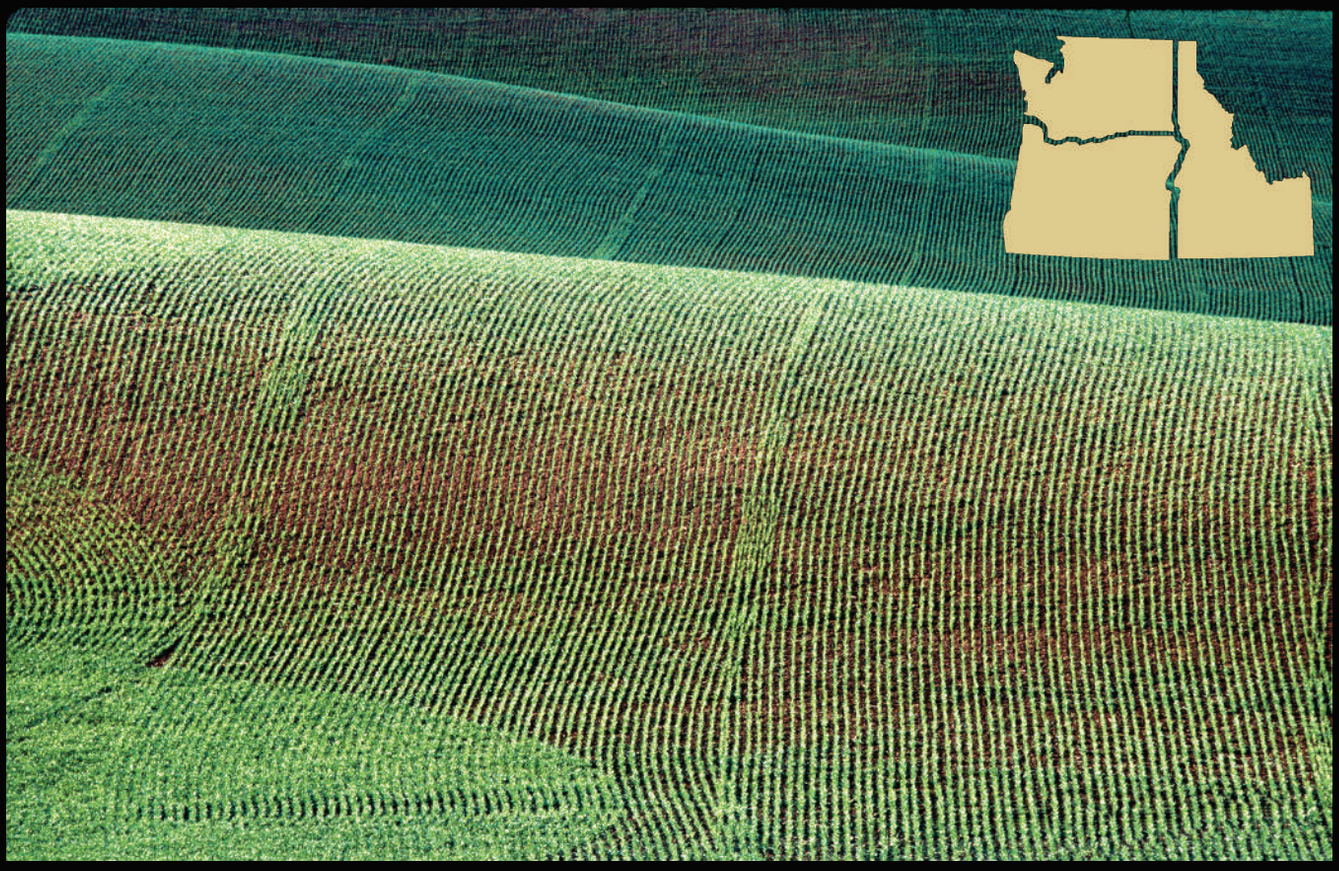
Regional Approaches to Climate Change for Pacific Northwest Agriculture

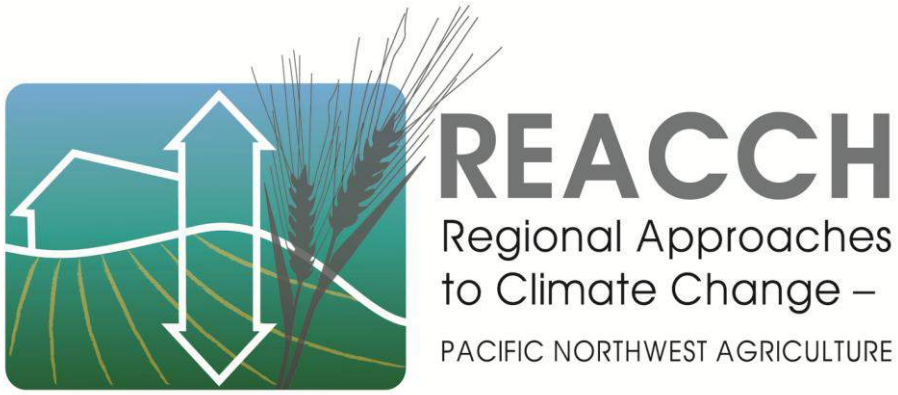
Climate Science Northwest Farmers Can Use



REACCH
Regional Approaches to Climate Change – PACIFIC NORTHWEST AGRICULTURE

Second Annual Report
February 2012 – February 2013

Climate Science Northwest Farmers Can Use



February 14, 2013

University of Idaho

Agricultural Research Service

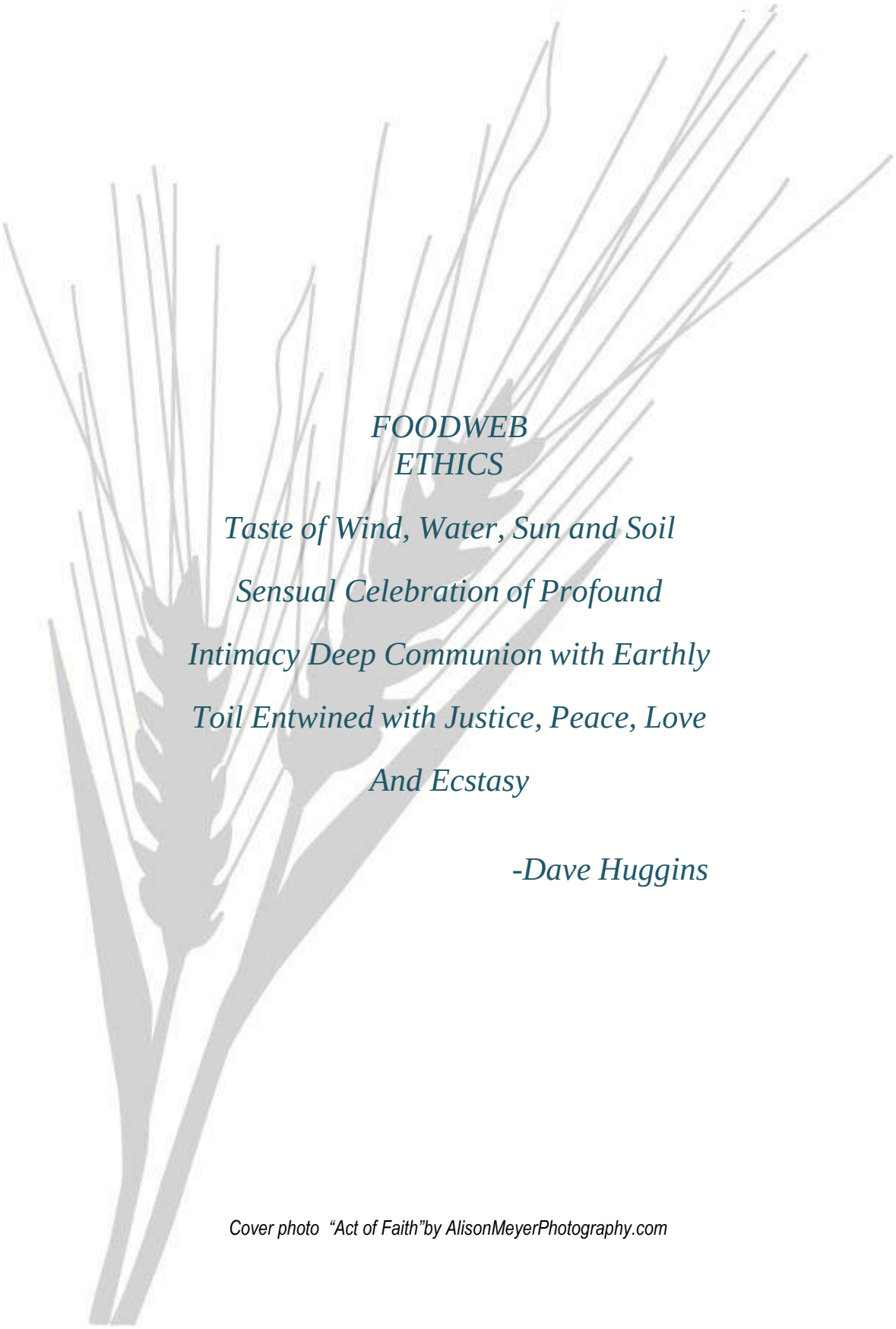
Washington State University

Oregon State University OSU

USDA United States Department of Agriculture National Institute of Food and Agriculture

Regional Approaches to Climate Change for Pacific Northwest Agriculture

Funded through Award #2011-68002-30191 from
USDA National Institute for Food and Agriculture



FOODWEB
ETHICS

Taste of Wind, Water, Sun and Soil

Sensual Celebration of Profound

Intimacy Deep Communion with Earthly

Toil Entwined with Justice, Peace, Love

And Ecstasy

-Dave Huggins

Cover photo "Act of Faith"by AlisonMeyerPhotography.com

An Overview: who we are, why we're funded and what we are doing

Managing agricultural systems efficiently, profitably and sustainably is a tremendous challenge. In the US we have addressed this challenge through partnerships between farmers, agricultural industries, researchers at land grant universities and the USDA Agricultural Research Service. Changing climates will "add another layer of complexity and uncertainty [to an agricultural] system that is already exceedingly difficult to manage on a sustainable basis" (Coakley et al. 1999). To address this, the National Institute for Food and Agriculture (NIFA) has funded more than 50 projects nationally within the Climate Variability and Change Program. These NIFA projects are charged to conduct research and extension focused on two areas: 1) *adaptation*, to projected climate variability and change and 2) *mitigation* of greenhouse gasses (GHG) emissions from agriculture that contribute to climate change.

Regional Approaches to Climate Change for Pacific Northwest Agriculture (REACCH-PNA, or REACCH in this report) is one of three $20 million, five-year Coordinated Agricultural Projects within NIFA's Climate Variability and Change program. Scientists and educators from three land-grant institutions (Oregon State University, the University of Idaho and Washington State University) and the USDA's Agricultural Research Service in the Pacific Northwest are working together to address the implications of climate change for cereal-based farming in the inland Pacific Northwest. REACCH is building upon the historically strong traditions of research, education and Extension partnerships in the region to improve soil conservation and the efficiency and profitability of the region's production systems. It is more broadly and deeply integrated and more comprehensively coordinated than previous efforts, bringing together climate, cropping systems and economic models, agricultural economics and rural sociology, agronomy, soil science, crop protection and other disciplines in an integrated, transdisciplinary manner. REACCH coordinates its research efforts with Extension to ensure that farmers, the agricultural industries and other stakeholders are engaged and benefit from its work. The project's research findings and approach are being incorporated into K-12 education in the region. Although it is a regional project, REACCH has a global context and is partnering with the national and international communities addressing the complex issues surrounding agriculture and climate change.

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Executive Summary of the REACCH Second Annual Report

REACCH has been funded for two years, with most activities commencing after our launch meeting (May 9-11, 2011). In this second annual report, we provide a summary of our activities so far, in order to inform the entire project membership and our stakeholders, and to solicit informed feedback and to contribute to the success of our second annual meeting to be held Feb. 13-15, 2013.

The *overarching goal* of REACCH is to *enhance the sustainability of cereal production systems of northern Idaho, north central Oregon, and eastern Washington under ongoing and projected climate change while contributing to climate change mitigation by reducing emissions of greenhouse gasses.*

Section I of this report summarizes our integrated efforts to address five supporting goals that contribute to meeting this overarching goal.

1) Develop and implement sustainable agricultural practices for cereal production within existing and projected agroecological zones throughout the inland PNW as climate changes.

Our approach uses a coupled modeling framework to incorporate climate, cropping system and economic models for a set of possible future scenarios (Representative Agricultural Pathways) to project agricultural productivity, potential types of agricultural practices and profitability into mid-21st century. The models will be refined with input from our 15 cropping system experiments across the region and data from cooperator producers. Projected changes in impacts of pests, diseases and weeds affecting wheat production are being developed for eventual incorporation into these models.

2) Contribute to climate change mitigation through improved fertilizer, fuel, and pesticide use efficiency, increased sequestration of soil carbon, and reduced greenhouse gas (GHG) emissions consistent with NIFA's 2030 targets.

GHG emissions are being monitored at multiple sites across the REACCH region using eddy flux towers or chamber systems. Other experiments are assessing water and wind erosion. Strategic measurements will allow assessment of the impacts of alternative practices on GHG emissions.

3) Work closely with stakeholders and policymakers to promote science-based agricultural approaches to climate change adaptation and mitigation.

The project has been informed from initiation by input from a Stakeholder Advisory Committee. We are communicating REACCH activities to producers through standard methods and emerging technologies. An Extension Specialist will be hired in February, 2013. Cooperator involvement and public and stakeholder surveys are guiding our research activities. Scientists across the project contributed to these efforts.

4) Increase the number of scientists, educators, and extension professionals with the skills and knowledge to address climate change and its interactions with agriculture.

REACCH hosted undergraduate student summer interns in 2012. The project is also supporting 19 graduate students and postdocs. Teacher workshops and curriculum

development for high school are under way. Scientists across the project contributed to these efforts.

5) Use innovative management and assessment approaches to promote integration across the entire project.
The project is managed to promote interactions amongst disciplines. Nearly weekly integration meetings open to all REACCH project members are designed to incite and incentivize collaboration.

Section II of this report provides more detailed summaries of activities in each of the 10 objective teams, Project Management, and Project Assessment that have contributed to the integrated effort.

A Modeling Framework (Objective 1): REACCH requires a conceptual and operational framework that captures the linkages amongst human, biological and climatic systems relevant to agriculture. Year 2 activities focused on developing initial approaches to coupling models.

Monitoring Carbon, Nitrogen and Emissions (Objective 2): In Year 2, eddy flux towers were installed at four locations and data were acquired. Two instrumented field-scale catchments were monitored for sediment, carbon, and inorganic nitrogen loading in run-off water.

Alternative Cropping Systems (Objective 3): Fifteen experiments at 11 locations were established across the region to test alternative production practices including nutrient management, tillage and crop intensification.

Social and Economic Factors (Objective 4): In Year 2, the longitudinal survey of wheat growers in the REACCH area was continued, and a comprehensive survey of producers was conducted.

Pests, Weeds, Diseases and Beneficial Organisms (Objective 5): Baseline surveys across the region were continued for a second year. Experiments were conducted to assess climate impacts on some organisms. The climate-based model of cereal leaf beetle was expanded to incorporate biological control of this pest.

K-12 Education (Objective 6): Survey results of teachers in ID, WA and OR were used to guide product development for teacher education. A brief overview of the REACCH project was given at teacher workshops within each state, and a brochure with this information was distributed. For our first workshop in the summer of 2012, a partnership with a NASA-sponsored climate education project was established in Year 1. Teacher workshops will continue in the summer of 2013.

Undergraduate and Graduate Education (Objective 6): A summer research experience for undergraduates program was conducted in summer of 2012, with placements across REACCH. Graduate student recruitment was completed (19 are funded or cofunded by REACCH, three are non-funded and affiliated with REACCH). Four postdocs were also recruited.

Extension (Objective 7): The search for the faculty Extension specialist position was completed in Year 2. REACCH graduate students are developing innovative and

experimental Extension products. A stakeholder survey was conducted on preferred and most widely used means of information access.

Cyberinfrastructure and Data Management (Objective 8): The REACCH Environmental Data Manager worked with the Northwest Knowledge Network to standup our web site, data portal, data management policy and procedures.

AgroEcological Zones (AEZ): AEZs of the region were characterized empirically, at a fine spatial scale, using statistical procedures and multiple years of the USDA-NASS Cropland Data Layer. These AEZ can be used as a baseline, tracked as they change through time, and as a guide to structuring other studies across the region.

Life Cycle Analysis: CropSyst runs in AEZ 3 (low rainfall, conventional tillage, WW-SF) based on one global climate model only and RCP8.5, suggest winter wheat yield gains in most of the region in the 2030's and increasing for the 2050's due to the beneficial effect of elevated CO_2 on crop growth and water-use efficiency that compensates for warming effects.

Project-wide Management: Project leadership met 42 times in Years 1 and 2 and objective teams met frequently. The emphasis in the leadership meetings was integration across objective teams. Central Desktop continued to provide cybercollaborative support. An Education Coordinator was hired.

Section III of the report enumerates the project's outputs, outcomes, and milestones, and provides summaries of leveraging and partnering activities.

Outputs: As described in the following sections, REACCH personnel have made 205 presentations to professional and scientific meetings; 101 presentations at producer meetings and field days; contributed to 41 refereed scientific articles; published 27 Extension, technical, poplar and industry trade journal articles; appeared 27 times in the popular press; created 4 webinars and extension videos; and conducted 5 Extension training sessions.

Outcomes and Impacts: Our publications and presentations have improved knowledge of climate change and agriculture among professionals and producers. Our modeling efforts are coordinated with other global efforts. Alternative crops and precision N use are increasing. Regional teachers' and Extension professionals' capabilities to communicate climate science have increased.

Leveraging and Partnering: In years 1-2 REACCH received $8 million of our award from NIFA, and leveraged these funds with 15 existing partners for $13,988,904.

This report is intended for stakeholders and supporting institutions and agencies. It contains examples of results that are in the process of being developed but have not been subjected to review.

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REACCH-PNA: 2011 and 2012

The REACCH PNA project is a large multi-institutional, regional effort to address the implications of changing climates for wheat production in the inland Pacific Northwest. The issue is complex because the entire system is affected, whether positively or negatively, from production practices, pest management issues and social and economic factors. The response must integrate research, education and extension in a transdisciplinary fashion. That is, scientists and educators from different disciplines must consider the system and the interplay of its components when formulating questions and objectives throughout project conception and execution. Transdisciplinary effort must include stakeholders throughout this process (Tress et al. 2003) to ensure findings are meaningful and "actionable", in the sense that they inform decisions at the government, business, and the household (farm) levels (Palmer 2012).

"Project-wide, REACCH efforts are coordinated integrated, and transdisciplinary."

In this section we review activities occurring across the project to address each of our five goals. The report is necessarily a summary, but additional detail can be found on the project website: http://www.reacchpna.org.

Goal 1: Develop and implement sustainable agricultural practices for cereal production within existing and projected agroecological zones throughout the inland PNW as climate changes.

The REACCH study region includes most of the predominantly dryland cereal production systems extending from northern Idaho, across eastern Washington and northern Oregon. Although the principal crop is wheat, climatic diversity marked by precipitation and temperature gradients influence production practices in various ways. The REACCH region can be divided into six agroclimatic zones based on soil depth, mean annual precipitation, and cumulative seasonal growing degree days (GDD) for wheat between 1 Jan and 31 May. Each of which generally supports certain cropping systems (Douglas et al. 1992)

Projected increases in annual temperatures and precipitation, with drier summers and wetter cool seasons (Objective 1) will shift the distribution of these zones and create a new zone with GDD and precipitation conditions not previously observed in the region (Fig. 1). As a foundation for addressing our first overarching goal, REACCH climate scientists are generating novel downscaled projections based on global climate models to help us better project climates for the region as a whole and at spatial scales of relevance to industry and to individual producers (e.g., Fig. 2).

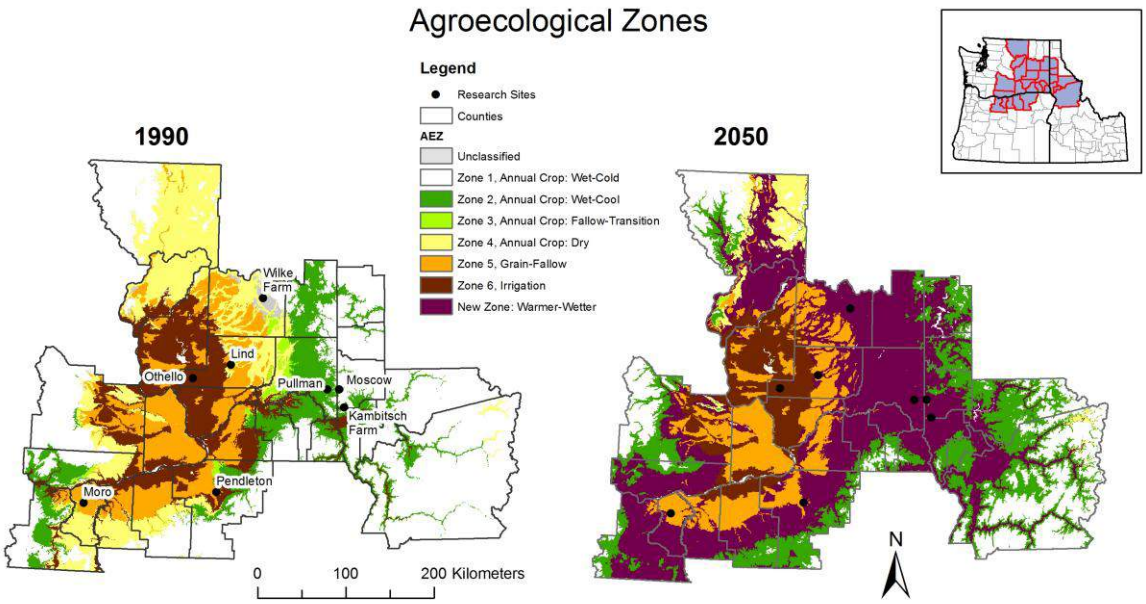


Figure 1. Current and projected agroclimatic zones of the inland Pacific Northwest under current and projected climates, using criteria following Douglas et al. (1992). Predominant cropping systems listed for each zone are based on production records and observations. Projection for 2050 was generated from the Canadian Centre for Climate Modeling and Analysis global climate model with the A2 emission scenario for CO_2. Locations of experiment stations and research farms with experiments that are part of the REACCH project are indicated.

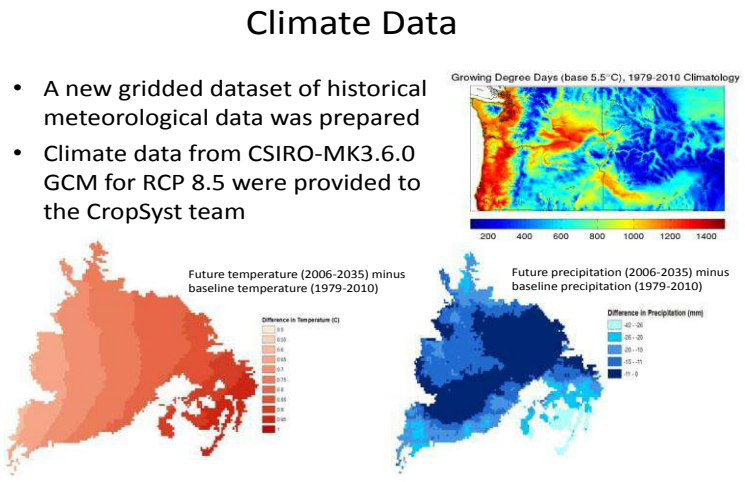


Figure 2. An example of downscaled climate projections being generated by REACCH climate scientists

These PNW climate models are being coupled with models of cropping systems and economic models to project conditions under a set of likely scenarios, termed *Representative Agricultural Pathways* (RAPS) (Objective 1). This coupled modeling effort provides a framework for organizing other efforts within REACCH. In addition, data from other parts of the project are being incorporated and will be used to drive these models. Examples of planned inputs include data from longitudinal and comprehensive producer surveys (Objective 4), the impacts of pests, weeds and diseases (Objective 5),

and the performance of alternative cropping systems (Objective 3). Modeling will also be used to generate tools for Extension and outreach.

The Cropping Systems Team (Objective 3) is quantifying and projecting the effects of current and potential alternative cropping systems and innovative technologies on carbon, nitrogen, water, and energy flows and budgets. Fifteen cropping systems experiments at 11 locations amongst the four major agroecological zones have been established to examine aspects of nitrogen management, crop rotation and diversification, reduced/no-tillage and recycled C and N. The data from the experiments will provide input for the modeling efforts of Objective 1. Some of the experiments are being monitored for insects, weeds and pathogens by the Objective 5 team, or monitored for greenhouse gas emissions by the Objective 2 team. Experimental design and interpretation will be facilitated by information from producer surveys conducted by Objective 4 in 2012 and planned for the duration of the project that include questions relevant to cropping systems management issues.

As a baseline for any future projections on the constraints on production, Objective 5 is measuring weed, insect and disease pressure on the REACCH experiments on stations and farms of nearly 50 collaborating producers. These measurements of 'biotic factors' also include earthworm samples. Current variation in climate within the region and future projections can be used to anticipate changing pressures as climates shift. Historic data from suction traps that were operated to trap aphids from 1984 to 2003 in the region are being examined to understand how climate and weather could affect aphid flights. Objective 5 will work with Objective 1 to project effects of changing climate on cereal production systems, specifically exploring incorporation of yield impacts of biotic factors and earthworms into the CropSyst model.

An important integrating framework for the project is being provided by surveys of producers, including a longitudinal survey (LS) of 50+ producers, conducted annually and a more extensive survey of 1300 agricultural producers (APS) conducted in 2012. The surveys include questions by each REACCH team so our research is informed by producer views and priorities. The surveys were designed working closely with the Extension Team (Objective 7) and will be especially important in our Extension programming.

The REACCH study region is delineated approximately by the agroclimatic zones in the inland PNW, based on the criteria developed by Douglas et al. (1992) (Fig. 1), but we are extending this concept significantly to delineate dynamic Agroecological Zones (AEZ). These are empirically determined from the National Agricultural Statistics Service Cropland Data Layers to identify the distribution of major production systems (annual cropping, annual crop-fallow transition, grain fallow, irrigated) at a fine spatial scale (57m). Although these are to a large extent determined by climate, social, economic Fedaphic and other factors introduce heterogeneity and dynamism.

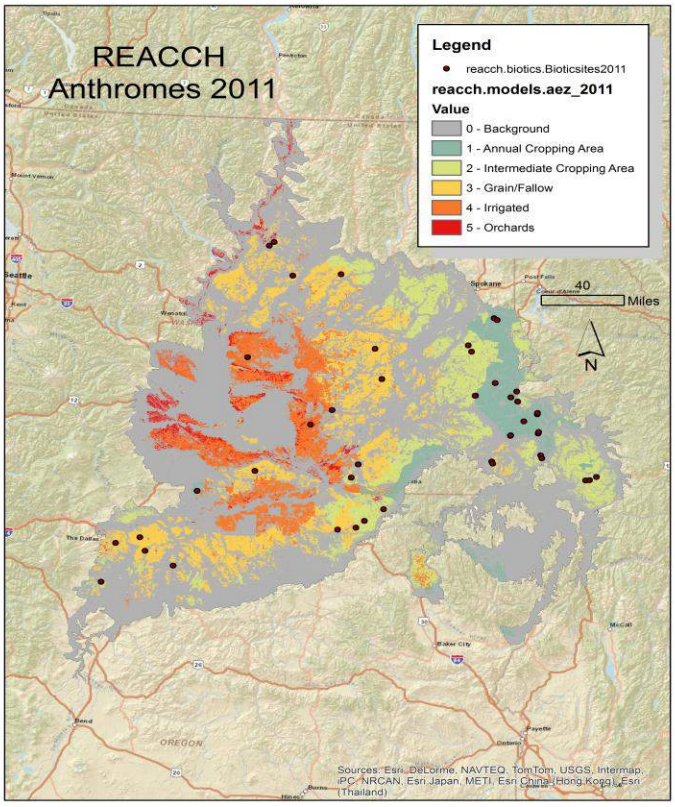


Figure 3. The REACCH region here delineated based on for Major Land Resource Areas (Columbia Basin, Columbia Plateau, Northern Rocky Mountains, Palouse and Nez Perce Prairies), here coded as background with contained cropping systems inferred from the 2011 NASS Cropland Data Layer (Rupp and Huggins). Locations of sampling sites for biotic factors and approximate locations of grower cooperator farms.

The AEZ aid regional assessment of agricultural mitigation and adaptation strategies, invite effort to identify the factors that lead to adoption of particular production systems, provide regional baseline and reference for future projections of agricultural practices, and guide other research efforts throughout the project (Fig. 3).

"REACCH dynamic Agroecological Zones (AEZ) provide a unique framework for understanding current and future production systems in the PNW."

Year 3 efforts will include first full year data collection from our 15 experiments, concerted parameterization of cropping systems and economic models with data from these experiments, biotic surveys and models and longitudinal surveys.

Goal 2: Contribute to climate change mitigation through improved fertilizer, fuel, and pesticide use efficiency, increased sequestration of soil carbon, and reduced greenhouse gas (GHG) emissions consistent with NIFA's 2030 targets.

Agriculture systems, including our PNW systems, emit the greenhouse gasses, nitrous oxide, carbon dioxide and methane that contribute to global warming. The extent of agriculture makes it an important non-point source of these gasses worldwide. Reducing these emissions can help mitigate human effects on climate. Fortunately, reducing emissions of nitrous oxide and carbon dioxide from cropping systems is generally beneficial for production and in the immediate interest of producers. Carbon dioxide emissions in excess of crop respiration represent loss of carbon from the system and potential depletion of soil carbon and reduced soil health. Nitrous oxide emissions represent loss of applied nitrogen that otherwise could be available for uptake by crops. REACCH is charged by NIFA to find ways to reduce carbon dioxide and nitrous oxide emissions from wheat production systems of our region, which can be achieved by improving soil organic carbon and improving the efficiency of nitrogen applications. To assess the potential for doing this and effects of treatments and impacts, we are measuring greenhouse gas emissions using eddy flux towers and static chamber systems and measuring nitrogen and carbon (Monitoring Team, Objective 2) (Figs. 4 and 5), but this must be done collaboratively within the project. Selection of monitoring sites and interpretation of results is occurring in collaboration with the Cropping Systems Team to ensure sites are representative since inferences from our sites to the region must be made. The general experimental design for the flux measurements, the C/N loss measurements, soil sampling design and for the chamber matrix experiment were developed with input and discussion with Objective 1 and 3 teams and AEZ participants.

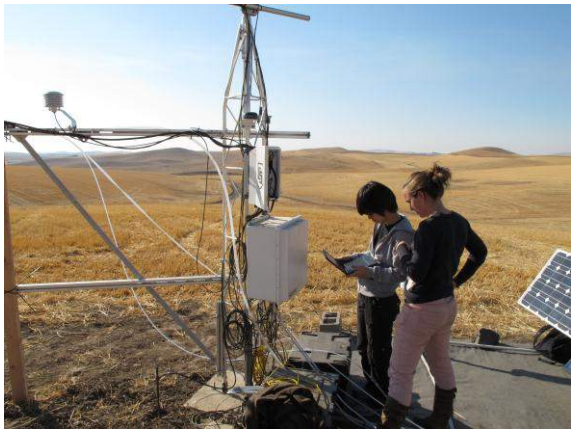
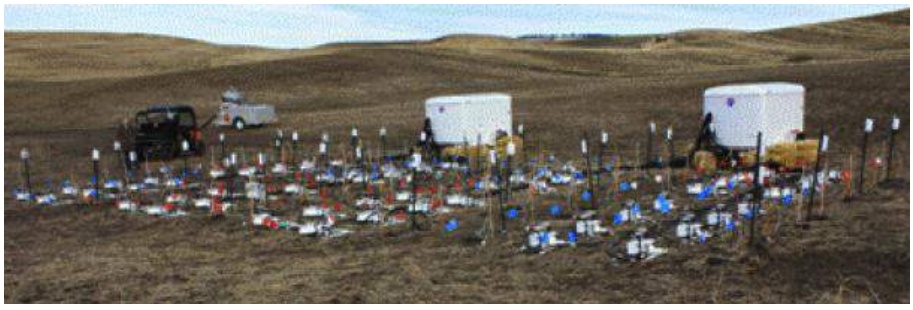


Figure 4. *above* Eddy Flux Tower at Cook Farm with two graduate students

Figure 5. *below* Static chamber array for measuring GHG release, Cook Farm installation.



An immediate opportunity exists to improve nitrogen use efficiency in our PNW systems (thereby reducing potential nitrous oxide emissions) through precision nitrogen application approaches. REACCH will devote resources to promoting understanding and adoption of this technology. An informal survey of equipment dealers and a major agricultural equipment wholesaler in the region indicates a very rapid increase in sales of GPS guidance and rate controlling equipment, as much as a ten-fold increase in annual sales over the past three years. There appears to be more activity in the high rainfall, variable landscape zones compared to the low rainfall, less variable zones. Through our Extension efforts in the coming years (Objective 7) we will be working with others to help increase adoption and effective use of precision application technologies. We have initiated researcher/grower and stakeholder/industry discussions on identifying key needs in making progress with site-specific N management technology transfer.

In Year 3, the Monitoring Team will begin to compare our flux measurements with CROPSYST simulations for evaluation purposes and to initiate integration of the flux data with regional CROPSYST runs. We will be investigating approaches for incorporating Water Erosion Prediction Project (WEPP) model predictions of soil carbon transport into the CROPSYST model. The microplot chamber data on N_2O emissions and measured contributions of nitrification and de-nitrification to N_2O emissions will be utilized to refine the N routines in CROPSYST and for model calibration. This will involve integration across Objectives 1, 2 and 3. Objective 2 will merge flux measurements and chamber results with the wind and water erosion data in order to construct C and N budgets for representative sites.

Goal 3: Work closely with stakeholders and policymakers to promote science-based agricultural approaches to climate change adaptation and mitigation.

Much of the research within REACCH is intended to be useful to producers and to lead to practices and technology that improves agricultural sustainability and profitability. But, the work will be ineffectual if it is not informed by producer needs and communicated effectively to producers and other stakeholders. In addition our work is relevant to other stakeholders in the long-term sustainability of local and global agriculture. A significant part of the project is devoted to Extension and outreach (Extension Team, Objective 7). Noteworthy activities so far have included involvement of our Stakeholder Advisory Committee (SAC) in planning our proposal to NIFA and the SAC panel discussion in our 2012 annual meeting. SAC members will be engaged in our 2013 annual meeting as well. The REACCH project has conducted a search for an Extension faculty member, who will join the project in early 2013 to ensure lines of communication are open.

"REACCH and its stakeholders represent an integrating partnership that is facilitated by Extension."

Extension and outreach are inherently integrative since communication about the project involves all aspects of the research effort. Our producers and other stakeholders are integrators since they are concerned with and must manage whole systems. Thus, REACCH and its stakeholders represent an integrating partnership that is facilitated by Extension. The Objective 7 Team collaborated with social scientists from Objective 4 to develop the producer needs assessment survey administered this year. Extension also assisted with revising enterprise budgets to permit growers to assess the financial impacts of adopting new production technologies. The Extension Team also worked with Objective 2 in piloting a "crowd-sourced video" extension product platform; collaboration with Objective 6 in training graduate students in Extension concepts; collaboration with Objective 8 in developing the REACCH website framework and laying the groundwork for cyber-infrastructure rich approaches to Extension; planning the Stakeholder Advisory Committee panel for the REACCH Annual Meeting; providing training/hosting discussion regarding stakeholder decision-making models for the REACCH PI's and larger team; and releasing an internal RFP to support Extension product development from REACCH product development from REACCH.

Figure 6. REACCH team and stakeholders on the summer tour, June 2012

REACCH personnel have made presentations and interacted with producers and crop advisors in many venues, including the Washington Biofuels Cropping Systems Winter Workshops, Far West Agribusiness Association Winter Conference, and the Pacific Northwest Direct Seed Association Annual Conference, Agricultural Marketing and Management Organizations, Asotin County Extension Growers, Idaho FFA, Reardan Seed Company Growers, National Association of County Agricultural Agents, American Society of Farm Managers and Rural Appraisers, Oregon Vocational Agriculture Teachers Association, Spokane County Crop Improvement Association, Tri State Grain Growers, Washington Association of Agricultural Education, and Washington State Horticultural Association (see Appendix A). Objectives 1, 2, 3, and 5 and 8 are working together to develop web-based tools for producers.

In Year 3, the Extension Team, under the leadership of our new Extension Specialist, will continue working across the entire REACCH project in activities including analysis and

evaluation of the producer needs assessment with Objective 4; support for graduate experiences in Extension with Objective 6; and crowd-sourced video production with REACCH scientists.

Goal 4: Increase the number of scientists, educators, and extension professionals with the skills and knowledge to address climate change and its interactions with agriculture.

Changing climates are one of the challenges to production systems that can be expected during the coming decades. Responding appropriately will require scientists, producers and other citizens equipped to cope with the complexity of the issues efficiently and comprehensively. To this end, REACCH, through its Education Team (Objective 6) is engaged in a K-20 effort to provide educational resources to teachers and to directly train undergraduate and graduate students in aspects of interdisciplinary climate change research in agriculture.

"Responding appropriately to climate change will require scientists, producers and other citizens equipped to cope with the complexity of the issues efficiently and comprehensively."

Our students at all levels are engaged in discipline specific training and activities, but they are also learning to work across disciplines and missions (research, education and Extension) and this involves coordinated effort across the entire REACCH project.

Undergraduate Interns: The project hosted 13 summer interns in 2012, working on cropping systems, biotic factors (earthworms and insects), hydrology, climate modeling, economics, GHG monitoring, and agricultural system modeling. The students, who hailed from all over the USA, stayed with us for 9 weeks and were mentored by REACCH scientists. They worked on individual projects and integrating activities organized by education coordinator Erin Corwin, Education Coordinator and Jodi Johnson-Maynard, Education Team lead. These including lectures and workshops on REACCH disciplines, integration, the Toolbox exercise and participation in the REACCH summer field tour. We will be hosting interns every year of the project.

Public School Teachers and High School Curriculum: Researchers from all project objectives participated in teacher workshops in June 2012 and January 2013 either by presenting introductory seminars, demonstrating monitoring equipment at field sites and/or leading discussions and answering teacher's questions on a one-to-one basis. A draft 9-12 high school curriculum on agriculture and climate change was developed by the Education Team and is being reviewed by members of all of our project teams. The secondary curriculum currently in development will integrate with each REACCH objective team. This curriculum will be systems-based, with a focus on wheat production systems in the Pacific Northwest. Each objective will be providing educational materials for use in this 9-12th grade Science and Agriculture semester course. In the coming year

we will develop online instructions for earthworm sampling and identification for K-12 teachers, and web based tools for accessing REACCH data.

Elementary Schools: Objective 5 developed and led activities with a local elementary class on earthworms. This will also be done in coming years.

Graduate Students: We have students working in each of our objective teams. Each has an individual graduate mentor, but all are involved in integrating activities to enhance their capacities for collaboration, especially in complex issues concerning agriculture and climate change. Integration activities include: a graduate student retreat in Sept. 2012; a Toolbox workshop (http://www.cals.uidaho.edu/toolbox) to enhance communication skills; participation in collaborative team projects; participating an integrative workshop in GIS based concepts relevant to climate change in PNW agriculture; and a series of webinars presented by various REACCH faculty from different disciplines. We have also incorporated REACCH data and research into classes: CEE 543 Eddy Covariance Measurements of Turbulent Fluxes: Theory and Practice -- Final Project, SBS 544 Nitrogen Cycling (NSF IGERT NSPIRE core course), CEE 588 Atmospheric Turbulence and Air Quality Modeling. Because of their participation in these shared activities, REACCH funded graduate students are developing connections with other climate-based researchers across the 3-state project.

Student Achievements and Highlights:

- Chelsea Walsh, PhD student in soils, presented on the first 2 years of earthworm data at the Northwest Climate Science Conference.
- Ivan Milosavljevic, PhD student in entomology, gave an invited symposium talk on wireworms in cereals at the 2012 Entomological Society of America
- Graduate student Tabitha Brown (WSU NSPIRE Fellow) is interning with Stockholm Environmental Institute and conducting a "road test" for agricultural nitrogen protocols relevant to wheat-based cropping systems in the PNW.
- Graduate student Elizabeth Allen (WSU BioEarth Fellow) is supporting REACCH Extension activities in stakeholder needs assessment.
- Linda Urban, a master's student at Boise State University, completed a major project titled "Ethnographic Research in Organizations" designed to better define transdisciplinary research within the context of the REACCH project and discover some of the facilitators and constrains of information exchanges among the academically diverse individuals participating in the project. Results from these interviews have informed the project evaluation team in designing follow-up activities and assessments.
- A team of Boise State University graduate students, including Linda Urban, Marnie Christenson and Susan Benson, conducted an evaluation of the 2012 REACCH Graduate Student Retreat. Dr. Seung Youn Chyung of the Boise State University's IPT Department is supervising this work.

- Adam Bond, a master's student at Boise State University, completed a literature review on social network analysis and its application to interdisciplinary research teams. A pilot study is underway to help maximize the REACH team's understanding of and support for this approach.

In Year 3, with all graduate students on board, we will be providing the project-wide webinar series, a workshop for all students on GIS-based integration within the project and a 2nd annual graduate student retreat. Our second cohort of summer interns will join us for 9 weeks in June 2013. Our high school curriculum modules will be completed and another summer workshop for high school teachers will take place in Moscow.

Goal 5: Use innovative management and assessment approaches to promote integration across the entire project.

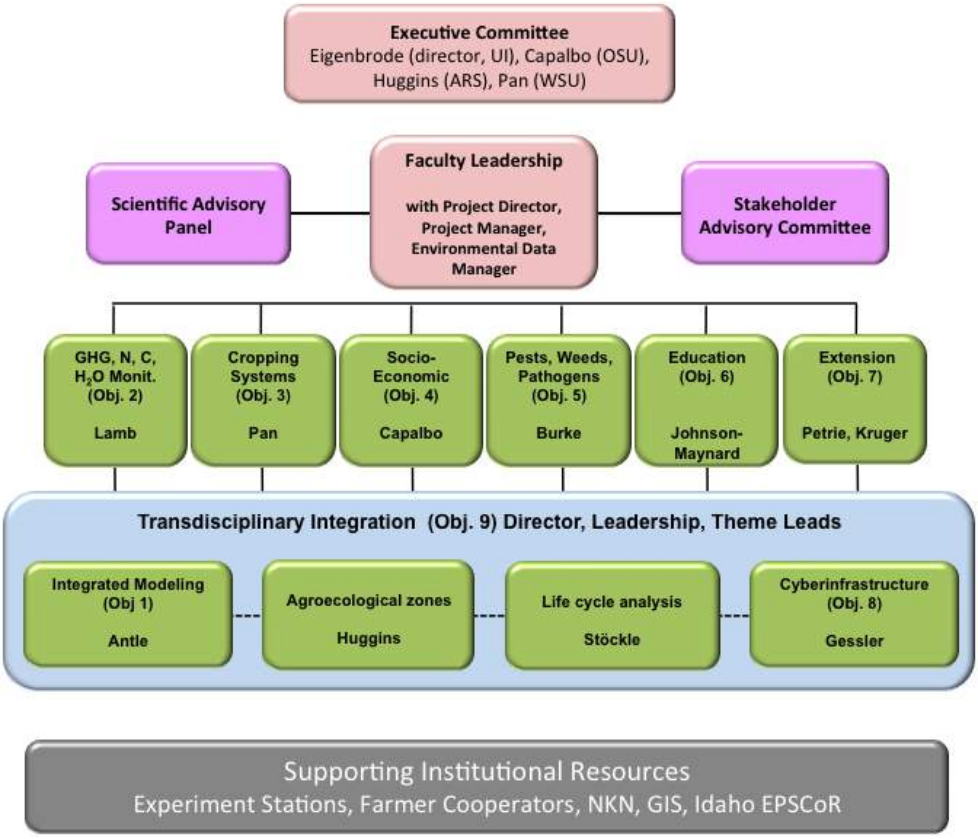


Figure 7. Organizational Chart for REACCH

REACCH is an extraordinarily large project in the scope of its goals, the number of institutions and disciplines involved, and the number of participating scientists, students and technical support (202). Each of the project's *Supporting Goals 1-4* requires close integration among disciplines in partnership with stakeholders. That is, each has a transdisciplinary mission. Our management structure supports the integration of 8 Objective Teams and two cross-cutting teams, but includes avenues for input by the stakeholder advisory team and the scientific advisory panel (Fig. 7). Support is provided

by institutional resources, including experiment stations and facilities, UI's Northwest Knowledge Network for support of data storage, data management and other cyberinfrastructure, and by grower cooperators. Considering the large public investment in REACCH, our aim is to establish infrastructure and networks to enable continuing, collaborative effort to improve sustainability of cereal-based cropping systems in our region, beyond the life of this project.

REACCH leadership meetings occur approximately 3 times/month and are open to all project personnel and can be accessed virtually, to enable broadest possible participation. In the second year of the project, many of the project-wide meetings emphasized integration among objective teams. The Project Director and Project Manager coordinate these meetings, reporting and project publicity, interfacing with other projects and attend to project-wide fiscal matters. Information is made available to the public via our web site: http://www.reacchpna.org. An on-line collaborative environment hosted by Central Desktop® where all project activities, and calendars, reports, announcements, photographs and other information are posted is used by our internal team.

> *"Our aim is to establish infrastructure and networks to enable collaborative effort towards sustainability of the region's cereal based cropping systems beyond the life of REACCH."*

Highlights of the integrating activities coordinated by REACCH project management and leadership during Year 2 include:

Interdisciplinary Activities

- *Integration meetings*. Since April, we have conducted approximately weekly integration meetings to discuss opportunities for novel collaboration within REACCH. There have been 42 such meetings in Year 1 and 2.
- *Virtual Watercoolers.* To provide opportunities for impromptu discussion within the project, we are holding virtual meetings without agenda every week. All project members and stakeholders are welcome to log in. The meetings are enabled by Gotomeeting®, which allows up to 26 participants to log into a video conference. Times are posted to Central Desktop®. To log in, just point your browser to https://www4.gotomeeting.com/join/973595695, at 8:30 am on Wednesdays, or other times that may be posted. Student watercoolers are held every Tuesday at 9:00 am.
- *Summer Tour.* Each summer we conduct a summer tour of research activities underway within REACCH. Stakeholders, students, summer interns and project scientists are urged to participate. Activities include presentations, assessment activities, socializing. The 2012 tour was sponsored by numerous stakeholders and collaborators.

Data Management

- *Database management and storage.* REACCH has continued to extend its enterprise database development efforts, and has built out areas for data storage for each functional objective area. In addition, our strategy for data uploading and metadata tagging (ESRI's Geoportal Server technology) is integrated with our database efforts. Data uploading process is being finalized in Year 3.
- *Application management.* Our focus of using application server technologies (ArcGIS Server, Tomcat Java servlets, and JavaScript application programming interfaces) has allowed us to tightly couple our methods of analysis with our data management – using both database technologies as well as file system data storage for larger data files (NetCDF).
- *Web portal development.* Both of the above areas are extended thru the use of secure web portal development that is coupled with the www.reacchpna.org web site. With a diverse research team spread across multiple institutions, as well as stakeholders and educators in three states – the use of web accessible content and data analysis – both secure and publicly available – is a critical strategy. This phased approach is coming along, with a new release of our web portal and analysis tools to be released at our 2nd annual REACCH conference in February 2013.
- *Server and systems management.* The above approaches are supported by a three-tier model for server management – including production systems for 1) databases, 2) applications, and 3) web portals. In addition, we have a staging environment for initial testing and data preparation that is continually being extended working with the Northwest Knowledge Network (www.northwestknowledge.net), a University of Idaho research team, in the areas of LDAP security management, data storage, and virtual server implementations. Our intention over the life of the project is to build upon this distributed systems model, which will provide for a strong cyberinfrastructure for any future REACCH analytical needs.

Assessment

- *Annual survey of the REACCH Project's Transdisciplinary Integration.* Using questions from existing scales of transdisciplinary attitudes and behaviors, the first survey was conducted in 2011 and a second is under way. Comparisons among years will be done to measure change over time.
- *Other measures.* In response to an additional survey, REACCH team members provided 91 comments regarding project successes and improvement recommendations and the Project Evaluator. These were used to structure discussions leading to recommendations that emerged from the 2012 annual meeting. During the summer tour in 2012, 45 bus riders were encouraged to use the informal bus atmosphere as a safe place to ask "tough questions" about the project. Semi-structured exercises helped participants generate 35 question cards across four themes. Questions related to these themes were assembled and posted to CD.

REACCH Milestones Outputs and Outcomes

Outputs summary *(*see Appendix A*)*

- refereed publications: 41
- presentations (Extension, Invited, Contributed, Scholarly): 205
- Publications((Extension, technical, Popular, Industry Trade Journals): 27
- Webinars and videos: 4
- Popular press articles: 27
- Extension Training sessions: 5

Project Milestones Completed

For a complete list of narrative milestones and deliverables see Appendix B. All milestones and deliverables for Years 1 and 2 are underway or completed with the exception of one cyberinfrastructure task which will be completed in Year 3. All Year 3 milestones have been started. Two Year 4 milestones are completed and 3 are initiated. One Year 5 milestone is initiated and one complete.

Project Outcomes Summary

"REACCH outcomes near the end of Year 2 consist primarily of changes in knowledge among producers, other agricultural professional, extension educators, high school educators and scientists."

Changes in knowledge of stakeholders
REACCH scientists have made 101 presentations to producers and other industry personnel (see Appendix A). Key activities with certain or measured impacts on stakeholder knowledge include:

- A webinar series introducing agriculture and climate change in the Pacific Northwest was initiated in November 2012 and will continue throughout the winter. The webinar had more than 230 participants (live and recorded) with 36 participants responding to the post webinar evaluation tool. A majority of those who responded to a survey about this webinar rated it as good or excellent in providing information that was useful (78%), timely (89%), research-based (97%), unbiased (100%) and easy to understand (83%). These results to date indicate *clear increases in participant knowledge about relevant science on the impact of climate change on PNW agriculture*.
- Washington Biofuels Cropping Systems (WBCS) project and REACCH research and extension programs have supported increased oilseed adoption in wheat rotations in 2011, also spurred by increased worldwide oilseed prices and regional demand for biodiesel. In WA, canola production increased by 40% in 2011 compared to 2008-2010, due to 1) increased canola prices, 2) favorable environmental growing conditions for winter canola, and 3) improved grower

awareness and knowledge of canola production opportunities and best management practices disseminated by our WBCS and REACCH programs.

- Interest in and purchase of equipment for precision agriculture has increased markedly over the last three years, based on a survey conducted by REACCH. REACCH outreach activities may have contributed to changes in knowledge concerning this technology, although this is difficult to gauge.
- Growers have become aware of the extent of cereal cyst nematode infestation in eastern Washington, via grower talks and proposals. Growers became aware of new diseases and pathogens as a result of our survey work, which has led to funding from the Washington Grain Commission for some projects. Growers became aware of herbicide resistance concerns in downy brome as a result of our survey work.
- Many of the longitudinal survey (LS) participants have implemented alternative production strategies for long enough to effectively increase the productivity and resiliency of their land relative to the dominant cropping system in their area. The strategies developed by pioneering growers demonstrate feasible systems that will help us develop potential future scenarios for our modeling efforts.
- Interacting with all the LS participants has brought awareness of our larger study and the issues involved to these growers as well as various farmer groups to which they belong. We were solicited to interview and analyze economics of a direct seed mentoring project mentioned above because of the REACCH project.

Changes in knowledge of extension educators

- Train the trainer activities designed to communicate the latest climate science to Extension and other agricultural professionals who interact locally with producers and land managers were rated effective. Post-training evaluations indicate that these "train the trainer" strategies have been effective at improving the capacity of educators. Table 7.1 provides an evaluation of learning objectives (before and after) for the first webinar in the series.
- A workshop we hosted on Climate Change Extension Programming held at the 4th International Climate Change Conference in July resulted in an engaged, "standing room only" crowd – indicating substantial interest by others in learning from our efforts in developing extension programs for climate change and agriculture.

Changes in knowledge of secondary school teachers

- Science teachers present at the K-12 workshops held in June 2012 *gained knowledge* related to how flux measurements are made, the differences between enclosure chamber methods and eddy covariance methods, and they were given access to typical data sets from the flux tower operations and chamber emissions data.
- These teachers gained skills in insect collection and classification methods useful for assessing the impacts of climate and agriculture on insect communities.
- Participating teachers are more aware of the scientific approaches to
- understanding climate change and its potential, realistic impacts. These teachers are also more aware of the role of agriculture and the need for sustainable

agricultural systems as well as methods to study agricultural sustainability from a biologic standpoint.

Changes in knowledge of graduate and undergraduate students

- Undergraduate students participating in the summer internship program have better knowledge of scientific research, how to prepare for graduate school and pressing issues revolving around food production under a changing climate.
- REACCH co-hosted an Interdisciplinary Climate Change seminar series (spring 2012, University of Idaho), which exposed the campus community to talks by specialists in various aspects of interdisciplinary climate change science.

Changes in knowledge in the research community

These changes have resulted from the publications and presentations of the REACCH team at professional meetings. These outputs are listed later in this report. Key activities with certain impacts on knowledge include:

- Northwest Scientists and Stakeholders: Von P. Walden, from the REACCH Objective 1 climate modeling group, was Chair of the 3rd annual Pacific Northwest Climate Science Conference, held in Boise, Idaho on 1-2 October 2012. About 15% of the submitted abstracts concerned climate and agriculture (with a significant contribution from REACCH researchers).
- A panel discussion was organized and facilitated at the 3rd annual PNW Climate Conference featuring representation from all of the federally funded integrated projects on agriculture and climate change in the PNW. The session was recorded and is available here. A follow-up article was published in the OutREACCH (g/files/3913/5414/2868/The_outreacch_Nov_2012.pdf)
- The CMIP5 downscaled climate model datasets that have been created for REACCH are also being utilized by the USGS Northwest Climate Science Center (CSC) and the NOAA NW Regional Integrated Science and Assessments (RISA) project.
- International Scientific and Modeling Community: At the international level, the methods developed by the economics group and Objective 1 (led by John Antle) for linking crop model simulations to economic models, and methods for creating future Representative Agricultural Pathways and related scenarios, are being utilized by the Agricultural Model Intercomparison and Improvement Project (AgMIP) in climate impact assessment projects in North America, Africa, and South Asia. Cropping System Model Group and LCA Objective Team (Claudio Stöckle), through AgMIP is providing linkage from REACCH to inform the Intergovernmental Panel on Climate Change (IPCC), the leading international body for the assessment of climate change, and the general public of the potential impacts of climate change on agriculture in the US and around the world.

- Entomologists: Sanford Eigenbrode coorganized a symposium on insects and climate change at the Annual Meeting of the Entomological Society of America in Knoxville Tennessee, Nov. 11. Approximately 150 attended the symposium, which provided information about climate change and forest and agricultural systems.
- Climate and Agriculture scientists: The AEZ concept as developed and presented represents a novel shift in traditional AEZ definition that enables a dynamic assessment of AEZ change over time in response to climate change or other biophysical or socioeconomic perturbations. In contrast to basing AEZ boundaries on relatively unchanging physical factors such as physiography or climate, our approach is to base major AEZ delineation on the annually NASS produced cropland data layer. This enables a spatio-temporal assessment of AEZs and crop constituencies as they respond to major biophysical and socioeconomic drivers. We think this approach could also be used for other regions of the country or world where spatially dense cropland data is available.

Broader Impacts of REACCH

In addition to these immediate outcomes listed above REACCH activities have had broader impacts.
In addition to these immediate outcomes listed above REACCH activities have had broader impacts.

- The CMIP5 downscaled climate model datasets that have been created for REACCH are also being utilized by the USGS Northwest Climate Science Center (CSC) and the NOAA NW Regional Integrated Science and Assessments (RISA) project. The down-scaled climate model produced by REACCH is being used in fire research, regional planning, hydrologic simulations and drought prediction, in addition to agriculture.
- The improved methods for linking crop model outputs to economic models, and the methods for development of Representative Agricultural Pathways, are being disseminated and used by researchers in various projects in the Unites States and globally.
- Agriculture is now an integral part of the program conference programs of the Northwest Climate Science Center.
- REACCH data and research are incorporated into numerous upper level graduate courses across our three institutions.
- Brian Lamb and Sarah Waldo presented results from REACCH measurements systems as part of a NSF Pan American Agriculture and Air Quality workshop for graduate students in La Plata, Argentina during August, 2012.
- Dialogue at various grower and industry meetings has indicated an increase in producer interest and adoption of precision nitrogen management.
- Washington Biofuels Cropping Systems (WBCS) project and REACCH research and extension programs have supported increased oilseed adoption in wheat rotations in 2011

- Biotics Team survey work has increased awareness among producers of the extent of cereal cyst nematode, and new diseases and pathogens in our study area.
- Objective 4 integration with climatological and crop modeling will provide methodological inputs to innovate data collection processes that allow producers to understand community- and landscape-level changes to contextualize their own farm-scale responses, while keeping their individual data confidential.
- AgTools™ will serve two broader purposes: to provide software programs and educational training to regional stakeholders for a clearer understanding of the longer term impacts of a changing climate and changing demands and markets for agricultural outputs in the region; and to establish the feasibility of using web-based methods for soliciting input from growers in real-time setting. Such advancements will add to our sets of methods and techniques for collecting behavioral socioeconomic data and to connect behavioral responses to site-specific and demographic contexts. https://www.agtools.org.
- One Extension Objective lead serves on the Scientific Advisory Panel of the Northwest Biocarbon Initiative – a collaboration of leading environmental organizations and foundations looking for ways to support agricultural and forest carbon mitigation activities.
- One REACCH PI is a lead author for the National Climate Assessment NW section chapter and two others are contributing authors. These and two others are part of the author team for the Northwest Climate Report, a volume to be published by Island Press in 2013.
- Development of a regional network for teacher professional development and the delivery of scientifically accurate and regionally specific data.
- Regional extension professionals have been trained in communicating climate science, improving the capacity of these educators.
- The AEZ approach that enables a spatio-temporal assessment of land delineations and crop constituencies as they respond to major biophysical and socioeconomic drivers could also be used for other regions of the country or world where spatially dense cropland data is available.
- The lead person of the LCA Team is an active participant in AgMIP, particularly in relation to case study and regional simulations of wheat systems in different world locations. Products developed within AgMIP are very important to establish a global benchmark for our efforts within REACCH.
- Cross CAP (Corn CAP, PINEMAP) coordination has increased the knowl3dge of large project management in the areas of graduate student education, E communities, data management, project management and Social Network Analysis.
- REACCH was instrumental in the WSU Cook Agronomy Farm designation as part of the USDA-ARS Long-Term Agroecological Research sites.
- Two NSF grants and one grant from the USDA Dry Pea and Lentil Council were submitted with links to REACCH taking advantage of the existing infrastructure of the REACCH project.

- John Antle, our Modeling Team leader is also the leader of Regional Economics Team, Agricultural Model Inter-comparison and Improvement Project (AgMIP), and member of AgMIP Leadership Team. International impacts include: http://www.tradeoffs.oregonstate.edu/contributed to the organization of international workshops in the US (October 2011), Kenya (January 2012), India (Feb 2012), USA (Sept 2012), Ghana (Sept 2012), Rome/FAO (Oct 2012), Sri Lanka (Nov 2012); organized the training of over 50 professional economists in the use of the TOA-MD model for regional climate impact assessment (2011-2012); and TOA-MD software downloaded and used by researchers at over 300 institutions globally (see http://www.tradeoffs.oregonstate.edu/ for map of locations).
- The Biotics Team had numerous international presentations in Mexico, Australia, and China. Team members hosted visiting international scholars from Scotland, Costa Rica, and Turkey.

KEY REACCH ACTIVITIES AND OUTPUTS

(Highlights from the second annual report)

- *Three land-grant universities and the USDA-ARS partnering in a transdisciplinary effort to address sustainability of PNW wheat systems*
- *Downscaled climate models generated to understand agriculture's responses to climate at a fine scale.*
- *Extension related activities have reached hundreds of producers and other citizens*
- *More than 40 scientific papers and 40 articles in Extension, technical, industry, popular and trade journals*
- *PNW Agriculture incorporated into the Pacific Northwest Climate Science conference, the National Climate Assessment report for the Pacific Northwest*
- *Baseline data obtained for pests, weeds and diseases affecting wheat across the region*
- *Yields for wheat-fallow systems mapped under projected changing PNW climates*
- *Fifteen field experiments initiated examining aspects of cropping system practices and useful to producers over the short-term and as a baseline for longer-term study*
- *Graduate students and postdocs across the project fuel the pipeline of professionals being prepared to work effectively to address climate and agriculture*
- *Greenhouse gas emissions measured to examine effects of N fertilization scenarios and tillage methods.*
- *More than 40 grower cooperators engaged in a long-term farm enterprise study to understand financial impacts of adopting new technology*
- *REACCH contributes to national and international efforts to help agriculture respond to changing climates*
- *Surveys have assessed attitudes and knowledge about climate change and agriculture among farmers, teachers and the general public in the PNW*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Objective 1, Modeling Executive Summary

Lead: John Antle, john.antle@oregonstate.edu

The goal of Objective 1 is to develop a conceptual and operational framework for carrying out coordinated climate, crop and economic modeling, linking human, biological and climatic systems relevant to agriculture.

Team Members: John Abatzoglou UI, John Antle OSU, Susan Capalbo OSU, Sanford Eigenbrode UI, Paul Gessler UI, Laurie Houston OSU, Dave Huggins USDA ARS, Brian Lamb WSU, Phil Mote OSU, Jianhong Mu OSU, Michael O'Rourke MSU, Rick Rupp WSU, Claudio Stockle WSU, Von Walden UI

The Modeling Framework team (Objective 1) uses computer simulations to investigate the possible impacts of climate change on farming activities in the REACCH region. The team will use computer simulations to project how possible changes in future climatic conditions might affect agricultural production systems and farm incomes, under a set of plausible future economic and technological conditions.

A crop simulation model developed at WSU (CropSyst) is being used to study the effect of climate, soils and farming practices on crop production, water usage, nutrient cycling and the environment. The model will then be used to test various farming practices like crop rotation, irrigation, the use of organic and inorganic fertilizers, different tillage strategies and residue management. On the economic front, the team will combine the results from CropSyst with data from farmers in the region in an economic model, the Tradeoff Analysis Model, developed at OSU. This economic model will help us evaluate the production, economic and environmental impacts of changes in climate along with possible changes in farming practices, economic conditions such as crop prices, and changes in policies such as soil conservation programs, and commodity producer subsidies.

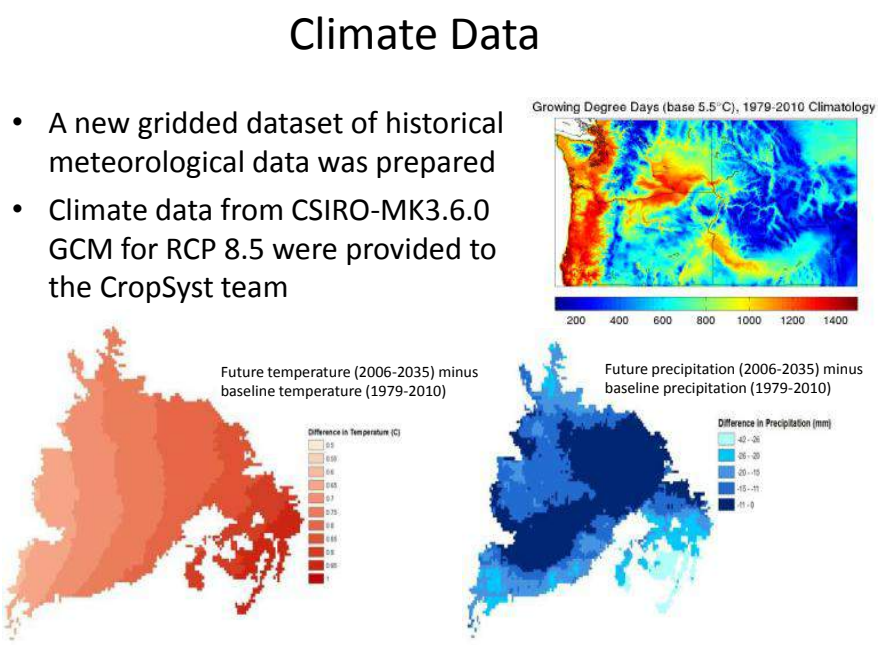

Figure 1.1. Climate data developed for the Proof-of-Concept modeling exercise.

Years 1 and 2 Outputs

The major outputs of the team involved: the development of a conceptual framework for the REACCH project's modeling (see Fig. 1.2); the preparation of bio-physical and economic data for implementation of a proof-of-concept exercise that linked climate data to crop model and economic model simulations in Year 1; new methods for developing future socio-economic pathways and scenarios; and the implementation of a proof-of-concept linked climate–crop – economic model simulation for the winter wheat-fallow system in Year 2. In addition, the Objective 1 team made presentations of its work at professional meetings, developed reports and publications, and disseminated its new methods through a global modeling consortium. Overall, Year 3 work plans conform to the project proposal, consistent with deliverable D1.3 and milestone M1.3.

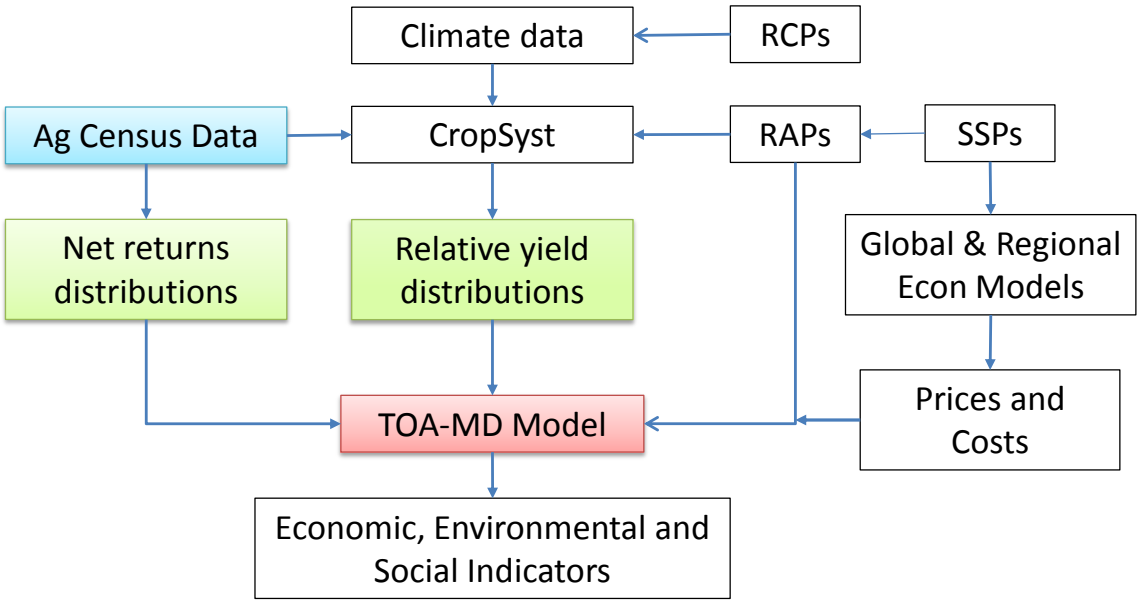

Figure 1.2. REACCH Regional Impact Assessment Design. Note: RCP = Representative Agricultural Pathway; SSP = Shared Socio-Economic Pathway; RAP = Representative Agricultural Pathway.

AEZ Group. The National Agricultural Statistical Service (NASS) Cropland Data layer for the years 2007, 2008, 2009, 2010 and 2011 were accessed for the REACCH study region. These data layers classify land use/cover at a 56- or 30-m resolution and provide annual spatial coverage of land use/cover for the region. The NASS cropland data layer was used to define major land use/cover classifications (e.g. agriculture, range, forestry, urban, water) that will be useful for providing a land use context for Objective 1 (Fig. 1.2a). The agricultural land use/cover was further subdivided and classified into four major agricultural systems: irrigated, grain-fallow, annual-fallow transition and annual cropping (Fig. 1.2b). Further information regarding AEZ development is provided in Objective 9a report. In Year 3, work will continue to finalize climate data needed by the crop modeling and economics groups, and to develop and implement dynamic AEZ concepts that can be linked to historical and future projected climate data.

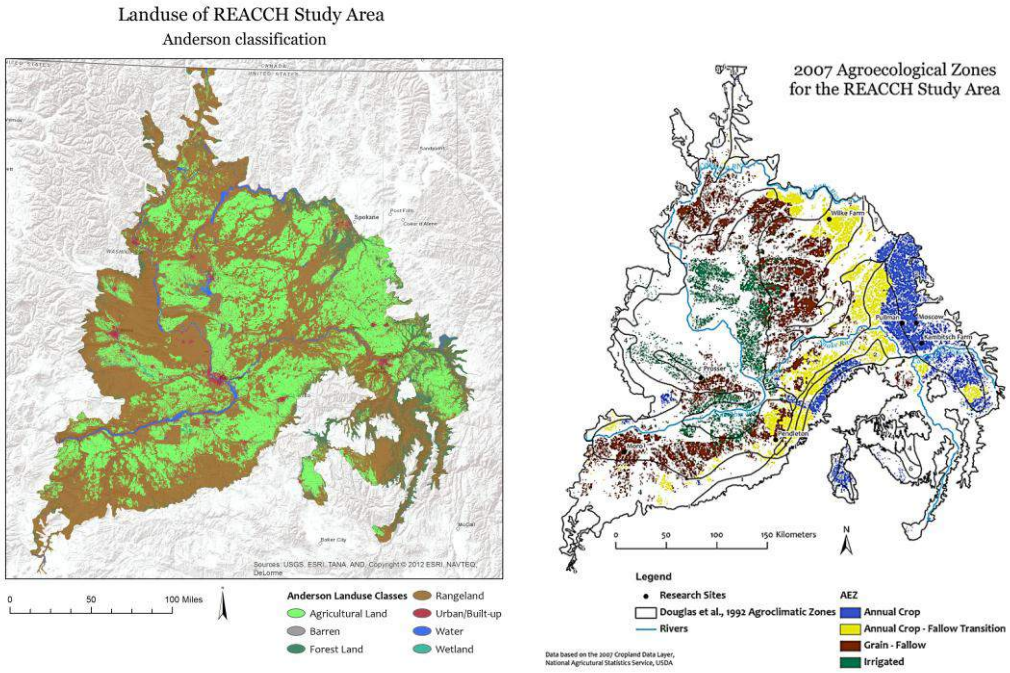

Figure 1.2a and 2b. Classification of major land use/cover groups (a); and sub-division of agricultural land into four major agroecosystems (b) for the REACCH study area.

Climate Group. During the first 2 years, the climate modeling group has produced both historical and future climate data for the REACCH team (Fig. 1.1). This effort has included acquiring the output from 27 different global climate models (GCMs) that were produced as part of the CMIP5; the GCM output include historical simulations, as well as simulations using three different Representative Concentration Pathways (RP) for future climate. The climate modeling group then performed an evaluation of the ability of each of the GCMs to reproduce the historical climate (Tmin, Tmax, precipitation) in the Pacific Northwest using four different historical datasets (PRISM, CRU, ERA-Interim, and NCAP-NCAR2 re-analyses) over the period 1979-2009. The rankings of the GCMs provided a means for selecting which models to use in the crop system simulations. All of the GCM output (including those selected for crop-system modeling) is now being downscaled using the Multivariate Adapted Constructed Analogs (MACA) method devised by Dr. John Abatzoglou. In year 3, the downscaling will be completed, and this large dataset will be transferred to the REACCH data archive for use by the crop modeling group and other researchers within REACCH. Samples of the MACA data were provided to the crop modelers in the fall of 2011, so this team is now ready to utilize the full dataset of future climate scenarios.

Crop Model Group. Regional assessment of yields and GHG emissions for historic and future climatic conditions are being conducted using CropSyst, a cropping systems model. Gridded historic weather data (4x4 km) for the period 1979 – 2010, and future weather projections by 9 general circulation models (GCM) and two representative concentration pathways (RCP) of atmospheric CO_2 concentrations (4.5 and 8.5) are available, for a total of 18 future scenarios.

"Early model runs show winter wheat yield gains across the region for the 2030's to 2050's due to the beneficial effect of elevated CO_2 on crop growth and water use efficiency."

Results for AEZ 3, based on only one GCM and RCP8.5, indicate WW yield gains in most of the region (Fig. 1.3) for the 2030s (2016-2045), further increasing for the 2050s (2036-2065) due to the beneficial effect of elevated CO_2 on crop growth and water-use efficiency, which more than compensates for warming effects. Results are also being obtained for N_2O emissions and changes in soil carbon. Because the number of scenarios to be evaluated over the study region has increased dramatically, significant efforts were invested to migrate CropSyst simulation capabilities from a Windows-based platform to a Linux-based platform, which will allow the implementation of regional simulations using the new centralized Washington State University high-performance computer cluster facility, significantly decreasing the time required for simulation runs and analyses.

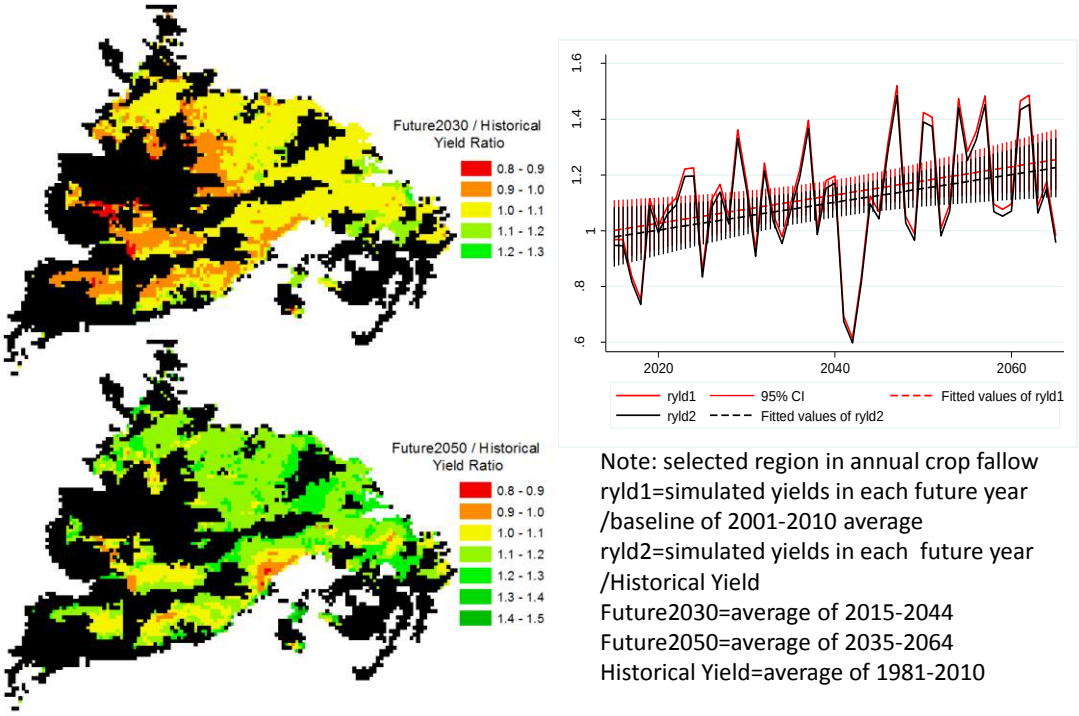

Figure 1.3. Winter Wheat Crop Yields Simulated for the Proof-of-Concept Modeling Exercise. Note: relative yields are defined as future project yield divided by historical yield.

Economics Group. During Year 1, the economic modeling group provided leadership for objective 1 and developed an overarching conceptual framework for the REACCH project modeling and scenario development. Using ag census data prepared in collaboration with the NASS office in Portland, a preliminary analysis of data for the wheat-fallow system in the REACCH region was completed, and reported at the

REACCH annual meeting. During Year 2, the economics group finalized the preparation of ag census data for the REACCH region; developed new methods for using crop model simulated yields in economic impact assessments, and developed a research publication based on that work; developed SAS programs to implement batch simulations for the REACCH project impact assessments; and plans to complete those assessments for analysis of impacts without adaptation. Presentations at conferences were made.

A proof-of-concept modeling exercise was designed and implemented for climate impacts in the winter wheat-fallow system of the REACCH region. The TOA-MD model was used for the economic impact, parameterized with the agricultural census data (Fig. 1.4).

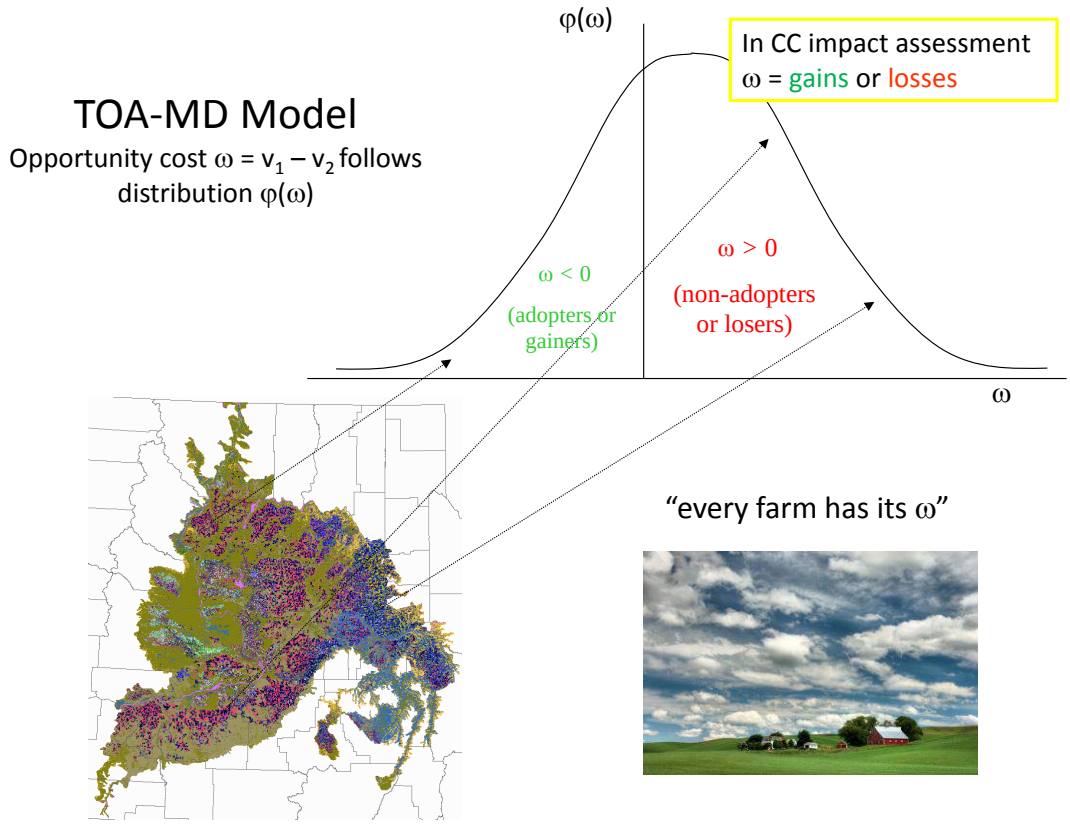

Figure 1.4. TOA-MD Model Approach to Climate Impact Assessment. Distributions of gains and losses are simulated, based on historical economic data and future projected crop yields and future Representative Agricultural Pathways.

The results of the analysis are summarized in Fig. 1.5. The results show that the simulated impacts are sensitive to the way that the data are aggregated, but in any case generally suggest positive impacts of climate change and CO2 fertilization on crop productivity and on profitability of wheat production.

Year	Temporal Aggregation	Gain (%)	Loss (%)	Net Loss (%)	Losers(%)
2030	N	42	19	-23	37
2060	N	57	14	-44	28
2030	Y	16	3	-13	23
2060	Y	38	1	-37	9

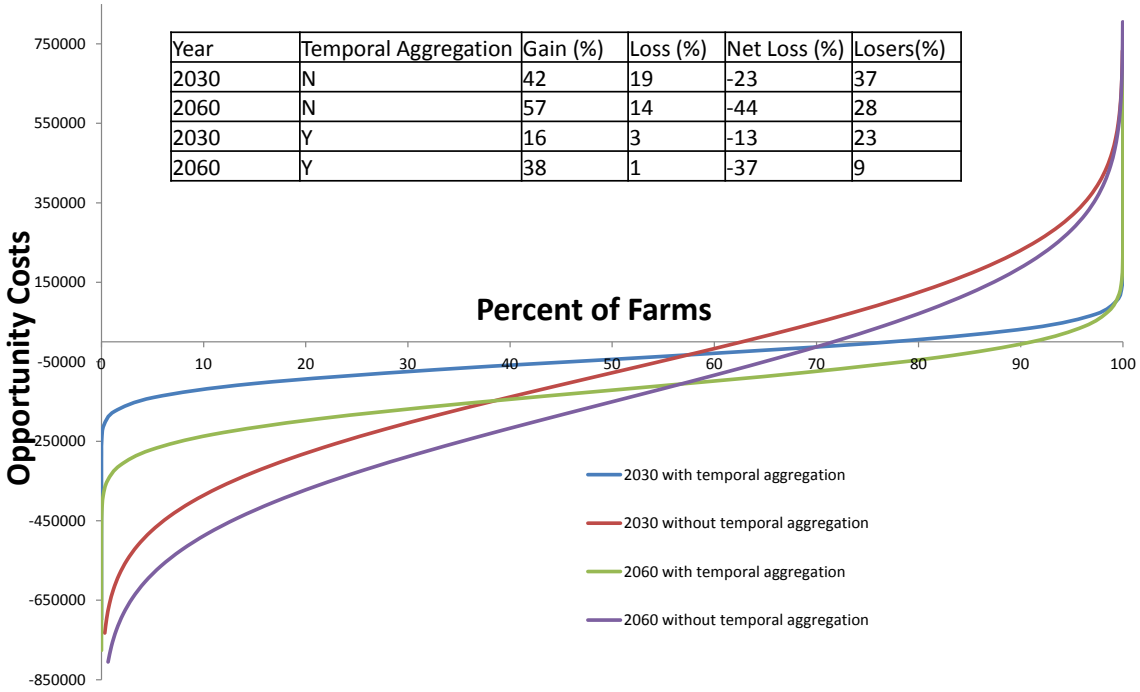

Figure 1.5. Shown are results from Proof-of-Concept Modeling Exercise for Winter-Wheat-Fallow System in the REACCH Region. The curves show the percent of farms that gain from climate change. Depending on the way the data are aggregated, the TOA-MD analysis projects that from 62 to 80 percent of farms would gain from climate change by 2030, and that 72 to 90 percent of farms would gain by 2060. The table shows the percent of gains and losses in net returns to wheat production. The table shows the percent of gains and losses in net returns to wheat production.

"Depending on the way data re-aggregated, the TOA-MD analysis projects that from 62 to 78 percent of farms would gain from climate change by 2030, and that 72 to 90 percent would gain by 2060."

During Year 3, the Economics Group will continue to implement impact assessments for other AEZ crop systems as data become available from the Crop Model Group. The Economics Group will also continue to organize the REACCH project's development of pathways and adaptation scenarios, and begin to develop scientific and outreach publications to disseminate findings.

Year 3 Plan-of-Work

The climate data group will continue to interface with the crop modelers to ensure that this team has the appropriate climate model scenarios for their simulations. The downscaling of the Coupled Model Intercomparison Project, version 5 (CMIP5) models were completed in September 2012, and the data will be stored at the REACCH data archive. The climate data group will continue to provide expertise to those needing to use the data for research, education, and outreach. A significant effort will be placed on creating tools for accessing and visualizing the climate data through both ArcGIS and web-based interfaces.

The crop modeling group will continue collaboration with the climate and economics groups to implement simulation of adaptation scenarios and linkage of crop model simulation outputs to the economic modeling. In Year 3, simulations of adapted technologies will be initiated, based on characterizations and data made available by the rest of the REACCH project. During Year 3, scenario generation and simulation runs will be expanded to include baseline rotations in the four AEZs and 18 weather projections. During the second half of Year 3 and early Year 4, the scenario generation, simulation runs, and LCA analyses will be applied to compare conventional tillage and reduced and zero tillage scenarios for the current crop rotations and the 18 weather projections, including simulation of N2O emissions and soil carbon changes (see LCA section).

The economics group will be implementing TOA-MD simulations for adaptation scenarios utilizing the data provided by the climate and crop model groups. This will involve the development of new methods for linking crop model simulations to economic models, and then implementing those methods with the data provided by the crop model group. The economics group will also be developing land use models for the REACCH region to couple with the TOA-MD model to simulate impacts of climate change on land use as a part of the adaptation scenario analysis. The economics group will also be planning reports and publications based on the modeling work.

Overall, Year 3 work plans conform to the project proposal, consistent with deliverable D1.3 for GCM output to be translated to scales need for agroecological models and milestone M1.3 to calibrate the CropSyst model so that is linked with climate and socio-economic models and that adapted cropping systems are characterized for economic models.

Objective 2, Monitoring Executive Summary

Lead: Brian Lamb, blamb@wsu.edu

The goal of Objective Team 2 is to establish a baseline and monitor changes in soil carbon, nitrogen levels and GHG emissions related to mitigation of and adaptation to climate change in the region's agriculture.

Team members: Heather Baxter WSU, Ryan Boylan UI, J Erin Brooks UI, David Brown WSU, Jackie Chi WSU, Jan Eitel UI, Laurel Graves WSU, David Huggins USDA ARS, Chad Kruger WSU, Brian Lamb WSU, Troy Magney UI, Bill Pan WSU, Shelley Pressley WSU, Richard Rupp WSU, Brendon Sharratt WSU, Claudio Stockle WSU, David Uberuaga USDA ARS, Lee Vierling UI

Figure 2.1. Jackie Chi and Sarah Waldo at Cook Farm eddy flux tower.

During Year 2 within the Objective 2 monitoring effort, we completed the installation of four flux towers and maintained operations and analyses of data flowing from these systems. The flux tower sites include a pair of annual wheat conventional till and no till sites, a high rainfall annual wheat conventional till site, and a low rainfall wheat fallow rotation site. Data from these sites flow automatically to a real-time website for displaying preliminary flux results. Each flux tower records CO_2, water and energy fluxes continuously and automatically. Results from each site are being processed to yield seasonal and annual totals of C uptake and loss. N_2O flux measurements were conducted at the no till site, but fluxes were very small and at the detection limit of the flux measurement system. Additional work using gradient and a novel line source tracer experiment was conducted to help document minimum flux detection levels for N_2O.

Analysis of archived dust samples for the low rainfall, fallow rotation site was completed and reports presented on the amount of C and N loss due to wind erosion for this site.

We measured C/N losses due to water erosion using event-based water samplers at five nested catchments ranging in size from 0.1 km^2 to 6,475 km^2. Water samples were analyzed for both organic and inorganic forms of carbon, total nitrogen, nitrate, and suspended sediment concentration. The water erosion measurements were made at two of the same 0.1 km^2 no-till and conventional till field sites as the flux towers in the high precipitation zone.

The automatic continuous chamber microplot experiment conducted between the falls of 2011-12 included an annual wheat no-till site at low elevation, with incremental N fertilization rates and glucose treatments serving as an additional carbon source. We measured the levels of NO_3^-, NH_4^+ and dissolved organic carbon in the soil samples as well as in soil solution via suction lysimeters, and controlled the levels of N_2O in gas traps to complement the chamber data. Preliminary estimates of the effects of soil levels of N on the greenhouse gas emissions were made, and the timing for the major N_2O flux events was identified. The study on the nitrification and denitrification-specific N_2O pools at variable soil moisture levels was conducted at the chamber microplot experiment via acetylene fumigation in situ and in the incubated soil cores during the fall 2012.

Years 1 and 2 Outputs

During Years 1 and 2, we deployed eddy covariance flux measurement systems to four field sites, we initiated a treatment experiment using a large array of enclosure chambers, we instrumented one site to measure C/N losses due to wind erosion and we deployed a number of systems at different sites to track C/N losses due to water erosion. The flux tower sites include a pair of annual wheat conventional till and no till sites, a high rainfall annual wheat conventional till site, and a low rainfall wheat fallow rotation site. Data from these sites flow automatically to a real-time website for displaying preliminary flux results.

We made preliminary N_2O eddy covariance flux measurements and outlined a plan to test and deploy two alternative approaches for measuring N_2O fluxes. We also conducted N analyses on archived dust samples to investigate potential N loss due to wind erosion. These samples were collected from conventional wheat-fallow cropping systems at multiple sites across the region. We measured C/N losses due to water erosion using event-based water samplers at five nested catchments ranging in size from 0.1 km^2 to 6,475 km^2. Water samples were analyzed for both organic and inorganic form of carbon, total nitrogen, nitrate, and suspended sediment concentration. The water erosion measurements were made at two of the same 0.1 km^2 no-till and conventional till field sites as the flux towers in the high precipitation zone.

The automatic continuous chamber microplot experiment conducted between the falls of 2011-12 included an annual wheat no-till site at low elevation, with incremental N fertilization rates and glucose treatments serving as an additional carbon source. We measured the levels of NO_3^-, NH_4^+ and dissolved organic carbon in the soil samples as well as in soil solution via suction lysimeters, and controlled the levels of N_2O in gas traps to complement the chamber data. Preliminary estimates of the effects of soil levels of N on the greenhouse gas emissions were made, and the timing for the major N_2O flux events was identified. The study on the nitrification and denitrification-specific N_2O pools at variable soil moisture levels was conducted at the chamber microplot experiment via acetylene fumigation in situ and in the incubated soil cores during the fall 2012.

Funds from both REACCH and Site-Specific Climate Friendly Farming (SCF) projects were used to develop and assemble an autonomous terrestrial laser scanner (ATLS) instrument capable of being mounted to a flux tower for continuous quantification of crop canopy growth and development. The ATLS instrument collected data at the Cook Experimental Farm during the 2012 growing season to determine crop height and aboveground crop biomass. A manuscript describing the instrument design and example datasets is currently in review in the journal Agricultural and Forest Meteorology (Eitel et al., in review). We anticipate that this sensor will provide important information with which to calibrate growth models in field conditions comprising a wide range of environmental stress.

"Improved understanding of crop canopy structural responses to stress over daily time scales is likely to provide new information for evaluating climate change vulnerability of crop systems."

The primary outputs from the Monitoring objective are data sets associated with each of the different monitoring approaches. We have preliminary processed data for two of the flux sites completed for Year 1, and we are in the process of finalizing the processing scheme for application to the data streams from all four sites. The Year 1 and 2 chamber experimental data have been reduced and preliminary analyses completed. The chamber measurements provided estimates for seasonal fluctuation of greenhouse gas emissions from soil in various N fertilization scenarios (Figs 2.2 and 2.3). We also evaluated the contributions of nitrification and denitrication to N_2O emissions in the fall following fertilization and rainfall events. Plans are underway to conduct a new experiment using a modified approach. The dust analyses have been completed on a series of archived dust samples and a poster was presented at the annual meeting and at the Showcase for Undergraduate Research and Creative Activities at Washington State University. Similarly, the water sample analyses have been completed and preliminary analyses have been completed and are the basis for a number of presentations.

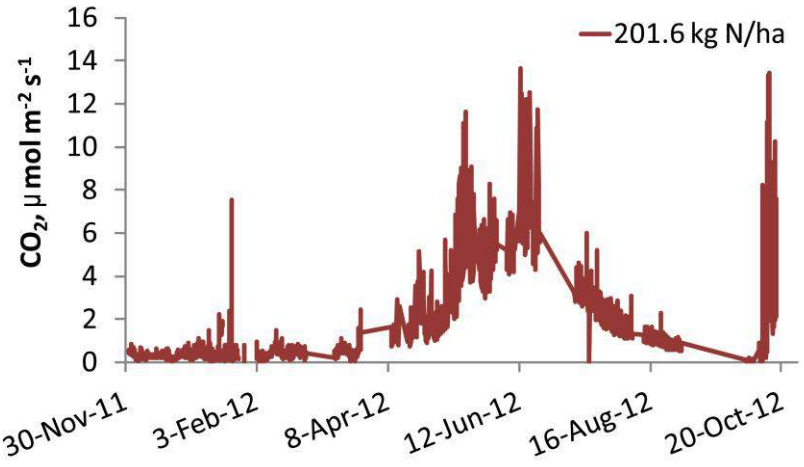

Figure 2.2. Emissions CO_2 measured with chambers for the 201.6 kg/N ha treatment during 2011-2012.

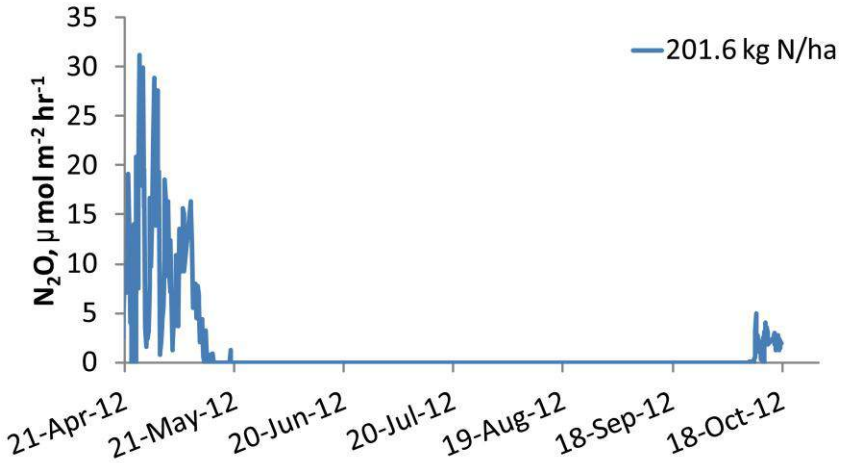

Figure 2.3. Emissions of N_2O measured with chambers during 2012 the 201.6 kg N/ha treatment.

Year 3 Plan-of-Work

During Year 3, we will continue to operate these various monitoring systems, and we anticipate deploying one additional flux system at an irrigated site. Our emphasis in Year 3 is to finalize the data processing for all of the flux sites and to update the archived data sets on an ongoing basis. We are in the process of finalizing the processing scheme for application to the data streams from all four sites. During Year 3, these data sets will be routinely updated and archived. We will continue our analysis of flux data in terms of net C and N exchange for each of the different field sites. We also will be using the Year 1 and 2 water erosion data to develop and assess the ability of physically-based erosion models to predict the detachment, deposition, and transport of carbon through the 0.1 km^2 no-tillage and conventional tillage field sites. We will be investigating relationships between particle size distribution and carbon in eroded sediments to improve model prediction of carbon transport by water. We will deploy enclosure chambers to the sites in target AEZs and continue the analysis of CO_2 and N_2O emissions data as well as the studies on nitrification and denitrification N_2O pools via acetylene inhibition and N-15 tracer methodology.

Objective 3, Cropping Systems Executive Summary

Lead: Bill Pan, wlpan@wsu.edu

The goal of Objective 3 is to determine the effects of current and potential alternative cropping systems on GHG emissions and carbon, nitrogen, water and energy budgets as well as local and regional farm income impacts using models and replicated field trials.

Team Members: Derek Apple WSU, Daniel Ball WSU, Taylor Beard WSU, Girard Birkhauser WSU, Brad Bull WSU, Hal Collins USDA ARS, Aaron Esser WSU, Curtis Hennings WSU, Dave Huggins USDA-ARS, Erling Jacobsen WSU, Jodi Johnson-Maynard UI, Ian Leslie UI, Stephen Machado OSU, Isaac Madsen WSU, Tai McClellan WSU, Daniel Neil WSU, Bill Pan WSU Steve Petrie OSU, Chon Rivera WSU, Dennis Roe UI/WSU, William Schillinger WSU, Anthony Spence WSU, Dave Uberuaga WSU, Cindy Warriner WSU, Clayton Waller WSU, Frank Young WSU, Lauren Young WSU

REACCH Cropping Systems Objective 3 is focused on quantifying and projecting the effects of current and potential alternative cropping systems and innovative technologies on carbon, nitrogen, water, and energy flows and budgets. Research is being coordinated with other objective groups directed at 1) refining and implementing best management practices related to these cropping system management tools, 2) identifying management impacts on carbon and nitrogen flows in and out of the crop-soil systems and impacts on GHG emissions, 3) developing win-win scenarios by identifying short and long term benefits of shifting C, N flows through these systems, and 4) improving cropping system flexibility for adapting to climate change.

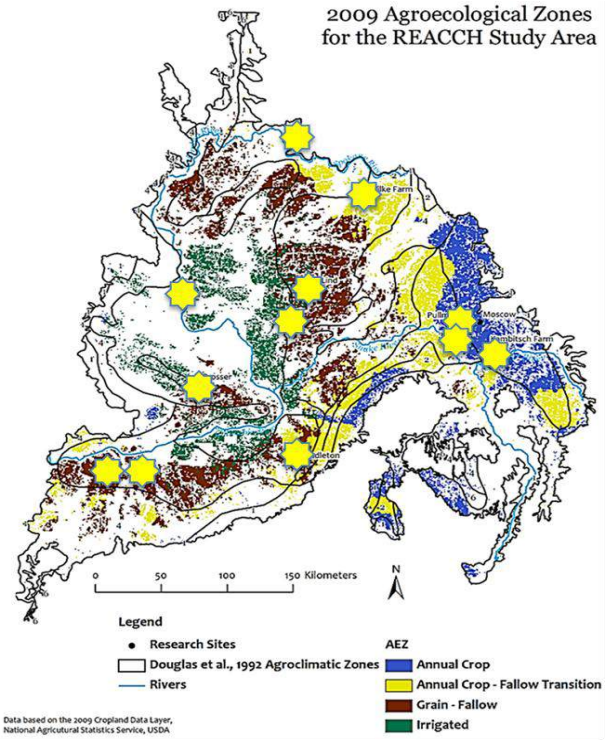

Figure 3.1. REACCH Obj. 3 cropping system experimental sites distributed across the REACCH AEZs.

Management variables include nitrogen management, crop rotation and diversification, reduced/no-tillage and recycled C and N. Fifteen cropping systems experiments at 11 locations amongst the four major agroecological zones have been established to achieve these goals in the context of climatic and soil relevant crop rotations and management approaches. Outputs have included field tours and winter workshops for stakeholders, extension publications, and journal publications. Comparative estimates of regionwide greenhouse gas reductions based on assumed levels of alternative management adoption are ongoing. Outreach events are coordinated with stakeholder partners such as FWAA, PNDSA, and WSDA.

Years 1 and 2 Outputs

A network of existing and new field CS experiments have been identified or established over the study region for comparative assessment of alternative agronomic adaptation and GHG mitigation practices in wheat-based systems. Fifteen experiments at 11 locations are distributed amongst the major agroecological zones across the tri-state region: high rainfall-annual cropping, intermediate rainfall-flex cropping, low rainfall-wheat-fallow, and very low rainfall-irrigated cropping. We inventoried and collected information on existing CS experiments, pictures, publications, students and collaborators. Site information was organized and posted by site on CD. A three state site tour was conducted in August 2011 to familiarize REACCH investigators with field sites and experiments, and another REACCH tour was conducted in June 2012 across five WA CS experimental sites. We designed and established new CS experiments at Davenport, WA (transition zone), Ralston, WA (fallow zone) and Prosser, WA (irrigated zone). We created and communicated a unified fall and spring sampling protocol to site managers and coordinated comprehensive soil and plant sampling during the 2012 growing season and initiated analyses and data compilation.

Year 3 Plan-of-Work

The Objective 3 Team will continue to maintain and monitor a network of experiments over the study region for comparative assessment of alternative agronomic adaptation and GHG mitigation practices in wheat-based systems. Production system alternatives to traditional wheat agronomic systems for specific agroecological zones relate to 1) residue management, 2) crop diversification and intensification, 3) N fertilizer management, and 4) recycling C, N byproducts. Standardized crop and soil measurements for soil water, N and C, crop growth and development are focused on developing carbon, nitrogen, water, and energy flows and budgets at all locations. Approaches to estimate water and N balances are utilized in wheat-based systems featuring alternative crops throughout the study region (Fig. 3.2). Soil C fractionation methodology will be refined for defining relative proportions of recalcitrant vs. non-recalcitrant C for application to selected sites. Soil GHG emissions will be measured on selected treatments and locations using an automated chamber system. Site specific N technologies and management across the landscape will be evaluated on a farm scale at multiple locations. We are identifying field subzones, sampling for soil N and water, and comparing a variable rate technology to uniform N management across landscapes. Journal manuscripts and extension publications will be published on regional life cycle analysis of projected regional canola adoption, cold tolerance and N management of canola; soil C accumulation affected by crop rotation/diversification in the wheat-fallow zone, camelina variety yield and oil performance, camelina N responses.

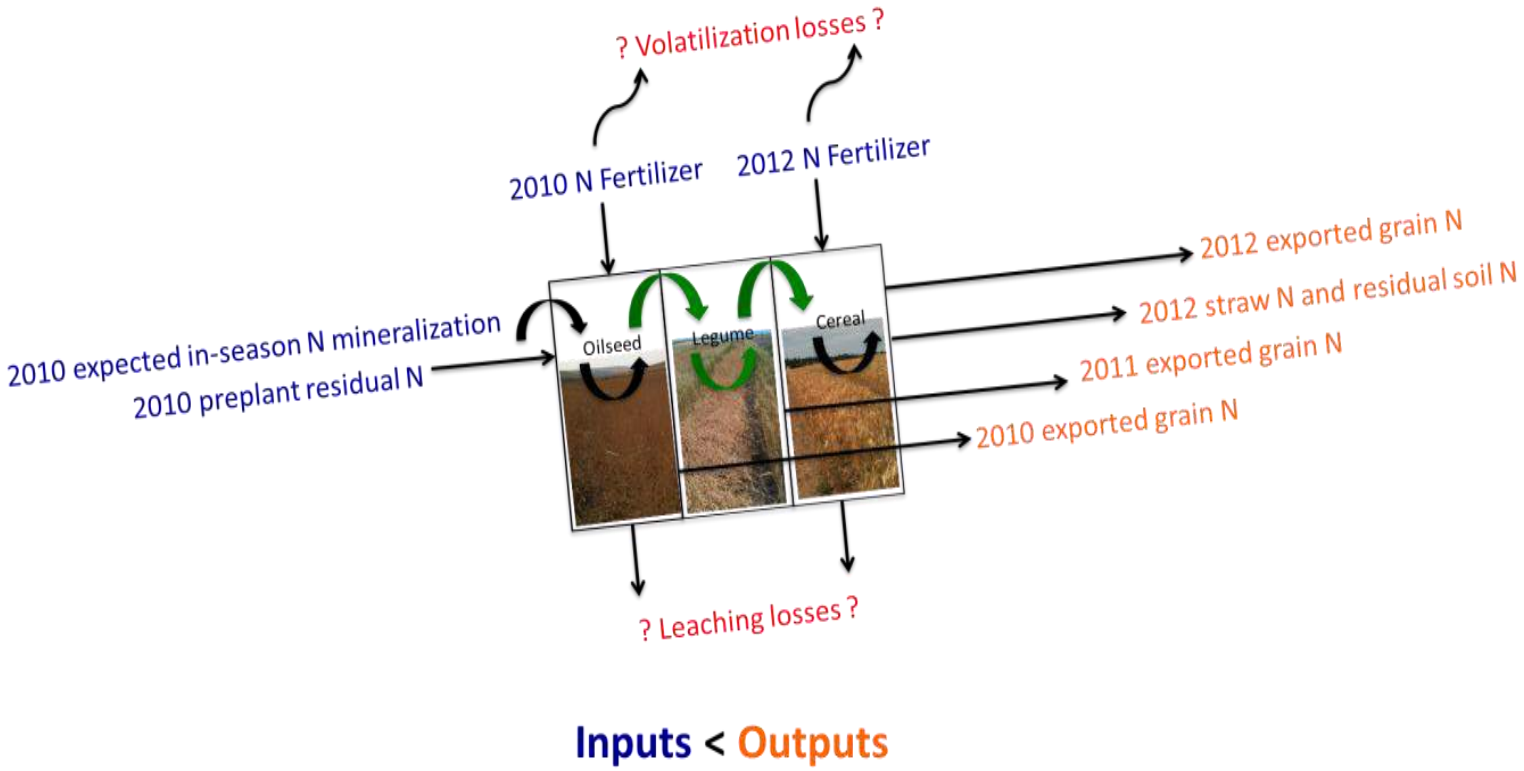

Figure 3.2. The nitrogen balance approach is a method used to assess N inputs versus outputs by agencies, such as the International Plant Institute. For REACCH, we have modified the N balance to provide a detailed budget of N in a 3-year cropping sequence involving cereal, oilseed, and legume crops. A positive N balance indicates that more N was exported in the grain or tied up in crop residues (outputs) than added as fertilizer or provided by pre plant residual inorganic soil N. This might occur when legumes (biological N fixers) are featured in the rotation, or if mineralization of organic N is enhanced during the cropping sequence. In contrast, a negative N balance results when fertilizer N inputs and pre plant residual inorganic soil N exceed the amount of N exported in seeds or remaining in crop residues. This might be due to net losses of N from leaching and volatilization, or an increase in the immobilization of soil N. (McClellan et al., 2012)

Objective 4, Economic and Social Factors Executive Summary

Lead: Susan Capalbo, susan.capalbo@oregonstate.edu

The goal of Objective Team 4 is to determine social and economic factors influencing agricultural management, technology adoption and development of policy to improve production efficiency while mitigating greenhouse gas emissions.

Team members: John Antle OSU, Leigh Bernacchi UI, Susan Capalbo OSU, Penelope Diebel OSU, Hilary Donlon UI, Laurie Houston OSU, Stephanie Kane UI, Kate Painter UI, Jeff Reimer OSU, Dennis Roe UI, Clark Seavert OSU, JD Wulfhorst UI

The Objective 4 Team is interested in understanding the economic and social profile of growers in the REACCH area, and factors which influence on-farm adaptation of new technology and implementation of new practices. These efforts will help policy makers understand how climate, energy and agricultural policies influence farming practices, and the types of incentives and policies that will most effectively sustain a highly productive and sustainable farming sector.

Each year Objective 4 Team conducts a longitudinal survey (LS) consisting of personal interviews of more than 50 growers across the study region, tracking cropping activities such as, dates for planting, crop emergence, and pest observations. This year we added two additional sample surveys, a telephone survey of the general public (GP) and an agricultural producer survey (AP). The GP is designed to assess the public's perceptions related to climate change and its potential impact on agriculture and food security in the region. The AP survey of agricultural producers across the study area, included questions related to current production practices, economic constraints, soil conservation, information sources, and addressed perceptions of climate change, its perceived effects, and willingness to adopt mitigation and adaptation strategies.

In Year 3, the team plans to continue the (LS) survey, analyze and report results from the LS, GP and AP surveys, design visualization workshops with stakeholders, develop web-based decision support tools, and develop a computable general equilibrium framework for evaluating regional impacts.

Figure 4.1. Eastern Washington producer Ron Jivara explains to the REACCH summer tour participants about regional bio-solids applicati0ns to his wheat fields.

Year 3 Plan-of-Work

The Objective 4 Team will continue collecting information and analyzing and interpreting data related to producer decision making and awareness of climate change effects. They will be developing methods to help predict and understand adoption rates for new technologies under a changing climate and changing policies, and the regional impacts.

These activities include:

- Continuing the longitudinal survey (LS) of a group of producers (50+) who are collaborating with this project
- Analysis and reporting of results from a telephone survey of the general public (GPS) in the states of Washington, Idaho, and Oregon conducted in the fall of 2012
- Analysis and reporting of results from a mail survey conducted with a large random sample of agricultural producers (APS) in the REACCH study area conducted in December of 2012
- Design of visualization workshops with stakeholders, to explore hypothetical climate-model-based scenarios and qualitative interviews with stakeholders to help inform the survey analysis
- Development of web-based decision support tools
- Development of a computable general equilibrium framework for evaluating regional impacts
- Integration across data sets other secondary sources of information for profiling farmers and existing and emerging technologies in the region.

Each of these is explained in greater detail below.

Longitudinal survey (LS): The Year 3 LS survey will be a continuation of the previous year's survey with additional questions submitted by other objective teams. We will send the survey (both by e-mail and regular mail) to our ongoing LS participants with new forms for tracking this year's cropping activities, including dates for planting, crop emergence, and pest observations. Included will be a postcard for scheduling Year 3 interviews. Objective 4 team members will then meet with the producers to complete the surveys. New grower participants are being added, with the goal of having at least 50 continuing participants.

General public survey (GPS): A total of 1,300 telephone surveys were completed via a stratified random sample of the general public, conducted in the fall of 2012, will be summarized and analyzed. The survey was designed to assess the public's perceptions related to climate change and its potential impact on agriculture and food security in the region. Participants were asked several questions regarding observed and perceived changes in weather and or climate, the related effects of these changes on agriculture and risks to agriculture, as well as actions to be taken in relation to climate change. Results will be available within Year 3 of the project.

Agricultural producer survey (APS): Quantitative data from the APS will be analyzed to estimate the willingness and ability of producers to adopt new production practices based on agroclimatic, social, and economic constraints, as well as evaluate past willingness to adopt new production practices. This data will be compared and calibrated with data available from the National Agricultural Statistics Service (NASS) Census of Agriculture. This data will also be useful to other objective teams, as the APS includes key questions suggested by other scientists within the REACCH project, along with questions included on NASS surveys, and social and cultural questions not typically asked on NASS surveys.

Qualitative interviews and visualization workshops: A content analysis of qualitative responses within both the APS and GPS will be conducted, in order to understand the communication terms for weather and climate change across our stakeholders and subjects. This will help Objectives 4 and 7 in their communications with specific targeted audiences. Analyses of both sets of survey data (APS and GPS) will result in visual outputs for use in mediated modeling and visualization workshops.

Web-based decision support tools: Objective 4 researchers, in collaboration with Objective 7 (Extension) researchers, will be utilizing web-based technologies to connect with growers and obtain spatially linked information on technology adoption behavior. The web-based decision support tool will utilize the AgTools™ software (www.agtools.org), which is being modified for the wheat areas of the REACCH region. It will upload down-scaled climate and crop yield information specific to the respondents' farming area to create a real-time context for understanding the long-term and short-term consequences of management decisions. More specifically, this decision support tool is designed to:

(1) better understand the behavior and decision-making process of stakeholders (growers) who manage and care for the agricultural land;
(2) provide site-specific financial (to separate from agronomic) information to individual growers to help them make more informed management decisions; and
(3) provide an innovative on-line decision tool (methodology) to complement and expand REACCH extension and research to stakeholders.

The web-based tool is an innovative means to connect growers and researchers and to help growers make more informed decisions while also helping researchers and policy-makers predict grower responses to changes in climate, policy, and other factors. It is envisioned as a two way real-time conversation and engagement with growers. Information provided to growers will utilize the down-scaled climate models and the crop models to predict yields and financial outputs. This will allow users to change input and output prices, markets and technologies against the backdrop of their own farming operation. Demographic information (age, education, years farming, size of operation, financial condition, etc.) collected from growers will serve as the variables that can be correlated with grower responses.

The web-based AgTools™ will be parameterized with data, models and information generated from REACCH and from related projects. It will be initially piloted with growers in the Pendleton, OR area, and then expanded to the entire REACCH region. Scenarios will involve changes in prices, markets, and technology all set in the context of each individual user's operation. Outputs will include information on how a grower would respond to a hypothetical situation using the context of his/her own farm, location, and demographic characteristics.

We plan to produce three manuscripts related to AgTools™: 1) one on the use of a web-based scenario tool to elicit valid responses from growers on future management and adoption choices, 2) a second on the results of the piloted use of AgTools™ with growers with a focus on the innovative use of alternative techniques and secondary data to create contextual and spatially-referenced information for improved management decisions, and 3) a third on the scaling up of this tool for better understanding regional patterns of adoption behavior under changing climate and changing economic factors. In addition growers will have a user-friendly version of AgTools™ that will be posted on the web. The input from Year 3 activities will lead to a REACCH AgTools™ academy workshop in Year 4 that will teach growers how to use this software.

Computable General Equilibrium Framework. The team will also create a Computable General Equilibrium (CGE) model which will be parameterized and used to evaluate the price and cost effects of Shared Socio-Economic Pathway scenarios developed by Objective Team 1, as part of the REACCH project. The CGE analysis will predict changes in numbers of jobs, commodity prices, wages, household income, and tax revenues, all at a relatively aggregate, regional level. As such, it will provide a complementary analysis of economic impacts to that of the TOA model being implemented by Objective Team 1.

Integration across data sets and information. In collaboration with Objective 1, the economics team will use the Agricultural Census data, data from the APS and LS conducted by this objective, and other USDA data on management, input use, and yields for the region to create an extensive profile of farming in the region. These data are part of the information used in Objective 1 to link the integrated analysis. The profile will serve as part of the ground-truthing for our objective 4 analyses in coming years.

Years 1 and 2 Outputs

The Objective 4 team, with input from researchers on other objective teams has developed additional integrated questions for this year's LS survey. Research activities and output for the LS team include personal interviews of more than 50 growers across the study region. Of these growers, 47 were suitable participants. An economic analysis was created for each LS participant's farm and sent to the participants via mail and email for review. A summary analysis of cropping activities, yields, costs per bushel, and fertilizer and pesticide usage was completed and grouped by AEZ and purged of any personal identifiers, so they can now be used without disclosing confidential material.

> *"Over half of the growers interviewed practice some form of variable rate fertilizer across a field."*

Year 2 research activities for the team also included the design and implementation of two additional sample surveys: the GPS and the APS. The GP survey is a telephone survey of residents of Idaho, Washington, and Oregon, completed in November 2012, to assess the public's perceptions related to climate change and its potential impact on agriculture and food security in the region. The APS, a survey of agricultural producers across the study area, fielded December 2012 – January 2013, integrated inquiries from all REACCH objective teams. The APS included questions related to current production practices, economic constraints, soil conservation, and information sources. In addition, this survey addressed perceptions of climate change, its perceived effects, and willingness to adopt mitigation and adaptation strategies.

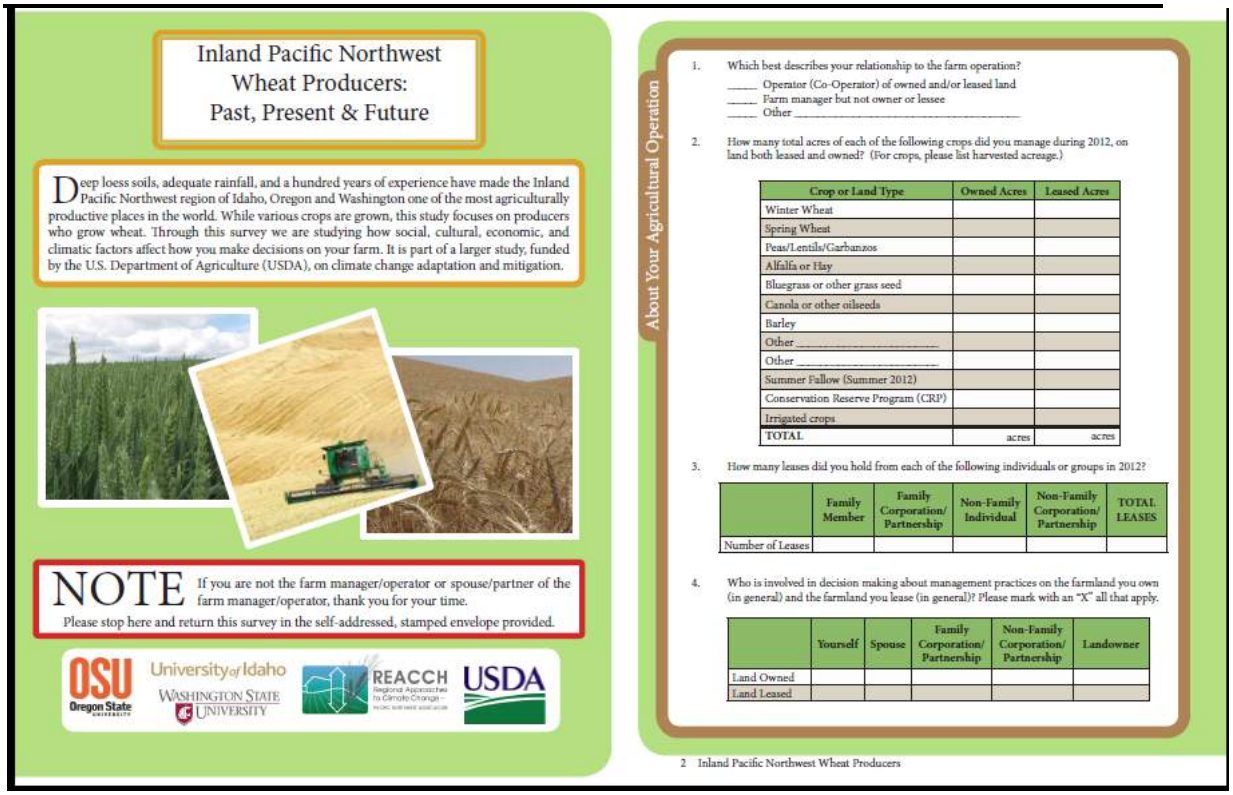

Figure 4.2. REACCH Agricultural Producer Survey

Other outputs include development of the sociological framework and research methodology to guide data collection through Year 5, including: ongoing literature review of key emerging areas not previously addressed, theoretical model for adaptation likelihood scenarios, and fieldwork protocols. The AgTools™ framework has been adopted for a web-based set of decision tools and is in the process of being piloted with growers in Pendleton, OR area. This is done in conjunction with the Extension and outreach objective of REACCH. As a result of working closely with Objective 1, we

were also able to compile summary crop statistics from the Agricultural Census data for 37 counties in Oregon, Washington, and Idaho.

In collaboration with Objective 1 team members, farm-level data from the agricultural census were acquired in an agreement with the NASS. Statistics on farm costs and returns were analyzed and used to construct estimates of means and standard deviations of crop yields, revenues, costs of production, farm size, government payments, and other relevant variables. These data were summarized in a report. Objective Team 1 will use this data to parameterize the TOA-MD model, and Objective Team 4 will use this data to ground truth data collected in surveys.

Objective 5, Biotic Factors Executive Summary

Lead: Ian Burke, icburke@wsu.edu

The goal of Objective 5 is to anticipate and develop approaches to climate change-related changes in crop protection requirements and the effects of beneficial biota within cropping systems.

Team Members: Iqbal Aujla WSU, Nilsa Bosque-Perez UI, Ian Burke WSU, David Crowder WSU, Seth Davis UI, Nathanial Foote UI, Ames Fowler UI, Laura Hancock UI, Jodi Johnson-Maynard UI, Brian Lach UI, Nevin Lawrence WSU, Ian Leslie UI, Tim Paulitz USDA ARS, Georgia Seyfried UI, Rachel Unger WSU, Chelsea Walsh UI, Ying Wu UI

Climate change can affect the biology, distribution, and management of pests such as insects, fungi, weeds, and beneficial organisms. Understanding how climate change affects these organisms will help farmers minimize risk associated with their operations. The Biotic Team (Objective 5) is employing monitoring, modeling, and field experiments, that will, in collaboration with Objectives 1, 3, 4, and the AEZ theme, allow us to understand the impacts of climate on key pests, weeds, pathogens and organisms. Research activities for the team included establishing baseline data for insect pests, crop pathogens, weeds, and earthworms (Fig. 5.1) throughout the study region with 2 years of sampling. Insect monitoring included monitoring aphids (Fig. 5.2), cereal leaf beetle, Hessian fly, orange wheat blossom midge, and wireworms. Pathogen monitoring focused on root lesion and cereal cyst nematodes, Fusarium crown rot, and monthly sampling for *Rhizoctonia* and *Pythium*. Sampling for weeds included extensive sampling of downy brome and mayweed chamomile across the REACCH study region. The Biotic Team continues to sample, monitor, study these pests and beneficials on farms throughout the region, in field studies, and in greenhouse and growth chamber studies. Ultimately, our goal is to understand how these organisms will adapt to climate on across the REACCH study region sufficiently to allow growers to utilize the information to mitigate risk.

Figure 5.1. A summer intern samples for earthworms with REACCH scientist Ina Leslie.

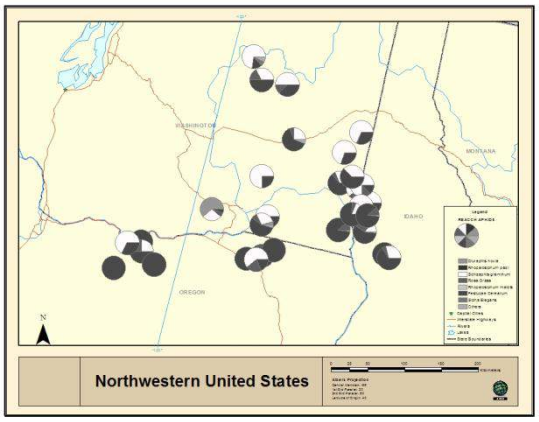

Figure 5.2. Aphid sampling, 2012. Pie charts indicate aphid community composition at sampled location.

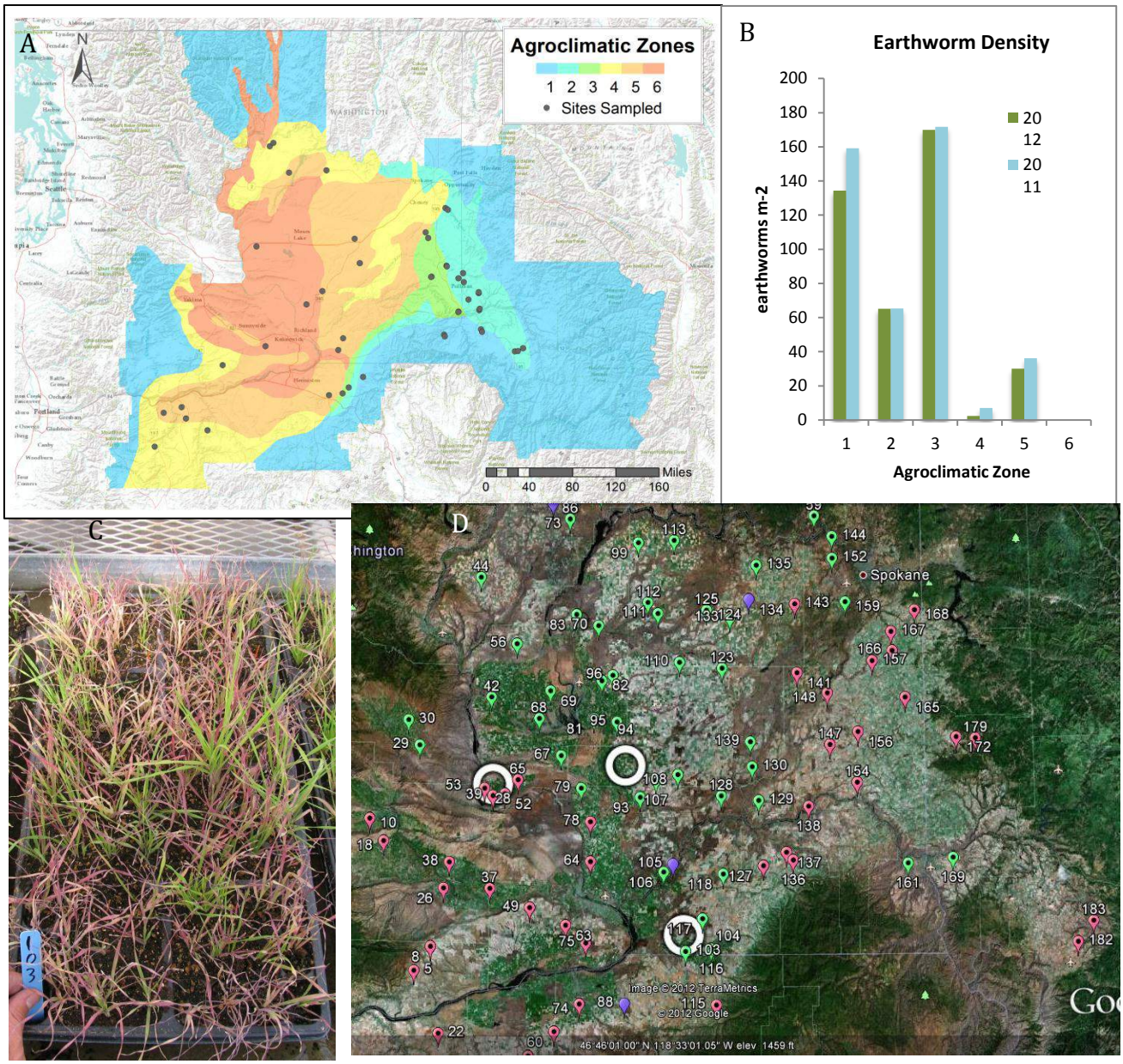

Figure 5.3. Maps illustrating earthworm and weed sampling and evaluation efforts: A) locations of 2011 and 2012 earthworm/aphid/weed sampling sites. The agroclimatic zones shown are based on soil depth, mean annual precipitation (ppt) and cumulative growing degree days (CGDD) (Douglas et al., 1992) B) earthworm density across agroclimatic zones in 2011 and 2012, C) phenotyping herbicide resistance in downy brome – downy brome population response when treated with propoxycarbazone, D) distribution of propoxycarbazone resistance in eastern Washington, indicated by open circles.

Years 1 and 2 Outputs

Research activities for the team included establishing baseline data for insect pests, crop pathogens and weeds throughout the study region with 2 years of sampling. This included monitoring aphids (12 species of cereal aphids), CLB, Hessian fly (Fig. 5.3), orange wheat blossom midge, and earthworms on approximately 40 grower cooperator farms and research plot locations during both years of the project.

A state-wide survey in 2012 also explored factors affecting the distribution of wireworms across spring wheat fields in Washington. Wireworms were detected throughout the sampled region, with two dominant species detected. Pathogen monitoring was completed for 2 years of survey work for root lesion and cereal cyst nematode, *Fusarium* crown rot, and monthly sampling for *Rhizoctonia* and *Pythium* from eastern Washington. We also completed 2 years of sampling to compare pathogens in one irrigated vs. non-irrigated trial and in several till vs. no-till sites. Sampling for weeds included a third cycle of seed bank sampling on the Cook Agronomy Farm and extensive sampling of downy brome and mayweed chamomile across the REACCH study region. Seed bank cores were collected from 40 grower cooperator farms.

The CLB model was extended to include its principal parasitoid, *Terastichus julis* and possible effects of climate change on pest and parasitoid overlap and biological control. This work was presented at several professional venues and a manuscript is in preparation. Archival suction trap data from the entire PNW from 1983 to 2006 were compiled into a database and used for preliminary analysis of effects of large-scale weather patterns such as El Niño and La Niña on flights of cereal aphids.

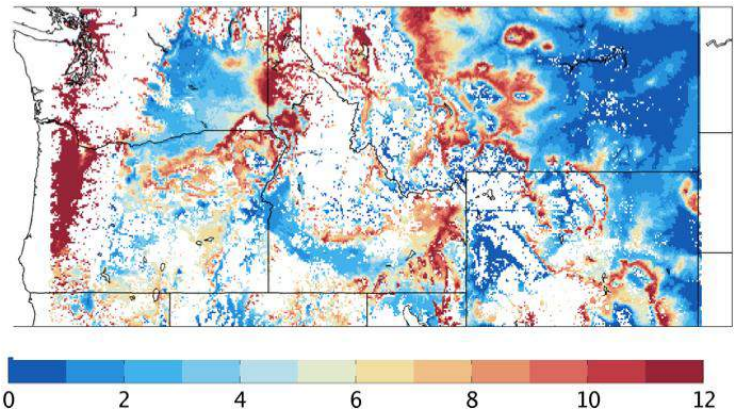

Figure 5.4. Projected change in the potential severity of cereal leaf beetle by mid-21st century based on climate models. Units are suitability index values. All are positive, indicating increased suitability by mid-century.

Year 3 Plan-of-Work

The Project Team will continue monitoring aphids, cereal leaf beetle (CLB), Hessian fly, orange wheat blossom midge and wireworms, earthworms, downy brome, Mayweed chamomile, Russian thistle, prickly lettuce, other economically important weeds and pathogens on farms throughout the region.

Baseline monitoring data will be used to produce manuscripts on the distributions of earthworms, aphids, *Rhizoctonia, Pythium*, root lesion nematodes, and *Fusarium* in response to climatic factors. A predictive model for wireworms is planned. We will explore interactions between wireworms and other pest species in cereal crops (weeds, aphids) and explore climatic factors affecting wireworm outbreaks. Other planned manuscripts include one on relationships between edaphic factors and terrain on nematode and weed distributions at Cook Agronomy Farm.

Modeling of selected organisms in response to projected climate change will be accelerated, following the precedent established with CLB in Year 2 of the project. The CLB paper will be published in its first form and refined by incorporating wheat phenology. We will publish one paper on downy brome responses to projected climates, refined based on downy brome phenology as determined in ongoing common gardens. Archived suction trap data for cereal aphids (at least three species) across Washington and Idaho will be used along with downscaled historical weather records to model flight responsiveness to weather and climate. We will complete a literature review on effect of soil and moisture on soilborne pathogens (*Pythium, Rhizoctonia,* and *Fusarium*). We will also compile data on stripe rust for modeling with projected climate models. We will publish two papers on the distribution of nematodes and effect of ephaphic factors, and one paper on the distribution of *Fusarium,* as affected by 30-year climate averages.

In Year 3, we will initiate growth chamber studies to examine the effects of temperature regimes on the Barley yellow dwarf virus-wheat cereal aphid (*Rhopalosiphum padi*) interaction. Chamber studies will be conducted based on earthworm field survey data from Year 1, and a literature review on climatic impacts on the most common earthworm species found in Years 1 and 2 is currently underway. The results will be used to determine the specific treatments in the chamber studies. Downy brome populations from throughout the region will be grown in common gardens to refine growth and development models. Seed bank cores from 40 grower collaborators will be evaluated for composition, and weeds collected for future study. Finally, growth chamber studies will used to understand and predict genes controlling growth and development in prickly lettuce.

Objective 6, Education Executive Summary

Lead: Jodi Johnson-Maynard, jmaynard@uidaho.edu

The overall goal of the REACCH Education Team is to introduce innovative agricultural approaches to climate change mitigation and adaptation into K-12 and undergraduate and graduate curricula to prepare citizens and professionals for climate related challenges and defining agriculture's role in providing food, energy and ecosystem services.

Team Members: Erin Corwine UI, Sanford Eigenbrode UI, Kris Elliot OSU, Paul Gessler UI, Jodi Johnson-Maynard UI, Jonathan Velez OSU, Troy White UI, Kattlyn Wolf UI (see Table 6.1 for full cohort of students on Objective Team 6)

During Year 2 of the REACCH project, we continued to build the foundation for an educational network needed to reach our goal. Teachers responding to our REACCH teacher survey and indicting interest in further participation attended a 4-day teacher workshop on climate change and agriculture. The workshop was jointly sponsored by REACCH and ICE-Net (a climate change education project funded by NASA). Post workshop surveys indicated that teachers felt that the workshop was useful and provided valuable information for incorporation into their classrooms. A draft high-school level curriculum based on the REACCH project structure was developed and is currently being reviewed by objective teams. Curriculum development is being led by Troy White, a REACCH PhD student who started in the fall of 2012. We continue efforts in building relationships with teachers; we visited a 4th grade classroom and did an activity based on carbon dioxide release by soils. An interdisciplinary, systems based covering ecosystem resilience concepts and food production was taught to undergraduate students. We also successfully hosted the first REACCH summer internship program.

Figure 6.1. Student interns 2012

A total of 13 students were recruited and worked at one of the course three REACCH institutions for a 9-week period. Students conducted independent research and presented their results at a research symposium. Currently, the REACCH faculty has recruited a total of 19 graduate students and one more is expected to join the project in Year 3. Education Objective Team members hosted a graduate student retreat in Sandpoint, ID that brought students from the three campuses together to ground students in the overall objectives of the REACCH project, begin the basis for interdisciplinary collaboration among students and faculty across the project and build community. A graduate student handbook was also drafted to clarify project requirements and opportunities.

Years 1 and 2 Outputs

Figure 6.2. REACCH graduate students at their Fall 2012 retreat.

Undergraduate and graduate. A capstone course focused on climate change and ecosystem resiliency was offered in spring 2012, partially completing deliverable D6.2 within undergraduate/graduate education. This course was anticipated to be multi-institutional, however, during 2012, new protocols for cooperatively listing courses between WSU and UI, slowed down this process. We will further explore options but it may not be possible to cross-list across each institution. Webinars are being discussed as an option to semester-long courses. Formation of cross-disciplinary graduate student teams at the graduate student retreat completes deliverable D6.2b. An undergraduate research internship program was established in Year 2. A total of 13 students were recruited, completed independent research and presented their findings in a symposium held at UI in August. The internship program partially completes deliverable D6.3. A graduate student retreat was held to better ground students in the goals of REACCH as well as to build capacity as a group of interdisciplinary researchers. The retreat revealed a wide level of understanding regarding the REACCH project, and the role of students within the project among graduate students. The event was successful in building community and in increasing awareness of REACCH goals. As a result of the retreat a graduate student handbook was developed to clarify requirements of REACCH-funded graduate students. The handbook should provide an easy-to-use resource for graduate advisors as well. The REACCH education coordinator has also initiated a newsletter which goes out to students and faculty advisors every other week. The goal of the newsletter is to capture the important project-wide events that impact REACCH students and to improve communication between REACCH advisors, students and members of the education objective team.

Figure 6.2. REACCH graduate students in the field.

Figure 6.3. Kindergarten class studying earthworms.

K-12. A comprehensive, region-wide, teacher survey was delivered, results analyzed and used to develop professional development materials. Results were presented at a national meeting. A manuscript is currently in the internal review process and will be submitted in Year 3, completing milestones under deliverable 6.1. A workshop for teachers interested in climate change and agriculture as identified through the survey in cooperation with ICE-Net (Intermountain Climate Education Network) was held in June, 2012. Several REACCH scientists provided presentations and hands-on training to 18 teachers from across the region. The development and dissemination of these professional development materials completed deliverable 6.1a (see Appendix B) and will form the basis of future teacher professional development workshops for teachers. A summary of the evaluations of this workshop is in Table 6.1. Under deliverable 6.3, two activities focused on earthworm biology and ecology were developed and carried out with a local elementary class. A third activity on decomposition and carbon dioxide production was carried out with a 4th grade class. A graduate student was recruited to write curriculum for the REACCH project, a temporary student was hired to help with the initial framework of the curriculum, and an education coordinator was brought on board to facilitate the integration and collaboration of educational components in all the REACCH objective groups.

Figure 6.4. Teachers attending a REACCH summer workshop participate in a pit-fall trapping experiment.

REACCH ICE-NET Teacher Workshop evaluation comments and trends with additional summary for RFA reporting

Five evaluations were completed by REACCH teachers. The first section of the evaluation asked teachers to rate the education value of activities and their agreement with a series of statements related to the curriculum pieces presented at the workshop and teachers interest in using the information presented in their classrooms. The second section of the evaluation asked teachers to comment on aspects of the workshop they liked best, what they thought could be added in the future and whether or not they were interested in continuing to work with the REACCH program. Teachers indicated that they would like to continue attending workshops that include opportunities to interact with researchers in their labs or in the field and that they would use the hands on activities with classroom students.

Table 6.1. Students and Post Docs on the REACCH Team

Name	Position	Institution
Troy White	PhD Student, Agricultural Education	University of Idaho
Taylor Beard	MS Student, Crop and Soil Science	Washington State University
Ryan Boylan	MS Student, College of Natural Resources	University of Idaho
Jinshu (Jackie) Chi	PhD Student, Lab for Atmospheric Research	Washington State University
Sarah Waldo	PhD Student, Civil and Environmental Engineering	Washington State University
Chelsea Walsh	PhD Student, Entomology	University of Idaho
Kris Elliot	PhD Student, Agricultural Education	Oregon State University
Kirill Kostyanovsky	Postdoctoral Associate,	Washington State University
Tai McClellan	PhD Student, Crop and Soil Sciences	Washington State University
Hilary Donlon	PhD Student, Agricultural Economics	University of Idaho
Linda Urban	PhD Student, Instructional and Performance Technology	Boise State University
Tabitha Brown	PhD Student, Soil Science	Washington State University
Gerard Birkhauser	PhD Student, Crop and Soil Sciences	Washington State University
Sihan Li	PhD Student, Earth, Ocean and Atmospheric Sciences	Oregon State University
Isaac Madsen	PhD Student, Crop and Soil Sciences	Washington State University
Honliang Zhang	PhD Student, Agricultural and Resource Economics	Oregon State University
Ed Flathers	PhD Student, Forest Rangeland and Fire Sciences, Statistical Science	University of Idaho
Nevin Lawrence	PhD Student, Weed Science	Washington State University
Ashley Hammac	PhD Student, Soil Science	Washington State University
Chris Kelley	PhD Student, Geology	Washington State University
Harsimran Kaur	PhD Student, Crop and Soil Science	Washington State University
Iqbal Singh Aujla	MS Student, Crop and Soil Science	Washington State University
Jason Morrow	MS Student, Crop and Soil Science	Washington State University

Table 6.1.continued

Name	Position	Institution
Leigh Bernacchi	Postdoctoral Associate, Agricultural Economics and Rural Sociology	University of Idaho
Seth Thomas Davis	Postdoctoral Associate, Entomology	University of Idaho
Adam Bond	MS Student, Instructional and Performance Technology	Boise State University
Seth Wiggins	MS Student, Applied Economics	Oregon State University
Brad Stokes	MS Student, Entomology	University of Idaho
Paul Rhoades	MS Student, Entomology	University of Idaho
Phil Honzay	MS Student, Natural Resources	University of Idaho
Rachel Unger	PhD Student, Soil Science	Washington State University
Laurel Graves	Undergraduate Summer Intern	Washington State University
Tasha Sitz	Undergraduate Summer Intern	Oregon State University
Kelsey Burkum	Undergraduate Summer Intern	Oregon State University
Stacy Hatfield	Undergraduate Summer Intern	Oregon State University
Kayla Novak	Undergraduate Summer Intern	Oregon State University
Heather Baxter	Undergraduate Summer Intern	Washington State University
Ames Fowler	Undergraduate Summer Intern	University of Idaho
Brian Lach	Undergraduate Summer Intern	University of Idaho
Laura Hancock	Undergraduate Summer Intern	University of Idaho
Georgia Seyfried	Undergraduate Summer Intern	University of Idaho
Stephanie Jenck	Undergraduate Summer Intern	Washington State University
Skye Pauly	Undergraduate Summer Intern	Washington State University
2 individuals	REACCH Summer Teacher Workshop	High School Agriculture Teachers
4 individuals	REACCH Summer Teacher Workshop	High School Science Teachers

Table 6.2.
Section 1: Percentages are calculated with N=5.

Please Rate the Educational Value of the following activities:	Poor	Fair	Good	Excellent
Dr. Sanford Eigenbrode' s REACCH overview				100%
Cook Agronomy Tour			20%	80%
Parker Farm Tour			50%*	50%*
Dr. Eigenbrode and Johnson-Maynard's Critters in the Soil				100%

Please rate your agreement with the following statements.	Strongly Disagree	Disagree	Agree	Strongly Agree
I am interesting in attending a follow up workshop next summer				100%
The topics addressed at this workshop were important to me				100%
I will be utilizing the information presented in my classroom			20%	80%
I would recommend this workshop to a colleague				100%
I would like to communicate with REACHH scientists regarding curriculum between now and next summer				100%
I would like to communicate with other REACCH teachers regarding curriculum between now and next summer				100%

*N=4, one participant did not attend the Parker Farm Tour.

Section Two: Numbers in parentheses indicate frequency of comment. For example, 3 people commented that they will incorporate Soil Critters in their classrooms.

Which two components of the workshop will you most likely incorporate into your classroom?	
Soil Critters (3) Matrix of NASA satellite Water cycle extensions Tree cookies	Carbon Cycle (2) N20 given off by crops Adventure learning Flux towers
Which portions of the workshop did you feel was least valuable?	
Adventure Learning- neat idea but out of budget for most teachers I felt there was dead time in the presentations. Teachers will collect a bit of data, but want to try things quickly.	
Which portion of the workshop did you feel was most valuable?	
Hands on labs (4) Collaboration with ICE_NET	Dr. Abatzoglou' s Overview of Climate Using motivated grad students
What would you like to see added to this workshop in the future?	
A student component Elementary school teacher component Same format, different activities/topics More University lab time (study scientists)	

Year 3 Plan-of-Work

Graduate education. During Year 3 we will shift our attention to supporting graduate students while they complete their courses and research. This includes providing 1) tools for students to communicate via distance 2) workshops and webinars that result in the transfer of research and communication skills 3) a GIS/AEZ short course and 4) opportunities for students to connect to each other as well as REACCH faculty and staff. More specifically, trainings will be focused on data management (Feb. 2013) and providing background knowledge of agriculture in the study area (date to be determined).

A REACCH subcommittee has started meeting to draft the syllabus and plan dates for the GIS/AEZ short course that will be offered during Year 3 of the project. In terms of networking and building community across the project, students will gather during the summer field tour. Students will also give presentations and receive informal feedback on their research and interdisciplinary projects at the annual meeting.

Undergraduate education. Undergraduate education in Year 3 will focus on further refining the capstone course as well as the summer internship program ran in Year 2. We submitted a NSF-REU proposal focused on climate change science and both cross-disciplinary communication and communication with stakeholders. We were not successful this year, but will try again in Year 3. If successful, the NSF funding will allow us to train a larger number of undergraduates and help with recruitment (since we will be able to utilize the NSF-REU website to advertise our project). We will complete a summer internship program in 2013. We will solicit projects from faculty in January 2013 and start advertising in February. Students will be selected and invited to join the program by mid-April. Discussions of a potential cross-CAP undergraduate exchange have also been initiated with faculty from the Corn CAP. The exchange may take the form of 9-week-long exchange of a few students from each project, or a shorter experience aimed at increasing knowledge of agricultural systems or conducting a specific experiment. A third possibility includes building on the previous year, by sending a student that has already experienced research as part of one program to the other for a 9-week-period.

K-12. We will continue to work with teachers who attended our first annual teacher workshop held in Year 2 of the project. In addition, we will work towards expanding the number of teachers active in the project, especially from Oregon (teachers participating in Year 2 were from Idaho and Washington only). We designed a 2-hour workshop on methods of classifying soil and litter dwelling organisms applicable to the classroom (Jan. 30, 2013). New materials will be developed and a second summer workshop offered in Year 3. K-12 curriculum that mirrors the REACCH project is currently being developed in the form of a course (Ag 515) that can be used in its entirety or as select modules. A REACCH funded PhD education student is working with objective teams to develop content for Ag. 515. Once Ag. 515 is developed we will conduct focused workshops to pilot the newly created curriculum. We will also make connections with K-5 teachers and begin work on curriculum aimed at these grade levels. The results of our initial teacher survey and the teacher workshop in Year 2 will form the basis of a manuscript submitted for publication in Year 3

Objective 7, Extension Executive Summary

Leads: Chad Kruger, cekruger@wsu.edu, Steve Petrie, steven.petrie@oregonstate.edu

Team Members: Elizabeth Allen WSU, Tabitha Brown WSU, Sylvia Kantor WSU, Chad Kruger WSU, Steven Petrie OSU, Georgine Yorgey WSU, Tara Zimmerman WSU

Promoting scientifically-based agricultural responses to a complex challenge like climate change mitigation and adaptation necessitates a coordinated Extension strategy that addresses multiple stakeholder audiences with different information needs using different educational methods. The USDA NIFA funded Regional Approaches to Climate Change for Pacific Northwest Agriculture (REACCH PNA) Coordinated Agriculture Project includes an Extension Objective that targets educational programming to a variety of stakeholder groups using a combination of traditional, contemporary and experimental Extension methodologies focused on overcoming barriers to improved agricultural management. Our Extension Team utilizes a Stakeholder Advisory Committee (SAC) with broad representation from producers, producer organizations, allied industry, government agency, environmental services market interests, and environmental organizations to guide Extension needs assessment, programming and product development. The team employs traditional methodologies such as field days, producer workshops and Extension publications as well as contemporary methodologies such as webinars, video, and electronic media. In addition, the team will pioneer experimental extension methodologies and products such as smart phone applications, web-based forums and decision-support tools that utilize the REACCH Cyber-Infrastructure and Research Databases. REACCH graduate students are expected to participate in the development of innovative and experimental Extension products.

Figure 7.1. *Left*: REACCH Tour Participants learn from graduate student Tabitha Brown about site-specific nitrogen management; *Right*: Professor Brian Lamb demonstrates the Eddy Flux Tower system for monitoring field-scale trace-gas fluxes to REACCH Tour Participants (Photo Credit: Sylvia Kantor)

Years 1 and 2 Outputs

Extension activities for the team included: planning and coordinating the Stakeholder Advisory Committee Survey and Panel Discussion at the REACCH annual meetings; collaborating with colleagues on the development, review and delivery of introductory climate change educational curriculum (two webinar series, a ten-part narrative power-point, and one formal Extension publication); development, review and delivery of a 6-part webinar series on agriculture and climate change science in the Pacific Northwest; publishing fifteen lay-person articles for popular/industry/web publications; presenting six posters and twelve oral presentations (including three keynote addresses); completing one educational video; planning and hosting five "training" sessions specific to climate change Extension; organizing a panel discussion on collaboration between federally funded integrated climate change and agriculture projects in the PNW at the 3rd annual PNW Climate Conference; collaborating with Objective 8 in developing the REACCH web-site framework; collaborating with REACCH Objective 4 social scientists in the development of a producer needs assessment; developing and conducting a needs assessment for environmental and public policy stakeholders; served in a scientific advisory capacity to the Northwest Biocarbon Initiative; developed and coordinated a "precision ag" farmer work-group; developing a needs assessment for agricultural industry and ag professionals (to be conducted in 2013); piloted a "crowd-sourced video" strategy for developing multi-media extension products for REACCH; developed and submitted proposal for cereal crops and climate change eXtension CoP; conducting a search for a new Faculty Extension Specialist in dryland cropping systems and climate change; development of an Extension Manual on High Residue Farming Under Irrigation (expected completion in 2013); collaborating with a leading environmental organization on the development of an agricultural nitrogen offset protocol "road test" publication (expected completion in 2013); publishing ten Extension Enterprise Budgets to provide growers with the means to assess financial impacts of adopting new technology.

Much of the research-based science on agriculture and climate change focuses on a long-term time horizon. Consequently, many individual farmers have limited interest in and/or capacity to effect management changes or make investments that will likely only accrue value in the distant future. Therefore, in addition to serving traditional extension audiences, achieving desired adoption of improved management practices and climate preparedness necessitates that Extension methodologies focus on a broader set of "influencers" that will direct future investments in policy and industry development. The REACCH project established a Stakeholder Advisory Committee (SAC) comprised of individuals representing many of the "influencer" audiences for the future of PNW agriculture (see Appendix C).

A needs assessment survey of the REACCH SAC provided insight into the complex blend of approaches and methods necessary to successfully communicate with the diverse stakeholder audiences of the REACCH project. The needs assessment indicated the importance of using a broad range of peer-reviewed extension product types and an increasing emphasis on high speed, mobile ready web-based delivery platforms.

Table 7.1. Responses to evaluation question: *How would you best describe your affiliation in reference to your participation in this webinar?*

Which of the following best describes your affiliation?	
Ag Industry	35%
Carbon Market/Finance	6%
Conservation District/NRCS	12%
Environmental Group	6%
Farmer	18%

What types of project outputs are you or your organization most likely to read or use?	
Fact sheets	16%
Ag media stories (e.g. radio, newspaper)	14%
Newsletters (i.e. general project updates)	14%
Project progress reports	13%
Journal articles	12%
Popular media stories	11%
Technical reports	11%
Extension bulletins/manuals	9%

What modes of delivery are most useful to you or your organization?	
Web-based documents	26%
Print publications	24%
Webinars	20%
Announcement list serves	16%
Blog posts	6%
Discussion list serves	4%
Social media	2%
Videos	2%

How important is peer reviewed information to you or your organization?	
Not at all	0%
Somewhat	24%
Very	65%
Extremely	12%

How do you access the internet?	
Dial-up modem	0%
Moderate internet speed	7%
Hi-speed internet	52%
Smart-phone/mobile device	41%

Year 3 Plan-of-Work

The Extension Team will continue to develop specific, durable products (publications, presentations, etc.) and web content based on available research findings from the REACCH team and from previous USDA-funded projects such as Solutions to Environmental and Economic Problems (STEEP) and the Climate Friendly Farming Project. We will also accomplish the following activities: complete and analyze needs assessments for producers, agriculture industry/ag professionals, environmental/policy stakeholders; hire of Faculty Extension Specialist; complete Extension Manual for High Residue Farming Under Irrigation; complete agricultural nitrogen offset protocol "road test" publication; continue collaborations with multiple carbon market industry organizations to develop/refine agricultural offset protocols and carbon marketing opportunities; continue coordination of a "precision ag" farmer work-group; refine and expand the "crowd sourced video" extension product; administer initial REACCH Extension mini-grant program; enhance the scientific advisory process for the Northwest Biocarbon Initiative; provide support to REACCH graduate students in developing and producing Extension products; coordinate/organize grower/ag professional educational activities and training opportunities; identify, develop and pilot REACCH smart-phone apps with the Cyber-Infrastructure Team; coordinate with the Extension Team from the Corn CAP in the development of nationally relevant web content and curriculum on

climate change and cropping systems; coordinate with other regional research and extension projects on agriculture and climate change.

Figure 7.2. *Left:* OSU scientists Stephen Machado and Steve Petrie present data on the Pendleton Long-term Cropping Systems Research Trial to the REACCH Team and SAC at the First Annual REACCH Meeting. *Right:* USDA ARS Scientist Dave Huggins explains the role of crop rotation in carbon and nitrogen cycling on the REACCH Summer Tour (Photo Credit: Sylvia Kantor)

Supplemental Information 1: REACCH Stakeholder Advisory Committee Poll (February 2012)

Members of the REACCH Stakeholder Advisory Committee (SAC) were polled regarding information access and interest in climate change topics in February 2012. Polling took place in person at the REACCH Annual Meeting in Pendleton, OR and online several weeks following the meeting. The combined response rate of 17 represents 49% of the total SAC membership. The range of reported affiliations include: ag industry (6), carbon market/finance (1), conservation district/NRCS (2), environmental group (1), farmer (3), government agency (1), grower organization (1), teacher (1), and tribe (1).

Information Access and Timing

Responses indicate that the types of outputs stakeholder organizations are most likely to use are fact sheets, ag media stories (e.g. radio, newspaper), newsletters (i.e. general project updates), followed by project progress reports, journal articles, popular media stories, technical reports, and extension bulletins/manuals (in that order). Participants indicated that the top three modes of information delivery they find most useful are web-based documents, print publications, webinars and list serves. Low on their lists were blogs, discussion list serves, social media, video, and Spanish language materials. It should be noted that the survey did not ask about other modes of delivery such as field days or in person workshops.

A majority (13) indicated that peer reviewed information was *very* important to them. Preferred document length varied with most (7) stating a preference for brief (2-3 pages) documents, but some (4) preferred shorter (less than one page) and some (5) moderately long documents (4-10 pages). One person indicated a preference for in-depth

documents (>10 pages). None of the participants use dial up modem to access the internet. All use moderate to high speed internet. As many as 41% (12) said they use a smart phone or mobile device to access the internet. A clear preference for monthly to quarterly contact regarding REACCH results was stated by a majority. However, some indicated a preference for weekly contact (2) and some expressed no preference at all (2). For one person contact twice a year was sufficient contact and for another once a year was enough.

Climate Change Topics
A majority of stakeholders (11) indicated interest in both mitigation and adaptation aspects of climate change. A few (3) expressed stronger interest in impacts and adaptation and a couple (2) showed stronger interest in mitigation. The top three mitigation topics of interest to stakeholders were precision fertilizer application (13), conservation tillage (12), and soil carbon sequestration (11). The topic of alternative crops follows closely behind these three topics (9). However, carbon credits (6), carbon policy/regulation (6), green payments (5), carbon footprints/life cycle assessment (5), energy use efficiency (5), and organically-derived soil amendments (e.g. manure, biosolids) (5) were of interest but did not rank as high. The top two specific projected climate change impacts of most interest to stakeholders were crop yield (14) and water supply for dryland cropping systems (11). In the middle range, were diseases (8), regulatory environment (8), weeds (7), water supply for irrigation (7), and insect pests (6), beneficial organisms (5) and Agroecological Zone shifts (5). Of least interest was crop insurance (3).

Supplemental Information 2: Climate Impacts and PNW Agriculture Webinar Evaluation Summary

The webinar titled, *What Do We Currently Know about the Impacts of Climate Change on Pacific Northwest Cropland Agriculture?* was presented live on November 1, 2012 to an audience of over 75 people. It is part of the webinar series, **Pacific Northwest Agriculture and Climate Change**, produced by the WSU Center for Sustaining Agriculture and Natural Resources (CSANR). Based on the fact that a changing climate will likely affect each of the highly diverse agricultural systems found in the Pacific Northwest, from extensive rain-fed cereal grain farming systems to intensive horticultural production systems dependent on irrigation, this webinar, presented by CSANR Director, Chad Kruger, explored how early research findings indicate that climate change may affect crop production in the Pacific Northwest. The webinar highlighted some of the ongoing research in the region that will provide additional scientific insight into this question over the next several years.

The webinar was recorded and archived for asynchronous viewing and as of November 20 had received 130 views, in addition to the live audience. The archived presentation can be found online at: http://csanr.wsu.edu/pages/AgClimateWebinars.

An evaluation was presented to participants at the end of the live presentation and garnered 36 responses (a rate of ~48% of the participants who viewed the live webinar).

Based on the evaluation responses, the composition of the audience was varied with a significant portion identifying their affiliation as University personnel (Table 1).

Table 7.1. Responses to evaluation question: *How would you best describe your affiliation in reference to your participation in this webinar?*

Affiliation	Response %	Count
Ag industry	8.3%	3
University professor, researcher, instructor	25.0%	9
University extension personnel	22.2%	8
University personnel - other	8.3%	3
Extension volunteers (e.g. Master Gardener, 4-H volunteer, etc.)	11.1%	4
Student	2.8%	1
Grower/producer	16.7%	6
County/state/federal agency personnel	5.6%	2
Non-profit organization personnel	2.8%	1
Tribe	0.0%	0
Media	0.0%	0
Interested member of the public	5.6%	2
Other (please specify)	5.6%	2

When asked to rate their own understanding as: non-existent, minimal, moderate, or considerable, participants indicated a significant increase in understanding of climate impacts related to all four main learning objectives listed below(Table 2). The greatest gain in understanding was for the topic: *variability of research results associated with global climate models and emissions scenarios*.

Table 7.2. Responses to evaluation question rating understanding of learning objectives before and after webinar (moderate and considerable ratings combined).

Learning Objective Topic	% reporting moderate or considerable understanding BEFORE webinar	% reporting moderate or considerable understanding AFTER webinar	Increase
Temperature and precipitation	61	94	33
Atmospheric CO2	50	92	42
Water supply and demand	50	92	42
Variability of research results associated with global climate models and emissions scenarios	40	89	49

A majority of those who responded to the survey rated the webinar as good or excellent in providing information that was useful (78%), timely (89%), research-based (97%), unbiased (100%) and easy to understand (83%).

The webinar in the series, on November 29, 2012, focuses on Agricultural Greenhouse Gas Emissions in the Pacific Northwest. Other webinar topics include soil carbon (January, 2012), nitrogen management, organic soil amendments, and impacts on pests and disease.

Objective 8, Cyberinfrastructure Executive Summary
Lead: Paul Gessler, paulg@uidaho.edu

The goal of Objective 8 is to develop the regional capacity for continued long-term research, education, and extension efforts - thru the planning and implementing of cyberinfrastructure and data management support for all elements of the project.

Team Members: Dianne Daley Laursen UI, Sanford Eigenbrode UI, Ed Flathers UI, Stephen Fricke UI, Greg Gollberg UI, Rick Rupp WSU, Erich Seamon UI, Linda Tedrow UI
Web team: Paul Gessler UI, Jennifer Hinds UI, Jodi Johnson-Maynard UI, Chad Kruger WSU, Erich Seamon UI, Kat Wolf UI, JD Wulfhorst UI

Objective Team 8 has been working extensively over the past year to implement systems and policy that will lay the foundation for REACCH's overall cyberinfrastructure and data management foundation. From an organizational perspective, several teams have been formed and have been meeting regularly to drive efforts in areas of web development, systems implementation, programming, data implementation, and policy. In addition, several students and additional resources have been added to the Objective Team 8 group helping to spur on efforts in the aforementioned areas.

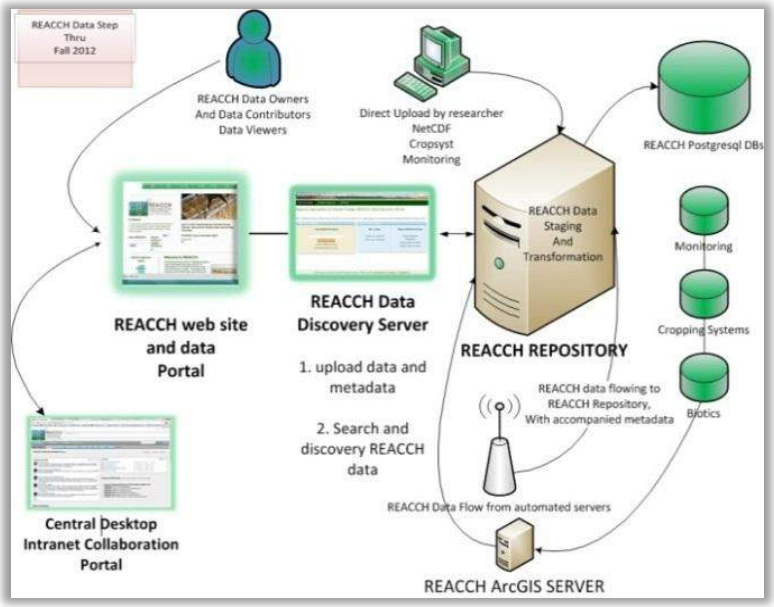

Figure 8.1. REACCH Overall Cyberinfrastructure

We have continued to work with our partners at the University of Idaho's Northwest Knowledge Network (NKN www.northwestknowledge.net) and Inside Idaho (www.insideidaho.org) to leverage virtual systems and geospatial processing, and have been designing a structure for user access to policy, data, and analytical tools via our http://www.reacchpna.org web site. In addition, we are finishing a re-design of www.reacchpna.organd expect to introduce this new design in February 2013 at our 2nd annual REACCH meeting in Portland, OR. Objective Team 8 additionally has developed a REACCH data access policy that is now in place and is accessible on our internal portal

Years 1 and 2 Outputs

A REACCH data management policy, collaborative institutional MOU, and web management protocol documents were all finalized during Year 2. The CI and data management team met weekly to continuously update tasks and priorities. These are documented weekly by the Data Manager reports. The REACCH web site was launched and has been under management by the Data Manager and project staff. Server and software access has been developed via collaboration with the Northwest Knowledge Network for both the web site and data portal management. Training was conducted for use of the Concrete5 content management system and project personnel began managing and updating the web site. The web team met monthly to design and implement the web site. Specific information is now online regarding REACCH public announcements, a project director's update, objective team developments, and both educational and project output resources for publications and presentations (reacchpna.org). The web site has also been used to organize and communicate information for both the annual meeting and summer field tour. It is also serving as an archive location for presentations from all REACCH related meetings in complement to the Central Desktop project management software. A web applications programmer and PhD. student were hired to develop web applications for interactive analysis and use of REACCH and regional datasets including downscaled climate scenario projections. A programming team meeting is occurring weekly to discuss and plan application development and implementation.

Figure 8.2. reacchpna.org Home Page

The REACCH data systems were brought online during Year 2, including our REACCH spatial database server (ArcGIS and PostgresQL) and our prototype metadata and data discovery server, running on Linux. In addition, several programming modules have been developed in Python that will enable the querying and analysis of REACCH collected data. Integrated with our REACCH web site – these three systems will serve as the foundation for data access, analysis, and uploading. Complementing the aforementioned systems development, a metadata standard was determined (ISO19115), and is in the process of being implemented.

The Data Manager and Objective 8 lead gave presentations and presented a poster at the annual meeting and have given five additional presentations at regional data management meetings. The objective lead also serves on the Northwest Knowledge Network advisory team and is leading the development of an Idaho strategic plan for cyberinfrastructure development to support research. We also sponsored the visit of ISO Metadata standard expert to advise on developing standards for interoperability.

Year 3 Plan-of-Work

2013 will be a very busy year for our Objective Team 8 efforts, with a much anticipated extension of our systems to REACCH team members for data uploading, metadata tagging, and analysis. We have been working extensively to develop a strong approach that will facilitate robust capabilities of information interaction between researchers, teams and other members of the REACCH project. The laying of this foundation has taken time, in terms of the strategy, operational structure, and the interaction mechanisms, but we feel that these initial efforts will pay off in the long term, as it relates to information interaction and analysis for scientific research.

The REACCH data manager and CI Team will continue to meet weekly to review tasks and prioritize use of CI resources to support the project. During Year 2 many of the foundational personnel, hardware, and software elements have gone into place for implementation of the REACCH web site and data portal. The portal will provide tools and access to resources to help researchers and the project teams manage, archive and explore their datasets. Drafts have been developed for a REACCH data management policy and memorandum of understanding (MOU) between collaborating institutions. These build on standards under development by NSF and other national efforts relating to scientific data management and interoperability. These will be finalized and we will continue to evaluate if additional policies are required to assist the formalization of both short and long-term data management. The institutional MOU will also serve as a vehicle for encouraging collaborative investment and leveraging with numerous efforts involved in data management across institutions and around the region.

The REACCH public web site (https://www.reacchpna.org) was launched during Year 2. During Year 3 the web team will continue to meet monthly to help refine web site management protocols and priorities. Training will continue on use of the open source Concrete5 web content management system so that research teams and project leadership can update and collaboratively manage the web site and connected data portal. A web

site management working document was developed, and we will continue to use our cyberinfrastructure funds to draw on external support for web design. The Data Manager (Seamon) and Objective 8 Team lead (Gessler) are involved in both regional (e.g. Northwest Knowledge Network, Idaho Regional Optical Network) and national efforts (e.g. NSF DataONE, NSF Earthcube, LTER, NEON etc.) developing resources and pathways for interactive data management and data integration to support ongoing and new science. In addition to the web site development and launch during Year 2, REACCH Facebook, Twitter and YouTube services have been activated and linked to the reacchpna.org web site, and will be used during Year 3 for communications with stakeholders and the public.

The Data Manager and Objective 8 lead will continue to meet with each team to review ongoing tasks and processes for archiving and accessing data. An applications programmer and Ph.D. student, hired during Year 2, will roll out preliminary web application tools that are being constructed in a modular way so we can continue to build information access for a variety of constituents (e.g. K-12 curricula, farmers, policy makers, researchers). We will also draw more actively on educational resources provided by the UI Library and NKN collaborators regarding metadata formats, interoperability standards, and visual analytic tools for data integration. We will test network access speeds and interoperability between institutions using the Idaho Regional Optical Network backbone and develop cloud capabilities for both data storage and processing.

Agroecological Executive Summary

Lead: Dave Huggins, dhuggins@wsu.edu

The goal of the AEZ Objective Team is to address climate change effects with a transdisciplinary research focus to enable researchers, stakeholders, students, the public, and policymakers to acquire a more holistic understanding of the interrelationships of agriculture and climate change.

Team Members: John Abatzoglou UI, Gerard Birkhauser WSU, David Brown WSU, Tabitha Brown WSU, Sanford Eigenbrode UI, Paul Gessler UI, Dave Huggins USDA-ARS, Harsimran Kaur WSU, Kirill Kostyanovsky WSU, Jason Morrow WSU, Bill Pan WSU, Jeff Perkins WSU, Rick Rupp WSU, Dave Uberuaga WSU, Rachel Unger WSU, Von Walden UI

AEZs are typically used as a descriptive tool to assess the spatial distribution of crop-relevant resources, their capabilities, and the potential for future uses as part of strategic planning. We are using AEZ's to: 1) provide baseline biophysical and socioeconomic characterization of current agricultural systems; 2) incorporate information from climate models, economic models, pest disease and weed vulnerabilities and other data sources to pursue a transdisciplinary examination of climate-driven AEZ futures; 3) develop AEZ-relevant mitigation and adaptation strategies; and 4) track changes in climate-related agricultural factors over time.

The key deliverables for the AEZ Team are: identify and geographically delineate major AEZ's based on regional cropland use data; develop biophysical and socioeconomic data layers that characterize AEZ's; and project shifts in AEZ's and their boundaries under different climate change scenarios

The key benefits of the AEZ concept are: provide geospatial data layers to aid regional assessment of agricultural mitigation and adaptation strategies: biofuels, alternative crops, crop intensification, genetic advancements, residue harvest, CRP, soil C sequestration, GHG production, precision ag; providing a regional framework for future projections: global climate change scenarios, shifts in production practices; and track regional agricultural sustainability factors: economic, social and biophysical.

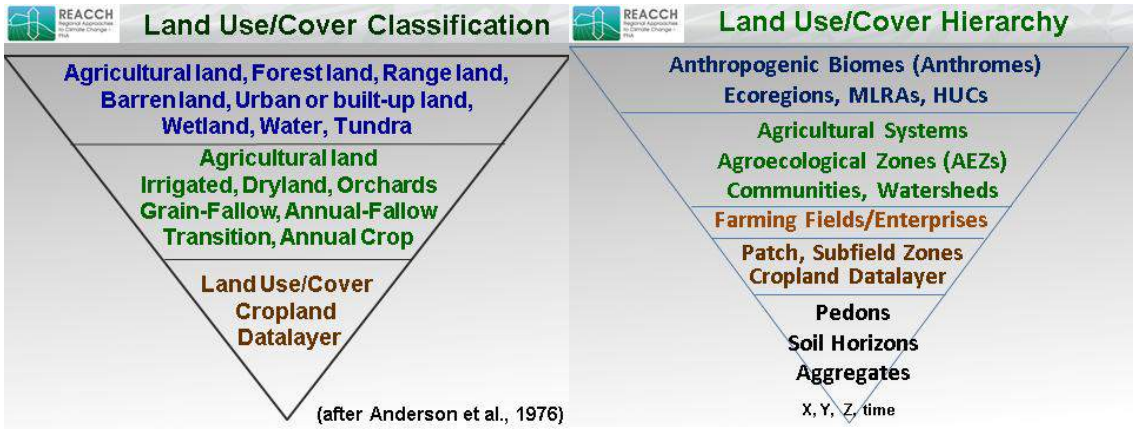

Figure 9a.1. Land use/cover hierarchy and classification for development of spatio-temporal integration and development of anthropogenic biomes (anthromes) and AEZs.

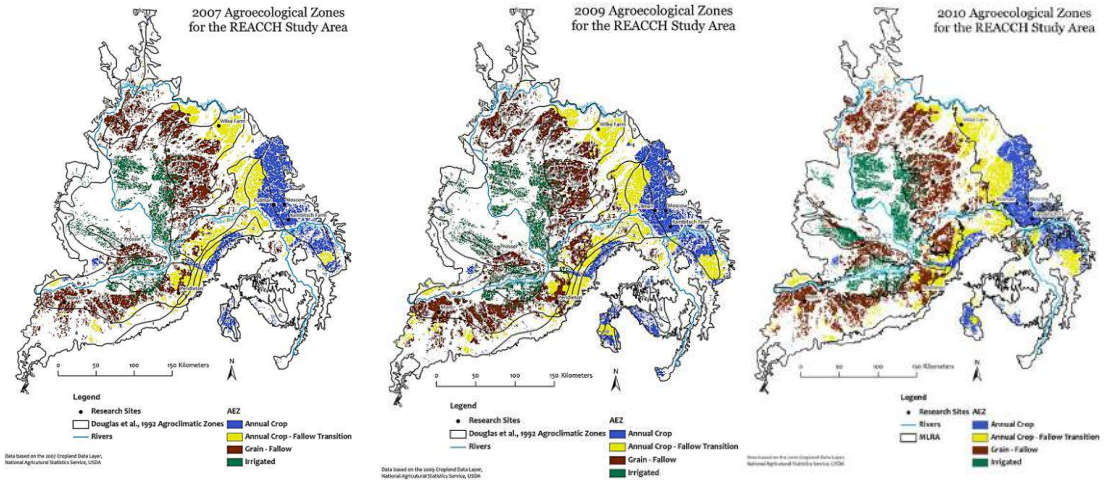

Figure 9a.2. Four major Agroecological Zones (Annual Crop, Annual Crop-Fallow Transition, Grain-Fallow and Irrigated) for the REACCH study area; years 2007, 2009 and 2010.

Years 1 and 2 Outputs

Research activities for the team included:

- The Major Land Use Areas (MLRA) comprising MLRA 7 (Columbia Basin), 8 (Columbia Plateau) and 9 (Palouse and Nez Perce Prairies) and a small portion of 43A (Northern Rocky Mountains) were used to define the REACCH study region in the inland Pacific Northwest.
- The National Agricultural Statistical Service (NASS) Cropland Data layer for the years 2007, 2008, 2009, 2010 and 2011 were accessed. These data layers classify land use/cover at a 57- or 30-m resolution and provide annual spatial coverage of land use/cover for the REACCH study area.
- The NASS cropland data layer was used to define major land use/cover classifications (e.g. agriculture, range, forestry, urban, water), develop a hierarchal land use/cover classification and define Anthropogenic Biomes (Anthromes) that include a mosaic of managed ecosystem land use/cover (Fig. 9a.1).
- The agricultural land use/cover was subdivided and classified into four major agricultural systems: irrigated, grain-fallow, annual-fallow transition and annual cropping.
- Baseline (2007) areas of land use/cover by various crops in the REACCH region were established and compared to other years (Fig. 9a.3).
- The soil classification data layer at the suborder level was identified and used in characterization of the REACCH study area.
- Climate data layers (annual precipitation and temperature) for characterization of the REACCH study area were obtained courtesy of the Parameter-elevation Regressions on Independent Slopes Model (PRISM) Climate Group, Oregon State University.

- Agro-climatic zones defined by Douglas et al. (1992) and Level IV Ecoregions developed by the EPA were identified as key classification schemes currently in use within the Pacific Northwest region.

Results were presented at eight presentations for stakeholders and at professional meetings (see Appendix A). In the remainder of Year 2, the team plans to submit one manuscript that will present concepts and methodology for defining dynamic anthromes for the Pacific Northwest REACCH region.

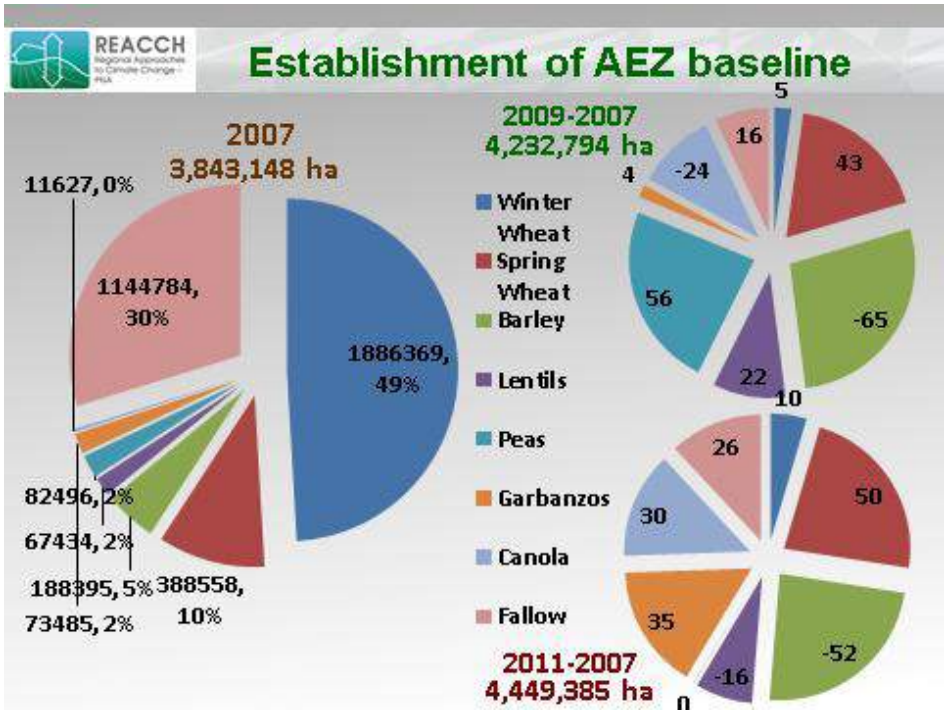

Figure 9a.3. Summary of major crops grown in REACCH agricultural regions and changes from 2007 to 2009 and 2011.

Year 3 Plan-of-Work

The AEZ Team will continue to develop the concept of AEZ and its application to enable researchers, stakeholders, students, the public, and policymakers to acquire a more holistic understanding of the interrelationships of agriculture and climate change. During Year 3 we plan to: 1) complete assembly of REACCH study area characterization data layers including biophysical and socioeconomic variables from Objective 1 and 2 activities; 2) assess how well biophysical and socioeconomic variables explain the spatial distribution of AEZs using multivariate analysis; 3) submit a manuscript on prediction of current AEZs using biophysical and socioeconomic variables; 4) explore use of predictor variables for representing future agroecological conditions including biophysical and socioeconomic responses to climate change; and 5) interact with REACCH graduate students and faculty in the development and implementation of AEZ/GIS short course.

Life Cycle Analysis Executive Summary

Lead: Claudio Stöckle, stockle@wsu.edu

This cross-cutting theme of the project is designed to integrate information from cropping systems modeling and alternative production trials to generate on-farm Life Cycle Assessment for current and projected cropping systems within the study region.

Team members: John Abatzaglou UI, Bryan Carlson WSU, Dave Huggins USDA-ARS, Tina Karimi WSU, Harsiman Kaur WSU, Kirill Kostyanovsky WSU, Roger Nelson WSU, Rick Rupp WSU, Claudio Stockle WSU, Usama Zaher WSU

The US inland Pacific Northwest region has been divided in 4 agro-ecological zones (AEZ): low, intermediate and high precipitation zones, and an irrigated zone. Typical cropping systems in each AEZ (Table 9b.1) are being evaluated during Years 2 and 3 of this project. Alternative cropping systems and management will be considered later.

Table 9b.1. Baseline crop rotation for each agro-ecological zone

AEZ	Rainfall	Tillage Intensity	Crop Rotation
1	High	Conventional	WW – SW - SP
2	Intermediate	Conventional	WW – SW - SF
3	Low	Conventional	WW - SF
4	Irrigated	Conventional	P – WW – C

WW = winter wheat; SW = spring wheat; SP = spring peas; P = potato; C = grain corn; SF = summer fallow.

Regional assessment of yields and GHG emissions for historic and future climatic conditions are conducted using CropSyst, a cropping systems model. Gridded historic weather data (4x4 km) for the period 1979 – 2010, future weather projections by 9 general circulation models (GCM) and two representative concentration pathways (RCP) of atmospheric CO_2 concentrations (4.5 and 8.5) are available, for a total of 18 future scenarios.

Results for AEZ 3, based on one GCM only and RCP8.5, suggest WW yield gains in most of the region (Fig. 9b.1) for the 2030s (2016-2045), further increasing for the 2050s (2036-2065) due to the beneficial effect of elevated CO_2 on crop growth and water-use efficiency that compensates for warming effects. In the case of N_2O emissions, a potent greenhouse gas, a small decrease is projected if N fertilization remains unchanged while yields increase, with a fraction of the area showing increased emissions. Soil carbon losses (not shown) may increase due to warming, despite the larger biomass and residue production. All results may change once all the 18 projections are analyzed.

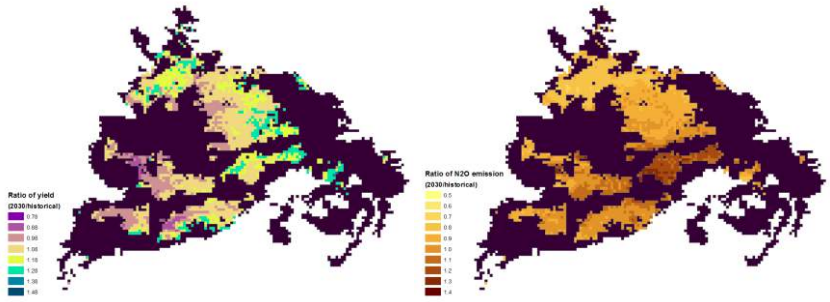

Figure 9b.1. Regional ratios of future (2030s) to historic yields and N_2O

Year 1 and 2 Outputs

We have extended our computer simulation efforts from a desktop PC-based regional analysis to a new high-performance computer cluster consisting of 168 processors with 6 cores each. To make use of this new facility at Washington State University, our MS Windows model has been ported to Linux, and protocols were developed for scenario generation, input of model parameters, simulation control, and output generation. This development will allow LCA analyses to include an array of weather projection scenarios, thus better accounting for climate model uncertainties, and will permit a better interaction of our regional work with the global assessment of climate change impacts on agriculture and climate change mitigation. The core of this interaction is taking place within AgMIP. Members of the LCA Team have participated in two global AgMIP workshops and in a workshop to discuss the improvement of crop models and exchange experimental data on carbon, temperature and water effects on crop productivity (September 2012). We will also participate in the third AgMIP global workshop in October 2012. We have participated in a comparison of wheat models applied to conditions in several world locations (Argentina, Australia, India, and the Netherlands), resulting in a manuscript under preparation. We have contributed to writing the section on wheat production for the National Assessment of Climate Change, which will be enhanced to produce a peer-reviewed review article. Within the context of these activities and through additional cooperative work with visiting researchers from Spain and Germany (4 visitors), a few improvements to CropSyst, our main cropping systems simulation tool, have been implemented.

Because the number of scenarios to be evaluated over the study region has increased dramatically due to the increased number of weather projections and cropping systems, significant efforts have been invested to transfer CropSyst simulation capabilities from a Windows-based platform to a Linux-based platform. A complex software program was developed to allow the implementation of regional simulations using the new centralized Washington State University high-performance computer cluster facility, significantly decreasing the time required to perform simulation runs and analyze output results. At this time, based on the reliability of GCM-based projections, the REACCH Climate Modeling Team is recommending the use of 9 GCM projections, hoping to include a couple more in the future. In addition, two RCP (Representative Concentration Pathway) scenarios (4.5 and 8.5), representing future atmospheric CO_2 concentrations and their effect on global warming, will be considered for a minimum total of 18 weather projections. By the end of the second year, the development of LCA methodologies and analytical approaches were completed and tested for a baseline rotation in one of the four agro-ecological zones (AEZs) in the REACCH study area. This approach was applied to gridded (4x4 km, over 4,500 cells for the entire study region) historical weather (1979-2010) and one GCM projection/RCP combination for the period 2010-2065. For the latter, simulations outputs were tallied for 30 years centered on 2030 and 2050, evaluating changes in crop yield, water use, nitrogen and carbon budgets, and greenhouse gas emissions. For carbon budgets, 120 years previous to 1979 were simulated to equilibrate soil carbon stocks with historical crop rotation residue inputs.

Year 3 Plan of Work

During Year 3, scenario generation and simulation runs will be expanded to include baseline rotations in the four AEZs and 18 weather projections. LCA analyses and changes in budgets for C, N, and water will be completed by the first half of the year. During the second half of Year 3 and early Year 4, the scenario generation, simulation runs, and LCA analyses will be applied to compare conventional tillage and reduced and zero tillage scenarios for the current crop rotations and the 18 weather projections. Additional scenarios including new crops and modified management practices will be considered in future years as they are prescribed by the Cropping Systems Team. The parameterization of all simulation runs will consider the current progress on experimental work and data collection within the project. As additional information for model parameterization and verification becomes available in subsequent years, model improvements will be implemented and new simulations performed to update LCA analysis interpretation and conclusions.

Other activities in Year 3 will include the parameter optimization of a N_2O emission model based on experimental data whose collection started in Year 2 and will be completed early on Year 3. The optimization will be done using a fraction of collected data, with the remainder reserved to conduct a verification of the model. In addition, a database of historical weather (1979-2010) for the REACCH study region, prepared with the assistance of a weather data generator using the existing network of weather observations, will be compared with the gridded historical weather prepared by the Climate Modeling Team. Regional comparisons using both sets of weather will be conducted to gain a better understanding of the strengths and weaknesses of gridded weather data downscaled from regional GCM projections. Finally, involvement on the activities of the global AgMIP (Agricultural Models Inter-comparison and Improvement Project) project will continue during Year 3. This is a very important project that provides a global perspective on the use of climate and cropping system models to inform the Intergovernmental Panel on Climate Change (IPCC), the leading international body for the assessment of climate change, and the general public of the potential impacts of climate change on agriculture in the US and around the world.

In addition to yields, new project outputs include regional analyses of changes in carbon footprint, expressed as Mg CO_2 equivalent/ha/year, and calculated as the sum of changes in soil organic carbon (SOC, positive for gain and negative for loss of SOC), N_2O emissions (negative quantity), and direct and indirect emissions associated with crop inputs and management (negative quantity). Fig. 9b.2 shows the changes in carbon footprint for the same set of simulation runs included in Fig. 9b.1 (only for one out of 18 projection scenarios).

"There is a trend to an increase in the regional carbon footprint, which is mainly a result of an acceleration of SOC oxidation (loss to CO_2) due to warming, despite an increase in crop yields and residue production."

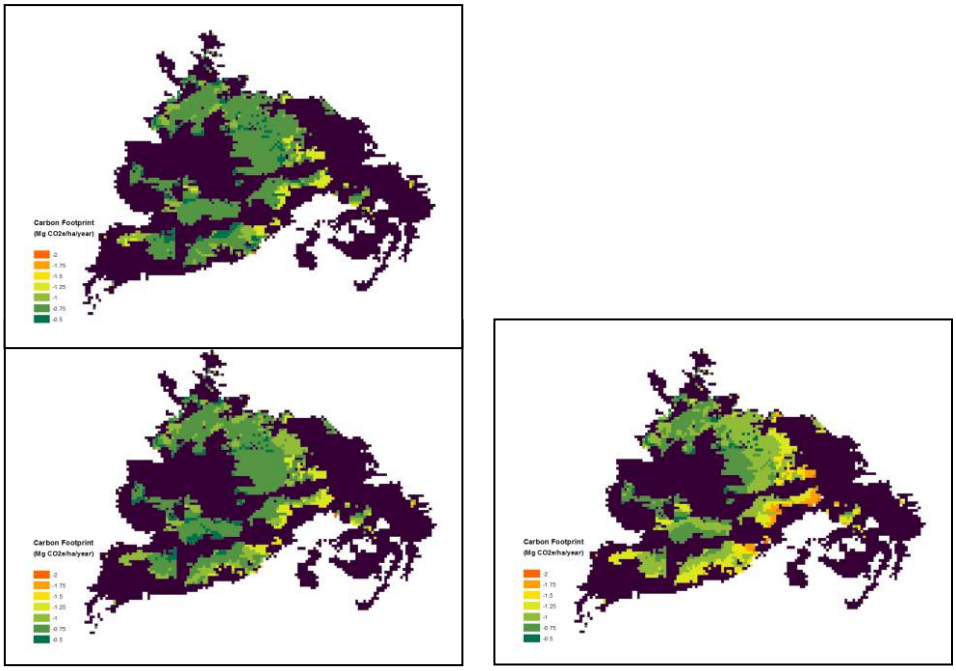

Figure 9b.2. Regional carbon footprint (Mg CO_{2e}/ha/year), average of 30 years of historic (top), 2030s (bottom left), and 2050s (bottom right) weather, for a winter wheat-summer fallow system in AEZ 3. Results correspond to one projection scenario out of 18 being evaluated.

Project Management Executive Summary

Leads: Sanford Eigenbrode Project Director, *sanforde@uidaho.edu*
Dianne Daley Laursen Project Manager, *diannedl@uidaho.edu*

Project Management is designed to facilitate communication, ensure transdisciplinary integration and thematic focus, and allow the effective integration of the research, extension and education components of the project. Our goal is to coordinate these activities seamlessly to allow participants to focus on the research, extension and education activities essential for the success of REACCH.

REACCH-PNA is a large, complex project spanning three states, four institutions, more than 12 academic departments and engaging the efforts of 224 scientists, staff, students, collaborators and stakeholders. Our website http://www.reacchpna.org and a quarterly newsletter the *OutREACCH*, were launched this past year to facilitate external stakeholder communication. Internal communication was enhanced through improved access to Central Desktop®, an internal collaboration intranet site; In Years 1 and 2, 42 semi regular project wide integration meetings, and in Year 2 weekly virtual watercooler session (open forum discussion forums) one for all project team members and one targeted to REACCH students.

The project has hosted four project conferences, and one summer field tour. We co-sponsored the NW Climate Science Conference and the *Interdisciplinary Climate Change Spring 2012 Seminar Series* at the University of Idaho. We participated in numerous collaborator seminars, conferences and panel presentations locally, regionally and nationally to stakeholder organizations and other lay audiences (see Appendix A). The Project Management Team is developing partners and looking at funding opportunities for continued scientific research, education and Extension outreach beyond the five year life of the REACCH grant. We are in the beginning stages of planning for an international conference in 2015.

Figure 9c.1. The OutREACCH is a quarterly newsletter for project stakeholders, team members and collaborators to highlight current events and research projects. Issues for 2012 are available on-line at: http://www.reacchpna.org/whatsnew/newsletters/

Year 1 and 2 Outputs

REACCH personnel were hired including the Project Manager, Environmental Data Manager, Education Coordinator; and Programmer. Interviews were completed and offers made for the REACCH Extension Specialist (see REACCH organizational chart). All graduate students and post docs were recruited (with the exception of one remaining PhD student in climate science at UI). The Scientific Advisory Panel (SAP) consisting of senior professionals representing key dimensions of the project and Stakeholder Advisory Committee (SAC), comprised of representatives from producers, agri-business, policy makers, consultants, NGO's, state and federal agencies, commodities and citizen groups were recruited and invited to be interactive members of the REACCH team. In total, 217 people including researchers, staff, technicians, students, stakeholders and others participate in REACCH in some way (see Appendix C).

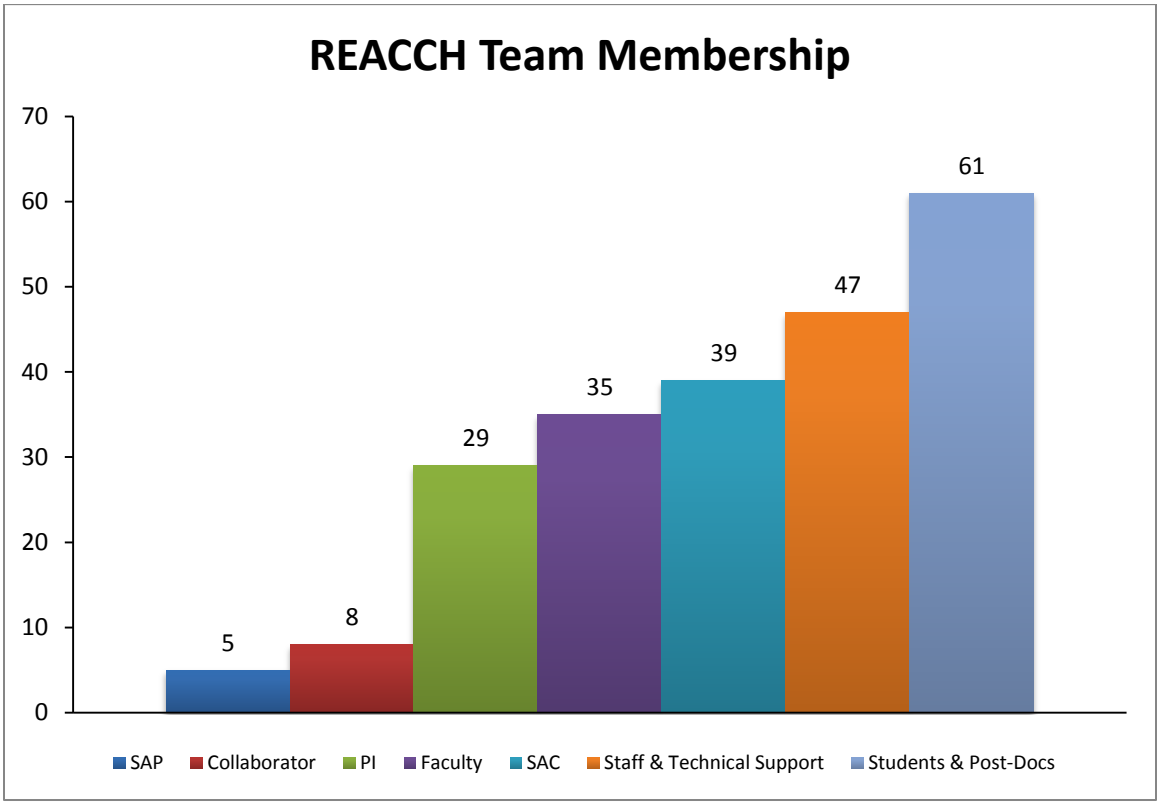

Figure 9c.2. 2012 REACCH Team Membership

Face to face time on a large complex project is invaluable. Project wide events held include: a Planning Meeting in February 2011, a Launch Meeting in May 2011, our first annual meeting in February 2012, a summer field tour in June 2012, an all student retreat in September 2012, and our second annual meeting in February 2013. In Year 1, 24 biweekly leadership team meetings were held, with all team members invited to participate. Policy, standard operating procedures, and objective team updates were discussed. In our second year, weekly integration meetings were held where invited guests and team members gave presentations on their research presenting outcomes, challenges, integration possibilities and future direction.

Figure 9c.3. REACCH Stakeholder Advisory Committee members at the first annual REACCH meeting

Internal and external communication has been enhanced through the use of Central Desktop® (CD), (http://www.centraldesktop.com) an on-line collaboration tool for all elements of internal project coordination within and between Project Management, objective team members, students and affiliated staff and researchers. In Year 2 all graduate students were given access to CD. Our website, http://www.reacchpna.org, targeting external audiences was launched. The *OutREACCH*, a quarterly newsletter for stakeholders was initiated. Three editions have been published to date (http://www.reacchpna.org/whatsnew/newsletters/).

A draft Service Level Agreement has been initiated with the Northwest Knowledge Network for multiple facets of date management, storage and accessibility. The following standard operation procedures have been adopted: authorship guidelines, a Citation Style Guide, protocols for CD use, templates for posters and presentations, a REACCH logo and print material guidelines , cross-project sampling protocols, Data Management Policy, and budget and administrative practices institutionalized.

REACCH has been a partner on numerous grant proposals across the region (see Appendix D) and thus has the potential impact for increasing the research capacity of the

region. REACCH has enhanced the capabilities of numerous ongoing and newly initiated agriculture and climate change programs (see Appendix D). The WSU Cook Agronomy Farm was selected by the USFDA-ARS as one of the ten initial Long-Term Agroecological Research (LTAR) sites with the support of REACCH.

Project Outputs to Date

There have been 27 articles in the Popular Press in the first two years of the grant (see Appendix A) in local and University newspapers and magazines, in the Alaska Airlines magazine in the Idaho Business Review, and in Capital Press among others. Additionally 205 presentations were made to stakeholder audiences (see Appendix A) REACCH cosponsored to participated in the NW Climate Science Conference in October 2012 http://pnwclimateconference.org/, sponsored the *Interdisciplinary Climate Change Spring 2012 Seminar Series* at the University of Idaho https://sites.google.com/site/interdisciplinaryclimatechange , participated in "Carbon Nation" in November 2011 at WSU, the 11th Annual Distinguished American Indian Speakers Series at the University of Idaho in October, 2011, and the NIFA Projects Director Meeting at the Tri-Societies meeting in Cincinnati, OH in October 2012. REAACH presented at both the PINEMAP and Sustainable Corn climate change CAPS annual meetings in 2012.

Year 3-Plan of-Work

The Project Management team will continue to plan and implement project-wide meetings such as the Year 3 annual conference (proposed location Coeur D'Alene, ID), the REACCH summer field tour for stakeholders and all REACCH team members and student retreats/training events. We are in the initial planning stages for an international conference on semi-arid areas in annual cereal production to be held in 2015. We will continue to look for opportunities to co-sponsor other events such as the NW Climate Science Annual Meeting to be held in Vancouver, British Columbia, Seattle or Portland in October 2013. REACCH will host guest speakers, seminars and webinars in the Tri-state area.

Project integration enhancement will continue through regularly scheduled project-wide integration virtual meetings weekly or bi-weekly that are open to all team members. Project members or invited guests give presentations that spur discussion on research integration needs, challenges and opportunities, with future action steps identified to increase, integration, knowledge and relevance of the project. The REACCH Extension Specialist (search in final stages of completion in February 2013) will be on board and working across all aspects of the project.

In addition to weekly integration meetings, project communication will continue to be enhanced through the use of virtual communication tools, web and print. The OutREACCH is a quarterly newsletter sent to all stakeholders, member and partners In Year 3 we will more fully implement our communication on social media, Facebook, Twitter, You Tube and smart phone applications. Web page content

management will improve. Weekly watercoolers (virtual meetings with no set agenda that provide opportunities for open discussion on any topic) will continue for researchers and students. REACCH graduate student use of Central Desktop®, an intra-net project management site, will increase cross project communication. Media opportunities and lay audience presentations will be pursued to broaden the general public knowledge of REACCH work.

The Toolbox Project, www.cals.uidaho/toolbox/, sponsors workshops and other activities that explore the philosophical dimensions of collaborating to further enhance project integration. In Year 3, REACCH team members will explore developing a customized module of Toolbox for the project.

The broader context of REACCH includes the widely recognized need for long-term agricultural projects that can address processes that span decades including climate change (Robertson et al, 2008). We are initializing discussions for planning the continuation of aspects of the REACCH project beyond our current five year grant. Additional funding sources are being pursued. A retreat will be held in Year 3 with new potential partners for continued research extending beyond REACCH.

Cross CAP opportunities with PINEMAP (pinemap.org), the southern pine climate CAP led by the University of Florida, and the Sustainable Corn (sustainablecorn.org), the corn climate CAP led by Iowa State University, will continue to expand in the areas of data management, project management and coordination, E-communities, graduate student education, and other areas. We will finalize a Service Level Agreement (SLA) with NKN to enhance our cyber-infrastructure and data management, accessibility and legacy storage.

Project evaluation will continue with changes to management changes implemented as deemed necessary. A Social Network Analysis (SNA) will be completed.

Project-wide Assessment Executive Summary
Lead: David Meyer, david.meyer.email@gmail

The goal the evaluation team (Objective 9) is to provide project accountability measures as well as feedback that fosters collaboration, cross-fertilization of ideas, and project improvement.

Team Members: Adam Bond BSU, Dianne Daley Laursen UI, Sanford Eigenbrode UI, David Meyer BSU, Linda Urban BSU

Successful evaluation of federally-supported projects ensures that tax money is spent wisely while giving participants the information they need to improve project efforts. These two goals are met by providing assessment of how the REACCH team is working together as well as a project-wide evaluation framework that tracks our commitments and results. Across all evaluation efforts, the evaluation team seeks to build on existing program strengths, make needed program changes in a timely manner, and respond to contextual factors that may influence long-term program success.

Team leads are held accountable to a project-wide logic model with clearly defined milestones and deliverables. This REACCH logic model serves as a timeline that helps team leads and project managers coordinate activities across objective areas. Team leads are responsible for the data collection, progress reporting, and performance management activities relevant to their objectives. The combination of objective-level accountability and project-level coordination helps identify program components and activities that are working and which may require modification.

One of the primary challenges for the project is to collaborate in a way that combines the appropriate research, education, and extension resources available across multiple institutions, disciplines, and social structures. How well the diverse expertise areas within REACCH integrate their efforts is assessed through observations, reviews of project records, interviews, surveys, social network analyses, and structured discussions. These activities assess the level of collaboration across researchers and other stakeholder groups and inform the entire REACCH team of potential opportunities, challenges, and management practices regarding our collaborative efforts.

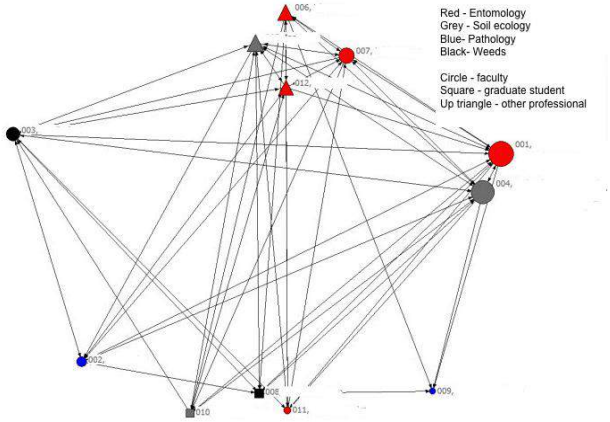

Figure 9d.1. A social network analysis of a REACCH Objective Team highlighting the interaction between 13 individuals across four different academic disciplines

Years 1 and 2 Outputs and Impact

Priority Planning at Project Launch
A pre-launch prioritization survey of PIs and CoPIs completed in March 2011 helped participants understand the REACCH project scope, rank objectives according to their own priorities, and identify key areas for potential collaboration and integration (quantitative ranking completed on-line, ranking results discussed at launch meeting).

Validated Scales of Transdisciplinary Integration
Outputs for the evaluation effort during Year 2 include an annual survey of the REACCH Project's Transdisciplinary Integration (N=36 representing 80% of invited PI's, Investigators, Prof. & Tech Staff on the project at that time). Using questions from existing scales of transdisciplinary attitudes and behaviors (Masse et al. 2008), the data from the 41-item survey provide six statistically sound measures: frequency of cross disciplinary collaboration, collaboration satisfaction, satisfaction with face-to-face communication, team trust, attitudes toward transdisciplinary research, and project productivity. These results will be compared with re-test results in subsequent years to measure change over time. In addition, these measures may be used in combination with other assessment tools, including the ethnographic interviews and the proposed social network analysis, to provide specific project- and program management insights for both the REACCH team as well as other large-scale interdisciplinary research projects.

Inclusive Cross-Project Dialogue Procedure
In an effort to better integrate our knowledge and efforts, the entire REACCH team was invited to complete three open-ended questions regarding the overall REACCH project in November 2011. REACCH Team members provided 91 comments regarding Project successes and improvement recommendations and the Project Evaluator used a qualitative data analysis procedure to organize these comments into five major themes. This report, including the themes and verbatim comments, were distributed at the February 29 to March 2, 2012 Annual Meeting to help structure a Delphi procedure consisting of two rounds of face-to-face small group discussions. These discussions yielded over 60 project improvement ideas that were then summarized by theme, distributed to participants, and discussed in a large group format during the third day of the annual meeting. A final document, "Next Steps for Further REACCH Integration," identifies approximately 14 "decision now" action items; some items have assigned responsibility to project managers or specific program leads. In addition, 12 items were assigned a "Down the Road" status for follow-up during 2012. All documentation is posted on Central Desktop for access by all REACCH team members and project managers.

Field Tour Community Building and "Tough Questions"
On June 19-20, 2012 REACCH participants were invited to a "Field Tour" of five area farms to learn more about research on sustainable farming practice in Idaho and Washington. In addition to the substantive agricultural information and stakeholder connections gained off the bus, the seven hours on the bus were used as an opportunity to

socialize with people across the entire REACCH project. The 45 bus riders were encouraged to use the informal bus atmosphere as a safe place to ask "tough questions"

Figure 9d.3. David Meyer, Project Evaluator, briefing summer field tour participants on assessment and team building activities for the bus ride.

about the project. Semi-structured exercises helped participants generate 35 question cards across four themes (Objective Area Improvements, Working Together, Education/Outreach, and IT/Data). At the end of the tour, each participant could select one question that they felt merited further discussion by the broader REACCH team. The questions and voting results were posted on Central Desktop ("REACCH Summer Tour Integration Summary June 19-20 2012.pptx") and discussed during a Friday Integration meeting in July 2012.

Organizational Capacity Building
During the course of Years 1 and 2, project objective leads have taken responsibility for summative project accountability measures. This information is reported and shared in a standardized form on Central Desktop (the project's cyberinfrastructure site) for performance management benchmarks and to identify opportunities for better cross-project collaboration.

Year 3-Plan-of-Work

A key goal of REACCH project assessment activities is to help participants design and use feedback tools that bring together multiple expertise areas and perspectives. This assessment process is intended to maintain an open and flexible approach that helps REACCH participants discover what we "know" as individuals and groups and begin to build the new communities of understanding that define transdisciplinary efforts. Such an approach is consistent with Klein's (2008) recommendation that evaluation of transdisciplinary efforts "evolves through a dialogue of conventional and expanded indicators of quality". This approach is also consistent with a utilization-focused

evaluation philosophy that provides meaningful feedback to program participants and other stakeholders (Patton, 2008).

The assessment activities during Year 3 focus on processes—how things get done—and are intended to illuminate which project components/activities are working and which may require modification. This information will provide the REACCH leadership team, participants in the research/extension/education activities, and other project stakeholders some of the information needed to modify the program in a timely manner, build on existing program strengths, and respond to contextual factors that may influence the longer-term program impacts (Durlak &DuPre, 2008; Eleni et al., 2009). As in Year 2, the PI's leading each activity area will continue to have primary responsible for outcome and impact evaluation and will collect and report the information that is germane to their activity areas. The assessment activities summarized here focus on the project-wide interactions and processes needed for effective collaboration across disciplines and stakeholder groups. Year 3 assessment activities include: a social network analysis, a cross-project dialogue procedure, and an evaluation of the Fall 2012 graduate student retreat.

The project Assessment Team will illustrate the cross-project interactions during Year 3 through a Social Network Analysis (SNA) that maps the interaction patterns between participants. SNA is increasingly popular to help organization shift from ad hoc interactions based on formal structure, homophily, and personal interests to a more balanced pattern of collaboration that highlights key roles and designated go-to people with the expertise needed for organizational effectiveness (Cross et al., 2006). A social network analysis approach may be useful to REACCH participants because it can illustrate the interaction patters across objective groups and interest areas (see Fig. 9d.1).

The SNA approach proposed for the REACCH project emphasize the social and contextual factors (Hackman, 2012; Salazar et al., 2012) that may support or inhibit effective collaboration. Once developed, these SNA graphs can be shared with REACCH participants to identity key information brokers, links between objective groups, opportunities for improving network relationships and other interdependencies (Prell, 2012). A pilot study started in November 2012 asked participants of one REACCH Objective Team two questions, one aimed at measuring the level of interaction with other team members and the other asking about the common interest or "platform" (Klein, 2012) for social and cognitive integration with other team members. The SNA approach, key concepts, and pilot study results (anonymized) will be shared with the entire REACCH team to teach project participants more about SNA techniques and opportunities as well as solicit additional input for how to best collect, analyze, and implement a social network analysis of the REACCH project. This collaboration will take place during integration teleconferences and at the annual meetings in February 2013 and 2014.

Another assessment activity during year three is a continuation of an inclusive cross-project dialogue procedure that identifies management and collaboration priorities. Under the supervision of the REACCH annual meeting planning team, a feedback system

similar to last year's Delphi process will be used to insure all REACCH participants have the opportunity to assess the project and give improvement recommendations. Last year's process organized answers to three open-ended questions from an anonymous on-line survey of all REACCH participants into themes. These themes and verbatim comments were then distributed at the 2012 Annual Meeting to structure two rounds of face-to-face small group discussions and a project-wide planning session.

A team of graduate students from the Instructional and Performance Technology (IPT) Department at Boise State University are conducting a multi-method evaluation of the September 14-16 REACCH Graduate Student Retreat. They are evaluating how successful the retreat was in helping REACCH graduate students understand the overall project, know what is expected of them, and lay a foundation for building capacity as a group of interdisciplinary climate and agricultural researchers. The evaluation project is being sponsored by Jodi Johnson-Maynard and Erin Corwine from the REACCH Education Objective Team.

Figure 9d.2. The REACCH logic model outlines the entire project in two pages. All activities, outputs, and impacts are further defined in the project management plan. These documents track progress across the project and the individual accountable for each goal.

Concluding Statement

The REACCH project is designed to contribute to the sustainability of agriculture and agriculturally dependent rural communities for the inland Pacific Northwest. The project focuses on cereal production systems, aiming to identify and promote approaches that promote resilience of these systems to anticipated changing climates, while simultaneously reducing their emissions of greenhouse gasses. We are working towards a production landscape that incorporates reduced tillage, more crop diversification, better nutrient and water management practices, enhanced soil carbon reserves and better systems for forecasting and responding to changing pressures from pests, weeds and diseases.

> *"The project is necessarily multifaceted and transdisciplinary, involving collaborations among cropping system modelers, agronomists, crop protection specialists, sociologists, economists, atmospheric and soil scientists, and others."*

It also includes coordinated effort encompassing the tripartite mission of research, education and extension. Extension aims to facilitate partnering with producers and other stakeholders to create the strongest possible communication of research findings to producers and insights and concerns of producers and other citizens to project personnel. Education efforts span K-20 and include training and curricula for public teachers and research training for graduate and undergraduate students. The project is creating and relies upon an extraordinary level of collaboration among three land-grant universities and USDA ARS. We are committed to establishing a physical and cyberinfrastructure that will allow continued long-term, coordinated research beyond the term of REACCH to address future challenges to the region's agriculture. This long-term legacy of REACCH will include an integrated-long term studies established on seven experimental farms throughout the region, an integrated system for managing and sharing data obtained from these experiments and related studies. Building upon existing healthy relationships between producers and scientists in the region we are creating a partnership to address the challenges to sustainability raised by climate change but which can be responsive to other threats and opportunities that may arise in the coming decades.

Results from REACCH Project

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Wetterau, S. P., I. C. Burke, J. P. Yenish, W. L. Pan, A. Esser, D. A. Ball, D. J. Wysocki, T. A. Rauch, D. C. Thill, and T. C. Paulitz. 2012. Management strategies for transition from conservation reserve program to crop production. West. Soc. Weed Sci. Abst. 64:121.

RESEARCH PRESENTATIONS

Talks, Posters or Display Presentations

Abatzoglou, J.T., 2011, Development of gridded surface meteorological data for ecological applications and modeling, International Journal of Climatology, doi: 10.1002/joc.3413.

Abatzoglou, J. Climate Science & Change: Science of Climate Change, What it Means for the Future, and Why Education is So Important. Northwest Climate Education Resources Workshop, June 19, 2012, Moscow, ID.

Adam, J.C., Barber, M.E., Chinnayakanahalli, K.J., Kruger, C.E., Malek, K., Nelson, R.L., Rajagopalan, K., Stockle, C.O., & Yorgey, G.G. 2011. Assessing the Impact of Climate Change on Columbia River Basin Agriculture through Integrated Crop Systems, Hydrologic, and Water Management Modeling. Pacific Northwest Climate Science Conference, Seattle, WA.

Antle, J.M. Representative Agricultural Pathways and Socio-Economic Scenarios. The Nature and Use of New Socioeconomic Pathways for Climate Change Research the National Center for Atmospheric Research, Nov. 2-4, 2011. Boulder CO (invited presentation).

Antle, J.M. Two presentations on the CMIP5 model evaluation and the REACCH downscaling effort were made at the "Workshop on Integrated Scenarios of Future Environment", USGS Climate Science Center, June 7-8, 2012, Portland OR.

Antle, J.M. REACCH Model Integration, Scenario Design and Preliminary Results. REACCH annual meeting, Feb. 29, 2012, Pendleton, OR (invited presentation).

Antle, J.M. Agricultural System Resilience as a Private and Public Good: Policy Implications. Annual meeting of the Agricultural and Applied Economics Association, Aug. 13, 2012, Seattle, WA (presentation).

Antle, J., S. Capalbo, H. Zhang and J. Mu. A Parsimonious Method for Evaluating Climate Change Adaptation Strategies: An Application to PNW Cereal Production. ASA, CSSA and SSSA International Annual Meetings, Oct. 21-24, 2012, Cincinnati, OH (presentation).

Antle, J., Stoorvogel, J., and Valdivia, R. New Parsimonious Simulation Methods and Tools to Assess Future Food and Environmental Security of Farm Populations. Scientific Discussion Meeting on Achieving Food and Environmental Security - New Approaches to Close the Gap, Dec. 3-4, 2012, Royal Society, London (invited paper).

Antle, J., Stoorvogel, J., and Valdivia, R., New Parsimonious Simulation Methods and Tools to Assess Future Food and Environmental Security of Farm Populations. *Philosophical Transactions of the Royal Society B* (expected publication 2013).

Beard, T.L., Borrelli, K., Pan, W.L., Xiao, C. A Comparison of Oilseed and Grass Crop Residue Si and Fiber Composition and Impacts on Soil Quality, Northwest BioEnergy Research Symposium. Nov 13, 2012. Seattle, WA (poster presentation).

Bernacchi, L. and J.D. Wulfhorst. Designing the Social Components of REACCH. Climate, Land Use, and Agricultural and Natural Resources: Activities in Interdisciplinary Research, Education, and Outreach. Washington State University, June 26, 2012, Pullman, WA.

Bernacchi, L. and J.D. Wulfhorst. Scaling Up Regional GeoVisualization Capacities among Human Subject Participants. Visualization Technologies to Support Research on Human – Environment Interactions. SESYNC: National Socio-Environmental Synthesis Center, July 22-23, 2012, Annapolis, MD.

Bernacchi, L., J.D. Wulfhorst, S. Kane, D. Young, P. Diebel. The Complexity of Farm Adaptation amidst Agroecological Constraints. Annual Meeting of the Rural Sociological Society, July 25-29, 2012, Chicago IL.

Boylan, R., Brooks, E.S. Transport of Carbon by runoff and erosion in the PNW dryland grain production region. REACCH Annual Meeting, Feb. 28- Mar. 1, 2012, Pendleton OR (poster presentation).

Boylan, R., Presentation to high school students at FFA field tour, May 2012, Moscow ID (oral presentation).

Boylan, R., REACCH Project Overview. Idaho FFA Association, June 7, 2012, Moscow ID.

Brooks, E.S., Boylan, R. Effects of Management on Carbon export by Water Erosion in the High Precipitation AEZ. The OutREACCH Newsletter, 1(1), 4 pp.

Brooks, E.S., Boylan, R., Chahal, M, Poggio, M., Brown, D. Hydrologic transport of carbon and nitrogen within the high precipitation AEZ of the Palouse. REACCH 2012 summer field tour June 19, 2012, Cook Agronomy Farm.

Brown, D.J., Brooks, E.S., Eitel, J., Huggins, D.R., Painter, K., Rupp, R., Smith, J.L., Stockle, C., Vierling, L. Site-Specific, Climate-Friendly Farming. 2011 Fall Meeting, AGU, Dec. 5-9, 2011, San Francisco CA (poster presentation).

Burke, I.C. CRP Transition to Crop Production. Colfax Direct Seeders Meeting, December 15, 2010 and Whitman County Growers, Lewiston, ID, January 3, 2011.

Chastain, T.G., S.O. Guy, W.F. Schillinger, D.J. Wysocki, and R.S. Karow. 2011. Camelina: Genotype and environment impacts on seed yield in Washington, Oregon, and Idaho. [CD-ROM]. American Society of Agronomy annual meeting. San Antonio, TX. October 2011.

Chinnayakanahalli, K.J., Adam, J.C., Stockle, C.O., Nelson, R.L., Brady, M.P., Rajagopalan, K., Barber, M.E., Dinesh, S., Malek, K., Yorgey, G.G., Kruger, C.E., Marsh, T.L., & Yoder, J. (2011). Incorporating agricultural management into an earth system model for the Pacific Northwest region: Interactions between climate, hydrology, agriculture, and economics. American Geophysical Union Fall Meeting, San Francisco, CA.

Connors, J. REACCH Project overview. Washington Association of Agricultural Education, June 30, 2011, Pullman, WA.

Dello, K. Climate Change 101. Oregon State University Summer Agricultural Institute. June 26, 2012, Corvallis, OR (invited oral presentation)

Donlon, H., K. Painter, D. Roe. A Longitudinal Survey Measuring Impacts of Climate Change for Wheat Growers across the Inland Pacific Northwest. 2012 ASA/ CSSA/SSSA International Annual Meetings, Cincinnati, OH, Oct. 21-24, 2012, Cincinnati OH (oral presentation).

Eigenbrode, S.D., REACCH Project Overview, Nez Perce/Latah/Asotin County Extension Cereal School, Lewiston, ID, Jan. 30, 2013.

Eigenbrode, S.D., REACCH Project Overview, Nez Perce/Latah/Asotin County Extension Cereal School, Greencreek, ID, Jan. 29, 2013.

Eigenbrode, S.D., S. Capalbo, P. Gessler, J. Gosz, D. Huggins, J. Johnson-Maynard, H. Kok, B. Pan, S. Petrie, and J.D. Wulfhorst, Planning a long-term agricultural project for dryland agroecosystems of the Inland Pacific Northwest. Direct Seed Cropping Systems Conference. Jan 20-21, 2010. Kennewick WA.

Eigenbrode, S.D., Abatzoglou, J. Projected range of cereal leaf beetle with climate change scenarios for the Pacific Northwest, Sustainable Corn CAP, Nov. 9, 2011, Chicago IL (oral presentation).

Eigenbrode, S.D., REACCH Project Overview, Sustainable Corn, Iowa Corn CAP Annual Meeting, Nov. 9, 2011, Chicago IL.

Eigenbrode, S.D., Abatzoglou, J., Projected potential for cereal leaf beetle infestations with climate change in the Pacific Northwest. Annual meeting of the Entomological Society of America, Nov. 15, 2011, Reno NV (poster presentation).

Eigenbrode, S.D., J.T. Abatzoglou, J. Antle, I.C. Burke, S. Capalbo, P. Gessler, D.R. Huggins, J. Johnson-Maynard, C. Kruger, B.K. Lamb, S. Machado, P. Mote, K. Painter, W.L. Pan, S.E. Petrie, T.C. Paulitz, C. Stöckle, V. Walden, J.D. Wulfhorst, K.J. Wolf, Regional Approaches to Climate Change for Inland Pacific Northwest Cereal Production Systems. Tri-State Grain Growers Meeting, Nov. 16-18, 2011, Spokane WA (poster presentation).

Eigenbrode, S.D. Vigilant management strategies to guard against insect pests as climate and weather patterns shift. Spokane County Crop Improvement Association, Nov. 19, 2011, Spokane WA (invited oral presentation).

Eigenbrode, S.D., Abatzoglou, J.T., Antle, J., Burke, I.C., Capalbo, S., Gessler, P., Huggins, D.R., Johnson-Maynard, J., Kruger, C., Lamb, B.K., Machado, S., Mote, P., Painter, K., Pan, W., Petrie, S., Paulitz, T.C., Stockle, C., Walden, V.P., Wulfhorst, J.D., Wolf, K. Regional Approaches to Climate Change for Inland Pacific Northwest Cereal Production Systems American Geophysical Union Meeting, Dec. 2011, San Francisco CA (This poster also presented in Chicago).

Eigenbrode, S.D. Notes from a basically applied scientist, University of Idaho Humanities Series, Jan. 24, 2012.

Eigenbrode, S.D. The REACCH Project gets moving. Pacific Northwest Direct Seed Conference, Feb. 9, 2012.

Eigenbrode, S.D. Climate change and PNW agriculture. Department of Geography, University of Idaho, Feb. 14, 2012.

Eigenbrode, S.D., Abatzoglou, J. Effects of projected climate change on the phenology of wheat and the cereal leaf beetle. Pacific Branch of the Entomological Society of America Annual Meeting, March 26, 2012, Portland OR (oral presentation).

Eigenbrode, S.D., Johnson-Maynard, J. Overview of REACCH Project. Northwest Climate Education Resources Workshop, June 19, 2012, Moscow, ID.

Eigenbrode, S.D., Johnson-Maynard, J. Critters in the Soil: Sustainable Farming. Northwest Climate Education Resources Workshop, June 21, 2012, Moscow, ID.

Eigenbrode, S.D., Abatzoglou, J. Effects of projected climate change on the phenology of the cereal leaf beetle and its parasitoid, *Tetrastichus julis.* BioEarth Annual Meeting, June 24, 2012, Pullman WA (poster presentation).

Eigenbrode, S.D., O'Rourke, M. Toolbox Function & Integration. REACCH Integration Meeting Presentation, July 20, 2012, Moscow ID (Project wide via Gotomeeting).

Elliott, K.M. & Velez, J. J., Key elements of the REACCH project, Oregon Vocational Agriculture Teachers Association, June 19, 2012.

Esser, A.D. and A. Kennedy. Presentation on changes in the soil on long-term direct seeded systems. Northern Lincoln County Field Day. Wilbur, WA. June 21, 2011.

Esser, A.D., J. Brown, and D. Robertson. Incorporating canola into no-till and conventional cropping systems. Variety Test Plot Tour. Davenport, WA. June 22, 2011.

Esser, A.D. The WSU Wilke Research and Extension Farm Production and Economic Report. Wilke Farm Grower Meeting. Davenport, WA. December 15, 2011.

Esser, A.D. Oilseed Crops in Rotation with Wheat. WSU Oilseed Grower Meeting. Odessa, WA. Jan. 24, 2012.

Esser, A.D. and K.S. Pike. Controlling Wireworms in Cereal Grain Production. Palouse Rock Lake Conservation District Grower Meeting. St. John, WA. Jan. 18, 2012. PNW Farm Forum. Spokane, WA. Feb. 9, 2012.

Esser, A.D. and K.S. Pike. Controlling Wireworms in Cereal Grain Production. Idaho Grain Commission Webinar. Ritzville, WA. Feb. 24, 2012.

Esser, A.D., R. Jones, and L. Lutcher. Mechanics and Weed Issues in a No-Till Fallow. NRCS Biofuels and Direct Seed Grower Information Day. Waterville, WA. Feb. 27, 2012.

Esser, A.D. Wilke Farm and Wireworms. Reardan Seed Company Grower Meeting. Reardan, WA. March 8, 2012.

Esser, A.D., K.S. Pike, and R. Dewald. Controlling Wireworms with Neonicotinoid Insecticides in Wheat. WSU Showcase. Pullman, WA. March 30, 2012.

Esser, A.D. and K.S. Pike. Controlling Wireworms in Cereal Grain Production. Franklin County Association of Wheat Growers and WSU Extension Variety Test Plot Tour. Kahlotus, WA. June 5, 2012.

Esser, A.D., On-Farm Testing in Today's Environment. National Association of County Agricultural Agents Annual Meeting and Professional Improvement Conference. July 15-20, 2012, Charleston, SC.

Esser, A.D., Milosavljevic, I., and Pike, K., Impact and management of infesting wireworms on spring wheat in Washington State. Entomological Society of America Annual Meeting. November 11-14, 2012, Knoxville TN.

Frear, C.S., Kruger, C.E., Granatstein, D.M., Chen, S., Macconnell, C.B., Shumway, C.R., Collins, H.P., Stockle, C.O., Harrison, J.H., Demirer, G., Higgins, S., Yorgey, G.G., Liao, W., Zhang, T., Jiang, A., Zhao, Q., Bishop, C., Streubel, J.D., & Oakley, K. (2011). Overview of anaerobic digestion of dairy manure research. Regional Approaches to Climate Change Annual Meeting, Moscow, ID.

Fricke, S., V.P. Walden, E. Seamon, B. Godfey Climate Visualization through Geoprocessing Services. 3rd Annual Pacific Northwest Climate Science Conference, October 2012, Boise, ID.

Fricke, S., V.P. Walden, E. Seamon, B. Godfey. 2012. Climate Data Access and Visualization through Esri's Web APIs. INSIDE Idaho GIS Day, November 2012, Moscow ID.

Gollberg, G. S.D. Laursen, P.E. Gessler, L. Sheneman. The Northwest Knowledge Network: cyberinfrastructure to support science and technology advancement. Annual REACCH Conference, March 2012, Pendleton OR.

Graves, L, Sharratt, B., Pressley, S., Carbon and nitrogen loss in windblown dust on the Columbia Plateau. Showcase for Undergraduate Research and Creative Activities. Washington State University, March 30, 2012.

Graves, L., Sharratt, B., Pressley, S., Soil nitrogen loss in windblown dust on the Columbia Plateau. Pacific Northwest Climate Science Conference. Oct. 1-2, 2012, Boise ID.

Hammac, W.A., W.L. Pan, and R.T. Koenig. 2011. Impact of Nitrogen Use Efficiency on Greenhouse Gas Emission in Canola Biodiesel Feedstock Production. Soil and Water Conservation Society International Conference. Washington, D.C.

Hammac, A. Nitrogen cycling in canola: implications for N management. WSU Cook Agronomy Farm, Pullman, WA. June 23, 2011.

Hammac, W.A., W.L. Pan, R.T. Koenig, and I. Burke. 2011. Nitrogen and Sulfur Fertility Effect on Canola (Brassica napus) Protein Content and Fatty Acid Profile. American Society of Agronomy annual meeting, Oct. 2011, San Antonio TX.

Hammac, A., R. Koenig, and W. Pan. Nitrogen management and cycling in canola. Oilseed production workshops. 2011, 2012.

Hammac, A., T. McClellan, B. Pan, and R. Koenig. Yield Potential, nitrogen use efficiency, and unit nitrogen requirement of spring canola in Eastern WA. Northwest BioEnergy Research Symposium. Nov. 13, 2012, Seattle WA (poster presentation).

Huggins, D.H. Agricultural mitigation of global climate change. Grangeville, ID. 2011.

Huggins, D.H. No-till agriculture: equipment, soil and pest issues. Choteau, Shelby, and Great Falls, MT. Jan. 3-4, 2011.

Huggins, D.H. Wheat residue harvesting or burning impacts on crop yield, soil nutrient removal and availability and C storage. Richland, WA Jan. 20, 2011.

Huggins, D.H. Long-term no-till cropping system impacts on economics, weed and disease management, soil C sequestration and precision N management. STEEP Annual Review. Richland, WA. Jan. 20, 2011.

Huggins, D.H. Conservation farming impacts on soil quality and the application of precision technologies in the Palouse. Pullman, WA. Feb. 1, 2011

Huggins, D.H. Conservation tillage and cropping systems for organic crop production in the Palouse. Pullman, WA. Feb. 2, 2011.

Huggins, D.H. Conservation farming impacts on soil quality and the application of precision technologies in the Palouse. Pullman, WA. Feb. 1, 2011.

Huggins, D.H. Field burning effects on nutrient losses and crop productivity. Spokane, WA. Feb. 8, 2011.

Huggins, D.H. N products used to reduce N losses and increase N use efficiency. Pomeroy, WA. Feb. 9, 2011.

Huggins et al., Dynamic Agroecological Zones for the Inland Pacific Northwest. REACCH Launch Meeting, Feb. 24-25, 2011 (display).

Huggins, D.H. Surface residue management effects on soil water storage. Reno, NV. March 2, 2011.

Huggins, D.H. Strategies to improve N use efficiency in wheat. Reno, NV. March 3, 2011.

Huggins, D.H. Evaluating N use efficiency. Pullman, WA. March 4, 2011.

Huggins, D.H. Field burning effects on nutrient losses and crop productivity. Spokane, WA. June 16, 2011.

Huggins, D.H. Presentation on field burning and residue harvest effects on nutrient losses and crop productivity. Pullman, WA. June 23, 2011.

Huggins, D.H. Precision farming: variable wheat density and N rates for increasing wheat yield. Presentation on precision farming technology research. WSU Cook Agronomy Farm, Pullman, WA. June 23, 2011.

Huggins et al., Dynamic Agroecological Zones for the Inland Pacific Northwest. Annual Meeting of the Sustainable Corn CAP, Nov. 7-9, 2011 (display).

Huggins et al., Dynamic Agroecological Zones for the Inland Pacific Northwest, USA. American Geophysical Union Annual Meeting, Dec. 4-9, 2011, San Francisco CA (oral).

Huggins, D.R. Presentations on soil productivity and oil seed production in conservation systems. Wilbur-Ellis meeting. Spokane, WA. Jan. 25-26, 2012. 300+ attendees.

Huggins et al., Dynamic Agroecological Zones for the Inland Pacific Northwest, USA. REACCH Annual Meeting, Feb. 28th, 2012, Pendleton OR (oral).

Huggins, D.R. Presentations on soil productivity and acidification in conservations systems. IASCD meeting. Lewiston, ID, 10/20/2011; Kootenai Cons. Dist., Coeur d'Alene, ID, 12/9/2012; Benewah Cons. Dist., Plummer, ID, 2/28/2012. 150 attendees.

Huggins, D. REACCH Project Overview. Washington FFA Association, May 11, 2012, Pullman, WA.

Huggins, D.R. Conservation Awareness Days. Spring Valley Reservoir, ID. May 17, 2012.

Huggins, D.R. Alternatives to wheat residue burning. Presentation on field burning effects on nutrient losses and crop productivity. Spokane, WA. Feb. 2, 2012 and June 12, 2012.

Huggins, D.R. Precision Farming Systems. Davenport, WA and Pullman, WA June 19-20, 2012.

Huggins et al., Dynamic Agroecological Zones for the Inland Pacific Northwest, USA. BioEarth meeting, June 26, 2012, Pullman WA (display).

Huggins, D.R. Agricultural mitigation of global climate change. REACCH Summer Intern,. Moscow, ID July 23, 2012.

Huggins et al., Dynamic Agroecological Zones for the Inland Pacific Northwest, USA. Sustainable Corn CAP Annual Meeting Aug. 5-9, 2012, Wooster, OH (display).

Huggins et al., Dynamic Agroecological Zones for the Inland Pacific Northwest, USA. WSU Crop and Soil Science Seminar, Sept. 24, 2012, Pullman, WA (oral).

Huggins et al., Dynamic Agroecological Zones for the Inland Pacific Northwest, USA. ASA annual meeting, Oct. 21-24, 2012, Cincinnati, OH (display).

Hughes, M., S. Hulbert, A. Hammac. Oilseed research update. Cook Farm Field Day. Pullman, WA. June 23, 2011.

Hulbert, S., F. Young, H. Collins, W. Pan (organizing committee). Bioenergy crops. The future is now. Future Energy Conference and Bioenergy Research Symposium. Seattle, WA. Oct. 18, 2011.

Johnson-Maynard, J.L. Experiential, on-farm education to teach sustainable food production system principles. Western Regional Teaching Symposium. September 2011, Moscow, ID.

Johnson-Maynard, J.L. Earthworms in Agroecosystems. Direct Seed Grower Workshop, Jan. 12, 2012, Colfax, WA (invited oral presentation).

Johnson-Maynard, J.L. Earthworms in PNW Agroecosystems. Direct Seed Grower Breakfast, Feb. 15, 2012, Lewiston, ID (invited oral presentation).

Johnson-Maynard, J.L., K. Wolf, J. Velez, E. Corwine, T. White, and S.D. Eigenbrode. Improving Student and Teacher Knowledge of Climate Change and Agricultural Science in the Inland Pacific Northwest. Annual Meeting of the American Society of America, Oct. 21-24, 2012, Cincinnati, OH.

Kandel, S., Elling, A., Smiley, R.W., Garland-Campbell, K, Nicol, J.M. and Paulitz, T.C. A survey of root lesion nematode (*Pratylenchus* spp.) in the dryland wheat production areas of eastern Washington. The 50th Annual meeting of the Society of Nematology, July, 2011, Corvallis, OR (poster presentation).

Kefyalew, D., Collins, H., Pan, W. Fransen, S., Norberg, S., Llewellyn, D., Double-Cropping Irrigated Biennial Canola with Green Pea for Biodiesel Feedstock, Crop Diversification, and Animal Feed. Northwest BioEnergy Research Symposium, Nov. 13, 2012, Seattle WA (poster presentation).

Kefyalew, D., Fransen, S., Okwany, R., Peters, R., Collins, H., Soil Profile Nitrogen under Different Biofuel Feedstock Grasses and Irrigation Regimes. Northwest BioEnergy Research Symposium. Nov. 13, 2012, Seattle, WA (poster presentation).

Kirill, K., Eddy Flux Covariance Estimates. Northwest Climate Education Resources Workshop, June 19, 2012, Cook Farm, WA.

Kostyanovsky, K., Huggins, D., Stockle, C, Smith, J., Brosn, D., Pan, B, Continuous Automated Measurements of Soil N2O and CO2 Emissions with the Portable IRGA System in the Static Chamber Microplot Study. W2170; Soil-Based Use of Residuals, Wastewater and Reclaimed Water Annual Meeting, June 24-26, 2012, Tacoma, WA (oral presentation). http://www.lgu.umd.edu/lgu_v2/homepages/attachs_Homepage/10996_Kostyanovsky_GHG%20measurements_W2170-_2012.pdf

Kostyanovsky, K.I., Huggins, D.R., Stockle, C. O., Smith, J.L., Brown, D.J., Pan, B.Dynamics of CO_2 and N_2O Emissions in the Wheat System: Continuous Automated IRGA Monitoring Study. ASA-CSA-SSSA Annual Meetings, Oct. 21-24, 2012 Cincinnati, OH (oral presentation).

Kruger, C.E. (2011). Agriculture and Climate Change in the Pacific Northwest: Impacts and Adaptation. Ag Link Farmer Workshop, Dayton, WA.

Kruger, C.E. (2011). Carbon Footprints in PNW Agriculture and Food Systems. WSU Carbon Master's Program. Whatcom County Extension, Bellingham, WA.

Kruger, C.E. (2011). Climate Change and Agriculture in Washington. Othello Sandhill Crane Festival, Othello, WA.

Kruger, C.E. (2011). Climate Friendly Farming: Improving the Carbon Footprint of Agriculture in the PNW. CAHNRS All Faculty Conference, Pullman, WA.

Kruger, C.E. (2011). Climate Friendly Farming: Opportunities and Challenges for Whatcom County Agriculture. Time to Act: Adapting to Climate Change in Whatcom County, Bellingham, WA.

Kruger, C.E. (2011). Sustainable Pathways to Bioenergy. Washington Future Energy Conference, Seattle, WA.

Kruger, C.E. (2011). Thinking about organics recycling in the context of Global Change. Keynote Presentation. Washington Organics Recycling Council, Ellensburg, WA.

Kruger, C.E., Yorgey, G.G., Chen, S., Collins, H.P., Feise, C.F., Frear, C.S., Granatstein, D.M., Higgins, S., Huggins, D.R., Macconnell, C.B., Painter, K.M., & Stockle, C.O. (2011). Climate Friendly Farming: Improving the carbon footprint of agriculture in the Pacific Northwest. Regional Approaches to Climate Change Annual Meeting, Moscow ID.

Kruger, C.E. 2012. Climate Change and the Future of Food. Keynote address. Climate Change and the Future of Food: Challenges and Adaptation Strategies. Bellingham, WA, October 2012.

Kruger, C.E. 2012. Pests and Other Agricultural Stressors. Climate Change and the Future of Food: Challenges and Adaptation Strategies. Bellingham, WA, October 2012.

Kruger, C.E. 2012. The Role of Agriculture & Natural Resources in Changing the Global Carbon Balance. Keynote address. Sustainable Path Town Hall: Biocarbon. Seattle, WA, February 2012.

Kruger, et.al. 2012. Climate Friendly Farming: Establishing a Transdisciplinary Framework for Agriculture and Climate Change Science in the Pacific Northwest. 3rd Annual Pacific Northwest Climate Science Conference. September 2012 (poster presentation).

Kruger, et.al. 2012. Blending Traditional and Contemporary Agricultural Extension Methods to Address Broad-Based Stakeholder Needs for Agriculture and Climate Change in Pacific Northwest Cereal Cropping Systems. Tri-Societies Annual Meeting: Visions for a Sustainable Planet. October 2012. (poster presentation)

Kruger, C.E. and J. Stevenson. 2012. Sustaining Pacific Northwest Agriculture & Food Systems in the Context of a Changing Climate. WSU Vancouver Environmental Science Seminar Series, February 2012; Marylhurst University, October 2012.

Kruger, C.E., Yorgey, G.G., Chen, S., Collins, H.P., Feise, C.F., Frear, C.S., Granatstein, D.M., Higgins, S., Huggins, D.R., Macconnell, C.B., Painter, K.M., & Stockle, C.O., Climate Friendly Farming: Improving the carbon footprint of agriculture in the Pacific Northwest. BioEarth Annual Meeting Poster Session, (2012), Pullman WA (poster presentation).

Lamb, B. Flux Tower Principles. Northwest Climate Education Resources Workshop, June 19, 2012, Cook Farm WA.

Machado, S. Developing Profitable and Sustainable Cropping Systems for North-Central Oregon and South-Central Washington. Soil and Water Conservation District breakfast meeting, Roosters Restaurant, Pendleton, OR. Jan. 2011. 40 attendees.

Machado, S. 2011. Soil Organic Carbon Dynamics in the Pendleton Long-Term Experiments: Implications for Biofuel Production in Pacific Northwest. ASA, CSSA, SSSA Annual Meetings. Laramie WY.

Machado, S. 2011. Soil Organic Carbon Dynamics in the Pendleton Long-Term Experiments: Implications for Biofuel Production in Pacific Northwest. ASA, CSSA, SSSA Annual Meetings. San Antonio TX.

Machado, S. Soil Organic Carbon Dynamics in the Pendleton Long-Term Experiments: Implications for Biofuel Production in Pacific Northwest. CBARC Field Day. Pendleton, OR. June 2011. 165 attendees.

Machado, S. Developing Profitable and Sustainable Cropping Systems for North-Central Oregon and South-Central Washington. CBARC Moro Field Day. Moro, OR. June 2011. 110 attendees.

Machado, S. An update of the CBARC Moro Long-term Experiment: Tillage Effects on Yield and Soil Organic Matter Dryland Extension Management Meeting. Umatilla County Extension Conference Room, Blue Mountain Community College, Pendleton, OR. Sep. 2011. 40 attendees.

Machado, S. OSU and CBARC Research Activities and Products. Wheat Fest, Pendleton Farmers Market. Sept. 2011. 1000 attended market, 100 stopped at OSU booth.

Machado, S. Dryland Cropping Systems Research highlights. Presentation to members of the Tiichám Conservation District, Farm Committee, and Land Acquisition Committee. CBARC, Pendleton, OR. Feb. 2012. 20 attendees.

Machado, S. Overview of the Pendleton long-term experiments. REACCH annual meeting. Feb. 2012. 20 attendees.

Machado, S. Overview of the Pendleton long-term experiments. Presentation to Ed Ray, OSU President and Steve Clark, Vice President for University Relations and Marketing. June, 2012.

Machado, S., L. Pritchett, and S. Petrie. 2012. Developing Sustainable and Profitable Cropping Systems for North-Central Oregon. Western Society of Crop Science Annual Meeting. July, 2012, Pullman, WA.

Machado, S. Overview of the Pendleton long-term experiments and agronomy program. NRCS Soil Health and Sustainability Workshop. Aug. 2012. 35 attendees.

Machado, S., L. Pritchett, and S. Petrie. 2012. Winter Wheat-Chemical Fallow Can Replace Conventional Tillage Winter Wheat-Summer Fallow in North-Central Oregon. American Society of Agronomy (ASA), Crop Science Society of America (CSSA), and Soil Science Society of America (SSSA) Annual Meetings, Oct. 24, 2012, Cincinnati, OH.

McClellan, T., Pan, W., Hamman, A., Young, F., Assessing Crop Rotational Nitrogen Use Efficiency Using an N Balance Approach. Northwest BioEnergy Research Symposium. Nov. 13, 2012, Seattle, WA (poster presentation).

Miller, B., Walden, V. Tying Adventure Learning to the Classroom: Greenland and Atmospheric Science. Northwest Climate Education Resources Workshop, June 21, 2012, Moscow ID.

Painter, K., S. Higgins, D. Huggins, C. Stockle, and C. Kruger. 2011. Carbon Credits as a Tool for Enhancing Profitability of Reduced Tillage Farming Systems: Results from the Climate Friendly Farming™ Project, Phase I. Launch meeting for the $20 million Regional Approach to Climate Change in the PNW (REACCH PNA) AFRI-CAP grant, 2011 (poster presentation).

Painter, K. Costs and Returns Analysis for Direct Seeding. Presentation at the Colfax Palouse Direct Seed Breakfast meeting, March 9, 2011, Colfax WA.

Painter, K. Economics of Cook Farm Rotations. Presentation at the Cook Farm Field Day, June 23, 2011, Pullman WA.

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Table B1. Milestones (M) and Deliverables (D) by Objective (1-9) and year

Explanation: M1.1 = Milestone 1 for objective 1, Year 1; D2.3 = Deliverable 1 for Objective 2 Year 3, etc.			
Note: multiple year items are shown as completed if on track through Year 2, the period of this report			
completed	in progress	on track for Year 3 completion	Year 4, 5

	Objective									
Year	1	2	3	4	5	6	7	8	9	Other
1	M1.1a M1.1b M1.1c	M2.1 M2.1a M2.1b M2.1c	M3.1	M4.1	M5.1	D6.1	M7.1 D7.1.1 D7.1.2 D7.1.3	D8.1	D9.1	Biannual meetings Y1-5
2	M1.2a M1.2b M1.2c D1.2		M3.2		M5.2	M6.2 D6.2 D6.2a D6.2b	M7.2 D7.2.1 D7.2.2	D8.2 D8.2a D8.2b D8.2c D8.2d	M9.2 M9.2a M9.2b M9.2c M9.2d D9.2 D9.2a	Collaboration Workshop
3	D1.3 M1.3a M1.3b				M5.3	M6.3 D6.3a D6.3b D6.3c	M7.3 D7.3.1 D7.3.2 D7.3.3 D7.3.4	D8.3	M9.3 D9.3	
4	D1.4a D1.4b	M2.4	D3.4				D7.4 D7.4.1 D7.4.2			
5	D1.5a D1.5b	D2.5		D4.5a D4.5b	M5.5a D5.5a M5.5b	D6.5a			D9.5a D9.5b D9.5c D9.5d D9.5e	International Conf Proc. Y5

ID	Description	Lead
M1.1a	Downscaled climate scenarios incorporated into transdisciplinary framework	Walden
M1.1b	Ag census and other data identified and prepared for economic analysis	Antle
M1.1c	Develop socio-economic scenarios 90% complete	Antle
M1.2a	GCMs selected and different scenarios evaluated	Mote
M1.2b	Cropping systems investigated under alternative climate and policy scenarios, parametrized	Antle
M1.2c	Current systems parameterized for TOA-MD model	Antle
D1.2	Historical gridded surface metrological data at scales needed or agroecological models	Abatzoglou
D1.3	GCM output translated to scales needed for agroecological modeling	Walden
M1.3a	Calibrated CropSyst model linked to climate and socio-economic models	Stockle
M1.3b	Adapted cropping systems characterized for economic models	Stockle
D1.4a	Simulation of cropping system performance in a GIS framework	Stockle
D1.4b	Parameterization of TOA-MD model for current and adapted systems (90% done)	Antle
D1.5a	TOA-MD evaluation of system adoption given market and incentive scenarios	Antle
D1.5b	Empirical analysis tradeoffs from the economic impact technology assessment	Antle
M2.1	GHG field monitoring network initiated and continued, Y1-4:	Lamb
M2.1a	Tower flux site and chamber based operations and analysis	Lamb
M 2.1b	Wind erosion measurements and analysis	Lamb
M2.1c	Water erosion measurements and analysis	Brooks
M2.4	GHG field monitoring and Integrated analyses, integrated assessments completed, Y1-4	Lamb
D2.5	GHG emission regional baseline completed, alternative scenarios assessed	Lamb
M3.1	Cropping alternatives and associated C, N, water measurements initiated , cont. Y1-4	Pan

ID	Description	Lead
M3.2	Analyses of NUE, WUE, C, energy and delivery of initial inputs for modeling, Y2-5	Pan
D3.4	Alternatives assessed, linked to biophysical and socio-economic modeling, Y4-5	Pan
M4.1	Longitudinal and key informant interviews following AEZ strata, Y1-5	KP/JDW
D4.5a	Spatial representation of adoption likelihood incorporating socioeconomic variability	KP/JDW
D4.5b	Socio-geographic functions for N, water, energy use shifts due to crop, policy, climate	JDW/KP
M5.1	Assess climate related vulnerabilities to pests and beneficials; initiate monitoring, Y1-4	SDE
M5.2	Predictions of climate related changes in pests, diseases, weeds and beneficial, Y2-4 20%	SDE
M5.3	Earthworm survival and reproduction as related to soil moisture and temperature	JJM
M5.5a	Comparative analysis of pressure from key insects, pathogens and weeds in alt. systems 10%	SDE
D5.5a	Assessment of climate adaptation and mitigation on selected pests and beneficials	SDE
M5.5b	Recommendations for climate-related changes in biota to producers and scientists	SDE
D6.1	K-12 teacher survey analyzed	KW
M6.2	k-12 teacher training	JJM
D6.2	Introductory classroom materials developed 60 %	JJM
D6.2a	Course materials on ag and climate change prepared	JJM
D6.2b	Formation of interdisciplinary teams based on research themes 50%	JJM
D6.3	Exchange programs with CAP and LTER sites, undergrad. summer courses, Y3-5 15%	JJM
D6.3a	Classroom activities developed from project results	JJM
D6.3b	Graduate level course on spatial statistics that covers AEZ concept 40%	JJM
D6.3c	Graduate level course on carbon and nitrogen cycle	JJM
D6.5a	Webinar on C and N cycling for non-physical science grad students	JJM,DH
M7.1	Stakeholder communication plan, interactive website, CoP within eXtension	Kruger
D7.1.1	Coordinate SAC	Petrie
D7.1.2	Develop and Implement SAC Plan	Petrie
D7.1.3	Annual Reporting for Objective	Kruger
M7.2	Develop Extension products for dissemination to Stakeholders	Kruger
D7.2.1	Develop and provide content for interactive website	Kruger
D7.2.2	Develop Extension publications, presentations ,and tools for stakeholders	Kruger
M7.3	Develop REACCH Extension Education Network	Kruger
D7.3.1	Hire Extension Faculty Coordinator 90%	Kruger
D7.3.2	Establish Community of Practice within extension 10%	Kruger
D7.3.3	Develop and train a virtual community of stakeholder educators 40%	Kruger
D7.3.4	Funding to Extension Network for product development and demonstrating 15%	Kruger
D7.4	Stakeholder evaluations	Kruger
D7.4.1	Stakeholder Surveys 30%	Kruger
D8.1	CI assessment, legacy data migration, data mgmt. policy created, followed, Y1-5 50%	Gessler
D8.2	Interface for researchers and stakeholders created, followed, Y2-5	Gessler
D8.2a	DM Implementation Project Initiation 85%	Seamon
D8.2b	DM Implementation Project Execution 52%	Seamon
D8.2c	Implementation Project Control 82%	Seamon
D8.2d	Interface for researchers and stakeholders created	Seamon
D8.3	Investigate, improve, and maintain cybercollaborative support, Y3-5	Gessler
D9.1	Annual project meetings	SDE
M9.2	Cross Cutting themes: AEZ databases developed 40%	Huggins
M9.2a	Systems modeling: TOA-MD, outcomes for climate and AEZ scenarios 35%	Stockle
M9.2b	LCA global warming potential IPNW cereal systems 30%	Stockle
M9.2c	AEZ Climate change, adaptation, mitigation, technology impacts on AEZ 5%	Huggins
M9.2d	Policy theme interaction	SDE
D9.2	Assessment of communication, collaboration and productivity, Y1-5	Meyer
D9.2a	Structured process of identifying and implementing project-wide improvements, Y 1-5	Meyer
M9.3	Identify International Conference partners, initiate promotion, Y3-5 (10%)	SDE
D9.5a	International conference, Y4; collaboration workshops,	SDE
D9.5b	Systems modeling: TOA-MD performance outcomes for climate scenarios, AEZ	Antle
D9.5c	LCA theme: global warming potential of current and projected cereal systems in IPNW	Stockle
D9.5d	AEZ: Climate change and adaptation and mitigation technology impacts on AEZ	Huggins
D9.5e	Policy theme: interaction with policy makers and development of science-based policy	Antle

Explanation: M1.1 = Milestone 1 for objective 1, Year 1; D2.3 = Deliverable 1 for Objective 2 Year 3, etc.

REACCH Team Membership List:

Last Name	First Name	Objective	Role	Institution or Organization	Comments
Abatzoglou	John	1, AEZ	PI	University of Idaho	
Allen	Liz	7	Student, PhD	Washington State University	
Allwine	Eugene	2	Faculty	Washington State University	Moved
Anderson	Karma	N/A	Collaborator	U.S Environmental Protection Agency	
Antle	John M.	1, 4	PI	Oregon State University	
Appel	Derek	3	Technical Support	Washington State University	WSU Farm Manager
Baxter	Heather	3	Student	Washington State University	
Beafume	Jean-Bruno	N/A	SAC Affiliate	Limagrain Cereal Seeds	
Beard	Taylor	6	Student, MS	Washington State University	
Belltawn	Burgen	3	Staff	Oregon State University	Moved
Bernacchi	Leigh	4	Student, P. Doc	Texas A&M University	
Birkhauser	Gerard	3, AEZ	Student, PhD	Washington State University	
Bolton	Ron	3	Technical Support	Washington State University	
Bonilla	Rodrigo	3	Technical Support	Washington State University	
Bosque-Pérez	Nilsa A.	5	PI	University of Idaho	
Bowers	Michael	N/A	Director	NIFA	
Boylan	Ryan	2	Student, MS	University of Idaho	
Brooks	Erin	2, 3	PI	University of Idaho	
Brown	David	2, 3	Collaborator	Washington State University	
Brown	Tabitha	3, 7, AEZ	Student, PhD	Washington State University	
Bull	Brad	3	Technical Support	University of Idaho	UI Farm Manager
Bullion	Elissa		Student	Washington State University	
Burke	Ian	5	PI	Washington State University	Obj. 5 Lead

Last Name	First Name	Objective	Role	Institution or Organization	Comments
Burkum	Kelsey		Student, Intern	Oregon State University	
Calmer	Rachel		Technical Support	Oregon State University	
Capalbo	Susan	1, 4, AEZ, LCA	PI	Oregon State University	Institutional Lead
Carlson	Bryan	LCA	Technical Support	Washington State University	
Carter	Arron	3	Faculty	Washington State University	
Cavalieri	Ralph		Student	Washington State University	Data Manager
Chen	Yunguang		Student, PhD	Oregon State University	
Chi	Jinshu	2	Student, PhD	Washington State University	
Cochran	Rebecca	3	Staff	USDA - ARS	
Collins	Hal	3	Faculty	USDA - ARS	
Daley-Laursen	Steven B.	N/A	Collaborator	University of Idaho	
Daley-Laursen	Dianne	8	Staff	University of Idaho	Project Manager
Diebel	Penelope (Penny)	4	Staff	Agricultural and Resource Economics	
Donlon	Hilary	4	Student, MS	University of Idaho	
Eigenbrode	Sanford	1,3,5,6,7,8, AEZ	PI	University of Idaho	Project Director
Elliot	Kristopher	6	Student, PhD	Oregon State University	Degree Completed
Esser	Aaron	3	PI	Washington State University	Extension Specialist
Fenton	Kurtis		Technical Support	Washington State University	
Fowler	Ames	5	Student, Intern	University of Idaho	
Gessler	Paul	1, 6, 7, 8	PI	Forest Ecology and Biogeosciences	Obj. 8 Lead
Gollany	Hero T.	3	Researcher	USDA - ARS	
Gourlie	Jennifer	3	Staff	Oregon State University	
Graves	Laurel	2	Student, Intern	Washington State University	
Hammac	Ashley	3, 6	Student, MS	Washington State University	
Hancock	Laura	5	Student, Intern	University of Idaho	

Last Name	First Name	Objective	Role	Institution or Organization	Comments
Hanhan	Nadine		Student	Oregon State University	
Harsimran	Kaur	3	Student, PhD	Washington State University	
Hasart	Brandon	3	Student	Washington State University	
Hatfield	Stacy		Student, Intern	Oregon State University	Moved
Heinse	Robert	3	Staff	University of Idaho	
Henshaw	Donald	8	Collaborator	Forest Service LTER	
Houston	Laurie	1, 4	Staff	Oregon State University	
Huggins	David	1, 2, 3, 7, AEZ	PI	USDA-ARS	AEZ Team Lead, USDA - ARS Lead
Hughes	Megan	3	Student	Washington State University	
Hulbert	Scot	3	Staff	Washington State University	
Iqbal	Singh Aujla	3	Student, PhD	Washington State University	
Jacobsen	Erling		Faculty	Sherman Station	
Jacobsen	John	3	Technical Support	Washington State University	
Jenck	Stephanie	3	Student, Intern	Washington State University	
Jinshu	Jackie	6	Student	Washington State University	
Jirava	Ron	3	Collaborator	Collaborator	
Johnson-Maynard	Jodi	3, 5, 6	PI	University of Idaho	Obj. 6 Lead
Kane	Stephanie	4	Faculty	University of Idaho	Moved
Kantor	Sylvia	7	Staff	Washington State University	
Kelley	Chris	2	Student, PhD	Washington State University	
Kostyanovsky	Kirill	2	Student, P. Doc	Washington State University	
Kruger	Chad E.	2, 3, 7	PI	Washington State University	Obj. 7 Lead
Lach	Brian	5	Student, Intern	University of Idaho	
Lamb	Brian K.	1, 2	PI	Washington State University	Obj. 2 Lead
Lawrence	Nevin	5	Student	Washington State University	

Last Name	First Name	Objective	Role	Institution or Organization	Comments
Leslie	Ian	3, 5	Staff	University of Idaho	
Li	Sihan	1, 6	Student	Oregon State University	
Machado	Stephen	3, 5, 6	PI	Oregon State University	
Madsen	Isaac	3	Student, PhD	Washington State University	
Martin	Tim	N/A	Collaborator	University of Florida	
McCellan	Tai	3, 6	Student, PhD	Washington State University	
McGrew	Larry	3	Technical Support	Washington State University	
Meyer	David	7	PI	Boise State University	Project Evaluator
Morrow	Jason	3, AEZ	Student, MS	Washington State University	
Morton	Lois	N/A	Collaborator	Iowa State University	
Mote	Philip	1, 2	PI	Oregon State University	
Mu	Jianhong (Elena)	1	Student, P. Doc	Oregon State University	
Mwenji	Jolene	3	Staff	Washington State University	Moved
Nelson	Roger L.	1	Student, Undergrad	Washington State University	
Novak	Kayla		Student, Intern	Oregon State University	
O'Keeffe	Patrick		Staff	Washington State University	
O'Rourke	Michael	1, 6, 9	Faculty	University of Idaho	
Painter	Kate	4	PI	University of Idaho	WSU Lead, Obj. 3 Lead
Pan	Bill	2, 3, 7, AEZ	PI	Washington State University	
Paulitz	Timothy C.	5	PI	USDA-ARS	Obj. 7 Lead
Pauly	Skye	AEZ	Student, Intern	Washington State University	
Pecharko	Mike	3	Staff	Washington State University	
Perkins	Jeff	3, AEZ	Technical Support	Washington State University	
Petrie	Steven	3, 7	PI	Oregon State University	
Pierzchanowski	Lenea	N/A	Staff	University of Idaho	Moved

Last Name	First Name	Objective	Role	Institution or Organization	Comments
Polumsky	Wayne	3	Technical Support	Oregon State University	
Pressley	Shelley	2	Faculty	Washington State University	
Pritchett	Larry		Faculty	Oregon State University	
Quick	Rich	3	Staff	USDA - ARS	
Ramaswamy	Sonny	N/A	National Director - NIFA	Oregon State University	
Reimer	Jeffrey	1, 4	PI	Oregon State University	
Rhinhart	Karl	3	Technical Support	USDA - ARS	
Rivera	Chon	3	Technical Support	Washington State University	
Roe	Dennis	3, 4	Technical Support	WSU - UI	President PNDSA
Rumph	John	3	Technical Support	Washington State University	
Rupp	David		Faculty	Oregon State University	
Rupp	Richard	1, 2, 3, 8, AEZ	PI	Washington State University	
Sawadgo	Wendiam	3	Staff	Washington State University	
Schiek	Benjamin		Staff	Oregon State University	
Schillinger	Bill	3, 7	PI	Washington State University	
Schimpf	Mark	3	Student, MS	University of Idaho	
Schofstoll	Steve	3	Technical Support	Washington State University	
Seamon	Erich	8	Staff	University of Idaho	
Seavert	Clark	1, 4	PI	Oregon State University	
Seyfried	Georgia	5	Student, Intern	University of Idaho	
Sharp	Darrin		Faculty	Oregon State University	
Sharratt	Brenton	2, 3	Faculty	USDA-ARS	
Silva	Monica	3	Technical Support	Washington State University	
Sitz	Tasha		Student, Intern	Oregon State University	
Sloot	Ron	3	Technical Support	Washington State University	

Last Name	First Name	Objective	Role	Institution or Organization	Comments
Spence	Anthony	3	Technical Support	Washington State University	
Stevenson	John		Staff	Oregon State University	REACCH Data Manager
Stöckle	Claudio O.	1, 2, 3, AEZ	PI	Washington State University	LCA Lead
Swan	Michael K.	3	Faculty	Washington State University	
Tedrow	Linda	8	Staff	University of Idaho	
Thorgersen	Paul		Staff	Pendleton Station	
Uberuaga	Dave	3	Technical Support	USDA - ARS	
Umiker	Kari		Staff		
Unger	Rachel	3, AEZ	Student, PhD	Washington State University	Hired as faculty RA
Urban	Linda	All	Student, MS	Boise State University	Ethnography
Velez	Jonathan	6	PI	Oregon State University	
Vickers	Dean		Faculty	Oregon State University	
Walden	Von	1, 2, AEZ	PI	University of Idaho	
Waldo	Sarah	2, 6	Student, PhD	Washington State University	
Waller	Clayton	3	Technical Support	Washington State University	
Walsh	Chelsea	5	Student, MS	University of Idaho	
Warriner	Cindy	3	Technical Support	Washington State University	
Wessel	Meghan	3	Student, MS	Washington State University	
West	Tyler	4	Student, Intern	Oregon State University	
White	Troy	6	Student, PhD	University of Idaho	
Wiggins	Seth	6	Student	Oregon State University	
Wolf	Kattlyn	6	PI	University of Idaho	
Wu	Ying	5	Staff	University of Idaho	
Wulfhorst	J.D.	4	PI	University of Idaho	
Yorgey	Georgine	7	Staff	Washington State University	

Last Name	First Name	Objective	Role	Institution or Organization	Comments
Young	Lauren	3	CS Coordinator	Washington State University	Obj. 3 Coordinator
Young	Frank	3	Technical Support	USDA - ARS	
Zaher	Usama	1	Staff	Washington State University	
Zhang	Hongliang	1	Student, PhD	Oregon State University	

Stakeholder Advisory Committee					
Last Name	**First Name**	**Objective**	**Role**	**Institution or Organization**	**Comments**
Barton	Dave	N/A	SAC	Grower	
Binns	Patrick	N/A	SAC	Westbrook Associates LLC	
Brogoitti	Lori	N/A	SAC	Pacific Northwest Direct Seed Company	
Campbell	Steve	N/A	SAC	USDA - NRCS	
Chatelain	Jeron	N/A	SAC	Limagrain Cereal Seeds	
Christensen	Sally	N/A	SAC	Oregon Wheat Growers League	
Cook	Kirk	N/A	SAC	State of Washington	
Dailey	Patricia	3, 7	SAC	Idaho Wheat Commission	
Davis	Berk	N/A	SAC	Pacific Northwest Direct Seed Company	
Diaz	David	N/A	SAC	The Climate Trust	
Erickson	Tracy	N/A	SAC	Washington Assoc. Cons. Districts	
Fitzgerald	Jim	N/A	SAC	Far West Agribusiness Association	
Flory	Bill	N/A	SAC	Idaho Wheat Commission	
Hawkins	Tanner	N/A	SAC	Oregon Wheat Growers League	
Hennings	Curtis	3	SAC	Grower	
Hogen	Mark	N/A	SAC	State of Idaho	
Hudson	Kevin	N/A	SAC	CTUIR	

Last Name	First Name	Objective	Role	Institution or Organization	Comments
Jones	Rick	N/A	SAC	Pacific Northwest Direct Seed Company	
Jones	Travis	3, 7	SAC	Idaho Grain Producers	
Lang	Mary Beth	N/A	SAC	State of Washington	
Mazza	Patrick	N/A	SAC	Climate Solutions	
Meyer	Kay	N/A	SAC	Pacific Northwest Direct Seed Company	PNDSA Executive Director
Morscheck	Fred	N/A	SAC	McGregor Company	
Newtson	Jeff	N/A	SAC	Oregon Wheat Growers League	
Page	Stephanie	N/A	SAC	State of Oregon	
Palmer Sullivan	Mary	N/A	SAC	Washington Grain Alliance	
Peterson	Jim	N/A	SAC	Limgrain (Wheat Research)	
Pollard	Jennifer	6	SAC	Genesee High School	
Poore	Joel	N/A	SAC	NRCS	
Powell	Walter		SAC	Oregon Wheat Growers League	Board of Directors
Rowe	Blake	3, 7	SAC	Oregon Wheat Growers League	
Sheffels	Mark	4, 5	SAC	PNW Direct Seed Association	
Simpson	Tana	N/A	SAC	Oregon Wheat Commission	
Vitale	Ben	N/A	SAC	The Climate Trust	
Wilson	Cathy	N/A	SAC	Idaho Wheat Commission	
Wittman	R.L. (Dick)	N/A	SAC	Wittman Farms/Consulting	
Zahl	Jerry	3, 7	SAC	Pendleton Station	
Zenner	Russ	3, 7	SAC	Grower	

Scientific Advisory Panel					
Last Name	**First Name**	**Objective**	**Role**	**Institution or Organization**	**Comments**
Asseng	Senthold	N/A	SAP	University of Florida	
Baker	Matt	N/A	SAP	Texas Tech University	
Garrett	Karen	N/A	SAP	Kansas State University	
Howitt	Richard	N/A	SAP	University of CA, Davis	
Robertson	Phil	All	SAP	Michigan State University	

Linkages and Partnerships

REACCH is one of many projects *regionally, nationally and internationally* working on aspects of agricultural sustainability and climate change. Our aim is to extend our impact and make the most efficient use of resources through partnering at all three levels.

> *"REACCH is extending its impact to make the best use of its resources through partnering."*

Regional partner projects. We have established a close linkage with the Site-Specific Climate Friendly project supported by a USDA-NIFA grant led by Dr. David Brown (Crop & Soil Sciences) at Washington State University. The detailed treatment experiment using a large array of enclosure chambers was a collaborative effort where both projects contributed equipment to the study. Soil C/N, soil moisture, and water samples are also shared between both projects allowing for a much more detailed understanding C/N cycling at the Cook Agronomy Farm. We have also collaborated with three graduate students working in the WSU Geologic Sciences department under the direction of Dr. C.K. Keller. This linkage has opened doors to better understand the subsurface transport of C and N through improved spatial and temporal sampling of both subsurface tile line measurements and shallow well water samples.

REACCH is also partnering with other funded projects in the region. Objective 3 is linked to the following funded projects: NSF NSPIRE, Washington Biofuels Cropping Systems (WBCS) Project, EPA RARE, NSF Igert at WSU and UI, Idaho EPSCor, the Oregon Climate Change Research Institute (OCCRI) the Northwest Regional BioCarbon Initiative, the PNW Climate Impacts Consortium, and USDA STEEP. In addition, we are collaborating in our outreach efforts with the Pacific Northwest Direct Seed Association, Far West Agribusiness Association, Washington Depts. of Agriculture and Commerce, EPA Region 10, regional precision agriculture equipment dealers, Climate Solutions. Research Project (OFOOT) led by Dr. Lynne Carpenter-Boggs (WSU) has many similar objectives as REACCH, but focused on organic farming systems. We continue to work on the OFOOT project and with WA grower participants to assess GHG footprints.

This year we partnered with the NASA-funded ICE-Net Project (Anne Kern, University of Idaho, Directing), focused on K-12 climate change education, to coordinate our teacher workshops. The NW Climate Science Center includes education aspects and may be a potential partner in the future. The REACCH education coordinator attended the NW Climate Science Center boot camp this year. Members of the Education Objective Team also worked with a Boise State PhD student to design an assessment protocol for the graduate student retreat. Eigenbrode, Capalbo and Johnson-Maynard from the team are coauthors with Chad Kruger on a chapter on climate change and NW agriculture to be published early next year by Sage Press. The chapter will appear in a volume co-edited by Phil Mote, REACCH member and director of the Oregon Climate Change Institute and Amy Snover, director of the Climate Impacts Group (CIG) headquartered at the University of Washington.

REACCH works with several organizations to extend our technology capabilities, including:

- Central Desktop, Inc. (Intranet collaboration portal services)
- ESRI, Inc. (geospatial software)
- Inside Idaho (Idaho statewide geospatial support services)
- Northwest Knowledge Network (NKN - University of Idaho technology research group)
- National Oceanic and Atmospheric Association (NOAA – collaborating on metadata and data discovery tools)
- FME, Inc. (metadata/data transformation tools)
- GoToMeeting, Inc. (virtual meeting collaboration)
- University of Idaho Library (metadata management, metadata services)
- IRON, the Idaho Regional Optical Network to facilitate advanced networking among institutions in Idaho and the Northern Tier States.

Individual investigators in the region. REACCH seeks to provide a framework for collaboration by scientists and educators who are not directly funded by REAACH but can work within our teams, or take advantage of our infrastructure, models and climate products. This year, the Objective 5 team (Biotic Factors) welcomes David Crowder (assistant professor of Entomology at WSU) and his student. Dr. Crowder's interests include wireworm ecology and management and community ecology of insects associated with cropping systems. He brings expertise in landscape ecology and biological control in Washington state crops. Objective 2, Monitoring, partnered with Lee Veirling, UI College of Natural Resources and his PhD student Troy Magney, on determining crop structure and physiological function using LiDAR and narrowband remote sensing on REACCH experiment field sites.

National partners. REACCH continues to work closely with the other two large NIFA Climate Change in Agriculture Projects, PINEMAP and Sustainable Corn. The partnership includes regular meetings by project directors to improve project management. This has resulted in a presentation to the Tri-Societies Annual Meeting (Wright Morton et al. 2012) about project integration. Our sociologists (Wulfhorst, Bernacchi) collaborated on survey design with the Sustainable Corn project, which will provide opportunities to compare responses from producers in the Midwest and our region concerning climate related issues. During Years 1 and 2, teleconferences were held within respective roles across the three NIFA CAP projects. REACCH, CSCAP, and PINEMAP Project Directors, Project Managers, and Project Evaluators have used these conversations to share project management practices and insights. In addition to bi-monthly evaluator meetings with the CSCAP, the project evaluators from NIFA's REACCH and PINEMAP Projects (David Meyer and Wendy-Lin Bartels, respectively) have held additional meetings discussing evaluation strategies for large-scale research projects based on qualitative, quantitative, and social network approaches.

REACCH is partnered with the NSF funded Toolbox project at the University of Idaho. Toolbox will develop customized modules for our project that are designed to improve communication and collaboration among interdisciplinary scientists.

REACCH is just beginning to develop collaborations with NIFA-funded Triticeae Coordinated Agricultural Project (T-CAP), which is a national network focused on developing new varieties of wheat and barley. Among the important goals of T-CAP are drought and heat tolerance and nitrogen use efficiency. Goals also include biotic stresses, such as stripe rust for the PNW. Partnerships developing include seeking additional funding to work on insect responses to drought and heat tolerant lines, collaboration on some aspects of graduate education, adding dimensions to our communications with shared stakeholders, and others. Arron Carter, wheat breeder at WSU is the REACCH T-CAP liaison.

International partners and collaborations
John Antle and Claudio Stöckle are members of the AgMIP with other climate impact assessment projects in North America, Africa, and South Asia. This group provides linkage from REACCH to inform the Intergovernmental Panel on Climate Change (IPCC), the leading international body for the assessment of climate change, and the general public of the potential impacts of climate change on agriculture in the US and around the world.

International collaborations by the AEZ Team have been initiated with scientists from China, scheduled to result in a manuscript on soil C sequestration due to crop residue incorporation throughout China is expected to be submitted by the end of 2012. An extended visit by a Chinese soil scientist will take place in 2013 to explore mutual scientific research interests in soil C and N cycling in agricultural systems.

The techniques and modeling used in our *Fusarium* paper are being extended to model the distribution of Australian cereal root pathogens by Dr. Grant Poole, South Australia Research and Development Institute. Dr. Paulitz from Objective Team 5 spent three months in Western Australia conducting a survey of *Rhizoctonia* pathogens from cereals, which could also be modeled with climate data.

Leveraging REACCH funding

Leveraged funding includes previously funded projects with which REACCH is partnering, funding that has been procured or is being solicited in part because of the resources and capabilities provided by REACCH.

Previously funded projects now linked to REACCH

Washington Grain Alliance funding for downy brome control used to cover REACCH graduate Student prior to starting on REACCH funds, generate control information based on GDD ($12,000), Burke.

Cook Agronomy Farm Fellowship ($15,000) Used to monitor weeds and understand nitrogen cycling on the Cook Farm. Data will be entered into REACCH database, Burke.

Legume Virus Project (AFRI RAMP) pea aphid monitoring effort has been used to develop approaches for future efforts to model and monitor cereal aphids ($5000), Eigenbrode.

NSPIRE support for 4 PhD students for 2 years each: $400,000 total; WBCS ($400,000/year), EPA RARE, Lamb and others.

US Dairy Adoption of Anaerobic Digestion Systems Integrating Multiple Emerging Clean Technologies: Climate, Environmental, & Economic Impacts. USDA NIFA AFRI (2012). $749,920. Co-Lead PI, Kruger.

PMU: WSC-Category 3: Watershed Integrated System Dynamics Modeling (WISDM): Feedbacks among biogeochemical simulations, stakeholder perceptions, and behavior. USDA NIFA. $1,495,640. Co-PI, Kruber.

BioEarth: Understanding Biogeochemical Cycling in the Context of Climate Variability Using a Regional Earth System Modeling. NSF EaSM / USDA NIFA (2011). $3,052,999. Co-PI, Kruger.

Life-cycle Analysis of Pacific Northwest Feedstocks for Biofuel Production. US EPA RARE Program (2011). $77,265. Kruger

Waste to Fuels Technology – 2011-2013. Washington State Department of Ecology. $225,000. Kruger

Columbia River Basin Water Supply Investment Plan: A Strategy to Develop Water Supply to Meet Water Demand Needs through 2030. $974,080. Washington State Department of Ecology. Co-PI, Kruger.

Needs Assessment: What is the state of knowledge of private forest landowners regarding global climate change and the impacts to western forests? USFS Pacific Northwest Research Station. $75,000, Kruger

Site-Specific Climate Friendly Farming™, USDA AFRI 2010, Climate Change Program, Standard Grant. $4.62 million, David Brown and others.

Straw Management and Crop Rotation alternatives to Stubble Burning: Assessing Economic and Environmental Trade-offs. WA Dept. of Ecology project for developing alternatives to straw burning. $92,000.

Role of Mixed Crop-Livestock Systems in Transitioning to Dryland Organic Farming in the Pacific Northwest. USDA-NIFA Organic Transitions. $695,000.

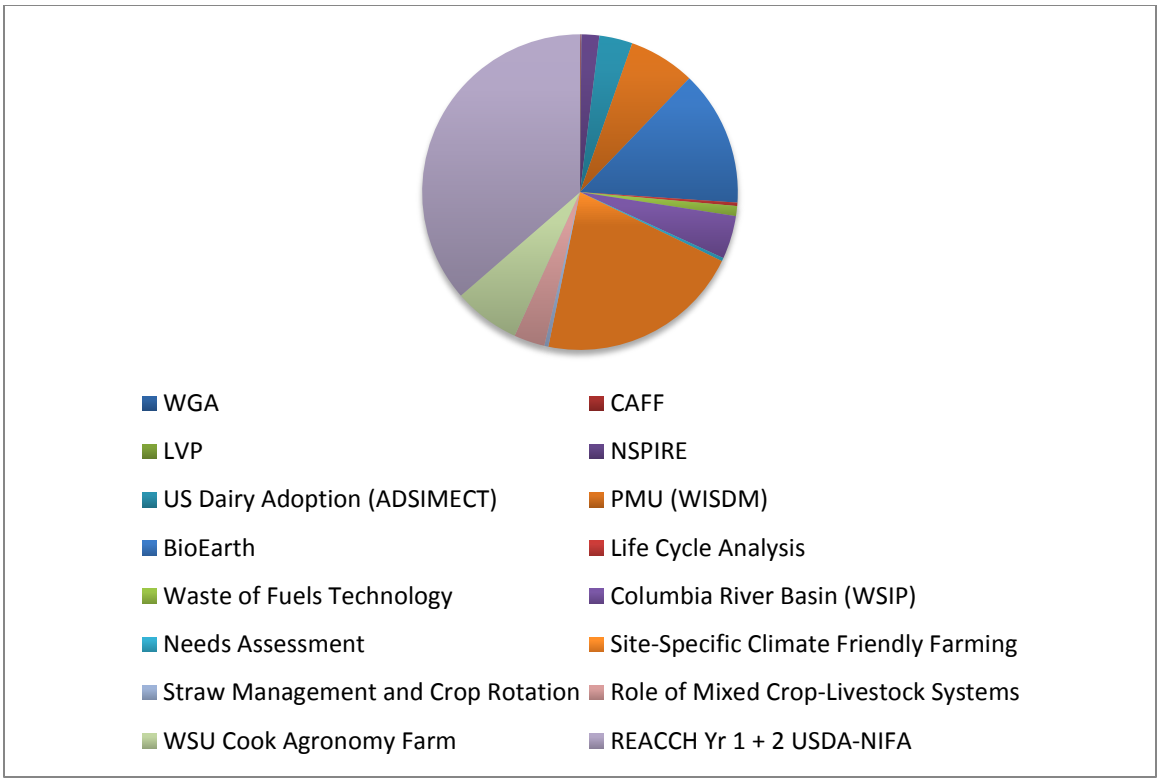

Figure D1. REACCH leveraging with existing projects, $13,988,904

REACCH data management leveraging

Use of virtual server management for technology processing from NKN which allows; REACCH to use funding for areas other than server purchases;

Use of Inside Idaho for reduced cost GIS server software access; and

Use of NKN for data storage efforts in a distributed fashion, with replication to the Idaho National Laboratory (INL).

Projects funded since 2011 in part due to the REACCH partnership

The WSU Cook Agronomy Farm (CAF) was selected in 2012 by the USDA-ARS, with Dr. Huggins as the Principle Investigator, as one of ten initial Long-Term Agroecological Research (LTAR) sites of a national network. A presentation on the CAF LTAR including elements of AEZ was presented at the LTER all-scientist meeting in Estes Park, CO. This was augmented by a two-day meeting with scientists at NEON headquarters in Boulder, CO.

The Organic Footprints Carbon Sequestration, Nutrient Bioavailability, and Environmental Services from Organic Agriculture, USDA NIFA Organic Ag. $1.5 million.

Proposals submitted with links to REACCH

NSF-REU proposal was submitted for funding. The proposed project takes advantage of REACCH infrastructure and, if funded, will allow the expansion of our undergraduate internship program. Johnson-Maynard.

NSF-SEE proposal to support work on interactions between climate and insect responses to drought and heat-resistant wheat lines. Seth Thomas with Eigenbrode.

USA Dry Pea and Lentil Council. Proposed project will extend monitoring for pea aphids and virus.

Specialized Acronyms and Definitions used in this Report

ACD	Annual Crop – Dry
ACFT	Annual Crop - Fallow – Transition
ACWC	Annual Crop - Wet - Cool
ACWCd	Annual Crop - Wet - Cold
AE	Agro-ecozone
AEZ	Agro-ecological Zone
AG-8	Anastomosis Group #8
AgMIP	Agricultural Model Inter-comparison and Improvement Project
AgriMet	Pacific Northwest Cooperative Agricultural Weather Network
AgWeatherNet	Washington Agricultural Weather Network
APS	Agricultural Producers Survey
ART	Agroecosystem Research Trial
ASA	American Statistical Association
ASABE	American Society of Agricultural And Biological Engineers
ATLS	autonomous terrestrial laser scanner
Biotic	Of or having to do with life or living organisms
BCSD	Bias Corrected Statistical Downscaling
BSWE	Biological Systems and Water Engineering
C	Carbon
CAEP	Center for Agricultural and Environmental Policy
CAF	Cook Agronomy Farm
CAP	Climate Agricultural Project
CART	Classification and Regression Tree
CBARC	Columbia Basin Agricultural Research Center
CD	Central Desktop
CDL	Cropland Data Layer
CEE	Civil and Environmental Engineering (WSU)
CEREO	Center for Environmental Research, Education & Outreach
CH_4	Methane
CF	Conventional Fallow
CFF	Climate Friendly Farming
CFM	Compact Flash Memory Card
CGE	Computable General Equilibrium framework
CLB	Cereal Leaf Beetle *(Oulema Melanopus)*
CLIMEX™	Climate Change Experiment
CM	Climate Model Group
CMIP5	Coordinated Model Inter-Comparison Project 5
C0	Carbon Monoxide
CO_2	Carbon Dioxide
ConsT	Conservation Tillage
CR	Residue Management
CropSyst	Cropping Systems Simulation Model
CRP	Conservation Reserve Program
CRU	Climate Research Unit

CS	Cropping Systems
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSSA	College Student Services Administration
CT	Conventional tillage
CUAHSI HIS	Consortium of Universities for the Advancement of Hydrologic Science, Inc.
CW	Continuous Cereal
D	Deliverable(s)
DataONE	Data Observation Network for Earth
DEM	Digital Elevation Model
DNA	Deoxyribonucleic acid
DOC	Dissolved Organic Carbon
DOE	Department of Energy
DS	Direct Seed
EaSM	Earth Systems Model
EC	Eddy Covariance
Eca	Electrical Conductivity
El	Eco-Climate Index
EPA	Environmental Protection Agency
ERA -ECMWF	European Centre for Medium Range Weather Forecasts
FOI	Freedom of Information
FWAA	Far West Agribusiness Association
GCAM	Global Change Assessment Model
GCM	Global Climate Model
GDD	Growing Degree Day
GF	Grain Fallow
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GLM	Generalized Linear Model
GMC	Global Climate Model
GP	Grass Pasture
GPS	Global Positioning System
GPS	General Population Survey (OBJ 4)
ha	Hectare (10,000 square miles or 2.47 acres)
H_2O	Water
HPC	High Performance Computing
HTTP	Hypertext Transfer Protocol
HPC	High Performance Computing
HTTP	Hypertext Transfer Protocol
HW	Hard Wheat
Hz	Hertz
I	Irrigated
ICE-Net	Intermountain Climate Education Network
IGERT	Integrated Graduate Education And Training Research
INL	Idaho National Lab
INW	Inland Northwest

IPCC	Intergovernmental Panel on Climate Change
IRB	Institutional Review Board
IRGA	Infrared Gas Analyzer
IRON	Idaho Regional Optical Network
KBS	Kellogg Biological Station
Km	Kilometer
LCA	Life Cycle Assessment
LDAP	Lightweight Directory Access Protocol
LTE	Long Term Evolution
LTER	Long-Term Ecological Research Site
LS	Longitudinal Survey
Lysimeter	A device for measuring water percolation through soil
MACA	Multivariate Adaptive Constructed Analog
M	Milestone(s)
MLRA	Major Land Use Areas
MOU	Memorandum of Understanding
MS	Master of Science degree
N	Nitrogen
N_2O	Nitrous Oxide
NARCCAP	North American Climate Change Assessment Program
NASA	National Aeronautics and Space Administration
NASS	National Agricultural Statistics Service
NCAP	National Center for Environmental Prediction
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NetCDF	Network Common Data Form
NGO	Non-governmental organization
NKN	Northwest Knowledge Network
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NSF	National Science Foundation
NSF EPSCoR	NSF Office of Experimental Program to Stimulate Competitive Research
NSF LTER	NSF Long Term Ecological Research Network
NSPIRE	Nitrogen Systems Policy-Oriented Integrated Research & Education
NT	No Till
NAT	Native Agroecosystem Trial
NTC	No Till Cereal
NTL	No Till Legume
NW CSC	Northwest Climate Science Center
NW-RBI	Northwest Regional Biocarbon Initiative
OAT	Organic Agroecosystem Trial
OPeNDAP	Open Source Project for a Network Data Access Protocol
OCCR1	Oregon Climate Research Institute

OSU	Oregon State University
P	Phosphorus
PAT	Perennial Agroecosystem Trial
PC	Particulate Carbon
PCFS	Palouse Conservation Field Station
PCR	Polymerase Chain Reaction
Phenology	Science of relations between climate and biological phenomena
pH	Acidity or Basicity of an Aqueous Solution
PI	Principle Investigator
PNA	Pacific Northwest Agriculture
PNDSA	Pacific Northwest Direct Seed Association
PNW	Pacific Northwest
PPT	Precipitation
PRISM	Climate Group Highest-Quality Spatial Climate Gridded Data, Oregon State University
QA	Quality Analysis
RAP	Representative Agricultural Pathway
RP	Representative Concentration Pathways
RCP4.5 IPCC	Representative Concentration Pathway 4.5
RCP8.5 IPCC	Representative Concentration Pathway 8.5
REACCH PNA	Regional Approaches to Climate Change in Pacific Northwest Agriculture
REU	Research Experience for Undergraduate
RISA	Regional Integrated Sciences and Assessments
S	Sulfur
SAS	Statistical Analysis System
SBS	School of Biological Sciences (WSU)
SAC	Stakeholders Advisory Committee
SAF	Safflower
SAFN	Sustainable Aviation Fuels Northwest
SAP	Scientific Advisory Panel
SARE	Sustainable Agriculture Research Education
SAS	Statistical Analysis Systems
SB	Spring Barley
SCF	Site-Specific Climate Friendly Farming
SDE	Staff Development for Educators
SF	Summer Fallow
SI	Suitability Index
SLA	Service Level Agreement
SNA	Social Network Analysis
SOC	Soil Organic Carbon
SOP	Standard Operating Procedures
SP	Spring Pea
SPSS	Statistical Package for the Social Sciences
SRN	Sustainable Research Networks
SSP	Shared Socio-economic Pathway

SSSA	Soil Science Society of America
STATSGO	State Soil Geographic Database
STEEP	Solutions to Environmental and Economic Problems
SW	Spring Wheat
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TCAP	Triticeae Climate Agricultural Project
TF	Tillage Fertility
THREDDS	Thematic Realtime Environmental Distributed Data Services
Tmax	maximum temperature
Tmin	minimum temperature
TOA-MD	Tradeoff Analysis Model for Multi-dimensional Impact Assessment
TOC	Total Organic Carbon
UCAR	University Consortium for Atmospheric Research
UI	University of Idaho
USDA	United States Department of Agriculture
USDA ARS	United States Department of Agriculture Agricultural Research Service
USDA NIFA	United States Department of Agriculture National Institute of Food and Agriculture
USGS	United States Geological Survey
VPR	Vice President of Research
WBCS	Washington Biofuels Cropping System
WCS	Web Coverage Service
WEPP	Water Erosion Prediction Project
WF-1	Preliminary analysis of wheat-fallow system
WMS	Web Map Service
WP	Wheat/Pea
WSDA	Washington State Department of Agriculture
WSU	Washington State University
WW	Winter Wheat
YM	Yellow Mustard

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