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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Period Covered

Federal FY2005
October 1, 2004 to September 30, 2005

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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, 2004 – September 30, 2005) 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 POW revision submitted on July 2, 2001.

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
School of Economic Sciences (formerly Agricultural and Resource Economics)
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
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 Agriculture and Home Economics, 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 FY2005, the ARC received and expended $1,968,749 in Hatch funds and $1,230,409 in Hatch Multistate Research funds.

Hatch and Hatch Multistate Research funds constitute 3.99 % and 2.49 %, respectively, of the total funds expended on Agricultural Research Center (ARC) projects. State appropriations are 41.76 % of the total with all other grants totaling 38.59 %.

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 2005

Funding Source	CSREES Goals					Total	% of Totals
	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5		
Hatch Funds	$1,081,293.78	$236,742.60	$28,759.45	$458,395.00	$163,558.20	1,968,749.03	3.99 %
Multistate Research Funds	$688,876.64	$371,808.72	$6,454.26	$161,628.38	$1,640.72	$1,230,408.72	2.49 %
Federal Research Grants	$3,053,957.79	$564,743.90	0.00	2,227,550.65	$342,937.60	$6,189,189.94	12.55%
State Appropriations	$12,822,649.37	$2,683,852.32	$532,328.40	$4,044,244.91	$510,054.98	$20,593,129.98	41.76 %
All Other Grants	$12,109,756.62	$2,053,550.90	$131,007.80	$4,353,427.20	$382,124.80	$19,029,867.32	38.59 %
Animal Health	0.00	$11,606.00	0.00	0.00	0.00	$11,606.00	0.02 %
McIntire-Stennis	$205,884.40	0.00	0.00	$87,378.80	0.00	$293,263.20	0.59 %
Totals	$29,962,418.60	$5,922,304.44	$698,549.91	$11,332,624.94	$1,400,316.30	$49,316,214.19	100.00%
Percentage of Total $	60.76 %	12.01 %	1.42 %	22.98 %	2.84 %	100.00%	
FTEs	302.69	64.79	7.63	123.62	9.83	508.56	
Percentage of Total FTEs	59.52 %	12.74 %	1.50 %	24.31 %	1.93 %	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 2005 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 300 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 and Central Washington. Western Washington is home to an extraordinarily diverse agriculture in an expanding urban environment in which local food systems have become quite important. 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 2005 under goal 1 were particularly noteworthy and included new thrusts in nutrient management by a number of departments and centers, in particular, the Animal Sciences Department, Biological Systems Engineering and the IMPACT Center. There is a continuous effort in the Biological Systems Engineering Department (found under both goals 1 and 4) to derive bio-based products out of the biomass (whey, manure, cull potatoes), which would ordinarily be cast aside. Seventeen million tons of biomass are produced in Washington per year. With the new processes developed by our Biological Systems Engineering Department, bio-waste is yielding methane, fiber, antibiotics, ethanol, lactic acid, etc. In joint efforts by the engineers and Food Sciences and Human Nutrition Department, there are efforts to make our foods safer and tastier by perfecting new preservation methods, particularly by microwave methods. The Department of Crops and Soil Sciences continues to develop, evaluate and release new germplasm (wheat and barley) tailored for the Pacific Northwest. For example, 62% of the 1,690,000 acres of soft white winter wheat in Washington is now planted with WSU varieties with gross value of $438 million. A formulation (invented by a faculty member in Horticulture) when sprayed on apples prevents apples from becoming sunburned, saving Washington orchard owners $20 million in the past two years. The Institute of Biological Chemistry continues to make fundamental discoveries in plant biochemistry including measuring the energy budget of a plant, elucidating terpenoid biosynthesis (including the enzymes in the pathway which produces Taxol, the anti-cancer drug), elucidating the nutrient exchange pathways in one of the bacteria performing nitrogen fixation in alfalfa, and discovering the peptides mediating the immune defense and polypeptide signaling in plants. The Department of Plant Pathology continues to work on the taxonomy and control of fungi damaging Washington crops (including wine grapes and the products of the vegetable seed industry. Grape growers estimate that disease forecasting coupled with a new oil-based management program has reduced the use of synthetic fungicides by 20 to 40% and lowered the chemical costs by $100 per acre. All in all, the researchers in the Agricultural Research Center are contributing to the knowledge base in agricultural and natural resource sciences.

DEPARTMENT OF ANIMAL SCIENCE

1. **Goal 1: WNP00181: Genetic variation in growth, carcass composition, quality and fatty acid composition of Wagyu, Angus and Wagyu-Angus cross cattle.**
   - **A. Key Theme:** Animal Production Efficiency.
   - **B. RPA 303**: Genetic Improvement of animals.
   - **C.** Description: The economics of long term feeding of Wagyu cattle for production of very high quality meat is being evaluated. After the last weigh period (484 days on feed, 716 days of age) feed cost per kg gain was $1.20 and the total cost of gain including $.40/d yardage was $2.19/kg.
   - **D. Impacts of research:** Because of a strong demand there is a great deal of interest by cattle producers in the development of niche markets for beef such as organic, natural, grass finished and other types. Wagyu beef has been shown to be more tender and able to achieve higher degrees of marbling with lower subcutaneous fat at heavier weights than other breeds. Wagyu also has a different and healthier fatty acid composition with a greater ratio of monounsaturated to saturated fatty acids.
   - **E. Source of Funding:** Hatch and State.

2. **WNP00446: A Candidate Gene Approach for Mapping of Quantitative Trait Loci for Marbling in Wagyu x Limousin Crosses.**
   - **A. Key Theme**: Animal Genomics, Animal Production Efficiency and Biotechnology.
   - **B. RPA 303:** Genetic Improvement of Animals.
   - **C.** Description: This study searches for genes or DNA markers that affect or are linked to economically important carcass traits in beef cattle.
   - **D. Impacts of research**: A fatty acid binding protein was found to be associated with both marbling and subcutaneous fat depth. This could greatly enhance the ability of cattle producers to select for better marbling.
   - **E. Source of Funding**: Hatch, State, Grant.

3. **WNP00538: Development of ex situ bovine spermatogenesis.**
   - **A. Key Theme**: Animal Genomics, Animal Production Efficiency and Biotechnology.
   - **B. RPA 301**: Reproductive Performance of Animals.
   - **C.** Description: The purpose of this research project is to characterize the expression profile of genes necessary and sufficient for the establishment of spermatogenesis in bulls and rats and to identify the factors that regulate spermatogonial stem cell (SSC) self-renewal and differentiation.
   - **D.** Impacts of research: Knowledge gained from this research will enhance our understanding of spermatogenesis in livestock species to improve reproductive efficiency in these animals and can be used to explore ways to overcome blocks in sperm production that result in male factor infertility.
   - **E. Source of Funding**: Hatch, State, NIH Grant.

4. **WNP00627: Associations of the Basal Mitochondrial Transcription Machinery Genes with Marbling in Beef Cattle.**
   - **A. Key Theme**: Animal Genomics, Animal Production Efficiency and Biotechnology.
   - **B. RPA 303**: Genetic Improvement of Animals.
   - **C.** Description: This study has focused on searching for markers in mitochondrial DNA that are associated with fattening in beef cattle. Mitochondria are important in regulating energy utilization in animals.
   - **D. Impacts of research**: Two SNP's were found for a mitochondrial transcription factor that were associated with marbling. This research could enhance selection for marbling in beef cattle.

E. Source of Funding: Hatch, State, Baxter Foundation Grant.

5. WNP04956: Sterilization Vaccine for Cattle.
- **A. Key Theme**: Animal Production Efficiency and Biotechnology.
- **B. RPA 301**: Reproductive Performance of Animals.
- **C. Description**: The purpose of this research is to develop vaccines to sterilize either male for female cattle.
- **D. Impacts of research**: Being able to vaccinate to sterilize an animal reduces the stress of invasive methods; and if gonadal hormones are not interrupted, faster gain and better feed efficiency will result.
- **E. Source of Funding**: Hatch, State, NRI Grant.

6. WNP08157: 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.** Description: The goal of this project is to obtain gaseous and particulate emissions data from cattle feedlots and to provide credible scientific information currently lacking to animal agricultural stakeholders and for making air quality policy decisions.
- **D. Impacts of research**: The result will be to reduce fluxes and ambient concentrations of nitrous oxide, methane, particulates, and carbon dioxide from cattle feeding operations.
- **E. Source of Funding**: Hatch and State.

7. WNP00154: Environmental and Economic Impacts of Nutrient Management in Dairy Forage Systems.
- **A. Key Theme**: Animal Production Efficiency and Biotechnology.
- **B. RPA 302**: Nutrient Utilization in animals.
- **C.** Description: Manure management is an important problem for dairy producers. This research focuses on methods to manage nutrient waste.
- **D. Impacts of research**: Winter (mid January) manure application was shown to be of value in terms of increased forage yield. The risk of off farm movement of bacteria and nutrients was shown to be minimal.
- **E. Source of Funding**: Hatch and State.

BIOLOGICAL SYSTEMS ENGINEERING

1. Goal 1: WNP00573: Physical Properties of Food Powders.
- **A. Key Theme:** Adding value to new and old agricultural products.
- **B. RPA 501:** New and Improved Food Processing Technologies.
- **C.** Brief description of the project: Designers and users of food processing equipment have difficulty dealing with powders in part because of lack of fast, reliable methods to determine the ease at which a powder flows through a chute or hopper. The purpose of this research is to determine a faster, more reliable method of making this calculation and to confirm the reliability of the method in laboratory experiments.
- **D. Impacts, Outcomes, and Scope of Research**:
  - i) Impacts of the research: The potential application of the research is in advancing the understanding of food powder physical properties and the relation to different mechanical processing operations. Furthermore, this research will provide a more rapid and trustworthy method for the characterization of food powders. The new index described above will allow for flowability equipment automation and its instant determination after shearing, improving repeatability and ease of use. Information generated will be useful in process research and development, and for storage and processing equipment designers and companies producing or using food ingredients.

ii) Geographic scope: The research will be useful in all parts of the country where food is processed into powders.
iii) The project has no integrated research and Extension activities.
iv) The project is not affiliated with a Multistate Research Committee.

E. Source of Funding: Hatch.

2. **WNP00467: (NE-136) Improvement of Thermal and Alternative Processes for Food.**

A. Key Theme: Agricultural competitiveness.
B. RPA: New and Improved Food Processing Technologies.
C. Brief description of the project: Improvement of food processing in the United States will improve the international competitiveness of American food products and provide safe, nutritious foods for American consumers. This project will apply new technologies to the processing of food in order to reduce the cost of production while improving nutrition and safety.
D) Impacts, Outcomes, and Scope of Research:
i) Impacts of the research: This project is significant because it includes thermal and nonthermal novel technologies. With regard to heating, the project is developing food processing methods that use shorter times of treatment, such as microwave or radio frequency energy. Nonthermal preservation methods under study include pressure, electricity, sound waves or light of high intensity focused in the inactivation of bacteria but at the same looking for fresh-like characteristics in the product. Besides that, other areas such as the design and development of biosensors and minimally processed food are also under research.
ii) Geographic scope: This work is important in all states with significant food processing industries.
iii) The project has no integrated research and Extension activities.
iv) The project is affiliated with a Multistate Research Committee (NE-136).
E) Source of Funding: Hatch.

3. **WNP00371: Using Microwave and Radio Frequency Energy in Food Safety, Phytosanitary and Quarantine Applications.**

A. Key Theme: Agricultural profitability.
B. RPA New and Improved Food Processing Technologies.
C. Brief description of the project: The lack of mathematical models to predict the use of microwave and radio frequency energy in processing foods makes it difficult to develop these processes for applications in food safety and sanitation. This project develops models that will be useful for microwave and radio frequency processing of foods. In the current year, researchers have started collaborative work with one of the largest seafood companies in the Pacific Northwest, Ocean Beauty Seafoods, Inc. (Seattle), and with a national organization, the Food Products Association's (FPA) Center for Northwest Seafood (Seattle) to develop an FDA-approved process for the preservation of salmon fillets.
D. Impacts, Outcomes, and Scope of Research:
i) Impacts of the research: Researchers have made major progress in the technological development of microwave sterilization of food. Two of the major accomplishments are: an effective computer vision system coupled with chemical markers and a computer simulation model that locates cold spots in packaged foods during the microwave sterilization process. The results from this research will benefit the nation's food industry in general, and the Pacific Northwest's seafood industry, in particular.

ii) Geographic scope: The emphasis on seafood will benefit states with large seafood industries. The research will be important to states with substantial food processing industries.

iii) The project has no integrated research and Extension activities.

iv) The project is not affiliated with a Multistate Research Committee.

E. Source of Funding: Hatch.

CENTER FOR PRECISION AGRICULTURE

1. Goal 1: WNP00551: (NCR-180) Advancing Precision Agricultural Systems Though Automation, Sensing, Control, and Information Systems

A. Key Theme: Precision Agriculture

B. Research Problem Area: RPA 404: Instrumentation and control systems

C. Project 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. Descriptions of this project

i). Impacts of research. The WSU Center for Precision Agricultural Systems (CPAS) has developed new wireless sensor network technologies for agriculture designed to assist growers in real-time monitoring and control. We continue to develop the regional agricultural weather network called AgWeatherNet (www.agweathernet.com) and in 2005 accomplished the following: 1) opened AgWeatherNet to the public in 2005 for the first time since 1997 when, due to lack of funding, it was converted to a subscription service, increasing subscribers from 120 in 2004 to > 1000 in 2005; 2) received funding from the Washington State Legislature to expand AgWeatherNet from 60 to > 120 stations; 3) develop new wireless network hardware to improve AgWeatherNet performance in support of the expansion; and 4) continued to add private weather stations to AgWeatherNet via commercial Resellers.

We completed the commercial launch of the AgFrostNet system, an on-farm wireless sensor network for frost protection, with two authorized Resellers selling the system to Washington growers. AgFrostNet includes hardware and software developed by CPAS and approximately 25 growers had the system installed in 2005. Further developments of sensor networks included the development and implementation of a real-time water quality monitoring system for agricultural producers in NW Washington State. The on-farm network was expanded to include real-time monitoring and control for irrigation, one for continuous move irrigation systems, and one for fixed irrigation systems. A patent was received for an apparatus and method for measuring the mass of vegetation or fruit supported on a trellis and this technology grape yield monitoring was also integrated into the on-farm wireless networks. These new applications were deployed and tested but not commercialized in 2005.

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: The AgWeatherNet system is important for both research and extension particularly in applications for IPM, water management, and frost protection. We have joint research using these technologies in WA State including two USDA-ARS units, in Montana with USDA-ARS, and in Wisconsin with the University of Wisconsin and are establishing collaborative efforts with USDA-ARS in Oregon. We have installed and operate regional weather networks in WA State and Montana

using these technologies (www.prosser.wsu.edu and www.agweathernet.com) and have installed on-farm networks in WA State and Oregon and deployed and tested real-time control of continuous move irrigation systems in Montana and North Dakota. We have commercialized these technologies through a non-disclosure manufacturing agreement with a WA State company and these products are currently marketed and sold by three registered resellers of CPAS technologies.

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, USDA-IFAFS; American Farmland Trust/ EPA Region 10; Washington Tree Fruit Research Commission (multiple grants); Washington State Legislature baseline funding for CPAS; Washington State Commission on Pesticide Registration; Washington Association of Wine Grape Growers; Private donations; Washington State University.

DEPARTMENT OF CROP AND SOIL SCIENCES

1. Goal 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, 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: The 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 wheat cultivars developed include hard red, hard white, soft white, and club. Barley cultivars include feed and malting types. Approximately 1.69 million acres of soft white winter wheat were grown in WA in 2005, of which 62% were planted with WSU releases, producing a gross value of $438 million dollars. Soft white winter club varieties were planted on 105,000 acres, with 99% of the acreage planted with WSU varieties, grossing $27 million. Hard red winter wheat was grown on 105,000 acres, with 61% planted to WSU varieties, grossing $14.4 million. Soft white spring wheat was grown on 248,000 acres with 90% WSU varieties grossing $43.9 million. Hard red spring wheat was grown on 169,000 acres with 24.8% planted to WSU varieties grossing $11 million. Twenty-five percent of the barley acreage is planted to WSU varieties. In addition, increasing research have stimulated interests in perennial wheat and organic wheat breeding.

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.

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. Goal 1: WNP05505: Development of and Integrated Pest Management Program Against Wood Burrowing Insect pests in Poplar Plantings.

A. Key theme: Agricultural Profitability.

B. RPA205: Plant Management and Production Systems.
RPA216: Integrated pest Management Systems.

C. Western poplar clearwing moths [*Paranthrene robiniae* (Hy. Edwards)] are endemic in Pacific Northwest riparian habitats at low population densities. These moths have colonized commercial hybrid poplar plantings. Moth populations increased rapidly and became a major pest as more plantations were developed. Trap catches of male moths in mid-season surveys increased 190-fold from 95 in 2001 to over 18,500 in 2002 across 6,597 hectares (ha) of poplars monitored. The outbreak of western poplar clearwing moth was widespread in 2002. Pheromone baited traps placed 1 trap per 81.75 ha over 13,274 ha of commercial poplars, captured >108,000 male moths in 2002. Damage to commercial poplars included girdling of saplings and burrows in limbs and trunks of trees. Repeated applications of chlorpyrifos failed to reduce the abundance of moths in 2002. Two management strategies over two separate plantations of approximately 6,500 ha each were contrasted from 2001-2005. Future control strategies recommend a halt to the use of contact insecticides that target adult moths. Short-term (3-5 years) control should involve a pheromone-based mating disruption strategy followed eventually by selection of a clone that is less susceptible to *P. robiniae* attack.

D. Impacts, Outcomes, and Scope of Research:

i) The project has had several significant impacts that are based on our integrated approach, mostly through the use of pheromones, to manage the Western poplar clearwing moth. This IPM approach has resulted in the reduction of chlorpyrifos use from 44,000 pounds in 2002 to zero in 2005. Damage in newly planted trees (which would have needed replanting) was reduced from 73,218 trees in 2003 to zero in 2005. This was a direct savings of $20,682 in replanting costs. Damage to one- and two-year old trees was reduced by 90% and 86% respectively. This resulted in a savings in excess of $51,000 for all poplar plantings. We can expand the savings of not having to replant trees when we examine the biology of the poplar plantation. The canopy closes within six months, which means that trees cannot be replanted after June of each year. If a newly planted tree is lost to clearwing moth attack, that space remains empty for 12 years. There are 50,000 acres of poplar in the Pacific Northwest. If these farms are managed for saw timber at 291 trees/acre and each tree has a market value of $48 (2005 value) then at harvest, for each 1% of trees that are not destroyed within the first six months, there would be a savings of $145,000. Thus far, three companies have accepted and implemented our pheromone-based strategies on 35,000 acres in eastern Oregon and Washington. Due partially to the success of controlling the clearwing moth, a new sawmill, that will employ 55 persons, is being built in eastern Oregon.

ii) Geographic scope: Regional

iii) Integrated research and extension: Constant contact is maintained with the industry through meetings and reports.

iv) Not affiliated with a multistate project.

E. Source of Funding: State Funds, other non-Federal Funds, and Hatch Funds.

2. WNP0455: Biological Diversity Studies of Arthropod Taxa.

A. Key Theme: Invasive species.

B. RPA 211: Insects, mites, and other arthropods affecting plants.

C. The primary focus of efforts during 2005 was moth studies at several Palouse Prairie sites located in eastern Washington and northern Idaho. We are continuing to develop baseline data on insects (especially moths) that inhabit native prairie sites. This is being compared to the fauna of agriculturally active, adjacent sites. The emphasis of these studies is to document the native fauna and then examine the condition of that fauna at sites of various size and physical state throughout the region. This information is of value to those conducting biological diversity studies as well as to individuals and entities examining the value of preserving patches of native prairie in order to preserve native plant and animal communities. These studies complement similar ones conducted throughout Washington and the Pacific Northwest during the past 10 years. We also continued efforts to document the moth fauna of Washington through our own collecting and the aid of cooperators throughout the state. Again, the endpoint of these efforts is to provide scientifically based information to those making agricultural pest management and land management decisions.

Cooperative projects with the University of Guam and Universidad del Valle de Guatemala resulted in trips by James Collection personnel to Guam and Guatemala. Beyond the examination of invasive species into Guam, these studies allow us to add material to the Collection that is then made available to taxonomists throughout the world who are conducting systematic studies.

During the calendar year 2005 we added a substantial amount of material to the M. T. James Collection. Approximately 5,000 specimens from native Palouse prairie, 6,000 specimens (from Guam) collected during cooperative studies with personnel at the University of Guam, 6,000 specimens from Guatemala (in cooperation with personnel in Guatemala), and over 10,000 donated specimens.

D. Impacts, Outcomes, and Scope of Research:

i) Specimens collected during biological diversity studies and housed in the James Collection are used as a basis for the identification of material from numerous research projects. Twenty-two loans of specimens (18,354 total specimens) were made to scientists in the United States, Canada, and Europe. Additionally, three graduate students are conducting Collection and Collection/field based studies. The Collection performed 312 identifications or requests for information for a wide variety of stakeholders including homeowners, commodity group personnel, students, the veterinary college, and state and federal regulatory agencies.

ii) Geographic scope: International

iii) Integrated research and extension: Cooperative research is conducted with USDA/ARS personnel as well as personnel at the University of Guam and Universidad del Valle de Guatemala. Extension interactions primarily are through presentations, specimen identifications, and filling requests for information concerning potential pest arthropods.

iv) Not affiliated with a multistate project.

E. Source of Funding: Hatch, State Funds, Other non-Federal funds, grant funds.

1. **Goal 1: WNP00346: Physiological and Biochemical Markers of Potato Seed-Tuber Age and Productivity.**
   A. Key Theme: Agricultural Profitability.
   B. RPA 205: Plant production and management systems.
   C. The main focus of this project is on the identification of biochemical/physiological markers of potato seed-tuber age and investigation of their efficacy for predicting the relative productivity of different lots of seed-tubers. The results include comparative evaluations of newly released cultivars for responses to factors that affect physiological age of seed, Characterization of the growth and yield responses from northern- and southern-grown seed in the Columbia Basin, an understanding of the basic relationships among stem numbers, tuber set, and tuber size distribution, and identification of a metabolic marker of relative seed productivity to be used in a "Crop Productivity Estimator".
   D. Impacts, Outcomes, and Scope of Work:
   i) This research has had a positive impact on seed and commercial potato growers. Both segments of the industry now recognize that there is an opportunity to add value to both seed and commercial crops by controlling the physiological age of potato seed-tubers. Seed growers are beginning to keep track of the heat-units accumulated by their crops from vine kill to planting the following season. This information can be used as a marketing tool to enhance the value of a particular seed crop. Seed growers recognize that providing a crop that consistently produces the same stem numbers year after year will allow commercial growers to adjust management practices to optimize tuber size distribution profiles for maximum value. This research has identified optimal spacing in relation to stem numbers for maximizing yield of the most desirable tuber size classes for seed, fresh, and processing markets for the main fresh and processing cultivars produced in the Pacific Northwest.
   ii) The geographic scope of this work is regional. The results will be applicable for potato growers in the Pacific Northwest.
   iii) It is not an integrated research and extension project.
   iv) It is not a multi-state research project.
   E. Source of Funding: Hatch, Commodity Commission.

2. **WNP00624: Potato Cultivar Evalution and Commercial Potato Seed Lot Trials.**
   A. Key Theme: Agricultural Profitability.
   B. RPA 205: Plant production and management systems.
   C. 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 resent 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 approximately $135 million farm gate. Value of the new varieties comes in the form of improved quality, increased yield, and decreased inputs. As 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, Commodity Commission and USDA.

3. 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. 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®, that reduces sunburn, 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 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® was issued by the US Patent and Trademark Office in February 2005. Three 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®. The third (a provisional) was filed November 27, 2004, on a new fruit surface temperature sensor that will be used to control evaporative cooling systems and perhaps other systems. The technology for RAYNOX® 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 was marketed widely in 2004 and 2005. It is estimated that RAYNOX® has saved Washington apple growers over $20 million in the past two seasons. RainGard™, the cherry protectant, was tested in the Southern Hemisphere during 2004/05 and in WA and OR during 2005. This technology was licensed by WSURF to FruitGard, LLC during 2004. RainGard™ will be introduced commercially during 2006 in WA and OR.

ii) Although the research that lead to the development RAYNOX® and the fruit surface temperature sensor was carried out in Washington State, the technology should be applicable in any location where similar environmental conditions (intense radiation and temperature) exist.

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, and Commodity Commission.

IMPACT CENTER

1. **WNP06901: Enhancing Competitiveness of Agricultural Products.**
   - **A. Key Theme:** Agricultural Competitiveness.
   - **B. RPA 511:** New and Improved Non-Food Products and Processes.
   - **C**. Project Description: Washington's potato growers harvest about 5 million tons of potatoes every year. About 10 percent are culls, potatoes that do not meet minimum size, grade or quality standards. Culls can't be processed or sold on the fresh market. About 15 percent end up as cattle feed or as some kind of a residual use byproduct. Growers receive less than $10 a ton for culls. That is $55 a ton less than it costs to grow potatoes. Fermentation and separation processes that are being developed will transform culls into high-value food and non-food products, including chitin, chitonase, and lactic acid. This process uses starch, protein, nitrogen and phosphate that remains in the wastewater following processing. The biggest challenge is making the process economical.
   - **D. Impacts, Outcomes and Scope of Research:**
     - i) Impacts of the research: Growers currently receive less than $10 a ton for culls. It is worthwhile to note that the current wholesale price of lactic acid, which is used as a food additive for flavor and preservation and in the development of poly-lactic acid, a product used to make biodegradable plastics and textiles, is 50 cents a pound. Pure chitin or chitonase is $4,500 a pound. Based on current data, a ton of fresh potatoes could yield an estimated $90 worth of lactic acid. Depending on purity, a ton of potatoes also could yield chitin estimated to be worth between $18 and $18,000.
     - ii) Geographic scope of the research: National and International.
     - iii) Integrated research and extension: None.
     - iv) Multistate affiliation: None .
   - **E. Source of Funding:** Contracts, grants, and competitive agreements, USDA, and other federal funds.

2. **WNP007901: Enhancing Competitiveness of Agricultural Products.**
   - **A. Key Theme:** Food Quality and Food Safety.
   - **B. RPA 501:** New and Improved food processing technologies.
   - **C**. **Project Description:** Milk is a very important product in the human diet, but sometimes it is not an available commercial product for difficult access areas and must be brought from distant places. Due to its short shelf life and perishable nature, fluid milk is not suitable for distant export. Currently, milk is pasteurized with conventional pasteurization methods and bulk-shipped for the specific areas of consumption. After the thermal pasteurization, the milk has been reduced in quality and nutritional aspects in order to ensure the microbiological safety. After the milk reaches its destination, it is re-pasteurized again before consumption. This process decreases the quality and increases the costs. Researchers in WSU's Biological Systems Engineering Department and Food Science and Human Nutrition Department have developed an economical method for extending the shelf life of fluid milk for more than 80 days by applying pulsed electric fields (PEF) treatments to thermally pasteurized milk. Pulsed electric fields inactivate potential spoilage microorganisms via electroporation and spoilage enzymes via hydrolysis.
   - **D. Impacts, Outcomes and Scope of Research:**
     - i) Impacts of the research: The four-fold extension of shelf life could dramatically expand the geographic area that fluid milk could be shipped to from Washington State, especially to Asian markets, such as India, China, Japan and other countries on the Pacific Rim. At the same time, the discovery signifies an

improvement in milk quality over milk currently processed with double thermal treatments.

ii) Geographic scope of the research: International.

iii) Integrated research and extension: None.

iv) Multistate affiliation: None.

E. Source of Funding: Contracts, grants, and competitive agreements, USDA, and other federal funds.

3. WNP00541: International Marketing Program for Agricultural Commodities and Trade.

A. Key Theme: Agricultural Trade and Profitability.

B. RPA 606: International trade and development economics.

C. Project Description: Many countries around the world impose tariffs on apples imported from the United States. These trade barriers are designed to protect local apple producers, but the tariffs also deflate demand for apples around the globe because of higher prices in importing countries. The tariffs also result in an oversupply of apples for the U.S. domestic market, lowering prices for U.S. apple growers. Washington apple growers harvested about 4.5 billion pounds of apples in 2003. About 3.5 billion pounds were fresh shipped. About 25 percent of that total was exported. These tariffs are negotiated by several different negotiating bodies. Trade policy, including tariffs, may be negotiated bilaterally between two countries, regionally between two multi-nation negotiation bodies like NAFTA or through the World Trade Organization. As organizations make their cases on tariffs, it is often difficult to get specific numbers on how these barriers will affect each country or region. This project used a spatial equilibrium trade model to evaluate the economic effects of alternative trade policies for apples. Most spatial equilibrium models rely heavily on past estimates or elasticity databases for their inputs and are calibrated. This study uses elasticity values from econometric estimation. Additionally, most spatial equilibrium models incorporate specific tariffs, which are fixed. This study employs ad valorem tariffs, which depend on the value of the goods, and are used by most countries as a protection measure.

D. Impacts, Outcomes and Scope of Research:

i) Impacts of the research: For example, using this data, U.S. negotiators could document how the demand by consumers in India for apples would grow if tariffs were reduced by 50 percent, 25 percent or at any level being negotiated. Information from this model is also useful for growers. This model provides an impetus for U.S. growers to become more involved in trade negotiations because the direct impact to their bottom line is spelled out in the analysis. Data from the model could also be useful in settling disputes between countries.

ii) Geographic scope of the research: International.

iii) Integrated research and extension: None.

iv) Multistate affiliation: None.

E. Source of Funding: Contracts, grants, and competitive agreements, USDA, and other federal funds.

INSTITUTE OF BIOLOGICAL CHEMISTRY

1) **Goal 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.** We have now established regulatory connections between the ATP synthase, the transthylakoid proton motive force, and the regulation of photosynthetic antenna (1-7) 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. We have made several important contributions to understanding the cytochrome bc1 and b6f complexes, which are essential parts of the plant energy transduction pathways in the mitochondrion and chloroplast 8-12. In particular, we now have a better understanding of, and a good working model for, how the enzyme carried out its unique redox cycle without killing the organism with toxic byproducts.
   - **D. Impacts and Scope of Research:**
     - i) Impacts of research: This research has focused on understanding the energy budget and regulation of photosynthesis, the process that powers essentially all life on the planet, scrubs the atmosphere of the greenhouse gas, CO2, and strongly impacts crop productivity.
     - 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 Theme:** 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.** 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: Matairesinol is a central biosynthetic intermediate to numerous 8-8 lignans, including to various heartwood-protecting substances, such as plicatic acid and its congeners, in western red cedar (*Thuja plicata*). It is formed by action of an enantiospecific secoisolariciresinol dehydrogenase, an NAD(H)-dependent oxidoreductase that catalyzes the conversion of secoisolariciresinol. To understand the molecular and enantiospecific basis of secoisolariciresinol dehydrogenase, crystal structures of the apo-form, binary and ternary complexes were determined at 1.6, 2.8 and 2.0 angstrom resolution, respectively. The enzyme is a homo-tetramer, consisting of an alpha/beta single domain monomer containing seven parallel beta-strands flanked by eight alpha helices on both sides. Its overall monomeric structure is similar to that of NAD(H)-dependent short-chain dehydrogenases /reductases, with a conserved Asp^{47} forming a hydrogen bond with both hydroxyl groups of the adenine ribose of NAD(H), and thus specificity toward NAD(H) instead of NADPH. The highly conserved catalytic triad (Ser^{153}, Tyr^{167}

and Lys^{171}) is adjacent to both NAD^+ and substrate molecules, where Tyr^{167} functions as a general base. Following analysis of high resolution structures of the apo-form and two complex forms, the molecular basis for both the enantio-specificity and the reaction mechanism of secoisolariciresinol dehydrogenase is discussed, and compared to that of pinoresinol-lariciresinol reductase.

D. Impacts and Scope of Research

i) Impacts of research: The data generated in this proposed study will be of enormous importance whether 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 Funds: Hatch, McIntire-Stennis, DOE, 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. Leaf membrane lipids of the Arabidopsis fab1 mutant contain a 35-40% increase in the predominant saturated fatty acid, 16:0, relative to wild type. This increase in membrane saturation is associated with loss of photosynthetic function and death of mutant plants at low temperatures. We have initiated a suppressor screen for mutations that allow survival of fab1 plants at 2 degrees C. Five suppressor mutants identified in this screen all rescued the collapse of photosynthetic function observed in fab1 plants. While fab1 plants died after 5-7 weeks at 2 degrees C, the suppressors remained viable after 16 weeks in the cold, as judged by their ability to resume growth following a return to 22 degrees C and to subsequently produce viable seed. Three of the suppressors had changes in leaf fatty acid composition when compared to fab1, indicating that one mechanism of suppression may involve compensating changes in thylakoid lipid composition. Surprisingly, the suppressor phenotype in one line, S31, was associated with a further substantial increase in lipid saturation. The overall leaf fatty acid composition of S31 plants contained 31% 16:0 compared with 23% in fab1 and 17% in wild type. Biochemical and genetic analysis showed that S31 plants contain a new allele of fad5, fad5-2, and are therefore partially deficient in activity of the chloroplast 16:0 delta7-desaturase. A double mutant produced by crossing fab1 to the original fad5-1 allele also remained alive at 2 degrees C, indicating that the fad5-2 mutation is the suppressor in the S31 (fab1 fad5-2) line. Based on the biophysical characteristics of saturated and unsaturated fatty acids, the increased 16:0 in fab1 fad5-2 plants would be expected to exacerbate,

rather than ameliorate, low-temperature damage. We propose instead that a change in shape of the major thylakoid lipid, monogalactosyldiacylglycerol, mediated by the fad5-2 mutation, may compensate for changes in lipid structure resulting from the original fab1 mutation. Our identification of mutants that suppress the low-temperature phenotype of fab1 provides new tools to understand the relationship between thylakoid lipid structure and photosynthetic function.

D. Impacts and Scope of Research:

i) Impacts of research: This research program uses the full range of biological techniques to examine the importance of membrane fatty acid composition in photosynthetic function and chloroplast organization. The fab1 mutant is chilling sensitive because of a defect affecting photosynthesis at low temperature. The work described on plant growth and productivity and to possibly manipulate membrane lipid composition of plants to better suit particular environmental conditions.

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. Ten genes from peppermint involved in isoprenoid precursor supply and menthol biosynthesis have been shown to improve essential oil composition and/or yield when expressed individually in transgenic plants. Stacking of these multiple candidate genes into peppermint is now in progress. Three additional genes of the menthone reductase gene family have been cloned, and the corresponding recombinant enzymes are being characterized. Studies on the regulation of these genes involved in the oil maturation process in peppermint are in progress. Mechanistic and structural studies with two terpenoid synthases (bornyl diphosphate synthase and limonene synthase, for which we have X-ray crystal structures, are in progress.

D. Impacts and Scope of Research:

i) Impacts of research: Several patents based on these technologies have been issued. WSURF has licensed these technologies to three industrial/commodity groups. Experiments have yielded a superior transgenic peppermint line suitable for commercial release.

ii) Geographic scope: National.

iii) The project does not integrate research and extension.

F. 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. Exchange and metabolism of nutrients by nitrogen-fixing symbiotic bacteria is at the center of the agronomically important symbiotic relationship. Several lines of research in the laboratory are exploring bacterial nutrient use including investigations of transport, electron flow and carbon catabolism through the TCA cycle. In addition, the laboratory has been leading a large scale genetic dissection of the Sinorhizobium meliloti genome in order to develop materials for genetic, physiological and life history analyses.

D. Impacts 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. Manipulation of the bacteria has shown that genes thought to be important in bacterial symbiotic metabolism can have multiple roles in the symbiosis.

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. 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 or Escherichia coli. Screening to determine the function of these genes in Taxol biosynthesis and taxoid metabolism is in progress. Work on the reconstruction of the early steps of Taxol biosynthesis in yeast has been completed. Attempts to obtain a crystal structure of abietadiene synthase are in progress to gain a detailed understanding of this unusual bifunctional enzyme.

D. Impacts and Scope of Research:

i) Impacts of research: Several patents based on these technologies have been issued. WSURF has licensed these technologies to two biotech firms that are attempting to improve Taxol production. Abietadiene synthase is being evaluated by another biotech company in specialty chemical manufacture.

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. During 2005, our studies of a 23 amino acid peptide, called AtPep1, which we isolated from Arabidopsis, have revealed that it plays a fundamental role in the innate immune system of plants. Peptides from plants had heretofore not been found to be involved in signaling for plant immunity against pathogens. The peptide is synthesized early during pathogen attacks and activates the plants defense systems against fungal and bacterial pathogens. From the amino acid sequence of the isolated peptide we identified its gene. By over-expressing the gene in transgenic Arabidopsis plants, the peptide was produced constitutively, in the absence of pathogen attacks, and these plants had gained an increased resistance to two Pythium species that are root pathogens. We have characterized the signaling pathways that the peptide activates in Arabidopsis and found that they activate defense genes associated with the innate immune response of plants. The peptides appear to have a role in amplifying the response initiated by pathogen elicitors, speeding up the timing and strength of the defense responses. We have found that several major agriculturally important crops contain close relatives of the gene, and if they play similar roles in these plants the genes may prove useful for both breeding and biotechnology programs to enhance innate immunity

against pathogens. We have isolated the receptor of AtPep1 and have identified its gene from sequence analysis of the purified receptor. The gene encodes an LRR receptor kinase, similar to receptor genes found in animals and plants associated with innate immunity. We have obtained two SALK insertional Arabidopsis mutants in which the gene is inactive and have shown that the plants are severely compromised in signaling, supporting its role as the AtPep1 receptor. Our research on the isolation, characterization and defense roles of hydroxyproline-rich glycopeptide systemins (HypSys peptides of 15 to 20 amino acids each) from leaves of petunia, nightshade, and potato has included transcriptional analyses of their precursor genes in response to wounding and jasmonates. These results further support the role of the peptides as amplifiers of systemin signaling. We completed a study of the cellular localization of the HypSys peptide precursor in tomato plants and showed that it is sequestered in the plant cell wall matrix. This is the first report of a peptide signal for defense originating from the plant cell walls.

D. Impacts and Scope of Research:

i) Impacts of research: AtproPep1 gene orthologs have been identified in several major agricultural crops. i) If the gene behaves as it does in the model plant Arabidopsis in amplifying defense signaling for activates defense genes against pathogens, then using gene transfer technology the orthologs from each agricultural crop may have a major impact on productivity by enhancing natural defense responses. ii) This research has applications for crops worldwide. iii) The research is currently the basis for collaborations with scientists to explore its potential in wheat, potato, corn, and soybeans to transform these crops with the proPep genes from each species to determine if the genes can increase resistances against pathogens.

ii) Geographic scope: International.

iii) This research is primarily fundamental, but is presently being integrated into applied activities.

E. Source of Funding: Hatch, NSF, State Appropriations and other Non-Federal Funds.

DEPARTMENT OF PLANT PATHOLOGY

1. Goal 1: WNP00423: Epidemiology and Management of Powdery Mildew of Wine Grapes.

A. Key Theme: Plant Health.

B. RPA 212: Disease and Nematodes Affecting Plants.

C. Powdery mildew of grape is a disease of foliage and fruit that is an annual threat to Washington's grape crop. The objectives of this project are to devise more efficient means of managing the most important disease of Washington wine grapes, lower pesticide usage, and preserve (through fungicide resistance management strategies) pesticides currently available. Mathematical models for predicting when to apply fungicides are currently based on crop phenology. Incorporation of pathogen inoculum load and meteorological variables along with phenology could improve the usefulness and applicability of this model. Testing and development of recommendations for spray oils for mildew control could reduce the application of synthetic fungicides and reduce development of fungicide-resistance in the pathogen.

D. Impacts, Outcomes, and Scope of Research:

i) Use of disease forecasting in conjunction with the spray oil-based powdery mildew management program developed in this project has been adopted by the Washington wine grape industry. Low-cost organic oils are now the most widely used fungicides on grapes. Their incorporation has resulted in a significant reduction of disease management costs to the grower, improved disease control, a significant reduction in the amount of synthetic fungicide

entering the vineyard environment, delayed the onset of resistance to synthetic fungicides, and improved worker safety by reducing exposure to synthetic fungicides. Growers estimate that this program has reduced use of synthetic fungicides by 20 to 40% and lowered chemical costs approximately $100 per acre.

ii) The results of this project are multi-state with greatest impact in the Pacific Northwest region of the U.S.

iii) Results of this project are disseminated through extension publications including the Pacific Northwest Plant Disease Management Handbook and WSU Extension bulletins, oral presentations to industry groups, the WSU Fruit Pathology website (http://fruit.wsu.edu/), and through popular and scientific publications.

iv) Affiliated Multi-state Research Committee – none.

E. Source of Funding: Hatch, State.

2. WNP00595: Integrated Disease Management of Small-seeded Vegetable Seed Crops in Washington State.

A. Key Theme: Plant Health.

B. RPA 212: Disease and Nematodes Affecting Plants.

C. The primary goals of the small-seeded vegetable seed pathology program are to provide support for retaining and contributing to an economical and vital small-seeded vegetable seed industry in Washington and the greater Pacific Northwest, and contribute towards a sustainable and secure food supply, both nationally and internationally. Selected research projects include: (1) yield loss and fungicide trials for control of spinach leaf spot; (2) evaluation of Mustard cover/biofumigant crops for control of weeds/Fusarium wilt in spinach seed crops; (3) evaluation of seed treatment for control of Black leg of Brassica vegetable crops; and, (4) quantification of potential losses caused by Iris yellow spot virus of onion in seed crops and evaluation of susceptibility of 46 cultivars.

D. Impacts, Outcomes, and Scope of Research:

i) Information on vegetable diseases was disseminated regionally, nationally, and internationally. Seed pathology expertise was provided to the Washington State Department of Agriculture (WSDA) Seed Program that, together with other specialists, culminated in implementation of the WSDA Crucifer Seed Quarantine to support the Washington State's Brassica vegetable seed industry. Naktuinbouw, a government agency in the Netherlands, has adopted a seed assay protocol developed in this project to test for several seedborne pathogens of spinach. Based on research results from this project, WSDA is seeking a Section 18 registration for tebuconazole seed treatment of *Brassica* sp. for black leg control.

ii) This project has regional, national, and international scope.

iii) Results of this project are disseminated through extension publications including the Pacific Northwest Plant Disease Management Handbook and WSU Extension bulletins, oral presentations to industry groups, the WSU Vegetable Pathology Team website (http://mtvernon.wsu.edu/path_team/vegpath_team.htm), and through popular and scientific publications.

iv) Affiliated Multi-state Research Committee – none.

E. Source of Funding: Hatch, Federal, and Private Foundation.

SCHOOL OF ECONOMIC SCIENCES

1. Goal 1: WNP00343: Strategic Freight Transportation.

A. Key Theme: Agricultural competitiveness.

B. RPA 603: Market Economics.

C. Research focused on rail and water borne transportation as the arteries of the marketing system in the state of Washington. Rail products move throughout the nation but in varying degrees. Chicago is the source and destination of most of our interstate movements. Waterborne traffic is mostly assembled up river for downriver movement while upriver movements are use in a distribution function.

D. Impacts, Outcomes and Scope of Research:

i) Research impacts: The reports on the waterborne and rail movements have been used by Washington State Department of Transportation to do freight traffic projections for movements on the highways that serve as the feeder system to both the rail and waterborne connections.

ii) Geographic Scope: statewide.

iii) Integrated research and extension: none.

iv) Not affiliated with multistate project.

E. Source of Funding: Hatch, State.

2. WNP00547: Improving the International Competitiveness of the Washington/Oregon Asparagus Industries.

A. Key Theme: Agricultural competitiveness.

B. RPA 603: Market Economics.

C. This research compared a selective mechanical asparagus harvester was compared to a hand crew. It obtained 56%-70% of recovery compared to a hand crew, and additional analysis demonstrated the machine would have achieved 76% had 90% of dropped product been collected. An economic model was used to determine the break-even efficiency of the machine harvester, which was 70.15%. Machine reliability was drastically improved from previous years and numerous improvements were made.

D. Impacts, Outcomes and Scope of Research:

i) Research impacts: The U.S. asparagus industry is facing increased competition from foreign producers. The actions of the Federal Government such as the North American Free Trade Agreement (NAFTA) and the Andean Trade Pact have placed the Washington/Oregon and Michigan asparagus industries at a competitive disadvantage in international and domestic markets. If the U.S. asparagus industry is to insure a competitive position, it must substitute technology for labor to lower per unit costs and shift the workforce to value-added employment. Instituting new technologies is imperative for the advancement of the industry now that the wage rate is indexed by the CPI-W in Washington.

ii) Geographic scope: statewide.

iii) integrated research and extension: none.

iv) Not affiliated with multistate project.

E. Source of Funding: Hatch, State.

3. WNP00998: Rural Communities, Rural Labor Markets and Public Policy.

A. Key theme: Economic policy Analysis.

B. RPA 608: Community Resource and Development Economics.

C. This research explores whether population growth follows job growth or job growth follows population growth in the Washington economy. A peer reviewed article was published that showed for the Washington economy, population growth is driven by in investment economic development.

D. Impacts, Outcomes, and Scope of Research:

i) Research impacts: Research shows that population growth is driven by job growth, not the other way around. This indicates that public investment that creates jobs will increase local

populations, but population growth itself will not stimulate economic development.

ii) Geographic scope: statewide.

iii) integrated research and extension: none.

iv) Multi-State Project: NE-1011.

E. Source of Funding: Hatch, State.

DEPARTMENT OF STATISTICS

1. Goal 1: WPN 00254: Evaluation of Methods Used to Analyze Resource Selection Data.

A. Key Theme: Other; statistical design.

B. RPA 901: Research Design and Statistics.
0254: Analysis of resource selection using generalized linear models.

C. Research focused on a review of current methods for design and analysis of resource selection studies for categorical resources variable and lead to research relating to autologistic models having applications to distribution of wildlife.

D. Impacts, Outcomes, and Scope of Research:

i) Research Impacts: The research resulted in a jointly written chapter entitled "Measuring Availability and Vertebrate Use of Terrestrial Habitats and Foods" in Techniques for Wildlife Investigations and Management (2005), C.E. Braun, editor. This chapter will have a significant impact in wildlife science for the next several years, because this widely read volume, which provides an overview of analyses appropriate for categorical resource variables, will not be revised for 8 to 10 years.

ii) Geographic scope of research: nationwide.

iii) This is not an extension/research activity.

iv) No multi-state regional project.

E. Source of Funding: Hatch and State.

WOOD MATERIALS AND ENGINEERING LABORATORY

1. Goal 1: WNP00453: Molecular Scale Engineering of Lignocellulosics Composites.

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

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

C. The project's objective was to develop novel techniques for the molecular scale characterization of lignocellulosics composites. Solid-state NMR and viscoelastic modeling of relaxation in wood/phenolic composites have been developed. Additional modeling of phenolic cure kinetics has been performed. Both of these analyses provide a molecular understanding of structure and morphology in lignocellulosic composites.

D. Impacts, Outcomes, and Scope of Research:

i) Impacts of Research: The molecular dynamic methods developed have given insight on the molecular scale interactions in these lignocellulosic composites. As such, they provide a lens on the molecular origin of performance, therefore enabling us to molecularly design performance. For instance, the kinetic modeling of phenolics is an ideal tool to optimize the hot-pressing conditions of traditional wood-based composites for performance. Currently valued at nearly $1 billion (USD) annually, the natural-fiber polymer composite industry has grown over seven-fold since 1997. While primarily focused on residential products such as exterior decking, railing, doors, and windows, the industry is currently developing a host of new products, including structural components for marine structures owned by the US Navy and civilian infrastructure applications.

ii) Geographic Scope: The project has an international scope

iii) Integrated research and extension: Not applicable.
iv) Affiliated with multi-state project: Not applicable.

E. Source of Funding: McIntire-Stennis.

GOAL 2

A Safe and Secure Food and Fiber System

EXECUTIVE SUMMARY: We gave chosen to report on one project under Goal 2.

FIELD DISEASE INVESTIGATIVE UNIT

1. Goal 2: WNP00858: Investigation of Food Animal Disease Problems in the State of WA.

A. Key Theme: Animal Health, Food Security and Foodborne Pathogen Protection.

B. RPA 311: Animal Diseases.

C. Preparturient heifers (n = 561) from 9 herds in 6 states (US) and one province (Canada) were enrolled in a study to test the hypothesis that prepartum intramammary therapy would cure existing intramammary infection (IMI) and lead to increased milk production, reduced linear somatic cell count (LSCC), and improved reproductive performance. Mammary secretions were collected 10 to 21 d prior to expected calving from each mammary quarter. Heifers were then assigned by identification number to receive intramammary therapy consisting of infusion of one tube of a lactating cow commercial antibiotic preparation containing cephapirin per mammary quarter or to a non-treated control group. Overall, 34.1% of mammary quarters were infected with a mastitis pathogen prior to parturition and 63.4% of heifers had at least one mammary quarter infected. The minor mastitis pathogen, the coagulase-negative staphylococci (CNS) caused the majority (74.8%) of prepartum IMI. The major mastitis pathogens, the coagulase-positive staphylococci, environmental streptococci and coliforms accounted for 24.5% of prepartum infections. Treatment had a significant effect ($P < 0.001$) on the cure rate of infected mammary quarters. Mammary quarters that were infected prepartum and treated with antibiotics had a 59.5% efficacy of cure rate and the percentage reduction in heifers with IMI was 51.9. Control quarters had a spontaneous cure rate of 31.7%. Treatment neither significantly affected milk production nor LSCC in the first 200 d of lactation; however, there was a significant treatment by herd interaction for milk production. Quarters cured of either CNS or major pathogens had a lower LSCC in the first 200 days of lactation. No significant effect on services per conception or days open between treatment and control groups was observed. This trial demonstrated that prepartum intramammary antibiotic therapy did reduce the number of heifer IMI postpartum. Milk production, LSCC and reproductive performance during the first 200 d of the first lactation were not significantly affected by treatment.

D. Impacts, Outcomes, and Scope of Research:

i) Use of prepartum intramammary antibiotic therapy in heifers as a universal strategy to increase milk production in first lactation dairy cows may not be warranted, but may have a role in herds with mastitis problems in heifers. Although intramammary infections were reduced by therapy, the lactation average milk production was not affected indicating that any benefit associated with the reduced number of infections did not have any long term impact. Moreover, milk quality as assessed by milk somatic cell counts were not improved. Similarly, there was no positive impact on reproductive performance. Yet the reduction in the number of

intramammary infections might be advantageous for heifers which have a higher incidence of major mastitis pathogens amongst heifers. Thus data from this project might have the potential to save dairy producers substantial sums of money associated with improper treatment of heifers before calving. Such intramammary treatment may be misdirected and unnecessary, a resulting costs incurred are associated with therapy and labor, and with the added risks of adding residues to postpartum milk and new iatrogenic infections.

ii) Geographic Scope: This was project that included dairies from several states (6) and a Canadian province (Ontario).

iii) 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 farm.

iv) This project was initiated and supported by the NE1009 Mastitis Resistance to Enhance Dairy Fod Safety; Multistate Regional Research Project.

E. Source of Funding: Hatch.

GOAL 3

A Healthy Well-Nourished Population

EXECUTIVE SUMMARY: We have chosen to report on a single project under Goal 3.

DEPARTMENT OF FOOD SCIENCE AND HUMAN NUTRITION

1. Goal 3: WNP00905: Nutrient bioavailability – Phyto nutrients and beyond.

A. Key Theme: A healthy well nourished population.

B. RPA 701: Nutrient composition of food.

C. A process has been developed to maintain the Angiotensin Converting Enzyme (ACE); enzyme activity of Whey Protein Concentrate 80 (WPC 80) hydrolysate that is usually destroyed when milk is heated.

D. Impacts of research: A whey drink is being developed that when consumed through ACE activity can reduce hypertension.

E. Source of Funding: Commodity, Hatch, and State.

GOAL 4

An Agricultural System That Protects Natural Resources and the Environment

EXECUTIVE SUMMARY: Certain impacts and outcomes achieved under goal four by ARC scientists can be considered noteworthy. These include focusing attention of the agricultural industry on the 17 million tons of biomass produced in Washington each year and offering options for converting that biomass into high value products. Our scientists are pioneering methods of anaerobic digestion of animal manure. With the increased number of cattle feeding operations and dairy operations in Washington and across the country, odorless disposal and conversion of manures to higher value product is beneficial to the environment and to the economy. Our Crop and Soil Sciences Department continues to recommend no-till systems and conservation-till in Eastern Washington, and the work with this system has resulted in reduced water erosion rates on the Palouse croplands. Our entomologists have developed IPM methods for the control of a number of exotic weed species. In this case, cost savings attributable to the diminished use of herbicides was $1 million in FY 2005. The employment of synthetic herbivore induced plant volatiles (HIPV's) to control insect populations has reduced by half the amount of insecticides in hop yards, while preserving cone quality or quantity. In the School of Economic Sciences, policies concerning water use, land use and environmental quality and the use of natural resources are the focus of research. A policy was developed including a quota trading model to predict quota prices and fleet behavioral responses to fisheries rationalization along with an evaluation of conservation potential. The policy on crab fisheries was implemented in FY 2005 to the benefit of harvesters, processors and coastal communities.

BIOLOGICAL SYSTEMS ENGINEERING

1. **Goal 4: WNP00553: Development and Application of Water and Nutrient Models for the Analysis of Agricultural Systems.**
   - **A. Key Theme:** Water quality**.**
   - **B. RPA 111:** Conservation and Efficient Use of Water.
   - **C.** Brief description of the project: The complexity of water and nutrient requirements for crops and for animal agriculture makes it difficult to judge the proper application of both water and nutrients. The purpose of this research is to help simplify these issues by developing computer models for best management practices in water and nutrient application.
   - **D. Impacts, Outcomes, and Scope of Research:**
     - i) Impacts of the research: Progress this year has allowed the research team to develop several prototype models for water-driven productivity and carbon-nitrogen cycling. Data previously collected were used to verify and gain confidence in these models. The various prototype models were incorporated into CropSyst, a comprehensive cropping systems simulation model. This will provide all researchers in this field with a tool to evaluate water and nitrogen management, crop water-use efficiency, and soil carbon sequestration for farming/cropping systems of interest in the Pacific Northwest, the U.S. and the world as a function of location, soil, and long-term weather and atmospheric carbon dioxide concentration conditions.
     - ii) Geographic scope: The work is important in all states in the United States and for countries around the world.
     - iii) The project has no integrated research and Extension activities.
     - iv) The project is not affiliated with a Multistate Research Committee.

E. Source of Funding: Hatch.

2. **WNP00450 (S-1007): Science and Engineering for a Biobased Industry and Economy.**
   A. Key Theme: Agricultural waste management.
   B. RPA 403: Waste Disposal, Recycling and Reuse.
   C. The agricultural industry in Washington State provides a tremendous amount of biomass that can potentially be used as feedstock for the production of biochemicals and bioenergy. Technical barriers exist in developing technologies that can produce bioproducts competitively. The purpose this project is to develop basic knowledge in characterizing biomass as a feedstock and to develop processes and technologies to reduce the cost for converting these feedstocks into bioproducts and bioenergy.
   D. Impacts, Outcomes, and Scope of Research:
      i) Impacts of the research: The research has attracted national and international attention and several companies have expressed a commercial interest. A number of journal articles have been published as a result of the research that add to the knowledge base.
      ii) Geographic scope: The work is important in all states with significant amounts of biological material that is now considered waste. Almost all states are affected.
      iii) The project has no integrated research and Extension activities.
      iv) The project is affiliated with a Multistate Research Committee (S-1007).
   E. Source of Funding: Hatch.

3. **WNP00554: Enhanced Anaerobic Digestion of Animal Manure with Nutrient Recovery.**
   A. Key Theme: Agricultural waste management.
   B. RPA 403: Waste Disposal, Recycling and Reuse.
   C. Brief description of the project: Management of manure from animal feeding operations has become an increasing challenge as the size of farms increases and available land area for manure disposal becomes limited. The purpose of the research is continued development of anaerobic digestion in order to reduce odors, produce by-products, and reduce the overall cost of waste management for producers.
   D. Impacts, Outcomes, and Scope of Research:
      i) Impacts of the research: The research experience has enabled the researchers to provide technical assistance to several local companies engaged in the construction of anaerobic digesters. The research group has also established a collaborative partnership with farmers and conservation districts that are interested in commercial application of this technology. The publication of research results has contributed to the knowledge base.
      ii) Geographic scope: The work is important in all states that have substantial amounts of animal waste in concentrated locations.
      iii) The project has no integrated research and Extension activities.
      iv) The project is not affiliated with a Multistate Research Committee.
   E. Source of Funding: Hatch.

CROP AND SOIL SCIENCES

1. **Goal 4: 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 Themes: An agriculture system which protects natural resources and the environment.

   B. RPA 102: Soil, plant, water nutrient relationships.

   C. 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 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. Impacts and Scope of Research:

   i) University researcher-grower partnerships have created 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 lead to contractual agreements ($40,000) between the National Research Defense Council and the Pacific Northwest Direct Seed Association. According to NRCS (2001) data, more than 40% of Palouse cropland is now under no-till or conservation-till, and water erosion rates have been reduced from an average of 45 Mg/hectare in 1978 to an average of 38 Mg/hectare in 2001. Soil erosion from dry farmed cropland in all regions of the Inland PNW still exceeds tolerable rates. CTIC reports that direct seeded wheat in 2004 occupied 10-18% of the acreage, but as high as 60-70% in Columbia County. 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; however 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 programs CP3 and STEEP, Wheat Commodity Commission, USDA-NRI.

1. **Goal 4: WNP0121: Biological Control in Pest Management Systems of Plants.**
   A. Key theme: Integrated Pest Management.
   B. RPA121: Management of Range Resources.
   C. During 2005, redistributions of 19 non-indigenous arthropod and plant pathogen species were made against 13 invasive weed species throughout Washington. Natural enemy enhancement was directed against populations of Canada thistle, Dalmatian toadflax, knapweed, poison hemlock, purple loosestrife, Russian thistle, and St. Johnswort. On Canada thistle, 7,400 *Larinus planus* adults were released in five eastern WA counties to diminish seed production. A total of 24,150 adults of the foliage feeding/stem boring weevil *Mecinus janthinus* were liberated at diverse sites in seven counties for toadflax suppression. The knapweed seed weevils *Larinus minutus* (8,750 adults) and *L. obtusus* (600 adults) were redistributed into nine counties. Over 6,750 larvae of the oecophorid moth *Agonopterix alstroemeriana* were placed into environments occupied by poison hemlock. Multiple sites infested by purple loosestrife in six eastern and western counties were recipients of over 47,000 foliage-feeding beetles (Galerucella spp.). The moth *Coleophora klimeschiella* was redistributed to counties infested by Russian thistle, with a total of 3,300 larvae being moved. A total of 12,400 *Chrysolina* spp. adults were released in two northeastern WA counties against St. Johnswort. The extent and impact of *Chaetorellia australis* and *C. succinea* on yellow starthistle and cornflower in southeastern WA was determined.
   D. Impacts, Outcomes, and Scope of Research:
      i) Enhanced deployment of exotic weed bioagents by private sector, state, federal, and tribal land managers has measurably reduced herbicide utilization, lowered land maintenance expenditures, increased forage and native plant species survival, and contributed to a marked improvement in the overall health of 25,000+ acres of rangeland, wild land, and wetland environments in Washington State. Cost savings attributable to diminished herbicide use and diminished application costs are estimated at $1,000,000 in FY 2005.
      ii) Geographic scope: Multistate.
      iii) Integrated research and extension: Presentations are made at Extension oriented meetings as well as at continuing education, pesticide education programs. The WSU scientist has co-authored a book on the biology and biological control of Dalmatian and yellow Toadflax.
      iv) Multistate project W-1185.
   E. Source of Funding: Hatch, Cooperative Agreements, other non-federal funds.

2. **WNP0430: Biological Control of Invasive Toadflaxes in Washington.**
   A. Key theme: Integrated Pest Management.
   B. RPA 215: Biological Control of Pests Affecting Plants.
   C. Dalmatian toadflax, *Linaria dalmatica*, and yellow toadflax, *L. vulgaris*, are Eurasian perennial weeds that have become widespread occupants and degraders of rangelands, forests, and croplands in the western United States. Both species are difficult to control by chemical or physical methods but biological control has proven to be highly effective. Of eight intentionally or accidentally introduced toadflax natural enemy species found in North America, *Mecinus janthinus*, a foliage feeding/stem boring curculionid, has proven to be most effective in diminishing population densities of toadflax, especially *L. dalmatica*, in Washington. From May to June 2005, adult weevils were gathered from established "nursery" locations in

northeastern WA and translocated to other counties for subsequent liberation by weed management personnel. This phytophage was redistributed to Chelan (100), Douglas (700), Franklin (200), Grant (6,300), Lincoln (12,250), Okanogan (4,500), and Skamania (100) County. To date, all areas where the insect has been established for three+ years show quantifiable toadflax density declines due to annual reductions in seed output and seedling recruitment. Additional transplantations of the weevil will be made at diverse sites in southeastern WA during 2006. Field and laboratory studies also will be undertaken to assess the impacts of *Mecinus* on the broadleaved and narrowleaved biotypes of *L. dalmatica* and on *L. vulgaris* in eastern WA. Attempts will be made in 2006 to acquire the root galling weevil, *Rhinusa linariae*, from Canadian cooperators for initial release against Dalmatian toadflax to effect its establishment within the state.

D. Impacts, Outcomes, and Scope of Research:

i) The biological suppression of Dalmatian toadflax by *M. janthinus* has been well documented in WA. Herbicidal and physical control use against toadflax has diminished because of landowner utilization of biocontrol, resulting in cost savings of over $500,000 in FY 2005 to such users. This is based on estimated costs of chemical and application. This trend is expected to increase over the next decade. Continued deployment of *M. janthinus* and other toadflax phytophages has slowed the weed's invasiveness, restored productivity of infested non-cropland sites for livestock and wildlife foraging, and facilitated native vegetation recovery.

ii) Geographic scope: Statewide.

iii) Integrated research and extension: Presentations are made at Extension oriented meetings as well as at continuing education, pesticide education programs. The WSU scientist has co-authored a book on the biology and biological control of Dalmatian and yellow Toadflax.

iv) Not affiliated with a multistate project.

E. Source of Funding: Hatch, Cooperative Agreements, other non-federal funds.

3. WNP0381: Development of Integrated Pest Management Systems for High Value Specialty Crops in Central Washington.

A. Key theme: Integrated Pest Management.

B. RPA 216: Integrated Pest Management Systems.

C. The use of synthetic herbivore-induced plant volatiles (HIPVs) as a means of enhancing early season predator populations continued to be explored and shows great potential for hop pest management. We continue to test the efficacy of various pesticides and their interactions with an IPM program that incorporates the HIPV strategy. One miticide was examined for efficacy in a hop yard trial conducted during June-August. Data were obtained on the impact of various miticides/aphicides on pests and natural enemies in commercial hop yards. A hop yard trial was conducted on the impact of fungicides on natural enemy populations. Aphid strains were collected for preliminary testing for imidacloperid resistance. A hop yard trial was conducted to obtain data on the impact of different fungicide regimes in population development of mites and aphids.

D. Impacts, Outcomes, and Scope of Research:

i) This research is having a significant impact on pesticide use in hop production by demonstrating that insecticide and miticide inputs can be substantially reduced when synthetic herbivore-induced plant volatiles (HIPVs) are used in an IPM program. In a sample of 10 hop yards (5 using HIPVs), an average of 0.6 miticide applications were made in the HIPV yards compared to two in the control yards. Similarly, an average of one aphicide application was made in the HIPV yards compared to 2.25 applications in the control yards. The quantity and quality of hop cones produced in

these yards did not differ.

ii) Geographic scope: Statewide.

iii) Integrated research and extension: Presentations are made at Extension oriented meetings with growers and other concerned stakeholders. Results of studies are presented at commission and professional meetings.

iv) Not affiliated with a multistate project.

E. Source of Funding: Hatch, Commodity funds, other non-federal funds.

NATURAL RESOURCE SCIENCES

1. Goal 4: 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. Brief 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.

D. Project Activities: 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. Further data will be collected during 2006.

i) Impact of Research: 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.

ii) Integrated Research and Extension Effort: No.

iii) Affiliated with a Multi-state Research Committee: No

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. Goal 4: 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: Conservation and Efficient Use of Water

C. 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: Stakeholders were educated on the drawbacks of relying on policies encouraging farmers to increase on-farm irrigation effectiveness to conserve agricultural water.

ii) Geographic scope: Western Region.

iii) Affiliated with integration of research/extension with the multistate project.

iv) Multistate W-1190.

E. Source of Funding: Hatch.

2. WNP00299: Fisheries Management and Marketing of Marine and Aquaculture Seafood.

A. Key Theme: Marketing of Seafood.

B. RPA 605: Natural Resource and Environmental Economics.

C. 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) Research Impacts: The crab policy developed under this project was implemented in August 2005, to the benefit of harvesters, processors and fishery dependent Alaska coastal communities.

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.

GOAL 5

Enhanced Economic Opportunity and Quality of Life for Americans

EXECUTIVE SUMMARY: We have chosen to report on only one project under Goal 5.

COMMUNITY AND RURAL SOCIOLOGY

1. Goal 5: 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. This research project, which has roots that date back to 1969, utilizes various methods, including cognitive interviews and field experiments with surveys, to develop procedures for reducing measurement and nonresponse error in sample surveys undertaken by mail, telephone, and now the Internet. Recent research results have show that collecting survey data by more than one survey mode can have a negative impact on the validity of results, and that visual layout differences have profound effects on questionnaire response rates. This research has led to improvements in the 2000 Decennial Census, the USDA's Agricultural Reource Management Survey, and will lead to changes in procedures proposed for use in 2010.

D. Impacts, Outcomes, and Scope of Research:

i) Findings from the ongoing research have been applied to the USDA's Agricultural Resource Management Survey (ARMS), which surveys more than 30,000 farmers in the U.S. each year. It is now possible to implement ARMS as a mail survey with an enumerator follow-up, rather than as a strict enumerator survey. These improvements have led to higher return rates at a lower cost, thus resulting in a significantly more effective survey.

ii) Geographical Scope: Nationwide.

iii) This project has integrated research and extension activities.

Iv) Multistate Research Committee: WERA-1001.

E. Source of Funding: USDA, NASS, and Hatch.

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 Agriculture and Home Economics 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. Fifty faculty members, plus eigh college administrators for a total of sixty-seven, 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
_X_Integrated Activities (Hatch Acts Funds)
___Integrated Activities (Smith-Lever Act Funds

Actual Expenditures

Title of Planned Program/Activity	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
Enhancing the Global Competitiveness of Red Meat			$29,188.42		
Integrated Management of Winter Annual Grass Weeds in Eastern Washington Dryland Crop SystemS			**$17,096.81**		
Marketing, Trade and Management of Fisheries and Aquaculture Resources			$57,895.47		
Impact Analysis and Decision Strategies for Agricultural Research			$11,191.92		
Benefits and Costs of Natural Resourve Policies affecting Public and Private Lands			$55,925.98		
Research Design and Managing Risk in Agricultural Conservation and Pest Management Systems			$61,167.53		
High Value Specialty Crop Pest Management			$23,138.91		
Disease Warning Systems for Potato and Mint			$13,167.92		
Stem Cell and Embryo Development and Manipulation for the Improvement of Livestock			$17,337.89		
Biology and Control of Cephalosporium Stripe			**$6,114.40**		
Genetic Variability in the Cyst and Root-Knot Nematodes			$57,638.13		
Total:			$349,863.38		

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 2005 we are choosing to report on a higher percentage (approximately 10.9 %) 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 05, we have chosen to feature: (1) enhancing the global competitiveness of meat; (2) integrated management of winter annual grass weeds in Eastern Washington dryland crop systems; (3) marketing, trade, and management of fisheries and aquaculture resources; (4) benefits and costs of natural resource policies affecting public and private lands; (5) high value specialty crop pest management; (6) disease warning systems for potato and mint; (7) stem cell and embryo development and manipulation for the improvement of livestock; (8) biology and control of cephalosporium stripe and (9) genetic variability in the cyst and root-knot nematodes. The total funding allocated to these integrated projects is $349,863.38 which is approximately 10.9% of our allocated Hatch formula funds.

0764 Enhancing the Global Competitiveness of Red Meat - $29,188.42

In collaboration with New Zealand scientists we compared effects of production system (grass- versus Grain-feeding) and age on nutritionally significant compounds. Beef from feedlot-finished cattle contained less iron than that from pasture-finished cattle, possibly due in part to an age effect. In addition, the feedlot-finished beef contained lower levels of taurine, carnosine, and coenzyme Q10, but not creatine. Intramuscular fat from pasture-finished cattle differed from that of grain-fed cattle, having 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. A study showing that yellow restaurant grease in beef feedlot corn-based diets increased CLA content without decreasing palatability was completed. In another study, direct sequencing of PCR products on DNA pools from high and low marbling animals revealed two G/C substitutions at positions 7516 and 7713, respectively. The former G/C substitution can be revealed by PCR-RFLP using restriction enzyme MspA1I and was genotyped on 246 F2 animals in the reference population. Genotype of bovine FABP4 gene significantly affected intramuscular and subcutaneous fat deposition, as indicated by marbling score (P=0.0321) and subcutaneous fat depth (SFD) (P=0.0246), respectively. In the second genomics study, two closely linked A/C and C/T single nucleotide polymorphisms (SNPs) were found in the bovine mitochondrial transcription factor A (TFAM) promoter and then genotyped on 237 Wagyu x Limousin F2 animals with recorded phenotypes for marbling and SFD. Statistical analysis demonstrated that both SNPs and their haplotypes were associated with marbling (P = 0.0153 for A/C, P = 0.0026 for C/T and P = 0.0004 for haplotype) and SFD (P = 0.0200 for A/C, P = 0.0039 for C/T and P = 0.0029 for haplotype), respectively. In that study, we also designed a pair of primers to amplify a fragment of 459 bp from positions 16,292 to 412 in the bovine mitochondrial DNA. We used 31 animals at the two tails of the marbling score distribution for mutation detection and initial association screening, including 15 samples with low marbling scores (ranging from 4 to 4.5) and 16 samples with high marbling scores (ranging from 7.5 to 9.5). A total of six polymorphic sits were identified, including five substitutions at positions G8A, T106C, A169G, A173G and C190T and one insertion/deletion at position 221 with one or two cytosines. However, Fisher's exact test revealed no significant differences in frequencies of all polymorphic sites between extreme high/low marbling pools (P>0.1).

Impact: Grass-fed beef may have some nutritional advantages over grain-fed beef, but further research is required to determine grazing/feeding regimes that optimize the content of nutritionally significant compounds and palatability. For almost half the fatty acids considered, there was a significant interaction between treatment group and muscle, which indicates that the results for one muscle do not necessarily apply to other muscles, although the ranking of the groups was usually the same for both muscles. Yellow grease in beef feedlot diets may be a low cost means of increasing beef CLA content without decreasing palatability. Genetic polymorphisms detected in fatty acid transport genes will provide a solid basis for investigating association of these genes with fat deposition in beef cattle. The first genomics study identifies a new target gene for marbling and SFD on this bovine chromosome, which could be used in beef breeding programs. The second genomics study suggests for the first time that the TFAM gene plays an important role in lipid metabolism and may be a strong candidate gene for obesity in mammals.

0584 – Integrated Management of Winter Annual Grass Weeds in Eastern Washington Dryland Crop Systems - $17,096.81

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 2004. While it is not the position of WSU 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, and 2005 with the exemption being granted in 2003. Information on winter annual grass management, Clearfield wheat, and resistance management was presented to growers at over 40 presentations in eastern Washington from 2003 through 2005.

0299 – Marketing Trade and management of fisheries and aquaculture resources - $57,895.47

A new fishery rationalization design was developed that assures harvesters, processors and communities benefit, without the controversial use of processing quota. The design is a blend of cooperative and partnership principles that creates a true bilateral monopoly negotiation between harvesters and the associated processor through which their catch history arose. The negotiations establish a formula price contract that splits the joint quasi rents for the operating fishery association, and it also sets the dissolution terms, should any firm leave for a preferred alternative. Upon signing a dissolution contract, only harvesters are awarded IFQ. It is formally proven that the design is efficient and distribution neutral.

Impact: This policy design is being considered for application in both the Gulf of Alaska groundfish fisheries and the BSAI non-pollock groundfish fisheries.

0605 – Impact Analysis and Decision Strategies for Agricultural Research - $11,191.92

A preliminary time series tests were conducted of the induced innovation hypothesis using a state-level panel data set for the 48 contiguous states from 1960 to 1999. Test results were only partially consistent with the hypothesis.

Impact: Although the induced innovation hypothesis received nearly uniform support by earlier studies, methods used for analysis have recently been severely criticized. Recent investigations using a variety of methods have rendered conflicting results for U.S. agriculture. Our research adds to the evidence that it is too early to assert a stylized fact for induced innovation in this sector. Because the economic implications of this hypothesis impact a broad range of important social policies and issues (e.g., productivity measurement, international trade policy, research policy and project selection), the conflicting results suggest that additional conceptual development and empirical testing are needed.

0448 – Benefits and Costs of Natural Resource Policies Affecting Public and Private Lands $55,925.98

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.

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.

An analysis of whether the type of buyer (public versus private) affects the price paid for conservation properties was completed.

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 - $61,167.53

Analysis of farmer survey data showed that higher levels of precipitation were associated with increased profitability of no-till systems in eastern Washington; however, economic performance of no-till in lower rainfall areas was close to that of conventional tillage. Economic evaluation of multi-year trials showed that no-till annual cropping systems were less profitable and more risky than conventional tillage wheat-fallow in areas with less than 12 inches average precipitation. However, increasing diesel fuel prices and decreasing glyphosate prices have increased the profitability advantage of minimum tillage wheat-fallow versus conventional tillage wheat-fallow in arid farming regions. Government subsidies increased the profitability of all farming systems but did not change the ranking of conservation and conventional systems.

***Impact*:** More farmers in low rainfall zones are experimenting with minimum tillage wheat-fallow systems in response to research/extension programs and changes in fuel prices.

0122 – High Value Specialty Crop Pest Management - $23,138.91

The USDA IR-4 Project 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 to the USDA/ IR-4 program and is on the Western Region Executive Advisory Board. His laboratory, located at the Irrigated Agriculture Research and Extension Center (Prosser WA), serves as the Field Research Center for EPA Region 10 (Eastern Oregon, Eastern Washington, and most of Idaho). All research conducted at the Center is inspected by IR-4 quality assurance personnel to validate compliance with Good Laboratory Practices (GLP) as mandated by the EPA. Since late 1998, over 100 GLP residue trials (14 during 2005) have been completed. Each trial encompasses a significant data package and typically contains over 100 printed pages. The State Liaison's responsibilities for 2005 included: attendance at the IR-4 prioritization workshop (3 day meeting September 2005 in San Diego CA); attendance at the IR-4 national meeting (2 day meeting October 2005 in Washington

D.C.); attendance at the Field Research Director GLP Certification Courses (Davis CA February 2005); attendance at the Western Region State Liaison Representative meeting (1 day meeting in Davis, CA October 2005) and attendance at the National IR-4 three day ornamental plants workshop in Charleston SC. GLP Magnitude of Residue Trials completed in 2005 (presented as Test Substance: Crop) include: Cyfluthrin: Alfalfa - mixed stands; Acequinocyl: Hops; Acetamiprid: Grape; Azoxystrobin: Potato; Captan: Pear; Diflubenzuron: Alfalfa; Diuron: Cherry; E2Y45: Grape; Ethoprop: Hops; Flumioxazin: Hops; Metaldehyde: Grasses (seed crop); Paraquat: Canola; Propiconazole: Mint: Spiromesifen: Bean (Dry, Succulent, Edible); and Thidiazuron: Grape, for a total of 14 GLP Magnitude of Residue trials.

Impact: WSU participation in the IR-4 process keeps pesticide registrations moving in Washington State crops that require a food tolerance for pesticides prior to registration. For the most part, these are specialty crops that would not otherwise have availability to pesticides that deal with arthropods, nematodes, or to some extent, weeds. In Washington these specialty crops include most vegetables, fruits, nuts, herbs, nursery and flower crops. Almost 80% of the emergency use exceptions for IR-4s are converted to final registrations. Additionally, over 80% of our IR-4s research efforts involved new pest management technology with biopesticides and reduced risk chemistries. The annual impact of IR-4 registrations on Washington State Crops surpasses $300 million. This figure is is based on new registrations and the continuation of registrations from the previous year's research.

0678 - Disease warning systems for potato and mint. – $13,167.92

The effects of tuber depth, soil type, and soil moisture on potato tuber infection due to Phytophthora infestans were assessed under greenhouse conditions in soil contained in large pots. Healthy tubers were used to assess infection and were either hand buried in soil at specific depths or naturally formed from potato plants growing in the soil. A spore suspension of P. infestans was chilled to induce zoospore formation and a suspension of resulting zoospores and sporangia were applied to the soil. Soil depth at which tubers because infected was used to determine the extent of spore movement in the soils. Tuber infection significantly decreased with increasing soil depth. Most infected tubers were at the soil surface; infection was rare on tubers at 5 cm or deeper in the soil. Amount of tuber infection varied among soil types. Significantly less tuber infection occurred in a Shano silt loam than in medium and fine sands. Only tubers on the soil surface were infected in the Shano silt loam. Depth in soil at which tubers became infected did not differ significantly among Quincy fine sand, Quincy loamy fine sand, and Quincy medium sand. Increased soil moisture did not significantly increase the soil depth at which tuber infection occurred, regardless of the soil type.

Impact: It was discovered that tuber blight due to late blight can be efficiently managed with cultural practices.

0706 –Stem Cell and Embryo Development and Manipulation for the Improvement of Livestock –$17,337.89

Mitochondrial transcription factor A (TFAM), a nucleus-encoded protein regulates the initiation of transcription and replication of mitochondrial DNA (mtDNA). Decreased expression of nuclear-encoded mitochondrial genes has been associated with onset of obesity in mice. Therefore, we hypothesized genetic variants in *TFAM* gene influence mitochondrial biogenesis consequently affecting body fat deposition and energy metabolism. In the present study, both cDNA (2259 bp) and genomic DNA (16,666 bp) sequences were generated for the bovine *TFAM* gene using a combination of *in silico* cloning with targeted region PCR amplification. Alignment of both cDNA and genomic sequences led to the determination of genomic organization and characterization of the promoter region of the bovine *TFAM* gene. Two closely linked A/C and C/T single nucleotide polymorphisms (SNPs) were found in the bovine *TFAM* promoter and then genotyped on 237 Wagyu x Limousin F_2 animals with recorded phenotypes for marbling and subcutaneous fat depth (SFD). Statistical analysis demonstrated that both SNPs and their haplotypes were associated with marbling (P = 0.0153 for A/C, P = 0.0026 for C/T and P = 0.0004 for haplotype) and SFD (P = 0.0200 for A/C, P = 0.0039 for C/T and P = 0.0029 for haplotype), respectively. A search for transcriptional regulatory elements using MatInspector indicated that both SNPs lead to a gain/loss of six putative binding sites for transcription factors relevant to fat deposition and energy metabolism. Our results suggest in the first time that *TFAM* gene plays an important role in lipid metabolism and may be a strong candidate gene for obesity in mammals.

Impact: WSU has identified a gene that plays an important role in lipid metabolism and obesity in cattle. Testing for the presence of the gene in cattle can identify those animals that can become obese affecting fertility.

0670 Biology and Control of Cephalosporium Stripe - $6,114.40

Four winter wheat cultivars and two advanced breeding lines were evaluated for resistance to Cephalosporium stripe in a field trial at the Palouse Conservation Field Station with three seeding dates. Disease was most severe at the earliest seeding date and decreased with subsequent seeding dates. Among the controls, Stephens had the largest disease index and Bruehl and Eltan had the lowest disease index. WA7970, an advanced breeding line, had a disease index similar to Eltan and Bruehl. Overall grain yield was lowest at the earliest seeding date and increased with subsequent seeding dates. WA7970 had the greatest yield at each seeding date and for the overall average. Average test weight was lowest at the earliest seeding date and increased with subsequent seeding dates. WA7970 had the highest average test weight and at each of the seeding dates.

Impact: The two advanced breeding lines tested for resistance to Cephalosporium stripe were derived from crosses between a wheat line with a chromosome from a wheatgrass, which confers resistance to Cephalosporium, and

a locally adapted eyespot-resistant line. WA7970 contains resistance genes to both pathogens and this was reflected in the highest overall yield, even with early seeding and severe disease pressure. These data demonstrate the potential value of combining resistance genes for these pathogens in controlling these two diseases without additional inputs such as fungicides or modification of cultural practices.

0185 Genetic Variability in the Cyst and Root-Knot Nematodes. - $57,638.13

In order to reduce fumigant applications and costs for plant parasitic nematode control, green manures, biologically derived nematicides and combination of green manures with half the recommended rate of fumigants are the possible alternatives. A blend of mustards used as green manure following a wheat rotation was able to control root knot nematodes. In addition Eruca sativa, arugula, has a good nematicide potential as it has dual properties. It can control nematodes either as a green manure or as a trap crop. In addition, fields with high densities of root knot nematode can be treated with arugula as a green manure followed by half the recommended rate of a fumigant.

Impact: This project provides impact to local growers, fellow scientists, mustard/arugula seed growers, and agricultural consultants by 1) providing them with knowledge and information on effective and environmentally sustainable nematode control options; 2) information of host plant resistance to nematodes.

SECTION IV

APPENDIX A

Agricultural Research Center
Administrative Advisors FY 2005

Ralph P. Cavalieri, CAHNRS Associate Dean and Director, Agricultural Research Center

W-006 "Plant Genetic Resource Conservation and Utilization"

NRSP-5 "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) "Research on 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) "Research on Diseases of Cereals"

Tom Wahl, Director, Impact Center

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

Linda K. Fox, Associate Dean and Associate Director, Extension

W-1001 "Population Change in Rural Communities"

Multistate Research Funds Travel (October 1, 2004 – September 30, 2005
Expenditures for WSU Participants (Not including Coordinating Committees)

MRF Committee	Title	Total
NC-131	Molecular Mechanisms Regulating Skeletal Muscle Growth and Differentiation	1178.84
NC-140	Rootstock and Interstem Effects on Pome and Stone Fruit Trees	1140.08
NC-1001	Systems Analysis of the Relationship of Agriculture and Food Systems to Community Health	1013.59
NC-1003	Impact Analysis and Decision Strategies for Agricultural Research	1010.25
NC-1007	Enteric Diseases of Swine and Cattle: Prevention Control and Food Safety	1660.23
NC-1009	Metabolic Relationships in Supply of Nutrients for Lactating Cows	1001.38
NE-1008	Assuring Fruit and Vegetable Product Quality and Safety Through the Handling and Market Chain	1341.86
NE-1009	Mastitis Resistance to Enhance Dairy Food Safety	1023.44
NE-1018	Postharvest Biology of Fruit	1087.91
NE-1020	Multistate Evaluation of Winegrape Cultivars and Clones	1042.64
NRSP-5	Develop and Distribute Deciduous Fruit Tree Clones that are Free of Viruses and Virus-Like Agents	905.29
NRSP-8	National Animal Genome Research Project (NAGRP)	585.50
S-222	Fruit and Vegetable Supply-Chain Management, Innovations, and Competitiveness	1341.26
W-6	Plant Genetic Resource Conservation and Utilization	496.03
W-106	Multistate Research Coordination, Western Region	3523.88
W-112	Reproductive Performance of Domestic Ruminants	1725.51
W-150	Genetic Improvement of Beans (Phaseolus vulgaris L.) for Yield, Disease Resistance and Food Value	1497.72
W-167	Family and Work Identities During Times of Transition	647.34
W-501	Management of Phytophthoran ramorum in U.S. Nurseries	302.50
W-1001	Population Change in Rural Communities	328.71
W-1003	Parent and Household Influences on Calcium Intake Among Preadolescents	1152.76
W-1004	Marketing, Trade and Management of Fisheries and Aquaculture Resources	814.36

W-1170	Chemistry, Bioavailability, and Toxicity of Constituents in Residuals and Residual-Treated Soils	699.29
W-1185	Biological Control in Pest Management Systems in Plants	628.50
W-1186	Genetic Variability in the Cyst and Root-Knot Nematodes	682.16
W-1188	Characterizing Mass and Energy Transport at Different Scales	1076.26
W-1190	Interfacing Technological, Economic, and Institutional Principles for Managing Inter-sector Mobilization of Water	900.46
	TOTAL	28,807.78

APPENDIX B

Current Multistate Coordinating Committees with WSU
Faculty and ARS Cooperator Participants
FY2005

MRF#	PI	Title	Term Date
WERA-001	Charles Gaskins	Beef Cattle Breeding in the Western Region	09/07
WERA-011	William Johnston Gwen Stahnke E. Miltner	Western Regional Turfgrass Research	09/09
WERA-020	K. C. Eastwell W. Howell Ralph Cavalieri (AA)	Virus and Virus-Like Diseases of Fruit Trees, Small Fruits, and Grapevines	09/06
WERA-021	J. Dobrowolski B. Zamora	Revegetation and Stabilization of Deteriorated and Altered Lands	09/09
WERA-027	M. Pavek N. Richard Knowles	Potato Variety Development	09/10
WERA-040	Linda Hardesty	Rangeland Ecological Research and Assessment	09/06
WERA-043	Jay Brunner John Brown (AA) Peter Landolt * Tom Umruh * Dave Horton * Alan Knight * Larry Lacey * Vince Jones John Dunley Elizabeth Beers Ralph Cavalieri (AA)	Establishing Bio-Intensive Pest Management Programs for Western Orchard Systems	09/08
WERA-055	Dave Scarnecchia	Rangeland Resource Economics and Policy	09/06
WERA-058	Rita Hummel	Production, Transition Handling, and Reestablishment of	09/09

		Perennial Nursery Stock	
WERA-060	John Dunley	Science and Management of Pesticide Resistance	09/07
WERA-066	Keith Pike William Turner	Integrated Management of Russion Wheat Aphid and Other Cereal Aphids	09/06
WERA-067	David Granatstein	Western Coordinating Committee for Sustainable Agriculture	09/05
WERA-069	D. Walsh L. du Toit	Coordination of Integrated Pest Management Research and Extension / Education Programs for the Western United States and the Pacific Basin Territories	09/10
WERA-077	J. Yenish	Managing Invasive Weeds in Wheat	09/09
WERA-081	Brady Carter	Systems to Improve End-Use Quality of Wheat	09/06
WERA-089	Hanu Pappu Jim Crosslin	Potato Virus Disease Control	09/06
WERA-097	Timothy Murray (AA)	Diseases of Cereals	09/05
WERA-099	Sandra Ristow (AA)	Broodstock Management, Genetics and Breeding Programs for Molluscan Shellfish	09/06
WERA-101	T. Wahl Sandra Ristow (AA)	Assessing the Chinese Market for U.S. Agricultural Products	09/05
WERA-103	Robert Stevens J. Davenport R. Koenig	Nutrient Management and Water Quality	09/06
WERA-203	Ron Kincaid Mark Nelson	Animal Utilization of Products from Processing Agricultural Commodities	09/05
WERA-204	Ruth Newberry	Animal Bioethics	09/05
WERA-205	R. Simmons	Integrated Water Quality Research and Extension Programs for the Western United States	09/05
WERA-207	M. Swan	Agricultural Literacy	09/06
WERA-208	H. Dennis Brown	Western Region Impact Statement Development	09/06
WERA-1001	D. Dillman V. A. McCracken (AA) Sandra Ristow (Co-AA)	Reduction of Error in Rural and Agricultural Surveys	09/07
NCR-131	R. Newberry	Animal Care and Behavior	09/07
NCR-193	G. Chastagner	Plant Health: Managing Insect Pests and Diseases of Landscape Plants	09/11
NCERA-180	Francis Pierce	Site Specific Manangement	09/06

	J. Davenport		
NCERA-194	K. Duft	Improving the Management and Effectiveness of Cooperatively Owned Business Organizations	09/08
NCERA-199	C. Gaskins	Implementation and Strategies for National Beef Cattle Evaluation	09/06

* UDSA Participant

Multistate Research Funds Travel (Oct. 1, 2004-Sept. 30, 2005)		
Expenditures for WSU Participants, Coordinating Committees Only		
MRF	**Traveler**	**Totals:**
NCERA-180	Pierce, Fran / Perry, Eileen	1042.47
NCERA-184	Tim Murray	1074.86
NCR-22	Moore, Pat	747.34
NCR-131	Newberry, Ruth	624.78
NCR-170	Alldredge, Rich	663.77
NCR-193	Chastagner, G	702.16
NCR-199	Gaskins, Charlie	644.92
WERA-001	Gaskins, Charlie	958.60
WERA-20	Cavalieri, Ralph	760.93
WERA-20	Eastwell, Ken	1216.14
WERA-21	Dobrowolski, James	861.61
WERA-27	Knowles, Rick	340.58
WERA-40	Hardesty, Linda	825.69
WERA-43	Brunner, Jay	397.76
WERA-77	Yenish, Joe	424.50
WERA-89	Pappu, Hanu	818.04
WERA-97	Murray, Tim	1467.54
WERA-99	Ristow, Sandra (AA)	1072.99
WERA-101	Wahl, Tom	339.10
WERA-103	Koenig, Richard	628.18
WERA-207	Swan, Mike	1166.51
WERA-1001	Dillman, Don	908.47
	Grand Total:	17,686.94

Appendix C

Faculty with Split Appointments or 100% Extension Appointments Attending Multistate Research or Coordinating Committee Meetings FY 2005

MRF#	R/T FTE	EXT FTE	Participant
NC-140	0.85	0.15	Whiting, Matthew
NC-1001	0.75	0.25	Jussaume, Ray
NCR-170	0.875	0.125	Alldredge, Rich
NCR-193	0.6838	0.3162	Chastagner, Gary
NE-1018	0.00	1.00	Kupferman, Eugene
NE-1020	0.4286	0.5714	Spayd, Sara
S-222	0.00	1.00	Schotzko, Tom
W-167		1	Fox, Linda
W-501	0.6838	0.3162	Chastagner, Gary
W-1001	0.6	0.4	Kirschner, Annabel
W-1004	0.90	0.10	Matulich, Scott
W-1185	0.75	0.25	Piper, Gary
W-1186	0.8	0.2	Riga, Ekaterini
WERA-21	0.14135	0.85865	Dobrowolski, James
WERA-40	0.50	0.50	Hardesty, Linda
WERA-77	0.25	0.75	Yenish, Joe
WERA-103	0.60	0.40	Koenig, Richard

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

Project	Title	MRF #	Term Date		Researcher
0913	Molecular Mechanisms Regulating Skeletal Muscle Growth and Differentiation	NC-131	09/2005	1	Dodson, M.V.
0467	Improvement of Thermal and Alternative Processes for Food	NC-136	09/2005	1	Powers, J.R.
0467	Improvement of Thermal and Alternative Processes for Food	NC-136	09/2005	2	Barbosa-Canovas, G.V.
0467	Improvement of Thermal and Alternative Processes for Food	NC-136	09/2005	3	Cavalieri, R.P.
0467	Improvement of Thermal and Alternative Processes for Food	NC-136	09/2005	4	Swanson, B.G.
0467	Improvement of Thermal and Alternative Processes for Food	NC-136	09/2005	5	Tang, J.
0467	Improvement of Thermal and Alternative Processes for Food	NC-136	09/2005	5	Clary, C.
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
0406	Characterizing Weed Population Variability for Improve Weed Management Decision Support Systems to Reduce Herbicide Use	NC-202	09/2005	1	Parker, R.
0128	Management of Grain Quality and Security for World Markets	NC-213	09/2008	1	Baik, B.K.
0403	Systems Analyses of the Relationships 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.
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.
0156	Multidisciplinary Evaluation of New Apple Cultivars	NE-183	09/2005	1	Barritt, B.H.
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 Physiology of Fruits	NE-1018	09/2008	1	Fellman, J.K.
0797	Postharvest Physiology of Fruits	NE-1018	09/2008	2	Kupferman, E.M.
0596	Multi-state Evaluation of Winegrape Cultivars and Clones	NE-1020	09/2017	1	Spayd, S.
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.
0563	Host Resistance as the Cornerstone for Managing Plant-parasitic Nematodes in Sustainable Agroecosystems	S-1015	09/2008	1	Riga, E.
0806	Fruit and Vegetable Marketing Innovations and Demand Assessment	S-1019	09/2008	1	Schotzko, R.T.
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	10	Greene, S.
0372	Mechanisms and Mitigation of Agrochemical Impacts on Human and Environmental Health	W-45	09/2005	1	Hebert, V.
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.
7996	Multistate Research Coordination, Western Region	W-106	09/2029	3	McCracken, V.
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.
0560	Genetic Improvement of Beans (Phaseolus vulgaris L.) for Yield, Disease Resistance, and Food Value	W-150	09/2005	1	Swanson, B.G.
0560	Genetic Improvement of Beans (Phaseolus vulgaris L.) for Yield, Disease Resistance, and Food Value	W-150	09/2005	2	Hang, A.N.
0647	Family and Work Identities During Times of Transition	W-167	09/2005	1	Fox, L.
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 - A Key to Human Nutrition	W-1002	09/2007	1	Shultz, T.D.
0276	Factors Influencing the Intake of Calcium Rich Food Among Adolescents	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.
0448	Benefits and Costs of Natural Resource Policies Affecting Public and Private Lands	W-1133	09/2007	1	McCluskey, J.J.
0448	Benefits and Costs of Natural Resource Policies Affecting Public and Private Lands	W-1133	09/2007	2	Wandschneider, P.R.
0448	Benefits and Costs of Natural Resource 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.
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 Global Competitiveness of U.S. Red Meat	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	Characterization of Flow and Transport Processes in Soils at Different Scales	W-1188	09/2009	1	Flury, M.
0152	Characterization of Flow and Transport Processes in Soils 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	W-1190	09/2009	2	Yoder, J.

	Mobilization of Water				
0160	Interfacing Technological, Economic, and Institutional Principles for Managing Inter-Sector Mobilization of Water	W-1190	09/2009	3	Chouinard, H.