ANNUAL REPORT
OF
ACCOMPLISHMENTS AND RESULTS

Agricultural Research Center

College of Agricultural, Human and Natural Resource Sciences

Washington State University

Pullman, Washington

Submitted to USDA/CSREES

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Period Covered

Federal FY2003
October 1, 2002 to September 30, 2003

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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, 2002 – September 30, 2003) 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
Agricultural and Resource Economics
Animal Sciences
Biological Systems Engineering
Crop and Soil Sciences
Entomology
Food Science and Human Nutrition
Horticulture and Landscape Architecture
Natural Resource Sciences
Plant Pathology
Rural Sociology

Special Program Units and Institutes
IMPACT Center
Institute of Biological Chemistry
Veterinary Medicine - Field Disease Investigation Unit

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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. 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 FY2003, the ARC received and expended $1,897,464.00 in Hatch funds and $1,381,668.00 in Hatch Multistate Research funds.

Hatch and Hatch Multistate Research funds constitute 5.14% and 3.75%, respectively, of the total funds expended on Agricultural Research Center (ARC) projects. State appropriations are 27.80% of the total with all other grants totaling 48.95%.

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 2003

Funding Source	CSREES Goals					Total	% of Totals
	1	2	3	4	5		
Hatch Funds	$1,304,516	$180,502	$3,809	$336,461	$72,176	$1,897,464	5.14
Multistate Research Funds	$850,606	$308,202	$1,443	$221,417	$0	$1,381,668	3.75
Federal Research Grants	$2,640,740	$431,804	$95,201	$1,795,951	$333,709	$5,297,405	14.36
State Appropriations	$5,728,669	$1,582,921	$385,417	$2,271,119	$286,182	$10,254,308	27.80
All Other Grants	$11,564,823	$2,120,963	$385,206	$3,648,038	$336,857	$18,055,887	48.95
Totals	$22,089,354	$4,624,392	$871,076	$8,272,986	$1,028,924	$36,886,732	--
Percentage of Total $	59.88	12.54	2.36	22.43	2.79	100.00	--
FTEs	243.22	54.09	8.39	84.99	7.67	398.36	--
Percentage of Total FTEs	61.06	13.58	2.11	21.33	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 2003 by faculty having appointments in the WSU Agricultural Research Center supports national **Goal 1**, "an agricultural system competitive in the global economy." Early on it was decided that in the face of diminishing state support, the focus of research in the WSU Agricultural Research Center would be on the food system of Washington and its stakeholders. Because the State is agriculturally diverse (over 250 different crops) there is much emphasis on the agricultural profitability of these enterprises. Indeed, the focus of the first Plan of Work 1999-2004 and its revision in 2001 was 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 (in this case-- biotechnology related to the food system) and on natural resources and the environment, which necessarily places the ARC focus on goals I and IV of the USDA-CSREES national plan. Although Eastern Washington is an area primarily devoted to large wheat farms and irrigated agriculture, an additional emphasis has been forming in the area of organic and sustainable agriculture and its profitability primarily in Western Washington. Western Washington is home to an extraordinarily diverse agriculture in an expanding urban environment in which local food systems have become quite important. 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 focused on their goals as stated in the 1999 and 2001 revised plans of work.

Certain impacts and outcomes achieved in 2003 under goal 1 were particularly noteworthy. New spring wheat varieties have been released in the important classes grown within the region including hard red, hard white, soft white and club wheats. These varieties will not only increase profits for Washington farmers, but they will have significance in international export markets. Importantly, the new wheat varieties, developed by the faculty of the Department of Crop and Soil Sciences, have resistance to the major disease problems associated with wheat, namely stripe rust and various root diseases. Eastern Washington wheat farmers were able to view demonstration plots of these new varieties at a number of WSU sponsored field days held in summer of 2003.

Faculty members of the Department of Horticulture and Landscape Architecture (HLA) located at the Wenatchee Tree Fruit Research and Extension Center have been developing new varieties of apples with outstanding eating qualities and varieties amenable to post-harvest preservation to help the Washington industry remain profitable, (Currently, Washington orchards produce 50% of the apples in the U.S.) A rain-fast coating to prevent "sunburn of apples" having the potential to save the industry $50 million annually was also perfected and introduced to growers this year. In the area of basic research in horticulture performed on the Pullman Campus, HLA is performing research on how plants sense and respond to changes in the environment using signal transduction studies. HLA also has an emphasis on the post-harvest biology of fruit, particularly on post-harvest oxidative disorders. It is anticipated that the outcomes of such basic research will ultimately allow the industry to compete with fresh crops of apples originating from the Southern Hemisphere during our storage season.

The Institute of Biological Chemistry (IBC), which focuses on cutting edge basic plant research, is achieving its goals of cataloguing the fundamental biochemical processes of plants and harnessing this knowledge to implement profitability in associated industries. One project, dealing with heartwood formation in trees has elucidated a number of processes in tissue which coordinate metabolism in heartwood. Another project, which is defining the enzymatic steps for the production of Taxol, the anti-cancer drug found in yews, has elucidated the majority of the enzymes involved for the *in vitro* production of that compound. Another project studying nutrient exchange and metabolism in the rhizobium-legume symbiosis, is exploring bacterial nutrient usage and investigating electron transport flow and carbon metablism at the genome level. Recent results have shown that genes thought to be important in bacterial symbiotic metabolism can play multiple roles in symbiosis. The enzymes directing terpenoid formation in mint, an

important minor crop in central Washington, have been defined and the research has yielded transgenic forms of peppermint with high yield and superior oil properties. The immunology of plants and signals for growth and development continue to be elucidated in experiments conducted in IBC. Polypeptide precursors and signal forms have been discovered which regulate growth and development.

The Department of Plant Pathology continues its work in controlling bacterial, viral, fungal and nematode-related diseases in the economically important crops in Washington. Significant outcomes this year include the adoption of new eyespot resistant strains of wheat grown on nearly a million acres in WA and the discovery of four new genes in these varieties which control the resistance. Plant Pathology is the primary department at WSU participating in the NRSP-5 project (centered in Prosser WA), which develops, propagates and distributes the virus-free material for apples, cherries, pears and plums. As a result of thee activities, scientists at Land Grant Universities and and commercial nurseries have access to virus-free propagation material; and for growers this means a more profitable worry-free operation. At the Western Washington Research and Extension Unit in Mt. Vernon, a member of the Plant pathology faculty, the head of the Statewide vegetable Pathology Team, investigated new fungicides and other procedures for the control of Late Blight and winter rot diseases of potato.

The Department of Community and Rural Sociology has actively studied the movement toward local food systems in Western Washington. Western Washington is a highly urbanized and rapidly growing area, which has lost agricultural land to urban development in the past several decades. Researchers have conducted surveys and have looked at reliable outlets by which farmers can sell their produce and have introduced the concept of “harvest festivals” at which the the visibility of the small farm is heightened in the eyes of the city dwellers attending these events. These activities are a prime example of integrated research and extension activities.

DEPARTMENTAL REPORTS

DEPARTMENT **OF ANIMAL SCIENCES**

1. WNP00154 Environmental and Economic Impacts of Nutrient Management in Dairy Forage Systems

a. **Key Theme:** Global Competiveness of Agricultural Production Systems

b. RPA 302-Nutrient Utilization in Animals

c. A winter manure application study was initiated in January 2002 to evaluate the uptake of manure nutrients applied during the early winter period and/or early summer application.

d. Impacts and Scope of Research
   i) **Impacts of research:** Winter manure application was shown to increase forage yield. Early summer application of manure in grass silage based dairy produced a better balance of forage protein and lower fall soil nitrate. Manure application practices can optimize forage production and reduce nitrate levels on the farm.
   ii) **Geographic scope:** This project has a scope of research that encompasses the state.
   iii) This project conducts on farm research with direct application to a particular location.
   iv) Affiliated with multistate project: NE-132 including: MI, WV, PA, NY, OR, WA, MA, MD, UT, MD, IN, IL, and NJ.

e. **Source of Funding:** Hatch, USDA CG, DOE, and Commodity Funds

2. WNP00167: Enhancement of Dietary Energy Use for Maintenance, Growth, and Lactation of Beef Cattle

a. **Key Theme:** Animal Production Efficiency

b. RPA 302-Nutrient Utilization in Animals

c. The study examined the potential variation in maintenance energy requirements that may exist among different breeds of cattle and relate animal energy expenditure to cellular energy metabolism. Eight heifers of Angus, Holstein, and Wagyu breeds were compared. Differences were found among the breeds for maintenance energy requirements. Animals that require less energy for maintenance will improve the efficiency of feeding cattle.

d. Impacts and Scope of Research
   i) **Impacts of research:** Identifying animals that have lower energy maintenance requirements will reduce feed costs and increase profitability.
   ii) **Geographic scope:** This project has an international scope of research.
   iii) This project does not have integrated research and extension.
   iv) Not affiliated with a Multistate Research Project.

e. **Source of funding:** Hatch, Other Non-Federal Funds, and State.

3. WNP00374: Nutrient Management Feeding for Reduced Excretion of Nutrients by Ruminants

a. **Key Theme:** Animal Production Efficiency

b. RPA 302-Nutrient Utilization in Animals

c. This project studied the role of the mineral selenium in the growing fetus. Forty-two gilts were assigned randomly to a selenium adequate or deficient diet and maternal and fetal liver samples were collected at 30, 45, 70, 90, and 114 days of pregnancy. Results show the maternal selenium intake can affect fetal selenium concentrations. Feeding a low level of selenium increases oxidative stress to the fetus.

d. Impacts and Scope of Research
   i) **Impacts of research:** Pigs are born with a reduced liver anti-oxidant capacity and this explains why they show selenium deficiency signs during times of stress. Ensuring adequate selenium in the diets of pregnant pigs should increase neonatal health of pigs.
   ii) **Geographic scope:** This project has an international scope of research.
   III) This project does not have integrated research and extension.
   IV) Not affiliated with a Multistate Research Project.

e. **Source of funding:** Hatch, DOE, and State.

4. WNP00706. Germ Cell and Embryo Development and Manipulation for the Improvement of Livestock.

a. **Key Theme:** Animal Production Efficiency

b. RPA 301-Reproductive Performance of Ruminants

c. A census of genes expressed in porcine embryos and reproductive tissues was done by mining an expressed tag database based on human genes.

d. Impacts and Scope of Research
   i) **Impacts of research:** The technique of clustering analysis of gene expression patterns in cattle tissues has the potential of tracing the developmental origin of tissues and organs.
   ii) **Geographic scope:** This project has a scope of research that has international impact.
   iii) This project does not have integrated research and extension.
   iv) Affiliated with multistate project: W-171 including: WA, CA, UT, LA, IL, MD, AR, OR, WI, CO, CT, and IA.

e. **Source of funding:** Hatch and State

5. WNP00957: Reproductive Performance In Domestic Ruminants

a. **Key Theme:** Animal Production Efficiency

b. RPA 301-Reproductive Performance in Ruminants

c. Immunization of bulls with LHRH fusion proteins was conducted on Nellore-Cross bulls divided into a castrate, LHRH fusion protein immunized and an intact control group. Intact bulls had greater carcass weights and muscle percentage compared to the other two groups. The castrated and the LHRH fusion proteins immunized group had greater marbling and fat percentages compared to intact bulls.

d. **Impacts and Scope of Research**

i) **Impacts of research:** LHRH fusion proteins may be an alternative to surgical castration with the added benefit of improved meat quality.

ii) **Geographic scope:** This project has an international scope of research.

iii) This project does not have integrated research and extension.

iv) Affiliated with multistate project: W-112 including: WA, CA, CO, OR, MT, NE, OH, KS, NV, NM, WY, MO, ID, TX, AK, AZ, HI, and MN.

e. **Sources of funding:** Hatch MRF Funds, State, Industry Grants and Agreements, and Other Non-Federal Funds

DEPARTMENT OF COMMUNITY AND RURAL SOCIOLOGY

1. WNP00230: Commodities, Consumers, and Communities: Local Food Systems in a Globalizing Environment

a. **Key Themes**: Agricultural Competitiveness, Small Farm Viability, and Organic Agriculture

b. RPA 608 Community Resource and Development Economics; RPA 803 Sociological and Technological Change Affecting Individuals, Families, and Communities

c. Description: A consumer telephone survey was conducted using random digit dialing in four Washington counties. This survey assessed interest in and purchasing from local farmers and obstacles to such purchases. Findings from this survey and from earlier work done in the area of small farm viability was communicated to more than 1,500 persons interested in small farm agriculture. In addition, researchers helped initiate and participate in annual harvest celebrations at several locations in Western Washington, and provided leadership to farmers markets in that area.

d. Impacts and Scope of Research

i) **Impacts of research:** Western Washington is a highly urbanized and rapidly growing area, which has continually lost agricultural land over several decades. Activities on this project have greatly heightened the visibility of small farms and their importance to a primarily urban audience. The farmers markets and harvest celebrations are providing reliable outlets for small farmers in the area to sell their products as well as enhancing the understanding of the importance of these farms for the overall livability of the area.

ii) **Geographical scope**: Statewide

iii) This project is closely tied to the Small Farms extension project at Washington State University

iv) This project is in association with Multistate Research Committee NE-1012 including: WA, MO, NJ, MI, WV, ME, NY, IA, NH, WI, VT, CA, OR, MA, MN, PA, and PR.

e. **Sources of funding:** Hatch, Non-Federal Funds, and Industry Grants and Agreements

2. WNP00127: Local Dimensions of the Globalization of Food and Agricultural Marketing Systems.

a. **Key Themes**: Agricultural Competitiveness, Small Farm Viability, and Organic Agriculture

b. RPA 608 Community Resource and Development Economics; RPA 803 Sociological and Technological Change Affecting Individuals, Families, and Communities

c. Description: Data entry and analysis were completed from a survey of farmers in 4 Washington counties conducted in 2002. This survey included farmer marketing practices, farmer views on marketing and farm policies, farmer environmental practices and informational needs. These data were put on a website (www.crs.wsu.edu/agsurvey/index.html). An in-depth analysis of producer attitudes toward genetically modified organisms on farms was also conducted. Results showed that production and marketing practices were more important than individual characteristics in explaining interest in using GMO's.

d. Impacts and Scope of Research
   i) **Impacts of research:** Data from the farmer survey website have been downloaded more than 200 times. Information from this survey is used to promote local agriculture and food systems. Survey findings have been used to help shape land-use decisions to preserve agricultural land in a rapidly growing county on the fringe of a large urban area.
   ii) **Geographical scope:** Statewide (WA)
   iii) This project is closely tied to the Small Farms extension project at Washington State University.

e. **Sources of funding:** Hatch and State

DEPARTMENT OF CROP AND SOIL SCIENCES

1. WNP00175: Adaptation Studies of Cereal Varieties and Selections
WNP00334: Improving Spring Wheat Varieties for the Pacific Northwest
WNP00232: Breeding and Genetics of Winter Wheat

a. **Key Theme:** Agriculture Profitability, Biotechnology, Plant Genomics, and Plant Germplasm.

b. RPA 201 Plant Genome, Genetics and Genetic Mechanisms

c. Description: Wheat germplasm improvement, variety development, selection and testing for yield, end-use quality, nutrient use efficiency, pest resistance, regional adaptability are the goals of our longstanding program for wheat breeding.

d. Impacts and Scope of Research
   i) **Impacts of research:** Competitive, new spring and winter wheat varieties are being and have been released in the economically important classes of the region: hard red, hard white, soft white and club wheats for addressing different domestic and international market opportunities. Resistance to stripe rust, root diseases, tolerance to glyphosate, improved baking and noodle making, increased protein quantity and quality are some of the features of new experimental and recently released lines. Public variety releases out of these programs (e.g. 'Eltan', 'Bruehl', 'Macon', 'Zak', 'Tara') dominate acreage in Eastern WA. From 80-95% of the 2,000,000+ WA wheat acreage was planted to WSU public varieties in 2003.

ii) **Geographic scope:** Variety releases have mainly regional impact 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 variety development, testing, and transfer to the agricultural community. This program devotes many hours to field days and to farmer outreach programs.

e. **Source of funding:** Hatch, Commodity Commission, Other Non-Federal Funds, State, Industry Grants and Agreements, USDA-NRI, and Other Federal Funds

DEPARTMENT OF HORTICULTURE AND LANDSCAPE ARCHITECTURE

1. WNP00326: Enhance Market Quality by Improving Fruit Finish in Apple.

a. **Key Theme:** Agricultural Profitability

b. RPA 203 Plant Biological Efficiency and Abiotic Stresses affecting Plants.

c. Several aspects of fruit finish in apples were studied. Sunburn that occurs on apples as a result of improper hand thinning was found to be similar to the Type 3 sunburn that occurs late in the season when non-acclimated apples are suddenly exposed to sunlight. A fruit surface temperature sensor has been developed to be used to control evaporative cooling and a patent application was filed with the US Patent and Trademark Office. A new strategy for sunburn protection was found by combining RAYNOX with evaporative cooling.

d. Impacts and Scope of Research
i) **Impacts of research:** Annual losses from sunburn of apple total about $100 million in Washington State. A new sunburn suppressant (RAYNOX™), which was developed in previous years of this project, has been shown to reduce sunburn by 50%. This new suppressant was commercialized on a limited scale during 2003 and has the potential to save Washington State apple growers up to $50 million annually. RAYNOX™ was shown during 2003 to be rainfast and, when combined with evaporative cooling, reduced sunburn by 98%. Thus, the potential economic impact is even greater than with RAYNOX™ alone. The technology for RAYNOX™ was licensed by the WSU Research Foundation to FruitGard, LLC during the reporting period, and the sunburn protectant was successfully introduced to apple growers in Washington State during 2003.
ii) **Geographic scope:** Although the research that led to the development of RAYNOX™ was carried out in Washington state, the technology should be applicable in any location where similar environmental conditions (intense radiation, and high temperatures) exist. Therefore, the scope is national and international.

e. **Source of funding:** Hatch, State, and Industry Grants and Agreements

2. WNP00260: Developing New Apple Cultivars for Washington State

a. **Key Theme**: Agricultural Profitability

b. RPA 202 Plant Genetic Resources and Biodiversity.

c. The goal of the WSU apple breeding program is to produce unique varieties with outstanding eating quality that will keep the Washington apple industry in the forefront of new products. Promising material has been selected and is currently being propagated and evaluated in central Washington. Several crosses of high fruit quality parents: Pink Lady, Honeycrisp and Braeburn, were made with fire blight resistant parents Splendour, Delicious, and BC 8S-69-23.

d. Impacts and Scope of Research
   i) **Impacts of research:** Over 20,000 hybrid seeds were collected from 25 new crosses. A new seedling/M.9 orchard of 5,362 seedling/M.9 trees was planted. Of these, 619 were resistant survivors from a greenhouse fire blight screening. More than 12 trees each of 19 promising selections were grown in the nursery for planting in replicated trials in 2004. During August, September and October, fruit was evaluated from over 12,000 2-, 3- and 4-year-old seedling/M.9 trees. Several hundred selections were made based on field evaluations and their fruit placed in cold storage. Fruit of each selection was removed from storage 2-3 months after harvest and evaluated for eating quality. Those with good eating quality were evaluated in the lab for soluble solids, acidity, sugar, firmness, and color. Since Washington produces nearly 50% of all apples grown in the United States, the development of varieties that are especially suited to the growing region will have significant impacts on the Northwest agricultural economy.
   ii) **Geographic scope:** Although the research described here emphasizes the development of new apple cultivars for Washington, resulting varieties may be suitable for production in other apple growing regions; therefore this project has national significance.

e. **Source of funding:** Hatch, Industry Grants and Agreements, and DOE

3. WNP00321: Calcium/Calmodulin-Mediated Transcription Networks in Plants

a. **Key Theme:** Agricultural Profitability

b. RPA 201 Plant Genome, Genetics, and Genetic Mechanisms.

c. This research has found that calcium, a universal second messenger, regulates diverse cellular processes in plants. Changes in intracellular calcium concentration can affect a number of physiological processes through the action of calmodulin (CaM). CaM, a calcium-binding multifunctional regulatory protein, is the primary transducer of the intracellular calcium signal. This laboratory has documented the presence of a family of six genes that encode for CaM-binding proteins and is rapidly and differentially induced by different environmental signals such as temperature extremes, UVB, salt and wounding; hormones such as ethylene and abscisic acid; and signal molecules such as methyl jasmonate, hydrogen peroxide and salicylic acid. It is estimated that there are over 100 genes involved in the calcium/CaM/AtSR signal network, and the expression of these genes is regulated by changes in calcium concentration in plants.

d. Impacts and Scope of Research
   i) **Impacts of research:** This research focuses on the development of an understanding of how plants sense and respond to changes in their environment. The area of signal transduction, particularly with respect to environmental signals, is important to the future enhancement of crop production, as well as the fundamental understanding of the biochemical/molecular regulatory mechanisms of plant responses. Understanding the complex process of signal transduction at the cellular and molecular level should help in the production of plants that are adaptable to adverse environmental conditions.
   ii) **Geographic scope:** This is basic research that will impact plant agriculture globally.

e. **Source of funding:** Hatch, NSF, NASA, and State

4. WNP00640: Breeding Superior Raspberry Cultivars for the Pacific Northwest

a. **Key Theme:** Agricultural Profitability

b. RPA 202 Plant Genetic Resources and Biodiversity

c. The objective of this research is the development of new raspberry cultivars that are adapted to the Pacific Northwest. The focus is on breeding new high yielding, high quality, pest resistant raspberry cultivars that will enhance the competitive ability of commercial growers in the Pacific Northwest. In

2003, 90 raspberry crosses were made with emphases on using RBDV (raspberry bushy dwarf virus) resistant parents, root rot tolerant parents and diverse genetic material. Approximately 5,800 seedlings were planted from the crosses made in 2001 and 2002. Thirty-five selections were made in 2002 and an additional 56 selections in 2003 among the 6,900 seedlings planted in 2000. Twenty-six selections were made among the 5,700 seedlings planted in 2001. Thirty-seven of the 82 selections made in 2003 have a RBDV resistant parent or possibly resistant parent. Nineteen of the selections have a root rot resistant parent. Emphasis on developing machine harvestable cultivars continued. The clones with the highest yields in 2003 were WSU 1309, WSU 1068, WSU 1307 and Cascade Delight. These four clones also were the four with the highest two-year yields.

d. Impacts and Scope of Research
   i) **Impacts of research:** It is expected that these new cultivars will benefit commercial growers, home gardeners, fruit processors and consumers. Fruit studies will provide information that will be used to identify clones with superior fruit characteristics.
   ii) **Geographic scope:** Pacific Northwest.

e. **Source of funding:** Hatch, State, and Industry Grants and Agreements

5. WNP00797: Postharvest Biology of Fruit.

a. **Key Theme:** Agricultural Profitability

b. RPA 503 Quality Maintenance in Storing and Marketing Non-Food Products

c. This research focuses on fundamental studies of enzymes and physicochemical phenomena in apples that have potential to create ontogenic markers for spray timing of certain growth regulators and minimizing oxidative disorders during the storage period for apples. The role of active oxygen species in apple scald development was determined using a chromotropic nitrone spin trapping agent. Two major species of nitrone-trapped radicals related to farnesene oxidation were identified with the highest seen in fruit from RA storage that scalded severely. Although weak, FPT expression appeared uniform across RA and CA. Inhibition of apple farnesyl protein transferase, a major signal transduction protein, resulted in increased levels of farnesene.

d. Impacts and Scope of Research
   i) **Impacts of research:** It is anticipated that reducing the occurrence of postharvest disorders, such as scald, will enhance Washington growers' ability to compete with fresh crops from the Southern Hemisphere during the storage season.
   ii) **Geographic scope:** This is basic biochemical research that would be applicable to fruit growing regions globally.
   iii) Associated with Multistate project NE-103 including: WA, MI, NC, MA, OR, CA, PA, NY, DC, GA, and MN.

e. **Source of funding:** Hatch MRF, State, Other Federal Funds, and Industry Grants and Agreements

INSTITUTE OF BIOLOGICAL CHEMISTRY

1. **WNP00202:** Metabolic Compartmentation During (Heart)Wood and Seed Coat Development

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. The purpose of this study is to understand and define the basic mechanisms by which plants utilize and coordinate their various metabolic pathways to confer protection during growth and development (i.e., in imparting and sustaining quality and durability in heartwood). The features of interest in this study address (heart)wood and seed coat development, using lignan biosynthesis as the biochemical marker to study both processes. The overall processes affording heartwood engage a mechanism common to essentially all woody forms, yet which differs in terms of the actual type of metabolites introduced into the tissue, primarily during post-lignification. Yet it is these substances which confer color, quality, rot resistance and durability to such and hence the extent of protection conferred.

d. Impacts and Scope of Research
   i) **Impacts of research:** A detailed understanding of the overall processes involved in lignification is necessary before such an important biological system can be biotechnologically manipulated and exploited, e.g., for improved lumber and raw materials for pulp and paper. Additionally, the metabolic processes associated with seed [coat] development, involving deposition of phenolic substances (e.g., secoisolariciresinol diglucoside in flax which accounts for about 3-4% of the total weight) needs to be established.
   ii) **Geographic scope**: National (Northwest and Midwest States) and International.
   Iii) The project does not integrate research and extension.

e. **Source of funding:** McIntire-Stennis, NSF, Public Health Service, NASA, State, and Non-Federal Funds

2. 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. Most early oxygenase steps in the Taxol pathway have been defined, and five of the responsible cytochrome P450 oxygenase genes have been isolated. The biosynthetic steps responsible for the assembly of the C13-side chain of Taxol have been defined, and the two acyltransferase genes involved have been isolated. Feeding studies with Taxus cells continue to define the sequence of biosynthetic steps leading to Taxol. Detailed studies on the mechanism and structure-function relationships of abietadiene synthase have continued in order to dissect the complex reaction conducted by this enzyme. Redesign of abietadiene synthase allows the possibility of controlling conifer defensive resin composition for improved viscosity and polymerization characteristics, and the production of useful intermediates for the perfumery industry.

d. Impacts and Scope of Research
   i) **Impacts of research:** An important objective of this project is to genetically engineer commercial mint species (peppermint and spearmint) for improved essential composition and yield. This project provides both the molecular tools and the metabolic content for genetic engineering of terpenoid production in plants. Fifty percent mprovement in both yield and composition of the terpenoid essential oil of commercial mint species has been demonstrated and these plants are in field trials.
   ii) **Geographic scope:** National (Northwest and Midwest states).
   iii) The project does not integrate research and extension.

e. **Source of funding:** Hatch MRF, Public Health Service, and State

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. We have investigated the role of polyunsaturated fatty acids in photosynthesis using a triple mutant of Arabidopsis that lacks trienoic fatty acids, fad3 2 fad7 2 fad8. Under normal growth conditions, the vegetative development and appearance of mutant plants are similar to wild type. At 0.2 - 1.0 kPa VPD (low VPD), maximum photosynthetic rates of wild-type and mutant plants were similar while stomatal conductance rates were up to two times higher in fad3 2 fad7 2 fad8. However, light-saturated rates of carbon assimilation and stomatal conductance in the mutant were lower than in wild-type plants when measured at ambient (35 Pa) CO2 and 2.0 - 2.8 kPa vapor pressure deficit (high VPD). The limitation to photosynthesis in the mutant plants at high VPD was overcome by saturating partial pressures of CO2 suggesting a stomatal limitation. Chlorophyll fluorescence measurements indicated that differences observed in maximum assimilation rates were not due to limitations within the photochemical reactions of photosynthesis. Stomatal response to VPD and intrinsic water use efficiency were drastically different in mutant versus wild-type plants. The results of this investigation indicate that for Arabidopsis, polyunsaturated fatty acids may be an important determinant of responses of photosynthesis and stomatal conductance to environmental stresses such as high VPD.

d. Impacts and Scope of Research
   i) **Impacts of research:** Each membrane of a cell has a characteristic and distinct complement of glycerolipid molecules that vary both in headgroup structure and in the length and degree of unsaturation of the fatty acid chains that constitute the hydrophobic portion of the membrane. This diversity implies that differences in lipid structure are important for proper membrane function. However, while a few particular lipids have defined roles, the dominant view of a membrane remains one in which lipids simply compose a bilayer matrix for the functional membrane proteins. Changing this simplistic view will require both an understanding of lipid metabolism and information on the lipid requirements for the proper functioning of membranes and for the production of lipid-derived signaling molecules. This information can then be the basis for mechanistic models of how the lipid composition of cell membranes affects plant function.
   ii) **Geographic scope**: International.
   iii) The project does not integrate research and extension.

e. **Source of funding:** Hatch, NSF, DOE, Public Health Service, State and Other Non-Federal Funds

4. 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. Some plants can obtain nitrogen, a needed nutrient, through interactions with symbiotic bacteria. Exchange and metabolism of nutrients by the bacteria is at the center of the relationship. Research in the laboratory is exploring bacterial nutrient use and includes investigations of transport, electron flow and carbon catabolism. In addition, the laboratory has been leading a large scale genetic dissection of the genome of the alfalfa symbiont 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, NSF, DOE, and State

5. 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. This research has contributed to the understanding of how plants store photosynthetic energy without self-destruction. We have elucidated major new processes by which the light reactions of photosynthesis are regulated, and respond to changes in the dark reactions and thus to changes in the environment. We have also developed a new model for understanding the mechanism of the key proton translocation step in photosynthesis and mitochondrial respiration, and have provided new evidence in support of this model. We elucidated the architecture of the quinol oxidase site of the mitochondrial cyt bc1 complex (related to the cyt b6f complex). This information is critical to understanding of the Q-cycle reactions, as well as the production of superoxide by the complex. We further showed that the Qo pocket could be simultaneously occupied by two quinone analogs, each binding in a very different way. We helped elucidate the mechanism of the cyt bc1 and b6f complexes. We determined the relationship between the electron paramagnetic resonance (EPR) g-factor axis with respect to the molecular axis for the Rieske iron-sulfur cluster (FeS). We demonstrated dramatic increases in the sensitivity of light harvesting antenna down-regulation as the CO2 level was lowered. We found that the major mechanism by which the regulation of the light reactions is achieved is via the ATP synthase. We proposed a new mechanism by which the dark reactions could modulate the ATP synthase to achieve variable regulation of the light reactions. Changes in inorganic phosphate then alter the kinetic properties of the ATP synthase. We have provided evidence that changing the fraction of transthylakoid proton motive force stored as electric field and pH gradient can modulate the sensitivity of antenna down-regulation. We have developed a new tool for isolating mutant strains of Arabidopsis defective in photosynthetic flexibility. With this tool, we have already identified and partially characterized several novel loci responsible for controlling flexibility responses. We have applied some of our new spectroscopic tools towards probing plant physiological status for precision agriculture applications, resulting in several new technologies.

d. Impacts and Scope of Research

i) **Impacts of research:** Understanding the regulation of photosynthesis will impact efforts to develop plants or growing conditions to improve crop health. Understanding reactive oxygen species production will impact disease research in both plants and animals. The fundamental mechanisms of energy transduction is important for basic understanding of life.

ii) **Geographic scope**: International.

iii) The project does not integrate research and extension**.**

e. **Source of funding:** Hatch, DOE, Other Federal Funds, State, and Other Non-Federal Funds

6. 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. Using genes isolated from the peppermint oil gland EST project, and sense and antisense technologies, transgenic peppermints with improved essential oil yield and composition have been prepared and are in field trials. Ten genes have been evaluated, including transcription factors, and stacking of multiple genes into peppermint is now in progress. The geranyl diphosphate synthase genes from mint (large and small subunit) have been fused into a functional construct to simplify biotechnological applications. Several new types of terpenoid biosynthetic genes were cloned and characterized. Mechanistic and structural studies with terpenoid synthases are in progress, and a second crystal structure for a monoterpene cyclase (limonene synthase) has been obtained. Improvement in both yield and composition of the terpenoid essential oil of commercial mint species has been demonstrated and those plants are in field trials.

d. Impacts and Scope of Research
   i) **Impacts of research:** This project will lead to genetically engineered commercial mint species (peppermint and spearmint) for improved essential composition and yield. This project provides both the molecular tools and the metabolic context for genetic engineering of terpenoid production in plants.
   ii) **Geographic scope**: National (Northwest and Midwest states).
   iii) The project does not integrate research and extension.

e. **Source of funding:** Hatch, NSF, DOE, Public Health Service, State, Industry Grants and Agreements, and Other Non- Federal Funds

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. This project has identified, isolated, and purified novel peptide signals (hormones) from plants. During 2003 we have isolated over 10 peptide signals, ranging from 15 to 20 amino acids in length, from potato, petunia, and nightshade leaves that are powerful inducers of defense responses in their respective species. The peptides are all hydroxyproline-rich glycopeptides, derived from precursors of about 150 to 200 amino acids in length that have moderately similar amino acid sequences. Three to four peptide signals are proteolytically cleaved from each precursor. Similar peptide signals and precursors had previously been isolated from tomato and tobacco leaves. Three peptide signals that appear to be involved in growth and/or development have also been isolated. One of these, called the Rapid Alkalinization Factor (RALF) arrests root growth, while the roles of the other two are currently under investigation.

d. Impacts and Scope of Research
   i) **Impacts of research:** The isolation of the new defense signals and genes in Solanaceae species provides a new opportunity to understand how plants cope with herbivore attacks. This knowledge is expected to be used to enhance crop productivity by improving the ability of plants to rapidly signal defense genes in response to attacking herbivores.
   ii) **Geographic scope**: International.
   iii) The project does not integrate research and extension.

e. **Source of funding:** Hatch, NSF, State, and Other Non-Federal Funds

DEPARTMENT OF PLANT PATHOLOGY

1. WNP00336 - Integrated Disease Control Programs for Fresh Market and Processing Vegetable Crops in Washington

a. **Key Theme:** Plant Health

b. RPA 212 Diseases and Nematodes affecting Plants

c. The activities of this project are directed at identifying and evaluating potential new approaches to control a variety of different diseases in several different vegetable crops grown in Washington State. In some cases, diseases on different crops have the same or similar causal agents and the control measures may, therefore, be similar. For example, late blight of potato and tomato are caused by the same pathogen, and pink rot and leak of potato tubers are caused by related organisms. Control measures tested include chemical, cultural, and disease resistant varieties.

d. Impacts and Scope of Research
   i) **Impacts of research:** Effective new fungicides and other materials were identified for the control of late blight and water rot diseases of potato tubers. Some of these materials are already registered, and these results provide growers with information that will enable them to make educated decisions for product selection. Likewise, the relative resistance of potato varieties to several diseases was measured, which provides growers with information needed to make informed decisions about which varieties to grow on their farms.
   ii) **Geographic scope:** The results of this project are multi-state with greatest impact in the Pacific Northwest region of the U.S. However, some results, especially those on chemical control have national impact.
   iii) This project has an integrated extension-research component. The lead scientist for this project, Dr. D. Inglis is leader of the Statewide Vegetable Pathology Team, which conducts workshops on vegetable diseases and provides research and extension information to clients through its website.

e. **Source of funding:** Hatch, USDA-NRI, Other Federal Funds, State, Industry Grants and Agreements, and Other Non-Federal Funds

2. WNP00388 - Management of diseases on Christmas trees and the identification of Christmas trees with superior postharvest characteristics

a. **Key Theme:** Plant Health

b. RPA 212 Diseases and Nematodes affecting Plants

c. The activities of this project are directed at identifying potential new diseases of conifers grown in commercial Christmas tree farms, to develop effective control measures, including chemical, cultural, and genetic, and to improve postharvest handling of Christmas trees to improve product quality for consumers.

d. Impacts and Scope of Research
   i) **Impacts of research:** Studies from this project identified the time period when Douglas fir trees are most susceptible to infection by the pathogen that causes Sudden Oak decline, which will enable growers to time their fungicide applications for maximum effectiveness. Since this is a new pathogen that is not yet established or widely distributed in Washington State, this work will allow growers to proactively prevent disease establishment and thus, protect their industry from potential losses resulting from embargo or quarantine.

   Studies on Annosus root rot have demonstrated that removal of stumps or treating the cut surface with a fungicide after cutting trees but before re-planting is an effective way to reduce losses to this

disease. Growers are now more aware of this disease and have modified their planting practices to include stump treatment.

Studies on postharvest handling of trees and the factors important to maintaining high-quality trees are being used to educate retailers on methods to minimize moisture loss in tree lots and provide consumers with higher quality Christmas trees.

ii) **Geographic scope:** This project has national and international scope.

iii) This project has an integrated extension-research component. Dr. Chastagner and others developed a one-day workshop in 2003 following the initial report of the Sudden Oak Death pathogen being detected in Washington State. The workshop, which had over 100 participants, provided current information on the biology of this disease, its geographic distribution, and potential economic consequences resulting from direct disease losses as well as impact on trade resulting from quarantines. Information on Annosus root rot and Swiss needle cast was delivered to growers through talks at field days and other venues.

e. **Source of funding:** Hatch and State

3. WNP00669 - Controlling eyespot in winter wheat with disease resistance

a. **Key Theme:** Plant Health

b. RPA 212 Disease and Nematodes affecting Plants

c. The activities of this project are directed at improving disease resistance in winter wheat to a soilborne fungal pathogen that is widespread throughout the wheat growing region of the Pacific Northwest U.S. and northern Europe. Disease resistance is the most effective, reliable, and least expensive method of controlling this disease for which cultural and chemical controls exist, but are not entirely effective.

d. Impacts and Scope of Research

i) **Impacts of research:** As a result of the research from this project, new disease resistance genes have been identified that will enable wheat breeders to diversify the genetic base of resistance to this disease in wheat. Prior to the beginning of the project, only one gene had been identified; four have now been identified and others are being studied. Eyespot-resistant varieties are now grown on nearly 1,000,000 acres in Washington State and the use of fungicides for control of this disease has decreased from a high of over 800,000 acres during the 1980s to less than 50,000 now. Considering a treatment cost of $15 per acre, the wheat industry saves several million dollars each year in fungicide costs alone.

ii) **Geographic scope:** This project has national and international scope

iii) Integrated research/extension activities. Information from this project has been communicated to growers at field days.

e. **Source of funding:** Hatch, State, and Industry Grants and Agreements

4. WNP01262 - National program for controlling virus diseases of temperate fruit tree crops.

a. **Key Theme:** Plant Health

b. RPA 212 Diseases and Nematodes affecting Plants

c. The activities of this project are directed at the development, propagation, and distribution of virus-free propagating material for temperate fruit crops such as apples, cherries, pears, plums, and others. In addition, the project provides diagnostic expertise for virus and virus-like agents of woody fruit trees that enables rapid and sensitive detection of pathogens that may not be present in the U.S.

d. Impacts and Scope of Research
   i) **Impacts of research:** As a result of this project, scientists at Land Grant Universities and commercial nurseries have access to virus-free propagation material. For growers, this project results in more profitable growing operations by reducing the long-term impacts viruses have on production. For consumers, this results in greater diversity of fruit varieties from which to choose, a higher quality product, and a more affordable product.
   ii) **Geographic scope:** This project has national and international scope.
   iii) Integrated research/extension activities - none
   iv) Affiliated Multi-state Research Committee NRSP-5 along with the 4 USDA regions it includes: WA, NY, WI, CA, SC, and Canada.

e. **Source of funding:** Hatch and Other Non-Federal Funds

GOAL 2

A SAFE AND SECURE FOOD AND FIBER SYSTEM

EXECUTIVE SUMMARY

Several Departments participate in work related to National Goal 2: the Departments of Food Sciences and Human Nutrition (FSHN), the Field Disease Investigative Unit and the Department of Biological Systems Engineering. All departments are making excellent progress in achieving their goals as stated in the original Plan of work and its revision in 2001.

Within FSHN there has been important research activity in the detection of pathogens in food and the prevention of spoilage of food. A rapid method has been developed for the detection of carbon dioxide from lactose fermentation by coliforms. In addition, a rapid non-invasive method to predict moisture and salt content of smoked and cured foods using a spectral device has been validated for commercial or regulatory settings.

The Field Disease Investigative Unit, a unit which is physically located in the College of Veterinary Medicine but associated with the Agricultural Research Center, resolves problems of food safety and security at the farm level and investigates incidences related to zoonotic disease. The group has been investigating incidences of salmonellosis, E. Coli 0157, and *Mycoplasma* mastitis in dairy herds.

Washington is home to a new and fast growing wine industry. Within the Biological Systems Engineering Department, finite element analysis has been used to model crop loads on grape vine trellises. Real time estimation of crop leads is a critical input for precision agricultural applications.

Major strides have been made in Biological Systems Engineering in studies of microwave and radiofrequency energy in food safety, phytosanitary practices and quarantine applications. FY 2003 data show that low frequency radio energy heating can kill insect pests in dry fruits and nuts. The coddling moth, navel orangeworm, Indian meal moth, Mediterranean fruit flay and the Mexican fruit fly have been destroyed by this treatment. It is likely that microwave and radiofrequency treatments will replace methyl bromide for phytosanitation.

DEPARTMENTAL REPORTS

DEPARTMENT OF BIOLOGICAL SYSTEMS ENGINEERING

1. WNP00271: Preservation of Foods by Oscillating Magnetic Fields

a. **Key Theme:** Food Safety

b. RPA 501 New and Improved Food Processing Technologies

c. The goal of the project was to study the possibility of preserving food using oscillating magnetic fields. The work was very comprehensive, yielding consistent negative results for all microorganisms studied regardless of the type of magnetic field used. The results obtained in this study demonstrated that static or pulsed magnetic fields with intensities up to 18T for up to 60 ms such as those used in this work do not constitute a successful approach as a preservation technology for food preservation due to its failure to inactivate microorganisms. Such negative results led us to re-orient our focus towards other more appealing novel preservation technologies.

d. Impacts and Scope of Research

i) **Impacts on research:** The use of magnetic fields with the purpose of preserving food products has been discontinued from our research program. Magnetic fields technology was thoroughly studied and the null hypothesis assuming that electric fields possess a bactericidal ability was rejected. There is no question that the technology was very attractive but it did not meet the level of expectations within the food processing community (the client for the research).
ii) **Geographic scope:** Improving food processing by focusing research elsewhere will affect all states in which food processing is important.
iii) The project has no extension component and is not affiliated with a multistate research committee.

e. **Source of funding:** Hatch, State, Industry Grants and Agreements, and Other Non-Federal Grants

2. WNPO0320: Coupled Heat and Moisture Transfer Finite Element Analysis in Food Products.

a. **Key Theme:** Food Accessibility and Affordability

b. RPA 501 New and Improved Food Processing Technologies

c. Finite element analysis (FEA) was used to analyze the orthotropic values of tensile and compressive material properties in apple tissue with respect to the core line. In both directions tensile elastic modulus was about 3 times greater than the respective compression values, and failure stress levels were about 25% less. These results were used to begin study on stress cracks in Gala apples just prior to harvest. The physical properties of seed germination material consisting of wheat biomass, starch and peanut oil were modeled using FEA. The FEA model predicted the amount of time required for denaturing of the oil and gelatinization of the starch, both required to strengthen the biomass. Germination material made from these components is of value to the NASA biological advanced life support system (BALSS) required for long-term space flight, and has value to terrestrial greenhouse industries. We continued development of multi-cell models of apple tissues and mapping single cell (size, shape, turgor pressure, cell wall thickness, strength, and pectin bonding strength) onto multi-cellular mechanical properties. In 2001, a major shift was made in project activities. We developed Finite Element Modeling focused on modeling crop loads on grape trellis wires. We developed FEA models for grape trellis tension as a function of fruit and other biomass load. We modeled the effect of wind, temperature and water uptake on the transient response of the wire to external excitation. Although the computer model indicated that the resonant frequency of the grape cluster is distinct from other biomass supported by the trellis wire, field measurements were unable to detect a frequency response due to the clusters.

d. Impacts and Scope of Research
i) **Impacts of research:** Understanding the relationship between single cell properties and tissue properties will allow for more precise growing and storage practices. Real time estimation of crop loads is a critical input for precision agricultural applications. The finite element modeling of the trellis wire tension due to crop load will help define the potential sensitivity of this application. The model will aid in the design of effective and inexpensive load cells and data analysis routines for grape trellis systems. The model can be easily extended to other crops supported by wires such as apples.
ii) **Geographic scope:** The results of the research will be felt in states with active research programs in precision agriculture, post-harvest storage of fruits and vegetables, and growing wine grapes.
iii) The project has no extension component and is not affiliated with a multistate research committee.

e. **Source of funding:** Hatch, State, Industry Grants and Agreements

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

a. **Key Theme:** Food Safety

b. RPA 503 Quality and Maintenance in Storing and Marketing Food.

c. The goal of the project is to determine the effectiveness of a 915 MHz microwave single mode sterilization system for food processing and for treatment of fruits and vegetables to kill insects. At a meeting of the microwave consortium, the industrial partners were pleased with the advances made in the project and agreed to support the design of a semi-continuous system in order to speed up technology development, transfer, and FDA approval processes. Several of our published papers in 2003 provide insight into interactions between selected foods and microwave and radio frequency energy at sterilization temperatures. This information should be of great value to scientists in the field. We have published a paper in the Transactions of the ASAE that provides for the first time a theoretical basis and convincing experimental data to support the hypothesis that insect pests can be preferentially heated by low frequency radio energy in dry fruits and nuts.

d. Impacts and Scope of Research
   i) **Impacts of research:** These findings provide a solid theoretical basis for the development of an effective thermal treatment that uses radio frequency energy for pest control in dry fruits and nuts. Similar treatments can be developed for other dry commodities (e.g., wood in intra-state and international trade). Because of the success of the project, two major food companies joined the Consortium (Ocean Beauty Seafoods, WA; Masterfoods USA, CA), making the WSU Microwave Sterilization Consortium the largest research consortium in food engineering led by a single university.
   ii) **Geographic scope:** The research is especially important in states such as Washington, Oregon, Idaho, and California that export large amounts of produce to countries that require quarantine treatment.
   iii) This project does not have an extension component and it is not associated with a multistate research committee.

e. **Source of funding:** Hatch, USDA-Cooperative Agreement, Department of Defense, Other Federal Funds, State, Industry Grants and Agreements, and Other Non-Federal Funds

4. WNPO0990: Assuring Fruit and Vegetable Product Quality and Safety through the Handling and Marketing Chain

a. **Key Theme**: Food Handling

b. RPA 503 Quality and Maintenance in Storing and Marketing Food

c. Studies have been focused on determining thermal-death kinetics of five major insect pests for fruits and nuts with the goal of developing technologies to kill the pests during quarantine treatment. The insects are codling moth, navel orangeworm, Indian meal moth, Mediterranean fruit fly and Mexican fruit fly. Navel orangeworm appeared to be the most heat resistant insect and Mexican fruit fly was the least heat resistant. The 0.5th order reaction model was found most suitable to describe the thermal death kinetics for these five insects. A theoretical basis and experimental evidence were found to support the hypothesis that insect larvae can be preferentially heated in dry nuts by radio frequency heating for pest control. A treatment protocol was developed to control fifth-instar navel orangeworm in walnuts without quality damage based on radio frequency energy. A study is in progress for the disinfestation of citrus and tropical fruits using radio frequency energy. Studies to improve postharvest technology related to asparagus harvest, handling, storage and packaging were conducted using different treatment combinations of modified atmosphere packaging, growth regulators, and hot water treatments. Repeatable results showed that vitamin C in asparagus was consistent for all treatments and modified atmosphere had higher TAA than asparagus spears from the other treatments, including RA storage.

d. Impacts and Scope of Research

i) **Impacts of research:** The impact of this research is very high because the project provides fundamental and essential information for developing heat treatments for postharvest pest control in fruits and nuts in order to replace chemical fumigation with methyl bromide.
ii) **Geographic scope:** The work is important in all states in which agricultural products are exported. The project has no extension component.
iii) This project is part of a multistate research committee NE 1008 including: WA, MI, NY, NC, MD, ME, HI, PA, GA, CA, and IN.

e. **Source of funding:** Hatch, MRF and State

THE FIELD DISEASE INVESTIGATIVE UNIT

1. WNP00858: Investigation of Food Animal Disease Problems in the State of Washington

a. **Key Themes:** Food Security, Food Borne Illness, Pathogen Protection, Animal Health, and Food Quality

b. RPA 311 Animal Diseases; RPA 712 Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins

c. The purpose of this project is to define and resolve problems of food safety and food quality generated at the farm level through on-farm research in animal agricultural production systems and define and resolve problems of zoonotic disease in agricultural animals by on-farm research. *Salmonella* surveillance in cattle shows that the apparent prevalence of mr-DT104 has declined, and is being replaced by a multiply drug resistance *Salmonella enterica* serovar Newport, resistant in particular to Ceftiofur. Dairy herds that have a combined sick cow/hospital pen and freshening cow pen are at significantly higher risk for herd outbreaks of salmonellosis. Patterns of fecal excretion of E coli 0157 have been evaluated and show age associations, patterns of epidemic excretion interspersed with no shedding, a seasonal influence and evidence for environmental proliferation. In the control of *Staph aureus* mastitis, the segregation and application of hygienic and therapeutic protocols with prompt collection of milk samples at parturition and at 7 and 14 days after parturition reduces the incidence of new intramammary infections. Shedding patterns of *Mycoplasma* in cows with mastitis have been defined. Bulk tank sampling may not be sufficiently sensitive for use in screening for herd infection. In herds that experience crooked calf disease following maternal consumption of lupine species, the difference in outcome is not determined by between-cow difference in alkaloid metabolism.

d. Impacts and Scope of Research
i) **Impacts of research:** We expect that in the future this research will lead to on-farm management strategies that will reduce the prevalence *E.coli* 0157 on farms and risk for food contamination.

The separation of the sick cow holding pens from that used to hold late pregnant and calving dairy cattle will reduce the risk of outbreaks of salmonellosis on dairy farms.

A control program for *Staph aureus* intramammary infections has been shown to reduce the incidence of new intramammary infections.

Research has shown that risk for crooked calf disease in association with the ingestion of *Lupinus* spp. is not associated with individual cow variance in susceptibility and that future research should concentrate on the determinants of grazing behavior.

ii) **Geographic scope:** Statewide (WA) and national.
iii) The study on the epidemiology and control of crooked calf disease integrates research and extension.

e. **Source of funding:** Hatch and State

DEPARTMENT OF FOOD SCIENCE AND HUMAN NUTRITION

1. WNP00369: Evaluation of Surface Irrigation Water as a Source of Contamination of Fruits and Vegetables with *E. coli 0257* and *L. Monocytogenes*

a. **Key Theme:** Food Safety, Food Security, and Food Borne Illness

b. RPA 501 New and improved food processing technologies; RPA 712 Protect Food from Contamination by Pathogenic Microorganisms, Parasites, and Naturally Occurring Toxins

c. Several rapid methods for monitoring coliforms in foods have been developed, but have problems in detection and time to results. A rapid and simple method using an electrochemical $C0_2$ sensor has been developed to determine $C0_2$ from lactose fermentation by coliforms.

d. Impacts and Scope of Research
   i) **Impacts of research:** Coliforms in water can be easily measured accurately within 13 hours using this $C0_2$ electrochemical sensor.
   ii) **Geographic scope:** National
   iii) There are no integrated extension/research activities.

e. **Source of funding:** Hatch, State, Industry Grants and Agreements, and Other Non-Federal Funds

2. WNP06305: Non-Invasive Method for Predicting Safety and Quality of Foods

a. **Key Themes:** Food Quality, Food Safety, and Food Borne Pathogen Protection
b. RPA 501 New and improved Food Processing Technologies; RPA 712 Protect Food from Contamination by Pathogenic Microorganism, Parasites, and Naturally Occurring Toxins; RPA 503 Quality Maintenance in Storing and Marketing Food

c. A rapid non-invasive method to predict moisture and salt in high value smoked and cured foods in lower salt forms is on the rise and increases the risk of pathogen growth.

d. Impacts and Scope of Research
   i) **Impacts of research:** A rapid non-invasive method to predict moisture and salt in smoked and cured foods using spectral measurements was developed. This technology can be used in a commercial or regulatory setting.
   ii) **Geographic scope:** Regional and National.
   iii) There are no integrated extension/research activities.

e. **Source of funding:** Contract, Grants, and Cooperative Agreements

1. WNP00846: Ecological and Viticultural Practices on Fermentation, Microbiology, Chemistry and Quality of Wines

a. **Key Theme:** Agricultural Competitiveness, Agricultural Profitability, and Food Quality

b. RPA 501 New and Improved Food Processing Technologies

c. Problem alcoholic fermentations were studied by examining how changes in the availability of one nutrient important for yeast growth (assimilable nitrogen) affects the cells needed for other nutrients such as vitamins.

d. Impacts and Scope of Research
   i) **Impacts of research:** H_2S was increased with an increase in available nitrogen under conditions of pantothenic acid defiency. This may explain why some wineries experience an increase of H_2S evolution when extras nitrogen is added.
   ii) **Geographic scope:** Nationwide
   iii) There are no integrated extension/research activities.

e. **Source of funding:** Hatch and State

GOAL 3

A HEALTHY WELL NOURISHED POPULATION

EXECUTIVE SUMMARY

The Department of Food Sciences and Human Nutrition is the primary department of the ARC which participates in activities related to Goal 3. Important outcomes this year have to do with diabetes type II self-management practices in Hispanic populations. Diabetes and obesity are major health problems within the Hispanic communities populating Central Washington. These studies are important for many reasons including that this group has been traditionally in an "under-served" status.

Another faculty member in FSHN, whose studies have primarily been cancer-related, has been establishing vitamin requirements for groups at risk, particularly smokers. He has found that an important transferase activity declines in smokers.

In a third project assigned to goal 3, the mechanisms and mitigation of agrochemical impacts on human and environmental health was studied. This was a collaborative study with faculty members from the University of Washington. In this study, members of our entomology faculty residing at the Food and Environmental Quality Laboratory (FEQL) at the Tri-Cities Campus provided analytical support to discover chemical residues of methamidophos in children. Children risk exposure to this chemical by living near potato fields routinely sprayed with the insecticide during the growing season. It was found that that proper timing of aerial spraying under the proper conditions minimizes exposure.

DEPARTMENTAL REPORTS

DEPARTMENT OF ENTOMOLOGY

1. WNP00372: Mechanisms and Mitigation of Agrochemical Impacts on Human and Environmental Health

a **Key Themes:** Pesticide Application, Workforce Safety, Human Health, and Risk Management

b. RPA 723 Hazards to Human Health and Society

c. In collaboration with UW, we provided field and analytical support for quantifying methamidophos residues (active ingredient in Monitor 4 Æ used on potato fields) in/on air sampling adsorbents, drift cards, and surface and hand wipes. Its principle metabolite, OS-dimethyl phosphorothioate (DMPT) was

also quantified from the collection of urine samples taken from one farm-family children taken over a 3-day exposure period. Analyses for methamidophos residues on drift cards, surface wipes, and air sampling adsorbents have also been completed. Urinary metabolite analysis has also been completed. Parent and metabolite residue data collected from air, wipe samples, and drift cards suggest limited exposure from off-target movement into an adjacent farming community after a single aerial spray application. The field and urinary data together with GPS information from this single application study has provided a snapshot of potential OP insecticide exposure to children living in close proximity to a field application event. Various results-oriented and analytical method publications have been generated from this Washington State University/University of Washington collaboration.

d. Impacts and Scope of Research
   i) **Impacts of research:** Results of this collaborative study indicate that proper aerial application techniques can result in minimal exposure to children living in close proximity to field potato pesticide applications.
   ii) **Geographic scope:** Regional
   iii) This project is associated with Multistate W-45 including: WA, UT, MD, OR, CA, NY, IN, HI, FL, NV, NM, and KS.

e. **Source of funding:** Hatch MRF and Industry Grants and Agreements

DEPARTMENT OF FOOD SCIENCE AND HUMAN NUTRITION

1. WNP00103: Dietary and Psychosocial Factors Affecting Self-Management of Type 2 Diabetes Mellitus

a. **Key Theme:** Human Health, Human Nutrition

b. RPA 703-Nutrition Education

c. A qualitative investigation was conducted of diabetes self-management practices and outcomes among Latinos/as with type 2 diabetes, a group with higher prevalence of diabetes than the general population. It was discovered family support appears to be a cross-cultural element in successful diabetes care, and can be incorporated into diabetes education programs. Goal setting may not be well understood by patients and more studies are needed for goal setting behaviors and processes.

d. Impacts and Scope of Research
   i) **Impacts of the research:** This research is applicable to the needs of an under-served population in the Pacific Northwest. Hispanics are a fast growing segment of the population in Central Washington. The population exhibits high rates of obesity and diabetes.
   ii) **Geographic scope:** Statewide
   iii) This project includes diabetes education as part of the extension education and is associated with behavioral and cultural research.

e. **Source of funding:** Hatch, State, and Other Federal Funds

2. WNP00118: Vitamin B-6 Intake: Smoking and DNA Damage

a. **Key Theme:** Human Health

b. RPA 702 Requirements and Function of Nutrients and Other Food Components

c. Serine hydroxyl methyl L transferase activity (SHMT) activity declines with vitamin B-6 deficiency and smokers exhibit reduced B-6 activity. Smokers and non-smokers were given diets with different levels of B-6 vitamin and SHMT was measured.

d. Impacts and Scope of Research
   i) **Impacts of the research:** SHMT activity may be used as a potential vitamin B-6 status indicator and smoking exerts a significant effect on SHMT activity.
   ii) **Geographic scope:** International
   iii) There are no integrated extension/research activities.

e. **Source of funding:** Hatch, State, and Public Health Service

GOAL 4

AN AGRICULTURE SYSTEM WHICH PROTECTS NATURAL RESOURCES AND THE ENVIRONMENT

EXECUTIVE SUMMARY

Agricultural Economics focused on the study of water management technologies, institutions and policies affecting economic viability and environmental quality. Their research focused on the linkages between on-farm irrigation effectiveness and water conservation, western water allocation institutions, reservoir sedimentation management and affected the agricultural conservation water laws in Washington.

Biological Systems Engineering made significant progress in modeling hydrological and erosion processes at the watershed scale. A model of hill slope erosion on a hill in the Mojave Desert showed how erosion rates progressed through the Holocene and Pleistocene periods. Results from this research have relevance to highly erodable lands everywhere. Another project in Biosystems Engineering developed a mathematical model that relates no-till farming to sediment reduction. A GIS based RUSLE model was developed to simulate the soil erosion for the watershed. The results verify and validate the value of the no-till method for conservation of soil. A third project focused on understanding and simulating the processes that lead to barley and wheat grain yield and nitrogen concentration variation across the landscape in the Pacific Northwest.

Further validation of the no-till cropping system was gained in research conducted in the Department of Crop and Soil Sciences in which cropping systems were evaluated for economic, agronomic and environmental performance. As a result of research work in this department on no-till the adoption of this practice by Pacific Northwest farmers has increased.

Because Washington is subject to new agricultural regulations designed to recover endangered salmonid populations, the Department of Natural Resource Sciences (NRS) has been working to discover what constitutes a functional riparian buffer to protect water quality and to improve salmon habitat. There has been a high degree of landowner (stakeholder) cooperation with this study, which involves several very contentious issues—including loss of cultivatable land. Another study from NRS, studying the effect of irrigated agriculture on cougar predation on white tailed deer, has caused the Fish and Game departments of two states and British Columbia to revise their management policies regarding deer and cougar.

Entomology faculty have studied ecological and toxicological approaches to estimate the effects of pesticides on non-target organisms and have discovered that susceptibility of certain species to pesticides is much more complex than previously thought and is related to life histories. Another important research discovery has been that a common flavor enhancer, monosodium glutamate and its analog, which is more rain-fast, are able to increase the feeding of neonatal forms of insects on pesticide coated materials. It is assumed that the new formulations will be able to lower the amount of pesticide.

DEPARTMENTAL REPORTS

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

1. WNP00160: Agricultural Water Management Technologies, Institutions and Policies Affecting Economic Viability and Environmental Quality

a. **Key Theme:** Natural Resource Management

b. RPA 605, Natural Resource and Environmental Economics

c. Research focused on the linkages between on-farm irrigation effectiveness and water conservation, Western water allocation institutions, reservoir sedimentation management, and law.

d. Impacts and Scope of Research
   i) **Research Impacts:** Education of policy makers that increased on-farm irrigation effectiveness can actually increase consumptive water use in return-flow river systems has affected the formation of agricultural water conservation law in the State of Washington.
   ii) **Geographic scope:** Western region
   iii) This project is associated with Multistate W-190 including: WA, CA, CO, AZ, UT, Hi, TX, ND, NM, IN, NE, GA, OR, KS, and NC.

e. **Source of funding:** Hatch MRF and State

DEPARTMENT OF BIOLOGICAL SYSTEMS ENGINEERING

1. WNP00352: A Watershed Scale Study on No-Till Farming System for Reducing Sediment Delivery

a. **Key Theme**: Water quality

b. RPA-112 Watershed Protection and Management

c. The goal of the project was to develop a mathematical model that relates no-till farming to sediment reduction. The project has developed a model framework that includes mathematical descriptions for the main hydrological and erosion processes on a watershed. Specific procedures were developed to be incorporated into the model. In addition, a GIS based RUSLE model was developed to simulate the soil erosion for the watershed. The model simulation revealed the significance of no-till as a stewardship practice in reducing the soil erosion. Results show that by adopting no-till practice on the entire watershed, the annual average soil loss potential can be reduced from about 11 tons to about 3 tons per acre. Moreover, a significant amount of data was collected at both field and watershed levels. Future work under this task includes model integration, data analysis, and additional data collection for the verification of the results predicted using the model.

d. Impacts and Scope of Research
   i) **Impacts of research:** The findings clearly demonstrate the environmental benefits of the no-till practice, especially for erosion reduction. The results provide a scientific base for developing policies that encourage farmers to adopt conservation tillage systems. The results are so convincing to the farmers that they are acquiring a better understanding of the relationship between their land management practices and environmental quality. This understanding will help to promote stewardship practices, which protect the water quality of their watersheds. In addition, the advancements made in theoretical studies have laid a foundation for future research that will ultimately result in a technical tool for more accurate prediction of the erosion processes in this region.

ii) **Geographic scope:** This research benefits the region (WA, OR, ID, MT) as well as other states in which water erosion from farmland is important.
iii) The project had no extension component and it is not associated with a multistate research committee.

e. **Source of funding:** Hatch, DOE, Other Federal Funds, State, Industry Grants and Agreements, and Other Non-Federal Funds

2. WNP00357: Use of Simulation Modeling and Other Computer-Based Tools for Decision Support in the Management of Agricultural Systems

a. **Key Theme:** Soil quality

b. RPA 133 Pollution Prevention and Mitigation

c. The focus of this project was on understanding and simulating the processes that lead to barley and wheat grain yield and N concentration variation and related N use efficiency components across the landscape in the inland Pacific Northwest. Experiments were aimed at gathering customized information on crop growth, yield and N uptake of spring wheat and barley as affected by landscape-distributed yield-limiting factors. At four selected positions on the landscape, treatments were applied consisting of two water availability levels (irrigated and dryland). Data from these positions were used to improve and calibrate the simulation model CropSyst. In addition, two years of experimental work including detailed growth analyses of two barley cultivars were completed and used to analyze biomass accumulation as affected by radiation- and transpiration-use efficiency. Three nitrogen treatments were imposed on 12 hectares on an experimental farm with well-know grid-based history of rotations, inputs, and yields. Three nitrogen treatments (a non-fertilized control and spring and split applications) were imposed on 26 selected points along transects across the landscape. Total above ground nitrogen, nitrogen in the grain, and grain nitrogen concentration were calculated for each location. These data were used to evaluate the performance of the model. On average, the model overestimated above ground biomass by 7%, with simulations of all spring applied nitrogen contributing to most of the overestimation. The observed and simulated biomass for the unfertilized treatment were on average almost identical, indicating that the model simulated adequately the effect of nitrogen shortage. This contrasted with the observed values of above ground nitrogen at harvest, which were on average 17% greater than observed due to a gross overestimation of nitrogen uptake by wheat in the spring nitrogen treatment. Field measurements indicated that nitrogen followed an alternative pathway or that the residual mineral nitrogen at harvest was greater than simulated values.

d. Impacts and Scope of Research
i) **Impacts of research:** The results from this project contributed to a better understanding of crop model applications for precision management of complex landscapes such as those in the Palouse region of the US Pacific Northwest. The agricultural systems of the future are expected to be smart systems that take full advantage of information age technology, providing a safe and adequate supply of agricultural products while protecting environmental quality and the natural resource base. Evaluation of management decisions based on crop models, however, will require interaction with and feedback from field sensors to account for complex and difficult-to-track processes that are not included in simulation models.
ii) **Geographic scope:** The research has application throughout the region (WA, OR, ID, MT).
Iii) The project has no extension component and it is not affiliated with a multistate research committee.

e. **Source of funding:** Hatch, Other Federal Funds, and State

DEPARTMENT OF CROP AND SOIL SCIENCES

1. WNP00250: Cropping systems research for low-precipitation dryland in eastern WA

WNP00182: Impact of no till on soil quality physical, chemical, and microbiological properties
WNP00373: Carbon and nitrogen cycling and management in alternative cropping systems
WNP00598: Eolian soils, global change, and Washington agriculture

a. **Key Themes:** Land Use, Soil Erosion, Water Quality, Air Quality, Nutrient Management, and Soil Quality

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 have been evaluated for economic, agronomic and environmental performance. Constraints on direct seed adoption, such as increased pest pressures have been identified. 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) **Impacts of research**: Grower adoption of reduced tillage and direct seeding systems in the Pacific Northwest has dramatically increased over the past decade. Improved soil carbon sequestration and soil quality with continuous direct seeded spring cropping in place of summer fallow has been demonstrated. Incidents of air quality violations reported by local municipalities due to soil particulate emissions have decreased.
   ii) **Geographic scope:** Environmental and economic impact is mainly regional WA, ID, and OR; however, the basic scientific principles have national/international impact.
   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, State, Industry Grants and Agreements, Other Non-Federal Funds, Other Federal Funds, and NSF

DEPARTMENT OF ENTOMOLOGY

1. WNPO0327: Ecological and Toxicological Approaches to Estimate Effects of Pesticides to Non-target Organisms

a. **Key Themes:** Integrated Pest management, Pesticide Application

b. RPA 216 Integrated pest management systems

c. A new approach has been developed for the evaluation of pesticide effects based on life table data and a matrix projection model. The model incorporates both lethal and sublethal effects and examines pesticide effects in terms of population recovery time after exposure. The new approach also challenges the way in which pesticides are evaluated, pointing out a major flaw in toxicology and presents new way to look at pesticide effects. It was found that the intrinsic rate of increase was negatively correlated with the delay in population growth indicating that species with high intrinsic rates of increase were less susceptible to equal levels of stress than species with lower intrinsic rates of increase. Because predators usually have much lower intrinsic rates of increase than their prey they are inherently more susceptible to pesticides than previously imagined.

d. Impacts and Scope of Research
   i) **Impacts of research:** Results of this study indicate that species susceptibility to pesticides is far more complicated than previously thought and that differences in life history variables of the organism should be considered when evaluating pesticide compatibility with biological control agents. The results of this study appear in Proceedings of the National Academy of Sciences (2003).

ii) **Geographic scope:** International

e. **Source of funding:** Hatch, Other Federal Funds, State, and Other Non-Federal Funds

2. WNP00405: Potential of Insect Growth Regulators for Controlling Insect Pests of the Pacific Northwest

a. **Key Theme:** Integrated Pest Management

b. RPA 211 Insects, Mites, and Other Arthropods; RPA-125 Agroforestry.

c. Brief Project Description: This project is developing an integrated pest management program to control wood burrowing insects in hybrid poplar plantings. We were awarded the first Regional Section 18 for a non-registered pesticide on May 29, 2003. Two formulations (membrane and aerial applied flowable) of the pheromone (a 4:1 ratio of (Z,E): (Z,Z)-3,13-octadecadienyl alcohols) that serve as the sex pheromone of the western poplar clearwing moth [WPCM (*P. robinae*)] were applied to 3,610 acres in Washington and 4,113 acres in Oregon. Trap capture of male moths were completely shut down immediately, and essentially no moths were captured the remainder of the season. Damage was definitely reduced; however, some moths had emerged, mated and oviposited before the time we were allowed to apply the pheromone.

Another important outcome of this project is that a formulation has been developed which will enhance feeding of neonate pests of orchard systems to reduce the amount of active ingredient needed and to increase the efficacy of pesticide that must be ingested to effective. Wilbur-Ellis has announced that they will be offering an adjuvant called 'Devour®' to be added to Success® for improved control of leafrollers and codling moth. This product contains monosodium glutamate (MSG). We have filed a patent disclosure for an MSG mimic, trans-ACBD that is more rainfast than MSG itself, but it stimulates orchard pests to consume more pesticide for up to 10 days with as much as 10 mm of simulated rain in field conditions. MSG added to pesticide formulations can increase the toxicity of Spinosad by a factor of 6, and the efficacy of *Bacillus thuringiensis* by 3.

d. Impacts and Scope of Research
   i) **Impacts of research:** With the pherormone treatment, we were able to reduce the use of chlorpyrifos [Lorsban®] from 44,000 pounds to zero within one year for control of the western poplar clearwing moth.

   Our basic research into feeding enhancing substances has moved from the laboratory to a commercial product in just 4 years. These formulations will reduce the amount of active ingredient needed and may be more economical for the industry.
   ii) **Geographic scope:** International

e. **Source of funding:** Hatch, USDA Grants, Contracts, Cooperative Agreements, State, and Industry Grants and Agreements

DEPARTMENT OF NATURAL RESOURCE SCIENCES

1. WNP000307: Forested Riparian Buffers: Species, Function, and Management for Agriculture.

a. **Key Theme:** Water Quality

b. RPA 112 Water shed protection and management

c. The project goal is to identify what constitutes a functional riparian buffer to protect water quality and improve salmon habitat on agricultural land in western Washington, and to determine the economic impact of such buffers on farm enterprises.

Project Activities: During the reporting period, we met with cooperating farmers to provide a detailed plan for the coming year, formalized agreements for conducting research, surveyed sites, prepared sites for spring planting of experimental buffers, installed 48 piezometers to determine ground water flow into the respective water courses, and held a training session for Skagit Valley College students who will be taking weekly measurements of water table depths.

d. Impacts and Scope of Research
   i) **Impacts of research:** This research is relevant to 19 western Washington counties that practice agriculture in riverine flood plain areas. This area includes 213,000 acres of cropland and 406,000 head of livestock. The research will also be relevant for commercial plant nurseries and western Oregon agriculture. One of the objectives is to estimate the economic impact of installing riparian buffers on agricultural land, which is presently unknown. All of Washington State is subject to new agricultural regulations designed to recover endangered salmonid populations, and potential economic impact is large: Washington's 1999 agricultural production totaled $5.3 billion.

      The high degree of landowner cooperation that has been achieved to-date in undertaking a project designed to address a significant regulatory issue (which was not well received by the agricultural sector initially) is highly noteworthy.
   ii) **Geographic Scope:** Northwest Washington and Oregon.
   iii) There is integrated Research and Extension Effort in the project.

e. **Source of funding:** McIntire-Stennis, USDA Contracts, Grants, Cooperative Agreements, Other Federal Funds, State, and Other Non-Federal Funds

2. 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 Aquatic and terrestrial wildlife

c. 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 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. The investigator is testing the apparent competition hypothesis by conducting a manipulative, controlled, replicated "press" experiment in two treatment and two control areas by reducing densities of white-tailed deer and observing any changes in cougar-mule deer relationships. White-tailed deer and mule deer densities are being monitored using annual aerial surveys and seasonal ground surveys. Changes in 1) cougar functional response (kills/unit time), 2) cougar aggregative response (cougars/unit area), 3) cougar numerical response (offspring/cougar), 4) total response (predation rate), and 5) predator and prey population growth are being monitored using radio telemetry. The experiment is scheduled to be completed over a period of 3 years. If apparent competition is causal in mule deer declines, irrigation agriculture may not have to be curtailed because increased harvest of white-tailed deer in agricultural zones could alleviate the problem.

   To date a total of 26 cougars have been captured and monitored; 562 aerial locations, and approximately 800 ground locations (total = 1362) have been collected. Cougars select for the pre-treatment study areas at ($P < 0.05$). To date, thirty-nine (19 white-tailed deer, 12 mule deer, and 8 unknown) kill sites have been found. Mean functional response is 1 kill/7 days. Cougars select for mule deer. To date we have observed 15 cougar litters. Mean litter size is 2.50 and mean reproductive rate is 1.2 kittens/year.

To date, thirty mule deer have been radio-collared as part of the cooperative mule deer project. Cougar and mule deer Survival-Fecundity Population Growth R is 0.80 and 0.88.

d. Impacts and Scope of Research
   i) **Impacts of research:** The Washington Dept. of Fish & Wildlife, Idaho Dept. of Fish & Game, & BC Ministry of Air, Land and Water Protection are revising their cougar and deer management programs because of our results to-date.
   ii) **Geographic Scope:** Northeast Washington, northern Idaho and southern British Columbia.
   iii) Integrated Research and Extension Effort: No.

e. **Source of funding:** Hatch, DOE, State, and Other Non-Federal Funds

GOAL V

EXECUTIVE SUMMARY

We have no projects with impact statements to report under goal five this year.

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 which seek registration for special uses of pesticides, WSCPR funds integrated pest-control strategies that minimize the use of pesticides through the use of biocontrol.

Three years ago, all units of the College participated in stakeholder meetings to develop comprehensive strategic plans directed at priority research and educational goals for the next 5 years. 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 which are 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 which 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 the states of 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 are 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. ALL ARE SUPERVISED BY ADMINISTRATIVE ADVISORS WHO FILE ANNUAL REPORTS IN ADDITION TO THE CRIS PROGRESS REPORTS FILED BY SCIENTISTS AT EACH COOPERATING INSTITUTION AND 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 those faculty with split appointments among research, teaching, and/or extension or those faculty with a 100% extension appointment who attended multistate research or coordinating committee meetings in FY 2003.

AGRICULTURAL RESEARCH CENTER – UNIVERSITY EXTENSION COORDINATION

Faculty of the ARC and CE cooperate in program planning and delivery primarily on an individual basis. Sixty faculty members, plus five college administrators for a total of sixty-five, 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.

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 2003, the target percentage is 3%; however, we are choosing to report on a higher percentage (approximately 5%) of integrated projects below.

Since Washington is an agriculturally diverse state, we have chosen to report on five projects encompassing benefits for a cross-section of Washington's citizens. For FY 03 we have chosen to feature work on (1) local food systems in response to our constituency who favor locally grown foods (primarily organic foods), (2) work on composting and the clopyralid problem, (3) work on reducing the load of pesticides in orchards and (4) efforts to control wheat disease, wheat being one of the largest exports of Washington State. The total funding allocated to these integrated projects is $185,651.10, which is approximately 5% of our allocated formula funds.

Local Dimensions of the Globalization of Food and Agricultural Marketing Systems

Project 0127

Analysis of the data collected during the fall of 2002 continued. Univariate distributions of all variables collected in the producers' survey were tabulate and placed in the public domain (http://www.crs.wsu.edu/agsurvey/index.html). An in-depth analysis of producer attitudes concerning the use of genetically modified organisms on farms was also conducted. Results show that individual farmer characteristics are less useful for explaining which farmers are/are not interested in using GMOs than their production and marketing practices. An additional ongoing analysis is focusing on the ways in which consumers and farmers are working to re-structure food systems in ways that are more responsive to their values and needs.

Impact Statement

Interest in, and use of, the information being disseminated to various farming audiences is ongoing. There is an increasing interest in various regions of the state in promoting local agriculture and food systems. For example, citizen groups like Skagitonians to Preserve Farmland have indicated that they find the data set that is available on the web to be of great value in their own efforts. Such responses indicate that there is a burgeoning interest in promoting local food systems, and that such types of marketing systems should continue to be supported state-wide.

$65.839.09 in Hatch Funds

Composting and the Presence of Clopyralid

Project 0722

The presence of clopyralid, a selective broadleaf herbicide, in compost near Spokane, WA in 2000 was attributed to grass clippings collected from area lawns and subsequently used as compost feed stock. A field study was conducted in 2001 to evaluate the effects of herbicide formulation and mowing practice on the clopyralid content of grass clippings. The objective was to develop guidelines that would limit the concentration of clopyralid in clippings, thereby reducing the amount of clopyralid entering the compost production stream. Clopyralid was applied to turfgrass as either a sprayable (S) or granular (G) formulation. Grass clippings were either collected in a bagging lawn mower and removed from the plots or returned into the plant canopy using a mulching mower designed to finely chop and disperse the leaf blades. Clippings were sampled for a period of ten weeks after application, and again in the summer of 2002, and analyzed for clopyralid content. Mowing treatment had no significant effect on clopyralid content of grass clippings. The S formulation resulted in higher concentration than the G at 4 hours after treatment (193 mg kg-1 and 53 mg kg-1, respectively). At 10 weeks after treatment (WAT), clopyralid concentration averaged 0.9 mg kg-1, and cumulative recovery of clopyralid in grass clippings was 35% and 29% of the amount applied for the S and G formulations, respectively. By 56 and 98 WAT, clopyralid concentration in clippings was 0.06 and 0.02 mg

kg-1, respectively. Based on these results, and depending on feedstock dilution and composting conditions, a waiting period of up to one year after application of clopyralid could be necessary for treated grass clippings to be safely used as compost feed stock.

Impact Statement

This work on clopyralid in compost was used to develop statewide restrictions and guidelines on clopyralid use. As a result compost producers and users in western Washington avoided serious clopyralid problems, and yard waste recycling remains a successful program**.**

$37,923.79 in Hatch funds

Potential of Insect Growth Regulators for Controlling Insect Pests of the Pacific Northwest

Project 0405

Monosodium glutamate was shown to be a feeding stimulant and an enhancer of pesticide toxicity against neonates of the codling moth. Monosodium glutamate alternative, trans-1-Aminocyclobutane-1,3-dicarboxylic acid, (trans-ACBD) alone and in the presence of Spinosad, was shown to increase leaf tissue consumption by codling moth neonates. In contrast to monosodium glutamate, trans-ACBD maintains its feeding stimulatory properties in the field even after 20mm of simulated rain, and effectively increases Spinosad efficacy both in laboratory and in the field experiments.

Monosodium glutamate, a taste enhancer widely used in food industry, was tested in the laboratory to determine its phagostimulatory effects on larvae of *Choristoneura rosaceana* (Harris). Larvae fed apple leaves treated with 50-700 µg/l monosodium glutamate increased leaf tissue consumption by approximately 40%. The stimulatory effect of monosodium glutamate (at 675 µg/l concentration) was maintained throughout 10 days of continuous exposure. Adding 675 µg/l monosodium glutamate to commercial formulation of *Bacillus thuringiensis* ssp. Kurstaki, DiPel“ 2X DF, lowered LC50 from 450 to 150 µg/l ($P<0.05$, Lethal Ratio Significance Test), indicating good potential of monosodium glutamate for enhancement of *Bacillus thuringiensis*- based formulations.

Impact Statement

In the future, the use of feeding stimulants may lower the amount of pesticide used by growers to control larvae in fruit orchards.

$37.348.70 in Hatch Funds

Disease Resistance & Cultural Practices for Control of Cephalosporium Stripe in Wheat

Project 670

A survey to collect isolates of *Cephalosporium gramineum* from across the Pacific Northwest U.S. (PNW) and assess them for genetic variation was conducted. Approximately 60 isolates were collected and evaluated using AFLP, DNA sequence analysis of the ITS region, and cultural variation to determine if there is significant genetic variation. Preliminary data indicate limited genetic variation in populations of this fungus from the PNW. A set of species-specific PCR primers was developed from the ITS region of the pathogen and a PCR protocol developed for detection and quantification of *Cephalosporium gramineum* in plants and seed. Approximately 25 different seed-associated fungi were collected from several thousand wheat seed representing a wide variety of geographic areas in the PNW and tested against these primers to ensure their specificity for *Cephalosporium gramineum*.

Impact Statement

Development of varieties with resistance to Cephalosporium stripe will reduce losses caused by the disease and allow growers to seed earlier in the autumn, thus reducing soil erosion and allowing the full agronomic yield potential to be realized. Such resistant varieties would be useful in all farming systems where Cephalosporium stripe occurs and would provide growers greater flexibility in management decisions now impacted by this disease. Understanding seed transmission of this pathogen better will enable us to address concerns for international movement of seed more effectively and potentially to develop control measures for this aspect of the disease**.**

$17,796.28

Improving Resistance to Eyespot in Winter Wheat

Project 0669

Winter wheat cultivars and breeding lines were tested for resistance to eyespot in a field plot near Pullman, WA. Disease was moderately severe with disease index ranging from 5 to 74 on a scale of 0 to 100. Yield ranged from 6.0 to 9.1 Mg/ha and test weight from 736.2 to 778.2 kg/cu m. Several advanced breeding lines had disease indexes and yield comparable to or better than existing varieties. Field studies were conducted to determine whether interactions occur between eyespot resistance gene Pch1 and *Tapesia yallundae* and *Tapesia acuformis*. Disease developed late in the season for both pathogens this year and was always greater on the susceptible variety Hill 81 than the resistant variety Madsen, regardless of pathogen*. Tapesia acuformis* had little impact on yield of either variety; *Tapesia yallundae* reduced yield of Hill 81 significantly more so than Madsen. In contrast to previous studies, there was no evidence of an interaction between these pathogens and resistance gene Pch1 this year.

Impact Statement

Development of varieties with more effective eyespot resistance than currently available and adapted to all Washington production areas will eliminate the need for fungicide application and reduce losses due to incomplete disease control attainable with cultural practices. Enhancing resistance will also allow growers to seed earlier, thus reducing soil erosion and allow the full agronomic yield potential to be realized.

$ 26,743.24 in Hatch Funds

Section IV

APPENDIX A

Agricultural Research Center
Administrative Advisors FY 2003

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

W-006 "Plant Genetic Resource Conservation and Utilization"

NRSP-5 "Develop & Distribute Deciduous Fruit Tree Clones That Are Free of Known Graft-Transmissible Pathogens"

WCC-20 "Virus and Virus-Like Diseases of Fruit Crops"

WCC-043 (co-AA) "Management of Codling Moth and Related Moths in the Orchard Ecosystem"

WCC-092 (co-AA) "Beef Cattle Energetics"

WCC-097 (co-AA) "Research on Diseases of Cereals"

Sandra Ristow, Associate Director, Agricultural Research Center

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

WCC-023 (co-AA) "Textiles and Apparel Coordinating Committee"

Vicki A. McCracken, Director, Academic Programs

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

WCC-101 "Assessing the Chinese Market for U.S. Agricultural Products"

Linda Arthur, Chair, Apparel, Merchandising, Design, and Textiles; Interior Design

WCC-023 (co-AA) "Textiles and Apparel Coordinating Committee"

John Brown, Chair, Entomology Department

WCC-043 (co-AA) "Management of Codling Moth and Related Moths in the Orchard Ecosystem"

Ray W. Wight, Chair, Animal Sciences Department

WCC-092 (co-AA) "Beef Cattle Energetics"

Tim Murray, Chair, Plant Pathology Department

WCC-097 (co-AA) "Research on Diseases of Cereals"

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

W-1001 "Population Change In Rural Communities"

W-167 “Family and Work Identities During Times of Transition”

FY 2003 Multistate Research Fund Projects with WSU Faculty and ARS Cooperator Participation

Prjct	Title	MRF #	Term Date		Researcher
0913	Molecular Mechanisms Regulating Skeletal Muscle Growth and Differentiation	NC-131	09/2005	1	Dodson, M.V.
0913	Molecular Mechanisms Regulating Skeletal Muscle Growth and Differentiation	NC-131	09/2005	2	Rodgers. B. D.
0467	Improvement of Thermal and Alternative Processes for Food	NC-136	09/2005	1	Barbosa-Canovas, G.V.
0467	Improvement of Thermal and Alternative Processes for Food	NC-136	09/2005	2	Powers, J.R.
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.
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	NC-202	09/2005	1	Parker, R.
	Decision Support Systems to Reduced Herbicide Use				
0128	Marketing and Delivery of Quality Cereals and Oilseeds	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.
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.
0119	Regulation of Photosynthetic Processes	NC-1142	09/2007	1	Okita, T.W.
0119	Regulation of Photosynthetic Processes	NC-1142	09/2002	2	Edwards, G.E.
0797	Postharvest Physiology of Fruits	NE-103	09/2003	1	Fellman, J.K.
0797	Postharvest Physiology of Fruits	NE-103	09/2003	2	Kupferman, E.M.
0154	Environmental and Economic Impacts of Nutrient Management on Dairy Forage Systems	NE-132	09/2004	1	Harrison, J.H.
0156	Multidisciplinary Evaluation of New Apple Cultivars	NE-183	09/2004	1	Barritt, B.H.
0409	Eradication, Contaiment and/or Management of Plum Pox Disease (Sharka)	NE-1006	09/2006	1	Eastwell, K.C.
0990	Technology & Principles for Assessing & Retaining Postharvest Quality of Fruits & Vegetables	NE-1008	09/2007	1	Tang, J.

0990	Technology & Principles for Assessing & Retaining Postharvest Quality of Fruits & Vegetables	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 Economic Development: Alternatives in the New Competitive Environment	NE-1011	09/2007	1	Holland, D.W.
0230	Commodities, Consumers, and Communities: Local Food Systems in a Globalizing Environment	NE-1012	09/2007	1	Jussaume, R.A.
0230	Commodities, Consumers, and Communities: Local Food Systems in a Globalizing Environment	NE-1012	09/2007	2	Ostrom, M.
0122	A National Agricultural Program to Clear Pest Control Agents for Minor Uses	NRSP-4	09/2004	1	Walsh, D.B.
1262	Develop & Distribute Deciduous Fruit Tree Clones That are Free of Known Graft-Transmissible s Pathogen	NRSP-5	09/2008	1	Eastwell, K.C.
1262	Develop & Distribute Deciduous Fruit Tree Clones That are Free of Known Graft-Transmissible Pathogens	NRSP-5	09/2008	2	Howell, W.E.
1262	Develop & Distribute Deciduous Fruit Tree Clones That are Free of Known Graft-Transmissible Pathogens	NRSP-5	09/2008	3	Cavalieri, R.P.
1262	Develop & Distribute Deciduous Fruit Tree Clones That are Free of Known Graft-Transmissible Pathogens	NRSP-5	09/2008	4	Murray, T.D.
0568	National Animal Genome Research Program	NRSP-8	09/2008	1	Jiang, Z
0806	Fruit and Vegetable Supply-Chain Management, Innovations, and Competitiveness	S-222	09/2003	1	Schotzko, R.T.
0450	The Science and Engineering for a Biobased Industry and Economy	S-1007	09/2007	1	Chen, S.
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2008	1	Lumpkin, T.A.
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2008	10	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.
0372	Mechanisms and Mitigation of Agrochmeical 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.
0957	Reproductive Performance in Domestic Ruminants	W-112	09/2006	1	Reeves, J.J.
0215	Freeze Damage and Protection of Horticultural Species	W-130	09/2003	1	Keller,M

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..
0690	Chemistry and Bioavailability of Waste Constituents in Soils	W-170	09/2004	1	Kuo, S.
0706	Germ Cell and Embryo Development and Manipulation for the Improvement of Livestock	W-171	09/2004	1	Wright, R.W.
0152	Characterization of Flow and Transport Processes in Soils at Different Scales	W-188	09/2004	1	Flury, M.
0152	Characterization of Flow and Transport Processes in Soils at Different Scales	W-188	09/2004	2	Wu, J. Q.
0160	Agricultural Water Management Technologies, Institutions and Policies Affecting Economic Viability and Environmental Quality	W-190	09/2004	1	Huffaker, R.G.
0399	Community Economic Development by Merchandising, Producing, and Distributing Textiles and Sewn Products	W-194	09/2004	1	Salusso, C.J.
0445	Population Change in Rural Communities	W-1001	09/2007	1	Kirschner, A.
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.
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.
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.
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	9/2007	1	Piper, G.L.
0185	Genetic Variability in the Cyst and Root-Knot Nematodes	W-1186	09/2008	1	Riga, E.

Multistate Research Funds Travel (October 1, 2002-September 30, 2003
Expenditures for WSU Participants (Not Including Coordinating Committees)

MRF Comm	Title	Total
NC-062	Enteric Diseases of Cattle: Prevention Control and Food Safety	975.29
NC-136	Improvement of Thermal and Alternative Processes for Foods	1536.77
NC-140	Rootstock and Interstem Effects on Pome and Stone Fruit Trees	613.40
NC-1185	Metabolic Relationships in Supply of Nutrients for Lactating Cows	512.34
NE-103	Postharvest Physiology of Fruits	3,555.37
NE-132	Environmental and Economic Impacts of Nutrient Management on Dairy Forage Systems	1029.85
NE-1008	Assuring Fruit and Vegetable Product Quality and Safety Through the Handling and Market Chain	563.74
NE-1009	Mastitis Resistance to Enhance Dairy Food Safety	977.22
NRSP 5	Develop and Distribute Deciduous Fruit Tree Clones that are Free of Viruses and Virus-Like Agents	1016.54
S-1007	The Science and Engineering for a Biobased Industry and Economy	1163.26
W-45	Mechanisms and Mitigation of Agrochmeical Impacts on Human and Environmental Health	1865.79
W-106	Multistate Research Coordination, Western Region	6910.50
W-112	Reproductive Performance of Domesic Ruminants	573.24
W-150	Genetic Improvement of Beans (Phaseolus vulgaris L.) for Yield, Disease Resistance, and Food Value	1394.76
W-188	Characterization of Flow and Transport Processes in Soils at Different Scales	786.14
W-190	Agricultural Water Management Technologies: Institutions & Policies Affecting Economic Visibility & Environmental Quality	690.68
W-1001	Population Change in Rural Communities	719.61
W-1002	Nutrient Bioavailability - A Key to Human Nutrition	30.00
W-1003	Parent and Household Influences on Calcium Intake Among Preadolescents	685.72
W-1133	Benefits and Costs of Resource Policies Affecting Public and Private Land	717.27
W-1185	Biological Control in Pest Management Systems of Plants	686.65
W-1186	Genetic Variability in the Cyst and Root-Knot Nematodes	847.88
	Total:	27,852.02

APPENDIX B

Current Multistate Coordinating Committees with WSU
Faculty and ARS Cooperator Participants
FY 2003

MRF #	PI	Title	Term Date
WCC-001	Charles Gaskins	Beef Cattle Breeding in the Western Region	9/07
WCC-011	William Johnston Gwen Stahnke E. Miltner	Turfgrass Research	9/04
WCC-020	K.C. Eastwell W. Howell Ralph Cavalieri (AA)	Virus and Virus-Like Diseases of Fruit Trees Crops, Small Fruits, and Grape Vines	9/06
WCC-021	J. Dobrowolski B. Zamora	Revegetation and Stabilization of Deteriorated and Altered Lands	9/04
WCC-023	Linda Arthur Sandra Ristow (AA)	Textiles and Apparel Coordinating Committee	9/04
WCC-027	Robert Thornton N. Richard Knowles	Potato Variety Development	9/05
WCC-040	Linda Hardesty	Rangeland Ecological Research and Assessment	9/06
WCC-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)	Management of Codling Moth and Related Moths in the Orchard Ecosystem	9/08
WCC-055	Dave Scarnecchia	Rangeland Resource Economics and Policy	9/06
WCC-058	Charles Johnson Rita Hummel	Production, Transition Handling, and Reestablishment of Perennial Nursery Stock	9/04
WCC-060	John Dunley	Science and Management of Pesticide Resistance	9/07
WCC-066	Keith Pike William Turner	Integrated Management of Russian Wheat Aphid and Other Cereal Aphids.	9/06

WCC-067	David Granatstein David Bezdicek Christopher Feise	Western Coordinating Committee for Sustainable Agriculture	9/05
WCC-069	D. Walsh L. Tanigoshi	Coordination of Integrated Pest Management Research & Extension/Education Programs for the Western United States and the Pacific Basin Territories	9/05
WCC-072	F. Chaddad	Agribusiness Research Emphasizing Competitiveness	9/04
WCC -077	Alex Ogg, Jr. Frank Young J. Yennish	Biology and Control of Winter Annual Grass Weeds in Winter Wheat	9/04
WCC-081	Brady Carter	Systems to Improve End-Use Quality of Wheat	9/06
WCC-089	Hanu Pappu Jim Crosslin	Potato Virus Disease Control	9/06
WCC-091	Steven Fransen	Improving Stress Resistance of Forages in the Western United States	9/04
WCC-092	Kristen Johnson Ray Wright, (AA) Ralph Cavalieri, (AA)	Beef Cattle Energetics	9/04
WCC-093	Alan Busacca Bruce Frazier	Western Region Soil Survey and Inventory	9/04
WCC-097	Timothy Murray, (AA) Ralph Cavalieri, (AA)	Research on Diseases of Cereals	9/05
WCC-099	K.K. Chew (UW) Sandra Ristow, (AA)	Broodstock Management, Genetics and Breeding Programs for Molluscan Shellfish	9/06
WCC-101	R. Tichy T. Lumpkin T. Wahl P. Thiers V. McCracken (AA)	Assessing the Chinese Market for U.S. Agricultural Products	9/05
WCC-102	F. Pierce	Climatic Data and Analyses for Applications in Agriculture and Natural Resources	9/05
WCC-103	Robert Stevens Greg Schwab	Nutrient Management and Water Quality	9/06
WCC-109	Scott Matulich Ron Mittelhammer	Seafood Marketing and the Management of Marine and Aquacultural Resources	9/03
WCC-110	Mark Nelson	Improving Ruminant Use of Forages in	9/04

		Sustainable Production Systems for the Western U.S.	
WCC-201	S. Ullrich J. Froseth	Enhanced Use of Barley for Feed and Food	9/04
WCC-203	Ron Kincaid Mark Nelson	Animal Utilization of Products from Processing Agricultural Commodities	9/05
WCC-204	Ruth Newberry	Animal Bioethics	9/05
WCC-205	R. Simmons	Integrated Water Quality Research and Extension Programs for the Western United States	9/05
WCC-207	M. Swan	Agricultural Literacy	9/06
WCC-208	H. Dennis Brown	Western Region Impact Statement Development	9/06
WCC1001	D. Dillman V.A. McCracken, (AA)	Improvement of Rural and Agricultural Sample Survey Methods	9/07
IEG-31	Holly Wang	Economics and Management of Risk in Agriculture and Natural Resources	9/04
NCR-022	P. Moore	Small Fruit and Viticulture Research Committee	9/06
NCR-059	D. Bezdicek J. Halvorson	Soil Organic Matter and Soil Quality	9/06
NCR-131	R. Newberry	Animal Care and Behavior	9/07
NCR-134	H. Wang	Applied Commodity Price Analysis, Forecasting and Market Risk Management	9/03
NCR-170	R. Alldredge	Research Advances in Agricultural Statistics	9/06
NCR-174	J. Harsh	Synchrotron X-Ray Sources in Soil Science Research	9/07
NCR-180	Fran Pierce B. Frazier Joan Davenport	Site Specific Management	9/06
NCR-189	L. Fox J. Froseth W.C. Davis	Air Quality Issues Associated with Animal Facilities	9/06
NCR-193	G. Chastagner	Maintaining Plant Health: Managing Insect Pests and Diseases of Landscape Plants	9/06
NCR-194	K. Duft	Improving the management and effectiveness of	9/03

	F. Chaddad	cooperatively owned business organizations	
NCR-199	Charles Gaskins	Implementation & Strategies for National Beef Cattle Evaluation	9/06

* UDSA Participant

Multistate Research Funds Travel (Oct. 1, 2002-Sept. 30, 2003)		
Expenditures for WSU Participants, Coordinating Committees Only		
MRF	**Traveler**	**Totals:**
NCR-022	Moore, Pat	853.85
NCR-170	Zhang, Hao	566.19
NCR-180	Pierce, Francis	759.95
NCR-193	Chastagner, Gary	793.02
NCR-199	Gaskins, Charles	585.05
SERA-IEG-31	Wang, Holly	1113.26
WCC001	Gaskins, Charles	814.02
WCC-011	Miltner, Eric	884.44
WCC-027	Knowles, N Richard	16.00
WCC-043	John Brown	703.48
WCC-043	Brunner, Jay	781.72
WCC-055	Scarnecchia, David	1333.99
WCC-058	Hummel, Rita	854.46
WCC066	Pike, Keith	949.71
WCC-069	Walsh, Doug	828.90
WCC-077	Yenish, Joe	344.99
WCC-081	Carter, Brady	825.17
WCC089	Pappu, Hanu	733.88
WCC092	Johnson, Kristen	953.91
WCC-097	Murray, Tim	143.12
WCC-099	Ristow, Sandra	1259.64
WCC-101	Wahl, Tom	534.97
WCC-103	Stevens, Robert G	597.64
WCC201	Froseth, John	942.51
WCC-203	Nelson, Mark	663.08
WCC207	Swan, Michael	775.88
WCC-1001	Dillman, Don	881.77
	Grand Total:	**20494.60**

Appendix C

Faculty with Split Appointments or 100% Extension Appointments Attending Multistate Research or Coordinating Committee Meetings FY 2003

MRF#	R/T FTE	EXT FTE	Participant
NCR-193	0.6838	0.3162	Chastagner, Gary
NE_temp621	0.4286	0.5714	Spayd, Sara
NE-132	0.5	0.5	Harrison, Joe
W-045	0.5	0.5	Hebert, Vincent
W-186	0.8	0.2	Riga, Katerina
W-1001	0.6	0.4	Kirschner, Annabel
W-1133	0.9	0.1	Wandschneider, Phil
W-1185	0.75	0.25	Piper, Gary
WCC-043	0.83	0.17	Brown, John
WCC-043	0.83	0.17	Brunner, Jay
WCC-069	0.25	0.75	Walsh, Doug
WCC-077	0.25	0.75	Yenish, Joe
WCC-097	0.83	0.17	Murray, Tim
WCC-201	0.4	0.6	Froseth, John