

# **ANNUAL REPORT OF ACCOMPLISHMENTS AND RESULTS**

**Agricultural Research Center**

**College of Agricultural, Human, and Natural Resource Sciences**

**Washington State University**

**Pullman, Washington**

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**October 1, 2005 to September 30, 2006**

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## SECTION I

### INTRODUCTION

The Agricultural Research Center (ARC) (state agricultural experiment station) College of Agricultural, Human, and Natural Resource Sciences (CAHNRS), Washington State University (WSU) chose to submit an individual Plan of Work (POW) rather than a joint plan with Cooperative Extension (CE) at WSU. Therefore, the contents of this Annual Report (October 1, 2005 – September 30, 2006) are for ARC only.

The ARC chose to develop the POW within the framework of the institutional strategic plan [1997-2002]. The Annual Reports of the individual units, which constitute Section II of this report, are built around their corresponding components of the WSU Strategic Plan and the 2001 and 2005-06 revised Plans of Work.

Each of the following units of CAHNRS were designated as a "program unit", each of which has one or more planned research programs addressing issues important to one or more components of the agricultural industry of the State of Washington.

#### **Program Planning Units**

Animal Sciences  
Biological Systems Engineering  
Community and Rural Sociology  
Crop and Soil Sciences  
Entomology  
Food Science and Human Nutrition  
Horticulture and Landscape Architecture  
Natural Resource Sciences  
Plant Pathology  
School of Economic Sciences  
Statistics

#### **Special Program Units and Institutes**

Center for Precision Agricultural Systems  
IMPACT Center  
Institute of Biological Chemistry  
Veterinary Medicine - Field Disease Investigation Unit  
Wood Materials Engineering Lab

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## **CERTIFICATION**

I, signed By Ralph P. Cavalieri, Ralph P. Cavalieri, Associate Dean, College of Agricultural, Human, and Natural Resources, and Director, Agricultural Research Center, do hereby certify that this Annual Report of Accomplishments and Results constitutes official submission of all required reports.

## **ANNUAL REPORT PREPARATION**

In the preparation of this report department chairpersons and research directors have provided the bulk of the information based on their respective portions of the revised POW. Their reports include research results and impacts benefiting stakeholders and members of the scientific community on research programs (projects), which were active at the time of preparation of the Washington State University Agricultural Research Center Plan of Work.

Individual unit expenditure data was taken from the CRIS AD419 report.

## **PLAN OF WORK UPDATE**

After the first Plan of Work Report was submitted in April, 2001, it became apparent from the instructions and key theme categories received from CSREES that an update/revision of the ARC POW was desirable. Accordingly, an update to the original five-year plan of work was prepared and submitted to the USDA-CSREES on July 2, 2001. A second revision to the Plan of Work for 2005-2006 was submitted on April 1, 2004. Preparation of the update included new research projects and shifted selected projects to their related federal goals. The revision more accurately reflects the research being performed under the auspices of the ARC.

## **RESEARCH FUNDING**

In federal FY2006, the ARC received and expended \$2,016,616.15 in Hatch funds and \$1,557,373.68 in Hatch Multistate Research funds.

Hatch and Hatch Multistate Research funds constitute 4.10 % and 3.17 %, respectively, of the total funds expended on Agricultural Research Center (ARC) projects. State appropriations are 45.21 % of the total with all other grants totaling 37.05 %.

Hatch Multistate Research funds are expended exclusively in support of approved Multistate Research Fund projects, Multistate Research Coordinating Committee projects, and partial support of faculty and staff salaries, goods and services, and travel on those projects.

Data extracted from the CRIS AD419 report documents the following total expenditures from various fund sources.

**EXPENDITURES FOR WSU AGRICULTURAL RESEARCH CENTER  
PROJECTS FEDERAL FY 2006**

Funding Source	CSREES Goals					Total	% of Totals
	1	2	3	4	5		
Hatch Funds	\$1,164,690.33	\$204,747.84	\$47,175.04	\$496,902.48	\$103,100.46	\$2,016,616.15	4.10%
Multistate Research Funds	\$917,577.89	\$386,536.25	\$17,128.03	\$232,971.40	\$3,160.11	\$1,557,373.68	3.17%
Federal Research Grants	\$3,445,273.27	\$63,012.20	\$59,596.90	\$1,267,935.40	\$0.00	\$4,845,817.77	9.85
State Appropriations	\$13,727,857.43	\$2,959,817.77	\$651,503.59	\$4,273,591.63	\$618,912.96	\$22,231,683.38	45.21
All Other Grants	\$11,455,903.87	\$1,923,425.05	\$125,516.20	\$4,437,150.50	\$280,055.90	\$18,222,051.52	37.05
Animal Health	0.00	11,656.00	0.00	0.00	0.00	11,656.00	0.02
McIntire-Stennis	172,863.70	0.00	0.00	119,792.05	0.00	292,655.75	0.60
<b>Totals</b>	<b>\$30,894,166.49</b>	<b>\$5,549,195.11</b>	<b>\$900,919.76</b>	<b>\$10,828,343.46</b>	<b>\$1,005,229.43</b>	<b>\$49,177,854.25</b>	<b>100</b>
Percentage of Total \$	62.82%	11.28%	1.83%	22.02%	2.04%	100.00	--
FTEs	292.97	71.27	6.35	114.06	9.71	494.36	--
Percentage of Total FTEs	59.26%	14.42%	1.28%	23.07%	1.96%	100.00%	--

## **SECTION II**

### **GOAL 1**

#### **AN AGRICULTURAL SYSTEM THAT IS HIGHLY COMPETITIVE IN THE GLOBAL ECONOMY**

##### **EXECUTIVE SUMMARY**

The majority of research performed in FY 2006 by faculty having appointments in the WSU Agricultural Research Center supports national **Goal 1**, “an agricultural system competitive in the global economy.” Early on, it was decided that in the face of diminishing state support, the focus of research in the WSU Agricultural Research Center would be on the food system of Washington and its stakeholders. Because the State is agriculturally diverse (over 250 different crops) the Plan of Work 1999-2004, its revision in 2001 and the new 2005-2006 extension of the Plan of Work have also focused on the food system. The new WSU and College Strategic Plans have also reinforced the “food systems” direction of our work. Within those plans there is a large focus on biotechnology and on natural resources and the environment, which necessarily places the ARC focus on goals I and IV of the USDA-CSREES National Plan. Although Eastern Washington is an area primarily devoted to large wheat farms and irrigated agriculture, an additional emphasis has been forming in the area of organic and sustainable agriculture and its profitability, primarily in Western Washington. Western Washington is home to an extraordinarily diverse agriculture in an expanding urban environment in which local food systems have become quite important. Washington State University and its research partners are gearing up to play a leading role in the nation’s efforts to develop clean and renewable bioenergy resources and technologies. Thus, the outcomes and impacts cited below emerge from the original POW and its revision as influenced by the strategic plans and the myriad of audiences the ARC serves. In this report, we cite impacts and outcomes by department. It is indeed evident that the departments and units are also focused on their goals as stated in the 1999 and in the 2001 and 2005-06 revised plans of work.

Certain impacts and outcomes achieved in 2006 under goal 1 were particularly noteworthy and included new thrusts in nutrient management by a number of departments and centers-- the Animal Sciences Department, Biological Systems Engineering and the IMPACT Center. There is an increased effort in the Biological Systems Engineering department in partnership with other units (under goals 1 and 4) to develop technologies and processes to convert a wide range of Washington-based biomass feedstocks to products and fuels. Examples include wheat straw, manure, food processing wastes, and biodiesel or fuel ethanol production residuals. The Anaerobic Digestion Team concluded that Washington State’s 250,000 dairy cows could, through anaerobic digestion of their manure, produce 50 megawatts of electricity as well as other valuable co-products. Joint efforts by Biosystems Engineers and Food Scientists are resulting in safer and tastier foods by using new preservation methods such as microwave and radiofrequency. The Department of Crops and Soil Sciences continues to develop, evaluate and release new germplasm and commercially competitive wheat and barley cultivars. For example, about 1.5 million acres of soft white winter wheat were grown in Washington in 2006, of which 62% were planted with WSU releases, producing a gross value of \$298 million dollars. . A new formulation (invented by a faculty member in Horticulture) when sprayed on apples prevents apples from becoming sunburned, saving Washington apple growers over \$30 million in the past three seasons. This research has led to the development of a new product that has promise in the reduction of cracking in cherries. The Institute of Biological Chemistry continues to make fundamental discoveries in plant biochemistry including measuring the energy budget of a plant, studying the control of heartwood formation in a tree, formulating the in vitro synthesis of the cancer drug taxol, elucidating the nutrient exchange pathways in one of the bacteria performing

nitrogen fixation, and discovering the immune defense and polypeptide signaling in plants. The Department of Plant Pathology continues to work on the taxonomy and control of fungi which damage Washington crops. The School of Economic Sciences has analyzed various invasive species management issues, and estimate the impact of an apple maggot spread to be in the multimillion dollar range. All in all, the researchers in the Agricultural Research Center are contributing to the knowledge base in agricultural and natural resource sciences.

## **DEPARTMENTAL REPORTS**

### **DEPARTMENT OF ANIMAL SCIENCES**

1. **WNP00181-Genetic variation in growth, carcass composition, quality and fatty acid composition of Wagyu, Angus and Wagyu-Angus cross cattle.**  
**WNPO00432- Pre and Post-Harvest Manipulation of Palatability, Appearance and Lipid Composition of Red Meat.**
  - A. **Key Theme:** Animal Production Efficiency.
  - B. **RPA 303:** Genetic Improvement of Animals; **RPA 307:** Animal Management Systems; and **RPA 308:** Improved Animal Products (Before Harvest).
  - C. **Project Description:** This project evaluates the potential for incorporating the genetic attributes of the Wagyu breed of beef cattle into domestic production systems to enhance marbling, tenderness and taste of beef.
  - D. **Impacts and Scope of Research:**
    - i) **Impact:** An improved, novel, and inexpensive of method of extracting and methylating fatty acids for quantitation using gas chromatography was developed and published. This methodology has widespread application in the animal and meat sciences and can be used on fresh, frozen or lyophilized tissues, oils, waxes and feedstuffs.
    - ii) **Scope:** International
    - iii) **Integration:** Overall project results are communicated to beef producers through extension personnel, however, the methodology development reported in this year's impact – does not have an extension component.
    - iv) No multi-state affiliation.
  - E. **Source of Funding:** Hatch, State, Industry donations, Wagyu Development Fund.
  
2. **WNP00374. Nutrient Management: Feeding for Reduced Excretion of Nutrients by Ruminants.**
  - A. **Key Theme:** Animal Production Efficiency.
  - B. **RPA 302:** Nutrient Utilization in Animals.
  - C. **Project Description:** This project identifies methodology to accurately quantify phosphorus excretion in cattle and applies those techniques to evaluate nutritional management strategies designed to reduce phosphorus excretion in dairy cattle.
  - D. **Impacts and Scope of Research:**
    - i) **Impact:** Management of dietary inputs of phosphorus in dairy cattle diets and methods to accurately assess phosphorus excretion rates are essential in developing comprehensive nutrient management plans for livestock operations.
    - ii) **Scope:** International
    - iii) **Integration:** Findings are being incorporated into recommendations made to producers by dairy extension personnel.
    - iv) No multi-state affiliation.
  - E. **Source of Funding:** Hatch, State, and Donated Industry Funds.

3. **WNP00627. Associations of the Basal Mitochondrial Transcription Machinery Genes with Marbling in Beef Cattle**
  - A. **Key Theme:** Animal Genomics.
  - B. **RPA 304:** Animal Genome.
  - C. **Project Description:** Three genes involved in promoting transcription initiation of the mitochondrial genome have been studied in association with marbling and sub-cutaneous fat depth in beef cattle.
  - D. **Impacts and Scope of Research:**
    - i) **Impact:** Marbling and sub-cutaneous fat depth are primary quantitative traits affecting carcass quality and production efficiency in beef cattle. This work provides important information on the role of the mitochondrial complex in influencing meat quality and potential to improve quality in the future.
    - ii) **Scope:** International
    - iii) **Integration:** Integration with Extension programming is not a part of this project at this time.
    - iv) **No multi-state affiliation.**
  - E. **Source of Funding:** Hatch, State, Industry donations.
  
4. **WNP08167. Emission Measurements of Ammonia, Methane, Nitrous Oxide and Particulates from Beef Production.**
  - A. **Key Theme:** Animal Production Efficiency and Biotechnology.
  - B. **RPA 307:** Animal Production Management Systems.
  - C. **Project Description:** This project applies flux measurement techniques to quantify emissions (NH<sub>3</sub>, N<sub>2</sub>O, CH<sub>4</sub>, and particulate matter) from ruminant concentrated feeding operations. Data collected allow evaluation and use of inverse dispersion models, and disjunct eddy accumulation techniques to measure emission fluxes.
  - D. **Impacts and Scope of Research:**
    - i) **Impact:** Science based models estimating emissions originating from livestock operations are essential components in the study of air quality. This project is contributing valuable data that incorporates animal, diet and management characteristics with real time emission measurements that are being used in emissions modeling.
    - ii) **Scope of Research:** International
    - iii) **Integration:** Information derived from this project is integrated with Extension activities and other nutrient management initiatives in which the investigators are involved. The direct involvement of the producer whose production facility is the site of data collection makes this research integrated with on-farm production.
    - iv) **No multi-state affiliation.**
  - E. **Source of Funding:** Hatch, State, NRI Competitive Grant.

#### **Department of Biological Systems Engineering**

1. **WNP00371: Studies of Using Microwave and Radio Frequency Energy in Food Safety, Phytosanitary and Quarantine Application.**
  - A. **Key Theme:** Food Safety.
  - B. **RPA 503:** Quality and Maintenance in Storing and Marketing Food.
  - C. **Description:** The goal of the project is to determine the effectiveness of a 915 MHz microwave sterilization system for food processing and for treatment of fruits and vegetables to kill insects. This year's progress is mostly in the area of microwave sterilization research. Specifically, with assistance from the Food Products Association Center for Northwest Seafood in Seattle, we have conducted microbial validation for several products, including salmon fillet in sauce, sliced beef in gravy and mashed



potatoes. We have extended computer simulation capacity to include coupled electromagnetic energy with heat transfer to guide system and process design. The research has also improved chemical marker/computer vision methods for detection of cold spots to ensure food safety in the microwave sterilization process and for future FDA approval processes. We obtained approval for a patent application on Oct. 11, 2006 that protects our invention of 915 MHz single-mode sterilization technology with the concept of phase shifts to improve heating uniformity.

**D. Impacts, Outcomes and Scope of Research:**

- i) Impacts of Research: Researchers have presented results to industry representatives and regulatory agencies at a national symposium on emerging technologies and received wide spread support for the work. Due to progress in the development and validation of chemical markers methods for cold spot determination and computer simulation models, and encouraged by pilot scale testing results, the industrial partners of the WSU Microwave Consortium (Tang as the Director) committed over \$300,000 in 2006 to develop a semi-continuous system for FDA approval.
- ii) Geographic Scope: The research is especially important in states such as Washington, Oregon, Alaska, and California that have substantial food canning and processing industries.
- iii) This project does not have research/extension integration.
- iv) This project is not affiliated with a multistate research committee.

**E. Source of Funding:** Hatch, Department of Defense, other federal funds, state appropriations, industry grants and agreements, and other non-federal funds.

**2. WNP00573: Physical Properties of Food Powders.**

**A. Key Theme:** Food Safety.

**B. RPA 501:** New and Improved Food Processing Technologies.

**C. Description:** The objective of the research is to develop a standardized method for the advances in understanding food powder physical and functional properties. The more specific objective of the project is to develop standards for the flowability of selected food powders and to disseminate these standards of physical and functional properties of food powders by short courses and workshops presented to scientists in government, academia, and industry.

**D. Impacts, Outcomes and Scope of Research:**

- i) Impacts of Research: The project has followed its 2005 publication of two books with a laboratory manual for food powders courses, all contributing significantly to the knowledge base for food powder systems. Progress continues on a critical review manuscript on the flowability of food powders. The Principal Investigator was an instructor for two short courses on food powders, one offered by the Institute of Food Technologists at its annual meeting and the other by the University of Barcelona in Spain.
- ii) Geographic Scope: The scope of the work is national and international—wherever food processing is producing powders.
- iii) This project does not have research/extension integration, but it has a substantial component of informal learning for professionals in the field of food processing.
- iv) This project is not affiliated with a multistate research committee.

**E. Source of Funding:** Hatch.

**3. WNP00990: Assuring Fruit and Vegetable Product Quality and Safety through the Handling and Marketing Chain.**

**A. Key Theme:** Food Safety.

**B. RPA 501:** New and Improved Food Processing Technologies; **RPA 502** New and Improved Food products.

- C. **Description:** Washington State University's contribution to this regional project was in the area of postharvest pest control in fresh commodities, including apples, oranges, and dry nuts. Studies revealed that combining pre-radio frequency (RF) hot water with short-time RF heating significantly improved heating uniformity and reduced localized overheating of oranges. In cooperation with Diamond Walnut Growers in California, the researchers scaled up RF post-harvest pest control protocols for use with in-shell walnuts. The treatment resulted in 100 percent mortality of fifth-instar navel orangeworm larvae, the most heat-tolerant target pest, in both unwashed and air dried walnuts.
  - D. **Impacts, Outcomes and Scope of Research:**
    - i) **Impacts of Research:** This project addresses critical emerging agricultural issues related to environmental quality and natural resource management, especially pest management challenges. The RF treatment developed in this study should also control codling moths, Indianmeal moths, and red flour beetles in in-shell walnuts. The research provides substantial hope that similar treatments can be used for post-harvest pest control of other nuts and dried products to provide an effective and environmentally friendly phytosanitary treatment technology for the produce industry.
    - ii) **Geographic Scope:** The research is important in states such as California with large nut productions and in states with large production of fresh fruits and vegetables for export to other countries (California, Oregon, Washington, Idaho, Florida, and Michigan).
    - iii) This project does not have research/extension integration.
    - iv) This project is affiliated with a multistate research committee (NE-1008).
  - E. **Source of Funding:** Hatch, USDA, industry.
4. **WNP05378: Radio Frequency Energy as an Alternative to Methyl Bromide Fumigation for Controlling Pests in Stone Fruits and Nuts.**
- A. **Key Theme:** Food Safety.
  - B. **RPA 503:** Quality and Maintenance in Storing and Marketing Food.
  - C. **Description:** The goal of this project is to develop a protocol for use of radio frequency energy as an alternative to methyl bromide fumigation for controlling pests in fruits and nuts intended for export to other countries. The project has scaled-up the equipment for use in an industrial setting for walnuts to replace chemical fumigation. The research has also demonstrated the use of this technology for other commodities, including legumes.
  - D. **Impacts, Outcomes and Scope of Research:**
    - i) **Impacts of Research:** As a result of this research, industries now have both scientific information and validated results for implementation of non-chemical pest control methods based on radio frequency energy for pest control in nuts and can extrapolate the same to pest control to legume and cereal grains.
    - ii) **Geographic Scope:** This research will be important in states such California with substantial nut production, especially for export. It will also be important in states such as Washington, Oregon, and Idaho that have substantial grain exports to other countries.
    - iii) This project does not have research/extension integration.
    - iv) This project is not affiliated with a multistate research committee.
  - E. **Source of Funding:** USDA, commodity group.

**CENTER FOR PRECISION AGRICULTURAL SYSTEMS**

- 1. **WNP00551, NCR-180. Advancing Precision Agricultural Systems Through Automation, Sensing, Control, and Information Systems.**

- A. **Key Theme:** Precision Agriculture.
- B. **RPA 404:** Instrumentation and Control Systems.
- C. **Description:** Develop and deploy wireless sensor network technologies that provide growers with real-time data and information needed improve the efficiency and efficacy of their management practices.
- D. **Impacts, Outcomes and Scope of Research:**
  - i) **Impacts of Research:** Our focus in 2006 was to continue the development of wireless sensor network (WSN) applications for agriculture over a range of spatial scales - regional, on-farm, and within-field. The Washington State University weather network, AgWeatherNet, received permanent operations funding from the Washington State Legislature beginning July 1, 2006. The WSU Center for Precision Agricultural Systems developed a new wireless data logging system, the AWN200, to upgrade the data logging and wireless network capabilities of AgWeatherNet as well as the agricultural weather network operated by the USDA-ARS research unit in Sidney, Montana, which is implemented in eastern Montana and western North Dakota. The AWN200 includes state of the art data logging hardware, a 900 Mhz frequency hopping, spread spectrum radio for long distance wireless connectivity, and firmware designed to operate the wireless network and to automatically populate remote data bases with 15 minute weather data. The AWN200 is also equipped with a GPRS (General Packet Radio Service) phone to create other applications including a remote irrigation monitoring and control system for orchard irrigation systems and a wireless system for crop load monitoring in grapes. We continued the development and evaluation of a remote irrigation monitoring and control system (RIMCS) for continuous move irrigation systems. We designed and tested a new controller board that greatly improved the RIMCS performance during the 2006 growing season. We continued the development of a graphical interface for the RIMCS that allows irrigation managers to create and update irrigation application maps via the Internet and will evaluate the interface during the 2007 growing season. We developed a prototype, low power, 900 MHz radio designed for use in high density data acquisition environments. Testing and improvement of this system continues in 2007.
  - ii) **Geographic Scope of Research:** CPAS technologies have been deployed primarily in WA State but also in the states of OR, MT, and WI.
  - iii) **Integrated Research and Extension:** Today, our AWN200 supports regional weather networks in two regions, Washington State and eastern Montana-western North Dakota. Our on-farm networks are sold commercially under the name AgFrostNet and include our FCC grant certified (2004) SS100 radios. We have developed and are now evaluating low powered, short distance radio technologies that will eventually be deployed in high density sensor network applications, which will be integrated via gateways to the Internet or to our existing regional and on-farm networks. Farmers and rural residents in WA, MT, and ND already benefit from the weather networks and Washington farmers utilize AgFrostNet networks. We continue to develop new applications that are still in the testing stage but will be available to farmers and researchers when fully developed. We expect the use WSN for agriculture to grow as these technologies, both hard and soft, become increasingly available.
  - iv) **Affiliation with Multistate Research Committee:** This project is affiliated with the North Central Regional Committee NCR180 on Site-Specific Management.
- E. **Source of Funding:** Hatch

## DEPARTMENT OF CROP AND SOIL SCIENCES

1. **WNPO0175: Adaptation Studies of Cereal Varieties and Selections.**
  - WNP00334: Improving Spring Wheat Varieties for the Pacific Northwest.**
  - WNP00232: Breeding and Genetics of Winter Wheat.**
  - WNP00359: Early Generation and Market Specific Quality Evaluation of New Wheat Varieties.**
  - WNP01006: Breeding and Genetics of Barley.**
  - WNP00196: Molecular Markers for Barley Disease Resistance Genes.**
  - A. Key Theme:** Agricultural profitability, plant germplasm, plant health, plant production efficiency and small farms viability.
  - B. RPA 201-**Plant genome, genetics and genetic mechanisms, **RPA 202-**Plant genetic resources and biodiversity, **RPA 204-**Plant production quality and utility (preharvest).
  - C. Description:** Wheat and barley germplasm improvement, variety development, selection and testing for yield, end-use quality, nutrient use efficiency, pest resistance, and regional adaptability are the goals of our program for wheat and barley breeding, genetics and end use evaluation.
  - D. Impacts and Scope of Research**
    - i) **Impacts of Research:** Researchers in these programs work collectively to develop, evaluate and release new germplasm and commercially competitive wheat and barley cultivars with improved yield potential, end use, and pest resistance with emphasis on fungal stripe resistance. Classes of winter and spring wheat cultivars developed include hard red, hard white, soft white, and club. Barley cultivars include feed, food, and malting types. About 1.5 million acres of soft white winter wheat were grown in WA in 2006, of which 62% were planted with WSU releases, producing a gross value of \$298 million dollars. Soft white winter club varieties were planted on 117,000 acres, with 96% of the acreage planted with WSU varieties, grossing \$37 million. Hard red winter wheat was grown on 202,000 acres, with 55% planted to WSU varieties, grossing \$29 million. Soft white spring wheat was grown on 137,600 acres with 69% WSU varieties grossing \$15 million. Hard red spring wheat was grown on 294,500 acres with 23% planted to WSU varieties grossing \$4 million. Approximately 205,000 acres of barley were planted in WA in 2006 with about 20% of the acreage planted to WSU varieties grossing over \$10 million.

WSU genetics research and breeding efforts have stimulated interest in perennial wheat and organic wheat. Overall WSU sustainable research has increased interest and acres of organic grain production.
    - ii) **Geographic scope:** Variety releases mostly have regional impact due to their specific adaptability to soil and climatic conditions but unique, basic approaches to genetic modification and variety development have national/international impact.
    - iii) **Research and extension** are well integrated among these programs to facilitate effective germplasm characterization and mapping, variety development, field testing, end use evaluation and transfer to the agricultural community. Researchers and extension specialists in these programs log many hours in field days, tours, grower meetings for farmer outreach.
    - iv) None are affiliated with multistate.
  - E. Source of funding:** Hatch, Wheat and Barley Commodity Commissions, Industry Grants and Agreements, State, USDA-NRI and other federal funds.

## DEPARTMENT OF ENTOMOLOGY

### 1. WNP001090: Management of Direct Insect Pests of Apple in Washington Tree Fruit Orchards.

- A. **Key themes:** Agricultural Profitability.
- B. **RPA 216:** Integrated Pest Management Systems.
- C. **Description:** Five technologies were assessed for delivering pheromones for the control of codling moth (CM): Scenty fibers, Hercon flakes, Suterra Checkmate sprayable, Pacific Biocontrol Isomate CM/LR and Trece Cidetrak dispenser. Scenty fibers applied to large plots were about as effective against CM as the currently used, standard Isomate C-plus treatment. However, the ground application system for fibers is not reliable and represents a barrier for grower adaptation of this technology.

Hercon CM Disrupt flake pheromone technology was evaluated in large plots. At some locations the flake treatments were as good as the Isomate C-plus treatment but at others it was inferior to the Isomate treatment. The ease of application of this technology makes it very attractive. However, there remain some barriers in the efficiency of adhering sufficient flakes on trees to obtain robust control of CM. Preliminary trials with a leafroller flake formulation were very promising.

The Suterra checkmate sprayable pheromone at 10 grams per acre suppressed CM capture in traps similar to an Isomate C-plus treatment in some locations but was less effective in the second generation and fruit injury was detected at every site despite use of supplemental insecticides.

A new dispenser produced by Trece, Cidetrak CM, showed very good activity against CM when compared to the industry standard, Isomate C-plus.

Several new insecticides were evaluated for their ability to control CM and leafrollers. Combinations of different modes of action in tank mixes were as good as the industry standard in protecting apples from CM injury. Some currently unregistered insecticides also showed promise as a control for CM and leafrollers in small plot trials.

Surveys of resistance in leafrollers showed that two field populations had significant tolerance to the insecticide, Spinosad, which has been used in fruit orchards for approximately seven years. There was no cross-resistance between organophosphate insecticides and two insecticides not yet registered on tree fruit. A bioassay method was developed for evaluating the effect of a juvenile hormone mimic, pyriproxyfen, against leafroller larvae.

#### D. **Impacts and Scope of Research:**

- i) Impacts - notable outcomes

The phase-out of organophosphate insecticides makes the research on new insecticides all that more important. Information generated from this research is the first step in switching from older, broad-spectrum insecticides to safer and less disruptive forms of integrated pest management. Adaptation of new insecticide technology will provide a safer working environment for farm workers, and reduce the threat of detrimental environmental impacts of orchard pest management practices. The unbiased information on new pest control technologies developed through this research protects growers from misleading claims about product performance. Research on new technology to deliver pheromones for control of codling moth and leafrollers has the potential to

reduce the use of insecticides and overall pest control costs for growers. Pheromones are a key part of Washington's integrated pest management program in apple and pear and advances in technology will help promote use by additional growers and at the same time reduce the use of broad-spectrum pesticides.

- ii) Geographic Scope - Regional
  - iii) Integrated Research and Extension  
The research reports on the effectiveness of several methods of delivering mating disruption pheromone treatments in orchards. This information has and continues to be disseminated through various outreach activities including presentations at grower and other stakeholder meetings and printed materials.
  - iv) Not affiliated with multistate.
- E. **Sources of Funding:** Hatch, other federal funds, cooperative agreements, state, other non-federal funds

2. **WNP00455: Biological Diversity Studies of Arthropods.**

- A. **Key Themes:** Invasive Species, Biological Diversity.
- B. **RPA 211:** Insects, Mites and Other Arthropods Affecting Plants.
- C. **Description:** During 2006 we cooperated with several individuals throughout Washington State to develop an inventory of the noctuid moths of Washington and some contiguous areas of Idaho and Oregon. The noctuid moths include the armyworms, cutworms, fruitworms, and other groups of significant economic importance. Specimens were collected at various locations through the state and we inventoried the three largest collections of specimens in Washington. These collections also house material from the Pacific Northwest in general and have significant holdings of material from all geographic regions of Washington, northern Idaho and northeastern Oregon. Slightly over 25,000 specimens were examined, label information collected, and then placed into an Excel spreadsheet. Information represented in the spreadsheet includes names of taxa with updates as appropriate, dates of collection, and counties in which material was collected. This is the most comprehensive listing of noctuid moths from Washington ever constructed. The list is formatted so that it will, eventually, be accessible via that web.
- D. **Impacts and Scope of Research:**
  - i) Impacts - notable outcomes:  
Slightly over 500 species of noctuid moths have been entered into the spreadsheet. We believe that this represents at least 80% of the species that are found in Washington State and all of those that are economically important. The data has importance to environmentally oriented, biological diversity studies and to those needing temporal and geographic information in order to better refine management programs. For instance, the data show temporal differences in the first flights of corn earworm and false corn earworm thereby allowing growers to separate the flights and treat only when true corn earworm populations are on the rise. Knowing what is presently housed in the represented collections also is allowing us to obtain taxa that we do not have. This allows for more accurate identifications when unknown taxa are submitted for determination.
  - ii) Geographic Scope – Regional.
  - ii) Integrated Research and Extension.  
The research reports on the geographic and temporal distribution of pestiferous species of moths. This information has and continues to be disseminated through various outreach activities including presentations at grower and other stakeholder meetings and printed materials.
- E. **Source of Funding:** Hatch, other federal funds, state, and other non-federal funds.

## DEPARTMENT OF HORTICULTURE AND LANDSCAPE ARCHITECTURE

1. **WNP00326: Enhance Market Quality by Improving Fruit Finish in Apple.**
  - A. **Key Theme:** Agricultural Profitability.
  - B. **RPA 203:** Plant biological efficiency and abiotic stresses affecting plants.
  - C. **Description:** The main focus of this research has been on the study of factors that cause sunburn in apple and the identification of management techniques that can be used for its prevention, and on development of a product that will reduce the impact of cracking in cherries. The apple sunburn work has resulted in a three pronged approach to prevention: 1) the creation of a product, RAYNOX<sup>®</sup>, that reduces sunburn, 2) the development of a fruit surface temperature (FST) sensor (patent pending) to be used with evaporative cooling systems that are employed to decrease sunburn, and 3) the development of a computer model that predicts occurrence of sunburn events, and provides growers with an effective management tool. The research in cherries has resulted in a new product, RainGard that has promise in reduction of cracking.
  - D. **Impacts, Outcomes, and Scope of Work:**
    - i) The patent for RAYNOX<sup>®</sup> was issued by the US Patent and Trademark Office in February 2005. Two other patents are pending. One is for a new formulation (RainGard) that shows promise of protecting cherries during rain from cracking/splitting. A second was filed in October 2004 to protect new intellectual property for improved formulations of RAYNOX<sup>®</sup>. The technology for RAYNOX<sup>®</sup> was licensed by WSU Research Foundation to FruitGard, LLC during 2003. The sunburn protectant was successfully introduced to apple growers in Washington State during 2003, and has been marketed widely in since. It is estimated that RAYNOX<sup>®</sup> has saved Washington apple growers over \$30 million in the past three seasons. RainGard<sup>™</sup>, the cherry protectant, was tested in the Southern Hemisphere during 2004/05 and in WA and OR during 2005 and 2006. This technology was licensed by WSURF to FruitGard, LLC during 2004. RainGard<sup>™</sup> was introduced on a limited basis commercially during 2006 in WA and OR.
    - ii) Although the research that led to the development of RAYNOX<sup>™</sup> and RainGard<sup>™</sup> was carried out in Washington State, the technology should be applicable in any location where similar environmental conditions exist (intense radiation, and high temperatures in the case of RAYNOX<sup>®</sup> and rain events at harvest in cherry in the case of RainGard<sup>™</sup>).
    - iii) This is not an integrated research and extension project.
    - iv) It is not a multi-state research project.
  - E. **Source of Funding:** Hatch, State Appropriations, Industry Grants and Agreements.
  
2. **WNP00624: Potato Cultivar Evaluation and Commercial Potato Seed Lot Trials.**
  - A. **Key Theme:** Agricultural Profitability.
  - B. **RPA 205:** Plant production and management systems.
  - C. **Description:** The emphasis of this project is on the evaluation of potato clones that are suitable for production in Washington State and other areas in the Pacific Northwest. Varieties are evaluated for adaptability to local conditions, dual utility for use in both fresh and processing markets, production efficiency, and multiple disease resistance. Tubers from Tri-State and Regional cooperative trials are evaluated for postharvest wound healing ability and processing out of storage, including resistance to low-temperature sweetening, fry color, fry texture, consumer preference, dormancy, reconditioning ability, rot resistance, and specific gravity. Economic evaluations are also conducted.
  - D. **Impacts, Outcomes, and Scope of Work:**

- i) Contributions from the potato cultivar evaluation trials lead to the recent releases of several potato cultivars, including: Modoc, Willamette, Summit Russet, GemStar Russet (A9014-2), Defender (A90586-11) and Western Russet (A7961-1). Defender, the result of a USDA/ARS cross, is the first product of efforts to develop varieties with resistance to late blight. Varieties evaluated in this program and recently released by the Tri-State program are now produced on over 100,000 acres and value to growers is placed at nearly \$150 million farm gate. Three new potato varieties, Highland Russet, Premier Russet and Yukon Gem were released in 2006. Value of the new varieties comes in the form of improved quality, increased yield, and decreased inputs. As these new varieties are adopted and fertilizer and pesticide inputs decrease, not only will profitability increase, additionally, environmental impact will be lessened. It is anticipated that the new cultivars will maintain or improve profitable and sustainable production for the grower, improved competitiveness of the Washington potato industry, a healthy, inexpensive food supply for American consumers, and an improved environment.
  - ii) The geographic scope of this work is regional. The results will be applicable for potato growers in the Pacific Northwest.
  - iii) This is an integrated research and extension project. Extension activities include the publication of results for grower use, maintenance of a grower accessible web site, information workshops around the state, and field day where growers have the opportunity to view new potato varieties being studied.
  - iv) It is not a multi-state research project.
- E. Source of Funding:** Hatch

## IMPACT CENTER

1. **WNP00541: International Marketing Program for Agricultural Commodities and Trade (IMPACT) Center.**  
**WNP00555: Quantitative Analyses of International Food and Commodity Markets.**
  - A. **Key themes:** An agricultural production system that is highly competitive in the global economy.
  - B. **RPA 501:** New and Improved Food Processing Technologies, **RPA 503:** Quality Maintenance in Storing and Marketing Food Products, **RPA 606:** International Trade and Development, **RPA 607:** Consumer Economics, **RPA 610:** Domestic Policy Analysis.
  - C. **Description:** The overall goal of this research project is to provide innovative solutions to problems related to exporting Pacific Northwest and US products. Many of these problems are related to barriers to trade including sanitary and phytosanitary issues. These projects also address the development of new products and processes that use existing crops in new and innovative ways as well as finding uses for by-products and waste. New markets for PNW products are also examined as well as competitors in the global marketplace.
  - D. **Impacts and Scope of Work:**
    - i) These projects will also provide Pacific Northwest exporters of food and agricultural products quantitative information on global as well as regional market development. Policymakers and stakeholders are provided with useful information that allows the assessment of trade policy on international markets. The results on WTO scenarios, decoupling effects, and tariff disputes are relevant for policy makers, industry, and producers. The results of the specialty crops analysis contribute to the discussion regarding policy preference of specialty crops producers in the new Farm Bill 2007.
    - ii) IMPACT projects address state, regional, national, and international issues.



- iii) Our projects are integrated in the sense that interdisciplinary teams of researchers are required.
  - iv) Not multistate.
- E. Source of Funding:** Hatch.

## INSTITUTE OF BIOLOGICAL CHEMISTRY

- 1. WNP00197: The flexibility of the Light Reactions of Photosynthesis.**
  - A. Key Themes:** Plant Health, Biotechnology, Plant Production Efficiency, Adding Value to New and Old Agricultural Products, Biobased Products, Nutrient Management, Agricultural Profitability, Precision Agriculture, Plant Genomics.
  - B. RPA 206:** Basic Plant Biology.
  - C. Description:** A major advance we made was the discovery of an entirely new class of photosynthetic mutant phenotype in *Arabidopsis* that show accelerated cyclic electron flow around photosystem I. This is a major discovery since this potentially very important energy storage pathway is not well understood in terms of basic biochemistry, regulation and physiological impact. We are currently cloning the mutants and characterizing their properties. We have now established regulatory connections between the ATP synthase, the transthylakoid proton motive force, and the regulation of photosynthetic antenna and are now working to determine what factors regulate these components. We developed a 'systems' model for the regulation of photosynthesis (1,4,7), which represents a paradigm shift in thinking about the chloroplast energy budget by considering both proton influx into the lumen and efflux out via the ATP synthase. This view was only possible with instrumentation and techniques developed in my laboratory over the past 9 years.
  - D. Impacts Outcomes, and Scope of Research:**
    - i) Impacts of the Research: Our work adds significantly to our understanding of photosynthesis, and impacts the development of advanced crops capable of storing higher levels of energy for crop yields, biofuels and wider growth range under changing environmental conditions. Such efforts require that we understand how photosynthesis is limited and regulated and to what extent these can be manipulated.
    - ii) Geographic scope: International.
    - iii) The project does not integrate research and extension.
  - E. Source of Funding:** Hatch, DOE, Other Federal Research Funds and State Appropriations.
  
- 2. WNP00202: Unraveling the Molecular Interactions at Lignin Initiation Sites and in Heartwood Formation.**
  - A. Key Themes:** Adding Value to New and Old Agricultural Products; Agricultural Profitability; Biotechnology; New Uses for Agricultural Products; Plant Health; Plant Production Efficiency; Biological Control; Forest Crops; Forest Resource Management.
  - B. RPA 123:** Management of Forest Resources.
  - C. Description:** This study is aimed to investigate how both initiation of lignin assembly and heartwood metabolite formation occur, using western red cedar, loblolly pine, *Cryptomeria japonica* and poplar, as needed, with the lignan biosynthetic pathway being employed as markers of heartwood deposition. Progress made this year is as follows: A phenylpropanal double-bond reductase (PPDBR) was obtained from cell suspension cultures of loblolly pine. Following trypsin digestion and amino acid sequencing, the cDNA encoding this protein was subsequently cloned, with the functional recombinant protein expressed in *Escherichia coli* and characterized. PPDBR readily converted both dehydrodiconiferyl and coniferyl aldehydes into dihydrodehydrodiconiferyl and dihydroconiferyl aldehydes, when NADPH was added

as cofactor. However, it was unable to reduce directly either the double bond of dehydrodiconiferyl or coniferyl alcohols in the presence of NADPH. During this reductive step, the corresponding 4-proR hydrogen was abstracted from [4R-3H]-NADPH during hydride transfer. This is thus the first report of a double-bond reductase involved in phenylpropanoid metabolism, and which is presumed to be involved in plant defense. In situ mRNA hybridization indicated that the PPDBR transcripts in *P. taeda* stem sections were localized to the vascular cambium, as well as to radial and axial parenchyma cell types. The cinnamyl alcohol dehydrogenase (CAD) multigene family in plants encodes proteins catalyzing the reductions of various phenylpropenyl aldehyde derivatives in a substrate versatile manner, and whose metabolic products are the precursors of structural lignins, health-related lignans, and various other metabolites. We determined the crystal structures of AtCAD5 in the apo-form and binary complex with NADP<sup>+</sup>, respectively, and modeled that of AtCAD4. Both AtCAD5 and AtCAD4 are dimers with two zinc ions per subunit and belong to the Zn-dependent medium chain dehydrogenase/reductase (MDR) superfamily. The catalytic Zn<sup>2+</sup> in both are tetrahedrally coordinated, but differ from horse liver alcohol dehydrogenase since the carboxyl side-chain of Glu70 is ligated to Zn<sup>2+</sup> instead of water. Using AtCAD5, site-directed mutagenesis of Glu70 to alanine resulted in loss of catalytic activity, thereby indicating that perturbation of Zn<sup>2+</sup> coordination was sufficient to abolish catalytic activity. The substrate binding-pockets of both AtCAD5 and AtCAD4 were also examined, and found to be significantly different and smaller compared to that of a putative aspen sinapyl alcohol dehydrogenase (SAD) and a putative yeast CAD. While the physiological roles of the aspen SAD and yeast CAD are uncertain, they nevertheless have high similarity in overall 3D structures to AtCAD5 and 4. With the bona fide CAD's from various species, nine out of the twelve residues which constitute the proposed substrate-binding pocket were, however, conserved. This is provisionally considered as indicative of a characteristic fingerprint for the CAD family.

#### **D. Impacts Outcomes, and Scope of Research**

- i) Impacts of the research. The data generated in this proposed study will be of enormous importance for transgenic organisms and/or in trait selection. For example, it is the heartwood tissue which typically contains >95% of the merchantable bole, and it is these (non-structural) components which engender particular characteristics to any given species, e.g. leading to enhanced durability, longevity, color, quality, odor and texture. Indeed, even the trend away from conventional wood treatment (e.g. chromate-copper-arsenate) argues for an enhanced understanding of how nature's mechanisms can be better deployed. The significance of the heartwood tissue becomes even more apparent in terms of its value (>\$135 billion annually, 1990 figures), which dwarfs all other plant (agriculture, horticulture) income. Consequently, it is timely and important to the national research effort that this area of plant metabolism is even more incisively investigated. The results stemming from this research will enable us to develop and apply rational biotechnological strategies to either modify sapwood/heartwood properties, or to introduce specific pathways into other woody plants, e.g. to improve lumber quality, durability, ease of paper making etc.
- ii) Geographic Scope: International.
- iii) This project does not integrate research and extension.

**E. Source of Funding:** Hatch, McIntire-Stennis, DOE, USDA, Other Federal Research Funds, Non-Federal Funds, NIH, NSF, and State Appropriations.

- 3. WNP00253: Lipid Biosynthesis in Leaves and Seeds.**
- A. Key Themes:** Plant Health, Biotechnology, Plant Production Efficiency, Adding Value to New and Old Agricultural Products, Biobased Products, Nutrient Management, Human Nutrition, Plant Genomics, Agricultural Profitability.
  - B. RPA: 201** Plant Genome, Genetics and Genetic Mechanisms.
  - C. Description:** Protein transfer across membranes is mediated by protein machinery embedded in the membrane. The complement of different lipid classes within a membrane is known to influence the efficiency of some protein translocation processes, but very little is known about whether the fatty acid composition of the membrane bilayer also affects protein transport. We investigated this issue using three mutants of Arabidopsis, *fad6*, *fad5*, and *fad3 fad7 fad8*, that have reduced levels of fatty acid unsaturation in their thylakoid membranes. Interestingly, the effect of reduced unsaturation was different for three distinct pathways of protein transport. In thylakoids from all three mutants, transport of the OE17 protein on the delta-pH/Tat pathway was reduced by up to 50% relative to wild-type controls, when assays were run at 10 degrees, 20 degrees or 30 degrees C. By contrast, transport of the OE33 protein on the Sec pathway was substantially increased in all the mutants at the three temperatures. Transport of the CFoll protein (ATPg) on the 'spontaneous' pathway was largely unaffected by reduced unsaturation of the thylakoid membranes. Experiments with intact chloroplasts from wild-type Arabidopsis and the three mutants confirmed these changes in thylakoid transport reactions and also demonstrated an increased rate of protein import across the chloroplast envelope in each of the mutants. This increased capacity of chloroplast protein import may partially compensate for the reduced capacity of thylakoid transport by the delta-pH/Tat pathway. The *fad5*, *fad6* and *fad3 fad7 fad8* mutants used in this study grow normally at 15-20 degrees C, but exhibit reduced photosynthesis and growth, relative to wild-type controls, at low temperatures (4 degrees C). The results reported here indicate that protein transport and chloroplast biogenesis may well contribute to these low-temperature phenotypes.
  - D. Impacts, Outcomes, and Scope of Research**
    - i) Impacts of the Research: A central dilemma in membrane biology is the need to explain lipid diversity. Each membrane of a cell has a characteristic and distinct complement of glycerolipid molecules that vary both in headgroup structure and in the length and degree of unsaturation of the fatty acid chains that constitute the hydrophobic portion of the membrane. This diversity implies that differences in lipid structure are important for proper membrane function. However, while a few particular lipids have defined roles, the dominant view of a membrane remains one in which lipids simply compose a bilayer matrix for the functional membrane proteins. Changing this simplistic view will require both an understanding of lipid metabolism and information on the lipid requirements for the proper functioning of membranes and for the production of lipid-derived signaling molecules. This information can then be the basis for mechanistic models of how the lipid composition of cell membranes affects plant function.
    - ii) Geographic Scope: International.
    - iii) This project does not integrate research and extension.
  - E. Source of Funding:** Hatch, USDA, NSF, NIH, DOE and State Appropriations.
- 4. WNP00268: Biochemistry of Plant Terpenoids.**
- A. Key Themes:** Plant Health, Biotechnology, Plant Production Efficiency, Adding Value to New and Old Agricultural Products, Biobased Products, Nutrient Management, Agricultural Profitability, Precision Agriculture, Plant Genomics.
  - B. RPA 206:** Basic Plant Biology.

- C. **Description:** Ten genes from peppermint involved in precursor supply and menthol biosynthesis have been shown to improve essential oil composition and/or yield when expressed individually in transgenic plants. Regulatory studies and stacking of multiple genes are in progress. Cloning of menthone reductases, isopulegone isomerase, and limonene-7-hydroxylase is in progress. Mechanistic and structural studies with several terpenoid synthases are in progress.
- D. **Impacts, Outcomes and Scope of Research:**
- i) Impacts of the Research: Several patents based on these technologies have been issued. WSURF has licensed these technologies to three industrial/commodity groups. Field trials with transgenic mint with improved oil yield and composition have yielded a superior peppermint line suitable for commercial release.
  - ii) Geographic scope: National.
  - iii) The project does not integrate research and extension.
- E. **Source of Funding:** Hatch, NIH, State Appropriations, Industry Grants and Agreements, and other Non-Federal Funds.
5. **WNP00773: Nutrient Exchange and Metabolism in the Rhizobium-Legume Symbiosis.**
- A. **Key Themes:** Plant Health, Biotechnology, Plant Production Efficiency, Adding Value to New and Old Agricultural Products, Biobased Products, Nutrient Management, Human nutrition, Plant Genomics, Agricultural Profitability.
- B. **RPA 201** Plant Genome, Genetics and Genetic Mechanisms.
- C. **Description:** Exchange and metabolism of nutrients by symbiotic bacteria is at the center of the symbiotic relationship. Several lines of research in the laboratory are exploring bacterial nutrient use including investigations of transport, electron flow and carbon and nitrogen metabolism in the symbiosis. A recent focus has been on bacterial mutations that alter effectiveness, the ability of the plant to benefit from symbiosis. Mutants that increase effectiveness have been isolated, as have those that still fix nitrogen but are ineffective.
- D. **Impacts, Outcomes and Scope of Research:**
- i) Impacts of research: Exploration of the physiology and genetics of *Sinorhizobium meliloti* is yielding new information about how this organism operates in supporting its nitrogen-fixing symbiosis with alfalfa. New mutations in polysaccharide synthesis and in nitrogen stress regulation have been implicated in modifying the relationship between the plant and the symbiotic bacteria.
  - ii) Geographic scope: International.
  - iii) The project does not integrate research and extension.
- E. **Source of Funding:** Hatch, DOE, NSF, USDA and State Appropriations.
6. **WNP00967: Diterpene Biosynthesis in Taxol Production and Conifer Defense.**
- A. **Key Themes:** Adding Value to New and Old Agricultural Products, Agricultural Profitability, Biotechnology, New Uses for Agricultural Products, Plant Health, Plant Production Efficiency, Biological Control, Forest Crops, Forest Resource Management.
- B. **RPA 123:** Management of Forest Resources.
- C. **Description:** All of the taxoid cytochrome P450 oxygenases (22), acyl/aroyl transferases (15), and candidate CoA ester ligases for side chain assembly (8) have been engineered for expression in yeast, *Escherichia coli*, or insect cells. Screening to determine the function of these genes in Taxol biosynthesis and taxoid metabolism is in progress. The target CoA ester ligase and taxoid-9-hydroxylase genes have been identified. Feeding studies with *Taxus* cells using early precursors have revealed a bifurcation in taxoid biosynthesis. A stable transformation system for *Taxus* cells has been developed. One undergraduate student is associated with this project.

- D. Impacts, Outcomes and Scope of Research:**
- i) Impacts of the Research: Several patents based on these technologies have been issued. The Washington State University Research Foundation has licensed these technologies to two biotech firms that are attempting to improve Taxol production.
  - ii) Geographic scope: International.
  - iii) The project does not integrate research and extension.
- E. Source of Funding:** McIntire-Stennis and State Appropriations.
- 7. WNP01791: Polypeptide Signaling for Plant Defense, Growth, and Development.**
- A. Key Themes:** Plant Health, Biotechnology, Plant Production Efficiency, Adding Value to New and Old Agricultural Products, Biobased Products, Nutrient Management, Agricultural Profitability, Precision Agriculture, Plant Genomics.
- B. RPA: 206** Basic Plant Biology.
- C. Description:** Our research in 2006 continued to be focused on studies of the three classes of defense signaling peptides that were first discovered in my laboratory, including systemin from tomato, HypSys peptides from tomato, tobacco, nightshade, potato, and petunia, and AtPep1 from Arabidopsis. The evidence from these studies indicates that the three classes of plant defense peptide signals amplify the signaling pathways for the synthesis of methyl jasmonate and salicylic acid, the two major mobile signals in plants that regulate expression of both defense genes and peptide precursor genes. This creates a feedback loop in which the peptide signals and defense genes are both amplified to provide a strong systemic response for the systemic activation of innate immune responses to cope with attacking pests and pathogens. We have continued our studies of the structure-function relationships of the HypSys and AtPep peptides by deletion analyses and amino acid substitutions. We are preparing large enough quantities to collaborate with NMR spectroscopists to analyze the structural conformations of the peptides in solution and to possibly identify the regions of the peptides that interact with receptors. We isolated and characterized a HypSys peptide in sweet potato and have isolated the gene that codes for the peptide. We found that a single protein harbors six related peptides. This is the first example of a proprotein with six peptides in plants, and to our knowledge only the proenkephalin precursor in brains is the only polyprotein precursor harboring more peptides, ie. seven enkephalin peptides. We completed a project with a graduate student from Thailand showing that a homolog of potato inhibitor I is a major protein in rubber tree latex. The results were published in Phytochemistry.
- D. Impacts, Outcomes and Scope of Research:**
- i) Impacts of the Research: During the past year, the WSU Foundation has been negotiating an agreement to license the AtPep1 technology to Monsanto for agricultural use, and New Biology, Inc. to use the same genes and peptides for home garden use. We are continuing to study the six genes coding for AtPep peptides in Arabidopsis and to extend these studies to Soybeans and Potatoes. My lab published seven papers in 2006 and have five manuscripts in various stages of preparation.
  - ii) This research is primarily fundamental, but is presently being integrated into applied activities.
  - iii) The project does not integrate research and extension.
- E. Source of Funding:** Hatch, NSF, State Appropriations and other Non-Federal Funds.

## Department of Plant Pathology

1. **WNP00313: Systematics and Biology of Economically Important Fungi in the Pacific Northwest.**
  - A. **Key Theme:** Plant Health.
  - B. **RPA: 206;** Basic Plant Biology/
  - C. **Description:** Powdery mildews are among the most common diseases of plants; gardeners and professionals encounter these diseases yet they remain poorly understood because they are considered difficult to identify to species. The objectives of this project are to inventory economically important fungi in the Pacific Northwest, emphasizing powdery mildews, and develop online databases to collect and access this information.
  - D. **Impacts and Scope of Work:**
    - i) A new online journal, *Pacific Northwest Fungi*, was created to facilitate reporting information on the region's fungi and the Pacific Northwest Fungi Database was created as a tool for researchers, teachers, and students interested in fungi occurring in the Pacific Northwest. The database originally was based on information published in Dr. C. G. Shaw's *Host Fungus Index for the Pacific Northwest*. Both publications are publicly available online to facilitate access by anyone with an interest in fungi.
    - ii) The results of this project are multi-state with greatest impact in the Pacific Northwest region of the U.S. Both publications are anticipated to expand and have national scope within two years.
    - iii) Results of this project are disseminated electronically through the internet (<http://pnwfungi.wsu.edu/programs/aboutDatabase.asp>), professional publications, and oral presentations to professionals, Master Gardeners, and the public.
    - iv) Affiliated Multi-state Research Committee – none.
  - E. **Source of Funding:** Hatch.

## SCHOOL OF ECONOMIC SCIENCES

1. **WNP00544: The Impacts of Policies Affecting Resources.**
  - A. **Key Theme:** Agricultural Competitiveness.
  - B. **RPA540:** Collective Reputation; Firm Incentives and Empirical Analysis.
  - C. **Description:** This research focuses on providing policy makers with quantified analysis with regards to alternatives having to do with agricultural and natural resources.
  - D. **Impacts, Outcomes, and Scope of Research:**
    - i) Research impacts: Policy makers have been considering changes to milk marketing orders, and have proposed taxing fat in food products. The work from this project directly addresses the issues these policy makers are examining. Two related manuscripts investigate the demand for dairy products and the effects of marketing orders and a tax on fat, respectively. The empirical evidence suggests there is little substitution between dairy products due to milk marketing orders. However, the welfare effects of the price changes associated with the orders vary across consumer groups. Young families are more likely to be hurt by the imposition of marketing orders than wealthier, childless couples. This manuscript has been submitted to the Journal of Law and Economics. Additional investigation of the demand for dairy products suggests the specific responses to price changes of dairy products are not large and do not vary by consumer groups. Thus, a tax on the amount of fat in dairy products will not greatly impact

the amount of fat consumed. This article has been submitted to Health Economics and Policy.

- ii) Geographic scope: National.
- iii) Integrated research and extension: none.
- iv) Not affiliated with multistate projects.

E. **Source of Funding:** Hatch.

2. **WNP00609: Commodity Markets: Food Safety, Invasive Species, and Econometrics.**

A. **Key Theme:** Agricultural Competitiveness.

B. **RPA547:** Improving the International Competitiveness of the Washington, Oregon, Asparagus Industry.

C. **Description:** This research addresses a number of wide ranging issues that can have direct impact on the profitability and long run sustainability of industries within the Agricultural Sector of the Economy.

D. **Impacts, Outcomes, and Scope of Research:**

- i) **Impact of Gluten Imports on Demand for U.S. Wheat Food Use by Class.** In this study, the effect of gluten imports on U.S. domestic demand for five classes of wheat (hard red winter, hard red spring, soft red winter, soft white, and durum wheat) are investigated. This study finds that gluten imports have substantial impact on domestic wheat prices, and quantitative level of impacts is identified in the analysis.

**Invasive Species Management: Foot-and-Mouth Disease in the U.S. Beef Industry.** A conceptual bioeconomic framework that integrates dynamic epidemiological-economic processes was designed to analyze the effects of invasive species introduction on decision-making in the livestock sector. The framework integrates an epidemiological model, a dynamic livestock production model, domestic consumption, and international trade. The impact of a foot-and-mouth disease outbreak would be at the multibillion dollar level, with the quantitative levels of impact being estimated in the study. The study has substantial implications for prevention and trade policies.

**Invasive Species Management: Economic Effects of Mitigating Apple Maggot Spread.** A partial equilibrium simulation model for perennial fruit production was developed to study the potential economic impact of a pest species like apple maggot. The model was designed to provide essential information, such as the intertemporal distribution of welfare, to aid the design of effective and efficient policy response to pest outbreaks. This model was used to simulate the economic impact of apple maggot spread in Washington on apple price, trade flows, and welfare changes. The impact of a apple maggot spread is estimated to be in the multimillion dollar range. The specific quantitative dollar amount is estimated in the study. Due to the lag between investment decision in apple production and the realization of a decision in apple market, the effect of mitigation policies on apple supply may not be observed until the apple trees reach reproductive maturity. It is essential that policymakers to be aware of the delayed response in price, as identified in this analysis.

**Trade Bans and BSE.** The recent single positive BSE test in the state of Washington is a good example of how swiftly countries impose trade bans and how difficult it has been for the US to reopen its export market with certain countries (including neighbors). The factors determining the likelihood that individual countries imposed a trade ban on the US after the 2003 BSE incident were analyzed. Empirical evidence suggests Asian countries had a higher probability of imposing a trade ban. Not significant were governance variables,

as well as membership in the European Union (EU). In all, the model provides 85% correct predictions on whether or not individual countries imposed trade bans on the US. The impact of this information is help for industry and governments to better formulate plans in order to mitigate future trade bans disruptions.

Price Formation in US Meat Demand. The study investigates how to theoretically and empirically incorporate demographic translating in consumer distance functions. Consumer distance functions yield inverse demand systems that are of interest when attempting to better understand questions of price formation. Translating procedures are important when incorporating pre-committed quantities, pre-allocated factors, or demographic variables (e.g., advertising, health or food safety information) in the inverse demand system. The price response to both food safety information was small, especially in comparison to price effects, but significant. Hence, laws and regulations changing food safety identification and reporting that alter the flow of information may affect consumer decisions regarding meat quality.

Disaggregated Household Meat Demand with Censored Data. This study extends previous meat demand work by using micro-level data to model consumer demand for disaggregated meat products. An important innovation is introduction of the EM algorithm as an estimator for micro-level demand systems. Findings related to food safety information are largely consistent with existing demand research, in that impacts are very small and not statistically significant.

The research in this project was published in four major articles contained in the Agricultural and Resource Economics Review, the Journal of International Agricultural Trade and Developments, the American Journal of Agricultural Economics, and the Journal of International Food & Agribusiness Marketing.

- ii) Geographic scope: statewide.
  - iii) Integrated research and extension: none.
  - iv) Not affiliated with multistate projects.
- E. **Source of Funding:** Hatch.

#### **DEPARTMENT OF STATISTICS**

1. **WPN00254: Evaluation of Methods Used to Analyze Resource Selection Data.**
  - A. **Key Theme:** Other; statistical design.
  - B. **RPA 901,** Research Design and Statistics; **RPA 0254:** Analysis of Resource Selection Using Generalized Linear Models.
  - C. **Description:** The research focused on the comparison of statistical methods currently used to analyze resource selection studies arising in wildlife science. In particular, statistical methods commonly used for these problems were compared in terms of appropriate application to data from various study designs, the underlying assumptions and the hypotheses being tested. Fundamental concerns regarding the statistical methods compared were raised and areas in need of future research were identified.
  - D. **Impacts, Outcomes and Scope of Research:**
    - i) The work summarized above was published in an article appearing in "The Journal of Wildlife Management" (jointly with J. Griswold). The primary impact is to raise concerns and problems with the application of currently available statistic methodologies to resource allocation problems arising in wildlife science.



Additionally, the article identifies for statisticians and wildlife scientists important areas of future research with regard to problems and concerns raised.

- ii) Geographic scope of research: nationwide.
  - iii) These are integrated extension/research activity.
  - iv) No multi-state regional project.
- E. **Source of Funding:** Hatch and State.

#### WOOD MATERIALS AND ENGINEERING LAB

### 1. WNP00582: Development of Cost Effective and High Performance Biopolyester Products.

A. **Key Theme:** (1) Adding Value to New and Old Agricultural Products; (2) Agricultural Profitability.

B. **RPA 511:** New and Improved Non-Food Products and Processes.

C. **Project Description:** During the past 12 months, development of biopolyesters (PLA and PHAs) was further investigated in several aspects including nucleating agents, toughening and reinforcing. In the literature, talc, nanoclay,  $\alpha$ -cyclodextrin, lignin and other chemicals have been used to nucleate PHA crystallization. However, the nucleating effects of these chemicals are significantly inferior to that of boron nitride which is the current nucleating agent in commercial PHB and PHBVs. We screened a series of organic and inorganic chemicals to identify potential alternatives to boron nitride, including saccharin, thymine, melamine, abeitic acid, thiocyanuric acid, and nano-sized  $\text{CaCO}_3$ . The results suggested that thymine showed the most similar nucleating effect to boron nitride, followed by melamine. Toughening of PLA and PHBV by poly(butylene adipate-co-terephthalate) (PBAT) was studied. It was concluded that the debonding induced shear yielding process was responsible for the significant toughening effect. To our knowledge, this study is the first to reveal the toughening mechanism of biopolyesters based on experimental evidence. PLA nanocomposites with nano-sized  $\text{CaCO}_3$  and nanoclay were studied and compared. At relatively low concentrations of nanoclay (<5 wt%), both reinforcing and toughening can be achieved. Nano-sized  $\text{CaCO}_3$  increased the ductility of PLA but not its strength. Different micromechanical deformation processes were involved in these two nanocomposites. Reinforcing PHBV using bamboo pulp fiber was also conducted. In contrast to many natural fiber/PHBV composites which show little or no increase in strength and reduction in toughness, adding bamboo pulp fiber results in an increase in both strength and toughness. Co-continuous PLA/soy protein blends were successfully prepared, representing significant progress in the development of bioplastics.

D. **Impacts and Scope of Work:**

i) Research impact:

The creative findings on toughening of PLA by PBAT, micromechanical deformation of PLA nanocomposites, PLA/soy protein co-continuous blend, and toughening/reinforcing of PHBV by bamboo fiber have broad and significant impact. They provide direct solutions to the most serious problems biopolyesters are facing, such as brittleness and inadequate cost effectiveness. These findings will definitely contribute to the future large scale of applications of biopolyesters as alternatives to petrochemical plastics. Since many natural polymers and some synthetic glassy polymers have disadvantages similar to that of biopolyesters, the findings from this study will also set a framework for other polymer systems.

ii) Geographic scope: The project has an international scope.

iii) This is not an integrated research and extension activity.

iv) Not affiliated with a multistate research project..

E. **Source of Funding:** Hatch.

## GOAL 2

### A SAFE AND SECURE FOOD AND FIBER SYSTEM

#### EXECUTIVE SUMMARY

Two Departments participate in work related to National Goal 2: the Departments of Food Sciences and Human Nutrition (FSHN) and the Field Disease Investigative Unit. Both departments are making excellent progress in achieving their goals as stated in the Plan of Work. The Field Disease Investigative Unit has had as its focus animal health and the prevention of zoonotic disease. This year it made important discoveries concerning the epidemiology of mastitis in dairy cattle, and hence its control. Key themes for Food Science and Human Nutrition research under Goal 2 include food quality, foodborne pathogens protection, and foodborne illness. This year they have reported on 3 projects under this goal.

#### DEPARTMENTAL REPORTS

##### FIELD DISEASE INVESTIGATIVE UNIT

1. **WNP00858: Investigation of Food Animal Disease Problems in the State of Washington.**
  - A. **Key Theme:** Animal Health, Food Security and Foodborne Pathogen Protection.
  - B. **RPA 311:** Animal Diseases.
  - C. **Description:** The Staphylococcal toxin C1 (SEC1) was modified by deleting amino acid sequence 94 to 106 and combining an amino acid sequence at the deleted portion to produce modified toxin acting as a vaccine, which forms antibodies for humoral immune responses as well as elicits non-specific cellular immune responses to protect against superantigenic properties of SEC1. Cows (n=40) vaccinated against this modified toxin had different T cell (CD4/CD8) responses when compared to controls, and responses appear to be dose and time dependent. Mycoplasma strains that cause mastitis also can be found at other body sites as determined by chromosomal digest technology. In a study of an outbreak of mycoplasma mastitis in a dairy herd, colonization of other body sites with the mastitis strain was quite common immediately after the outbreak, with nearly half of all livestock (cows and replacements) were shedding the pathogen. But, within 3 months after the outbreak less than 3% of livestock were shedding the clone of mycoplasma that caused the initial outbreak. Research studying the reduction of the length of the dry period has largely ignored the effects on udder health. Four herds have been enrolled where cows are allocated to either 30 day, or greater than 45 day, dry periods. Preliminary data suggests no untoward effects of a reduction in the dry period length on prevalence or rate of new intramammary infections.
  - D. **Impacts, Outcomes, and Scope of Research:**
    - i) a. We will ultimately determine if a vaccine using modified Staphylococcal Enterotoxin C can be used to protect against *S. aureus* mastitis. We will initiate study employing 60 cows with various vaccination groups and then challenge these cows with intramammary instillations of *S. aureus*. If successful, the incidence and prevalence of *S. aureus* mastitis will be significantly reduced. Moreover, this might have a positive impact on milk safety. A significant proportion of *S. aureus* produce enterotoxins, these are emetic toxins that can

cause food poisoning. Clearly any reduction in *S. aureus* numbers in milk that produce such toxins might have a positive impact on food safety. Moreover, given that the antigen used is a modified version of staphylococcal enterotoxin, we would hypothesize that local production of immunoglobulin against the enterotoxin might also help neutralize this poison.

b. Through our efforts to continue to follow the dynamics of mycoplasma mastitis, and body site colonization in the outbreak herd, we will be able to gain a better understanding of the epidemiology of the disease, and hence, its control. Given that the agent is difficult to diagnose and refractory to treatment, control through prevention has the most potential to reduce the prevalence and incidence of this disease.

c. We will continue to study the effect of shortened dry period on mastitis at parturition. Dairy managers have long taken advantage of the dry period as a time to treat cows for mastitis, during the non-lactating period when milk withdrawal, and meat withhold, are not concerns. During this time a larger dose of antibiotic, in a longer acting vehicle, can be used. With a shortened dry period, such treatments, which have both curative and prophylactic value, may not be used given the risk of residues. Thus, exploration of new therapy strategies is warranted to protect food safety and dairy profitability.

- li) Geographic Scope: This project has included research on farms in Washington and Idaho.
- lii) Although this project did not formally integrate research and extension, it can be used directly by extension personnel since the results have strong application to current dairy management on any dairy farm.
- liv) This project was initiated and supported by the NE 1009 Mastitis Resistance to Enhance Dairy Food Safety, a Multistate Regional Research Project. (<http://www.nimss.umd.edu/homepages/home.cfm?trackID=1294>).

**E. Source of funding:** Hatch.

#### DEPARTMENT OF FOOD SCIENCE AND HUMAN NUTRITION

### 1. WNP00288: Microbial and Chemical Factors Affecting Calcium Lactate Crystal Formation in Cheddar Cheese.

- A. **Key theme:** Food Quality, Foodborne Pathogen Protection, and Foodborne Illness.
- B. **RPA 501:** New and improved Food Processing Technologies.
- C. **Description:** Cheddar Cheese made with and without race muse-positive non-starter lactic acid bacteria were cubed, vacuum packaged and flushed with gas to determine the effect of various gasses upon calcium lactate crystal (CLC) formation.
- D. **Impacts of Research:**
  - i) **Impacts of Research:** This research shows that low levels of contamination with certain nonstarter lactic acid bacteria (NSLAB) can result in CLC, regardless of lactose:protein ratio. Further, gas flushing, regardless of gas composition, milk composition and presence of NSLAB can contribute to the development of CLC on cheese surfaces. These findings stress the importance of packaging to cheese quality.
  - ii) **Geographic Scope:** National.
  - iii) There are no integrated extension/research activities.
  - iv) No multistate affiliation.
- E. **Source of Funding:** Hatch, State, Commodity.

2. **WNP00305: Applications of Spectroscopic Methods to Improve Food Quality and Safety of High Value Aquatic Food Products.**
  - A. **Key Theme:** Food Quality, Foodborne Pathogen Protection and Foodborne Illness.
  - B. **RPA 712:** Protect Food from Contamination by Pathogenic Microorganisms, Parasites and Naturally Occurring Toxins.
  - C. **Description:** Spectrophotometric methods have been developed to predict microbial growth in fish (production of metabolites, microbial cell injury both in model and real food systems).
  - D. **Impacts, Outcomes and Scope of Research:**
    - i. **Impacts of Research:** This project was the first to use spectral methods to predict microbial growth in fish products and will have important application to food safety implementation.
    - ii. **Geographic Scope:** National.
    - iii. There are no integrated extension/research activities.
    - iv. No multi-state affiliations.
  - E. **Source of Funding:** Hatch, State, USDA.
  
3. **WNP00369: Development of New Rapid Method for Estimation of Escherichia coli in Foods.**
  - A. **Key theme:** Food Quality, Foodborne Pathogen Protection and Foodborne Illness.
  - B. **RPA 712:** Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins.
  - C. **Description:** Rapid method for detection of Escherichia coli (E. coli) has been developed for use in foods.
  - D. **Impacts, Outcomes, and Scope of Research:**
    - i) **Impacts of Research:** This project developed a rapid, simple, and economical method for detection of E. coli in foods. This method can save time, energy, and cost for detection of food safety microorganisms. For example, this method can save 10-14 hours compared to conventional methods. This time savings is very important for food safety.
    - ii) **Graphic Scope:** National.
    - iii) There are no integrated extension/research activities.
    - iv) No multistate affiliation.
  - E. **Source of Funding:** Hatch, Grants.

## **GOAL 3**

### **A HEALTHY WELL NOURISHED POPULATION**

#### **EXECUTIVE SUMMARY**

The Department of Food Sciences and Human Nutrition is the primary department of the ARC which participates in activities related to Goal 3. Important outcomes this year has to do with oxalate content of food and the development of a resource of use to practicing dietitians advising patients with calcium oxalate kidney stones, and the use of goal setting in the development of quality programming in diabetes education.

## DEPARTMENTAL REPORTS

### Department of Food Science and Human Nutrition

1. **WNPO103: Dietary and Psychosocial Factors affecting Self-Management of Type 2 Diabetes Mellitus.**
  - A. **Key Theme:** Human Health and Human Nutrition.
  - B. **RPA 703:** Nutrition Education and Behavior
  - C. **Description:** Determine stages of dietary self-management after diabetes education when the type 2 patient adjusts dietary goals set during diabetes education. Identify the psychosocial influences associated with changes in dietary goals, including self-efficacy, and social and environmental factors. Identify characteristics of patient experiences with goals setting during and after diabetes education that can be developed as evidence-based indicators for patient monitoring, program evaluation, and quality improvement. Instigate projects that address the needs of at-risk and underserved groups with diabetes and their health care providers as a priority effort for risk reduction in Washington State communities.
  - D. **Impacts, Outcomes, and Scope of Research:**
    - i) Diet has important preventative and treatment roles relative to certain chronic disease. Diet has a primary treatment role in the self-management of Type 2 Diabetes mellitus (non-insulin-dependent diabetes), the predominant type of diabetes. Behavioral changes related to food preparation and intake have tremendous potential to both enhance self-care and lower cardiovascular disease risk.
    - ii) Geographic Scope: National
    - iii) There are no integrated extension/research activities
    - iv) No multistate affiliation
  - E. **Source of Funding:** Hatch, State, USDA.
  
2. **WNP00370: Nutrition and Kidney Stones**
  - A. **Key Theme:** Human Health and Human Nutrition.
  - B. **RPA 702:** Requirements and Function of Nutrients and Other Food Components.
  - C. **Description:** Dietitians provide medical nutrition therapy for patients with kidney stones. If the stones contain oxalate or the patient has been diagnosed with hyperoxaluria, reduction of dietary oxalate may be appropriate. Differences in oxalate values for a single food may be due to analytical methods, and/or biological variation for several sources including cultivar, time of harvest and growing conditions. Bioavailability of food oxalate, and thus urine oxalate, will also be affected by salt forms of oxalate, food processing and cooking methods, meat composition and the presence of *Oxalabacter formigenes* in the patient's gut. A review was accepted for publication in 2007 which summarizes this information from published references. As a companion to the review, a database of all food oxalate values was published on the web.
  - D. **Impacts, Outcomes, and Scope of Research:**
    - i) **Impacts of Research:** Previously, twelve different compiled lists had to be consulted to find all values for oxalate content of a food. Reasons for the differences in published values were not discussed, and references to original methodology were not given. The review article comprehensively reviews all factors that affect food oxalate amount and bioavailability. The supporting database gives all published values in a spreadsheet format, with references. This is a valuable resource not only for researchers but also for practicing dietitians advising patients with calcium oxalate kidney stones or hyperoxaluria.
    - ii) Geographic Scope: National.

- iii) There are no integrated extension/research activities.
  - iv) No multi-state affiliation.
- E. **Source of Funding:** Hatch, State, NIH.

## **GOAL 4**

### **AN AGRICULTURE SYSTEM WHICH PROTECTS NATURAL RESOURCES AND THE ENVIRONMENT**

#### **EXECUTIVE SUMMARY**

Noteworthy achievements of the Departments of the ARC were the efforts to convert waste biomass into more environmentally friendly substances that would also contribute to the economy and the well-being of the farmer. The agricultural industries in WA provide millions of tons of biomass that could, if properly converted, be transformed into bioenergy and biochemicals. There is an increased effort in the Biological Systems Engineering department in partnership with other units (under goals 1 and 4) to develop technologies and processes to convert a wide range of Washington-based biomass feedstocks to products and fuels. The Department of Crop and Soil Sciences is continuing its studies of no-till and systems cropping research for conservation of the land and turning a profit both for the organic and conventional farmer. According to NRCS data, more than 40% of high rainfall Palouse cropland is now under conservation-till, and water erosion rates have been reduced from an average of 45 Mg/ha in 1975 to 23 Mg/ha in 1990 to 9 Mg/ha in 2005. In the School of Economic Sciences, faculty members are studying the management of inter-sector mobilization of water in irrigation.

#### **DEPARTMENTAL REPORTS**

##### **DEPARTMENT OF BIOLOGICAL SYSTEMS AND ENGINEERING**

1. **WNP00450: The Science and Engineering for a Biobased Industry and Economy.**
  - A. **Key Theme:** Agricultural Waste Management.
  - B. **RPA 511:** New and Improved Non-Food Products and Processes.
  - C. **Description:** The research proceeded in several areas. A fungal pelletization technology was developed that allows the control of fungal morphology to a desired form to increase significantly the productivity of the fermentation processes. Different pretreatment and hydrolysis methods were tested for their effectiveness in liberating sugar from manure fiber. A strategy was developed for high cell density algal culture with cell density reaching as high as 100 mg/l with glycerol as the raw material.
  - D. **Impacts, Outcomes and Scope of Research:**
    - i) **Impacts of Research:** The research is oriented to the development of commercially viable products and processes. A collaborator in Canada is evaluating the scale-up of the pelletization technology. The pretreatment procedure was used for laboratory production of fumaric acids from manure fiber. The algal culture technology can be used to produce omega-3 polyunsaturated fatty acids from glycerol, a biodiesel waste. This process can help to improve the economics of biodiesel production.
    - ii) **Geographic Scope:** The work is important in any state with significant animal agriculture in enclosed facilities.

- iii) This project does not have research/extension integration.
    - iv) This project is not affiliated with a multistate research committee.
  - E. **Source of Funding:** Hatch, USDA, private foundation.
- 2. **WNP00554: Optimize Anaerobic Digestion System for Dairy Manure Treatment.**
  - A. **Key Theme:** Agricultural Waste Management.
  - B. **RPA 402:** Engineering Systems and Equipment; **RPA 403:** Waste Disposal, Recycling, and Reuse.
  - C. **Description:** The goal of this research is to help transform manure into products that have value instead of treating it as a waste. Major progress in the previous year includes the operation and evaluation of the pilot digester at the WSU dairy center, the development of an ammonia recovery process, the new knowledge on phosphorous in the effluent of dairy anaerobic digester, and the completion of a working ADM1 model for dairy manure application.
  - D. **Impacts, Outcomes and Scope of Research:**
    - i) **Impacts of Research:** The progress in the previous year makes it possible to develop an integrated anaerobic digestion system that not only allows harvesting for renewable energy but also for nutrient recovery to produce organic fertilizers.
    - ii) **Geographic Scope:** The work is important in all states with substantial animal agriculture in confined facilities.
    - iii) This project does not have research/extension integration.
    - iv) This project is not affiliated with a multistate research committee.
  - E. **Source of Funding:** Hatch, USDA, Washington Technology Center, private foundation, industry.
- 3. **WNP00553: Development and Application of Models for the Analysis of Agricultural Systems in the State of Washington.**
  - A. **Key Theme:** Water Quality.
  - B. **RPA 102:** Soil, Plant, Water, Nutrient Relationships; **RPA 111:** Conservation and Efficient Use of Water; **RPA 205:** Plant Management Systems; **RPA 511:** New and Improved Non-Food Products and Processes.
  - C. **Description:** The goal of this project is to develop mathematical models to improve decision-making in agricultural operations, especially with regard to application of water and nitrogen to crops and with regard to nutrient management in dairy farms. In the previous year, a complex two-canopy-fractions photosynthesis and transpiration model, developed and tested last year, was used to evaluate the transferability across climatic conditions of simple radiation-use and transpiration-use efficiency models to predict biomass production. The development of a linked soil carbon-nitrogen cycling model, important in the continuing development of mathematical models, was completed. A version of CropSyst, a comprehensive cropping systems simulation model written in Visual Basic for Applications, was developed in Microsoft Excel and subsequently linked to Access, allowing for the generating of basic elements of a farming systems tool by combining data base management and cropping systems simulation.
  - D. **Impacts, Outcomes and Scope of Research:**
    - i) **Impacts of Research:** Progress this year has allowed the research team to develop better models for water-driven productivity and carbon-nitrogen cycling. The completion of CropSyst and its availability in Excel and Access provides the researchers and others with tools to evaluate water and nitrogen management, crop water-use efficiency, the soil carbon sequestration for farming/cropping systems of interest in the Pacific Northwest, the United States, and around the world as a function of location, soil, and long-term weather and atmospheric carbon dioxide concentration conditions.
    - ii) **Geographic Scope:** This research has importance throughout agriculture.

- iii) This project does not have research/extension integration, although dissemination and use of the model is important to the researchers.
    - iv) This project is not affiliated with a multistate research committee.
  - E. **Source of Funding:** Hatch, USDA, private foundation.
  
- 4. **WNP00630: Animal Waste Treatment, Management, and Utilization for Protection of Air and Water Qualities.**
  - A. **Key Theme:** Agricultural Waste Management.
  - B. **RPA 133:** Pollution Prevention and Mitigation; **RPA 403:** Waste Disposal, Recycling, and Reuse.
  - C. **Description:** Research is focused on the addition of value to animal waste and other low-value agricultural residuals through bioconversion of these materials in hydrogen. Part of the preliminary work is focused on improving production yields using base material (glucose, for example). Another area of interest is the investigation of novel nitrogen mass balance for estimation of nitrogen loss from animal feeding operations. Further research is proceeding on the stabilization of animal manure through limited-aeration treatments. This work also is considering the relationships between pH, dissolved oxygen, and oxidation-reduction potential during limited aeration of dairy wastewaters to determine suitable methods for monitoring and control of this treatment process.
  - D. **Impacts, Outcomes and Scope of Research:**
    - i) **Impacts of Research:** The work provides a more practical method of determining ammonia loss from animal facilities and facilitates development of appropriate intervention points and control measures. The work provides a more convenient and accurate method for controlling and monitoring of aerobic stabilization processes of dairy wastewaters for researchers and producers. An alternative and cost-effective process of stabilization of dairy wastewater using limited aeration treatment is available for producers.
    - ii) **Geographic Scope:** This work is important in states with large agricultural industries in confined animals, especially dairy-producing states.
    - iii) This project does not have research/extension integration.
    - iv) This project is not affiliated with a multistate research committee.
  - E. **Source of Funding:** Hatch, State of Washington, Commodity Commission.
  
- 5. **WNP07319: Modeling Hydrology and Erosion under Winter Climatic Conditions of the Pacific Northwest: Modifying WEPP.**
  - A. **Key Theme:** Water Quality.
  - B. **RPA 104:** Protect Soil from Harmful Effects of Natural Elements; **RPA 112:** Watershed Protection and Management.
  - C. **Description:** The main goal of this study was to improve the winter hydrology and erosion routine of the Water Erosion Prediction Project (WEPP) through combined experimental and modeling approaches. It was focused especially on issues related to soil that freezes and thaws during the course of the year. The research has been instrumental in issuing new releases of the model, the most recent of which is version 2006.5. It is accessible to the public at the USDA NSERL website. The new version, compiled in large part through this research, offers significant improvements over older versions of the same model.
  - D. **Impacts, Outcomes and Scope of Research:**
    - i) **Impacts of Research:** Results and findings from this study have contributed to the advancement of knowledge in frozen soil erosion and provided a much improved water erosion prediction model for practical uses.
    - ii) **Geographic Scope:** This research has importance in areas where crops are raised in soil that freezes and thaws, which is most of the most-northern states.



- iii) This project does not have research/extension integration, although dissemination and use of the model is important to the researchers.
- iv) This project is not affiliated with a multistate research committee.
- E. **Source of Funding:** Hatch, USDA, regional research foundation.

#### DEPARTMENT OF CROP AND SOIL SCIENCES

1. **WNP00250: Cropping systems research for low-precipitation dryland in eastern WA.**  
**WNP00182: Impact of no till on soil quality physical, chemical, and microbiological properties.**  
**WNP00363: Nutrient management for improved crop yield and quality for dryland cropping systems.**  
**WNP00373: Carbon and nitrogen cycling and management in alternative cropping systems.**  
**WNP00722: Organic amendments and cover crops in sustainable agricultural systems.**
  - A. **Key Theme:** Agriculture system that protects natural resources and the environment.
  - B. **RPA 102** Soil, plant, water nutrient relationships.
  - C. **Description:** These programs in the Department of Crop and Soil Sciences seek identification of improved crop and soil management practices and crop rotations for reducing soil erosion, and reducing negative impacts of farming practices on soil, air and water quality. Their purpose is to characterize critical soil and plant processes involved in soil stability, improving soil quality, nutrient cycling, carbon sequestration, and water and nutrient use efficiency. Variations on reduced tillage and no-tillage systems as well as organic production systems have been evaluated for economic, agronomic and environmental performance. Fundamental understanding of driving factors in wind erosion/particulate emissions are more clearly delineated, allowing for more effective particulate transport modeling.
  - D. **Impact and Scope of Project:**
    - i) **Impacts and Scope of Research:** University researcher-grower partnerships have spawned the Pacific Northwest Direct Seed Association, which has become an independent grower organization formed to promote the adoption of direct seeding in the PNW. Improved soil carbon sequestration and soil quality with reduced tillage cropping has been demonstrated. Crop rotation studies have documented impacts of direct seeding on carbon sequestration, which in turn has led to contractual agreements (\$40,000) between the Natural Resource Defense Council and the Pacific Northwest Direct Seed Association to reward farmers for carbon-friendly farming practices. According to NRCS data, more than 40% of high rainfall Palouse cropland is now under conservation-till, and water erosion rates have been reduced from an average of 45 Mg/ha in 1975 to 23 Mg/ha in 1990 to 9 Mg/ha in 2005. CTIC reports that direct seeded wheat in 2004 occupied 10-18% of the acreage, but as high as 60-70% in Columbia County due to focused extension efforts. Soil erosion from dry farmed cropland in all regions of the Inland PNW still exceeds tolerable rates indicating more work needs to be done. Incidents of air quality violations reported by local municipalities due to soil particulate emissions have decreased. Constraints on direct seed adoption, such as increased pest pressures have been identified.
    - ii) **Geographic scope:** Environmental and economic impact is mainly regional, but basic scientific principles have national/international impact. Organic grain cropping systems research has increased the interest and responded to market demand for organic and sustainably produced grains. Locally marketed flour produced under a sustainable market label has increased consumer interest in local agriculture.

- iii) Research and extension are well integrated. Information on alternative systems and their impacts is regularly disseminated to the agricultural, environmental and legislative segments of society.
- E. **Source of Funding:** Hatch; USDA Special Grants: CP3, STEEP, Grass Seed Cropping systems, Cool Season Food Legume; Wheat Commodity Commission; USDA-NRI.

## DEPARTMENT OF NATURAL RESOURCE SCIENCES

1. **WNP0411: Effects of Irrigation Agriculture and White-Tailed Deer on Cougar Predation of Mule Deer: A Test of the Apparent Competition Hypothesis.**
  - A. **Key Theme:** Wildlife Management.
  - B. **RPA 135:** Natural Resource and Environment.
  - C. **Description:** Mule deer in the semi-arid regions of the western U.S. are declining and white-tailed deer are increasing because of habitat changes resulting from irrigation agriculture. Recent research by this PI suggests that increasing white-tailed deer populations are resulting in increased predation by cougars on mule deer (apparent competition or alternate prey hypothesis). Increased white-tailed deer and cougars are also causing increased agricultural damage to crops and livestock. Cougar harvest appears ineffective as a solution because of cougar in migration from adjacent areas to the high-density white-tailed deer areas. The apparent competition hypothesis predicts that as densities of alternate prey (white-tailed deer) increase, so do densities of predators, resulting in increased incidental predation on sympatric native prey (mule deer) or livestock.

This experiment is now in its last year (2006), the apparent competition hypothesis has so far been supported. Based on the tracking of radio and GPS collared animals over the several years, it appears Cougars to follow and subsist on their primary prey (white-tailed deer) throughout the year. When white-tailed deer move into mule deer occupied areas in summer, the cougars follow, and predation on mule deer increases dramatically. Cougars select for and disproportionately prey on mule deer during the summer. This selective predation appears to be the cause of mule deer population declines in our study areas. Data collection was completed in the summer of 2006. The PI and his graduate students are continuing to analyzing the data and are drafting multiple refereed journal articles for submission based on this work.

- D. **Impacts, Outcomes, and Scope of Research:**
  - i) State and Federal wildlife agencies now are beginning to accept that invasion by non-native white-tailed deer is contributing to mule deer population declines. White-tailed deer management in Western North America is expected to change as a result.
  - ii) Geographic Scope: Northeast Washington, Northern Idaho and Southern British Columbia.
  - iii) There is no integrated Research and Extension Effort in the project.
  - iv) Not affiliated with a multistate project.
- E. **Source of funding:** Bonneville Power Administration, National Science Foundation and the Washington State Department of Fish and Wildlife, Hatch Funds.

## SCHOOL OF ECONOMIC SCIENCES

1. **WNP00160: Interfacing Technological, Economic, and Institutional Principles for Managing Inter-sector Mobilization of Water.**
  - A. **Key Theme:** Natural Resource Management and Other: Policies Concerning Water Use, Land Use, and Environmental Quality.
  - B. **RPA 111:** Agricultural Water Management Technologies, Institutions and Policies Affecting Economic Viability and Environmental Quality.
  - C. **Description:** The research focused on the linkages between on-farm irrigation effectiveness and water conservation, and water allocation institutions in the Western United States, showing that current water allocation institutions do not protect other irrigators or ecological instream-flow users from the negative impacts of increased consumptive use.
  - D. **Impacts, Outcomes, and Scope of Research**
    - i) **Research impacts:** Dams are the key means of storing water to be allocated among competing economic sectors. Dams have been designed traditionally as nonrenewable resources whose productive lives are cut short because rivers refilling reservoirs transport sediments that choke off reservoir storage capacity. The large environmental and economic costs of restoring storage capacity by constructing new dam/reservoir projects is prompting a shift in paradigm toward managing existing projects as renewable resources. This requires sediment control strategies that stabilize reservoir storage capacity by balancing sediment inflow and removal rates.

This project analyzes the economic dynamics of reservoir sedimentation management using the hydrosuction-dredging sediment-removal system—an emerging removal strategy engineered to be environmentally friendly. In the course of formulating optimal decision rules, a ‘critical-minimum threshold’ measure of a reservoir’s remaining storage capacity is derived. The threshold indicates whether the manager optimally manages the reservoir as a renewable or a nonrenewable resource. When storage capacity exceeds this threshold, a sustained sediment removal policy is optimal for an infinite decision horizon. Alternatively, when storage capacity is below this threshold, the optimal policy is to abandon the reservoir and allow it to eventually fill with sediment.

The work will help policy makers in understanding the economic implications of managing reservoir sediment using the hydrosuction method. The work was published in the *Journal of Economic Dynamics and Control*.
    - ii) **Geographic scope:** Western Region.
    - iii) **Affiliated with integration of research/extension with Multistate W-1190.**
  - E. **Source of Funding:** Regional Research Funds, USDA, and State Appropriations.
2. **WNP00299: Designing Efficient and Equitable Fishery Rationalization Policy Using Only Individual Fishing Quota—The Gulf of Alaska Context.**
  - A. **Key Theme:** Marketing of Seafood.
  - B. **RPA605:** Natural Resource and Environmental Economics
  - C. **Description:** The research focused on developing a quota trading model to predict quota prices and fleet behavioral responses to fishery rationalization, including an evaluation of conservation potential.
  - D. **Impacts, Outcomes and Scope of Research:**
    - i) A non-linear mixed integer quota trading model for BSAI red king crab fishery was completed. This research contributes to the congressionally mandated 18-month review of the crab rationalization policy that was enacted into law, January 2004 and implemented August 2005. The model reveals that IPQs had

no inimical effect on harvesters, as some academics, agencies and politicians had argued.

A paper was also completed that formally proves a dissolution fishery association that complies with the recently reauthorized Magnuson-Stevens Act limited access privilege program is both distributionally neutral and efficient. This paper formally proves that an institutional structure based on a cooperative/partnership framework in which ITQs are allocated only to harvesters who sign a private dissolution contract with traditional processors will advance efficiency without unintended redistribution. The framework conforms to the new federal limited access privilege requirements of MSA.

A Law Review article was completed concerning BSAI crab rationalization (forthcoming March 2007). Magnuson-Stevens Act legislative history reveals NMFS routinely undercuts MSA's special administrative process whereby policy formulation is the sole prerogative of the Regional Fishery Management Councils and the lead federal agency (the National Marine Fisheries Service, as delegate of the Secretary of Commerce) is relegated to policy implementation. It does so through the regulations it writes. The paper reviews a recent example in which NMFS attempted to undermine the North Pacific Fishery Management Council's crab rationalization policy through the regulation-writing process--a clear violation of MSA. A simple solution to help avoid future abuse of authority was provided. The article offers a constructive solution to a perennial problem. Impact remains to be seen.

- ii) Geographic Scope: International.
  - iii) Integrated research and extension: 10% of the PI's time is spent on Extension activities.
  - iv) Not affiliated with multistate activity.
- E. **Source of Funding:** State Appropriations and Other Non-Federal Funds.

## **GOAL 5**

### **ENHANCED ECONOMIC OPPORTUNITY AND QUALITY OF LIFE FOR AMERICANS**

#### **EXECUTIVE SUMMARY**

Currently, there are only three Departments which contribute to the work under goal V. These are the Department of Horticulture and Landscape Architecture, the Department of Community and Rural Sociology, and the Department of Natural Resource Sciences. The sole project reported on this year is from the Department of Community and Rural Sociology - the Social Sciences Research Center reports that the manner in which a survey is laid out often influences the outcome of the survey.

#### **DEPARTMENTAL REPORTS**

## COMMUNITY AND RURAL SOCIOLOGY

1. **WNP00942: How Visual Design and Layout Influences Answers to Self-Administered Paper and Internet Surveys.**
  - A. **Key Themes (Other):** Public Policy, Improving the Quality of Public and Private Data Gathering.
  - B. **RPA: 805:** Community Institutions and Social Services.
  - C. **Description:** This research project, whose origins date back more than three decades, utilizes cognitive interviews and field survey experiments to discover procedures for reducing measurement and nonresponse error in mail, telephone and internet surveys. Earlier research led to specific suggestions and changes that led to improvements in the conduct of the 2000 Decennial Census. Further improvements to the design of forms and implementation procedures will be made to the 2010 Decennial Census as a result of discoveries made during the course of conducting this research.
  - D. **Impacts, Outcomes and Scope of Research:**
    - i) **Impacts of Research:** Results from the research conducted as part of this project are being cited extensively by researchers throughout the world. The citation impact can be expected to increase substantially in the next few years and have a significant impact on the conduct of survey research around the world. Over 650 citations were noted on publications related to this project in 2006 alone.
    - ii) **Geographical Scope:** Nationwide.
    - iii) This project has integrated research and extension activities.
    - iv) **Multistate Research Committee:** WERA-1001.
  - E. **Source of Funding:** Hatch and State.

## **SECTION III**

### **PROGRAM REVIEW PROCESS**

There have been no significant changes in the ARC research program review process since the 5-year POW was submitted, nor are any important changes under consideration.

### **STAKEHOLDER INPUT PROCESS**

The active engagement of College of Agricultural, Human and Natural Resource Sciences with its stakeholders is fostered by the statewide presence of our College in every county of Washington and through the College's network of Research and Extension Centers. The Centers address mainstream issues of organizations, communities, and enterprises within the state. The resulting partnerships garner and direct financial resources towards priority needs of stakeholders.

The College focuses on critical stakeholder issues through a variety of mechanisms. Ongoing dialogues stimulate effective communication about current and emerging issues. A formal advisory council includes representatives from major agricultural commodities, food processors, special interest groups and organizations, and partnering state agencies and institutions. Representatives of our College regularly attend meetings of commodity commissions and agricultural organizations such as Washington Ag Presidents, Washington Friends of Farms and Forests, the West AgriBusiness Association, and the Washington Sustainable Food and Farming Network.

The Agricultural Research Center (ARC) coordinates research reviews at which College faculty present annual reports on their past research efforts and request new funds in support of new research. Major commodity research review panels involve wheat, barley, peas and lentils, potatoes, and tree fruits. The ARC also coordinates with the Washington State Commission for Pesticide Registration (WSCPR) to fund research proposals involving new pesticides or IPM strategies to protect both major and minor crops. In addition to funding projects seeking registration for special uses of pesticides, WSCPR funds integrated pest-control strategies that minimize the use of pesticides through the use of biocontrol.

Five years ago, all units of the College participated in stakeholder meetings to develop comprehensive strategic plans directed at priority research and educational goals. Department chairs participated in three statewide stakeholder meetings to review their plans and develop the framework for funding requests for both state and federal levels. A comprehensive white-paper was developed from the stakeholder input and discussions that occurred during these meetings.

In each case, stakeholder input is carefully considered so that the Agricultural Research Center remains responsive to all groups within our constituency. Stakeholder input has been woven into our Strategic Plan as well as the research plans and programs carried out within the College.

### **EVALUATION OF THE SUCCESS OF JOINT REGIONAL AND MULTISTATE ACTIVITIES**

The ARC POW described the ongoing regional cooperation and joint activities that have existed among the Pacific Northwest land-grant institutions and others for several decades. The POW identified joint regional projects in which research efforts continue to produce desired results. Those listed below are special USDA grant-funded projects.

- Tri-state potato variety breeding programs conducted cooperatively by scientists at University of Idaho (UI), Oregon State University (OSU), USDA-Agricultural Research Services (ARS), and WSU.
- Cool Season Food Legume Research Program with scientists at UI.

- Jointed Goatgrass: A Threat to U.S. Wheat Production involves coordinated research in Colorado, Idaho, Kansas, Montana, Nebraska, Oklahoma, Oregon, Utah, Washington, and Wyoming.
- STEEP III - Solutions to Environmental and Economic Problems. Includes research and extension programs to protect soil and water resources in the Pacific Northwest - UI, OSU, WSU, and USDA-ARS.
- Grass Seed Cropping Systems for a sustainable Agriculture is conducted in cooperation with UI and OSU.
- PM-10 involves particulate emission prediction and control from agricultural land with scientists from WSU, USDA-ARS, and UI.
- The Barley Genome Study involves personnel at WSU and OSU.
- WSU, OSU, USDA-ARS, and UI have entered into joint agreements on release of all new varieties on all crops, the majority of which are cereal grains.
- The Northwest Center for Small Fruit Research and Northwest Center for Nursery Crop Research continue to be effective vehicles for obtaining stakeholder input on research needs and coordination of research for the Pacific Northwest land-grant universities.
- Aquaculture Idaho-Washington is a collaborative program between the University of Idaho and Washington State University, which seeks to solve disease, production, and marketing problems in the trout aquaculture industry.

Each of the multistate research projects is subjected annually to review, and progress reports are submitted via CRIS. Because these programs are “stand-alone” joint multistate projects and have detailed objectives for each of the cooperating institutions, the ARC POW did not further identify objectives, outputs, and outcomes. Information about each is available through CRIS and will not be duplicated in this report. The joint efforts on the projects have resulted in continued program effectiveness benefiting agricultural producers in many locations, especially the Pacific Northwest.

WSU research scientists participate in a large number of multistate research projects and coordinating committees. Administrative advisors file annual reports in addition to the CRIS progress reports filed by scientists at each cooperating institution. These reports will not be duplicated in this report. See Appendix A for a list of WSU ARC faculty serving as administrative advisors to various multistate projects.

Appendix B is a list of current Multistate Research projects and Coordinating Committees in which WSU faculty and ARS cooperators participate. It also includes Hatch Multistate Research Funds travel expenditures for WSU participants to the annual MRF meetings as well as the coordinating committee meetings. Appendix C lists faculty members with split appointments among research, teaching, and/or extension or faculty members with a 100% extension appointment who attended multistate research or coordinating committee meetings in FY 2005.

## **AGRICULTURAL RESEARCH CENTER – UNIVERSITY EXTENSION COORDINATION**

Faculty of the ARC and WSU Extension cooperate in program planning and delivery primarily on an individual basis. Sixty one faculty members, plus eight college administrators for a total of sixty-nine, have split appointments between ARC and Extension. Such assignments assure a significantly high level of cooperation and coordination, although most is informal. Scientists stationed at the off-campus Research and Extension Centers/Units routinely conduct research and extension education responsibilities jointly. Appendix C illustrates the split appointments for faculty participating in multistate research and coordinating committee projects.

U.S. Department of Agriculture  
 Cooperative State Research, Education, and Extension Service  
 Supplemental to the Annual Report of Accomplishments and Results  
 Multistate Extension Activities and Integrated Activities  
 (Attach Brief Summaries)

Institution: Washington State University  
 State: Washington

Check One:  Multistate Extension Activities  
 Integrated Activities (Hatch Acts Funds)  
 Integrated Activities (Smith-Lever Act Funds)

Actual Expenditures

Title of Planned Program/Activity	FY 2006
Enhancing the Global Competitiveness of Red Meat	\$28,365.12
Integrated Management of Winter Annual Grass Weeds in Eastern Washington Dryland Crop Systems	\$28,748.59
Benefits and Costs of Natural Resource Policies Affecting Public and Private Lands	\$42,467.61
Research Design and Managing Risk in Agricultural Conservation and Pest Management Systems	\$63,958.87
High Value Specialty Crop Pest Management	\$22,721.40
Disease Warning and Management Systems for Potato and Mint	\$13,417.09
Stem Cell and Embryo Development and Manipulation for the Improvement of Livestock	\$79,226.33
Berry Crop Water and Nutrient Management for Optimal Yield and to Avoid Soil-Borne Disease and Leaching	\$66,287.67
 Total:	 \$345,193.17

\_\_\_\_\_  
 Ralph Cavaliere  
 Director

\_\_\_\_\_  
 Date

Form CSREES-REPT (2/00)



## WSU COMPLIANCE WITH AREERA

In July 2000, ARC requested a post-waiver from target percentage for Integrated Activities with Extension. The appropriate forms on file at CSREES document that the target percentage for FY2000 was zero. For the FY 2004, the target percentage is 5%; however, for FY 2006 we are choosing to report on a higher percentage 10.3% of integrated projects below.

Since Washington is an agriculturally diverse state, we are reporting on eleven projects encompassing benefits for a cross-section of Washington's citizens. For FY 06, we have chosen to feature: (1) enhancing the global competitiveness of meat; (2) integrated management of winter annual grass weeds in eastern Washington dryland cropping systems; (3) benefits and costs of natural resource policies affecting public and private lands; (4) research design and managing risk in agricultural conservation and pest management systems; (5) high value specialty crop management; (6) disease warning systems for potato and mint; (7) stem cell and embryo development and manipulation for the improvement of livestock; and (8) berry crop water and nutrient management for optimal yield, and to avoid soil-borne disease and nitrate leaching. The total funding allocated to these integrated projects is \$345,193.17 which is approximately 10.3% of our allocated Hatch formula funds.

### **0764 Enhancing the Global Competitiveness of Red Meat - \$28,365.12**

Work conducted in collaboration with New Zealand scientists which compared the effects of production system (grass- versus Grain-feeding) and age on bio-active compounds was published. Beef from feedlot-finished cattle contained less iron than pasture-finished cattle, possibly due in part to an age effect. Moreover, feedlot-finished beef contained lower levels of coenzyme Q10, taurine, and carnosine, but not creatine. Intramuscular fat from pasture-finished cattle had a lower ratio of n-6/n-3 PUFAs, lower levels of trans C18:1 except for trans vaccenic acid (TVA), and higher levels of both a potentially anticarcinogenic CLA as well as its precursor TVA than that of grain-fed beef. Collaborative work with a genomics faculty member resulted in two peer reviewed journal articles. In one study, both cDNA and genomic DNA sequences were annotated for the bovine PAPD1 gene and ten genetic markers were detected in the promoter and exon 1 region. Among seven markers assayed on ~ 250 Wagyu x Limousin F(2) animals, two single nucleotide polymorphisms (SNPs) in the promoter region were significantly associated with intramuscular fat ( $P < 0.05$ ). However, there was a significant interaction ( $P < 0.05$ ) between a third SNP, which causes an amino acid change in coding exon 1, and each of these two promoter SNPs on intramuscular fat deposition. In particular, the differences between double heterozygous animals at two polymorphic sites and the slim genotype animals exceeded 2.3 standard deviations for the trait in both cases. In the second study, we added two novel positional candidate gene regions, one on BTA1 and one on BTA13 for beef marbling. Further studies are needed to confirm and characterize these genes on how they are functionally involved in the genetic control of beef marbling variation. This study may also provide important information to unravel genetic complexity of obesity on these two chromosomal regions in humans. We also developed and published a widely applicable, novel, simple and inexpensive method for extracting and methylating fatty acids for gas chromatography. Its unique performance, including easy sample preparation, is achieved because water is included in the FAME reaction mixtures rather than eliminated.

**Impact:** Grass-fed beef is higher in certain bioactive compounds than grain-fed beef, but we need to determine grazing regimes optimizing content of nutritionally significant compounds and palatability. For several fatty acids, an interaction between treatment group and muscle indicated that muscles do not react exactly the same to treatment, but group rankings were usually the same for both muscles. In our first genomics study, differences between double heterozygous animals at two polymorphic sites and slim genotype animals exceeded 2.3 standard deviations, providing evidence for a new mechanism - involvement of compound heterosis in extreme obesity. Our simplified approach to genome screening of

quantitative trait loci (QTL) involves integration of amplified fragment length polymorphism (AFLP) with DNA pooling and selective genotyping and comparative bioinformatics tools and is inexpensive, less time consuming, and is particularly suitable for screening and mapping QTL-linked markers when targeting one or a few complex traits. We also added two novel positional candidate gene regions, one on BTA1 and one on BTA13 for beef marbling. We need to confirm and characterize how these genes are involved in the genetic control of beef marbling. Our method for fatty acid methyl ester synthesis meets a number of criteria for fatty acid analysis including not isomerizing conjugated linoleic acids or introducing artifacts. It is applicable to fresh, frozen, or lyophilized tissue samples, oils, waxes and feedstuffs. It saves time, effort and is economical.

#### **0584 – Integrated Management of Winter Annual Grass Weeds in Eastern Washington Dryland Crop Systems - \$28,748.59**

Over 30 weed management studies were conducted in eastern Washington in each of the past 4 years. Grass species include downy brome (*Bromus tectorum*), jointed goatgrass (*Aegilops cylindrical*), Italian ryegrass (*Lolium multiflorum*), and rattail fescue (*Vulpia myroides*). These studies have determined various methods to culturally, mechanically, or chemically manage winter annual grass weeds. The research was conducted in all major crops and several alternative crops for the area. Data from these studies were used to support several labels or label exemptions which allowed the use of herbicides in crop and noncrop areas of eastern Washington. Much of the research was done under direct seed systems and many of the herbicide practices, including optimal application timing of preemergence herbicides, have been adopted by direct seed farmers. While direct seed systems provide both environmental and economic benefits, weeds are a primary reason state for lack of adoption. Improved chemical, cultural, and integrated control of weeds is needed to ensure the success of direct seed systems. Research has been initiated on optimum rates and timings of sequential nonselective herbicide application for direct seed systems. Much of the weed control research arose from collaboration with other Washington State University, University of Idaho, Oregon State University and USDA-ARS scientists where improvements were needed in general weed control or for specific crops or weed species in order to meet the overall goals of collaborative research. Although greater than 75% of these studies involved using herbicides as the primary management tool, much research was done evaluating weed ecology biology and the potential to integrate crop management tools into production systems. Weed ecology and biology studies, while fewer in number, represented roughly an equal amount of time and resource expenditure as herbicide studies due to their more involved nature. Benefits of research in weed biology, ecology, and integrated management systems include reduced pesticide use, increased yield, increased crop quality, and overall better use of production resources. Specific discoveries in the area of weed ecology and biology include determining the benefits of increased seeding rates and the use of taller wheat varieties to minimize the impact of jointed goatgrass. Another significant study was to quantify and characterize seed production of spring emerging jointed goatgrass, a species largely considered to be winter annual in biology. More effective use of spring crops to manage jointed goatgrass in crop rotations will result from this research.

**Impact:** With the recent introduction of the Clearfield/Beyond herbicide resistant crop weed control system, information from a nonbiased source was necessary for growers to optimally integrate the system into their production. The use of this system is the only method to selectively control jointed goatgrass in PNW winter wheat. Reports indicate that there were 300,000 acres of Clearfield winter wheat planted in Washington in the fall of 2006. While it is not the position of Washington State University to interfere with free enterprise in the release of such a program, it is in the best interest of the grower and the manufacturer that products are correctly integrated into production systems. Moreover, it is important that the grower understand all current and future implications of a herbicide product or system to the future of their farming operation. The implications include, but are not limited to herbicide persistence, variety selection, and herbicide resistance. Additionally, management of ACCase (group 1) herbicide resistant Italian ryegrass was addressed. Programs researched the use of alternative herbicide mode of

action and combinations of mode of action for the resistant biotypes. A section 18 label exemption was supported for Axiom herbicide in 2003, 2004, 2005, and 2006 with the exemption being granted in each of those years. Information on annual grass management, Clearfield wheat, and resistance management was presented to growers at over 40 presentations in eastern Washington from 2003 through 2006.

**0448 – Benefits and Costs of Natural Resource Policies Affecting Public and Private Lands  
\$43,467.61**

Many federal and state agencies, as well as private landowners, face difficulty in balancing economic feasibility with environmental quality. Work is being completed on the theoretical basis in a multiple option value model with stochastic returns to development. The empirical analysis is complete. The consideration of more than one option value in a portfolio-of-options context is an important and novel contribution to the literature. This paper will be submitted to the American Economic Review. A game theoretic model that analyzes the incentives and interaction between the landowner and the government in the takings of development rights from landowner was revised this year. This paper is currently under peer review.

**Impact:** The research on option values for conservation properties is useful for policy makers and groups considering making a conservation purchase.

**0347 - Research Design and Managing Risk in Agricultural Conservation and Pest Management Systems - \$63,958.87**

Increased adoption of conservation farming systems will reduce resource degradation and off-site damage to human health, recreational values, and other impacts. This project examines the impacts of such systems on farmer profits and income stability. This research confirmed that conservation tillage wheat-fallow systems were both more profitable and less risky than annual no-till cropping systems in low rainfall areas of eastern Washington.

**Impact:** In part, as a result of our research, the Washington Association of Wheat Growers was able to secure a \$900,000 federal grant to provide 50 farmers 50% cost sharing to secure undercutter implements to adopt conservation fallow systems.

**0122 – High Value Specialty Crop Pest Management - \$22,721.40**

USDA/IR-4 is a federal/state/private cooperative that aspires to obtain clearances for pest control chemistries on minor crops. The WSU representative serves as the State Liaison from Washington State to the USDA/IR-4 program and is on the Western Region Executive Advisory Board. His laboratory serves as the Field Research Center for EPA Region 10. EPA Region 10 consists of Eastern Oregon, Eastern Washington, and most of Idaho. All IR-4 research--field and laboratory--is carried out according to Good Laboratory Practice (GLP) requirements as mandated by EPA. The research process is inspected by IR-4 quality assurance personnel to validate compliance. Since late 1998, over 60 GLP residue trials have successfully completed. Each trial encompasses a significant data package and typically contains over 100 printed pages. The State Liaison responsibilities in 2006 included attendance at an IR-4 prioritization workshop in Indianapolis and attendance Field Research Director GLP Certification Courses. GLP Magnitude of Residue Trials Completed in 2006 (presented as Test Substance: Crop) include: 2,4-DB: lentil; acequinocyl: cherry (sweet); etoxazole: mint Captan; fomesafen: potato Captan; halosulfuron: apple; Ksugamycin: pear; linuron: pea (dry); pyrimethanil:cherry; V-10118: apple.

**Impact:** The IR-4 magnitude of pesticide residue program in Washington State continues to provide Washington State specialty crop producers with most of the new reduced risk crop protection chemicals that serve as replacements and improvements on traditional broad spectrum pest control chemistries.

#### **0678 - Disease warning systems for potato and mint. – \$13,417.09**

Spatial patterns of mint plants with symptoms of Verticillium wilt caused by *Verticillium dahliae* were characterized in 10 commercial mint fields in Washington using several spatial analysis methods. The disease was assessed in 0.76-by-0.76-m quadrats (width of mint rows was 0.76 m) in randomly selected study sections varying in size from 5 to 76 m wide by 57 to 396 m long. The variance-to-mean ratio identified aggregation of diseased stems within quadrats even though probability distributions associated with cluster data did not fit the data well. Generally, there was more clustering within than across rows according to both doublets and runs analyses. Total number of wilt foci ranged from 5 to 170 per field, and mean size of foci ranged from 1 to 2.7 quadrats. In one field observed repeatedly, total foci increased from 24 to 104, and the mean size of foci increased from 1.0 to 1.3 quadrats in the same section of the field from one year to the next. Size of foci increased to 2.7 quadrats in a third year of sampling the same field. Mean focus size was larger within than across crop rows in 10 of 13 field-sampling occasions. The proximity index ranged from 0.88 to 1.00, indicating highly compacted disease foci. The statistical methods employed were useful in describing, quantifying, and visualizing spatial patterns of infected mint in commercial fields. Verticillium wilt spread during the life of the perennial mint crop. Inoculum from much of the secondary increase likely did not directly originate from microsclerotia present in soil before the crop was planted or from infected rhizomes that originally were planted.

**IMPACT:** Verticillium wilt was demonstrated to spread within commercial mint fields during the life of the perennial crop. Previously, either inoculum in soil or in infected mint rhizomes present before the crop was planted was thought responsible for all infected mint plants. Disease management strategies should include reducing initial inoculum in soil and mint rhizomes before the crop is planted and also secondary inoculum that is responsible for the secondary spread.

#### **0706 –Stem Cell and Embryo Development and Manipulation for the Improvement of Livestock \$79,226.33**

Initial cultures produced vesicles 0.2mm to 4.0mm in diameter. After four days vesicles formed were 0.1mm to 1.0mm in diameter. Vesicles 4.0mm in diameter were able to attain a maximum size of 1.5cm by 20 days in culture. Maximum diameter varied according to initial size, with smaller vesicles exhibiting less expansion as compared to larger vesicles. Average growth rate obtained for all vesicles greater than 2.0mm in diameter at formation was 0.25mm/day. Once maximum size was attained, vesicles began to develop outgrowths in an organized fashion. Localized tissue formation was accompanied by a decrease in vesicle diameter. Condensation of the main vesicle took place at the localized site of tissue formation. Large vesicles (over 1.5mm in diameter) were able to maintain free floating nature for 65 days, at which time culture was terminated and vesicles histologically sectioned. Smaller vesicles (under 1.5mm in diameter) reattached to plates within one week of formation, and cells of the vesicles plated out in a monolayer. No new vesicles formed from the cells of reattached vesicles. Contractile elements formed as early as 7 days, and as late as 34 days of culture. Formation of the contractile heart in the developing pig embryo occurs at 20 days. Contractile elements and vasculature formed from either plated cellular aggregations or from thickened areas of the floating vesicles. All observed contractile regions were closely

associated with a very dense cellular region. Contractions were rhythmic and constant over two measurements five minutes apart, consisting of up to 102 beats/minute. Contraction rates of vesicles changed daily, with no apparent pattern of change being noted. Rate of contraction was not correlated to time in culture, change to fresh media, or change in temperature that occurred during time of measurement (from 37 C to 30 C). Contractions continued until vesicles were sectioned for histological examination (30 to 45 days), or in the case of plated cell contraction elements, until culture was terminated (7 days). Within three days of contractile element formation, tubular structures were identified in association with contractile areas. Movement of cells within these areas was noted, and was in synchrony with contractions, indicating the direct control of fluid and cell movement through the tubule by the contractile element. Examination of histological sections gave evidence of the formation of eosinophilic cells, blood islets, and contractile elements with no evidence of a forming neural system. Blood islets and eosinophilic cells were associated with the contractile elements forming an apparent vascular tissue matrix. Contractile elements were positive for the formation presence of calcium activated ATP-ase activity, and were unresponsive to acid reversal of calcium activated myo-fibrillary ATP-ase activity at pH 4.3 and pH 4.5, indicating a similarity to cardiac muscle fibers.

**IMPACT:** The ability to produce large numbers of vesicles from dispensed embryo cells, and the evidence of a controlling region of cell differentiation that is morphologically viable, demonstrates that trophoblastic vesicles are a model to study the embryonic event of cardiac organ formation and may serve as a source of stem cells for cardiac cells.

### **0633- Berry Crop Water and Nutrient Management for Optimal Yield, and to Avoid Soil-Borne Disease and Nitrate Leaching - \$66,287.67**

Trials of preharvest, harvest and postharvest irrigation deficit effects were established in blueberry cv. 'Duke' and raspberry cv. 'Meeker' at WSU-Vancouver REC. There were no significant differences among raspberry treatments in total yield or fruit size. Preliminary measurements of primocane length indicate that the fully irrigated plots had the longest primocanes. Blueberry plants receiving an irrigation deficit through the harvest season did have significantly lower yields than those in the other treatments. Evaluations of this season's plant growth and of bud development in the treatments are ongoing. Trials to evaluate effect of drip line placement on raspberry root rot development were established at WSU-Puyallup REC and WSU-Mount Vernon NWREC. Plots of industry standard 'Meeker' and highly resistant variety 'Cascade Bounty' were irrigated via drip lines above the crown, above and offset 6 inches from the crown, or buried 6 inches to the side of the crown. All plots received the same amount of water. Recording tension meters installed near the crown of the raspberry plants document that the soil at the crown stayed much wetter for much longer following irrigations when the drip line was directly above the crown. This may substantially affect the development of raspberry root rot. There were no differences in vegetative growth among irrigation treatments; canes of 'Meeker' were longer than those of 'Cascade Bounty'. Trials to evaluate the effect of N fertilizer timing and amount and of soil amendments with composted and non-composted dairy solids were established at WSU-Mount Vernon NWREC. Soluble soil nitrate levels at the end of the growing season (October) were significantly lower in amended plots than in non-amended plots, indicating that there was a reduced probability of nitrate leaching from the amended plots. The raspberry plants responded favorably to the amendments; above-ground biomass was greater in the amended plots than in non-amended plots.

**IMPACT:** his work has begun to identify critical water use periods for raspberry and blueberry, which will help producers better time their irrigations for these high-value crops. Our finding that raspberry plants watered directly above the crown remained much wetter for a long time strongly suggests that drip line placement will be a useful tool for growers seeking to reduce root rot problems. The beneficial effects of soil amendments on both plant growth and reduced nitrate leaching potential strongly suggest this practice for raspberry establishment, but confirmation in a second year is required.

## **SECTION IV**

### **APPENDIX A**

#### **Agricultural Research Center Administrative Advisors FY 2006**

##### **Ralph P. Cavalieri, CAHNRS Associate Dean, Director of the Agricultural Research Center**

W-006 "Plant Genetic Research Conservation and Utilization"

NRSP-5 (Co-AA) "National Program for Controlling Virus Diseases of Temperate Fruit Tree Crops"

WERA-20 "Virus and Virus-Like Diseases of Fruit Trees, Small Fruits, and Grapevines"

WERA-043 (Co-AA) "Establishing Bio-Intensive Pest Management Programs for Western Orchard Systems"

WERA -097 (Co-AA) "Diseases of Cereals"

##### **Sandra Ristow, Associate Director, Agricultural Research Center**

WERA-099 "Broodstock Management, Genetics and Breeding Programs for Molluscan Shellfish"

WERA-101 (Co-AA) "Assessing China as a Market and Competitor"

WERA-1001 (Co-AA) "Reduction of Error in Rural and Agricultural Surveys"

##### **Vicki A. McCracken, Asst VP/VProvost Enrollment Services**

WERA-1001 "Reduction of Error in Rural and Agricultural Surveys"

##### **Jay Brunner, Director, Tree Fruit Research and Extension Center**

WERA-043 (Co-AA) "Establishing Bio-Intensive Pest Management Programs for Western Orchard Systems"

##### **Tim Murray, Chair, Plant Pathology Department**

WERA-097 (Co-AA) "Diseases of Cereals"

##### **Tom Wahl, Director, Impact Center**

WERA-101 (Co-AA) "Assessing China as a Market and Competitor"

##### **Linda K. Fox, Dean and Director, Extension**

W-1001 "Population Change in Rural Communities"

WDC005 "Obesity: Assessment, Prevention and Intervention"

**FY 2005-2006 Multistate Research Fund Projects with WSU Faculty and ARS Cooperator Participation**

<b>Prjct</b>	<b>Title</b>	<b>MRF #</b>	<b>Term Date</b>	<b>Researcher</b>
0452	Rootstock and Interstem Effects on Pome and Stone Fruit Trees	NC-140	09/2007	1 Barritt, B.H.
0452	Rootstock and Interstem Effects on Pome and Stone Fruit Trees	NC-140	09/2007	2 Whiting, M
0128	Management of Grain Quality and Security for World Markets	NC-213	09/2008	1 Baik, B.K.
0403	Systems Analyses of the Relationship of Agriculture and Food Systems to Community Health	NC-1001	09/2006	1 Jussaume, R.A.
0605	Impact Analysis and Decision Strategies for Agricultural Research	NC-1003	09/2006	1 Shumway, R.
0261	Enteric Diseases of Swine and Cattle: Prevention, Control and Food Safety	NC-1007	09/2007	1 Besser, T.E.
0261	Enteric Diseases of Swine and Cattle: Prevention, Control and Food Safety	NC-1007	09/2007	2 Gay, J.M.
0261	Enteric Diseases of Swine and Cattle: Prevention, Control and Food Safety	NC-1007	09/2007	3 Hancock, D.D.
0261	Enteric Diseases of Swine and Cattle: Prevention, Control and Food Safety	NC-1007	09/2007	4 Call, D. R.
0261	Enteric Diseases of Swine and Cattle: Prevention, Control and Food Safety	NC-1007	09/2007	5 Cobbold, R
0862	Metabolic Relationships in Supply of Nutrients for Lactating Cows	NC-1009	09/2007	1 McNamara, J.P.
0581	The Chemical and Physical Nature of Particulate Matter Affecting Air, Water, and Soil Quality	NC-1022	09/2009	1 Harsh, J.
0467	Improvement of Thermal and Alternative Processes for Foods	NC-1023	09/2010	1 Barbosa-Canovas, G.V.
0467	Improvement of Thermal and Alternative Processes for Foods	NC-1023	09/2010	2 Powers, J.R
0467	Improvement of Thermal and Alternative Processes for Foods	NC-1023	09/2010	3 Tang, J.
0467	Improvement of Thermal and Alternative Processes for Foods	NC-1023	09/2010	4 Clary, C.
0913	Molecular Mechanisms Regulating Skeletal Muscle Growth and Differentiation	NC-1131	09/2010	1 Dodson, M.
0119	Regulation of Photosynthetic Processes	NC-1142	09/2007	1 Okita, T.W.
0119	Regulation of Photosynthetic Processes	NC-1142	09/2007	2 Edwards, G.E.
0409	Eradication, Containment and/or Management of Plum Pox Disease (Sharka)	NE-1006	09/2006	1 Eastwell, K.C.
0990	Assuring Fruit and Vegetable Product Quality and Safety Through the Handling and Marketing Chain	NE-1008	09/2007	1 Tang, J.
0990	Assuring Fruit and Vegetable Product Quality and Safety Through the Handling and Marketing Chain	NE-1008	09/2007	2 Fellman, J.K.
0709	Mastitis Resistance to Enhance Dairy Food Safety	NE-1009	09/2007	1 Fox, L.K.
0709	Mastitis Resistance to Enhance Dairy Food Safety	NE-1009	09/2007	2 Davis, W.C.
0998	Rural Communities, Rural Labor Markets and Public Policy	NE-1011	09/2007	1 Holland, D.W.
0230	Sustaining Local Food Systems in a Globalizing Environment: Forces, Responses, Impact	NE-1012	09/2007	1 Ostrom, M.

0230 Sustaining Local Food Systems in a Globalizing Environment: Forces, Responses, Impact	NE-1012	09/2007	2	Jussaume, R.
0797 Postharvest Biology of Fruits	NE-1018	09/2008	1	Fellman, J.K.
0797 Postharvest Biology of Fruits	NE-1018	09/2008	2	Kupferman, E.M.
0596 Multi-state Evaluation of Winegrape Cultivars and Clones	NE-1020	09/2017	1	Davenport, J.
0596 Multi-state Evaluation of Winegrape Cultivars and Clones	NE-1020	09/2017	2	Keller, M.
0154 Whole Farm Dairy and Beef Systems for Environmental Quality	NE-1024	09/2010	1	Harrison, J.H.
0122 High Value Specialty Crop Pest Management	NRSP-4	09/2009	1	Walsh, D.B.
1262 National Program for Controlling Virus Diseases of Temperate Fruit Tree Crops	NRSP-5	09/2008	1	Eastwell, K.C.
1262 National Program for Controlling Virus Diseases of Temperate Fruit Tree Crops	NRSP-5	09/2008	2	Howell, W.E.
1262 National Program for Controlling Virus Diseases of Temperate Fruit Tree Crops	NRSP-5	09/2008	3	Cavalieri, R.P.
1262 National Program for Controlling Virus Diseases of Temperate Fruit Tree Crops	NRSP-5	09/2008	4	Murray, T.D.
0568 National Animal Genome Research Program	NRSP-8	09/2008	1	Jiang, Z
0450 The Science and Engineering for a Biobased Industry and Economy	S-1007	09/2007	1	Chen, S.
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	1	Jones, S.S.
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	2	Coyne, C.J.*
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	3	Clement, S.L.*
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	4	Hannan, R.M.*
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	5	Johnson, R.C.*
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	6	Dugan, F.M. *
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	7	Cavalieri, R.P
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	8	Welsh, M.
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	9	Bradley, V.
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	10	Hellier, B.
1134 Plant Genetic Resource Conservation & Utilization	W-006	09/2008	11	Greene, S.
7996 Multistate Research Coordination, Western Region	W-106	09/2029	1	Cavalieri, R.P.
7996 Multistate Research Coordination, Western Region	W-106	09/2029	2	Ristow, S.S.
0957 Reproductive Performance in Domestic Ruminants	W-112	09/2006	1	Reeves, J.J.
0957 Reproductive Performance in Domestic Ruminants	W-112	09/2006	1	McLean, D.
0445 Population Change in Rural Communities	W-1001	09/2007	1	Kirschner, A.
0445 Population Change in Rural Communities	W-1001	09/2007	1	Fox. L.
0905 Nutrient Bioavailability – Phytonutrients and Beyond	W-1002	09/2007	1	Shultz, T.D.
0276 Parent and Household Influences on Calcium Intake Among Preadolescents	W-1003	09/2007	1	Edlefsen, M.S.



0570	Marketing, Trade, and Management of Fisheries and Aquacultural Resources	W-1004	9/2008	1	Matulich, S.
0372	Agrochemical Impacts on Human and Environmental Health: Mechanisms and Mitigation	W-1045	09/2010	1	Hebert, V.
0448	Benefits and Costs of Natural Resources Policies Affecting Public and Private Lands	W-1133	09/2007	1	McCluskey, J.J.
0448	Benefits and Costs of Natural Resources Policies Affecting Public and Private Lands	W-1133	09/2007	2	Wandschneider, P.R.
0448	Benefits and Costs of Natural Resources Policies Affecting Public and Private Lands	W-1133	09/2007	2	Yoder, J.
0564	Managing Plant Microbe Interactions in Soil to Promote Sustainable Agriculture	W-1147	09/2008	1	Riga, E.
0564	Managing Plant Microbe Interactions in Soil to Promote Sustainable Agriculture	W-1147	09/2008	2	Weller, D.M.
0564	Managing Plant Microbe Interactions in Soil to Promote Sustainable Agriculture	W-1147	09/2008	3	Grunwald, N.J.
0564	Managing Plant Microbe Interactions in Soil to Promote Sustainable Agriculture	W-1147	09/2008	4	Paulitz, T.
0564	Managing Plant Microbe Interactions in Soil to Promote Sustainable Agriculture	W-1147	09/2008	5	Okubara, P.
0560	Exotic Germplasm Conversion and Breeding Common Bean ( <i>Phaseolus vulgaris</i> L.) for Resistance to Abiotic and Biotic Stresses and to Enhance Nutritional Value	W-1150	09/2010	1	Hang, A.N.
0560	Exotic Germplasm Conversion and Breeding Common Bean ( <i>Phaseolus vulgaris</i> L.) for Resistance to Abiotic and Biotic Stresses and to Enhance Nutritional Value	W-1150	09/2010	2	Swanson, B.
0690	Chemistry, Bioavailability, and Toxicity of Constituents in Residuals and Residual-Treated Soils	W-1170	09/2009	1	Kuo, S.
0706	Germ Cell and Embryo Development and Manipulation for the Improvement of Livestock	W-1171	09/2009	1	Wright, R.W.
0764	Enhancing the Competitiveness of U.S. Meats	W-1177	09/2007	1	Busboom, J.R.
0121	Biological Control in Pest Management Systems of Plants	W-1185	09/2007	1	Piper, G.L.
0185	Genetic Variability in the Cyst and Root-Knot Nematodes	W-1186	09/2008	1	Riga, E.
0152	Characterizing Mass and Energy Transport at Different Scales	W-1188	09/2009	1	Flury, M.
0152	Characterizing Mass and Energy Transport at Different Scales	W-1188	09/2009	2	Wu, J. Q.
0160	Interfacing Technological, Economic, and Institutional Principles for Managing Inter-Sector Mobilization of Water	W-1190	09/2009	1	Huffaker, R.G.
0160	Interfacing Technological, Economic, and Institutional Principles for Managing Inter-Sector Mobilization of Water	W-1190	09/2009	2	Yoder, J.
0160	Interfacing Technological, Economic, and Institutional Principles for Managing Inter-Sector Mobilization of Water	W-1190	09/2009	3	Chouinard, H.

Multistate Research Funds Travel (October 1, 2005 – September 30, 2006  
Expenditures for WSU Participants (Not including Coordinating Committees)

MRF		
Comm	Title	Total
NC-140	Rootstock and Interstem Effects on Pome- and Stone Fruit Trees	724.39
NC-1009	Metabolic Relationships in Supply of Nutrients for Lactating Cows (NC-185)	1039.65
NC-1022	The Chemical and Physical Nature of Particulate Matter Affecting Air, Water and Soil Quality. (NCR174)	1591.70
NC-1023	Improvement of Thermal and Alternative Processes for Foods (NC136)	1631.86
NE-1008	Assuring Fruit and Vegetable Product Quality and Safety Through the Handling and Marketing Chain	239.94
NE-1009	Mastitis Resistance to Enhance Dairy Food Safety	979.65
NE-1018	Postharvest Biology of Fruit	1862.65
NE-1020	Multi-state Evaluation of Winegrape Cultivars and Clones	1003.79
NE-1024	Whole Farm Dairy and Beef Systems for Environmental Quality	724.30
NRSP-5	National Program for Controlling Virus Diseases of Temperate Fruit Tree Crops	262.71
NRSP-8	National Animal Genome Research Program (From NSRP-8)	562.06
W-6	Plant Genetic Research Conservation and Utilization	1249.15
W-112	Reproductive Performance in Domestic Ruminants	862.61
W-1001	Population Change in Rural Communities	524.00
W-1002	Nutrient Bioavailability--Phytonutrients and Beyond	745.20
W-1003	Parent and Household Influences on Calcium Intake Among Preadolescents	1572.20
W-1004	Marketing, Trade, and Management of Fisheries and Aquaculture Resources	1035.09
W-1045	Agrochemical Impacts on Human and Environmental Health: Mechanisms and Mitigation (from W045)	1734.52
W-1133	Benefits and Costs of Natural Resources Policies Affecting Public and Private Lands	1141.20
W-1170	Chemistry, Bioavailability, and Toxicity of Constituents in Residuals and Residual-Treated Soils	878.67
W-1188	Characterizing Mass and Energy Transport at Different Scales	1055.26
	TOTAL	21,420.60

## APPENDIX B

<b>Multistate Research Funds Travel (Oct. 1, 2005-Sept. 30, 2006)</b>		
<b>Expenditures for WSU Participants, Coordinating Committees Only</b>		
<b>MRF</b>	<b>Traveler</b>	<b>Totals:</b>
NCCC-22	Moore, Pat	706.29
NCCC-170	Zhang, Hao	1048.26
NCDC-207	Feise, Christopher	958.92
NCERA-180	Pierce, Francis	912.69
NCERA-199	Gaskins, Charles	821.16
NCR-131	Newberry, Ruth	815.13
NECC-63	Smith, Trenton	1380.28
NECC-1009	Barritt, Bruce	843.40
SCC-76	Wang, Hong (Holly)	1295.04
WERA-001	Gaskins, Charlie	1007.45
WERA-20	Cavalieri, Ralph	883.01
WERA-20	Howell, William	1022.85
WERA-40	Hardesty, Linda	770.44
WERA-43	Brunner, Jay	1230.61
WERA-66	Ullrich, Steve	841.61
WERA-69	Walsh, Doug	1509.45
WERA-77	Yenish, Joe	638.70
WERA-89	Pappu, Hanu	803.15
WERA-97	Murray, Tim	921.10
WERA-99	Ristow, Sandra (AA)	1622.21
WERA-101	Wahl, Tom	1368.34
WERA-103	Koenig, Richard	1633.54
WERA-202	Peters, R. Troy	1320.40
WERA-1001	Dillman, Don	1202.63
	<b>Grand Total:</b>	<b>25,556.66</b>

## Appendix C

### Faculty with Split Appointments or 100% Extension Appointments Attending Multistate Research or Coordinating Committee Meetings FY 2006

MRF#	R/T FTE	EXT FTE	Participant
NCDC-207	0.50	0.50	Feise, Christopher
NE-1020	0.4286	0.5714	Spayd, Sara
NE-1024	0.50	0.50	Harrison, Joseph
W-1001	0.60	0.40	Kirschner, Annabel
W-1004	0.90	0.10	Matulich, Scott
W-1045	0.5819	0.4181	Hebert, Vincent
WERA-001	0.83	0.17	Gaskins, Charles
WERA-40	0.50	0.50	Hardesty, Linda
WERA-69	0.25	0.75	Walsh, Doug
WERA-77	0.25	0.75	Yenish, Joseph
WERA-97	0.83	0.17	Murray, Timothy
WERA-103	0.60	0.40	Koenig, Richard
WERA-202	0.20	0.80	Peters, R. Troy