gases confirmed that this is an important and strategic element for the project. In order to create a bioenergy strategy and programming for the project, we have expanded the role of Dave Sjoding of the WSU Extension Energy Program and are actively seeking additional resources to fund this work. We have also partnered with WSU's Compost Facility to work on the development of a research, education and demonstration facility called the Sustainable Waste to Energy Education Technology Center (SWEET) on the WSU campus. This facility would provide a platform for comparative research, evaluation and demonstration of various waste biomass to energy / product technologies and would be the first such university based facility in the US. Hal Collins implemented a biofuel variety trial at his Paterson research site to document agronomic and economic potentials of various energy crops in the region.
5. Efforts to promote the adoption of Climate Friendly Farming systems will clearly be helped or hindered by the economic considerations of these systems (everything from farm-level enterprise budgeting to macro-economic policy prescriptions). A variety of economic and business/marketing tools and expertise is required to adequately address the wide variety of socio-economic questions the Project is raising. With this in mind we have expanded our economics team to include Hayley Chouinard and Richard Shumway – both of WSU's School of Economic Sciences. Chouinard and Shumway bring expertise and skills complementary to Phil Wandschneider, our economics lead. In addition, we are actively seeking additional funding and collaborative partnerships to expand our economic capabilities, for instance, to bring on a community / regional economic impact specialist and a marketing specialist)

6. Our successful proposal to the USDA Natural Resource Conservation Service Conservation Innovation Grants Program enabled us to bring on Joe Harrison, WSU Dairy Nutrient Management Specialist to begin work on nutrient extraction from dairy digester effluent in year 2 of the Project.
7. One of the obstacles and opportunities of seeking supplemental funding is that most new funding proposals require the inclusion of additional tasks and objectives beyond those in the core project. Thus, not all of the new funding secured will directly apply to the core project activities. The opportunity in new funding enables us to address research issues that were not funded under the original scope of work but that are obviously complementary (i.e., bioenergy). We will continue to seek resources to supplement core funding.
8. New Collaborations:

We have made numerous connections and are nurturing partnerships with many different organizations, agencies and individuals. The following are partners with which we have formed a new collaboration that includes an exchange of resources (not including grant agreements), formal agreement, or a collaborative proposal.

Anaerobic Digester technology development and evaluation: Andgar Corporation (Ferndale, WA), Vander Haak Dairy, LLC. (Lynden, WA), Multi-Form Harvest, LLC. (Seattle, WA), Washington Department of Ecology, WSU Compost Facility / Sustainable Waste to Energy Education Technology Center, Energy Northwest

Yakima County Anaerobic Digestion Feasibility: J&J Bosma Dairy (Sunnyside, WA), the Institute for Washington's Future, Washington Dairy Federation, Yakima Clean Air Authority, Prometheus Energy Company

Yakima County Anaerobic Digestion Workshop: Washington Dairy Federation, the Institute for Washington's Future, Northwest SEED, Harvest Clean Energy Program (Climate Solutions), South Yakima Conservation District, Yakima RC&D, Yakima Clean Air Authority

Policy Arena (climate change, agricultural research): Center for Clean Air Policy, WSU Energy Program / EPA – State Greenhouse Gas Inventory, Center for Rural Affairs (Nebraska)

Research (climate change, agricultural research): WSU: Laboratory on Atmospheric Research, Center for Precision Agriculture

How have the Grant Funds been spent to-date? Describe how Grant Funds and other revenue have been spent during the grant year. Provide an actuals vs. budget financial statement.

Year 1 Narrative for Financial Report

1. Length of year 1.

Initial funding for the project was received from PGAF on Nov. 7, 2003. WSU and PGAF mutually agreed that it would be more suitable to have a renewal date at the end of February than on Nov. 6, allowing more of the previous season's results to be analyzed and reported. Thus, the project year for Year 1 runs from Nov. 7, 2003 through Feb. 28, 2005. Given that most new project personnel were not hired for several months after start-up, PIs have been able to stretch the original 12 month budget a little further to cover this first year. Most hired personnel are on annual appointments and thus their salary for the 12-month period is encumbered in the accounting system and subtracted from the account balance. Therefore, some accounts will require a month or two of additional salary beyond what is encumbered already to get to Feb. 28.

WSU and PGAF also agreed that for the purposes of annual reporting, the financial reporting year would run from Jan. 1 through Dec. 31 (except in this first year, starting Nov. 7). This will allow a report to be produced by the end of January that can then be forwarded to PGAF and its advisors prior to the February review meeting.

2. Dairy.

The overall plan for the digester construction changed early into the first year. We had an opportunity to partner in the building of a commercial dairy farm digester, as a dairy farm in Whatcom County received a federal grant to help with digester construction. Funds from CFF (\$160,000) were able to make the project viable, and we entered into a contract with the farm. The contract allows for on-going monitoring and data collection from the digester, along with educational access, to meet CFF project objectives. The digester was permitted, designed, and built all within Year 1, in contrast to the project schedule of Years 2-4. This acceleration meant that the experimental digester could not be integrated into the commercial digester, as the research and development was not completed. The arrangement also retained \$90,000 of the original \$250,000 cost share for the digester, and these funds will support R&D and the build-out of an experimental digester (mobile unit) being built in Pullman.

The cost-share (\$250,000) was originally slated for Year 2 budget. In order to make the payment to the partner dairy farm, we used \$87,601 from unbudgeted funds (Year 1 budget was ~\$912K, first year payment was \$1,000K), plus funds from the dairy subproject that had not been spent due to other outside funding being secured. We took \$48,704 from the dairy account, which will be paid back in Year 2. We took \$23,695 from Home, which also will be repaid.

3. Equipment vs. Materials and Supplies.

Most of the GHG and environmental monitoring equipment that was purchased in 2004 was charged to the Materials and Supplies object, not the Equipment object as originally budgeted. This is because most of the purchases were for items under the \$5,000 threshold for equipment. Spending for this variety of equipment is not quite complete, but the cost will end up being very close to the original budget estimate.

4. Travel.

Most components did not budget enough travel funds for their work plan. This was particularly true for the Home account that covered travel expenses for the 3 team meetings during the year. No funds had been designated for this purpose, while costs were over \$2,000.

5. How we adjusted the budget.

The original budget request to Vulcan was for \$4.77 million over 5 years. PGAF provided funding of \$3.75 million over 5 years (78.6% of the request). Our team revised the original budget to reflect this shortfall in the following manner:

- Fully fund each component Year 1-3
- Fund Year 4 at 75%
- Fund Year 5 at 25%

The team will bring in outside funding to make up the difference (\$1.02 million). Already, the team has brought in over \$1 million of new funding to help make up the difference. This was not evenly spread across components, so more fund-raising will continue. Some of the new funding also added new tasks to the project.

6. First year remaining balances.

Several of the PIs had outside funding in this first year to help pay for project expenses and thus hold project funds in reserve for future years when the budget was cut. This explains much of the unspent balances in some accounts.

- MacConnell - \$78,500 from Whatcom County for fiber research; supported personnel
- Huggins – \$20,000 for personnel
- Stockle - \$105,000 from other sources provided substantial support for two graduate students and a post-doc, working on the model for irrigated corn and potatoes, and for the water model validation for Lind (crop-fallow region)
- Home/Outreach – \$16,441 (\$7,693 Outreach Account, \$8,748 Home Account) in salary and benefits that was designated to cover parts of salary for David Granatstein, Chris Feise, and Cindy Murray-Armstrong; these were unspent, will be held in reserve for future years; instead WSU paid this same amount for the personnel

Category		Dairy	Dryland	Irrigated	Modeling	Econ.	Outreach	Home	Digester	Totals
		Chen/ MacConnell	Huggins	Collins	Stockle	Wand.	Granat.	Granat.	Subcontr act	
Salary and Wages	Budgeted	126,170	53,425	39,352	144,028	31,651	43,841	22,860		461,327
	Actual	81,060	46,252	30,681	102,250	16,241	33,958	0		310,442
Fringe Benefits	Budgeted	47,176	15,565	13,829	48,979	12,361	14,582	6,098		158,590
	Actual	24,865	11,954	8,230	35,681	5,468	10,849	0		97,047
Equipment (06, 16)	Budgeted	70,000	21,000	11,000	4,800	2,500	2,800	100,000		212,100
	Actual	7,115	0	0	2,272	2,370	0	3,494		15,251
Materials & Supplies	Budgeted	31,260	20,000	870	2,494	500	4,200	9,094		68,418
	Actual	45,213	19,354	13,285	1,838	671	2,695	80,354		163,410
Travel	Budgeted	5,000	0	800	2,000	900	3,264	0		11,964
	Actual	7,358	191	0	1,237	517	3,078	2,279		14,660
Subcontract to Vander Haak Dairy*	Budgeted	0						0	0	0
	Actual	48,704						23,695	87,601	160,000
Total Direct Costs from PGAFF funds	Budgeted	279,606	109,990	65,851	202,301	47,912	68,687	138,052		912,399
	Actual	214,315	77,751	52,196	143,278	25,267	50,580	109,822	87,601	760,810
Est. offsets from other resources		78,500	20,000		105,000		7,693	8,748		219,941
Total Project Expenditures through 12/31/04		292,815	97,751	52,196	248,278	25,267	58,273	118,570	87,601	980,751

- *The subcontract to the Vander Haak Dairy was budgeted as cost-share for a commercial digester in Year 2 of the grant, but needed to be paid in year 1 (See narrative # 2). A new account was created for this payment.
- This budget report was developed by the Project Management Team using WSU budget reports. An official financial report will be provide by WSU Sponsored Programs.
- PGAFF provided \$1 million in funding in year 1. The \$87,601 of unbudgeted money from year 1 was set aside in a separate account and used to pay the commercial digester subcontract.

Appendix I: Milestones**Dairy Component**

<u>Year 1</u>	<u>Accomplishments</u>	<u>Completed</u>
Interim Report: Baseline collection of emissions data	Field monitoring of GHGs initiated in Pullman; Report by Bingcheng	yes
Interim Report: Evaluation of pilot-scale digester operation	Report by Shulin; benchtop experiments, 1-cow pilot system; development and coding of AD simulation model for research; published AD surveys by Goksel Demirer	yes
<u>Year 2</u>		
Final Report: Completion of baseline emissions data collection	Provisional patent applied for Dec. 2004, on new digester concept	
Final Report: Completion of pilot-scale digester evaluation Begin commercial digester permitting and design	Completed in April 2004	yes
<u>Year 3</u>		
Interim Report: Initiation of nutrient recovery studies Begin commercial digester construction	Started May 2004	yes
Fiber end use suitability study and market study completed	Several fiber studies completed; key technology for peat replacement developed	
<u>Year 4</u>		
Final Report: Implementation of nutrient recovery process Complete digester construction (early Yr 4) On-site demonstration/ education workshop	Completed in October 2004	yes
Interim Report: Initiate monitoring program for commercial digester	Protocol developed; commercialization agreement signed with Andgar	
<u>Year 5</u>		
Final Report: Completion of the commercial digester evaluation		

Irrigated and Dryland Components

Year 1

Complete baseline evaluation of cropping system performance, including C and N, GHG, productivity, economics,

Accomplishments

Field monitoring of GHGs initiated; Report by Armen and Dave; Report by Hal and Shawel

Completed

yes

Year 2

Interim Report: Analysis of first year monitoring of GHG and cropping systems

Year 3

Interim Report: Analysis of second year monitoring of GHG and cropping systems

Integrate results with modeling/socioeconomic efforts

Presentation at PCFS field day, June 2004, and Paterson field day, July 2004

Agronomic field day

Preliminary Report: Recommended climate friendly farming systems

Year 4

Interim Report: Analysis of third year monitoring of GHG and cropping systems

Preliminary Report: Recommended climate friendly farming systems

Year 5

Integration of all study results with modeling/socioeconomic results

Final Report: Recommended climate friendly farming systems

Modeling Component

<u>Year 1</u>	<u>Accomplishments</u>	<u>Completed</u>
Develop conceptual models for GHG cycles	Conceptual model developed, subroutine coded, testing in process	yes
Finalize data collection protocol for model verification	team development, monitoring went to field in dryland, irrigated and dairy	yes
Create experimental database for systems	lit review for dryland database completed; expt. to model irrigated corn, potatoes completed; model calibration for dryland at Lind	yes
<u>Year 2</u>	<u>Year 2</u>	
Model water, nutrient, carbon, and gas emissions from all systems	Modeled rotation effect on C in the Palouse	
<u>Year 3</u>		
Complete coding and mathematical equations for all models		
<u>Year 4</u>		
Completion of the calibration and validation of all the models		
<u>Year 5</u>		
Prediction of GHG emission reduction from all systems		
Release of the trial version of the decision support system		

Socio-economics Component

<u>Year 1</u>	<u>Accomplishments</u>	<u>Completed</u>
Coordinate data collection for baseline evaluation	Evaluated farm budget programs from 50 states, selected an open-source code program that can be adapted to analyze farm enterprise budgets, GHG emissions, social-impact / benefit-cost analysis. Have developed trial budgets for dryland wheat and dryland oilseeds to test/refine the application and protocol for using the multiple-perspective budgeting software.	yes
<u>Year 2</u> Begin adoptability studies - i.e. fiber market research		
<u>Year 3</u> Evaluate profitability and adoptability studies	M.S. Thesis completed on adoption behaviors for conservation systems in summer-fallow / dryland region of WA. Development of survey tool has continued and will be adapted for other systems.	partial
<u>Year 4</u> Evaluate profitability and adoptability studies		
<u>Year 5</u> Evaluate profitability and adoptability studies		

Outreach / Management Component

<u>Year 1</u>	<u>Accomplishments</u>	<u>Completed</u>
Popular article completion	BioCycle - Nov. 2004; WSUF Connections - Fall 2004	yes
Identification of possible new funding sources	CIG, Ecology, WTC, STEEP, NRI, EPA, Bullitt	yes
<u>Year 2</u>		
Proposal drafted for new funding	CIG, Ecology, WTC, STEEP, NRI, EPA, Bullitt	yes
Field day		
Popular article completion		
Carbon trading organizations contacted		
<u>Year 3</u>		
Project included in one commodity meeting	PNW Vegetable Association - Nov. 2004; Farm Forum - Jan. 2005	yes
Plan for "Climate Friendly Farms" workshop drafted		
Field day		
New funding secured	CIG, Ecology, WTC, STEEP in 2004	yes
Popular article written		
<u>Year 4</u>		
"Climate Friendly Farms" workshop completed and fiber marketing results disseminated		
Field day		
Additional funding secured		
Popular article written		
<u>Year 5</u>		
New proposals drafted for future direction of project		
Field days		
Major media stories		
Findings and methods presented at national and international meetings		
Peer review articles written		

Appendix II: Funding and grant proposals

Additional funding related to the project totals \$1,162,920. Sources include:

- Whatcom County for fiber research (\$110,000)
- Washington Department of Ecology for straw management/crop rotations to reduce burning (\$63,000)
- Columbia Plateau Wind Erosion/Air Quality Project for flex cropping and chem fallow potentials (\$90,000) and assessing adoption of Best Management Practices (\$15,000)
- Farming and the Environment (Kellogg Foundation) for a policy forum (\$25,000)
- NRCS Conservation Innovation Grant for co-product demonstration from anaerobic digestion (\$683,920).
- Washington Department of Ecology for a mobile anaerobic digester (\$100,000) plus a match from other WSU departments (\$66,000)
- Institute for Washington's Future for evaluating a dairy anaerobic digester feasibility study (\$5,000)
- Washington Technology Center for research leading to the commercialization of Dr. Chen's novel approach to anaerobic digestion (\$105,000)

Submitted proposals for which we have not received notification include:

- USDA CSREES International Science & Education Program (\$100,000) for sustainable agriculture and biogas workshops in China
- USDA CSREES NRI Small Farm & Rural Community Prosperity (\$500,000) for evaluation of community economic impacts and cost-benefit analysis of bioenergy production
- USDA SBIR (with Andgar Corporation) animal waste management (\$80,000) for research leading to the commercialization of Dr. Chen's novel approach to anaerobic digestion
- Pacific Northwest Solutions to Environmental and Economic Problems - STEEP (2 proposals) for precision agriculture and organic cropping systems.
- Vulcan, Inc. (\$200,000) for small-scale applications of anaerobic digestion technology in developing countries and (\$140,000) for combining small-scale AD with water purification and other technologies.

Proposals submitted, but not funded

- EPA Collaborative Science & Technology Network for Sustainability – (\$300,000) for research and outreach on Climate Friendly Farming agroecosystems.
- WSARE Research & Education (Pre-proposal) – (\$130,000) for Climate Friendly Farming Handbooks.
- USDA NRI Managed Ecosystems Program – (\$607,000) for Coupling Environmental Sensing and Process Modeling for Site-Specific Regulation of Nitrogen Flow in Wheat-Based Systems.
- USDA - Pest Management Program (RAMP) for reducing the Risk Associated with Direct Seeded Wheat Through Innovative Mechanical and Cultural Management of Weeds, Diseases and Crop Residues.

Appendix III: The Project in Images

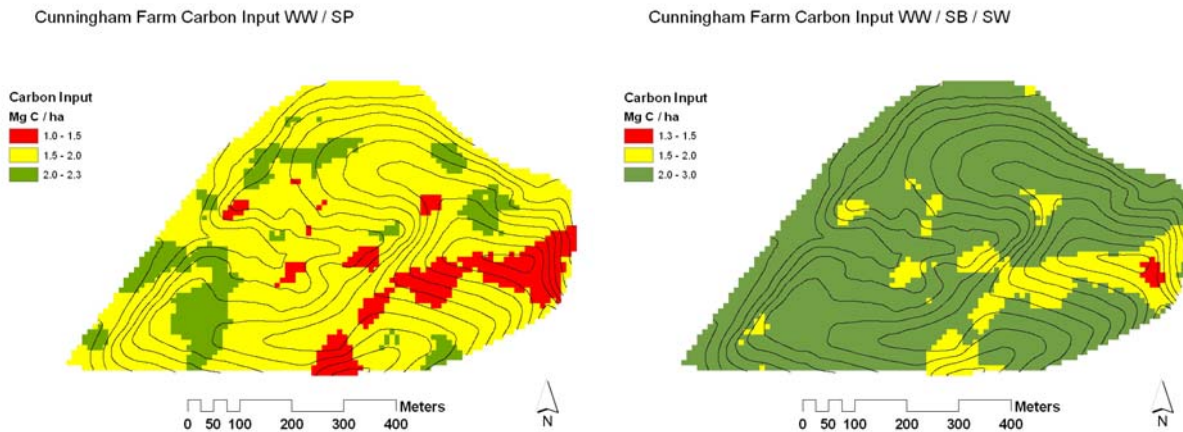


Figure 1. Spatial variability in C input in a typical Palouse landscape for two rotations: winter wheat – spring peas and winter wheat – spring barley – spring wheat. The legends were selected to show in red areas that could have no gain or even lose C, in yellow areas of low to moderate C storage, and in green areas of definite net C storage. We assumed a C residue concentration of 430 g C kg⁻¹ residue.



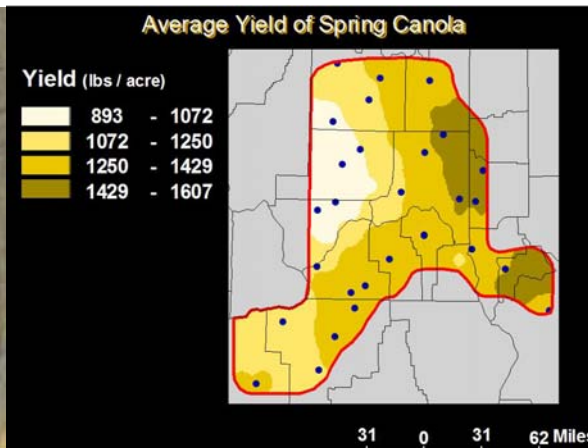
5 in a series anaerobic digester reactor



Dairy Digester Fiber Plant Growth Trial 2004.1



Biofuel variety trial at Paterson



Spring Canola yield map for dryland region