

**ANNUAL REPORT
OF
ACCOMPLISHMENTS AND RESULTS**

**Agricultural Research Center
College of Agriculture and Home Economics
Washington State University
Pullman, Washington**

Submitted to USDA/CSREES

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Period Covered

**Federal FY2002
October 1, 2001 to September 30, 2002**

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SECTION I

INTRODUCTION

The Agricultural Research Center (ARC) (state agricultural experiment station) College of Agriculture and Home Economics (CAHE), 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, 2001 – September 30, 2002) are for ARC only.

During the period of this report CAHE was at the end of the implementation of a 1997-2002 Strategic Plan. The ARC chose to develop the POW within the framework of the institutional strategic plan. 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 CAHE 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

In addition, ARC shares responsibility for fiscal and programmatic management at the following off-campus research and extension centers/units, which were designated program-planning units.

- WSU-Puyallup Research and Extension Center (WWREC)
- WSU-Vancouver Research and Extension Unit (SWREU)
- WSU-Wenatchee Tree Fruit Research and Extension Center (TFREC)

Faculty members from several of the disciplines are located at the off-campus units.

Reports relating to the federal FY2002 CSREES Budget can be obtained by searching using key themes or keywords.

CONTACT INFORMATION

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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 and extension center 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 FY2002, the ARC received and expended \$2,032,285.00 in Hatch funds and \$1,373,287.00 in Hatch Multistate Research funds.

Hatch and Hatch Multistate Research funds constitute 5.84% and 3.95%, respectively, of the total funds expended on Agricultural Research Center (ARC) projects. State appropriations are 31.66% of the total with all other grants totaling 48.81%.

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 2002

Funding Source	CSREES Goals					Total	% of Totals
	1	2	3	4	5		
Hatch Funds	\$1,499,389	\$13,845	\$56,356	\$443,207	\$19,488	\$2,032,285	5.84
Multistate Research Funds	\$931,203	\$171,003	\$12,236	\$246,171	\$12,674	\$1,373,287	3.95
Federal Research Grants	\$1,650,850	\$351,140	\$49,087	\$1,332,851	0	\$3,383,928	9.73
State Appropriations	\$7,109,423	\$897,433	\$241,445	\$2,432,238	\$329,950	\$11,010,489	31.66
All Other Grants	\$11,514,607	\$1,026,162	\$234,515	\$3,607,445	\$590,712	\$16,973,441	48.81
Totals	\$22,705,471	\$2,459,582	\$593,639	\$8,061,912	\$952,823	\$34,773,427	--
Percentage of Total \$	65.30	7.07	1.71	23.18	2.74	100.00	--
FTEs	263.92	26.04	7.26	85.06	5.65	387.93	--
Percentage of Total FTEs	68.03	6.71	1.87	21.93	1.46	100.00	--

SECTION II

EXECUTIVE SUMMARY

The majority of research performed by faculty having appointments in the WSU Agricultural Research Center supports national **Goal 1**, “an agricultural system competitive in the global economy.” Certain impacts and outcomes achieved in 2002 were particularly noteworthy. For example, the IMPACT Center issued several cross-country surveys pinpointing countries and cultures accepting or rejecting GMO foods. Significant outcomes from research conducted by the Animal Sciences Department were: Manipulation of the diet of ruminants reduced the environmental loads of phosphorus, zinc, and selenium while still maintaining levels of production. Market opportunities for Northwest beef producers have increased with progeny testing of Wagyu bulls, ensuring high quality carcasses for the Japanese market.

The Center for Precision Agricultural Systems (CPAS) had several important outcomes and impacts during the last year. Most notable were development and implementation of the Technology Roadmap for Tree Fruit Production, which has the goal of enhancing the competitiveness of the tree fruit industry by reducing the cost of production of the highest quality fruit 30% by 2010. New data loggers/telemetry hardware, new sensors and software have been developed by CPAS. Trellised Crop Mass monitors have been produced for the grape industry. The AgWeatherNet™ system utilizing remote sensing of temperatures, frost conditions, disease states, threat of pests and soil moisture in farm fields shows promise for making farming in the PNW more profitable.

Crop and Soil Sciences provided a number of benefits for stakeholders including: new plant varieties which increased production, reduced cost of pesticides, diversified the cropping system, and increased access to new markets for cereals, food legumes, hops alternative agronomic crops and turf. The translocation in DNA which confers complete resistance to Cephalosporium Stripe was identified and transferred to wheat. Through a Material Transfer Agreement with the WSU Research Foundation and private industry, four new winter wheat lines with Clearfield™ novel traits were identified. One hard white spring wheat, a spring club wheat, and a hard red spring wheat were released or approved for pre-release.

The Department of Entomology has reported that the deployment of six seed-destroying bioagents against yellow starthistle in Washington has reduced this non-native plant's invasiveness and abundance 50-75% in numerous localities. Food Sciences and Human nutrition reported progress in the identification of the anti-bacterial factors in malolactic fermentation which can improve the quality of wine.

Horticulture and Landscape Architecture reported new potato varieties adapted to Washington growing and processing conditions in a state in which 90% of the crop is processed. A new variety which is Late Blight resistant and amenable to processing is estimated to save the industry \$20 million dollars per year. Factors reducing apple sunburn have been identified which will lead to increased profits in the industry. Part of the apple industry has opted for organic methods of growing apples resulting in fewer pesticide and herbicide applications. At the Wenatchee Research and Extension Center the basis for the use of bioregulators for plant growth and pruning is being developed. Research within the IMPACT Center has developed edible films for apples which maintain the integrity of fruit in order to withstand shipping and handling.

The Institute of Biological Chemistry continues its basic research focusing on the improvement and enhancement of wood products, the genetics and biological mechanisms of plants, and crop improvement. Outcomes from this group have included: the elucidation of the metabolic pathways to lignified sapwood and heartwood, the improvement of the fatty acid composition of seed oils, elucidation of pathways producing the anticancer agent, taxol, insights into the mechanisms of storage in plant vacuoles and elucidation of plant defense mechanisms.

Plant Pathology has developed new management methods for grape, cherry and hop powdery mildews resulting in fewer applications of fungicides. The project NRSP-5 is maintaining and distributing virus-free rootstocks in order to keep the nursery industry and the pome and stone fruit tree industries viable.

With regard to **Goal 2**, “the safety and security of our food and fiber system”, the Department of Biological Systems Engineering has completed its work on oscillating magnetic fields for food preservation and has found the technique to be inadequate. The researchers are now disseminating this information to processors. New rapid methods were developed to detect harmful *enterobacteriaceae*, reducing the time for testing by 10-14 hours. New enzyme time-temperature indicators for evaluating Pasteurization processes have been developed which reduce the time for testing to 15 minutes. Entomology has studied insect communities to discover complex communities containing natural enemies for new biocontrol methods in order that excessive use of pesticides may be avoided. It was found by researchers in Horticulture that 1-methyl chloropropanol treatment of cranberries with controlled atmosphere storage decreases the amount of unsellable fruit. The use of pheromones for insect management in orchards has reduced broad-spectrum pesticide use by 75% in many cases. Efficacy testing of new pesticides, coupled with large plot implementation sites has demonstrated that some pesticides against the codling moth will suppress populations of other pests such as leafrollers, below damaging levels without additional pesticides. This information may reduce pest control costs to WA growers by \$4-5 million per year.

In order to ensure “a healthy, well-nourished population” (**Goal 3**) our researchers showed that improving dietary B-6 consumption would improve immune response in young women and that DNA damage can be caused in persons who smoke and consume the currently recommended levels of B-6. The researchers have suggested that the B-6 recommendation be raised for smokers. In patients with diabetes, it was shown that culturally specific education programs increase a patient’s ability to manage the disease.

With regard to an agricultural system which protects natural resources and the environment (**Goal 4**), our researchers in natural resource economics have been credited by external sources with changing the course of a national policy concerning property rights and improving management of federal fisheries. Research performed by Biological Systems Engineering is improving the computer modeling for soil erosion and sediment transport on a watershed scale. The effectiveness of no-till farming for reducing run-off and erosion is being validated. Precision farming tools and refinements in remote sensing, global information systems and global positioning systems have increased the efficiency of fertilizer and pesticide use and in turn increased economic return. An agreement has been reached between the Department of Natural Resource Sciences and the Colville Confederated Tribes, which will restore 60,000 acres of shrub-steppe and riparian habitat on lands managed by the tribes.

Research in several departments has resulted in enhanced economic opportunity and a better quality of life (**Goal 5**). The distinction between commercial and recreational harvesting of wild berries has resulted in an increased recognition of the important of managing these crops on public lands. The Department of Rural Sociology has conducted interviews with industry, government, and community sources leading to the construction of more environmentally sound buildings. Surveys have indicated that the public (farmers, consumers and retailers) desires to market and purchase products on a more local basis and that this trend will support direct/local marketing initiation.

Taking together, the results reported in this document support the conclusion that research associated with the Agricultural Research Center are making excellent progress towards goals established for the period 2000-2004.

GOAL 1

AGRICULTURAL & RESOURCE ECONOMICS

GOAL I: Overview:

Research programs of the Department of Agricultural and Resource Economics are: (1) Production Economics, and (2) Agricultural Marketing.

A. Research Results From Research Projects Supported By Hatch Formula Funds

Economic studies of agricultural production and marketing resulted in greater understanding by producers, scientists, and policy makers of risk management options for Pacific Northwest farmers, effective machinery management for asparagus, grain, and bean production, economics of beef cattle genetic improvement, the economics of product quality, reputation, and labeling, promotion and supply chain management of fresh fruit, firm concentration in the wine industry, pitfalls of financing cooperatives through patron demand deposits, costs of alternative agricultural transportation systems, estimation methods and model design.

B. Outcomes That Have Resulted in Significant Changes

1. The finding that the greatest opportunity for profit in the highly concentrated wine industry occurs with small wineries specializing in premium table wines has led to continued growth of the Washington wine industry.
2. Apple producers increased profits by participating in promotion investments emphasizing improved quality standards of importance to consumers.
3. A study of the costs of producing, packing and storing potatoes was used to negotiate target producer prices with domestic processors.
4. Documentation that crop revenue insurance can reduce farm risks with less expense than a combination of yield insurance and futures market investment resulted in establishment of a partnership agreement between WSU and the Spokane Office of USDA RMA.
5. The finding that continuous no-till wheat generates net returns equivalent to conventional tillage has resulted in no-till and minimum-till practices being increasingly implemented on dryland grain farms in Eastern Washington.
6. Research findings on labeling of genetically modified food caused the Washington wheat industry to reconsider its planned switch to Roundup Ready wheat.
7. Research findings that breaching Snake River dams will increase energy consumption and emissions output from grain transportation only modestly has tempered public debate on adverse effects of breaching.
8. A financing practice once common among Washington cooperatives has been curtailed following analysis of its legal and economic implications.

C. Benefits to Clientele (Stakeholders)

1. Investors in small Washington wineries specializing in premium table wines face excellent prospects for profit, growth, and low risk.
2. Apple producers have profited by participating in promotion investments emphasizing improved quality standards of importance to consumers.
3. Potato producers received higher target prices from domestic processors because of the documentation of costs of producing, packing and storing potatoes.
4. Revenue insurance can reduce risks with less expense than a combination of yield insurance and futures market investment.
5. Implementation of no-till practices on grain farms increases profit to many farmers and reduces health risks to state residents by improving soil, air, and water quality.
6. Research findings on labeling of genetically modified food helped postpone an industry decision to produce GMO wheat that could have had disastrous economic impacts on the region.
7. Public debate on dam breaching was benefited by the research findings that alternative grain transportation forms would only modestly increase energy consumption and emissions output.

D. Accomplishments Based on Department/Unit POW for 2002

1. Historical producer output and input decision making was examined for U.S. farm and food processing outputs in response to changing technologies, markets, and/or public policies.
2. Historical demand and/or market performance was examined for four Washington agricultural commodities.
3. Ten strategies were developed for increasing firm profits and/or reducing risks in response to new technologies, major market and/or policy changes, and/or new marketing opportunities.
4. Number of refereed journal articles, bulletins, policy and trade magazine articles published and related products in which the findings of production and marketing economic research were communicated – 43.
5. Documented improvements possible from alternative decisions through increased profits and/or decreased risks include: (a) Investments in small wineries that produce premium table wines can produce positive cash flow within three years, are likely to be very profitable and at worst sustainable, (b) Washington potato producers received significantly more favorable treatment from domestic processors following the study that documented costs of producing, packing and storing potatoes, (c) Eastern Washington grain producers can earn at least as much profit and reduce air and water pollution by implementing no-till or minimum-till practices, (d) Beef producers can achieve very high genetic improvement at lower cost than average genetic improvement by careful selection of AI bulls.

E. Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	\$15,000
Hatch Multistate Research	\$7,000
Federal Research Grants	\$51,000
State Appropriations	\$550,000
Other Grants	\$483,000

Total Faculty/Staff FTEs: 12.0

KEY THEME: Agricultural Profitability

Research Program: Production Economics

CRIS projects 0269, 0275, 0303, 0347

- A. Economic studies of production agriculture resulted in greater understanding by producers, scientists, and policy makers of: (1) risk management options for Pacific Northwest farmers, (2) effective machinery management for asparagus, grain, and bean producers, (3) economics of beef cattle genetic improvement, and (4) appropriate design of agricultural production models for policy analysis.
- B. Impacts:
 1. Documentation that crop revenue insurance can reduce farm risks with less expense than a combination of yield insurance and futures market investment has resulted in establishment of a partnership agreement between WSU and the Spokane Office of USDA RMA and considerable interest in this option among growers.
 2. The finding that continuous no-till wheat generates net returns equivalent to conventional tillage has resulted in no-till and minimum-till practices being increasingly implemented on dryland grain farms in Eastern Washington.
 3. Profit-maximizing genetic improvement in beef cattle can be obtained at lower cost than average genetic improvement.
 4. Improved accuracy in estimating the impact of changing policies on agricultural production result from new tests for consistent commodity-wise and geographic aggregation.
- C. Scope of Impact includes WA, OR, and ID scientists and farmers, state and national policy makers, and scientists working in many research institutions and organizations world-wide.

KEY THEME: Agricultural Competitiveness

Research Program: Agricultural Marketing

CRIS projects 0218, 0278, 0301, 0317, 0343, 0378, 0418, 0806

- A. Economic studies of agricultural marketing resulted in greater understanding by scientists, growers, agribusinesses, and policy makers of: (1) the economics of product quality, reputation, and labeling, (2) promotion and supply chain management of fresh fruit, (3) firm concentration in the wine industry, (4) pitfalls of financing cooperatives through patron

demand deposits, (5) costs of alternative agricultural transportation systems, and (6) estimation methods.

B. Impacts:

1. Apple producers increased profits by participating in promotion investments emphasizing improved quality standards of importance to consumers.
 2. Research findings on labeling of genetically modified food is being used by U.S. and Australian policy makers and has caused the Washington wheat industry to reconsider its planned switch to Roundup Ready wheat.
 3. The finding that the greatest opportunity for profit in the highly concentrated wine industry occurs with small wineries specializing in premium table wines has led to continued growth of the Washington wine industry.
 4. Research findings that breaching Snake River dams will increase energy consumption and emissions output from grain transportation only modestly has had a significant impact on the public debate since it is counter to claims from the industry.
 5. A study of the costs of producing, packing and storing potatoes was used to negotiate target producer prices with domestic processors and is currently being used to negotiate lower tariffs on Washington potatoes sold to Canadian buyers.
 6. A financing practice once common among Washington cooperatives has been curtailed following analysis of its legal and economic implications.
 7. Electronic asparagus graders sort more accurately and more economically than hand sorting thereby improving the marketability of the fresh product.
 8. Improved econometric estimators were developed that provide more precise estimates of demand, supply, market equilibrium, and other quantitative economic modeling objectives.
- C. Scope of Impact includes WA, OR, and ID scientists, farmers, and agribusinesses; state and national policy makers; and scientists working in many research institutions and organizations world-wide.
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Animal Science

Goal 1: Overview:

Research programs of the Department of Animal Sciences are: (1) Nutrition and Nutrient Flows of Livestock, (2) Reproduction of Livestock Species, (3) Genetics and Animal Breeding, (4) Biology of Muscle and Animal Growth, and (5) Animal Diseases.

A. Research Results From Research Projects Supported by Hatch Formula Funds.

Scientists in the unit conduct research on nutrition, reproduction, genetics, and disease on several livestock species. Research results from these studies include:

1. Plasma leptin concentration in beef cattle did not reflect carcass quality grade.
2. Incorporation of several carotenoids in food improved the immune status of dogs and cats.
3. An optimal defined culture media was developed that induced the transformation of adipofibroblasts to adipocytes.
4. Soluble factors produced by equine leukocytes induced the proliferation of myoblasts that are important in muscle fiber regeneration.
5. Cobalt requirements for the feed of dairy cattle were defined.
6. New predictive models were developed which improved the accuracy of protein utilization by dairy cows.
7. Predictive models were developed to reduce the wastage of feed nitrogen and subsequent loss to the environment.
8. Genetic linkage maps of cloned trout were used to study the immune system of trout.
9. Studies of the immune system of trout will lead to the development of vaccines to control disease.
10. A PCR based assay system is being developed to identify the presence of *R. Salmoninarum* disease organism in trout.
11. The hormone oxytocin was studied to improve the reproductive performance in gilts.
12. Sperm chromatin integrity was found to be a useful predictor of stallion fertility.
13. Sire summaries for Wagyu bulls were developed and used to select for growth and marbling characteristics.
14. Alcohol consumption was found to negatively impact reproductive efficiency in pigs with implications as a human model.
15. Several species of rumen fungi were found to improve the digestion of cellulose in cattle.
16. Development of a vaccine against the LH hormone shrinks the testicle and eliminates the need for surgical castration in livestock species.
17. Different feed formulations were shown to reduce the excretion of nitrogen, phosphorus, zinc, and selenium from cattle into the environment.
18. Inclusion of carotenoids in the diet of cats and dogs was shown to reduce the development of mammary cancers.

B. Outcomes That Have Resulted In Significant Changes

Results of these studies that have resulted in significant changes include:

5. The annual Wagyu Sire Summary has improved the genetic selection for carcass traits and quality.
6. The inclusion of various carotenoids in the diet of dogs and cats have significantly improved immune health.
7. New feed requirements for the amount of cobalt in ruminant diets have improved animal health.
8. Genetic linkage maps and studies of the immune system have advanced vaccine development significantly against trout diseases.

9. Manipulation of the diet of ruminants reduced the environmental loads of phosphorus, zinc, and selenium while still maintaining levels of production.

Progress was made toward goals for all projects with impacts given above representing completed goals with significant findings.

C. Benefits to Clientele (stakeholders)-Impacts

1. The market opportunities for Northwest beef producers has increased with the progeny testing of Wagyu bulls ensuring high quality carcasses to the Japanese market.
2. The determination of cobalt feed requirements for ruminants is being adopted by cattle producers across the United States.
3. The inclusion of carotenoids in companion animal feed is used throughout the pet food industry.
4. Predictive models to optimize feed to maintain production in cattle while reducing the environmental load of phosphorus, selenium, and zinc are being used by producers and feed consultants across the United States.
5. The negative effect of alcohol consumption on fetuses in the pig serves as a model to study fetal alcohol syndrome in the human by researchers across the United States.

D. Accomplishments of the Department/Unit POW for 2001

Improvement in livestock production has been achieved by the development of strategies improving the nutrition, reproduction, disease/immune status, muscle biology/growth and genetics and animal breeding of cattle, swine, salmonids, dogs, cats, and horses.

E. Source of Funding and F.T.E.

Total expenditures for all projects

Source of Funds	Amount
Hatch	\$47,768
Hatch Multistate Research	\$261,327
Federal Research Grants	\$15,616
State Appropriations	\$785,891
Other Grants	\$631,607

Total Faculty/Staff F.T.E. 19.67

KEY THEME: Animal Production Efficiency

Research Program: RPA 301-Reproductive Performance of Animals
CRIS Projects 0706, 0928, 0957, 0380, and 6957

- A. Basic studies of the physiology and endocrinology of both female and male reproductive systems resulting in a greater understanding of:
 1. The oviduct in relationship to sperm survival and selection for fertilization in cattle.
 2. The role of oxytocin in the estrous cycle and early embryonic death in swine.

3. The detection of the polymeric immunoglobulin receptor and its role in early embryonic death in swine.
 4. The endocrine control of the estrous cycle and post-partum period in cattle.
 5. The production of a vaccine against hormones for the sterilization of animals without castration.
- B. Impacts include:
1. Development of a vaccine with LHRH fusion proteins reduced testicular size in mice and cattle, which may lead to an alternative to surgical castration and control of aggression.
 2. Using an *in vitro* oviductal culture system, sperm from horses, cattle, and pigs can be selected for viability to perform with a higher rate of efficiency used in assisted reproductive techniques.
 3. The role of oxytocin and the polymeric immunoglobulin receptor in the uterus of swine enables scientists to study the high early embryonic death phenomenon in swine.
- C. Scope of Impact
1. USA and international scientists, commercial biotechnology companies, and livestock producers interested in improving reproductive efficiency.

Allocated Resources:

Faculty/Staff F.T.E. 2.44

Source of Funds	Amount
Hatch	\$124
Hatch Multistate Research	\$165,562
Federal Research Grants	\$8,551
State Appropriations	\$88,652
Other Grants	\$20,736

Research Programs: RPA 302-Nutrient Utilization of Animals
CRIS Projects 0167, 0213, 0862, 0304, 0328, and 0374

- A. Basic studies on the biochemistry and nutritive properties of feedstuffs resulting in a better understanding of:
1. How optimal rations are formulated to maximize maintenance, lactation, growth, and efficiency of livestock and reduce excess nutrients into the environment.
 2. How to improve the utilization of cellulose in the rumen by different bacterial strains and feed additives.
 3. How to develop computer simulations that maximize protein utilization in beef and lactating dairy animals.
- B. Impacts include:
1. Using computer simulations, scientists can optimize ration formulations for beef and lactating dairy cows to maintain optimum production and reduce excess nutrients to the environment.
 2. Scientists and commercial feed companies will utilize the findings of selected strains of bacteria and feed additives to improve cellulose digestion in the rumen.

3. Adding lipid to the diets of beef cattle and changing conjugated linoleic acid content and meat palatability will be used by scientists in the USA, producers, consumers, and beef commodities to market the advantages of meat in the diet.

C. Scope of Impact:

1. USA and scientists worldwide studying nutrient metabolism, veterinarians concerned with nutrition, and health of animals, animal producers, feed manufacturers, and consumers of beef.

Allocated Resources

Faculty/Staff F.T.E. 6.50

Source of Funds	Amount
Hatch	\$24,237
Hatch Multistate Research	\$48,582
Federal Research Grants	\$1,349
State Appropriations	\$299,775
Other Grants	\$49,457

Research Program: RPA 303-Genetic Improvement of Livestock
CRIS Projects 0181, 0764

- A. Predicting heritability of the genetic traits for marbling, growth, birth weight, and feedlot efficiency will enable scientists to select superior bulls of the Wagyu breed.

B. Impacts include:

1. Identification of superior Wagyu bulls will allow introduction of these genetics to improve breed efficiency.
2. Use of superior Wagyu genetics to increase marbling of meat results in producers receiving a premium for the product and access to the Japanese livestock market.

C. Scope of Impact:

1. USA and scientists worldwide working on the Wagyu breed, livestock producers, meat packers, and consumers of beef.

Allocated Resources:

Faculty/Staff F.T.E. .68

Source of Funds	Amount
Hatch	\$2,978
Hatch Multistate Research	\$0
Federal Research Grants	\$0
State Appropriations	\$36,449
Other Grants	\$0

Research Program: RPA 305-Animal Physiologic Profiles
CRIS Projects 0769, 0913, 0237, 0249

- A. Basic studies of the nutritional requirements and nutrient utilization of dairy and beef cattle resulted in a greater understanding of:
 - 1. Nutrient requirements of dairy cattle.
 - 2. How changes in the diet of cattle can affect meat quality.
 - 3. Management systems designed to improve on-farm decision making and profitability.
- B. Impacts:
 - 1. Quantifying nutritional requirements of lactating cows and sows resulted in optimal feed formulations to maximize production and improve animal health.
 - 2. Optimization of a cell culture system using muscle cells to study cell regeneration and communication between muscle cells.
- C. Scope of Impact:
 - 1. USA and scientists worldwide studying wound healing and regeneration
 - 2. Livestock producers, feed manufacturers and veterinarians concerned with the nutrition and health of livestock

Allocated Resources

Faculty/Staff F.T.E. 4.30

Source of Funds	Amount
Hatch	\$6,024
Hatch Multistate Research	\$46,284
Federal Research Grants	\$0
State Appropriations	\$147,709
Other Grants	\$141,526

Research Program: RPA 311- Animal Diseases
 CRIS Projects 0289, 0331, 0709, 0379, and 0389

- A. Basic studies on the immune system of trout resulted in a greater understanding of:
 - 1. Developing a vaccine against I.H.N.V. infection in trout.
 - 2. Using cloned trout, specific genes were found to be involved in non-specific cytotoxicity in rainbow trout.
 - 3. Greater characterization of the immune system in trout.
 - 4. Technologies that were developed to ensure adequate water quality and increase well-being of trout in culture.
- A1. The inclusion of various carotenoids in the diets of dogs and cats resulted in:
 - 1. Improved immune status
 - 2. Decreased incidence of mammary tumors
 - 3. Improved health status of geriatric dogs
- A2. Basic studies on the disease organism *S. aureus* resulted in strategies to reduce the incidence of mastitis in dairy cows.

2. Impacts include:

1. A better understanding of the immune system in trout improves the probability of developing vaccines against disease.
2. The inclusion of carotenoids in the diet of dogs and cats is used worldwide by pet food manufacturers.
3. The finding that *S. aureus* impacts the udder in lactating cows in different regions will lead to different treatment strategies to control mastitis.

C. Scope of Impact

1. Scientists in the USA and worldwide studying trout diseases, commercial fish operations, and the consumers of trout.
2. Scientists in the USA and worldwide, veterinarians, and producers treating and studying mastitis in dairy cattle.

Allocated Resources

Faculty/Staff F.T.E. 3.76

Source of Funds	Amount
Hatch	\$2,631
Hatch Multistate Research	\$899
Federal Research Grants	\$30,091
State Appropriations	\$163,083
Other Grants	\$370,036

Statement of Issue

Livestock producers face three key issues as we move toward the new millennium: 1) effects of increased US market concentration, corporate agriculture and larger production in units, 2) implications of competing in an ever increasing global economy, and 3) demand for increased management and technology advancement to increase efficiency of production. These three issues must be addressed in an atmosphere of increased accountability in environmental stewardship and reduced federal subsidy.

Performance Goal(s)

1. Improve the efficiency of livestock production by developing strategies gained through studies on the nutrition, physiology, diseases, genetics, and animal breeding of beef and dairy cattle, swine, and salmonids.
2. Develop new approaches to make animal food and fiber competitive in an ever increasing global economy.
3. Develop new management approaches that will ensure good environmental stewardship.

Program Components

1. Continue basic nutritional studies designed to optimize feed components of rations to provide maximum efficiency at the lowest cost.

2. Study reproductive physiology to elucidate mechanisms that control early embryonic death, control of the estrous cycle and breeding efficiency in beef and dairy cattle, and swine.
3. Develop vaccines to control many of the common diseases found in hatchery-raised salmonids.
4. Evaluate new production practices and educate producers on improving environmental stewardship.

Internal and External Linkages

1. Many of our departmental scientists work together on nutrition, reproduction, genetics, and animal breeding programs and with researchers in other departments. Examples include the Wagyu Beef Project, Food Animal Disease Investigative Unit, Western Regional Aquaculture Consortium, and The Center For Reproductive Biology. Nine of our scientists cooperate on regional research projects and all of our research faculty interact with producers, commodity groups and private companies. Our faculty conduct information symposiums, serve on the boards of commodity organizations and work closely with the Dairy Products Commission, Dairy Federation, Washington Swine and Sheep Producers, Washington Beef Commission, and Cattle Feeders Association.

Target Audiences

1. Target audiences include all segments of the livestock industry in Washington including small and large-scale producers and the meat processing industry.
2. Scientific societies and professional colleagues to exchange information and build collaborative relationships.
3. Commodity groups and organizations to deliver information and learn of their needs and future directions.
4. Private companies working in the livestock industry and collaborate to better meet the needs of our common clientele.

Evaluation Framework

1. The evaluation framework includes refereed papers, abstracts, presentations at scientific meetings, graduate student theses, articles in proceedings, extension bulletins and reports, patent applications, and popular press articles as evidenced by peer review evaluation and acceptance of this new information into production practices and management.

Output and Outcome Indicators

1. The acceptance of Wagyu genetics into the Pacific Northwest by over 30 cow-calf feedlot operators, and packing plants as a profitable niche beef commodity.
2. New dietary recommendations for selenium, cobalt, and zinc levels in the diets of dairy cattle and swine.
3. Proving no reduction in feedlot performance or carcass quality by the inclusion of potato by-product in barley-fed cattle compared to straight corn-fed cattle.
4. Development of a restructured steak product to create a value added product from the low valued round of beef.
5. Using animal models to study early embryonic death, the effect of chronic alcohol consumption, wound healing and muscle regeneration that have a direct impact on animal and human health.

6. The identification of different varieties of barley and wheat as improved sources of animal feeds.
7. The inclusion of carotenoids in the diet to optimize the animal's immune system to fight disease.

Program Duration

The research programs have both programmatic and basic science components. The basic science components have more of a long-term timetable until these results reach the livestock industry.

CENTER FOR PRECISION AGRICULTURAL SYSTEMS

GOAL I: Overview:

This report summarizes the research projects, outcomes, and impacts associated the WSU Center for Precision Agricultural Systems (CPAS). The CPAS was funded in July, 1999 and the Director hired in September, 2000.

In July, 2002, CPAS hired Eileen Perry in the position of assistant director. She brings to CPAS 25 years of experience in remote sensing and GIS, with notable expertise in hyperspectral imaging and spatial analysis. A major role for her is the development of agricultural remote sensing and GIS research capabilities for WSU. Advances in remote sensing by CPAS will be discussed later in this report.

A major focal point of CPAS is the development of the Technology Roadmap for Tree Fruit Production (www.treefruitresearch.com/technology_roadmap.htm), which has the goal of enhancing the global competitiveness of the tree fruit industry through technological innovation. The first draft of the Technology Roadmap was made public by a presentation to the annual meeting of the Washington Horticultural Association in Wenatchee in December 2001 by the CPAS director. The Roadmap outlines the research and development needs of the tree fruit industry needed to achieve its stated vision "to be globally competitive, the U.S. Tree Fruit Industry must reduce the cost of production of its highest quality fruit by 30 % by 2010". Significant progress in the Roadmap process was achieved during the year 2002. The Roadmap has been recognized and supported by a broad range of growers, industry, politicians, and researchers with remarkably little if any dissension from any sector within or outside the tree fruit industry. The Washington Tree Fruit Research Commission formed a new subcommittee to support research in technology in support of the Roadmap and is exploring ways to fund research in support of the roadmap priorities. In July 2002, John Deere embraced the roadmap and by September was actively pursuing research in the Yakima valley with autonomous vehicles in orchards and vineyards and has included aspects of the Roadmap in their corporate business plan. Deere will be testing a robotic sprayer and robotic mower in the Yakima Valley in 2003. In August, Congress included report Language in the FY 2003 appropriations legislation that "requests that USDA develop a plan to address the tree fruit industry's needs and report its progress to the committee in this regard no later than January 1, 2003." The CPAS director is a member of the steering committee that wrote the report language in collaboration with USDA-ARS national program staff. In December, 2002, the first "Technology Session" was offered at the Washington Horticultural Association in Yakima, organized with the CPAS and other WSU scientists. In March 2003, a National Technology Roadmap Workshop is being held in the Washington DC area to nationalize the Roadmap and to prepare the Roadmap document in preparation for securing

support from Congress. CPAS wrote a successful proposal to the Farm Foundation to support the workshop. The CPAS was instrumental in initiating the Roadmap process and is at the core of the process.

The CPAS has been developing and implementing new technologies for sensor networks. We have developed new data logger/telemetry hardware, new sensors, and software to operate networks. AgWeatherNet™ (www.agweathernet.com) is a new weather network system currently being deployed in eastern WA and beyond. It will eventually replace the Public Agricultural Weather System (PAWS) as it is aging and needs revitalization. Attempts to patent the IP in these technologies within WSU have not been successful. Therefore, to enable CPAS to move forward with implementation of the networks, we created the CPAS Service Center that allows CPAS to build and market its technology. Furthermore, to protect IP, CPAS has created exclusive agreements with Manufacturing Services Inc. in Kennewick, WA, to manufacture CPAS technologies. We now have the capability develop, test, manufacture, install, and sell technologies developed by CPAS and its scientists. Over the last 12 months, we have two grants from AFT/EPA Region 10 and one from the WA State Department of Ecology to implement and demonstrate these technologies in Washington state (total of \$145,000). At the request of the Washington Tree Fruit Research Commission, we have submitted a broad proposal on the development and implementation of sensor networks in orchards. A final decision on this grant has not been made as yet but it is the largest single proposal request ever considered by this commission.

CPAS has worked with Julie Tarara, USDA-ARS to continue the development of the Trellised Crop Mass Monitor (TCMM). CPAS recruited and partially supported a post-doctorate research to continue this work and have received a provisional patent in August 2002 on this sensor technology. Research conducted in 2002 confirmed earlier results and added more support to the patent application. We hope to have a non-provisional patent application completed in early 2003. Because of this work, Dr. Tarara received a post-doctorate research position for two years from USDA-ARS. Research will continue in 2003 with this research support and continued support from CPAS.

The CPAS has been building capacity in the area of remote sensing, spatial analysis and GIS for the last two years. The hiring of Eileen Perry in mid-2003 and the two years of collaboration by CPAS with Resource21, a remote sensing image provider, has started to pay off. CPAS has purchased a multispectral radiometer and a hand-held hyperspectral radiometer. Resource21 has provided CPAS with a hyperspectral radiometer, a gyro stabilizer for airplane remote sensing, and high precision reflective tarps for image calibration. Resource21 is also a partner in remote sensing research projects now underway with the tree fruit industry and planned for the wheat industry in 2003. We now have technical and researcher capabilities to develop a world class remote sensing program in agriculture and have the implicit support from the WA tree fruit industry in advancing the use of remote sensing in their industry.

Our IFAFS (Initiative for Future Agriculture and Food Systems) funded proposal on "Maintaining the Competitiveness of Tree Fruit Production Through Precision Agriculture" made considerable progress in 2002. This project is jointly funded with the University of Florida, Washington State University, and the Oregon State University. The 2002 growing season was our first field season to evaluate N management in apples on fruit quality and yield and to yield and quality map apples. Joan Davenport and Robert Stevens lead the N management research and Fran Pierce and Eileen Perry led the yield map/quality mapping work. NASA was able to provide IKONOS imagery each month throughout the growing season. CPAS with Resource21 was able to fly two high resolution image flights. These images have led to new research opportunities with the tree fruit industry and helped create the working relationship between CPAS and Resource21. We mapped two orchards in the fall of 2002 and have worked to develop an automated system to determine apple quality for each bin in the packing house.

The Washington Potato Commission providing funding in 2002 in support of a project to establish a technology showcase/field laboratory as WSU IAREC. Pierce Irrigation had already donated the linear move system and Fresno valves donated some of the pumps and filters for the system. USDA-

ARS scientists contributed to the soil science and production aspects of the 2002 research on the site. New WSU faculty developed research programs in the areas of water management (Clyde Fraisse) and in nematode ecology (Ekaterina Riga). CPAS supported the site development and contributed to the field operations. Four proposals were submitted for research at this site by Dr. Fraisse, Dr. Riga and the CPAS. Only one was funded for 2003 with an NRI grant still under consideration. CPAS will fund the continuation of the showcase for 2003. The WA Department of Ecology grant will fund technology demonstration at this site for 2003. Dr. Collins and Dr. Alva, USDA-ARS, will continue to support various aspects of research in the technology showcase (field laboratory). USDA-ARS is co-sponsoring with CPAS a post-doctorate researcher to work with Dr. Fraisse and Dr. Stockle to develop and test potato models for use in decision support systems for potato growers in Washington State.

Research efforts continued on the Cunningham Farm project led by Dr. James Cook, WSU, and Dr. David Huggins, USDA-ARS in collaboration with a number of WSU scientists. The goal of the research is to develop no-tillage, rotation based cropping systems in the Palouse region of Washington State and to incorporate precision agricultural principles and practices into the wheat based cropping systems in Eastern Washington. Field days and meetings held at the research site in 2002 indicate great interest in the work being done in this project. The need for reduced tillage for soil conservation and soil quality goals in the highly erodible loess derived soils of the Palouse region drives the acceptance of the new systems being evaluated in this project.

The source of funding and FTEs are as follows:

Total expenditures for all projects: \$201,950.15

Source of Funds	Amount
State Appropriations	\$198,531.48
Other Grants	\$3,418.67

Total Faculty/Staff F.T.E. 0.29

KEY THEME: Precision Agriculture:

Research Programs: RPA 205 – Plant Production Systems
 CRIS Project Numbers: WNP0333

The following are research efforts in this program area:

1. **Maintaining the Competitiveness of Tree Fruit Production Through Precision Agriculture.**

- A. Dr. L. Won Suk at the University of Florida and F. J. Pierce at Washington State University are the principal investigators on this project funded by the IFAFS (Initiative for Future Agriculture and Food Systems) program in September, 2001. The purpose of this project is to develop precision agriculture for Florida citrus and tree fruit production in the Pacific NW that can be adapted to other horticultural crops at other locations.
 - B. Project completed its first field season in 2002.
 - C. This is a joint project with FL, WA, and OR
- 2. Technology Roadmap for Tree Fruit Production**
- A. This effort is lead by Dr. Francis J. Pierce, WSU, and Dr. James McFerson, Manager of the WA Tree Fruit Research Commission. The purpose of this project is to develop and implement a National Technology Roadmap for Tree Fruit Production that outlines the research and development priorities needed to meet the vision of the Roadmap stated as: "to compete globally, the U.S. Tree Fruit Industry must reduce the cost of production of its highest quality fruit 30 % by 2010".
 - B. The technology roadmap is a process that has been well received both regionally and nationally. A workshop will be held in March, 2003, to nationalize the Roadmap in part in response to a request by Congress in August, 2002 to USDA that it report to Congress in early 2003 on how it is working to assist this industry with this effort.
 - C. The project was initiated in Washington State but has achieved national support from all tree fruit producing regions in the US. We have also initiated research with the private sector, at this time John Deere.
- 3. A Micro -Environment Field Laboratory and Technology Showcase**
- A. This project is led by Dr. Francis J. Pierce in collaboration with C. W. Fraisse, E. Riga, and M. Williams, WSU, and H. Collins, and A. Alva, USDA-ARS. The intent of this project is to establish a field laboratory at the Prosser Irrigated Research & Extension Center (IAREC) dedicated to the development, evaluation, and showcasing of technologies that will advance the science and practice of precision agriculture. In 2002, the site was established in a potato-wheat-corn rotation with precision irrigation sponsored in part by a grant from the WA Potato Commission. Progress has been made in the development of sensor networks with new research planned for 2003 to investigate precision drip irrigation systems for potatoes.
 - B. The potato industry is a major target for technological development here and supported research in 2002.
 - C. The new efforts in precision drip irrigation will be done in collaboration with Oregon State University.
- 4. Site-Specific Management in a Wheat Cropping System.**
- A. This research is lead by Dr. James Cook, WSU, and Dr. David Huggins, USDA-ARS in collaboration with a number of WSU scientists. The goal of the research is to develop no-tillage, rotation based cropping systems in the Palouse region of Washington State and to incorporate precision agricultural principles and practices into the wheat based cropping systems in Eastern Washington.
 - B. Field days and meetings held at the research site in 2002 indicate great interest in the work being done in this project. The need for reduced tillage for soil conservation and

soil quality goals in the highly erodible loess derived soils of the Palouse region drives the acceptance of the new systems being evaluated in this project.

- C. No other states but Washington are involved in this project but this work applies to similar conditions in adjacent states of Idaho and Oregon.

RPA 205 – Instrumentation and Control Systems

Two research efforts were conducted in this program area.

1. Crop estimation in grapes by sensing trellis load tension.

- A. This research program is led by Dr. Julie Tarara, USDA-ARS in collaboration with Francis J. Pierce and Marvin Pitts, WSU. The goal of the research is to develop a real-time sensor that relates trellis load tension to crop load in wine and juice grapes. Research in 2002 supported findings from 2001. A provisional patent on a crop load mass sensor was obtained in August 2002. There is a linear relationship between temperature corrected trellis load and grape fresh mass from berry set to final yield.
- B. Crop load prediction and management and predicting in-season fruit load are high priority research items listed by the Washington Wine Advisory Board. Little progress in crop load estimation has been realized until this research project. This research is critical to advancing the development of this technology in grapes and should lead to commercially available crop load sensors for vineyardists.
- C. No other states but Washington are currently involved in this research. However, there is interest from Oregon and California in this technology.

2. Site-Specific Data Networks

- A. This research program is led by Dr. Francis J. Pierce and in 2002 involved five WSU scientists in the area of pest and disease models. The goal of this research is to develop telemetry based data loggers and sensors that are research grade but affordable and advance the real-time use of environmental data into crop management decisions.
- B. In 2002, this new sensor network technology was deployed in the Yakima Valley and Horse Heaven Hills regions primarily in support of new weather networks (www.agweathernet.com). New grants in 2002 were submitted and now funded to place networks in the Wahluke and Royal slope areas and in the Wenatchee Valley in early 2003. This system will eventually replace existing weather stations in the WA Public Agricultural Weather System (PAWS) and, due to their low cost and network capabilities, will facilitate the growth of PAWS to new areas and site-specific uses on WA farms. This new system will allow for faster weather reports, more weather products of use to farmers, and the ability of farmers to add weather stations in their farming operations to the existing network. New applications in frost networks, pest networks, and vehicle tracking are in various phases of development, with beta systems being deployed in early 2003. Benefits to growers will be found in irrigation scheduling and pest and frost forecasting.

Sensor networks were being deployed primarily in Washington State in 2002 but plans are underway to place them in other states, currently WI and Montana.

CROP AND SOIL SCIENCES

Goal 1: Overview:

A. Research results:

1. Improved varieties have been developed in cereals, cool season food legumes and alternative crops for improved quality and yield; cloning barley stem rust resistance in barley; breeding value added barley.
2. Advanced scientific information on the genetics, molecular biology, physiology, and biochemistry of crops and weeds have been developed to increase the efficiency of end use, market potential, and adaptation to the region.
3. New cultivars, crops, and germplasm have been developed with improved end-use and/or value-added qualities recognized in the global market with particular attention to production efficiencies, yield, and adaptation to improved cropping systems.

B. Successes:

1. WA007916, an Eltan, a hard white winter variety developed through backcross breeding with superior dual purpose hard white quality will benefit growers when released in 2003.
2. Cephalosporium resistant lines in a madsen background advanced to Variety Testing trials will enable increased resistance for varieties available to growers.
3. New genetic knowledge about quantitatively inherited malting quality traits will allow for greater understanding of these traits and more directed breeding efforts.
4. Molecular breeding has produced useful germplasm combining yield and malting quality to be used in new cultivars released to PNW growers.
5. Barley feed with the small amount of transgenic grain provides an alternative for broiler feed in areas where corn cannot be grown for climatic reasons or has to be imported.
6. Identification and mapping of barley resistant gene analog (RGA) potential disease resistance genes will help to associate them with actual disease resistance genes mapped by their phenotype.
7. Isolation and characterization of the durable stem rust resistance gene Rpg1 will lead to a better understanding how plants resist invasion by pathogenic fungi.
8. Irreplaceable plant bio-diversity and genetic resources for a strong and competitive U.S. agricultural industry have been preserved.
9. Identification of host resistance genes from germplasm will allow producers to reduce reliance on pesticides to resist pests and environmental stress.
10. Technology for eliminating seed borne viruses in large seed collections is now used by international germplasm centers around the world.
11. Identification and mapping of potential disease resistance genes in barley will help to associate them with actual disease resistance genes mapped by their phenotype.
12. The translocation of DNA that confers complete resistance to Cephalosporium stripe was identified in 2000 providing the first transfer of Cephalosporium resistance to wheat reported in the world.

13. New species, cultivars, and germplasm evaluation will provide recommendations for turfgrasses to be used in the Pacific Northwest.
14. New genetic knowledge gained on inherited malting quality traits and molecular breeding will be used to release new cultivars to PNW growers.
15. The WSU variety testing program has provided growers and the seed industry with comprehensive results of variety performance required to make variety selections for planting.
16. Results from the Extension variety testing program has provided wheat breeders, pathologists, growers and agribusiness personnel information that enabled them to evaluate best adapted varieties/lines for areas susceptible to stripe rust and Hessian fly.
17. Through Material Transfer Agreement with WSU Research Foundation and private industry (BASF), four new winter wheat lines with Clearfield™ novel traits were identified.
18. Two varieties, 'Macon' (hard white spring) and 'Eden' (spring club) were approved for variety release; the hard red spring wheat variety 'WA7859' was approved for pre-release.
19. Grain quality testing for Washington breeding lines for Crop Year 2001 was used to assist plant breeders in making selections based on end quality use important to foreign and domestic industry markets.
20. Perennial ryegrass, an excellent rotational crop with potatoes, has reduced the need for field burning and has increased the viability of the grass seed industry.
21. New tillage strategies and cropping systems for protection of our soil, water, and air resources are available to growers through the STEEP and PM-10 programs in the PNW through cooperation of grower, industry, NRCS, and university-USDA scientists.
22. New genotypes, alternative crops, and tillage practices have been identified that expand the cropping options and improve the economic return in the annual rainfall and wheat-fallow regions in the PNW.
23. Research and education efforts through the STEEP and PM-10 programs have identified alternative crop and tillage options for controlling weeds, pathogens, and insects in the PNW.
24. The beneficial effects of direct seeding have positively impacted soil quality, soil biology, and water-use efficiency in crops.
25. The economic benefits of new cropping systems and tillage practices have been documented through many conferences, trade shows, video tapes, tour, field days, and various publications.
26. Molecular techniques, genome mapping, and access to unique germplasm have allowed plant breeders to develop wheat, barley, peas, lentil, chickpea, sugar beet, hop, and turf varieties with better quality, and more resistance to diseases and insects.

C. Benefits to clientele:

1. New plant varieties have increased production, reduced cost of pesticide inputs, diversified the cropping system, and increased access to new markets for cereals, food legumes, hops, alternative agronomic crops, and turf.

2. Discoveries of new techniques in molecular biology, genetics, and advanced marker techniques have allowed our scientists to speed up the time for release of new varieties, to detect disease-causing genes, and to develop varieties with new end-use qualities.
3. Alternative crops in combination with reduced tillage practices have increased the efficiency of crop production through reduced fertilizer and pesticide inputs.

D. Accomplishments based on POW:

1. The Department of Crop and Soil Sciences has fully integrated its two main program areas, cultivar development and cropping systems through research, teaching, and extension.
2. Linkages through cooperation within this unit and with linkages to other units, colleges, branch campuses, USDA-ARS, commodity groups, international centers, and industry have provided synergy and cooperation in out reach programs.
3. Grower acceptance of our programs has been excellent as determined from the audiences at numerous functions conducted by Crop and Soil Sciences.

E. Source of Funding and FTE:

Total Expenditures for all projects: \$3,792,665.77

Source of Funds	Amount
Hatch	\$407,829.84
Hatch Multistate Research	\$359,170.75
Federal Research Grants	\$289,623.76
State Appropriations	\$1,161,803.35
Other Grants	\$1,574,238.08

Total Faculty/Staff FTE's: 48.37

ENTOMOLOGY

GOAL 1: Overview:

The Department of Entomology's mission statement has three stated objectives:

1. The integration of biological control into existing and developing integrated pest management programs. Major research areas found within the department are: integrated biological control, integrated pest management and the reduction of our citizenry's dependence on broad-spectrum pesticides.
2. The responsibility for addressing pesticide issues, including the education of the public and researching the ecotoxicological questions of pesticides in our environment.
3. We support a basic research emphasis that depends upon an insect model to explain fundamental questions in biology.

KEY THEME: Apiculture

Research Program: Insects, mites, and other arthropods affecting plants.
CRIS projects 0244, 0416

Molecular Genetics of Honey Bee Subspecies & Selection and Breeding of New World Populations Progress in a number of areas continued in 2002 (not previously reported). 1) The Tien Shan Mountain honey bees were described as a distinct subspecies (*Apis mellifera pomonella*). 2) evaluated the 3rd generation of selected WSU honey bee lineages and measured an increase in hygienic behavior within selected stocks from the original level (50%) to over 90%. 3) acquired queens and established foundation stocks for USDA-IFAFS funded WSU/Cornell/USDA breeding project. 2002 acquisitions represented approx. 50% of the commercial queen producers in the U.S.

Newly described *A. m. pomonella* may occur sympatrically with *A. cerana* in western China. This possibility has implications for established resistance in *A. mellifera* to the parasitic honey bee mite *Varroa destructor*. *V. destructor* originally host-shifted from *A. cerana* to *A. mellifera*. IPM research on Washington honey bees demonstrated the efficacy and safety of sucrose octanoate as a "soft" chemical control for parasitic honey bee mites. These findings assisted in securing EPA registration in late 2002.

Beekeepers continued to support the WSU breeding program - provided 60 package colonies and field assistance 2002 in the Puyallup apiary. Colony increases necessary to establish and maintain the foundation breeding stock prevented distribution of WSU queens to beekeepers for evaluation in 2002. Additional distributions will occur in 2003.

Allocated Resources:

Total Expenditures for all projects:

Source of Funds	Amount
State Appropriations	\$56,859.85
Other Grants	\$2,903.13

Total Faculty/Staff FTEs: 0.60

KEY THEME: Invasive Species

Research Program: Biological Control of Pests Affecting Plants.
CRIS projects 0272, 0337, 0430

Biological Management of Yellow Starthistle in Washington. Research efforts focused on yellow starthistle (*Centaurea solstitialis*) biological control agent acquisition and release at multiple, noncropland sites in 11 eastern Washington counties during the project period. A total of 102,250 *Eustenopus villosus* and 15,070 *Bangasternus orientalis* were released intrastate. Both capitulum-infesting curculionids are now prevalent at most *C. solstitialis*-infested sites. Additional releases of 468 *Larinus curtus*, another capitulum feeding weevil, were made at several new locations in eastern Washington in 1998 and 1999. Surveys revealed that the highly destructive capitulum dwelling tephritids *Chaetorellia succinea* and *Urophora sirunaseva* were present in the

state. An additional 6,500 *C. succinea* were released in eastern WA to further enhance its distribution. Post-release impact studies on *Chaetorellia australis* indicated that the flies preferred host was *C. cyanus* (90%+ infestation) and not yellow starthistle (20%+ infestation). A multiyear study assessing the practicality of herbicide and bioagent integration at range land sites in Columbia and Garfield counties was concluded.

Deployment of six seed destroying insect bioagents against yellow starthistle in Washington has reduced this non-native plant's invasiveness and abundance by 50-75% at numerous localities. Two or more natural enemies now occur in all *C. solstitialis* occupied counties. Increased utilization of biocontrol by affected landowners has reduced herbicide inputs, diminished land management costs, increased land productivity, enhanced floral/faunal diversity, and protected environmental quality. Research data suggest that integration of biological control agents with other management practices is both practical and essential for enduring suppression of yellow starthistle.

Biological Control of Aphid Pests Field research was completed on green peach aphid (*Myzus persicae*) relative to its winter survival (anholocyclic populations) on watercress, mallow, tumble mustard, shepherd's-purse, flixweed, and stork's-bill. It is clear now that asexual populations exist year around in Washington, which means there is a variety of different weed hosts from which the aphid originates in the spring and summer to infest potatoes. It is also clear now why programs attempted years ago to control the aphid during its sexual phase on peach trees were futile and its full biology in the temperate zone was not recognized. Green peach aphid populations on the weedy hosts are attacked by aphidiid parasites (minute wasps that utilize strictly aphids, no other organisms). The role and importance of these parasites in keeping the target aphid from reaching pest status in potatoes is still under evaluation. In addition to the studies on green peach aphid, new findings were published on the aphidiid parasites of Guam, and of juniper aphids.

Research findings are helping to establish improved management measures for aphid pests in potatoes and small grains. Systematic research on newly discovered aphid-parasites in and about the agricultural regions of Washington is a support essential to the applied research. A multitude of intertwining connections exists between pest and beneficial species involved directly and indirectly in the cropping systems.

Enhancement of Dalmatian Toadflax Biological Control in Washington In 2002, an intensive biological control effort was initiated against Dalmatian toadflax, *Linaria genistifolia* spp. *dalmatica* (Scrophulariaceae), an economically and ecologically important invasive weed of Eurasian origin that negatively impacts pasture, rangeland, wildland, and noncropland habitats. The European stem-boring curculionid, *Mecinus janthinus*, was collected for intrastate redistribution from several locations in northeastern Washington where the beetle has adventively established from Canadian populations originally released near the U.S.-Canada border in the early 1990's. A total of 28,064 adult weevils were translocated to multiple toadflax-infested locations in Adams, Chelan, Douglas, Grant, Lincoln, Klickitat, Okanogan, and Spokane counties between May and July. Noticeable damage to toadflax populations in Ferry and Stevens counties was evident. Movement of this bioagent into these and other affected counties throughout the state will be continued in 2003.

The eventual widespread translocation of *M. janthinus* and additional host-specific biocontrol organisms will diminish the occurrence and/or severity of Dalmatian toadflax on thousands of acres of cropland and noncropland in Washington. Growers, livestock producers, and others engaged in weed control activities are employing this insect to restore weed-infested lands to a productive state in lieu of using costly, sometimes ineffective, and potentially environmentally damaging herbicides.

Allocated Resources

Total Expenditures for all projects:

Source of Funds	Amount
State Appropriation	\$54,831.43
Other Grants	\$87,649.34
HATCH	\$121,072.93

Total Faculty/Staff FTEs: 2.75

FOOD SCIENCE AND HUMAN NUTRITION

Goal 1: Overview:

1. Research Results from Research Projects Supported by Hatch Formula Funds

The overall purpose of this research is to explore new processes to produce safe, value added, food products and ingredients and to develop a better understanding of the physical and microbiological changes that food and food components undergo during storage and value added processing.

2. Outcomes that have resulted in Significant Changes

It was found that care must be taken to completely clean and sanitize dairy equipment prior to cheese making as biofilms may inoculate cheese with non-starter microorganisms that may be capable of contributing to calcium lactate crystal formation. Prevention of calcium lactate crystals could save the dairy industry millions of dollars each year. New rapid methods for E. coli detection can save time, energy, and cost for monitoring of food borne pathogens, leading to safer food products and industry savings. The food industry was provided with new information for the formulation of new legume based snack foods. New research demonstrated the extrusion parameters required for utilization of peas, Red Chief lentils, apple pumace and wheat bran in extruded snack foods. The food industry can use this new information in the formulation of new snack foods.

The wheat quality research program resulted in an increased efficiency of the breeding programs and the production of wheat varieties better suited for regional and export markets. Information on function properties of waxy wheat varieties will be helpful for developing new wheat varieties with appropriate amylose and protein content for producing white salted noodles. Wheat for this purpose has a marketing edge for overseas markets. Also it was found that bread of an extended shelf life could be produced from wheat of reduced starch amylose content, thus decreasing food wastage and increasing profits.

As a result of research on sun exposure and temperature, grape growers and winemakers are starting to selectively remove over-exposed clusters during thinning operations in the vineyard. Better understanding of the anti-microbials produced by yeasts will lead to improved rate of wine fermentation, successful inducement of malolactic fermentation, and an increased overall quality in Washington Wines.

A whey protein, altered by exposure to high hydrostatic pressure, may have enhanced functionality for use as a food ingredient leading to increased food quality and increased utilization of whey protein concentrates and isolates. A rapid time-temperature indicator assay

was developed and only takes about 15 minutes. This will save food processors time and energy in completing their thermal processing processes.

3. Source of Funding and FTEs

Total Expenditures for all projects: \$893,074.64

Source of Funds	Amount
Hatch	\$13,995.08
Hatch Multistate Research	\$112,165.94
Federal Research Grants	\$51,553.37
State Appropriations	\$359,307.96
Other Grants	\$355,052.29

Total Faculty/Staff FTEs: 12.55

KET THEME: **Adding value to New and Old Agriculture Products**

Research Program: New and improved food processing technologies

CRIS Projects: 0208, 0205, 0537, 0288, 0560, 0719, 6305, 3846, 0467, and 0369. 0379

Microbiological and Chemical Factors Affecting the Flavor and Textural Quality of Cheddar Cheese. Cheeses aged at 50F showed higher rate of lactose fermentation than cheeses stored at 45F. D(-)-lactic acid increased to 40% of total lactic acid in cheeses with added adjunct *L. curvatus* at the end of 4 weeks of ripening, but was less than 15% in cheeses made with added *P. acidilacti* and *S. saprophyticus* at the end of 6 months of ripening.

Impacts: These results show that most care must be taken to completely clean and sanitize equipment prior to cheese making as biofilms may inoculate cheese with non-starter microorganisms that may be capable of contributing to calcium lactate crystal formation. The formation of these crystals result in millions of dollars lost by the dairy industry each year.

Enological and Viticultural Practices on Fermentation Microbiology, Chemistry, and Quality of Wines. Attempts were made to identify the anti-bacterial factor produced by some yeasts that inhibit malolactic fermentation.

Potential Impact: Better understanding of the anti-microbials produced by yeasts will lead to improved rate of fermentation, successful inducement of malolactic fermentation, and overall quality in Washington Wines.

(New) Evaluation of Surface Irrigation Water as Source Contamination of Fruits and Vegetables with *E. coli* 0157 and *L. monocytogenes*. Two new rapid methods were developed to rapidly monitor *Escherichia coli* counts in food. These new methods saved about 10-14 hrs incubation leading to more rapid results compared to conventional plating methods.

Potential Impacts: These developed rapid methods can save time, energy, and cost for detection of food borne pathogens, leading to safer food products and industry savings.

(New) Engineered Enzyme-Based Time Temperature Indications (TTIS) for Validating Food Pasteurization Processes. Kinetics of inactivation of enzyme based TTIS (amylase) and food borne pathogens were tested and provided a rapid method for determining the adequacy of a thermal process.

Impact: This assay takes about 15 minutes and will save food processors time and energy in completing their thermal processing processes.
Genetic Improvement of Beans (*Phaseolus vulgaris* L.) for Yield, Disease Resistance, and Food Value. Dietary Fiber supplementation of extruded peas and lentils decreased the expansion index and increased density linearly with fiber concentration.

Impact: This study demonstrated the extrusion parameters required for utilization of fellow peas, Red Chief lentils, apple pumace and wheat bran in extruded snack foods. The food industry can use this new information in the formulation of new snack foods.

Milling and flour quality characteristics of Wheat Selections. For the crop year 2001-2002, 3211 samples were received from Washington State wheat breeders and analyzed for various end-use parameters.

Impacts: The results were supplied directly to the wheat breeders so that new wheat varieties could be developed with superior end-use quality to enhance the marketability of PNW wheat. This resulted in an increased efficiency of the breeding programs and the production of wheat varieties better suited for regional and export markets.

Surface Hydrophobicity and Functionality of Proteins in the Molten Globule State. Beta-Lactoglobulin was treated with high hydrostatic pressure at 600 MPa and 50C for selected times as long as 64 min. and these conditions induced a conformational change that was stable for up to three months.

Potential Impacts: This altered protein may have enhanced functionality for use as a food ingredient leading to increased food quality and increased utilization of whey protein concentrates and isolates.

Research Program: New and improved Food Products. CRIS Projects 0205, 0305, 0537

Factors Affecting the Quality of Washington Wine and Wine Grapes (*Vitis vinifera*). Anthocyanin and phenolic profiles of berry skins from *Vitis vivifera* cv. Merlot in the Yakima Valley of Washington State were influenced by sun exposure and temperature.

Impacts: This work has made industry more aware of potential quality reductions due to over exposure of fruit on west-exposed canopies. Growers and winemakers are starting to selectively remove over-exposed clusters during thinning operations in the vineyard.

Develop a Non-Invasive Spectroscopic Method to Predict Safety/Quality of Cured/Smoked Food Products.

Research Program: Quality Maintenance in Storing and Marketing Food Products
CRIS Project: 0128

Marketing and Delivery of Quality Cereals and Oilseeds. Amylose content positively correlated with optimum cooking time of white salted noodles as determined by a sensory panel test. As protein content increased, optimum cooking time of noodles also increased in noodles made with wheat of similar amylose content. Also bread baked from partial waxy wheat flours exhibited a slower forming rate during storage compared to bread made from hard red spring wheat.

Potential Impact: These results will be helpful for developing wheat varieties with appropriate amylose and protein content for producing white salted noodles. Wheat for this purpose has a marketing edge for overseas markets. Bread of an extended shelf life can be produced from wheat of reduced starch amylose content, thus decreasing food wastage and increasing profits.

HORTICULTURE AND LANDSCAPE ARCHITECTURE

GOAL 1: Overview:

The Department of Horticulture and Landscape Architecture maintains research programs in the following areas:

1. Breeding, management, and production of tree fruits and small fruits.
 2. Breeding, management, and production of vegetable crops.
- A. **Research Results** from projects supported by Hatch formula funds.

Scientists in the unit conduct research related to the breeding, management, and production of many horticultural crops. The research results from these studies include:

1. An understanding of the causes of stem-end splitting in apple.
2. Knowledge about the physiological and biochemical mechanisms that explain the occurrence of sunburning in apple.
3. Information related to the suitability of conventional, organic, and integrated orchard management systems.
4. The identification and cloning of genes that encode for calmodulin-binding proteins that control growth and development in plants.
5. An understanding of the factors that affect optimum yield in concord grapes and cold hardiness in wine grapes.

6. The identification of new crop varieties in vegetables that have the potential to improve the competitiveness of Washington agriculture.

7. An understanding of the impacts of volunteer potatoes on subsequent year crop yields;

B. Outcomes that have resulted in significant changes within the state.

Results of these studies have caused significant changes in the horticultural industries of the state. Although some changes can be seen that could be considered the result of one year's work, most of the changes are a reflection of the impact of ongoing research programs. Some of these changes are: (1) The effect of the Tri-State program on the Washington potato industry is demonstrated by the change in acreage planted to Russet Burbank vs. new cultivars during recent years. Ten years ago 76% of the potato acreage in Washington was planted to the Russet Burbank cultivar. In 2002 approximately 96,500 acres (nearly 60% of the total potato acreage in Washington) was planted to cultivars other than Russet Burbank. At least 90% of this non-Russet Burbank acreage was planted to cultivars identified by the WSU cultivar-testing program as being adapted to Washington growing conditions. These potatoes have also been shown to have characteristics that make them especially suitable to post-harvest processing, an important consideration in a state where nearly 90% of the crop is processed. Other important changes are: (2) The work related to environmental stress in apple has resulted in new information that helps identify management approaches that can reduce sunburn; (3) Changes are occurring, although slowly, as a result of the information produced by the research directed at orchard management systems. There has been an increase in the number of growers who are practicing organic or integrated management.

Many of the specific research programs in the Department, such as the breeding programs in tree fruits and small fruits and the variety testing programs in potatoes and grapes, have long-term objectives. The changes that result from this research will occur over the next one or two decades.

C. Benefits to clientele (stakeholders) – Impacts

The benefits to clientele result from improved economic efficiency, and reduced environmental impacts. These include: (1) New potato cultivars: The Estimated value of potato cultivars evaluated by the Tri-State and regional variety trials is \$240,000,000 in farm-gate value per year. These new potato varieties are also better suited to Washington growing conditions, requiring fewer inputs of chemical fertilizers and pesticides, which increases grower profits, and reduces environmental impacts. They also provide increased profits due to their improved processing characteristics. Perhaps just as important as the identification of potato varieties that are well adapted to Washington conditions is the identification of varieties that should not be grown, thus sparing growers the costs associated with lower production; (2) New products and approaches that reduce the incidence of sunburn in apples result in a smaller amount of damaged fruit, and increased grower profit; (3) Organic and integrated orchard management systems result in fewer inputs of chemical fertilizers and pesticides, and decreased environmental impacts; (4) Changes in management practices in vineyards have resulted in reduced water use, and improved yields.

D. **Accomplishments** of the department/unit POW 2002

Scientists in the Department of Horticulture and Landscape Architecture have made significant progress in identifying new fruit and vegetable varieties, and new approaches to production and management that result in a more competitive and environmentally sound horticultural industry. As noted, much of the research conducted by department scientists has long term goals, and much is yet to be learned that will improve the situation of the horticulture industry in the state.

E. Source of funding and FTE

Total Expenditures for all projects \$1,315,702.78

Source of Funds	Amount
Hatch	\$102,950.46
Hatch Multistate Research	\$0.00
Federal Research Grants	\$411,444.29
State Appropriations	\$418,468.97
Other Grants	\$382,839.06

Total Faculty/Staff FTEs: 17.97

KEY THEME: Agricultural Competitiveness

Research Program - **Breeding, management, and production of tree fruits and small fruits**

CRIS projects: 0201, 0210, 0452, 0480, 0519, 0937, 1639, 6703

A. Basic and applied research resulted in new information and a better understanding of:

- 1 The effects of foliar applications of calcium on the reduction of stem-end splitting in apple;
- 2 The physiological, biochemical, anatomical, and environmental factors contributing to photo-oxidative stress in apple;
- 3 The suitability of conventional, organic, and integrated orchard management systems;
- 4 The factors effecting optimum yield in concord grapes;
- 5 Environmental factors and managements practices influencing wing grape crop physiology and cold hardiness;

B. Impacts include:

1. Research has also resulted in new information that helps identify management approaches that can reduce sunburn.
2. Changes are occurring, although slowly, as a result of the information produced by the research directed at orchard management systems. There has been an increase in the number of growers who are practicing organic or integrated management.

C. Scope of Impact

1. WA and OR scientists and other scientists working in many research institutions and organizations worldwide.

KEY THEME: Agricultural Competitiveness

Research Program - **Breeding, management, and production of vegetable crops**

CRIS projects: 0044, 0168, 0239, 0321, 910, 1984, 6046

- A. Basic and applied research resulted in new information and a better understanding of:
- 1 New potato varieties that have the potential to improve the competitiveness of Washington agriculture.
 - 2 The impacts of volunteer potatoes on subsequent year crop yields.
 - 3 The suitability of potato seed for production in Washington.
- B. Impacts include:
1. Ten years ago 76% of the potato acreage in Washington was planted to the Russet Burbank cultivar. In 2001 approximately 96,500 acres (nearly 60% of the total potato acreage in Washington) was planted to cultivars other than Russet Burbank. At least 90% of this non-Russet Burbank acreage was planted to cultivars identified by the WSU cultivar-testing program as being adapted to Washington growing conditions. These potatoes have also been shown to have characteristics that make them especially suitable to post-harvest processing, an important consideration in a state where nearly 90% of the crop is processed.
 2. Volunteer potatoes have a significant impact on yield of crops grown in following years. Research has identified cropping systems, tillage methods, and chemical materials that will reduce the growth of residual tubers to minimize the problem.
 3. Commercial seed lot trials have provided growers with information about the potential for disease (potato leaf roll virus, black leg, mosaic, and weak plants) in various potato seed sources.
- C. Scope of Impact:
- WA, ID and OR scientists and other scientists working in many research institutions and organizations worldwide.

IMPACT CENTER

Goal 1: Overview: Agricultural Competitiveness

The International Marketing Program for Agricultural Commodities and Trade, known as the IMPACT Center, is a multi-disciplinary research center. The overall goal of the IMPACT Center is to use science and technology to improve the competitiveness of Washington agricultural products in the world market. To achieve this goal IMPACT uses a multi-disciplinary approach to solve economic, social, or technical problems that impede export of Washington's agricultural products; uncover new or expanded export opportunities for Washington's agricultural products; gather information about

foreign markets, consumers, distribution channels, and trading systems; and develop new products, processes, and technology to increase exports of Washington's agricultural products.

A. Research Results:

1. Uncovering new or expanded export opportunities for Washington agricultural products and gathering information about foreign markets, consumers, distribution channels, and trading systems

- A. A survey of consumers in China about their attitudes towards genetically modified food products. The survey of Chinese consumers suggests that they are willing to pay a premium for GM food products with direct benefits such as golden rice. Chinese consumers appear to trust science and government information about the safety of GM products.
- B. A study of the westernization of Chinese consumers' diets indicates that western foods, such as French fries, are acceptable even if the potatoes are GM.
- C. A survey of Japanese consumers suggests that they have dramatically reduced beef consumption in response to recent mad-cow outbreaks rather than shift to other sources such as the US or Australia.
- D. China's accession into WTO will result in significant changes in China's agricultural policies and will likely lead to increased wheat imports. A study assessing the likely effect of WTO disciplines on China's wheat, rice, and corn trade with the U.S. suggests that China will import additional wheat from the U.S., while rice and corn trade will not change significantly. The results suggest that a shift from wheat to corn production in China will result due to an increased demand for feed grains by the livestock sector.
- E. An analysis of the Indian apple market suggests that the large middle class (300 million) is a potential market. Apples prices in India are relatively high compared to other fruits such as pears, plums, grapes, etc. Indian consumers tend to prefer softer and thin skinned apples. Lack of appropriate storage facilities at wholesale and retail facilities results in apples that are damaged and unattractive to consumers.

2. Solving technical impediments to exports of Washington State agricultural products

- A. Quarantine treatments for cherries and apples were developed to replace the use of methyl bromide to eliminate insect pests to meet export requirements. The system uses a combination of heat and radio frequency to eliminate insects. The effects of controlled atmosphere in combination with the system were also assessed. A systematic methodology for quarantine and phytosanitary treatments for insect pests based upon insect mortality and product quality is being developed. As part of a consortium of scientists, non-chemical treatments based upon radio frequency energy are being developed to control a broad spectrum of insect pests in a quarantine environment.
- B. A molecular seed assay of *Botrytis* spp. which is associated with neck rot in onions is being developed to better understand the relationship and to develop a treatment. An analysis of the cost of neckrot to the industry and the benefits of the potential treatment are being analyzed.
- C. A rapid test for catalase activity is being developed to better assess microbial activity using biosensors. Microbial activity is an important index for food quality and safety. An accurate and automated sensor to measure catalase activity as an indicator of food spoilage is being developed.

- D. To help improve access to international markets for organic and reduced input apples, an assessment of the costs and practices associated with organic, conventional and integrated apple production systems were compared. The results suggest that organic and integrated production systems are economically competitive, but that organic apples tend to be smaller but have comparable or better flavor and crispness.

3. New products and New processes

- A. White salted noodles, which are popular in Japan and Korea, were evaluated. The results indicate that the quality of white salted noodles is closely related to amylose content. Partial-waxy and waxy wheat, which are lower in amylose content, may be more suited to making white salted noodles for these markets. The results of this research will help guide the breeding selection process by providing an understanding of the required starch characteristics of various wheat varieties.
- B. Edamame (edible soybeans) and azuki bean cultivars continue to be selected to develop uniformity for the Japanese market and select the strains that are best suited to be grown in the PNW.
- C. Edible films and coating systems were developed to reduce moisture transfer, oxidation, or respiration in fruits including apples, cherries, pears, and strawberries. The barrier, mechanical, and shelf-life properties of various potential edible films are being evaluated using apple slices. The films help the fruit maintain its integrity and better withstand shipping and handling. The combination will result in a better product with international marketing potential.
- D. Pulsed electric fields (PEF) were evaluated for microbial inactivation in a continuous handling system. PEF processing conditions were evaluated for the inactivation of spoilage and pathogenic flora. Key electrical parameters that define processing conditions, including total delivered energy and lethal dosage, were evaluated and optimized to identify the processing conditions necessary to yield a safe, shelf-stable product. PEF in combination with heat was found to be an alternative to traditional thermal pasteurization of skim milk to extend shelf life.
- E. Pasteurization methods to improve food safety and extend shelf-life of salmon roe products were evaluated. New regulatory requirements for the Japanese and Australian markets make pasteurization of roe products mandatory. A radio frequency pasteurization process was developed that shortened heat treatment and resulted in improved texture. The process is being evaluated for application to other high valued products facing stringent export requirements.
- F. A study of advanced drying technologies for fruits and vegetables has resulted in a process that improves nutrient retention and reduces microbial activity, resulting in a safer, more nutritious dried product. A high quality asparagus product has been developed for the Japanese market. Energy efficiency of the several technologies for drying pureed vegetables including pureed pumpkin, which is popular in Asia as a soup and desert ingredient, was evaluated. Other drying technologies for strawberries have resulted in products comparable to or better than current freeze-dried products.
- G. High pressure food processing technologies continue to be developed. A combination of thermal and high pressure processing (HHP) demonstrated acceptable microbiological and quality characteristics. High hydrostatic pressure processing technologies resulted in greater levels of retention of vitamins C, B and B₆.
- H. The use of biosensor controls for food processing was assessed. The use of a fiber optic spectrophotometer to assess peroxidase (POX) activity during the blanching of

vegetables without time-consuming sample preparation was evaluated.

B. Outcomes

Assessing consumer attitudes towards GM products provides industry with insights into potential markets and consumer acceptance of biotech products. Chinese appear to be willing to accept GM products without substantial discounts and appear to be willing to pay a premium for products with attributes that directly benefit consumers such as golden rice.

The large middle class in India appears to be a viable market for apples, particularly for soft and thin skinned apples. However, cold storage facilities in India are very limited and apples in the marketplace tend to be in poor condition due to poor storage as well as poor transportation and handling procedures.

Assessments of China's agricultural competitiveness suggest that China will import additional grains and products that are land intensive and will export products such as fruits and vegetables, which tend to be labor intensive. Changes in China's agricultural policies under WTO will encourage a shift towards its comparative advantage in labor intensive agricultural products. Another assessment of the effects of WTO on China suggests that current rural-urban labor migration policies will limit the potential gains of liberalization to China's economy.

Organic apples were found to demonstrate firmness and flavor comparable to conventional fruit. Edible films will help fruit maintain its integrity and better withstand shipping and handling, delivering a better product to markets, including international destinations. Biosensors were found to reduced blanching time and result in savings in energy and improved product quality.

C. Benefits to Clientele

The results of our research have helped exporters make more informed decisions, have solved major problems faced by growers, developed alternative crops suitable for export and have provided a new value-added product for producers. Our reports on WTO help key industries understand the benefits and costs of liberalizing agricultural trade. New technologies have helped to enhance the competitiveness of PNW firms through reduced energy use, more shelf-stable products and greater consumer appeal. Alternative quarantine treatments using heat and radio frequencies to eliminate insects will provide an alternative to methyl bromide, which will soon be banned.

D. Accomplishments of the department/unit POW for 2002

IMPACT researchers have assessed the implications of WTO and China's competitiveness on PNW agriculture. IMPACT researchers have developed alternative fumigation treatments for export to replace the greenhouse gases that are being banned. Edamame, and other crops have been developed as alternative crops targeted at the Japanese market. New technologies have been developed to process fruits, fruit juices, and vegetables for export. These technologies improve efficiency, reduce energy use, and/or result in a better product. IMPACT researchers have educated the agricultural and food industry on opportunities and challenges in the international marketplace.

E. Expenditures

Total Expenditures: \$666,758

Source of Funds	Amount
Hatch	\$0.00
Hatch Multistate Research	\$0.00
Federal Research Grants	\$368,286.00
State Appropriations	\$298,472.00
Other Grants	\$0.00

Faculty and Staff FTEs: 9.05 man months

Key Theme: Agricultural Competitiveness

Center Research Program: Enhancing Competitiveness of Pacific Northwest Agricultural Exports
CRIS Projects: 00171, 00972, 00974, 3801, 3901, 4901, 5901

A. Activities

1. The Asian Crops program has developed strains of edamame and other crops for PNW conditions. Work on burdock has led to commercial plantings for export. The appropriate use of new technologies such as pulsed electric fields, microwave drying and high hydrostatic pressure has been determined for PNW crop and animal products.
2. Market opportunities for high-valued products in Asia were assessed. Testing and sampling of wheat and barley over a number of seasons was completed to develop reliable near-infrared transmittance analyzers.
3. A comprehensive project on wheat and barley included the investigation of the quality characteristics for potential value-added products. 1) We determined quantitative changes in composition and qualitative changes in protein and starch of grains collected from three hard red spring (HRS) and three soft white spring (SWS) wheat cultivars in two locations during the grain filling period. 2) We determined changes in protein quality and starch properties of hard white wheat (HWW) as grain protein content varied from 10.0 to 16.0%, and evaluated the influence of protein and starch on the quality of Asian noodles and bread. Protein content exhibited significant influences on loaf volume of bread, color and hardness of noodles. 3) Roller-milled flours from two non-waxy and two waxy barley cultivars were extruded to form expanded and puffed products using a modified laboratory single-screw extruder. Effects of die diameter, moisture content, screw speed, barrel temperature and feed rate on the physical properties of barley extrudates were determined.
4. A number of projects are ongoing that examine various aspects of trade liberalization in APEC and the Pacific Rim. Articles and papers have been published that are a result of continuing research on high-valued food products and food demand in the Pacific Rim. Other projects include the effects of infrastructure on productivity, the effects of changes in agricultural policy on rural/urban incomes in China, the implications of technology and technology transfer on trade, and the effects of biotechnology on trade and economic development. Assessments of the effects of WTO and trade liberalization on agricultural trade are ongoing.
5. The potential effects of WTO, APEC, and trade liberalization on the agricultural exporting

industry in the PNW were assessed. New processing, packaging, and pasteurization technologies are being developed. Technical problems that inhibit exports of PNW agricultural products are being developed.

B. Benefits

1. Our understanding of quantitative and qualitative changes in protein and starch during the grain filling period will enable us to identify wheat genotypes with high quality characteristics with stable expression in diverse growing environments. Information regarding protein quality and starch properties of hard white wheat will be helpful for developing wheat varieties suitable for making bread and noodles. Results will provide valuable information regarding material selection, milling and processing to produce value-added products and increase utilization for food products.
2. Work on new processes and products have provided processors with local expertise to help them remain competitive.
3. The project results have helped exporters make more informed decisions, have solved major problems for pear, wheat and barley growers and provided a new value-added product for beef producers.
4. Our reports on WTO helped key industries understand the benefits and costs of liberalizing agricultural trade. New technologies have helped to enhance the competitiveness of PNW firms through reduced energy use, more shelf-stable products and greater consumer appeal. Alternative quarantine treatments using heat and radio frequencies to eliminate insects provide an alternative to methyl bromide, which will soon be banned.

C. Scope of benefits

1. Washington and PNW agricultural industries, including producers, processors, and exporters; consumers; as well as researchers and scientists working in research institutions worldwide.

INSTITUTE OF BIOLOGICAL CHEMISTRY

GOAL 1: Overview:

The major goals of the Institute of Biological Chemistry are to:

1. Improve and enhance wood products.
2. Understand the genetic and biological mechanisms in plants.
3. Improve the products obtained from plants.
4. Improve the yields of various crops including those of forest species.

The Lewis research group continues to delineate the basic mechanisms by which plants utilize their various metabolic pathways to obtain lignified sapwood and heartwood, respectively as well as how various plant species generate cancer-preventative substances such as secoisolariciresinol diglucoside (SDG). In terms of lignification as well as heartwood lignan biosynthesis, metabolic flux studies together with transcriptional profiling have demonstrated that phenylalanine availability, *p*-

coumarate-3-hydroxylase and cinnamate-4-hydroxylase represent key factors controlling carbon allocation to the pathway; these findings are of critical importance in rationally explaining numerous results obtained with transgenic plants which involve downregulation of various steps in phenylpropanoid metabolism. Work is now underway linking how control of carbon allocation to phenylalanine occurs via an in-depth analysis of the genes, enzymes and metabolic intermediates involved in the chorismate-shikimate pathway, and hence how metabolic cross-talk occurs.

Another component of the research involves how plicatic acid-derived lignans in heartwood are formed, as well as lignan-containing chemopreventative substances (SDG-derived) in flaxseed. The enzyme pinoresinol-lariciresinol reductase has been obtained in recombinant form, and its structure resolved. Site-directed mutagenesis has revealed the catalytic centers. With flaxseed, one of the corresponding PLR's was obtained, which catalyzes the opposite enantiospecific conversion. Thus the pathways to these systems are being fully elucidated, as is how such enzymatic steps are being catalytically defined.

The Browse laboratory continues its focus on lipid biosynthesis in leaves and seed, as well as how seed oil composition can be modulated in order for vegetable oil improvement. A number of Arabidopsis mutants have been isolated with various levels of polyunsaturation being achieved in the lipid component of membranes associated with the photosynthetic machinery. This has resulted in the opportunity to examine *in situ* how such mutants affect the photosynthetic centers (PSI/PSII), and hence of photosynthesis itself. In a somewhat related study, directed towards improving seed oil composition, the Browse laboratory has isolated several key lipid desaturase genes and are now comprehensively analyzing their biochemical characteristics in order to define how such transformations are manifested, in advance of obtaining transgenic plants with altered vegetable oil compositions.

With the Croteau group, most of the genes involved in formation of the anticancer agent, taxol, including the C-13 side-chain, have now been isolated and experiments are underway to identify missing enzymatic steps. Conifer defense systems, leading to the abietadiene derivatives, are also making much progress, with both mechanistic and structure-function studies underway. In this regard, abietadiene synthase is a most important enzyme, catalyzing the first committed steps to oleoresin formation in gymnosperms. Another most significant advance made was in identifying all of the steps involved in menthol biosynthesis, with transgenic mint plants being developed to improve essential oil composition and yield. Numerous patents have been obtained in all of these areas.

The Kahn laboratory, since completion of the sequencing of the *S. melioto* gene involved in rhizobium-legume symbiosis, has made a very good progress in understanding how bacterial and plant metabolism is coupled, with the knowledge of the full genomic sequence of the symbiont bacteria. This is involving determining the function of various enzymes/proteins in processing by the bacterium of certain carbon compounds from plants. If this can be better understood, symbiosis should be able to be exploited to give higher crop yields.

The Kramer laboratory, with a strong focus on mechanistic biochemistry of photosynthesis *in situ*, has developed new instrumentation and related techniques this year (e.g. for the study of how mitochondria produce free radicals), in order to address the overall photosynthetic energy budget, as well as how it is regulated including in response to environmental changes. This is delineating, at the most sophisticated biochemical level, how photosynthesis is carried out and regulated *in vivo*. Moreover, some of the devices being developed are anticipated to have important roles in the study of overall plant photosynthetic efficiency, as well as, for example, how crop productivity can be monitored during growth and development.

The Okita research group has made very substantial progress again this year in defining factors affecting carbon metabolism in storage carbohydrates (starch) and in protein synthesis, and how it occurs. This includes RNA targeting studies, which have identified that there are substantial differences in the molecular and biochemical events leading to protein synthesis when compared to animal studies. These revolutionary findings can be anticipated to be of considerable significance in, for example, improving seed quality.

The Rogers laboratory, with an emphasis on how and what plants store in vacuole, has identified a vacuole-within-a-vacuole, which stores phytic acid. This together with identifying the various hydrolytic enzymes involved in vacuole lysis or digestion is providing some excellent insights into how storage (e.g. of proteins) occurs in seed tissues.

The Ryan laboratory has as one of its focuses, delineation of how plants defend themselves against encroaching predators and how this process of defense compares with the mammalian defense system. The work this year has been extraordinarily successful, with the isolation of a receptor for systemin (the latter being the first polypeptide hormone recognized to have a role in plant defense). This receptor work is opening up a new scientific area as to how polypeptide signaling is involved in various aspects of plant biochemical processes including, for example, defense, reproduction and development.

A. Research Results from research projects supported by hatch formula funds

The Institute of Biological Chemistry has, as a central focus, defining and ultimately utilizing the various basic biochemical processes in plants for the further benefit of humanity through the genetic improvement of selected agricultural and forestry species. The Institute programs are currently primarily directed towards the following: determining how plants biochemically defend themselves against opportunistic pathogens and predators, and biotechnologically optimizing these systems for the improved vigor of selected agronomical and forestry species; in identifying the means to improve the nutritional quality of edible oils, and in extending the geographical range of various agronomically important crops; in enhancing the nutritional basis of various staple foodstuffs, such as increasing edible protein and carbohydrate levels; in determining the basic mechanisms whereby certain plants and bacteria synergistically “fix” nitrogen from the air, thereby eliminating the need for fertilizer; in identifying the biochemical processes involved in formation of various anticancer and antiviral components, such as taxol and podophyllotoxin, and increasing their availability by genetic engineering; in identifying the underlying biochemical processes involved in heartwood and sapwood formation.

B. Outcomes that have resulted In significant changes

Outcomes that have resulted in significant changes within the state (detailed below).

C. Benefits to Clientele (Stakeholders)

Accomplishments of the department/unit POW 2003 (detailed below).

D. Source of funding and FTEs

Total expenditures for all projects: \$5,967,091.62

Source of Funds	Amount
Hatch	\$121,804.03
Hatch Multistate Research	\$24,833.66
Federal Research Grants	\$281,626.80
State Appropriations	\$1,157,966.91
Other Grants	\$3,015,810.86

Total Faculty/Staff FTEs: 68.51

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

Research Program: Forestry Product Enhancement
CRIS projects: 0202, 0967, 6204

Metabolic Compartmentation during (Heart)wood and Seed Coat Formation – Norman G. Lewis - Vascular plants produce plant defense metabolites, such as the (oligomeric) lignans and isoflavonoids, with both classes of compounds being offshoots of the phenylpropanoid pathway. The constitutive deposition of various lignans and isoflavonoids significantly help confer durability, longevity, and resistance to heartwoods of many tree species against wood-rotting fungi and also confer protection to the coats of seeds of various plant species. Interestingly, formation of (–)-lariciresinol was observed only when the recombinant protein was incubated in the presence of (–)-pinoresinol and NADPH. No conversion was observed when (+)- or (±)-pinoresinols were used as substrates. Methodology is being developed in order to produce larger amount of PLR-Lu for crystal structure determination, and thus to further determine the basis of substrate binding, catalytic mechanism and enantiospecificity.

A. Impact:

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). 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. A detailed understanding of the overall processes involved is thus 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.

Molecular Basis of Wood Formation – Norman G. Lewis - In this study, transcriptional modulation of metabolic flux towards the monolignols, *p*-coumaryl and coniferyl alcohols, precursors of lignins and lignans, was demonstrated using mRNA profiling of phenylpropanoid pathway genes in *Pinus taeda*.

A simple counter-staining procedure has also been developed for comparative GUS expression and anatomical localization in transgenic herbaceous arabidopsis and tobacco which is applicable to gene expression in developing woody tissues. This protocol provides good anatomical visualization for monitoring chimeric gene expression at both the organ and tissue levels. It can be used with different histochemical stains.

A. Impact:

The reasons for biotechnologically manipulating heartwood and secondary xylem formation are to optimize wood properties for lumber and paper production; to produce

new biopolymers which are expected to be valuable as replacements for petroleum-derived polymers; and to either introduce or enhance novel defense functions in plants (*i.e.* antioxidants, biocidal properties and the like) thereby reducing reliance upon non-biological control (pesticides, fungicidal agents). The goals address (heart)wood and seed coat development, using lignan biosynthesis as the biochemical marker to study both processes: heartwood is the merchantable bole in woody plants, and represents overall the most important commercial plant crops.

Project goals are being achieved but have not yet resulted in significant changes within the State. Documented Benefits: Biotechnological applications are in development. Intellectual property has provided licensing income to the Institution. Accomplishments and Plan of Work: The goals of the Work Plan are being met in a timely fashion as documented by publications and patent submissions.

B. Scope of Impact: (all subprojects within project):

National/International. Heartwood: National/International. Pacific Northwest and Atlantic Southeast (conifer wood and paper production).

Diterpene Biosynthesis in Taxol Production and Conifer Defense – Rodney B. Croteau –

Most early oxygenase steps in the Taxol pathway have been defined, and five of the responsible cytochrome P450 oxygenase genes have now been isolated. The acyltransferases responsible for the assembly of the C13-side chain of Taxol have been defined. Feeding studies with *Taxus* cells are in progress 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 industrial intermediates.

A. Impact:

Several patents based on these technologies have been issued. WSURF has licensed these technologies to a pharmaceutical company that is attempting to improve Taxol production. Abietadiene synthase is being utilized by another biotech company in specialty chemical manufacture.

B. Scope of Impact:

National/International, Pacific Northwest and Atlantic Southeast (conifer wood production and paper production).

Key Themes: Biotechnology; Plant Health; Precision Agriculture; Plant Genomics; Global Change and Climate Change; Medicinal Plants; Nutraceuticals; Advances in Biotechnology to Develop New Agricultural Products; Adding Value to New and Old Agricultural Products; Agricultural Profitability; New Uses for Agricultural Products; Plant Production Efficiency; Nutrient Management; Sustainable Agriculture; Plant Production Efficiency; Biobased Products; Plant Genomics; Human Nutrition;

Research Program: Crop Improvement by Biotechnological Means

CRIS projects: 0119, 0197, 0253, 0262, 0268, 0590, 0773, 1791, 3252, 3589, 3775, 4589

Lipid Biosynthesis in Leaves & Seeds – John Browse – In order to examine the effects of reducing membrane polyunsaturation on photosynthesis, new *Arabidopsis* mutant lines with various levels of polyunsaturation were generated. Characterization of this mutant has proven to be a useful new approach in studying the importance of polyunsaturated lipids in thylakoid membrane function and photosynthesis.

A. Impact:

Studies of lipid metabolism in leaves are increasing our understanding of the roles of membrane lipids in photosynthesis and in the temperature responses of plants. An improved understanding of temperature responses is important for enhancing plant growth and crop yields in temperate climates.

B. Scope of Impact: National/International.

Genetic and Molecular Approaches to Modifying the Composition of Seed Oils; Biochemistry of Oil Seeds – John Browse – Conventional and mutation breeding have provided some desirable alterations in the composition of several oilseeds. However, very few changes that require more sophisticated genetic engineering techniques have been possible because the biochemistry and regulation of oilseed triacylglycerol synthesis are not well understood and because only in the last few years has it been possible to isolate and clone some of the genes involved. This work has used mutants of *Arabidopsis* with alterations in seed fatty acid composition to study oilseed metabolism. Success in cloning genes encoding *Arabidopsis* desaturases provided the means to clone many different desaturases from the nematode *Caenorhabditis elegans* and from microbes.

A. Impact:

Many plants accumulate seed reserves as oils composed of triacylglycerols. These vegetable oils constitute important sources of food and industrial products with commercial production worth \$25 billion worldwide. There is considerable interest among plant breeding and biotechnology companies in using research such as ours to produce modified oil crops which will help to diversify farm economies and to advance sustainable agricultural systems.

B. Scope of Impact: National/International.

RNA Targeting in Plants – Thomas W. Okita – The cis-elements of the prolamine RNA that confer transport specificity to the protein body endoplasmic reticulum were identified.

A. Impact:

This research is at the cutting edge of plant biology and is the only known documented case of RNA sorting in plants. The textbook description of plant gene expression basically follows the processes described in animal cells where RNAs are transported from the nucleus where they are immediately engaged in protein synthesis. Results to date indicate that the molecular and biochemical events leading to protein synthesis in plants are distinct from the general perinuclear processes utilized by animals. The understanding of RNA transport and targeting processes will provide insights on the control of protein synthesis in plants and may have practical applications in improving seed protein quality and in using plants as phytofactories for the production of proteins of industrial and pharmaceutical value.

B. Scope of Impact: National/International.

mRNA Targeting to Subdomains of the Endoplasmic Reticulum: The Role of RNA Binding Proteins – Thomas W. Okita – Studies on the intracellular location and expression of Rp120, a RNA binding protein found in an enriched protein body-cytoskeleton fraction were conducted.

A. Impact:

RNA localization is a common phenomenon in animal cells and is readily observed in cells with a polarized structure. To date, the only documented case of RNA targeting in plants is that involving the rice storage protein RNAs which are targeted to distinct subdomains of the cortical endoplasmic reticulum in developing rice seeds. Information obtained from this study should lead to greater insights on how protein synthesis is controlled in plant cells and may lead to practical applications in improving seed protein quality and quantity and in using developing seeds for the production of value-added proteins.

B. Scope of Impact: National/International.

Control of Photosynthetic Electron Flow in the Steady State – David M. Kramer – *In vivo* Photosynthesis - Photosynthesis is the central process in which energy is taken up into the biosphere and only major pathway for uptake of CO₂ from the atmosphere. It is thus critical to understand the processes that limit and regulate the productivity of photosynthesis. The photosynthetic apparatus must balance and regulate energy flow to meet biochemical demands while preventing over-excitation of the reaction centers, which in turn can lead to photoinhibition. New instrumentation and techniques developed in our laboratory have allowed us to address key issues about the overall energy budget of photosynthesis, its regulation and response to environmental changes:

The Mechanism of Quinol Oxidation, Superoxide Production and Detoxification, Proton-Coupled Electron Transfer and Metals in Biochemical Systems: We also work on the molecular mechanisms of electron transfer processes, particularly those involving quinol oxidation, which are important for energy transduction in mitochondria and chloroplasts, and contribute significantly to the production of reactive oxygen species.

A. Impact:

Photosynthesis is absolutely required for plant productivity. On the other hand the photosynthetic apparatus can, under adverse conditions, produce toxic side products which can damage or kill the plant. Our work on *in vivo* photosynthesis will impact our understanding of how the photosynthetic apparatus delivers sufficient energy for life, while protecting itself from deleterious side reactions. Our development of non-invasive spectroscopic tools for this work has allowed us to probe many photosynthetic partial reactions in living plants in their natural environments. These tools offer the opportunity to detect the status of crop plants in the field, with applications to precision agriculture and plant breeding. Our work on the cytochrome bc₁ and b₆f complexes impact our basic understanding of the mechanisms of energy transduction in both plants and animals. In addition, our studies of the interaction of Q_o site semiquinone intermediates with O₂ (producing the toxic superoxide) should impact our understanding of aging- and stress-related diseases. Our work on the mechanisms of quinol oxidation should impact our understanding of an important but little-understood type of reaction in biology: the proton-coupled electron transfer reaction. Theory for strict electron or proton transfer reactions is fairly well-advanced, but that for the coupled transfer of an electron and proton is in its infancy. We have developed a set of systems for studying quinol oxidation by these reactions with to date the highest detail. These reactions are important for

understanding how many energy transducing enzymes work, and how they misbehave to produce disease. Our work on the EPR center will make advanced EPR techniques available for the researchers at WSU and other institutes nearby.

B. Scope of Impact: National/International/Regional.

Sorting of Proteins to Vacuoles in Plant Cells – John C. Rogers – We have proven that protein storage vacuoles have two compartments, one for storage products and one, the globoid cavity, surrounded by its own membrane and representing an internal vacuole. This internal vacuole-within-a-vacuole, the globoid compartment, contains crystals of phytic acid as well as hydrolytic enzymes that are characteristic of a lytic or digestive vacuole.

A. Impact:

This concept will have profound implications for understanding how storage proteins in seeds are protected during seed development, but are rapidly degraded during germination. In addition, it requires phytate to be deposited within a specific compartment in order for formation of a phytic acid crystal. This concept suggests that it should be possible to diminish or abolish phytate storage without disrupting accumulation of storage proteins.

B. Scope of Impact: National/International.

Metabolic Engineering of Plants for Enhanced Productivity – Thomas W. Okita – Previous efforts from our laboratories demonstrated a correlation between photosynthetic capacity, growth and capacity to accumulate leaf starch when wildtype plants were compared to plants defective in starch. To determine whether this correlation extended to plants that accumulated excess leaf starch as compared to wildtype, an up-regulated Arabidopsis AGPase large subunit gene was transformed into TL46 line which lacks this corresponding functional AGPase gene.

A. Impact:

In the past, dramatic improvements in crop yields were obtained by improvements in agricultural technology and the application of mineral nutrients and chemicals to ward off pests and diseases. Future increases in crop production will, in all likelihood, result from genetic improvement of existing cultivars allowing increased efficiency of photosynthate yield in addition to buttressing the plant's defenses against biotic and abiotic agents. Since small increases in the efficiency of photosynthesis can result in dramatically higher crop yields, much effort is directed towards the enhancement of photosynthesis. Information generated from this project will identify the basis for limitations in phosphate recycling and may lead to new approaches to increase photosynthesis and, in turn, plant productivity and yields.

B. Scope of Impact: National/International.

Structure, Evolution and Function of Plant Proteinase Inhibitors – Clarence A. Ryan – The systemin receptor has been purified from suspension cultured tomato cells. Microgram quantities of the receptor have been analyzed by mass spectroscopy to yield several internal polypeptide sequences that are being used to identify a cDNA.

Polypeptide signals in plants were first isolated under this project. Other polypeptide signals have been reported since that are involved in defense, development, and reproduction. We have developed a novel, rapid assay to identify polypeptide signals in plants using suspension-cultured cells, which respond to receptor-mediated polypeptide signals by causing the pH of the cell culture medium to increase. Using the assay to monitor the signaling polypeptides during purification, we have identified five novel receptor-mediated polypeptide signals from tobacco,

tomato and alfalfa and are utilizing the assay to investigate the presence of polypeptides throughout the plant kingdom.

A. Impact:

Our studies of signaling polypeptides and their receptors in plants will provide an entirely new understanding of plant signaling for defense and development, with important relevance to ecology and agriculture.

B. Scope of Impact: National/International.

Biochemistry of Plant Terpenoids – Rodney B. Croteau – All but one of the genes of the menthol biosynthetic pathway in peppermint have now been isolated and their overexpression and knockout are being evaluated singly and in combination in transgenic mint to improve essential oil composition and yield. The geranyl diphosphate synthase gene from grand fir was isolated and the recombinant enzyme was characterized to demonstrate the structural diversity of this class of prenyltransferase. This gene is also being used in transgenic application. One enzyme of the menthol pathway (isopiperitenol dehydrogenase) was unexpectedly localized to the mitochondria of mint oil gland cells. The organizational and regulatory implication of this finding are being explored. Several new types of monoterpene synthases were cloned and characterized, and the stereochemical origins of (+)- and (-)-pinene were determined. The crystal structure of the monoterpene cyclase bornyl diphosphate synthase was solved and that for a second monoterpene cyclase (limonene synthase) is now essentially complete.

A. Impact:

Several patents based on these technologies have been issued. WSURF has licensed these technologies to three industrial/commodity groups. Field trials with transgenic mint with improved oil yield and composition are in progress. The use of these genes for microbial production of terpenoids is being developed by industrial partners.

B. Scope of Impact: National (WA, OR, ID, IN, WI, MI, MT)/International.

Nutrient Exchange and Metabolism in the Rhizobium-Legume symbiosis; Genetics - Symbiotic Effect on Legumes - Michael L. Kahn – Nitrogen-fixing bacteria associated with legume roots can provide these plants with a nitrogen source and contribute to the supply of nutrients available to the agricultural ecosystem. Understanding how bacterial metabolism is coupled to plant metabolism is key to understanding the dynamics of this interaction. During the last year we have made progress in determining the operation of important enzymes in the bacterial processing of carbon compounds obtained from the plant and in characterizing the genetics of the bacterial symbiont. We have cloned a large number of the genes from *S. meliloti*, with a goal of using these to analyze their importance in its free-living and symbiotic growth.

A. Impact:

The description of the *S. meliloti* genome provides for the first time a complete look at the metabolic potential of the organism. Methods we are developing will allow us to expand on this understanding and provide a model for genetic analysis of bacteria.

B. Scope of Impact: National/International.

Genetics of Symbiotic Effectiveness in Legumes - Michael L. Kahn - We have developed a more rapid and more reproducible way to measure nitrogen fixation using electrospray mass spectrometry and are using this method routinely to evaluate effectiveness. We have begun to analyze the heritability of symbiotic effectiveness of recombinant inbred lines (RILs) of *Medicago truncatula*, a relative of alfalfa, in order to associate the gene(s) responsible for phenotypic

variation in effectiveness with quantitative trait loci. Using bacterial strains that are more productive on one of the parents we have preliminary data that links effectiveness of two loci on two different chromosomes of *M. truncatula*.

A. Impacts:

Application of new methodology for measuring nitrogen fixation will affect breeding strategies for legumes, allowing breeders to focus on higher nitrogen fixation efficiency as a breeding goal. Work with the RILs should give some insight into how many plant genes might be involved in determining this trait. If the preliminary results hold up and can be generalized, this would provide a small number of genes that might be followed in trying to breed for increased effectiveness.

B. Scope of Impact: National/International.

Key Themes: Integrated Pest Management, Biotechnology; Nutrient Management, Sustainable Agriculture

Research Program: Plant and Pathogen Controls in Crops

CRIS project: 3153

Polypeptide Signaling for Plant Defense, Growth, and Development - Clarence A. Ryan –

Using a novel 'medium alkalization' assay for identifying polypeptide signals in plants using suspension cultured cells, we have isolated three new polypeptide defense signals from tomato plants. The three polypeptides, 15, 18 and 20 amino acids in length, are hydroxyproline-rich and glycosylated, and they activate proteinase inhibitor synthesis in leaves when supplied to young tomato plants through their cut stems, similar to 18 amino acid tomato polypeptide systemin. The three hydroxyproline-rich polypeptides are processed from a single precursor by proteolysis. We have named all plant-derived, wound-signaling defense polypeptides 'systemins', due to their origins in plants and their roles in defense signaling in response to herbivore attacks (wounding). Potato plants were transformed with the prosystemin gene and found to cause the production of high levels of defense proteins in both leaves and tubers. The total protein nitrogen and free amino acids of the tubers increased to about 150% of levels found in wild type tubers. The transgenic potato plants are being propagated for further studies of their biochemical and horticultural characteristics.

A. Impact:

The identification of hydroxyproline-rich glycopeptide defense signals and genes in both tomato and tobacco provides a new opportunity to understand how plants cope with herbivore attacks, and to utilize the new knowledge about polypeptide signaling to enhance crop productivity. Improving the ability of plants to rapidly signal defense genes in response to attacking herbivores is an important way to deter the pests. Modifying potato plants with signals that regulate the synthesis of storage proteins provides a novel and safe approach to substantially increase nutritious proteins for human consumption.

B. Scope of Impact: National/International.

Department of Natural Resource Sciences

Goal 1: Overview:

Research programs in the Department of Natural Resource Sciences are centered around 1) the effects of UV-B radiation and CO₂ Levels on ecophysiology of tree species and 2) the physiological and genetic control of hybrid poplar nutrition. All research conducted under this goal may be classified a long-term, basic research.

A. Research Results From Research Projects Supported By Hatch Formula Funds

Scientists within the Department of Natural Resource Sciences continue to work toward developing a better understanding of how forest tree species with contrasting leaf anatomies and shoot growth characteristics respond to projected increases in UV-B radiation. Specific findings suggest:

1. Possible deleterious effects of enhanced UV-B radiation on growth are likely to result in altered competitive abilities of forest tree species resulting in changes in species composition and biological diversity in forest ecosystems.
2. Altered production of secondary metabolites in some tree species caused by enhanced UV-B radiation will likely affect herbivores and thus have impacts on higher trophic levels in forest ecosystems.

B. Outcomes That Have Resulted In Significant Changes

Expanding demand for products and other amenity values of forest trees are coupled with finite resource bases that are becoming further constricted by increasing regulations governing forest management on public and private lands. Similarly increasing levels of UVB radiation and CO₂ levels in the atmosphere are affecting these same trees. Although few changes in land management have resulted to-date from the ongoing UVB research included under Goal 1, the possible deleterious effects of enhanced UV-B radiation on growth identified as a result of this research is likely to result in altered competitive abilities of forest tree species resulting in changes in species composition and biological diversity in forest ecosystems. Similarly, altered production of secondary metabolites in some tree species caused by enhanced UV-B radiation will likely affect herbivores (particularly insects) and thus have impacts on higher trophic levels in forest ecosystems. As the implications of these findings and similar work centered around other species become more widely known, it is expected that these results will begin altering land management decisions on public and private lands or at a minimum lead to increased monitoring of public and private forest lands in the state.

Improved understanding nutrient use efficiencies in hybrid poplar clones will allow better selection of planting stock to optimize fertilizer inputs and reduce possible losses of nitrogen to ground water systems. This research is the subject of considerable interest by the forest products companies of the state and region who have been investing heavily in the intensive culture of hybrid poplar plantations. No specific data exists in terms of the acres affected or other similar measures as this basic research and is only in the early stages of development. However, the forest products companies in the Pacific Northwest have expressed considerable interest in this research.

Quantification of nitrogen use by different poplar clones will aid in using hybrid poplars in riparian buffer systems to capture waste nutrient runoff before it enters stream channels. Research in this

area has been of considerable interest by the dairy industry as well as other aspects of the agricultural sector due to increased regulatory pressure being placed on the these industries in recent years.

C. Benefits To Clientele (Stakeholders)

Benefits to clientele to-date are limited due to the basic nature of the research and the relative stage of its development. The quantification of nitrogen use by different poplar clones, which will aid in using hybrid poplars in riparian buffer systems to capture waste nutrient runoff before it enters stream channels, has the greatest potential to affect the clientele of the state in the region over the next several years as this work develops further. In addition, clientele have benefited from an improved understanding of the effects of increased levels of UVB and CO₂ in the atmosphere.

D. Accomplishments Based on Department/Unit POW for 2002.

Scientists in the department have made significant progress toward our long-term goal of empowering the agricultural and forestry system with knowledge that will improve competitiveness in domestic production, processing and marketing. Some short-term objectives have been accomplished, but much more remains to be done, before the long-term objectives are accomplished.

E. Source of Funding and FTE:

Total Expenditures for all projects \$26,949.06

Source of Funds	Amount
State Appropriations	\$26,322.35
Other Grants	\$626.71

Total Faculty/Staff FTEs: 0.50

KEY THEME: Biotechnology

Research Program –Ecophysiology and intensive culture of forest trees

CRIS Project 0113 and other federal grant supported projects. All projects included under this program are funded under McIntire-Stennis.

A. Basic Studies of environmental physiology of several commercially important Pacific Northwest forest tree species resulted in greater understanding by scientists of

1. Potential perturbations of forest ecosystems resulting from depletion of stratospheric ozone and concomitant increases in solar ultraviolet radiation (UV-B radiation) at the Earth's surface;
2. Effects of enhanced UV-B radiation on photosynthesis and growth of forest tree species of with contrasting leaf anatomies and shoot growth patterns;
3. UV-B-induced production of secondary metabolites and their impact on higher trophic levels in forest ecosystems;
4. Nitrogen use by different clones of hybrid poplars cultivated for short rotation fiber production;

5. Relationships between biomass production and nitrogen requirements by various hybrid poplars;
6. Biomass accumulation in these different clones at the same level of nitrogen nutrition.

B. Impacts include:

1. Forest tree species with contrasting leaf anatomies and shoot growth characteristics respond differently to projected increases in UV-B radiation.
2. Possible deleterious effects of enhanced UV-B radiation on growth is likely to result in altered competitive abilities of forest tree species resulting in changes in species composition and biological diversity in forest ecosystems.
3. Altered production of secondary metabolites in some tree species caused by enhanced UV-B radiation will likely affect herbivores and thus have impacts on higher trophic levels in forest ecosystems.
4. Understanding nutrient use efficiencies in hybrid poplar clones will allow better selection of planting stock to optimize fertilizer inputs and reduce possible losses of nitrogen to ground water systems.
5. Quantification of nitrogen use by different poplar clones will aid in using hybrid poplars in riparian buffer systems to capture waste nutrient runoff before it enters stream channels.

C. Scope of Impact

1. Global climate change research involving interdisciplinary scientists from multiple units at WSU and the University of Idaho.
2. Impacts on climate change research throughout the world.
3. Regional, national, and international cooperation on short-rotation fiber farming.
4. Regional, national and international exchanges on non-point-source pollution control using forested riparian buffer systems.

PLANT PATHOLOGY

GOAL 1: Overview:

Research programs of the Department of Plant Pathology are:

- 1 Biology of disease-causing organisms.
- 2 Ecology and epidemiology of plant diseases.
- 3 Detection of disease-causing organisms and control of plant diseases.

A. Research results from projects supported by Hatch formula funds.

Scientists in the unit conduct research on several different crops, diseases, and pathogen groups. Research results from these studies include:

1. Greater understanding of transmission of Cherry leafroll virus in cherry orchards.
2. Isolation of distinct variants of Apple chlorotic leafspot virus from trees expressing apple green crinkle disease.
3. Completed cloning and sequencing of mating genes from *Ascochyta rabiei*.
4. Demonstrated that the yeast *Ascobotryozyma cognata* is present on the surface of the nematode *Panagrellus dubius* in galleries of the long-horned beetle *Saperda clacarata* in *Populus* and the weevil *Cryptorhynchus lapathi* in *Salix*.
5. Complete sequencing of six genes from closely related grass smuts to delineate species boundaries.
6. Completion of a monograph of the genus *Nemania* elucidating 37 taxa.
7. Demonstration that management of grape powdery mildew beginning when first signs of disease are present resulted in three fewer fungicide applications that industry-standard practices with no difference in disease control.
8. Demonstration that rotations of direct-seeded winter and spring wheat and barley are agronomically and economically superior to rotations of cereals with broadleaf crops or conventional wheat/fallow in eastern Washington.
9. Demonstration that TBZ-resistant isolates of *B. cinerea* were present on decayed fruits from packing houses and that the fungicide fenhexamid was effective in controlling *B. cinerea* when applied preharvest.
10. Demonstration that populations of *Tapesia acuformis* and *T. yallundae* in eastern Washington are undergoing genetic recombination.
11. Improved control of cherry powdery mildew with fungicides when the initial application was made with the first irrigation or when the first signs of disease appeared.
12. Demonstration that the bacterial biocontrol agent 1100-6 can persist in soil and plant tissue for up to 8 months.
13. Modifications to the heat therapy and shoot regeneration regime dramatically improved survival of peach and cherry plants.
14. Development of species-specific PCR primers for detection of *Cephalosporium gramineum* in plant tissue and seed.
15. Demonstration that sporangia and zoospores of *P. infestans* survived longer on soil when it was shaded than in direct sunlight.
16. Strategic timing of fungicide applications in hops during burr formation and cone development significantly reduced cone infection and cone browning caused by powdery mildew.

17. NRSP-5 received 44 new clones from USDA-ARS breeding programs and distributed over 24,518 buds of several hundred varieties to over 100 individuals.
18. Demonstration that the grape mealybug is the predominant species in Washington wine grapes.

B. Successes that have resulted in significant changes within the state.

Results of these studies have resulted in significant changes including:

1. Assisting growers in the high-rainfall area of the PNW in making the transition to a continuous direct-seeding system both agronomically and economically feasible.
2. Information on population structure in *A. rabiei* has been used to redesign inoculation procedures in breeding nurseries, which will ensure growers have access to cultivars with effective resistance.
3. Improved control of cherry powdery mildew with biorational fungicide increases grower profitability and reduces spread of fungicide resistance.
4. Altered methods of screening wheat for resistance to eyespot to account for genetic variability within both *T. yallundae* and *T. acuformis*, which will ensure cultivars with highly effective resistance.
5. Effective control of powdery mildew helps to maintain the economic viability of hop producers.
6. Virus-free propagating material produced and maintained by NRSP5 is distributed to commercial nurseries that produce planting material for growers and thus helps maintain economic viability of fruit production.

C. Benefits to stakeholders.

Benefits to clientele include:

1. A better understanding of the transmission of CLRV via pollen will allow development of management strategies to minimize the economic impact of this virus.
2. Isolation of variants of Apple chlorotic leafspot virus could lead to the first diagnostic laboratory test for this virus, which will help to protect the industry from spread of this pathogen.
3. Greater understanding of the relationships between yeast and nematodes colonizing insect galleries in trees may lead to biological control of these insect pests, which will reduce wood decay, wood staining, and insect-vectored diseases
4. Development of species-specific PCR primers that unambiguously identify smut species present in grain and seed samples may help limit their impact on the U.S. wheat export industry
5. Knowledge that fungicide resistant isolates of *B. cinerea* are present in orchards will allow identification of alternative fungicides and management strategies for control.
6. Demonstration that a potential biological control agent for crown gall of grape can survive for an extended period of time will help establish parameters for their potential commercial use.

7. Improving survival of peach and cherry trees following heat therapy reduces the number of clones requiring repeated treatment and increases the speed with which the virus-free clones are provided to the industry.
8. Development of a molecular detection protocol for *Cephalosporium gramineum* will provide a tool for studies of seed transmission and its control, which has the potential to effect international seed trade but for which knowledge is limited
9. Knowledge of sporangia and zoospore survival in soil will help growers better manage tuber rot caused by *P. infestans*.
10. Identification of the predominant species present in Washington will provide growers with critical information regarding the role of mealybugs in dissemination of debilitating grape viruses.

D. Accomplishments of the department POW for 2001.

Scientists in the Department have made significant progress toward our long-term goals of developing environmentally sound agricultural production systems, environmentally friendly and effective disease control, and increasing our understanding of pathogens and their interactions with plants and the environment. Some short-term objectives have been accomplished, but much remains to be done before all long-term objectives are accomplished.

E. Source of funding and FTE

Total Expenditures for all projects \$2,838,504.43

Source of Funds	Amount
Hatch	\$101,660.46
Hatch Multistate Research	\$313,389.20
Federal Research Grants	\$337,856.52
State Appropriations	\$966,330.05
Other Grants	\$1,119,268.20

Total Faculty/Staff FTEs: 18.49 (Prosser, Pullman, & Wenatchee)

KEY THEME: Plant Health

Research Program: Biology of Disease Causing Organisms
 CRIS Project Numbers: 231, 290, 300, 565, 572, 837, 876, 947, 1767

A. Activities

Basic studies of plant pathogen biology have resulted in:

1. Greater understanding of transmission of Cherry leafroll virus in cherry orchards.
2. Isolation of distinct variants of Apple chlorotic leafspot virus from trees expressing apple green crinkle disease
3. Completed cloning and sequencing of mating genes from *Ascochyta rabiei*.
4. Demonstration that the yeast *Ascobotryozyma cognata* is present on the surface of the nematode *Panagrellus dubius* in galleries of the long-horned beetle *Saperda clacarata* in *Populus* and the weevil *Cryptorhynchus lapathi* in *Salix*
5. Complete sequencing of six genes from closely related grass smuts to delineate species boundaries
6. Completion of a monograph of the genus *Nemania* elucidating 37 taxa.

B. Impacts

1. A better understanding of the transmission of CLRV via pollen will allow development of management strategies to minimize the economic impact of this virus.
2. Isolation of these variants could lead to the first diagnostic laboratory test for this virus, which will help to protect the industry from spread of this pathogen.
3. Information on population structure in *A. rabiei* has been used to redesign inoculation procedures in breeding nurseries, which will ensure growers have access to cultivars with effective resistance.
4. Greater understanding of these relationships could potentially lead to biological control of these insect pests, which will reduce wood decay, wood staining, and insect-vectoring diseases.
5. Development of new markers will facilitate development of species-specific PCR primers that can be used to unambiguously identify species present in grain and seed samples, which may help limit their impact on the U.S. wheat export industry.
6. Basic mycological studies enable scientists to better understand biodiversity issues in plant pathogens and their host plants, which is prerequisite to meaningful pathological and molecular studies.

C. Scope of Impact

1. The research has multistate impacts: WA, OR, ID, and has international implications. This project is associated with NRSP-5.
2. The research has multistate impacts: WA, OR, ID, and has international collaborations. This project is associated with NRSP-5.
3. The research has multistate impacts: WA, ID; associated with the Cool Season Food Legume Project.
4. This research is state specific and has international impacts: WA.
5. This research has multistate impacts and has international impacts: WA, OR, ID, TX, CA, MD.

6. This research has multistate impacts and has international impacts: WA, HI,.

KEY THEME: Plant Health

Research Program: Ecology and Epidemiology of Plant Diseases

CRIS Project Numbers: 212, 274, 367, 669, 795

A. Activities

Studies on the ecology and epidemiology of several plant diseases resulted in:

1. Demonstration that management of grape powdery mildew beginning when first signs of disease are present resulted in three fewer fungicide applications that industry-standard practices with no difference in disease control
2. Demonstration that rotations of direct-seeded winter and spring wheat and barley are agronomically and economically superior to rotations of cereals with broadleaf crops or conventional wheat/fallow in eastern Washington.
3. Demonstration that TBZ-resistant isolates of *B. cinerea* were present on decayed fruits from packing houses and that the fungicide fenhexamid was effective in controlling *B. cinerea* when applied preharvest.
4. Demonstration that populations of *Tapesia acuformis* and *T. yallundae* in eastern Washington are undergoing genetic recombination
5. Improved control of cherry powdery mildew with fungicides when the initial application was made with the first irrigation or when the first signs of disease appeared.

B. Impacts

1. Altered growers' approach to disease management that reduce fungicide input and hastened adoption of fungicide resistance management strategies.
2. Assisted growers in the high-rainfall area of the PNW in making the transition to a continuous direct-seeding system that was both agronomically and economically feasible.
3. Knowledge that fungicide resistant isolates of the pathogen are present will allow identification of alternative fungicides for control.
4. This knowledge has been used to revise strategies for screening potential new winter wheat varieties for eyespot resistance.
5. Improved control of mildew increases grower profitability and incorporates biorational fungicide resistance management strategies.

C. Scope of Impact

1. This research has multistate impacts: WA, CA, NY.
2. This research has multistate impacts: WA, ID, OR.
3. This research has multistate impacts: WA, OR.

4. This research has multistate impacts: WA, OR, ID.
5. This is state specific research: WA.

KEY THEME: Plant Health

Research Program: Detection of Disease-Causing Organisms and Control of Plant Diseases
 CRIS Project Numbers: 185, 248, 292, 390, 670, 678, 823, 1262, 1844, 5263

A. Activities: Studies on the detection of plant pathogens and control of plant diseases resulted in:

1. Demonstration that the bacterial biocontrol agent 1100-6 can persist in soil and plant tissue for up to 8 months.
2. Modifications to the heat therapy and shoot regeneration regime dramatically improved survival of peach and cherry plants.
3. Development of species-specific PCR primers for detection of *Cephalosporium gramineum* in plant tissue and seed.
4. Demonstration that sporangia and zoospores of *P. infestans* survived longer on soil when it was shaded than in direct sunlight.
5. Strategic timing of fungicide applications in hops during burr formation and cone development significantly reduced cone infection and cone browning caused by powdery mildew.
6. NRSP-5 received 44 new clones from USDA-ARS breeding programs and distributed over 24,518 buds of several hundred varieties to over 100 individuals.
7. Demonstration that the grape mealybug is the predominant species in Washington wine grapes.

B. Impacts

1. Demonstration that this biological control agent can survive for an extended period of time help establish parameters for their potential commercial use.
2. Improving survival following heat therapy reduces the number of clones requiring repeated treatment and increases the speed with which the virus-free clones are provided to the industry.
3. Development of a molecular detection protocol will provide a tool for studies of seed transmission and its control, which has the potential to effect international seed trade but for which knowledge is limited.
4. This knowledge will help growers better manage tuber rot caused by *P. infestans*.
5. Effective control of powdery mildew helps to maintain the economic viability of hop producers.
6. NRSP5 is the chief defense against diseases caused by virus and virus-like pathogens of pome and stone fruits in the U.S. and other parts of the world.

7. This information will provide growers with critical information regarding the role of mealybugs in dissemination of debilitating grape viruses.

C. Scope of Impact

1. This research has multistate impacts: WA, OR.
2. This research has multistate impacts: WA, OR.
3. This research has multistate impacts: WA, OR, ID.
4. This research has multistate impacts: WA, OR, ID.
5. This research has multistate impacts: WA, OR.
6. This research has multistate impacts: WA, PA, WV, CO, CA, MI.
7. This research has multistate impacts: WA, OR.

WSU WENATCHEE RESEARCH AND EXTENSION CENTER

GOAL 1: Overview:

Research programs at the Tree Fruit Research and Extension Center involve several disciplines with a common mission to develop and implement environmentally sound practices for the production of tree fruit crops. Areas of research include nutrient management, use of bioregulators to manage plant growth and fruit quality, development of new apple varieties, and pest management, including integration of pesticides and biological controls, models and use of treatment thresholds.

KEY THEME: Plant production efficiency and nutrient management: An agricultural system that is highly competitive in the global economy. CRIS Topic Area: Plants and their systems (RPAs 201-206 – Plant Production)

Research Programs - Tree fruit production and management
CRIS projects 0298, 0747, 0156, 0260

Overview:

Research on bioregulators is providing the basis for utilization of these products in apple, pear and cherry. Synthetic bioregulators are useful in managing plant growth which can reduce production costs by reducing pruning activities and enhancing pest control due to better spray coverage. It may also be possible to enhance fruit quality with bioregulators.

Washington soils are characteristically low in certain micronutrients that are required for good tree growth and productivity. Research on boron and zinc has led to recommendations for the best products to use in rectifying plant deficiencies.

The apple breeding program is highly efficient, producing thousands of crosses as potential selections for new varieties. This is long-term and high-risk research, as very few selections will ever lead to a successful new variety. For example, of the 9,000 selections evaluated in 2000 only 145 are considered promising enough to continue onto to phase-2 studies. This research is the hope for the future to develop varieties that are adapted to growing conditions of Washington so that highest quality can be produced year after year.

A. Research Results:

1. NUTRITION:

- A. Boron applied tank-mixed with zinc (Zn) plus oil at delayed dormant timing is as effective as boron applied at pink timing in apple, pear and sweet cherry. Spray application of high rates of Zn sulfate during the dormant period (a traditional recommendation) was the only Zn treatment that substantially improved winter bud Zn status of apple trees. These results justify keeping the current Washington Department of Agriculture exemption allowing higher heavy metal (in this case, Zn) application rates when the heavy metal is required for plant nutritional purposes. The Zn in the Zn phosphate-based NutraPhos 24 and NutraPhos ZnK is essentially not phytoavailable. Oxide, basic Zn sulfate, chelated and organically based Zn products contain more-or-less equally phytoavailable Zn, with small differences between products. The main distinguishing characteristic likely will be price per unit phytoavailable Zn.
- B. Calcium (Ca) chloride sprays substantially reduced bitter pit in Honeycrisp apple where the incidence of bitter pit was high. Starting sprays in June was more effective than starting sprays in July. Starting sprays in May was no more effective than starting in June. Ca sprays had a substantial effect on bitter pit in Fuji apple in 2001 when the background incidence of bitter pit was high but not in 2002 when the background bitter pit incidence was low. Boom-spray applications of high rates of Ca thiosulfate to soil failed to reduce bitter pit incidence in Honeycrisp or Fuji apple. Contrary to a Polish report, applying very high rates of Ca as Ca chloride or MiraCal failed to improve apple fruit firmness.
- C. TechSpray Copper (Nutrient Technologies) at the 2-qt/acre rate applied at first cover substantially improved internal leaf copper (Cu) concentrations of Golden Delicious apple trees compared to the previous year (from 4.5 to 14 mg/kg).

2. BIOREGULATORS:

- A. Apogee (6 oz/100 gallons) was applied dilute to vigorous, 10th-leaf Fuji/M.26 apple trees in 2002 with a strategy designed to evaluate the ability of Apogee to control a second flush of shoot growth. None of the 2002 Apogee treatments proved capable of completely suppressing the second growth flush induced by the first two Apogee applications. However, interrupting the application sequence for six weeks from late May to early July, when the second flush began, resulted in a stronger second flush even when two more applications of Apogee were made. These results confirm and clarify previous observations, which suggested that once a second growth flush begins, it is more difficult to obtain growth control with subsequent Apogee applications. At this point it is not possible to recommend an economically reasonable strategy for Apogee use that will assure the absence of a second growth flush under vigorous growth conditions.
- B. Cyclanilide was mixed with 50% v/v interior latex paint and painted as bands around the lower portions of 1-year-old and 2-year-old branch sections on Scarletspur Delicious/B.118 and Granny Smith/MM.106 prior to budbreak and again at green-tip.

The objective was to see if such treatments could be used to stimulate budbreak from buds that normally do not grow into lateral shoots unless stimulated by pruning or other cultural practice. There was no shoot growth response whatsoever to any of the treatments in either cultivar.

- C. Cyclanilide alone, Promalin alone or a tank-mix of cyclanilide and Promalin was applied to whole trees of second-leaf Scarletspur Delicious/B.118 apple trees when new terminal shoots averaged approximately 16 cm in length. A single application of cyclanilide alone increased activity of lateral buds by about 30-fold; most of the activated buds formed spurs but not shoots. Promalin alone increased lateral bud activity by about the same amount as cyclanilide, but the proportion of shoots formed was twice as high as with cyclanilide alone, and the number of buds forming spurs was not as great. The tank-mix was about as effective as cyclanilide alone in forming new lateral shoots but did not significantly increase spur formation from lateral buds.

3. BREEDING & CULTIVARS:

- A. In May 2002, 4,891 seedling/M.9 trees were planted at TFREC, mostly from crosses made in 1997 and 1998. The total number of seedling/M.9 planted in TFREC orchards between 1998 and 2002 is 18,049. Two-year-old seedlings in the nursery (from the 2000 crosses) were screened for mildew susceptibility (natural infection). The most susceptible 36% were discarded. In addition, 5,362 seedling/M.9 trees were grown in the nursery for planting at TFREC in 2003. These are primarily from 1999 crosses. In September 9,300 seedlings from crosses made in 2000 were budded onto M.9 in the nursery. Forty-nine promising selections (mostly from 1994 crosses) were budded on M.9 in the nursery to produce trees for a replicated second test trial.
- B. In fall 2002, fruit was evaluated on 11,443 seedling/M.9 trees from crosses made in 1995, 1996 and 1997. Over 130 promising selections were made. The crosses from which the largest number of promising selections were made were Gala x Fuji, Braeburn x Arlet, Gala x NY632, Honeycrisp x BC 8S-27-51, Honeycrisp x Enterprise and Hatsuaki x Honeycrisp. Also approximately, 10,000 seeds were collected from new crosses using several parents including Braeburn, Pink Lady, Delorgue, Granny Smith, Golden Delicious, Honeycrisp and Gala.

4. ROOTSTOCKS

- A. Trial plantings at TFREC-Columbia View were established in 1998, 1999 and 2001 with new Cornell-Geneva apple rootstocks and standard rootstocks M.9, M.26, M.7 and MM.106. Data on tree health, growth and productivity are collected annually. All the plantings are young, data are preliminary, and at present recommendation cannot be made. In 2002 (year 5) in the Gala trial the most yield efficient of 12 rootstocks were CG.12 and CG.757 and the least efficient were CG.910 and P.14. On a cumulative basis, M.9 WAF, CG.12 and CG.757 were the most efficient and P.14 and CG.910 the least efficient. In the Jonagold trial there were no significant differences in yield efficiency among the rootstocks CG.41, G.16 and M.9E. There were also no differences on a cumulative basis. In the Fuji Dwarf trial (year 4), the most yield efficient rootstocks were CG.5179, Supporter 2 and M.9 and the least efficient were Supporter 4 and CG.4013. On a cumulative basis, the most efficient rootstocks were CG.5179, CG.16TC and CG.16N and the least efficient were Supporter 4 and CG.4013 while in the Fuji semi-dwarf trial the most yield efficient rootstocks were CG.4814 and CG.30N although none was significantly different from M.26 or M.7. On a cumulative basis, the most efficient rootstocks were CG.4814 and CG.30N and the

least efficient were CG.4210 and M.7. In the fourth year of the Gala dwarf and semi-dwarf trial the three dwarfing CG rootstocks fell between M.9 and M.26 in tree size (TCA). The efficiency for the dwarf rootstocks was highest for CG.4214 and lowest for M.26. The following dwarf rootstocks are in the Golden Delicious trial: M.26, M.9, CG.4011, CG.5890, CG.2022, CG.4814, CG.5012 and G.11, and the following semi-dwarf rootstocks are included: M.7, CG.6874, CG.6006, CG.6589 and CG.6143.

B. Outcomes:

1. NUTRITION

This research has allowed growers to make informed decisions on boron supplements to crops to reduce plant deficiencies. The result has been that growers can use lower cost products to achieve desired results. Research on zinc has substantiated the historical use patterns for Washington and identified some products that were not efficacious, thus saving the growers from using inappropriate treatments. The discovery of incompatible tank mixes of Zn and Ca will prevent crop loss due to inappropriate practices. The Ca treatments that were reported to work elsewhere but did not work in Washington point to the need to evaluate protocols in the area where they would be used.

2. BIOREGULATORS:

This research has shown that use of Apogee for control of apple vegetative growth is not a viable tactic for Washington. Two products look very promising for stimulating branching of nursery trees and trees in orchards. These results, if confirmed, will help earlier development of a fruiting canopy in trees and thus start the cropping and payback cycle earlier.

3. BREEDING & CULTIVARS:

This by its nature is long-term research. The outcomes at this point are in the promise of new genetic material that will eventually result in new and unique products for Washington growers and potentially new world varieties. The initiation of the second phase for some selections is important. The program has also shortened the evaluation of the first phase from five to four years, a significant advance in getting products into second phase testing regimes. Screening for some diseases early helps to eliminate the most susceptible selections and saves time and resources for more important activities.

4. ROOTSTOCKS:

- A. The ability to be included in "first tests" of Cornell-Geneva rootstocks will allow assessment of those rootstocks adapted to Washington environment, providing an advantage to the industry in utilizing these management tools early in their development.
- B. Growers are making better decisions on rootstock-variety combinations for their growing sites and are avoiding incompatible combinations that will result in lower yields or reductions of fruit quality.

C. Benefits To Clientele:

1. NUTRITION:

- A. This research has allowed Washington apple growers to make informed decisions on boron-based products, getting the best results for the least cost.
- B. Results on boron confirm WSU recommendations for use of calcium products in tree fruit.
- C. New but provisional zinc nutritional spray products and application timing have been established for Washington apple growers. The need for Zn in apple supports the need for the state regulatory agencies to exempt agricultural uses from those applied to fertilizers.
- D. Ca recommendations arising from the research will allow growers to apply only the best products and avoid recommendations from biased sources that rely upon data from studies done in other areas. This saves the grower money in two ways, by avoiding use of ineffective products and by getting the best possible crop quality from products that are used.

2. BIOREGULATORS:

- A. This research provides the only unbiased assessment of new or potential products for plant growth regulation in the Northwest. As a result, growers and pesticide registrants are provided with information necessary to make optimal management decisions and whether or not a product should move forward in the registration process.
- B. Plant bioregulator research in Washington is critical because of our unique environment and growing practices. This makes it impossible to directly transfer recommendations on use of such products from other production areas. The active research program on bioregulators of plant growth and fruit quality in Washington has increased the interest of agricultural chemical companies to evaluate new and potentially beneficial products in Washington. The result is the testing of products to stimulate branching in young trees that was described above. The payoff for getting trees in high-density plantings into production one or two years early is worth hundreds of dollars per acre to the grower.

3. BREEDING & CULTIVARS:

- A. Data from cultivar trials help producers make informed decisions of which varieties of apple perform best under Washington conditions and therefore should be considered for new plantings. New cultivars are being selected that are specifically adapted for Washington growing conditions. These new varieties are developed under "traditional" methods so will not hold any GMO stigma. Consumers have shown that they have a propensity to shift purchasing to new cultivars, especially if they meet high quality criteria. The breeding program is producing future products for the Washington fruit industry and will be the key to long-term competitiveness in a globally competitive economy.

4. ROOTSTOCKS:

- A. Grower decisions upon planting have long-term consequences, positive or negative. Information on the winter injury of certain cultivar-rootstock combinations will help growers avoid choices that could result in severe economic consequences.

D. ACCOMPLISHMENTS:IN RELATION TO WENATCHEE PLAN:

1. NUTRITION:

- A. Our plan outlined efforts to provide knowledge on the impact of micro-nutrients on apple trees. Research reported shows that progress has been made in recommendations for growers on products used to address the deficiencies of zinc common in Washington soils, use of calcium to address deficiencies in fruit and preventing bitter pit, and boron to address deficiencies that affect many orchards.
2. BIOREGULATORS:
- A. Our plan outlined an approach to develop knowledge on how to use plant bioregulators to modify tree growth without negatively affecting fruit quality. Research revealed some limitations of using certain bioregulators in pear. Use of bioregulators on other crops, apple and cherry, are very promising.
3. BREEDING & CULTIVARS:
- A. Our plan clearly laid out a long-term effort to develop new products (cultivars) unique for Washington growing conditions. Tremendous progress has been made in producing new genetic material for selection of new varieties of apple. The project is about one year ahead of schedule due to efficiencies in the program.
4. ROOTSTOCKS:
- A. Our plan outlined an approach to examine new rootstock-variety combinations for apple grown under Washington conditions. The results of these trials have and will continue to provide growers with the information they need to select trees for their site to have the best chance at producing high yielding, high quality fruit.

E. Source of funding and FTE

Total Expenditures for all projects: \$617,533.04

Source of Funds	Amount
Hatch	\$93,723.68
Hatch Multistate Research	\$551.25
Federal Research Grants	\$0.00
State Appropriations	\$355,669.98
Other Grants	\$167,588.13

Total Faculty/Staff FTEs: 7.0

**WESTERN WASHINGTON RESEARCH AND EXTENSION CENTER
WSU-PUYALLUP, MOUNT VERNON, VANCOUVER, LONG BEACH**

Goal I: Overview:

Research programs at the WSU-Puyallup Research and Extension Center focus on agricultural and environmental issues in Washington State with emphasis on western Washington. Areas of research include economically and environmentally sustainable production of high value specialty crops.

KEY THEME: Plant Germplasm

Research Program: Management of Forest Resources
CRIS Project Numbers: 0307, 0038, 0640, 0336,

A. Research Results:

Field studies determined nitrogen storage in leaves, branches, and stems of two contrasting hybrid poplar clones. Field studies also determined nitrogen uptake by poplars used for municipal waste treatment and dairy manure treatment. Tree and leaf growth rates on leaf rust were studied using a semi-hydroponic system.

B. Benefits to stakeholders.

Poplar research will provide unavailable information about nutrient use by hybrid poplar clones for production and use as a biofilter to remove excess nutrients from municipal and dairy waste.

C. Scope of each impact:

Project 307 - state-specific for WA

KEY THEMES: Plant Germplasm

Research Program: Plant Product Quality and Utility
CRIS Projects: 038, 640.

A. Research Results:

1. 124 strawberry crosses were made in 2002 and 8,700 seedlings were planted from 2001 crosses. 73 clones were planted in a new yield planting. Second year yields were harvested from 2000 replicated plantings.
2. 90 raspberry crosses were made in 2002 and seed from 77 crosses in 2001 were saved for sowing in 2003. 62 selections were made in 2002 from 10,000 seedlings planted in 1999 and 2000. 35 selections were made among 6,900 seedlings planted in 2000. A nonreplicated machine harvestable planting was made.

B. Benefits to stakeholders:

1. Strawberry clones had a second year yield 20% greater than the first year. WSU 2462 produced good yields of large, firm fruit.
2. Raspberry clones with the highest replicated yields were the new releases 'Cascade Nectar' and 'Cascade Delight'.

C. Scope of impact:

1. Project 038 – multistate-specific WA, OR, and Canada, BC
2. Project 640 – multistate-specific WA, OR, and Canada, BC

Research Program: Plant Genetic Resources and Biodiversity

CRIS Project Numbers: 314

A. Research Results:

A wine grape variety trial of high quality red wine grapes, a rootstock trial of Pinot Noir, and a varietal pretest of three plants per variety were planted at Mt. Vernon and Everson in 2000. Sufficient fruit was harvested in 2002 for evaluation and production of a varietal wine.

B. Benefits to stakeholders:

This trial will provide reliable information for establishing a successful vineyard.

C. Scope of each impact:

Project 314 – state-specific for WA

Research Program: Plant Genetic Resources and Biodiversity

CRIS Project Numbers: 314

A. Research Results:

A wine grape variety trial of high quality red wine grapes, a rootstock trial of Pinot Noir, and a varietal pretest of three plants per variety were planted at Mt. Vernon and Everson in 2000. Sufficient fruit was harvested in 2002 for evaluation and production of a varietal wine.

B. Benefits to stakeholders:

This trial will provide reliable information for establishing a successful vineyard.

C. Scope of each impact:

Project 314 – state-specific for WA

KEY THEMES: Ornamental/Green Agriculture

Research Program: Plant Biological Efficiency and Abiotic Stresses on Plants

CRIS Project Numbers: 285, 314

A. Research Results:

Roots of Scotch pine and shore pine seedlings and hybrid poplar cuttings were manipulated to develop a model system for the study of girdling roots. Stem caliper, height, and width were measured at intervals after treatment. Hybrid poplars were used to measure water transport through the xylem. Secondary roots were used to monitor the movement of dye to monitor the effects of root girdling.

B Benefit to stakeholders:

This system can be used to determine the susceptibility of different species to root girdling and to evaluate the efficacy of treatments aimed at preventing and/or correcting girdling roots.

C. Scope of each impact:

Project 285 and 314 both are state-specific for WA

KEY THEMES: Plant Germplasm

Research Program: Plant Genetic Resources and Biodiversity

CRIS Project Numbers: 314

A. Research Results:

A wine grape variety trial of high quality red wine grapes, a rootstock trial of Pinot Noir, and a varietal pretest of three plants per variety were planted at Mt. Vernon and Everson in 2000. Sufficient fruit was harvested in 2002 for evaluation and production of a varietal wine.

B. Benefits to stakeholders:

This trial will provide reliable information for establishing a successful vineyard.

C. Scope of each impact:

(314) state-specific for WA

KEY THEMES: Plant Germplasm

Research project:-Plant Product Quality and Utilization (Preharvest)

A. Progress report of research projects:

Bosc pears on various rootstocks produced a full crop of marketable fruit and yield data was taken on all plots. A new stone fruit plot was added, including peach and plum varieties. A plot of sweet cherry varieties on dwarfing rootstocks produced a good crop and showed considerable promise.

B. Benefits to stakeholders:

Bosc pears on various rootstocks produced a full crop of marketable fruit and yield data was taken on all plots. A new stone fruit plot was added, including peach and plum varieties. A plot of sweet cherry varieties on dwarfing rootstocks produced a good crop and showed considerable promise.

C. Scope of project:

Project 217 and 314 both are State-specific to WA

KEY THEMES: Invasive Species

Research Project: Disease and Nematodes Affecting Plants

A. Research Results:

Transmission of potato late blight from seed pieces to sprouts was tested using various inoculum densities of *Phytophthora infestans*. Reducing late blight foliar fungicide applications by using blight resistant germplasm plus a reduced fungicide spray was documented. Potato tuber rots were managed in storage by testing Phostrol. Several new potato seed piece products were tested for black scurf control on red potatoes. Several products were tested on peas for downy mildew control. Testing continued towards marker-assisted selection to Fusarium-wilt resistance. A reduced spray strategy was tested for late blight control on tomatoes.

B. Benefits to stakeholders

\$20 million in savings from potato losses due to late blight have been estimated as a result of this research. Treatment of potato seed pieces is used on over 12,000 acres of potatoes, eliminating 50% of fungicide treatments saving \$200 per acre. Phostrol is a promising new fungicide for tuber storage. Section 18 registration of fosetyl-AI for the pea industry was obtained, affecting 18,000 acres of peas. Pea germplasm evaluation will be used on the development of a new pea cultivar.

C. Scope of impact

Project 336 – multistate-specific WA

KEY THEMES: Invasive Species

Research Project: Weeds Affecting Plants

CRIS Project: 297

A. Research Results:

Weed control trials were conducted on ornamental bulbs, vegetable crops, vegetable seed crops, small fruit, and non-crop areas. Over 20 post-emergent herbicides were evaluated in grower's cranberry fields against hard-to-control perennial weeds.

B. Benefits to Stakeholders:

Resulted in new and continuing Section 3, Section 18 and Section 24c registrations for 28 herbicides in 20 minor crops.

C. Scope of each impact:

Project 297 – State-specific to WA

KEY THEMES: Invasive Species

Research Project: Plant Genetic Resources and Biodiversity

CRIS Projects: 270

A. Research Results:

Black vine, strawberry, and rough strawberry weevils were exposed to three days of direct exposure to bifenthrin (Capture) insecticide. Two acaricides, Acramite 50WS and Thiodan 50WP, were evaluated for cyclamen mite efficacy as a renovation treatment on 'Totem' strawberries. Two rates of bifenthrin and two rates of thiamethoxam were added to a soil potting mix to determine black vine weevil control. Six reduced risk products were tested and compared to Diazinon and bifenthrin for winter moth control.

B. Benefits to stakeholders:

Black vine, strawberry, and rough strawberry weevils were reduced 80%, 60% and 100% by bifenthrin (Capture) insecticide in the lab. Acramite and Thiodan were significantly different after three and eight days posttreatment compared to the check. Compared to the untreated check, bifenthrin (Capture) and two rates of thiamethoxam (Platinum) were significantly different than the check in potting soil media. Bifenthrin (Capture) caused 100% mortality of winter moth in tower assays. Several of the reduced risk products performed well and at reduced risk to the environment.

C. Scope of each impact:

Project 270 – State-specific for WA

KEY THEMES: Invasive Species

Research Project: Plant Genetic Resources and Biodiversity
CRIS Projects: 270

A. Research Results:

Black vine, strawberry, and rough strawberry weevils were exposed to three days of direct exposure to bifenthrin (Capture) insecticide. Two acaricides, Acramite 50WS and Thiodan 50WP, were evaluated for cyclamen mite efficacy as a renovation treatment on 'Totem' strawberries. Two rates of bifenthrin and two rates of thiamethoxam were added to a soil potting mix to determine black vine weevil control. Six reduced risk products were tested and compared to Diazinon and bifenthrin for winter moth control.

B. Benefits to stakeholders:

Black vine, strawberry, and rough strawberry weevils were reduced 80%, 60% and 100% by bifenthrin (Capture) insecticide in the lab. Acramite and Thiodan were significantly different after three and eight days posttreatment compared to the check. Compared to the untreated check, bifenthrin (Capture) and two rates of thiamethoxam (Platinum) were significantly different than the check in potting soil media. Bifenthrin (Capture) caused 100% mortality of winter moth in tower assays. Several of the reduced risk products performed well and at reduced risk to the environment.

C. Scope of each impact:

Project 270 - State-specific for WA

KEY THEMES: Niche Markets

Research Project: Soil, Plant, Water Nutrient Relationships
CRIS Project: 375

A. Research Results:

1.8 acres of land has been certified as organic. 25 cultivars of edamame, 70 dry beans, 30 cucurbits, 30 leafy Asian vegetables, and 11 trellised Asian vegetables have been trialed for western Washington.

B. Benefits to stakeholders:

Commercial seed catalogs have added cultivar listings based on this research. Growers are commercially growing recommended varieties.

C. Scope of each impact:

Project 375 – State-specific to WA

Source of Funding and FTEs

Total expenditures for all projects: \$1,102,904.24

Source of Funds	Amount
Hatch	\$173,185.59
Hatch Multistate Research	\$0.00
Federal Research Grants	\$0.00
State Appropriations	\$589,838.28
Other Grants	\$339,880.37

Total Faculty/Staff FTEs: 18.29

GOAL 2

BIOLOGICAL SYSTEMS ENGINEERING

GOAL 2: Overview: A safe and secure food and fiber system

A. Research Results from Research Projects Supported by Hatch Formula Funds

For this goal, the Department of Biological Systems Engineering is reporting activity in three Research Problem Areas: 402 Engineering Systems and Equipment, 501 New and Improved Food Processing Technologies, and 503 Quality Maintenance in Storing and Marketing Food Products. Research results include development of techniques used in processing and storage to reduce bruising or to improve processing equipment to reduce bruising, with particular emphasis on apples, potatoes, and onions, important crops in Washington State and elsewhere; development and application of harvesting and processing technologies for production of value added fruit and vegetable products; preservation of foods by oscillating magnetic fields, a technique of interest for many applications; improvement of thermal and alternative processes for food including advanced thermal processing, novel non-thermal processing technologies, gel networks and glass transition in food systems; application of electromagnetic energy at microwave and radio frequencies in food and agricultural processes including developing novel thermal processing technologies and material properties related to microwave heating, developing radio frequency sterilization technology for large food trays and for non-chemical pest control. This large array of activities is consistent with the departmental objectives to advance research in the field of food process engineering and post harvest.

B. Outcomes That Have Resulted in Significant Changes

The activities of the Department of Biological Systems Engineering have resulted in research results with specific impact in the state of Washington and the nation. The research on preservation of foods by oscillating magnetic fields is comprehensive and complete, with faculty researchers often invited to talk on this topic. Results of improved thermal and nonthermal processes for food have prompted the development of a workshop for the food industry, regulatory agencies, and researchers on the opportunities and limitations of these technologies. Industrial reliance on clean technologies and electricity-based technologies will grow to compensate for the gradual depletion of petroleum sources. Research results are exploring unique applications of a highly efficient energy delivery method – microwave and radio frequency. The use of electromagnetic energy for pest control in fruits and nuts is laying a solid foundation that has a long-term impact on future development of conventional and new thermal methods for non-chemical treatment of agricultural commodities. The work on preventing bruising of fruits and vegetables has both theoretical and practical results. It has demonstrated fundamental engineering properties of fruits and vegetables that affect bruising, resulting in specific recommendations that some growers and packers are following to condition these products to prevent bruising. Research on harvesting technologies is addressing field evaluation of several harvesting systems for fruits and vegetables that will serve as a platform for adoption of new harvesting and handling systems.

C. Benefits to Clientele (Stakeholders)

New thermal and non-thermal food processing technologies, non-chemical pest control methods, and improved harvesting and processing technologies are directly benefiting the food processing industry and fruits and vegetable growers. Based on our experience and research results, Washington State University has hosted a research-industry roundtable to discuss development of research programs that address the immediate needs of the tree fruit industry and produce deliverables for immediate application to the production system.

D. Accomplishments Based on Department/Unit POW for 2002

Development and application of novel food process technologies and harvest and post-harvest methods are a major objective of the departmental POW for 2002. This report clearly shows the progress toward the accomplishment of this objective.

E. Source of Funding and FTEs

Total expenditures for all projects: \$1,332,998.84

Source of Funds	Amount
Hatch	\$15,019.35
Hatch Multistate Research	\$30,710.20
Federal Research Grants	\$430,866.80
State Appropriations	\$400,174.42
Other Grants	\$456,228.07

Total Faculty/Staff FTEs: 13.23

ENTOMOLOGY

GOAL 2: Overview:

The Department of Entomology's mission statement has three stated objectives:

1. The integration of biological control into existing and developing integrated pest management programs. Major research areas found within the department are: integrated biological control, integrated pest management and the reduction of our citizenry's dependence on broad-spectrum pesticides.
2. The responsibility for addressing pesticide issues, including the education of the public and researching the ecotoxicological questions of pesticides in our environment.
3. We support a basic research emphasis that depends upon an insect model to explain fundamental questions in biology.

KEY THEME: Food Safety

Research Program: Integrated Pest Management. CRIS projects 0122, 0206, 0335, 0415, 0426.

A National Agricultural Program to Clear Pest Control Agents for Minor Uses Over 20 magnitude of residue field trials were conducted that covered the field phase of IR-4 activities for EPA reegion 10. These magnitude of residue studies support pesticide registration that result in millions of dollars of saved and or increased revenues to agricultural producers by limiting the impact of pest and disease damage on crops.

Development of Crop Protection Chemicals. This project aided the registration of arthropod pest management tools for grape producers. Products registered for use on grapes in 2002 include

buprofezin, fenpyroximate, fenprothrin, and bifenthrin. All of these insecticide/miticide products are classified as reduced risk to humans and are serve as good organophosphate insecticide replacements. Grape producers now have new options for crop protection other than chlorpyrifos.

Pesticide Information Coordination. Presentations were made to state clientele regarding the status of pesticide registrations. Four regional meetings in the area of pesticide regulation were attended in order to represent WA interests. The Pesticide Notification Network sent 360 notifications to interested parties on changes to pesticide labels and/or regulations. The 20,000 records in the Pesticide Information Center On-Line label database were updated to include CY2002 registrations for WA and OR. The 5300 records in the Pesticide Information Center On-Line tolerance database were updated to include CY2002 tolerance levels. The label and tolerance databases were both upgraded to a faster, more user-friendly operating system in CY2002. The web site (<http://wsprs.wsu.edu>) was completely remodeled to serve as a catalog of WA State pest management resources. An advisory committee of stakeholders continues to provide comment and direction to the program. Crop profiles are under development for sweet cherry, chickpea and onion.

Dispersal of pest management information on changes in federal and state pesticide regulations continues to be a critical need for the growers in Washington State. Information collected at the state level continues to be important to policy makers at the national level for informed decision-making.

Utilizing Complex Communities of Natural Enemies in Biocontrol

Evaluations of Airborne Herbicide Residues on Wine Grape Production Ambient air and wet/dry deposition monitoring was conducted for airborne auxin agonist herbicide residues at established vineyards in southeastern Washington in 2001. Sampling was performed when wine grapes are most susceptible to injury by the off-target aerial movement of auxin agonist herbicides. Deposition samples were collected from eight sites. Exposed deposition sample trays were collected on a weekly basis during the study and replaced with unexposed trays. Deposition sample trays were open to atmosphere to capture either wet or dry deposition. Two-stage, high-volume air samplers were operated two days per week at four sites. Each air sampler consisted of a porous air filter and an XAD-2 polystyrene resin pillow designed to collect both particulate and gaseous pesticide residues. After the approximately 24 hour interval of operation, the filter and XAD-2 resin pillows were collected from the sampler and taken to the FEQL Analytical Laboratory.

In general, the analytical methods for the determination of the target herbicides, dicamba and 2,4-D, involved an initial cyclohexane extraction of the sample matrix for isolation of 2,4-D esters followed by determination using gas chromatography with electron capture detection. A second extraction of the matrix was performed using base solution to quantify any free acids of 2,4-D and dicamba. Subsequent hydrolysis, liquid-liquid partition and derivatization of the free acids were performed for determination by gas chromatography using electron capture detection. Method recoveries were acceptable. Dicamba extraction efficiencies from the XAD-2 resin were less than desirable and lead to inconsistent recoveries. However, the dicamba method was reliable to detect the presence of this substance in air at concentrations of $> 0.007 \text{ mg m}^{-3}$. The high volume air sampler results show that 2,4-D air residues were detected at roughly equal concentrations (i.e., from 0.017 to 0.018 mg m^{-3}) in two remotely located air samples that were taken over a 24-hour interval. The limited number of air sampling data points, however, makes it difficult to conclude that a regional air mass contamination was occurring over this time period. Air sampling data usually showed little overall phenoxy-type herbicide concentrations in the air mass over the April to June sampling period. Overall, the air residue data results supported vineyard survey observations at these locations of mild to moderately low vine herbicide injury. During this time period, however, significant injury to wine grapes allegedly from off-target phenoxy-type herbicide movement was observed at the Coyote Vineyard location. Air samplers were not

positioned at this site. Deposition samplers that were collected from June 7 through June 15, 2001, did detect 2,4-D residues of ca. 0.002 to 0.003 mg cm⁻² at this location. Surface deposition at these concentrations can likely result in symptomologies typical of auxin agonist herbicides. The presence of 2,4-D residues in both air and deposition samplers were subsequently confirmed using GC-mass spectroscopy.

2,4-dichlorophenoxyacetic acid (2,4-D) and dicamba are broad-spectrum herbicides used throughout Washington and Oregon for the control of broadleaf weeds in cereal grain crops, pastures and along rights of way. In particular, grape vines are susceptible to damage from the airborne movement of these herbicides. Vineyard damage is usually noted to some degree after every growing season. Recently, alleged winegrape injury was substantial in southeastern WA. From just one vineyard in this area, reduction in yield due to phenoxy-like symptoms was estimated to have reduced revenues by \$290,000. Other vineyards in the Columbia River Valley have also expressed strong phenoxy-type symptoms. State and federal regulatory agencies have operated under the assumption that drift is occurring directly from specific fields. More concern is now being expressed that the source of injury is directional in nature and emanating from various sources many miles from the application sites. Based on prevailing climatic conditions, the possibility remains that directional atmospheric transport of phenoxy esters can cause injury to wine grapes at a time when vineyards are most susceptible to plant damage and yield reduction. Preliminary results from 2001 suggest that regional transport may still be occurring. The results of this work supports the needs of Washington and Oregon wine-grape/cereal grain growers and regulatory bodies in eliminating the use of semivolatile phenoxy-type esters after March 30.

Allocated Resources

Total Expenditures for all projects:

Source of Funds	Amount
State Appropriations	\$258,232.94
Other Grants	\$172,616.57

Total Faculty/Staff FTEs: .75

FIELD DISEASE INVESTIGATION UNIT

GOAL 2: Overview:

Prevalence and virulence of Shiga-toxigenic *E. coli* (STEC) from dairy, feedlot and range cattle is being examined. Currently we are examining the hypothesis that feeds represent an important means of dissemination of resistant bacterial clones and resistance genes to and among farms. Evidence to date indicates that feeds are commonly contaminated with resistant *E. coli* and *Enterococci* spp. and that, at least occasionally these become part of the flora of cattle. In a related USDA-NRI-funded project in collaboration with colleagues at University of California at Davis we are examining the hypothesis that a substantial fraction of multiresistant commensal *E. coli* and *Campylobacter* spp. found on widely separated farms are disseminated clones as opposed to having acquired their resistance genes on the farms where they are found. We have found many phenotypic matches (resistotype and biotype) between farms and are in the process of testing them genetically.

We have recently completed a study in which we tested the hypothesis that there is a low correlation between genetic and geographic distance for *E. coli* O157:H7 isolates from around the world. Our confirmation of this low correlation means, in practical terms, that closely related isolates (which share a recent common ancestor) are commonly found on different continents. This is consistent with a mode of frequent intercontinental transmission. Our finding of *E. coli* O157:H7 in feeds-in-commerce lends evidence to our hypothesis that feed is an important vehicle, particularly for international dissemination.

In a collaborative study the prevalence of *Listeria monocytogenes* in bulk milk from three Pacific Northwest states was assessed in 474 herds at three time-points. Sample collections occurred in November 2000 and June 2001, and the prevalence was 4.9% and 7.0%, respectively. Fifty-one of the 55 isolates belonged to serogroup 1/2a, while six belonged to serogroup 4. Six herds were positive for *L. monocytogenes* at both time points. Of these six herds, four had indistinguishable PFGE patterns at both time points. Twenty-five of the 33 herds that were positive in June 2001 were sampled again in June 2002. *L. monocytogenes* was recovered from 17 of the 25 herds (68%), eight of which had identical Apal restriction enzyme digestion profiles (REDP) as isolates recovered from the previous year. Apal REDP of the bulk milk isolates were compared to isolates recovered from environmental and human samples that were collected by the Washington Department of Health (n = 23). We found no direct REDP matches between bulk milk and clinical isolates.

The shedding of mycoplasma from milk of cows with infected mammary glands was studied. Ten cows confirmed to have mycoplasma intramammary infections were enrolled for 4 consecutive weeks in this study. The number of mycoplasma colonies per ml of milk was enumerated to determine shedding patterns of infected animals. Milk samples were collected daily for 28 days using aseptic techniques. Mycoplasma isolation from milk samples was initiated by directly plating fresh milk onto mycoplasma agar and also by inoculating mycoplasma enrichment media once a week; enrichment media was incubated for 4-5 days, and then transferred to agar. A bimodal frequency distribution of mycoplasma shed in mammary composite and quarter milk samples was observed. In composite milk samples, mycoplasma was not recovered in 29% of the samples, while 54% of the samples had more than 1 million colonies per ml in milk. In 43% of the quarter milk samples mycoplasma was not recovered while in 39% of the samples there were greater than 1 million colonies per ml. The milk of mycoplasma infected cows may contain insufficient numbers of mycoplasma organisms to be detected by standard culture procedures approximately one-third of the time. This could result in misdiagnosis of infected cows.

The effects of storage and thawing on the viability of Mycoplasma species in milk from cows with intramammary infections. The trial was designed using a control sample and seven freezing regimen's subjected to two methods of thawing. The results of this study indicate that storage and thawing of milk samples is harmful to mycoplasma organisms. Fresh samples should be used to improve detection of Mycoplasma species from milk of infected cattle. If frozen samples are used, then length of storage time should be minimized and thawing milk at ambient temperature will improve isolation rates.

We have examined the alkaloid absorption, metabolism and excretion of cows that have borne crooked calves and cows that have not -both groups having had the same exposure risk to lupine. We found no difference in alkaloid metabolism, nor in fetal response, between the two groups. The results of this study suggest that grazing behavior is a more important determinant of risk than cow to cow variation in alkaloid metabolism.

A prospective study of risk factors for pink eye in cattle in the Kittitas valley showed no evidence for trace element deficiency or inter-current upper respiratory viral infection as risk factors. Large populations of face fly (*Musca autumnalis*) were considered the major risk factor.

Benefits to stakeholders:

The benefits to stakeholders of the aforementioned research is significant. The enteric pathogens studied pose a health risk to both humans and livestock. Zoonoses becomes a critical element when considering disease prevention. Our work in Shiga-toxigenic *E. coli* O157:H7 remains a major thrust of our efforts and results from our studies will reduce the threat of zoonotic spread of this pathogen. Also, a major focus of our work is transfer of antimicrobial resistance genes and a developing program with *L. monocytogenes*. Lastly, the work in contagious mastitis, specifically *S. aureus* and mycoplasma mastitis, will impact food safety and milk quality. Both pathogen types can cause significant alterations in milk quality. We continue to address animal disease problems of regional significance to the State.

Unit Goals and objectives:

Definition and resolution of animal and zoonotic disease by epidemiological definition of risk factors and the development of on-farm control programs.

KEY THEMES -Food Safety, Food Security, Foodborne Pathogen Protection

Research Program Definition and resolution of emerging animal diseases in agricultural production systems. CRIS Project 0858

We shall continue on-farm investigations of new and unresolved disease problems within the state. We shall continue our close on-farm and commodity contacts, our liaison with the Washington Animal Diseases Diagnostic Laboratory and the monitoring of submissions to it, the contact with private practitioners and livestock agents and the perusal of local and overseas scientific veterinary literature.

Statement of Issues

Emerging animal diseases threaten the viability of farms. Zoonotic disease is a concern to the health of farm families from direct transmission and to the community as a whole from transmission through animal products used for human food. Control of these infections at the level of the farm reduces risk for human disease at the lower end of the farm-to-fork food chain.

Performance Goals

We shall define the epidemiology of zoonotic and emerging diseases in farm animals and the farm environment. We shall also develop disease control strategies based on knowledge of the ecology and epidemiology of disease agents in the farm environment.

Key Program Components

We shall continue epidemiological studies on zoonotic agents such as *E. coli* O157:H7, *Listeria monocytogenes*, *Salmonella typhimurium* DT104 and *S. aureus* and *Mycoplasma sp.*, at the level of the farm. Next, we shall develop intervention strategies for control.

INTERNAL AND EXTERNAL LINKAGES

The Field Disease Investigation Unit is funded as a conjoint program between the WSU College of Agriculture and Home Economics and the WSU College of Veterinary Medicine. This linkage allows close collaboration with scientists in the agricultural disciplines and with cooperative extension personnel in the State. There is a close linkage with the Washington Animal Diseases Diagnostic Laboratory and there are linkages with veterinary scientists and in the basic sciences. The unit relies on close collaboration with the animal agricultural community, and with individual private farms for its on-farm research.

Target Audiences

Target audiences include private farmers, private and public sector veterinarians, veterinary educators and veterinary scientists and cooperative extension personnel.

Evaluation Framework

The evaluation framework includes both quantitative and qualitative data. Specifically, changes in disease control and management practices by our clientele would be a significant factor in evaluation.

Output indicators

Output indicators would include: number and importance of diseases researched; publications and new or revised disease control or management strategies developed.

OUTCOME INDICATORS

Outcome indicators include: improved knowledge of the epidemiology and ecology of emerging and zoonotic disease agents by producers and veterinarians; reduction of disease and/or infection at the level of the farm and adoption of disease control and management strategies.

Program Duration

The program has both short term and long-term features.

Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	\$70,214.27
State Appropriations	\$173,483.10

Total Faculty/Staff FTEs: 3.07

HORTICULTURE AND LANDSCAPE ARCHITECTURE

GOAL 2: Overview:

The Department of Horticulture and Landscape Architecture maintains research programs in the following areas: Post-harvest quality of fruits and vegetables.

A. **Research Results** from projects supported by Hatch formula funds.

Scientists in the Department conduct research related to post-harvest storage, handling, and quality of several fruit and vegetable crops. The research results from these studies include:

1. Flavor chemistry studies have found that fruit quality can be maintained with proper post-harvest storage techniques.
2. Volatile production by controlled atmosphere (CA) stored fruit increases with consecutive harvest dates until 163 days after full bloom (DAFB) and during the post storage ripening period. This indicates that flavor can be regenerated after CA storage.
3. 1-methylcycloproene (MCP)-treated cranberries were evaluated for storage rot. MCP treatment in combination with CA storage decreases the amount of unsalable fruit at 6 and 12 weeks post storage.
4. Studies in seed potatoes indicate that levels of proteases, protease inhibitors, and soluble carbohydrates change appreciably during tuber aging, thus constituting biochemical markers of tuber age that could be used to predict the yield potential of seed.
5. The discovery of a new class of naturally-produced, volatile compounds that inhibit sprouting that will be useful for post-harvest storage of potatoes;
6. Assessment of storage and processing characteristics of several new potato cultivars that are suitable for production in the Pacific Northwest.

B. **Outcomes** that have resulted in significant changes within the state.

Results of these studies have caused significant changes in the horticultural industries of the state. Although some changes can be seen that could be considered the result of one year's work, most of the changes are a reflection of the impact of ongoing research programs. Some of these changes are:

1. Ten years ago 76% of the potato acreage in Washington was planted to the Russet Burbank cultivar. In 2001 approximately 96,500 acres (nearly 60% of the total potato acreage in Washington) was planted to cultivars other than Russet Burbank. At least 90% of this non-Russet Burbank acreage was planted to cultivars identified by the WSU cultivar-testing program as being adapted to Washington growing conditions. These potatoes have also been shown to have characteristics that make them especially suitable to post-harvest processing, an important consideration in a state where nearly 90% of the crop is processed.
2. Over the years the post-harvest studies related to tree-fruits have resulted in significant changes in how fruit is stored and handled. This work has also supported the development and adoption of new tree-fruit varieties that have the potential to maintain fruit quality during long-term storage.

C. **Benefits to clientele** (stakeholders) – Impacts: These include:

1. New potato cultivars: Nearly 90% of the Washington potato crop is processed. The new potato cultivars that are being identified by the Tri-State Variety Testing program have characteristics that make them especially suitable for processing.
2. New potato storage regimes, and use of newly identified sprout inhibitors have the potential to reduce the amount of crop that is lost after harvest.
3. New information about storage regimes and post-harvest handling procedures that maintain fruit quality results in greater economic return to growers and packers of tree-fruits.

D. **Accomplishments:**

Scientists in the Department of Horticulture and Landscape Architecture have made significant progress in identifying new fruit and vegetable varieties that are suitable for post-harvest storage and handling. They have also identified new post-harvest crop management products and procedures that will result in a more competitive horticultural industry. As noted, much of the research conducted by Department scientists has long term goals, and much is yet to be learned that will improve the situation of the horticulture industry in the state.

E. **Source of funding and FTE**

Total Expenditures for all projects \$234,275.59

Source of Funds	Amount
Hatch	\$0.00
Hatch Multistate Research	\$37,525.71
Federal Research Grants	\$114.39
State Appropriations	\$40,375.06
Other Grants	\$156,260.43

Total Faculty/Staff FTEs: 3.75

KEY THEME: Food Quality

Research Program - **Post-harvest quality of fruits and vegetables**
CRIS projects: 0346, 0797

A. Basic and applied research resulted in new information and a better understanding of:

1. The use of a chromotropic nitrene spin trapping agent to determine the role of active oxygen species in apple scald development. The amount of radicals trapped need to reach a certain level before symptoms occur. In some apples ('Gala') the radicals appear, yet there are no scald symptoms.
2. The ripening-related events that affect flavor perception in apples. Ester production was always closely linked to the onset of climacteric ripening, while prolonged low-oxygen storage was usually detrimental to volatile production.

3. Timing of the optimum harvest for maintaining sweetness, sourness and aroma generating capacity during CA storage.
4. The relationship between the internal ethylene maturity indicator and flavor retention and regeneration after storage for different lengths of time in “Red Chief” apple. It was found that overall flavor perception and perceived fruit ripeness began to increase at the onset of the climacteric. CA conditions reduced post-storage volatile production when compared to those stored in refrigerated air although not to a level below those displayed in “over-mature” fruit at harvest after 3 months in storage.
5. The responses to factors (growing environment, storage) that affect physiological age of seed, and elucidation of the postharvest handling procedures that may be useful for manipulating seed age to optimize yield and grade for various markets in Ranger and Umatilla Russet.
6. The growth and yield responses from northern- and southern-grown seed in the Columbia Basin. This knowledge will provide growers the opportunity to adjust management practices to achieve maximum productivity (yield & grade) for a particular market, when using seed from these areas.
7. The relationships among stem numbers, tuber set, yield, and tuber size distribution for Ranger Russet, Umatilla Russet and Russet Burbank cultivars. The resulting models provided the basis for development of relative ‘Crop Productivity Estimator’ calculators for northern- and southern-produced seed for use by the WA potato industry.
8. The role of 2-methyl butanol as a metabolic marker of relative seed productivity and its application in the ‘Crop Productivity Estimator’. When assayed at the end of the storage season, this marker accurately predicted the productive potential of our RB seed over three seasons.

B. Impacts include:

1. Due to overproduction, apple producers need to have high quality produce during the storage season to compete with fresh crops from the Southern Hemisphere. Fundamental investigations of flavor preservation in storage intend to assist producers competitiveness. Establishment of guidelines for producers to harvest fruit for immediate use or long-term storage ensures the highest quality possible. Fundamental studies of enzymes and physicochemical phenomena in apples has potential to create ontogenic markers for spray timing of certain growth regulators and minimizing oxidative disorders during the storage period for apples, thus lowering the unit cost of production.
2. The butanol content of seed-tubers at the end of the storage season (i.e. prior to planting) was a good indicator of the number of aboveground mainstems produced from both northern- and southern-grown Russet Burbank seed-tubers planted in the Columbia Basin. Since tuber set and size distribution could be predicted from stem numbers, the concentration of 2-m-butanol in seed can be used as a relative indicator of seed productivity. Productivity, however, can be defined in many ways. For example, productivity could simply refer to the total, U.S. #1 or marketable yields. Such a narrow definition is not adequate, however, since it is possible for these yields to be equal among different ages of seed-tubers, while the yield profile (e.g. tuber size distribution) varies greatly, as demonstrated for different seed sources and/or selected physiological ages. This research has led to the development of more complete seed and crop productivity estimators for the Columbia Basin of WA state.

- C. Scope of Impact: WA, ID and OR scientists and other scientists working in many research institutions and organizations worldwide.

WSU Wenatchee Research AND EXTENSION Center

GOAL 2: Overview:

Washington State University is recognized as a leader in tree fruit pest management worldwide. Systems integrating pesticides and biological control were pioneered in Washington at the TFREC, and this tradition has continued with the introduction of tools to better time pesticides, adoption of new technology to reduce use of broad-spectrum insecticides, the development of sampling plans and treatments thresholds to make the most effective use of both agricultural products and time of crop consultants, and practices that conserve biological control agents in orchards.

Research on integrated pest management serves to protect crops from losses by pests but also to preserve the important natural resources in Washington. New pesticides are always being introduced for use on fruit crops. These require someone to provide an unbiased evaluation for efficacy and non-target impacts, especially on biological control agents that are operating in fruit orchards. Conservation of natural enemies in fruit orchards results in the savings of several millions of dollars annually for growers. Our research provides Washington fruit growers with information allowing them to make informed decisions that save pest control expenses. New degree-day models have been developed that provide for better timing of pesticide applications for a newly emerging pest.

A. Research Results:

PEST MANAGEMENT SYSTEMS - PESTICIDES

1. The neonicotinoids thiamethoxam, acetamiprid, thiacloprid and imidacloprid all provided good control of white apple leafhopper, as did indoxacarb.
2. Pyriproxifen, methoxyfenozide, and spinosad provided good control of leafrollers of the overwintering generation.
3. Several chloronicotinoids have proven effective for control of pear psylla. In addition, large plot tests using neem-based products provided seasonal suppression of pear psylla while conserving natural enemies. An areawide management program based on use of prebloom applications of Surround (kaolin) reduced psylla densities and provided a better synchronization of the first generation, allowing other selective insecticides to perform better.
4. Grape mealybug laboratory bioassays indicated new neonicotinyl compounds (chloronicotinyls) would be useful in mealybug management. Field trial indicated that neonicotinyls were effective against this pest. Applaud was also shown to be effective at controlling grape mealybug.
5. Field studies showed that acetamiprid and thiacloprid gave good control for codling moth in a seasonal program. Increased spider mite populations noted in 2001 with acetamiprid use were mitigated by addition of oil.

PEST MANAGEMENT SYSTEMS – RESISTANCE MANAGEMENT

Baseline dose-mortality curves were developed for several pesticides (azinphos-methyl, acetamiprid, thiacloprid, methoxyfenozide, indoxacarb) against Codling Moth (CM) adults. Base-line mortality curves were developed for emectin benzoate, spinosad, and two CM

granulosis viruses (Carpovirusine and Cyd-X) against CM larvae. An ovicidal bioassay was developed for CM and data collected for two insecticides, methoxyfenozide and thiacloprid. A field-aged bioassay was developed for insecticide residues on apple against CM larvae, and data were collected for three insecticides, methoxyfenozide, acetamiprid and thiacloprid. A field-aged bioassay was also developed for insecticide residues on apple against CM eggs, and data were collected for five insecticides, methoxyfenozide, pyriproxyfen, thiacloprid, indoxcarb, and difluorobenzamide. All these bioassays provide the bases for assessing suspected resistant populations when control has failed or to provide a comparative basis to assess populations to determine if resistance is changing.

PEST MANAGEMENT SYSTEMS – MODELS

1. A degree-day model has been validated and was implemented for *L. subjuncta* control in 2002. This model helps growers better time the applications of pesticides to achieve control due to optimal timing.
2. Male flight as monitored by the DA lure (kairomone) was closely correlated to pheromone captures as well as Codling Moth model predictions during both generations. However, second generation observation and prediction correlations may be confounded by the size of a partial third generation.
3. Detailed observations of oviposition and egg hatch reflected the same pattern as moth flight in regards to model predictions for both generations.

PEST MANAGEMENT SYSTEMS – BIOLOGY AND BEHAVIOR

1. Adult thrips appeared on dandelion flowers before apple flowers developed and first appeared on apple buds at delayed dormant. On the orchard floor, dandelion flowers, as well as other flowers sampled, harbored thrips until frost, sustaining a resident population in the orchard. Thrips fed and reproduced throughout the year in near-orchard habitats by switching hosts that produced new leaves and flowers in different seasons. Some plants, such as arrowleaf balsamroot, *Balsamorhiza sagittata*, bloomed in spring and then were dormant until the next year. Others, such as gray rabbitbrush, *Chrysothamnus nauseosus*, provided growing shoots throughout the spring and summer and flowers in the fall. The dominant climax woody species of the steppe, big sagebrush, *Artemisia tridentata*, attracted great numbers of thrips when in bloom in the fall.
2. Of the newer cultivars evaluated, Gala, Fuji, Cameo, and Granny Smith showed some damage by campylopus feeding. Only Braeburn did not show any damage symptoms under the experiment conditions. The susceptibility of the cultivars Gala, Granny Smith, Fuji, and Cameo was similar to that of Delicious, and lower than that of Golden Delicious. Golden Delicious, the most susceptible cultivar tested, had a visibly lower density of trichomes on the surface of the fruitlet during bloom compared with the other six cultivars.
3. Lab studies on the delay in mating of Oblique Banded Leaf Roller (OBLR) show that at least two factors contribute to the observed reduction in population growth. First, older females tend not to mate and are more likely to be completely infertile. Second, delayed mating reduces egg production, increases the generation time and increases the time required for the population to double in size.

PEST MANAGEMENT SYSTEMS - MONITORING

1. The stink bug aggregation pheromone, methyl (2E, 4Z)-decadienoate, was placed in prototype lures by commercial companies and provided for testing. Two of the lures showed promise, equaling or exceeding attraction achieved by the WSU-lure.

2. Various traps baited with AA lures attracted from 5%-35% as many moths as the standard-load pheromone lure in a large delta-style trap. The wing-style trap captured the highest number of moths on average, but there were no significant differences among trap styles.
3. The AA-based technology was implemented on a larger scale to monitor both leafroller species at 21 orchards throughout Washington State as part of the Areawide II (AWII) program managed at WSU TFREC, Wenatchee. Moth captures in AA-baited traps were only moderately correlated with pheromone lure captures and did not represent a significant improvement in predicting larval populations.
4. Monitoring of leafroller larvae was conducted to determine the spatial relationships of populations. It appears that a distance between sampling sites of 30 meters would provide independence of data. These data will be used to optimize sampling for leafrollers.
5. Evaluations of a new lure technology, DA2313 (Trécé, Inc.), developed by a USDA scientist indicated that it is a good new tool for monitoring CM. The DA lure and high-load pheromone lures (10x) were about equal in performance. The pheromone lure tended to capture moths in the first generation, and the DA lure tended to capture moths in the second generation, but the differences in overall capture of moths/season were minor. The frequency of when the DA or pheromone lure captured or did not capture moths was almost the same in both years of the comparison.
6. Delta traps and Pherocon II traps caught significantly fewer campyloomma than did 1C traps. Efficiency did not correlate exactly with the amount of sticky surface. The efficiency of the delta trap was approximately half that of the 1C. The total capture in the Pherocon IIB trap was not significantly different from that of the 1C.
7. Geostatistical analysis of pandemis leafroller (PLR) and obliquebanded leafroller (OBLR) populations showed that damage begins in small pockets and each pocket expand outwards until they join. Spatial variation accounted for an average of 77% (range of 39-99%) of the total observed variation in mean population level. Application of Bt in our plots resulted in a distribution of LR that was fragmented into a large number of pockets, probably related to the spray coverage in the field.

PEST MANAGEMENT SYSTEMS – BEHAVIORAL CONTROL

1. IPM without organophosphate insecticides: Fifteen (15) paired apple sites of 20 to 40 acres have been established throughout Washington. All sites received pheromone treatments for control of codling moth, (*Cydia pomonella*). In half of each site supplemental controls followed a conventional pest control program while in the other half selective pesticides were used that did not include organophosphate insecticides. Orchards were monitored weekly with pheromone and bait/kairomone baited traps for codling moth (CM), leafrollers (*Choristoneura rosaceana* and *Pandemis pyrusana*) and lacanobia fruitworm (*Lacanobia subjuncta*). Six paired pear sites have also been established throughout Washington. Populations of pests at different apple sites were generally lower in 2002 versus 2001 based on monitoring results. At harvest there was no difference in the level of fruit injury from CM, leafrollers (LR), or lacanobia fruitworm (LF). There were fewer pesticide applications made in the Non-OP (7.3 ± 0.9) versus the OP (8.2 ± 0.9) programs, and while there was no difference in the cost of the two programs, costs in the Non-OP program declined an average of \$60/acre compared to 2001 (\$250 in 2001 versus \$189 in 2002).

2. Different selective programs to manage pear pests were implemented at six sites in Washington. The approach compared a conventional pest control program with one based on using insect growth regulators or other selective insecticides. There was no difference noted between programs in 2002 in either pest densities or program costs.
3. Evaluation of pheromone delivery technology: Sprayable pheromones were evaluated for management of CM and LR. Sprayable pheromone from the 3M Company did not show any activity against CM as measured by suppression of captures in pheromone traps. Sprayable pheromone from Suterra did provide control of CM in a low-pressure situation similar to a half rate of hand-applied pheromone treatment for the second year.
4. Evaluations of currently available hand-applied CM pheromone dispensers (Isomate, Checkmate, NoMate, and Disrupt) were evaluated for a second year in 2002. Aged dispensers were analyzed for residual pheromone content. These analyses showed differences in release characteristics among dispenser types.
5. A fiber formulation was evaluated as a delivery system (Scentry NoMate fibers) for effects on CM and LR. The fibers remained attractive when placed in a pheromone trap for over 50 days, and when aged on leaves for up to 35 days there was no difference in attraction between new and the oldest fibers. Fibers were retained on foliage for 35 days in both generations. Preliminary field trials applied with a prototype ground applicator showed suppression of moth activity of CM and LR for several weeks.

BIOLOGICAL CONTROL

1. The spatial distribution of leafrollers attacking apples in Washington was examined using isotropic variograms. The analysis showed that significant autocorrelation existed in all situations except when populations were only found in one small portion of a field. The range of autocorrelation was 5-9 meters when every tree within an area was sampled but varied from 222–210 meters at the larger scales.

B. Outcomes:

1. Recommendations from pesticide studies are used annually to develop recommendations on uses of new products in the tree fruit IPM program. These recommendations take into account not only efficacy of products against pests but also impacts on natural enemies. Fruit growers from several western states use WSU recommendations on pest control. The base-line data on pest susceptibility provide a foundation for assessing future questions about resistance.
2. The establishment of apple and pear implementation sites associated with the IFAFS and RAMP projects demonstrates to growers the opportunities and risks of moving away from traditional organophosphate based IPM programs. The new programs are designed to conserve natural enemies and reduce farm worker exposure to potentially harmful pesticides.
3. The development of new non-pheromone monitoring systems for Lepidopteran pests has not provided the resolution of pest densities initially hoped for. These tools have proven useful in research projects to assess such things as mating status and the impact of tactics on male and female densities.
4. Gaining a greater understanding of thrips biology and behavior is providing insights into possible new approaches to orchard management. The research on campyloomma impact on new apple cultivars is showing that most are susceptible to injury and that thresholds used on traditional varieties will likely work for new ones.

C. Benefits to Clientele:

PEST MANAGEMENT SYSTEMS

1. The evaluation of new pesticides for insect and mite control provides the unbiased information for WSU recommendations and eliminates inappropriate uses of pesticides. WSU recommendations save growers money because 1) they use the best pesticide for the situation and 2) they do not use pesticides that disrupt biological control.
2. Setting of baseline susceptibility for pests and then periodically reexamining susceptibility levels of field populations provide an early warning system of pesticide resistance development or can discount claims that resistance has developed in a pest population.
3. *L. subjuncta* is a pest on about 40% of Washington fruit acreage and a potential pest on all acres, and individual growers have reported crop losses as high as 30%. The degree-day model for *L. subjuncta* has proven its value by allowing control of this pest with a single well-timed application versus the two applications used in the past. This has the potential to save Washington fruit growers over \$2 million per year (\$30/acre times 68,000 acres).
4. The efficacy testing of new pesticides against pests, coupled with large plot implementation sites (IFAFS and RAMP project), has demonstrated that applications of some pesticides against one pest, codling moth, will suppress populations of other pests, leafrollers and *L. subjuncta*, below damaging levels without additional pesticide treatments. This information has the potential to reduce pest control costs to Washington growers by \$4 to 5 million each year.
5. The use of pheromones for insect management in Washington has reduced broad-spectrum pesticide use by 75% in many apple orchards. The development of aggregation pheromones as a monitoring tool and potentially a control strategy for stink bugs will reduce crop losses from this pest group that is a major threat to "soft" pest management programs.

BIOLOGICAL CONTROL

1. Sampling for leafrollers has revealed the timing of when certain parasites are present in the field. This will help in developing structured monitoring programs to assess not only leafroller densities but also the impact of natural controls on leafroller populations.

D. Accomplishments: IN RELATION TO WENATCHEE PLAN:

PEST MANAGEMENT SYSTEMS

1. Our plan is multi-faceted with the goal of moving away from a broad-spectrum dominated pest control system to a multi-tactic system that encourages natural controls. Our research has helped bring several new insecticides to registered status for use in tree fruit orchards. Our plan has provided for the development of baselines of susceptibility for key pests as a foundation for resistance management studies. These have now been established for several pest-pesticide combinations.
2. Our plan called for the development of tools to reduce dependence on pesticides or make them more effective. The model developed for *L. subjuncta* will improve control with fewer pesticide applications and allow the use of more selective insecticides against this pest.
3. Research on new non-pheromone sampling methods has not provided a better system for estimating in-orchard pests of leafrollers, codling moth or *L. subjuncta*. These have

provided useful tools for intensive research studies but not pest management implementation.

4. Research on use of pheromones to control pests addresses our plan's goal to develop IPM tactics that are environmentally friendly, encourage survival of biological control agents in orchards and make the orchard a safer workplace.

BIOLOGICAL CONTROL

1. This report shows progress in understanding the effects of new insecticides on biological control agents providing the basis for integrating their use in IPM programs. The development of pheromone-based pest controls will reduce dependence on broad-spectrum pesticides, thus conserving biological control agents in orchards.

E. Source of funding and FTE:

Total Expenditures for all projects: \$1,189,998.19

Source of Funds	Amount
Hatch	\$72,603.28
Hatch Multistate Research	\$153,706.95
Federal Research Grants	\$224,952.25
State Appropriations	\$266,416.88
Other Grants	\$472,318.83

Total Faculty/Staff FTEs 6.84

GOAL 3

FOOD SCIENCE AND HUMAN NUTRITION

Goal 3: Overview

A. Research Results from Research Projects Supported by Hatch Formula Funds

The Food Science and Human Nutrition Department continued to conduct research on the bioavailability and health aspects of several nutrients including vitamin B-6, calcium, and conjugated linoleic acid. Behavioral nutrition research continued to investigate culturally sensitive education for diabetes management and factors affecting calcium consumption.

B. Outcomes that have resulted in Significant Changes

Consumption of normal table salt in patients with kidney stones was shown to affect calcium loss and these results should affect current dietary counseling for these patients.

Improving dietary B-6 consumption was shown to improve immune response in young women and that the current vitamin B-6 level in the Recommended Dietary Allowance may not be adequate to prevent DNA damage and cancer, especially in smokers.

Culturally specific education programs for Diabetes patients will increase the patient's ability to manage this important disease.

E. Source of Funding and FTEs

Total Expenditures for all projects: \$432,575.38

Source of Funds	Amount
Hatch	\$56,041.81
Hatch Multistate Research	\$12,236.49
Federal Research Grants	\$174,672.12
State Appropriations	\$0.00
Other Grants	\$189,624.96

Total Faculty/Staff FTEs: 5.05

KET THEME: Human Nutrition

Research Program: Requirements and Function of Nutrients and other Food Components.
CRIS Projects: 0118, 0286, 0370, 0905

Vitamin B-6 Intake, Smoking and DNA Damage. Relationships among vitamin B-6 status, DNA strand breaks and smoking in men and women were investigated. Data suggest that vitamin B-6 inadequacy increases uracil incorporation in DNA, while smoking reduces B-6 status and increases oxidative damage to DNA.

Impact: This study suggests that the current vitamin B-6 Recommended Dietary Allowance may not be adequate to prevent DNA damage and cancer.

Nutrient Bioavailability – A key to Human Nutrition. Vitamin B-6 status improved with increased B-6 intake as measured by plasma pyridoxal Phosphate and urinary 4-pyridoxic acid. When subjects consumed 2.1 mg B-6/d for 7d, lymphocyte proliferation significantly increased by 35% compared to the mean value after consumption of 1.5 mg B-6/d for 14d.

Impact: Improving vitamin B-6 status in young women by consuming a B-6 intake greater than 1.5mg/d may have a positive effect on immune response as reflected by a significant enhancement of lymphocyte proliferation.

Nutrition in the Treatment and Prevention of Calcium Kidney Stones. Increases in dietary salt increased urinary calcium over the range of intakes commonly consumed. Both salt loading studies found that increased urinary calcium losses were approximately 40mg for each 2300mg increase in dietary salt.

Impact: These results are expected to impact dietary counseling of kidney stone patients to prevent stone recurrence.

Research Program: Nutrition Education
CRIS Projects: 0103, 0276

Dietary and Psychosocial Factors Affecting Self-Management of Type 2 Diabetes Mellitus. Funding for this project has been secured, and data collection has started for a project to develop culturally sensitive diabetes education for Hispanic patients with type 2 diabetes.

Potential Impact: Culturally specific education programs for Diabetes patients will increase the patient's ability to manage this important disease.

GOAL 4

AGRICULTURAL & RESOURCE ECONOMICS

GOAL 4: Overview:

One of the research programs of the Department of Agricultural and Resource Economics is Natural Resource and Environmental Economics.

A. Research Results From All Projects Supported By Hatch Formula Funds

Economic studies of resource and environmental economics resulted in greater understanding by scientists, growers, fishers, environmental groups, and policy makers of the impact of alternative laws, institutions and mechanisms on efficient allocation of water, value of reducing particulate pollution from agricultural sources, feasibility of incentive-based conservation policies, and potential and impact of rights-based fishing.

B. Outcomes That Have Resulted in Significant Changes

1. Research on resource and environmental economics was particularly important in impacting public policy in the arena of conflicting agricultural and environmental interests.
2. Washington policy makers have relied on agricultural water conservation research results to legislate water conservation practices.
3. USDA ERS is including our research results on mitigating farmer impacts of endangered species policy in a key policy report to the Risk Management Agency.
4. Research that discovered win-win property rights policies for public fisheries have been used by policy makers to improve management of federal fisheries.

C. Benefits To Clientele (Stakeholders)

1. The results of resource economics research at Washington State University had important impacts on environmental and water policy decisions at the state level.
2. Direct, policy-relevant information about conservation practices assists policy-making when agricultural and environmental conflicts emerge.
3. Research on property rights in public fisheries is having enormous financial implications for Washington fishers and processors.

D. Accomplishments Based on Department/Unit POW for 2002

1. The largest financial impact of resource economics research applied to the North Pacific fishing fleet and fish processors. The industry value of this fishery exceeds that of any Washington agricultural commodity, and most of the economic benefits of the fishery accrue to Washington. WSU research has had major impact and has been credited by external sources with changing the course of national policy, with enormous financial implications for the Washington seafood industry (per unsolicited stakeholder input).
2. Strong acceptance by clientele of resource economics research contributions was also evident in state policy formulation on water and environmental issues.

3. Nine refereed journal articles, bulletins, policy and trade magazine articles, and related products were disseminated that communicate the findings of natural resource and environmental economics research.

E. Source Of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	\$2,000
Hatch Multistate Research	\$27,000
Federal Research Grants	\$0
State Appropriations	\$162,000
Other Grants	\$77,000

Total Faculty/Staff FTEs: 2.4

KEY THEME: Natural Resource Management

Research Program: Natural Resource and Environmental Economics
CRIS projects 0160, 0299, 0691

- A. Economic studies of resource and environmental economics resulted in greater understanding by scientists, growers, fishers, environmental groups, and policy makers of: (1) the impact of alternative laws, institutions and mechanisms on efficient allocation of water, (2) value of reducing particulate pollution from agricultural sources, (3) feasibility of incentive-based conservation policies, and (4) potential and impact of rights-based fishing.
- B. Impacts:
 1. Research on resource and environmental economics was particularly important in the policy arena of conflicting agricultural and environmental interests.
 2. Washington policy makers have relied on agricultural water conservation research results to legislate water conservation practices.
 3. USDA ERS is including research results on mitigating farmer impacts of endangered species policy in a key policy report to the Risk Management Agency.
 4. Research that discovered win-win property rights policies for public fisheries have been used by policy makers to improve management of federal fisheries.
- C. Scope of Impact includes WA, OR, and ID scientists, farmers, and environmentally-conscious citizens, state and national policy makers, and scientists working in many research institutions and organizations world-wide.

BIOLOGICAL SYSTEMS ENGINEERING

Goal 4: Overview: An agricultural system that protects natural resources and the environment

A. Research Results from Research Projects Supported by Hatch Formula Funds

For this goal, the Department of Biological Systems Engineering is reporting activity in three Research Problem Areas: 112 Watershed Protection and Management, 113 Pollution Prevention and Mitigation, and 403 Waste Disposal, Recycling, and Reuse. Research results include field and catchment-scale hydrologic modeling using GIS and simulation models; characterization of the 3-d sediment and basalt occurrence and development of synthetic subsurface stratigraphic structures at the INEEL Idaho Nuclear Technology and Engineering Center; evaluation of no-tillage farming as a sustainable system that reduces environmental impact while protecting soil resources, including comparison of soil losses with conventionally-tilled farms and development of models to predict sediment delivery at a watershed scale; use of simulation modeling and other computer-based tools for decision support in the management of agricultural systems, with particular emphasis on site-specific crop management aimed at reducing pollution while preserving productivity; and development of an integrated nutrient management model for dairy production systems featuring dynamics and optimization. This large array of activities and research results is consistent with the departmental objectives to advance research in the field soil and water conservation from field to watershed scales.

B. Outcomes That Have Resulted in Significant Changes

New methodologies and models to study and to evaluate soil losses from fields and watersheds have been a significant contribution of these research projects. Findings have demonstrated the environmental benefits of no-till practice, especially for erosion reduction and water infiltration enhancement. Results are also contributing to increased understanding for the application of site-specific crop management approaches and to aid in the development of computer models that can be used to support crop management. Results are also helping to improve animal waste management practices that protect the environment.

C. Benefits to Clientele (Stakeholders)

Results on no-till practices provide a scientific base for developing policies that encourage farmers to adopt conservation tillage systems. They also contribute to a better understanding by farmers of the relationship between land management practices and environmental quality. Computer models are also helping our understanding of the benefits and consequences of land management decisions. The agricultural systems of the future are expected to be "smart systems" that take full advantage of information age technology. The comprehensive animal nutrient management systems being developed are designed as a tool to aid in the formulation of animal nutrient plans required by new US EPA rules for concentrated animal feeding operations.

D. Accomplishments Based on Department/Unit POW for 2002

Development and application of novel soil and water conservation methods and computer-assisted tools for evaluation and management are a major objective of the departmental POW for 2002. This report clearly shows the progress toward the accomplishment of this objective.

E. Source of Funding and FTEs

Total Expenditures for all projects: \$737,390.41

Source of Funds	Amount
Hatch	\$16,339.54
Hatch Multistate Research	\$5,191.98
Federal Research Grants	\$198,885.14
State Appropriations	\$194,012.97
Other Grants	\$322,960.78

Total Faculty/Staff FTEs: 10.05

Key Theme: **Food Quality**

Research Problem Area 402: **Engineering systems and equipment**

A. Research results.

The purpose of this project is to develop techniques used in processing and storage to reduce bruising or to improve processing equipment to reduce bruising. The research continues to focus on the conclusion from previous results that turgor conditioning or temperature conditioning can reduce bruise threshold and bruising by improving tissue strength and elasticity. Research is focusing on mathematical models that have guided work in the past to develop ways of measuring thermal properties of bruised and sound apple tissue in order to determine why bruises change temperature at different rates than does sound tissue, making bruises visible in thermal images during heating or cooling of the fruit.

B. Successes and outcomes.

The results of this work can be used by growers and processors of particular fruits and vegetables to reduce impact bruising. The research has been especially specific with regard to apples, potatoes, and onions with results applicable in states where these commodities are common (WA, OR, ID, MI, ME, GA).

C. Benefits to stakeholders. This information is integrated into section B above.

D. Accomplishments based on department/unit POW.

This research has measured properties of foods, especially thermal and other properties related to bruising. It has developed mathematical and computer models important in guiding future research and the application of the research in the areas of improved equipment for handling fruits and vegetables during harvesting and processing.

E. Total expenditures for all projects: \$150,596.11

Source of Funds	Amount
Hatch	\$841.22
Hatch Multistate Research	\$30,710.20
Federal Research Grants	\$40,853.80
State Appropriations	\$78,190.89

Total Faculty/Staff FTEs: 1.38

Research Problem Area 501: **New and Improved Food Processing Technologies**

A. Research results.

The project on using oscillating magnetic fields in food processing has concluded research and is now more heavily involved with analyzing and publishing data. The work has revealed that this technology shows little promise compared to other advanced nonthermal methods of food processing. The general topic of nonthermal methods of food processing is now part of a broad regional project on improving alternative food processing technologies. A project on mathematical modeling for food processing has developed data that will be useful in designing effective and inexpensive load cells and data analysis routines for grape trellis systems. Research projects on using electromagnetic energy for food processing have developed a finite difference time domain model to guide the design and manufacture of a new pilot-scale microwave sterilization system operating at 915 MHz. Testing continues for the model and for the sterilization system. The project has also developed a second-generation pilot-scale radio frequency sterilization system that is simpler to operate while providing more process stability than the first version. A project on developing improved gels used in food processes now has a novel infrared spectroscopy-system to characterize gellan gels, especially gelation points. This system will make research on gels much easier. A project focusing on asparagus is developing new ways of processing asparagus, especially those using electromagnetic energy.

B. Successes and outcomes.

The magnetic fields project has demonstrated the ineffectiveness of this technology for food processing and is preparing to move on to other technologies. The mathematical modeling project has developed results that might be useful in the general area of measuring the progress of crops through the season. The project on electromagnetic energy is improving methods for processing and sterilizing several foods, including asparagus, using this technology at various frequencies. The gels project has developed fundamental research methodologies that will allow greater progress in this general area.

C. Benefits to stakeholders. This information is integrated into section B above.

D. Accomplishments based on department/unit POW.

These projects are developing new knowledge of physical properties of foods and of computer modeling for food processing. They are also working with industrial and other collaborators to develop and to put into use new technologies in the use of electromagnetic energy in food processing.

E. Total expenditures for all projects.

Total Expenditures for all projects: \$836,081.05

Source of Funds	Amount
Hatch	\$10,735.59
Hatch Multistate Research	\$0.00
Federal Research Grants	\$79,727.25
State Appropriations	\$289,390.14
Other Grants	\$456,228.07

Total Faculty/Staff FTEs: 9.66

Research Problem Area 503: **Quality Maintenance in Storing and Marketing Food Products**

A. Research results.

A project on development and application of harvesting and processing technologies for production of value-added fruit and vegetable products has just begun with a focus on apples. After talks with representatives of the tree fruit industry, the project is trying to improve quality and reduce production costs by developing mechanization and new technologies for production, harvesting and processing systems. A project on nonchemical pest control methods is focusing on radio frequency energy for this task and is now studying the thermal death kinetics of several important insects.

B. Successes and outcomes.

The project on new harvesting and processing technologies has made contact with important grower and commodity organizations in the state and developed research projects of mutual interest. These groups, especially apple growers and wine grape growers, are highly motivated to develop and to implement new technologies that this project will produce. The nonchemical pest control project has published results of its work on thermal death kinetics of insects that will be useful to researchers studying thermal treatments for pest control. This work is especially applicable in states with substantial apple, wine grape, or post-harvest industries (WA, OR, CA, ID, MI, NY, NJ).

C. Benefits to stakeholders. This information is integrated into section B above.

D. Accomplishments based on department/unit POW.

These projects are working toward developing new knowledge of physical properties of foods and they are working with industrial and other collaborators to develop and to put into use new technologies in food processing.

E. Total expenditures for all projects: \$346,321.68

Source of Funds	Amount
Hatch	\$3,442.54
Federal Research Grants	\$310,285.75
State Appropriations	\$32,593.39

Total Faculty/Staff FTEs: 2.19

Key Theme: **Water Quality**

Research Problem Area 112: **Water: Watershed Protection and Management**

A. Research results.

One project in this RPA is focused on developing improved computer modeling for soil loss. As a part of this work, the project worked toward characterizing the three-dimensional sediment and basalt occurrence at the Idaho Nuclear Technology and Engineering Center, which has been extensively studied for its subsurface geology. The project developed an improved characterization of the subsurface for this site and an improved model for soil erosion and sediment transport on a watershed scale. Another project in this area is evaluating no-till farming as a sustainable system that reduces environmental impacts from farming while protecting soil resources. The research shows that no-till farming can significantly enhance infiltration of water

into the soil, reducing runoff and erosion. Further research showed that no-till farming resulted in the formation of fewer rills compared with other tillage systems.

B. Successes and Outcomes.

This research is improving computer modeling for soil erosion and sediment transport on a watershed scale. It is demonstrating the effectiveness of no-till farming for reducing runoff and erosion.

C. Benefits to stakeholders. This information is integrated into section B above.

D. Accomplishments based on department/unit POW.

These projects are developing and confirming new computer models for water movement and solids transport.

E. Total expenditures for all projects: \$474,623.32

Source of Funds	Amount
Hatch	\$11,347.02
Hatch Multistate Research	\$5,948.32
State Appropriations	\$139,982.61
Other Grants	\$317,345.37

Total Faculty/Staff FTEs: 5.68

Research Problem Area 113: **Pollution Prevention and Mitigation**

A. Research results.

The goal of the major project associated with this RFP is to understand and to discriminate spatially and temporally distributed yield-limiting factors throughout the dryland cropping region of the Palouse with the aim of establishing the foundation of a decision support system for site-specific crop management. The project has completed developing data for experiments aimed at gathering customized information on crop growth, yield and nitrogen uptake and partition as affected by yield limiting factors distributed across the landscape. Data are now being analyzed. The project has completed an evaluation of the computer model CropSyst as applied to a particular landscape for two barley cultivars. The goal is to improve the model to the point where it can be used to help in management decisions for precision agriculture.

B. Successes and outcomes.

The project was able to identify locations for experiments that are representative of sites used for dryland cropping in the Palouse and to gather data on the sites. The analysis of data and the expanding of research on CropSyst will move toward better computer models that will enable producers to take full advantage of computer technology to ensure a safe and adequate supply of agricultural products while protecting the environment and natural resources.

C. Benefits to stakeholders. This information is integrated into section B above.

D. Accomplishments based on department/unit POW.

The projects working on this RPA are confirming computer models that can be used in agricultural systems.

E. Total expenditures for all projects: \$207,682.11

Source of Funds	Amount
Hatch	\$68,930.81
Federal Research Grants	\$66,791.81
State Appropriations	\$54,030.36
Other Grants	\$17,929.13

Total Faculty/Staff FTEs: 3.77

Research Problem Area 403: **Waste Disposal, Recycling, and Reuse**

A. Research results.

The project is nearing completion of a computer model called Comprehensive Animal Nutrient Management. It includes mathematical models for the physical, chemical, and biological transformation processes of nutrients during collection, storage, and land application; it also includes these changes in nutrients in soil after land application. Ammonia volatilization is part of the model. Data collection has begun for testing the decision support system in dairy farms.

B. Successes and outcomes.

The project has completed and tested the Dairy Manure Systems Planner with a user's manual and spreadsheet in Excel. Work toward publishing the Comprehensive Animal Nutrient Management model is continuing and is on track. The results of this work have been presented in scholarly publications and in a regional Cooperative Extension conference on water quality, ensuring that wide audiences have access to the information.

C. Benefits to stakeholders. This information is integrated into section B above.

D. Accomplishments based on department/unit POW.

This research is studying waste management in agricultural and aquacultural operations in order to develop better policies and better models.

E. Total expenditures for all projects: \$132,093.33

Source of Funds	Amount
Hatch	\$0.00
Hatch Multistate Research	\$0.00
Federal Research Grants	\$132,093.33
State Appropriations	\$0.00
Other Grants	\$0.00

Total Faculty/Staff FTEs: 1.85

CROP AND SOIL SCIENCES

GOAL 4: Overview:

A. Research results:

1. A better understanding of the environmental impact of chemicals and soil, air and water pollutants have been achieved using precision application and detection technologies.
2. Environmental Precision management of fertilizer and needed pesticide inputs, new cropping systems and reduced tillage practices have been developed using alternative crops, to minimize environmental impact and to maximize net returns to growers.

B. Successes

1. GIS and remote sensing are effectively used to predict soil type in inaccessible areas critical to planning of recreational uses.
2. Remote sensing of winter soil cover allows us to measure the success of cover crops in reducing wind erosion.
3. We have a better understanding on how eolian sediments have been spread across the Columbia Plateau to better identify the variables controlling eolian deposits for better predicting future global change.
4. A better understanding of soil properties and microclimates enables us to critically site vineyards for the grape industry in the PNW.
5. Available Landsat image data, digital elevation models, Shuttle radar, and land type associations from the US Forest enables us to predict soils in inaccessible areas for recreational planning.
6. Modeling at the watershed scale has shown that we can predict from one watershed to another.
7. Researchers have gained a greater understanding of the physics of soil and water erosion, enabling growers to use new tillage techniques for maintaining productivity while reducing erosion.
8. In situ mobilization of native colloidal particles in Hanford sediments is possible under conditions of a tank leak, preventing colloid-facilitated transport of cesium.
9. Predicting metal accumulation in soil cropland is soil type dependent and changes even after a year or more.
10. Perennial ryegrass, as a rotational crop with potatoes, has reduced the need for field burning and has increased the viability of the grass seed industry.
11. Particulate organic matter (POM) and light fraction (LF) of soil carbon accumulate quickly under direct seeding and can be used as indicators of soil quality in the transition period.
12. Increase in water infiltration under direct seeding from old root and earthworm channels reduces water runoff and erosion.
13. Variable rate N management significantly reduces the potential for nitrate leaching below the plant root zone without adversely impacting crop yield or quality.

14. Research has provided organic and integrated apple growers in the Pacific Northwest with new production and marketing tools.
15. Grasslands in the western United States provide refuge for wildlife, enhancing regional biodiversity, and serve as essential reservoirs for biological control agents of crop pests.
16. Fragmentation of shrubsteppe communities could alter pest-natural enemy dynamics in nearby cropland, increasing pest pressure.
17. New tillage strategies and cropping systems for protection of our soil, water, and air resources are available to growers through the STEEP and PM-10 programs in the PNW.
18. New genotypes, alternative crops, and tillage practices through the STEEP and PM-10 programs have identified new cropping and tillage options that improve the economic return in the annual rainfall and wheat-fallow regions in the PNW.
19. The translocation of DNA that confers complete resistance to *Cephalosporium* stripe was identified, providing the first transfer of *Cephalosporium* resistance to wheat reported in the world.
20. Through abiotic factors such as soil physical characteristics, slope, and aspect, models are used to predict weed pressure and the type of management required for growers.
21. The study of decay and resistance in weed seeds has led to new approaches for managing weeds in developing the science for future research.
22. Perennial ryegrass, an excellent rotational crop with potatoes, has reduced the need for field burning and has increased the viability of the grass seed industry.
23. New tillage strategies and cropping systems for protection of our soil, water, and air resources are available to growers through the STEEP program in the PNW through cooperation of grower, industry, NRCS, and university-USDA scientists.
24. Through the encouragement of growing alternative crops, the STEEP and PM-10 programs have opened new markets that have improved the economic returns to growers and communities in the region.
25. The economic benefits of new cropping systems and tillage practices have been documented through many conferences, trade shows, video tapes, tours, field days, and various publications.
26. Production practices documented of organic and integrated apple growers in the Pacific Northwest and in the ability of conventional apple growers to convert to organic production methods will help expand economic opportunities for farmers and promote reduced use of agrochemicals.

C. Benefits to clientele:

1. Reduced tillage through direct seeding and reduced tillage has reduced our dependence on summer fallow and reduced soil erosion and air pollution through the STEEP and PM-10 programs.
2. Precision farming tools and refinement in remote sensing, Global Information Systems, and Global Positioning Systems have increased the efficiency of fertilizer and pesticide use and increased economic return.

3. Dissemination of information through bulletins, conferences, workshops, tours, case studies, and www information has informed our clientele of the most recent advancements in technologies for crop improvement, soil management, and marketing potential.

D. Accomplishments based on POW:

1. The Department of Crop and Soil Sciences has fully integrated its two main program areas, cultivar development and cropping systems through research, teaching, and extension.
2. Linkages through cooperation within this unit and with linkages to other units, colleges, branch campuses, USDA-ARS, commodity groups, international centers, and industry have provided synergy and cooperation in out reach programs.
3. Grower acceptance of our programs has been excellent as determined from the audiences at numerous functions conducted by Crop and Soil Sciences.

E. Source of Funding and FTE:

Total expenditures for all projects: \$1,667,620.97

Source of Funds	Amount
Hatch	\$48,011.96
Hatch Multistate Research	\$14,376.50
Federal Research Grants	\$250,581.26
State Appropriations	\$788,943.57
Other Grants	\$565,707.68

Total Faculty/Staff FTE's: 16.72

ENTOMOLOGY

GOAL 4: Overview:

The research program of the Department of Entomology is focused on the integration of biological control into existing and developing integrated pest management programs. Major research areas found within the department are: integrated biological control, integrated pest management and the reduction of our citizenry's dependence on broad-spectrum pesticides.

KEY THEME: Hazardous Materials

Research Program: Pollution Prevention and Mitigation.
CRIS projects 0349, 0372, 0470

Managing Agrochemical Behavior under drip irrigation systems. Drip irrigation is an efficient method for using water in the arid agroecosystems of the western U.S. Drip systems eliminate surface runoff and therefore overland movement of contaminants to aquatic systems. Surface

drip systems are easier to maintain than subsurface systems because of easy access to the pipe and examination of emitter functioning. Subsurface irrigation offers some advantages for weed control because the soil surface in a well functioning system remains dry. Furthermore, water is delivered in the root zone, so less is lost due to evaporation. The research reported shows that systemic insecticides like imidacloprid can be delivered adequately to the root zone regardless of whether applied in a surface or subsurface system. Also, leaching is very limited, even in the subsurface system. However, if mere detectability is a benchmark for environmental quality, than the surface drip system has some advantages over the subsurface system because residues do not seem to leach significantly below the main root zone. The reported research also suggests that imidacloprid, which is a very effective systemic aphicide but considered highly mobile and fairly persistent in soil, may dissipate comparatively quickly under typical conditions of the arid Pacific Northwest.

Mechanisms and Mitigation of agrochemical impacts on human and environmental health. The goal of our research is to help growers reduce the cost of pesticide applications while simultaneously maintaining efficacy and reducing worker exposure and off-target drift. We have hypothesized that new sprayer technology can allow reduced application rates in reduced volumes of water. During the 2002 growing season, we conducted a field experiment in a commercial orchard. The objectives were to compare residue deposition and efficacy of reduced rates of azinphos-methyl (Guthion) and methoxyfenozide (Intrepid) when applied by a conventional airblast sprayer and the newer reduced volume Proptech sprayer

Thus far, our field experiments suggest that insecticides commonly used to control codling moth damage in pome fruits can be effectively used at one-half of the recommended application rates. Reduction of application rates without sacrificing fruit quality will lower worker exposures and reduce pesticide residue load in the environment.

Reducing the potential for environmental contamination by pesticides and other organic chemicals. No-spray buffer zones are often required in forestry operations to prevent direct entry of pesticides applied by air into aquatic resources. The buffer zones often overlap with riparian management zones, and best management practices are recommended to minimize deposition in these areas. Little research has been conducted to characterize deposition of pesticides in riparian zones and to validate required no-spray buffer zone widths. We tested the hypothesis that riparian vegetation surrounding Christmas tree plantations would filter pesticide residues, thereby effectively minimizing contamination of streams or ponds

Pesticide spray drift is often associated with initially high concentrations of residues in water. Because these peak concentrations may be close to toxicological endpoints that are relevant to the health of aquatic organisms, no-spray buffer zones should be developed that are protective yet do not reasonably detract from commercial productivity. Development of toxicologically relevant no-spray buffer zones will help achieve this goal. The research reported shows that riparian buffer zones intercept drifting pesticide residues at very low concentrations. Furthermore, the model AgDRIFT reasonably predicts the drift-deposition function. Thus, the model can be used to set reasonable no-spray buffer zones, but the size of the no-spray buffer zone will need to be set to a specific forest-land use or agricultural field.

Source of funding and FTE:

Total Expenditures for all projects:

Source of Funds	Amount
Multi-State	\$294.50
Other Grants	\$108,064.34

Total Faculty/Staff FTE: .77 FTE

KEY THEME: Biodiversity and Biological Control

Research Program: Insects, mites, and other arthropods affecting plants.
CRIS projects 0243, 0315

Biological Diversity studies of arthropod taxa. During the past year this project has continued intensive, ongoing biological diversity studies of the Hanford Nuclear Site in southcentral Washington State. A sixth year of funding was procured from The Nature Conservancy and Department of Energy. The geographic area of study has moved to the north side of the Columbia River in the Saddle Mountain and Wahluke Wildlife Areas. We primarily are examining ground dwelling beetles (e.g., Carabidae and Tenebrionidae), spiders, and sun spiders, among others. Studies primarily are being conducted in three diverse habitats that will not only allow us to sample diversity, but will also allow us to make comparisons between habitats and within habitats. While literally thousands of specimens have been collected, approximately 7,000 have been prepared and/or identified, and are in various stages of curation. This material is being deposited into the James Entomological Collection. Species continue to be added to our "Hanford" list, which now numbers just over 1,800 species. Additionally, we have several hundred species still awaiting identification.

Biology and integrated management of insect and mite pests of wine grapes. Biological Control of Grape Leafhoppers. Detailed information on the egg parasitoids of grape leafhoppers in eastern Washington, essential for development of biological control programs, is now available for the first time. Six species of *Anagrus* wasps were identified from vineyards, with three responsible for the majority of leafhopper egg parasitism. All these species represent new records or range extensions for Washington State. *Anagrus erythroneuræ* was the dominant parasitoid captured on sticky traps in vineyards, although *A. tretiakovæ* was the dominant species reared from western grape leafhopper (WGLH) eggs. Grape leafhopper predators were significantly more abundant at sites with no pesticide input than at sites with high or low inputs. Enhancement of *Anagrus* populations during the first leafhopper egg generation is the key to improved biological control of grape leafhoppers. One strategy to achieve this may be cultivation of domestic roses near to vineyards. Studies on garden roses and roses planted at the end of vineyard rows in 2002 indicated substantial recruitment of rose leafhoppers and *Anagrus* spp. during September-November. Roses appear to be a good overwintering habitat for *Anagrus* spp. and may be an attractive cultural option for wine grape growers to improve biological control of leafhoppers.

Biological control of spider mites on grapes. Sampling sites for spider mites and natural enemies were established in June 2001 at 48 high-input, low-input and no-input vineyards in south central Washington. These sites were visited monthly from June until September in 2001 and 2002 for leaf and vacuum sampling of arthropods.

This research program is benefiting the Washington wine grape industry by developing pest management systems that are cost-effective, practical, sustainable and environmentally acceptable. Although still in its infancy, this research is beginning to alter management practices in vineyards. For example, growers now have the opportunity to use pesticides that are

compatible with biological control agents, rather than materials that are disruptive to vineyard ecology. Using predator-friendly chemicals encourages biological control and ultimately reduces the amount of chemical needed.

Extension of the large amount of data now flowing from this research to growers and consultants will progressively change vineyard pest management practices. Although not detailed in this report, conduct of the annual Wine Grape IPM Workshop (in collaboration with WAWGG) is an integral part of the research and extension process. Feedback from the 2000, 2001 and 2002 workshops indicates growers are modifying pest management practices based on our research and this will clearly increase as more results become available.

Source of funding and FTE:

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	\$120.51
State Appropriation	\$88,335.16
Other Grants	\$90,622.62

Total Faculty/Staff FTEs: 1.10

KEY THEME: Biological Control

Research Program: Biological Control of pests affecting plants.
CRIS project 0121

Biological Control in Pest Management Systems of Plants. New releases or redistributions of 42 weed phytophage species were affected at numerous locations throughout Washington State against 15 noxious weed species between 1993 and 2002. A 90% rate of bioagent establishment was achieved. Life history and impact assessment studies were completed for diffuse knapweed, yellow starthistle, purple loosestrife, common mullein and Scotch thistle natural enemies in Washington State.

The widespread utilization of biocontrol agents by weed management practitioners has lowered herbicide inputs, reduced land maintenance costs, increased forage plant productivity, enhanced indigenous plant survival, and diminished environmental degradation on thousands of acres of rangeland and wildland in Washington State.

Source of funding and FTE:

Source of Funds	Amount
Multi-State Hatch Funds	\$317.22

Faculty FTE: .25

KEY THEME: Integrated Pest Management

Research Program: Integrated Pest Management Systems.
CRIS projects 0302, 0339, 0381, 0392, 0405

Dynamics and Management of Pest and Natural Resource Populations Theoretical studies were continued on population dynamics, the structure of ecological communities, and methods for analyzing and modeling multi-species communities. A book was published on population cycles

and their causes through trophic interactions. Papers were published on the concept of population and regulation, and on the importance of population theory in pest management.

Continued study of the mechanisms of conifer defense against insects and fungi as part of the CONDEF project headquartered in Aas, Norway. We tested methyl jasmonate, a chemical elicitor of the defensive reaction of Norway spruce, as a method for increasing spruce resistance to infection by pathogenic fungi.

The work on conifer defenses has led to a better understanding of the interaction between bark beetles, pathogenic fungi and the host tree and is heading towards the possibility of immunizing conifers against insects and fungi.

Development of Integrated Arthropod Management Systems for irrigated crops in central Washington.

Overwintering larvae:

Data indicates that female current borers are being mated outside the fields then flying back in to oviposit. To combat this effect in 2002 densities of pheromone dispensers were increased at the two problem fields to ~ 300 per acre compared to ~ 200 per acre in 2001. Additional dispensers were also placed where possible for about 10 meters beyond field edges. Three applications of Danitol were also made during late May/early June to bring CB populations down to a lower level.

Mating Disruption Trial 2002:

The cane samples taken during winter 2001/02 indicated that mating disruption successfully suppressed numbers of current borer (CB) larvae in fields where only low populations (e.g. 0.1 larvae/cane) of CB existed prior to the use of pheromones. In fields where populations were moderate-high at the time of pheromone deployment suppression was less successful. Highest levels of larval infestation in pheromone-treated fields with large populations to begin with, was found in canes around the perimeter, indicating moths mated outside the fields and females re-entered to oviposit. These results indicate that it may be necessary to bring CB populations down to a low level before mating disruption can be employed and relied upon to maintain a low population. This research appears likely to result in replacement of the current insecticide-based control program for CB in Washington red currants, by mating disruption. The removal of insecticides for CB control will improve sustainability of production, while reducing crop and environmental contamination.

Development of Integrated Management Systems for High Value Specialty Crops in Central Washington A pest management program based entirely on biological control was again successful in maintaining mite and aphid populations below economic injury thresholds in a WSU hop yard. This is the third consecutive season in which a harvestable crop has been produced without chemical intervention. Biological and ecological studies on the arthropod fauna in this yard provide a model of biological control. Implementation of biological control strategies in three commercial hop yards reduced levels of pesticide use.

Development of a practical and sustainable arthropod management program in hops which is based on conservation biological control, is beginning to provide significant benefits to growers. Pesticide inputs and costs are being reduced, while efficacy and sustainability of pest management are being increased.

Biology and Management of Mealybugs in Washington Wine Grape Vineyards This project aided the registration of arthropod pest management tools for grape producers. Products registered for use on grapes in 2002 include buprofezin, fenpyroximate, fenpropathrin, and bifenthrin. All of these insecticide/miticide products are classified as reduced risk to humans

and are serve as good organmophosphate insecticide replacements. New insecticides serve as replacements for disruptive organophosphate insecticides.

Biology and Management of Mealybugs in Washington Wine Grape Vineyards Mealybugs in Washington wine grape vineyards in 2002 were relatively uncommon as they were in 2001. Samples of adult mealybugs were obtained from 12 vineyards and all were identified as the grape mealybug, *Pseudococcus maritimus*. Mealybug abundance and distribution was monitored monthly at 30 vineyard sites with either conventional, low or no pesticide input, in the Lower Yakima, Upper Yakima, Mattawa, Columbia Valley, and Walla Walla regions. Mealybug abundance was greater in conventional pesticide input vineyards and in the Upper Yakima and Mattawa regions. Very few mealybugs were found on low input and no input grapes. These data support the hypothesis that insecticide use is a factor in causing mealybug outbreaks, through disruption of natural enemies. Clarification of the species of mealybug(s) predominant in Washington vineyards is an important first step in developing management strategies for these pests and the virus (leafroll) they are believed to vector.

Potential of Insect Growth Regulators for Controlling Insect Pests of the Pacific Northwest. This project evaluated feeding stimulants to control neonates of lepidopteran orchard pests. The proposed strategy relied upon incorporating the feeding stimulants into pesticide formulations acting via the alimentary tract, and reducing the amount of active ingredients without reducing overall efficacy of pest control strategy. In 2002 we concentrated on four specific objectives: (1) Improving rain-fastness of monosodium glutamate, (2) Large-scale field trial with pesticide formulations enhanced with MSG, (3) Initiation of studies on universal potential of MSG as feeding stimulator and enhancer of pesticides that have stomach activity, and (4) Investigation of neonate's behavior on leaves treated with MSG.

We have initated our research toward incorporating the use of insect growth regulators in hybrid poplar plantings, by acquiring a Section 18 for the use of Dimilin®, an IGR that prevents chitin deposition.

Total source of funding and FTE: \$213,474.28

Source of Funds	Amount
Hatch	9197.56
State Appropriation	\$69,868.92
Other Grants	\$134,407.80

Total Faculty/Staff FTEs: 2.41

HORTICULTURE AND LANDSCAPE ARCHITECTURE

GOAL 4: Overview:

The Department of Horticulture and Landscape Architecture maintains research programs in the following areas: Environmental horticulture and the effect of plants on people.

A. Research Results from projects supported by Hatch formula funds.

Scientists in the Department conduct research on environmental horticulture and the effects of plants on people. Several publications resulted from the research on the effects of plants on people. One of these looked at human-horticulture relations in North and South America, and others reported on the relationship between childhood experiences and environmental preferences.

B. Outcomes that have resulted in significant changes within the state.

It is difficult to point to specific cases where the results of this research have caused changes within the state. The research related to human responses to plants and nature, the changes have taken the form of a more widespread recognition or understanding of the value of plants to society. This is the result of many oral presentations and seminars provided by faculty and staff involved with this research to garden clubs, master gardener classes, and other interested groups around the state.

C. Benefits to clientele (stakeholders) – Impacts

The research reported here produced benefits to society in the form of a better understanding of the effect of plants on human well-being. The research supports earlier findings that the presence of plants in the workplace results in reduced levels of stress, and lower employee absence.

D. Accomplishments of the department/unit POW 2002

Scientists in the Department of Horticulture and Landscape Architecture have made significant progress developing an understanding of the relationship between human well being and plants. These are on-going studies, and much is yet to be learned that will benefit the horticulture industry and the citizenry of the state.

E. Source of funding and FTE

Total Expenditures for all projects \$52,487.81

Source of Funds	Amount
Hatch	\$1,830.13
Hatch Multistate Research	\$0.00
Federal Research Grants	\$59.22
State Appropriations	\$50,598.46
Other Grants	\$0.00

Total Faculty/Staff FTEs: 0.82

KEY THEME: Other – Environmental Horticulture and Human/Plant Relations

Research Program - Environmental horticulture and the effect of plants on people
CRIS projects: 0695

A nationwide survey was conducted of adults in metropolitan areas and found that childhood experiences with nature influence adult sensitivities to trees and that the influence is very strong. More than 80% of the U.S. population lives in urban areas, where chances to interact with nature are greatly reduced. As the few remaining pockets of natural landscape become progressively more urbanized, more trees will be threatened to make room for new development. These research results provide information that could be useful to urban foresters/horticulturists and park managers.

A. Impacts include:

Trees are critical for healthy cities: they clean the air, reduce erosion, and save energy. People living in housing units with trees are calmer, healthier, and less violent. Children raised in homes with trees learn better. Nearly all urban adults, regardless of ethnic background, understand that trees are important in cities. They do not agree that trees cost cities too much or that trees are problems in cities. Children need contact with trees, plants, and nature to help those children grow up to understand the benefits of trees to their quality of life. Any types of programs that help urban children interact with plants and nature are helpful, including tree plantings, vegetable gardening, and bird watching. City parks, lakes, and even single trees can help those who have the opportunity to be near them.

B. Scope of Impact:

WA, ID and OR scientists and other scientists working in many research institutions and organizations worldwide.

DEPARTMENT OF NATURAL RESOURCE SCIENCES

Goal 4: Overview:

Research programs in the Department of Natural Resource Sciences are centered on Conservation biology and ecological restoration. Research conducted under this goal is a blend of basic and applied.

A. Research Results From Research Projects Supported By Hatch Formula Funds

Scientists in the Department of Natural Resource Sciences continue to work toward developing:

1. A better understanding of the ecology and propagation of rare native plants that are critical to restoration of the highly endangered Palouse Prairie ecosystem (one of the most endangered grassland ecosystems in North America).
2. Ecological data on seedling recruitment and population dynamics for three eriogonum (i.e., buckwheat) species that could prove beneficial for revegetation of highly disturbed mine spoils and arid landscapes in the Columbia Basin.
3. An experimental test of alum injection and hypolimnetic oxygenation to reduce phosphorus availability, primary productivity, and algal blooms, and thereby improve water quality in the Newman Lake ecosystem.

B Outcomes That Have Resulted In Significant Changes

Two outcomes have already had a significant effect on resource management in eastern Washington. First, the increased understanding of ecological factors affecting flowering, seed production, seed viability, and seed recruitment for three important native species of buckwheat in the Columbia Basin has provided new insights into their use in a variety of restoration applications. Second, the demonstration of the long-term improvements in water quality through alum injections and hypolimnetic oxygenation of selected lake ecosystems impacted by urban development and watershed degradation has resulted in significant improvements in two eastern Washington Lakes near Spokane, WA. This technology is now being applied to additional lakes in the area exhibiting similar problems, with the potential for additional gains through follow on research efforts. In addition, the completion of a draft book manuscript on the ecology, conservation, and restoration of *Camas* and *Chalochortus* spp. – two groups of lilies, whose bulbs are important food and cultural resources for native American tribes in the western U.S. will have significant effect on public land management decisions in the region. In addition, this will become an important cultural resource reference for Native Americans.

C. Benefits To Clientele (Stakeholders):

Benefits to clientele to-date include improved water quality in selected eastern Washington lakes as well as increased knowledge of a growing list of native plant species suitable for use in a variety of land restoration situations in eastern Washington and throughout the northern portions of the Inland West.

D. Accomplishments Based on Department/Unit POW for 2001.

Scientists in the department have made significant progress toward our long-term goals of:

1. Expanding basic knowledge on autoecology and population/community ecology of plant and animal species of local/regional significance from the standpoint of biodiversity.
2. Expanding the basic knowledge of the form/function of terrestrial and aquatic ecosystems, and the response of such ecosystems to past/current perturbations.

3. Development of improved management strategies and techniques to both conserve-preserve existing form/function and biodiversity severely impacted ecosystems.
4. Effective dissemination of research derived, basic/applied knowledge to both the scientific community and to potential user groups and other constituents. However, much more remains to be accomplished.

E. Source of Funding and FTE:

Total Expenditures for all projects: \$312,349.95

Source of Funds	Amount
Hatch	\$209.65
Hatch Multistate Research	\$77,981.16
Federal Research Grants	\$100,163.20
State Appropriations	\$0.00
Other Grants	\$133,995.94

Total Faculty/Staff FTEs: 4.05

Key Theme: Biodiversity

Research Program: Conservation biology and ecological restoration

CRIS Projects 0247, 0238, 0221, and other extramurally funded projects.

A. Both basic and applied research on conservation of biodiversity in terrestrial and aquatic ecosystems in Washington State resulted in improved information for natural resource managers and a variety of federal, state, and private clientele. Key results include:

1. Better understanding of the ecology and propagation of rare native plants that are critical to restoration of the highly endangered Palouse Prairie ecosystem (one of the most endangered grassland ecosystems in North America).
2. Ecological data on seedling recruitment and population dynamics for three *Eriogonum* (i.e., buckwheat) species that could prove beneficial for revegetation of highly disturbed mine spoils and arid landscapes in the Columbia Basin.
3. An experimental test of alum injection and hypolimnetic oxygenation to reduce phosphorus availability, primary productivity, and algal blooms, and thereby improve water quality in the Newman Lake ecosystem.

B. Impacts include:

1. Creation of a long-term cooperative agreement with the Plant Materials Center of the Natural Resources Conservation Service at Washington State University to develop and implement a native plant conservation and restoration program.
2. Partial completion of a 20-acre demonstration watershed restoration project at Washington State University.
3. Development of a permanent endowment by the Mariposa Foundation to fund continued research on the conservation and propagation of rare native plants.
4. An agreement to provide technical research assistance and planning for ecological restoration on about 60,000 acres of shrub-steppe and riparian habitat on lands managed by the Colville Confederated Tribes.
5. Completion of a draft book manuscript on ecology, conservation, and restoration of *Camas* and *Chalochortus* spp. – two groups of lilies whose bulbs are important food and cultural resources for native American tribes in the western U.S.

6. Understanding of ecological factors affecting flowering, seed production, viability, and seed recruitment for three important native species of buckwheat in the Columbia Basin.
7. Demonstration of the long-term improvement in water quality that may be possible from alum injections and hypolimnetic oxygenation of selected lake ecosystems impacted by urban development and watershed degradation in Washington.
8. Began the creation of native plant, plant materials facility at the Washington State University, Steffen Center, Pullman, WA. The goals of this facility will be centered on the establishment of a wide array of native plants at the Steffen Center, with particular emphasis being given to those adapted to xeric conditions, and the production of limited quantities of seed for use in restoration projects. The facility is expected to become an important teaching facility in the future as well.

C. Scope of Impact:

Federal and state resource management agencies, native American tribes (e.g., Colville, Spokane), private landowners, and citizen lake associations in Washington have been actively participating in these research projects and applying the research results.

WESTERN WASHINGTON RESEARCH AND EXTENSION CENTER WSU-PUYALLUP, MOUNT VERNON, VANCOUVER, LONG BEACH

Goal 4: Overview:

Research programs at the WSU-Puyallup Research and Extension Center focus on agricultural and environmental issues in Washington State with emphasis on western Washington. Areas of research include economically and environmentally sustainable production of high value specialty crops.

KEY THEMES: Nutrient Management, Soil Quality and Water Quality

Research Program: Soil, Plant, Water Nutrient Relationships
CRIS Project Numbers: 256, 308, 689, 690, 722

A. Progress reports of research projects.

Lysimeters were installed in lawns near shorelines to measure the nitrate-N and P concentration in the runoff. Over 24 soil samples were collected from soils near the perimeter of Lake Steilacoom.

Column studies were designed to simulate potential weathering of putting green sands. Two acidification rates were used to simulate weathering of the sands in one column while mildly acidic irrigation water was used in the second. Column contents will be measured for various factors.

The rate of cadmium and zinc release from a triple superphosphate and a western phosphate rock was measured as water soluble, dilute-acid soluble, and concentrated acid soluble.

Biosolids processing on the quantity and timing of plant-available nitrogen (PAN) release in the first and second growing seasons after application were measured on established tall fescue. A single biosolids application was made and grass yield and N uptake were measured for two growing seasons.

B. Benefits to stakeholders:

This study shows that the increase in soluble reactive P or inorganic N in the creeks is unrelated to a specific source, as assumed by a previous study and controlling P and N inputs into the soil within the watershed is critical to reduce the lake water productivity.

Previous years work indicated that calcareous sands can be changed both physically and chemically through artificial weathering processes. Current research is subjecting sands and simulated field weathering conditions and measuring physical and chemical changes but is inconclusive at this time.

Cadmium in phosphate rock is more available than previously thought in acid soils so phosphate rock containing high cadmium levels should not be used continuously for crop production.

Biosolids users and regulators have reliable biosolids N availability, more accurate rate estimates, and reduce the potential for leaching loss.

C. Scope of each impact:

Projects 308, 690, and 722 are state-specific for WA.

KEY THEMES: Integrated Pest Management

Research Project: Integrated Pest Management Systems
CRIS Project: 4741

A. Progress report of research projects:

Several large-scale replicated field trials were conducted against cranberry girdler larvae and root weevil larvae to evaluate the efficacy of imidacloprid and thiomethoxam applied in the summer and several fungicides for control of twig blight disease were conducted in a commercial bed of 'McFarlin' cranberries.

B. Benefits to Stakeholders:

New insect and disease control measures were developed or improved for cranberries.

C. Scope of Impact:

Project 4741 – State-specific to WA

D. Total Expenditures for all projects: **\$543,816.09**

Source of Funds	Amount
Hatch	\$122,655.81
Hatch Multistate Research	\$99,763.33
Federal Research Grants	\$31,740.15
State Appropriations	\$106,660.55
Other Grants	\$182,996.25

Total Faculty/Staff FTEs: 6.93

GOAL 5

Department of Natural Resource Sciences

Goal 5: Overview:

Research programs in the Department of Natural Resource Sciences are centered around:

1. The contribution of an expanded special forest products industry to community and economic development.
2. Natural resource based communities in the era of globalization.

A. Research Results From Research Projects Supported By Hatch Formula Funds

Scientists in the Department of Natural Resource Sciences have developed a better understanding of:

1. The distinction between commercial and recreational harvest of wild edible huckleberries and its social/economic complexity.
2. Have developed a cost effective inventory technique for noble fir boughs – a non-timber forest product used in the production seasonal greenery products.

B. Outcomes That Have Resulted In Significant Changes

Research completed under Goal V has contributed to the increasing emphasis being placed on the management of non-timber forest products on a commercial as well as a personal use level within the state of Washington over the past few years. It has also contributed significantly to the increased understanding of the complexity of the relationships between local societies and non-timber forest resources. Hence this research has directly affected the management of millions of acres in the state of Washington and the Pacific Northwest. Further, research completed on non-timber forest products in the Pacific Northwest has strongly influenced similar work in other regions of the United States and Canada, due to the high concentration of research underway in the Pacific Northwest relative to the rest of the United States and Canada at this time.

C. Benefits to Clientele (Stakeholders)

Benefits to clientele to-date are the development of improved inventory methods for use in estimating harvestable quantities of noble fir boughs for use in seasonal decorations and an increased understanding of the importance wild edible huckleberry production in north eastern Washington and northern Idaho. The use of improved inventory methods for estimating harvestable quantities of noble fir boughs are currently in the early stages of adoption by the US Forest, the Washington Department of Natural Resources and land owners/managers in the state. Adoption of this methodology should further increase the amount of revenue garnered from the sale of these products and the enhanced management of the species for the boughs as well as a variety of other market and non-market values. Similarly, the increased insights gained into the importance of wild edible huckleberry production to a wide variety of stakeholders in north eastern Washington has already resulted in an increased recognition of the importance of managing for these products on public lands.

D. Accomplishments Based on Department/Unit POW for 2002.

Scientists in the department have made significant progress toward our long-term goals of:

1. Expanding knowledge of the social and economic natural resource values in Washington and elsewhere in the region.
2. Developing information promoting new and/or improved means to attain sustainable and environmentally/socially acceptable economic benefits from natural resources.
3. Developing strategies and approaches to increase adaptability to changes in resource management and policies in resource dependent communities/sectors of society.
4. Developing and demonstrating new and/or refined approaches for conflict resolution on natural resource issues and 5) effective dissemination of research-derived, basic/applied knowledge to both the scientific community and to potential user groups and other constituents of the state and region. However, much more remains to be accomplished.

The contribution of an expanded special forest products industry to communities and economic development portion of this area of research is in its final stages and will be terminated during 2003, except for the publication of the final manuscripts resulting from this work. Other work pertaining to affect of exogenous forces on rural communities in the West will continue with the emphasis shifting to the affects of wild fire on communities.

E. Source of Funding and FTE

Total Expenditures for all projects: \$103,028.20

Source of Funds	Amount
State Appropriations	\$12,260.61
Other Grants	\$90,767.59

Total Faculty/Staff FTE: 2.07

Key Theme: **Impact of Change on Rural Communities**

Research Program – Social and economic dimensions of natural resource sciences
CRIS Projects 0312, 0396 and other extramurally funded projects.

A. Studies pertaining the social and economic dimensions of natural resources have shown 1) that the simple distinction often drawn by land managers between commercial and recreational harvest of wild edible huckleberries is potentially a great over simplification, 2) development of cost effective inventory techniques for noble fir – a non-timber forest product used in the production seasonal greenery products and 3) the after affects of wild fire on rural communities is critical to the development of effective public land management policy.

B. Impacts Include:

1. Increased recognition of non-timber forest products generally and wild huckleberries in particular to local people in areas where they occur.
2. The development of cost effective inventory techniques for noble fir will contribute significantly to the improve management of these species.

3. Cost-effective inventory methods will increase the feasibility of managing non-timber forest products on a sustainable basis.
4. Increased emphasis on management of non-timber forest products on a commercial as well as a personal use level.
5. Increased understanding of the complexity of the relationships between local societies and non-timber forest resources.

C. Scope of Impact

WA, OR, CA, ID, MT scientists and other scientists working in many research institutions and organizations worldwide.

DEPARTMENT OF RURAL SOCIOLOGY

Goal 5: Overview:

Research Programs in the Department of Rural Sociology are aimed at the development of knowledge to help individuals, families, and communities participate in and guide their own change in a globalizing world.

A. **Research Results** from Research Project Supported by Hatch Formula Funds

Research on projects in the Department of Rural Sociology are quite varied and include finding better survey techniques with emerging web-based technologies, delineating factors related to family well-being, exploring the implications of social and demographic changes for local communities, improving local and direct marketing of agricultural products, and assessing factors related to energy conservation and environmentally sound buildings.

B. **Outcomes** That have Resulted in Significant Changes

1. Work is being done on improved visual techniques to reduce errors when conducting surveys.

2. Interviews with industry, government and community sources resulted in a set of policy recommendations aimed at encouraging the building industry to pay more attention to constructing environmentally sound buildings.
3. Analysis of data on marital interaction documented that self and spouse perceptions can impact marital satisfaction and thus stability
4. Interviews with farmers, consumers and retailers showed a growing desire to market products on a more local basis, and are being refined to help support possible direct/local marketing initiation.
5. Examination of recently released data from the 2000 Census showed a rapid increase in the Hispanic population in many small, agricultural counties in Washington.

C. Benefits to Clientele (Stakeholders)

1. Better visual techniques on questionnaires and web-based surveys is making it easier to conduct quality surveys at a lesser cost.
2. Information on factors influencing marital satisfaction has been communicated to policy makers to help them alleviate problems that lead to marital instability.
3. Survey results are helping policy makers at the county level work towards better local marketing systems for locally grown products.
4. Significant attention is being paid by policy makers on processes and incentives that will enhance the environmental quality of buildings.
5. Information on changes in the social and demographic composition of local areas is being used by community leaders and decision makers to shape more accurate community development plans.

D. Accomplishments based on Department/Unit POW for 2002

As the above indicates, progress has been made in all areas of the department's POW: enhancing attention to constructing environmentally sound buildings, helping communities cope with changing food systems and social and demographic characteristics, investigating factors that will improve family well-being and investigating the emerging survey techniques.

E. Source of Funding and FTE

Total Expenditures for all Projects:

Source of Funds	Amount
Hatch	\$17,658.00
Hatch Multistate Research	\$12,673.64
Federal Research Grants	\$117,938.00
State Appropriations	\$253,057.30
Other Grants	\$441,489.91

Total Faculty/Staff FTEs: 3.78

Key Theme: Community Development

Research Program: Sociological and Technological Change Affecting, Individuals, Families and Communities; CRIS projects: 0127, 0230, 0280, 0932, 0942, 0981

A. Description of Activities:

In 2002 Research Faculty in Rural Sociology carried out studies on: 1) differences in survey collection techniques, question structures, and visual designs, 2) family well-being, 3) the links between consumers, commodities and communities, 4) factors influencing the construction industry to adopt more energy efficient buildings, and 5) the changing racial and ethnic make up of rural communities.

B. Impacts:

1. Research on better survey visual and branching techniques is being used to reduce the cost and enhance the accuracy and response rates to these surveys.
2. Ongoing research on the consequences of self and spouse perceptions for marital satisfaction and individual well-being helps family practitioner and counselors alleviate family problems that lead to marital conflict and instability.
3. Local extension agents and farmers learned of the need to have more locally oriented marketing systems in eastern Washington and are continuing to assist with research that would help improve these systems.
4. Policy makers in western states learned of several methods for encouraging the construction industry to build more environmentally friendly, energy efficient building.
5. Community leaders, businesses and policy makers have a better understanding of the changing social/demographic characteristics of the populations in their areas.

C. Scope of Impact

1. National and part of W-183 (now WCC 1001)
 2. National
 3. Washington state, national, and part of NE 185
 4. West Coast (California, Oregon, Washington) and national
 5. Oregon, Washington and part of WCC-84
-

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.

Two 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.

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 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, a list of multistate research projects in which WSU faculty and ARS cooperators participate, and Hatch Multistate Research Funds travel expenditures for WSU participants to the annual MRF meetings.

Appendix B is a list of current Multistate Research Coordinating Committees in which WSU faculty and ARS cooperators participate and information about expenditures from multistate funds in support of travel by faculty to 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 2001.

AGRICULTURAL RESEARCH CENTER – COOPERATIVE EXTENSION COORDINATION

Faculty of the ARC and CE cooperate in program planning and delivery primarily on an individual basis. Forty-nine faculty, including 15 college administrators for a total of sixty-four, have split appointments between ARC and CE. 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.

The assigned funding for the Safe Food Initiative has enabled and ensured even more jointly planned and implemented research/extension programming. Refer to Appendix D for information on the results of the SFI.

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 2002, the target percentage is 3%; therefore, we have provided a report on these activities below.

WSU COMPLIANCE WITH AREERA

WSU has elected and was approved to report on 3% integrated research and extension activities for the Plan of Work Report for federal FY2002. Since Washington is an agriculturally diverse state, we chose to report on three projects encompassing benefits for a cross-section of Washington's citizens. Integrated research and extension projects include: composting for a variety of crops, weed interference and herbicide effects on Western Washington crops, and management of diseases on field and greenhouse grown ornamental bulb crops.

Composting

Three focus groups with organic and conventional small-acreage farmers were held in western Washington during FY 2002. Topics were organic soil amendments, soil fertility, soil testing, cover crops, and riparian management. Information from the focus groups has been compiled and results are being used in planning research and extension activities for this project. New field experiments were established in both Washington and Oregon and laboratory testing for Nitrogen availability was performed at OSU on local organic materials (composted and uncomposted dairy solids, poultry manure, and yard trimmings). A long-term organic systems experiment was begun to evaluate effects of amendments, cover crops, and tillage on crop production, soil quality, and economics in an annual vegetable crop rotation. Effects of composted and non-composted dairy solids on disease suppression in a sweet corn-snap bean rotation are now being evaluated in a long-term field experiments and greenhouse bioassays. Disease suppression appears to be correlated with indicators of active soil organic matter and soil biological activity. The effect of amendments on disease suppression in raspberry is also being evaluated. A soil biology workshop was held in February, 2002, (attended by 400 farmers, gardeners, and agency personnel), and presentations were made at the Washington Tilth Conference in November, 2002, and at an organic agriculture symposium sponsored by the Washington State University Center for Sustaining Agriculture and Natural Resources. Details on the design and results of research, and educational posters from this project are available on the web at: <http://www.puyallup.wsu.edu/soilmgmt/IFAFS.htm>.

Impact: Immediate outcomes of this project are the use of focus group information in facilitating research and educational programs, and the dissemination of knowledge and discussion stimulated by the soil biology workshop. Research projects remain in progress; and thus, it is too early to evaluate on-farm impacts.

Weed Interference and Herbicide effects on Western Washington Crops

Research trials were conducted in Western Washington, which included a variety of agricultural and noxious weeds in a variety of crops. In all, 260 trials including over 4,900 individual treatments have been implemented since 1997. Crops on which trials were performed during 2002 included ornamental bulbs (tulip, daffodil, and iris), vegetable crops (cauliflower, sweet corn, potatoes, green peas, cucumbers, squash, and pumpkin), vegetable seed crops (spinach, beet, cabbage, coriander/cilantro, carrot, parsley, dill, and parsnip), and small fruit (blueberries, strawberries, and raspberries). Non-crop studies were also performed (meadow knapweed, reed canarygrass, blackberry, wild chervil, and general weed control). Results of these trials were communicated to growers.

Outcomes and Impact: Results from trials conducted in minor crops contributed toward new and continuing Section 3 (federal label), Section 18 (emergency use label), and Section 24(c) (special local needs label) registrations for 28 herbicides in 20 western Washington crops. Washington agriculture includes 240 crops, most of them considered minor crops. In order to sustain these industries, including a major seed industry in Northwestern Washington, it is necessary that registrations for the use of pesticides be made available. [The total value of crop production in Washington was \$3.3 billion in Y2000.]

Management of Disease in Bulb Crops

Washington has a major stake in ornamental crops, including the bulb industry. Conditions in Skagit County, Washington, are very favorable for growing tulips, daffodils and other bulb crops. In fact, growers in Skagit County compete with the industry in Holland. Pathogens of ornamental bulb crops can be carried on the surface of bulbs and corms, contributing to the spread and buildup of diseases during storage and production. Management of disease is generally based on a combination of cultural practices, environmental manipulations, and application of fungicides. Recently, there has been increased interest in general biocides or disinfectants as part of an overall disease management program. One of the disinfectants used to kill various pathogens in the food processing industry is chlorine dioxide, a replacement for gaseous chlorine in drinking water and in various meat and fruit/vegetable processing facilities. During the past two years, the effect of a one-hour exposure to varying levels of ClO₂ gas on the survival against five pathogens including: *Botrytis cinerea*, *Alternaria alternate*, *Fusarium oxysporum* f. sp. narcissi, and *Penicillium spp.* to 5 ppm ClO₂ was measured. Although the former pathogens were killed at 5 ppm, cells of the bacterium *Rhodococcus fascians*, which can occur on lily bulbs, required about 25 ppm ClO₂ gas to effect kill. Preliminary data from these trials indicate that exposure of the bulbs to low levels of ClO₂ significantly reduced the severity of blue mold that develops during pre-cooling. Results of the experiments have been shared with growers.

Impact Statement : If ClO₂ treatment is proven effective, and there are no adverse effects on the growth of bulbs, growers will be able to use this technology to reduce the threat of some production and post-harvest diseases.

Total Expenditures

Source of Funds	Amount
Hatch Funds	\$126,887.97
State Appropriations	\$94, 648.46
Other Grants	\$117, 334.36
Total:	\$338,870.79

Total Faculty/Staff FTEs: 4.38

Scope of impact: Regional, National, and International

SECTION IV

APPENDICES

Appendix A Multistate Administrative Advisors, Participants, and Travel

Appendix B Multistate Regional Coordinating Committee Activities

Appendix C Research/Travel/Extension Faculty Appointments

Appendix D Safe Food Initiative

APPENDIX A

Multistate Research Administrative Advisors, Participants, and Travel

Agricultural Research Center
Administrative Advisors FY 2002

Ralph P. Cavalieri, CAHE 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"

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"

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, Cooperative Extension

W-1001 "Population Change In Rural Communities"

W-167 "Family and Work Identities During Times of Transition"

FY 2002 Multistate Research Fund Projects with WSU Faculty and ARS Cooperator Participation

Prjct	Title	MRF #	Date	Term	Researcher
0913	Molecular Mechanisms Regulating Skeletal Muscle Growth and Differentiation	NC-131	09/2005	1	Dodson, M.V.
0467	Improvement of Thermal and Alternative Processes for Food	NC-136	09/2005	1	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
0119	Regulation of Photosynthetic Processes	NC-142	09/2007	1	Okita, T.W.
0119	Regulation of Photosynthetic Processes	NC-142	09/2002	2	Edwards, G.E.
0862	Metabolic Relationships in Supply of Nutrients for Lactating Cows	NC-185	09/2007	1	McNamara, J.P.
0406	Characterizing Weed Population Variability for Improve Weed Management Decision Support Systems to Reduced Herbicide Use	NC-202	09/2005	1	Williams, M.M.
0128	Marketing and Delivery of Quality Cereals and Oilseeds	NC-213	09/2003	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
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.
0301	Private Strategies, Public Policies, and Food System Performance	NE-165	09/2002	1	McCluskey, J.J.
0156	Multidisciplinary Evaluation of New Apple Cultivars	NE-183	09/2004	1	Barritt, B.H.
0230	Commodities, Consumers, and Communities: Local Food Systems in a Globalizing Environment	NE-185	09/2007	1	Jussaume, R.A.
0230	Commodities, Consumers, and Communities: Local Food Systems in a Globalizing Environment	NE-185	09/2007	2	Ostrom, M.

0409	Eradication, Containment 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	Hyde, G.M.
0990	Technology & Principles for Assessing & Retaining Postharvest Quality of Fruits & Vegetables	NE-1008	09/2007	2	Tang, J.
0990	Technology & Principles for Assessing & Retaining Postharvest Quality of Fruits & Vegetables	NE-1008	09/2007	3	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.
0122	A National Agricultural Program to Clear Pest Control Agents for Minor Uses	NRSP-4	09/2003	1	Walsh, D.B.
1262	Develop & Distribute Deciduous Fruit Tree Clones That are Free of Known Graft-Transmissible s Pathogen	NRSP-5	09/2003	1	Eastwell, K.C.
1262	Develop & Distribute Deciduous Fruit Tree Clones That are Free of Known Graft-Transmissible Pathogens	NRSP-5	09/2003	2	Howell, W.E.
1262	Develop & Distribute Deciduous Fruit Tree Clones That are Free of Known Graft-Transmissible Pathogens	NRSP-5	09/2003	3	Cavalieri, R.P.
1262	Develop & Distribute Deciduous Fruit Tree Clones That are Free of Known Graft-Transmissible Pathogens	NRSP-5	09/2003	4	Murray, T.D.
0806	Fruit and Vegetable Supply-Chain Management, Innovations, and Competitiveness	S-222	09/2003	1	Schotzko, R.T.
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2003	1	Lumpkin, T.A.
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2003	10	Coyne, C.J.*
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2003	2	Clement, S.L.*
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2003	3	Hannan, R.M.*
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2003	4	Johnson, R.C.*
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2003	5	Dugan, F.M. *
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2003	6	Cavalieri, R.P.
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2003	7	Welsh, M.
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2003	8	Bradley, V.
1134	Plant Genetic Resource Conservation & Utilization	W-006	09/2003	9	Hellier, B.
0372	Mechanisms and Mitigation of Agrochemical Impacts on Human and Environmental Health	W-45	09/2005	1	Felsot, A.S.
0470	Reducing the Potential for Environmental Contamination by Pesticides and Other Organic Chemicals	W-82	09/2005	1	Felsot, A.S.
0470	Reducing the Potential for Environmental Contamination by Pesticides and Other Organic Chemicals	W-82	09/2005	2	Gamerding, A.P.
0136	Control of Animal Parasites in Sustainable Agricultural Systems	W-102	09/2004	1	Jasmer, D.P.
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.

0447	Micro-Irrigation: Management Practices to Sustain Water Quality and Agricultural Productivity	W-128	09/2004	1	Fraisse, C
0215	Freeze Damage and Protection of Horticultural Species	W-130	09/2003	1	Keller, M
0691	Benefits and Costs of Resource Policies Affecting Public and Private Land	W-133	09/2002	1	Wandschneider, P.R.
0560	Genetic Improvement of Beans (<i>Phaseolus vulgaris</i> L.) for Yield, Disease Resistance, and Food Value	W-150	09/2005	1	Swanson, B.G.
0560	Genetic Improvement of Beans (<i>Phaseolus vulgaris</i> L.) for Yield, Disease Resistance, and Food Value	W-150	09/2005	2	Hang, A.N.
0664	Seed Biology, Technology, and Ecology	W-168	09/2003	1	Warner, R.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.
0764	Enhancing the Global Competitiveness of U.S. Red Meat	W-177	09/2002	1	Busboom, J.R.
0121	Biological Control in Pest Management Systems of Plants	W-185	9/2007	1	Piper, G.L.
0185	Genetic Variability in the Cyst and Root-Knot Nematodes	W-186	09/2003	1	Riga, E.
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.
0227	Rural Communities and Public Lands in the West: Impacts and Alternatives	W-192	09/2002	1	Holland, D.W.
0399	Community Economic Development by Merchandising, Producing, and Distributing Textiles and Sewn Products	W-194	09/2004	1	Salusso, C.J.
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.

**Multistate Research Funds Travel (October 1, 2001-September 30, 2002
Expenditures for WSU Participants (Not Including Coordinating
Committees)**

MRF Comm	Title	Total
NC-062	Enteric Diseases of Cattle: Prevention Control and Food Safety	1063.10
NC-136	Improvement of Thermal and Alternative Processes for Foods	1536.77
NC-140	Rootstock and Interstem Effects on Pome and Stone Fruit Trees	486.25
NC-142	Regulation of Photosynthetic Processes	567.27
NC-185	Metabolic Relationships in Supply of Nutrients for Lactating Cows	1217.89
NE-103	Postharvest Physiology of Fruits	2351.23
NE-112	Mastitis Resistance to Enhance Dairy Food Safety	620.05
NE-132	Environmental and Economic Impacts of Nutrient Management on Dairy Forage Systems	854.84
NE-179	Assuring Fruit and Vegetable Product Quality and Safety Through the Handling and Market Chain	1709.93
NE-183	Multidisciplinary Evaluation of New Apple Cultivators	486.25
NE-185	Sustaining Local Food Systems in a Globalizing Environment: Forces, Responses, Impact	483.10
NE-1006	Eradication Containment and/or Management of Plum Pox (Sharka) Disease	1011.62
NRSP 5	Develop and Distribute Deciduous Fruit Tree Clones that are Free of Viruses and Virus-Like Agents	1016.54
W-106	Multistate Research Coordination, Western Region	1860.00
W-112	Reproductive Performance of Domesic Ruminants	434.68
W-133	Benefits and Costs of Resource Policies Affecting Public and Private Land	1239.47
W-183	Improvement of Rural and Agricultural Sample Survey Methods	989.18
W-188	Characterization of Flow and Transport Processes in Soils at Different Scales	836.07
W-190	Agricultural Water Management Technologies: Institutions & Policies Affecting Economic Visibility & Environmental Quality	523.51
W-191	Parent and Household Influences on Calcium Intake Among Preadolescents	576.89
W-194	Community Economic Development by Mercandising, Producing, & Distributing Textiles & Sewn Products	707.34
Total:		20571.98

APPENDIX B

Multistate Research Coordinating Committee Activities

Current Multistate Coordinating Committees with WSU
Faculty and ARS Cooperator Participation
FY 2002

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	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	Carol Salusso	Textile and Apparel Research Coordination	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	Management of Codling Moth and Related Moths in the Orchard Ecosystem	9/03
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	Y. Duval	Agribusiness Research Emphasizing	9/04

Competitiveness

WCC -077	Alex Ogg, Jr. Frank Young J. Yennish A. Kennedy*	Biology and Control of Winter Annual Grass Weeds in Winter Wheat	9/04
WCC-081	Brady Carter Craig Morris	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	Beef Cattle Energetics	9/04
WCC-093	Alan Busacca Bruce Frazier	Western Region Soil Survey and Inventory	9/04
WCC-097	Timothy Murray, 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	Assessing the Chinese Market for U.S. Agricultural Products	9/05
WCC-102	Mary Hattendorf	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 Sustainable Production Systems for the Western U.S	9/04
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	Ray Huffaker 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	T. Wahl 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. Forseth W.C. Davis	Air Quality Issues Associated with Animal Facilities	9/06
NCR-193	G. Chastanger	Maintaining Plant Health: Managing Insect Pests and Diseases of Landscape Plants	9/06
NCR-194	K. Duft F. Chaddad	Research on Cooperatives	9/03
NCR-199	Charles Gaskins	Implementation & Strategies for National Beef Cattle Evaluation	9/06
NEC-063	D. MacKenzie	Research Committee on Commodity Promotion Programs	9/06

* UDSA Participant

Multistate Research Funds Travel (Oct. 1, 2001-Sept. 30, 2002)		
Expenditures for WSU Participants, Coordinating Committees Only		
MRF	Traveler	Totals:
NCA-13	Kirschner, Annabel	973.23
NCR-022	Moore, Pat	492.40
NCR-170	Zhang, Hao	1134.93
NCR-180	Pierce, Francis	1152.00
NCR-193	Chastagner, Gary	1234.63
NCR-199	Gaskins, Charles	982.09
NCR-59	Bezdicsek, Dave	100.00
NCT-183	Jausaume, Ray	614.98
SERA-IEG-31	Wang, Holly	1074.46
SRDC-0003	Chen, Shulin	1183.68
WCC001	Gaskins, Charles	822.82
WCC020	Crosslin, Jim	1483.43
WCC021	Dobrowolski, James	1022.44
WCC-023	Salusso, Carol	665.94
WCC-027	Knowles, N Richard	383.36
WCC-043	Brunner, Jay	319.61
WCC-055	Scarnecchia, David	918.36
WCC066	Pike, Keith	866.62
WCC-067	Granatstein, David	820.56
WCC-081	Kidwell, Kimberlee	534.39
WCC084	Kirschner, Annabelle	560.22
WCC089	Johnson, Dennis	1093.95
WCC-091	Fransen, Steve	792.15
WCC092	Johnson, Kristen	1084.01
WCC-093	Busacca, Alan	1340.00
WCC-097	Murray, Tim	1362.79
WCC-101	Wahl, Tom	1411.30
WCC-103	Stevens, Robert G	1380.94
WCC201	Froseth, John	802.17
WCC-203	Nelson, Mark	557.28
WCC-205	Stevens, Robert	1294.64
WCC207	Swan, Michael	506.42
	Total:	40759.03

Appendix C

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

FY 2002

MRF#	R/T FTE	EXT FTE	Participant
NCA-13	0.6	0.4	Kirschner, Annabel
NCR-170	0.875	0.125	Zhang, Hao
NCR-193	0.841	0.159	Chastagner, Gary
NCT-183	0.75	0.25	Jaussaume, Ray
NE-103	0	1	Kupferman, Eugene
NE-132	0.5	0.5	Harrison, Joe
NE-185	0.2	0.8	Ostrom, Marcy
W-045	0.8	0.2	Hebert, Vincent
W-133	0.9	0.1	Wandschneider, Philip
WCC-021	0	1	Dobrowolski, James
WCC-043	0.83	0.17	Brunner, Jay
WCC-067	0	1	Granatstein, David
WCC-084	0.6	0.4	Kirschner, Annabelle
WCC-089	0.5	0.5	Johnson, Dennis
WCC-091	0.6	0.4	Fransen, Steve
WCC-097	0.83	0.17	Murray, Tim
WCC-103	0	1	Stevens, Robert G
WCC-201	0.4	0.6	Froseth, John
WCC-205	0	1	Stevens, Robert

R/T = Teaching and /or Research Appointment
 Ext. = Extension Appointment

APPENDIX D

Safe Food Initiative

IMPROVING AND PROTECTING THE SAFETY OF OUR FOOD, FOOD PRODUCTION, AND THE ENVIRONMENT

A summary of progress under the Washington State University Safe Food Initiative

Background: Serious societal concerns continue over food safety and the protection of the environment and natural resource base on which food production is dependent. Deaths and illness due to food-borne pathogens, pesticides in the environment, and emerging food-related pathogens stimulated a request from Washington State University to increase its research and educational capacity to address these concerns.

The Safe Food Initiative was approved in the 1999 legislative session to create a variety of research and education positions within three Washington State University colleges. These positions augment and enhance ongoing research efforts to improve the safety, quality and marketability of Washington grown food products, while improving production efficiency and environmental impacts.

Funding history:	1999 – 2001:	\$4.25 million
	2001 – 2003:	\$7.50 million

External grant support generated by SFI faculty:	\$7.65 million
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Examples of progress against SFI benchmarks:

Improving food safety and quality for domestic and global markets

- Five new wheat varieties have been introduced with high-value end use qualities. Nearly 100,000 acres are already in production of the first variety approved. Five additional wheat varieties are being evaluated for introduction.
- Identification of the end use characteristics in wheat varieties desirable to Asian markets coupled with outreach and education to growers are improving competitiveness in global markets.
- Field trials indicate that modest potassium chloride fertilization in winter and spring wheat production can offset soil chloride deficiencies, potentially increasing yields by 3 to 5 bushels per acre, or up to \$10 million in value annually.
- New testing techniques have been developed with the potential to significantly reduce the time required to test for microorganisms, including *E. coli* 0157:H7, in food production.
- Introduction of new potato varieties is the result of evaluation of traits that improve quality, reduce waste in potato storage and processing and increase profitability. Ten percent reduction in waste will save the industry \$20 million annually.

- A group of naturally occurring chemicals found in many fruits and vegetables is proving potentially as effective as the most commonly used synthetic herbicide for inhibiting sprouting in stored potatoes. The technology has been patented.
- A genetic typing system for cattle is in development to provide a critical tool for developing more effective vaccines, identifying disease-resistant cattle, and preventing genetic mismatch that can result in early loss of bovine embryos.
- Microarray research is identifying differences in such pathogens as *E. coli* 0157:H7 and *Listeria monocytogenes* that will lead to improved methods for on-farm control of these food-borne pathogens.
- Methods for rapid and specific identification of exotic pathogens, specifically the high priority Contagious Bovine Pleuropneumonia, are in development. Rapid identification is critical to reducing losses from accidental or intentional introduction of exotic agents into agricultural animal production.

Protect Food Crops from Devastating Pests

- Mating disruption techniques are now used on 40 percent of the state's apple orchard acreage to control codling moth, reducing use of organophosphate pesticides by two to three applications annually. Each application avoided saves \$1.69 million per spray, and reduces insecticide use by 153,600 pounds.
- A new post-harvest disease – *Phacidiopycnis rot* – has been discovered that causes decay on pears and apples in storage, allowing the fruit packing industry to implement controls.
- A new biological control method combining beneficial insects and approved herbicides in carrot crops potentially will save growers up to \$ 1 million annually.
- Discovery of an aggressive foliar pathogen in spinach seed crops and its association with another fungus has lead to more effective fungicide use for their control, a discovery with important ramifications for both domestic and European spinach seed production.
- A lower-risk pesticide for Brassica seed crops received Section 24c approval by the Washington State Department of Agriculture and a second is in the approval process as a result of research into the efficacy and timing of fungicide application.
- The Washington State Commission for Pesticide Registration has undertaken 109 new projects on over 40 different agricultural crops to develop effective alternatives to pesticide use. The Commission also funded a program to promote the use of Integrated Pest Management strategies at schools and parks. WSCPR receives \$1.34 in matching funds for every dollar of public funds received.

Protecting Natural Resources with Economically Viable Food Production Systems

- A state-certified water quality testing laboratory has been established at WSU-Pullman providing water and soil analyses and water quality monitoring for conservation districts and other agencies, helping them obtain funding for water quality improvement, and WSU faculty compete for external grants.
- Using software to adjust diets of dairy cattle is proving effective in on-farm research in reducing nitrogen import to the farm by up to 8 percent while improving milk production and dairy profitability.

- An extensive outreach effort by a statewide team to landowners and watershed councils is disseminating the latest scientific and technical information on watershed management, effective riparian buffers and rangeland management.
- Research into methods for maximizing the benefits of direct seeding (no till) techniques are helping growers transition to direct seeding more profitably and with less risk. Data show that direct seeding is increasing organic matter in soil, improving water filtration and reducing erosion.
- Courses in small-scale and sustainable farming are now available at WSU-Puyallup, emphasizing agricultural entrepreneurship, business planning, marketing and ecologically based crop and livestock production. Students complete the course with a functional business plan.

SAFE FOOD INITIATIVE STATUS

Today's Date: April 2, 2003 ~ Questions, contact Rebecca Armstrong (509) 335-2822, armstro@wsu.edu

SEARCH TITLE	Rank	Current Salary	Appt	POS #	LOCATION	NOTES
ANIMAL SCI/BIO SYS ENG Dairy Nutrient Mgmt Specialist	4	\$35,387.40 \$35,387.76	.50E .50R	84085 84156	Puyallup	Joe Harrison, eff. 7/1/01
Ag. Research Tech. III		\$41,520.00	100R	42372	Puyallup	Debra Davidson, eff. 7/1/01
BIOLOGICAL SYS ENG Animal Nutrient Mgmt.	2	\$17,499.96 \$52,500.12	.25E .75R	84305 84304	Pullman	Post-Doctoral Research Associate: Goksel Demirer, eff. TBD
Research Tech. II		\$28,956.00	100R	82604	Pullman	Jonathan Lomber, eff. 3/14/02
CROP & SOIL SCIENCES Cereal Chemist/Bio Chemist	2	\$46,500.00	100R	84151	Pullman, W. Wheat Quality Lab	Brady Carter, eff. 7/31/00
Ag Research Tech I (Wheat Breeding Tech.)		\$14,124.00	.50R	85875	Pullman	Tracy Harris, eff. 8/1/01
CROP & SOIL SCIENCES Weed Scientist	2	\$56,599.20	100R	84042	Prosser	Martin Williams, eff. 1/1/01
Research Tech. Supervisor		\$41,329.32	.9021R	40366	Prosser	Virginia Prest, eff. 7/1/01
CROP & SOIL SCIENCES Soil Fertility/Soil Quality	2	\$22,680.00 \$34,020.00	.40E .4339R	84086 84152	Pullman Johnson Hall	Bill Pan, eff. 7/1/02
Research Tech. III		\$35,542.80	.90R	40573	Pullman	Eric Harwood, eff. 3/1/02
WHEAT BREEDING (CSS) Research Tech. Supervisor		\$45,816.00	100R	51886	Pullman	Gary Shelton, eff. 11/1/01
WHEAT BREEDING (CSS) Ag. Research Tech. III		\$34,092.00	100R	81952	Pullman	Kerry Barlow, eff. 5/1/02

SAFE FOOD INITIATIVE STATUS

Today's Date: April 2, 2003 ~ Questions, contact Rebecca Armstrong (509) 335-2822, armstro@wsu.edu

SEARCH TITLE	Rank	Current Salary	Appt	POS #	LOCATION	NOTES
ENTOMOLOGY Bio Control Specialist	2	\$17,100.00 \$39,900.00	.30E .70R	83943 84009	Pullman Food Science Building	William Snyder, eff. 10/2/00
Research Assistant		\$10,867.50	.50R	86927	Pullman	Amanda Koss, eff. 8/16/01-5/15/02
Research Assistant		\$11,191.50	.50R	86928	Pullman	Renee Prasad, eff. 8/16/01-5/15/02
ENTOMOLOGY IPM Tree Fruit Entomologist	2	\$24,277.44 \$49,290.60	.33E .67R	83942 84010	Wenatchee	Vincent Jones, eff. 9/1/00
Associate in Research		\$34,999.20	100R	86390	Wenatchee	Callie Eastburn, eff. 4/1/02
FOOD SCI/HUMAN NUTR Microbiology/Food Scientist	2	\$22,609.92 \$33,914.88	.40E .60R	83946 83956	Pullman Food Science Building	Dong-Hyun Kang, eff. 10/25/00
Research Tech. II		\$36,708.00	100R	85900	Pullman	Peter Gray, eff. 7/1/01
HORT & LAND. ARCH. Scientist		\$88,329.60	100R	81922	Pullman	N. Richard Knowles, eff. 7/1/01
Assistant Scientist		\$38,187.12	.84R	66679	Pullman	G.N.M. Kumar, eff. 7/1/01
INFORMATION Media Relations Specialist	A/P	\$60,000.00	100E	84080	Renton, WA	Denny Fleenor, eff. 5/1/01
NATURAL RES SCIENCES Rangeland Management	3	\$66,354.00	100E	84084	Pullman Johnson Hall	James Dobrowolski, eff. 10/15/00
PLANT PATHOLOGY Tree Fruit Pathologist	2	\$18,586.68 \$37,737.36	.33E .67R	84078 84044	Wenatchee	Chang-Lin Xiao, eff. 8/1/00

SAFE FOOD INITIATIVE STATUS

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SEARCH TITLE	Rank	Current Salary	Appt	POS #	LOCATION	NOTES
Scientific Assistant		\$45,135.00	100R	66564	Wenatchee	Robin J. Boal, eff. 7/1/01
PLANT PATHOLOGY Vegetable Pathologist	2	\$22,529.76 \$33,793.92	.40E .60R	84077 84043	Mt. Vernon	Lindsey du Toit, eff. 9/1/00
Ag Research Tech. III		\$41,520.00	100R	86454	Pullman	Michael Derie, eff. 7/1/01
NE DISTRICT Dryland Crops Agronomist	2	\$52,576.80	100E	83947	Davenport (Wilke)	Dennis Tonks, eff. 12/1/00
Ag Research Tech. II		\$34,932.00	100E	85077	Lincoln Co.	Darla Rugel, eff. 8/1/00
NW DISTRICT Small Scale/Urban Ag. Leader	2	\$27,587.40 \$16,552.44 \$11,034.96	.50E .30E .20R	84153 87420 87424	Puyallup	Marcia Ostrom, eff. 9/15/00
County Agent, E-2 Asst. Research Professor		\$38,400.00 \$4,800.00	.80E .20R	86107 88097	Puyallup	David Muehleisen, eff. 7/1/02
SE DISTRICT Livestock	2	\$25,962.48	.6551E	83944	Kittitas	Vacant (Justen Smith), eff. 7/1/00
SE DISTRICT Livestock	2	\$22,966.68	.6106E	83945	Grant/Adams	Sarah Smith, eff. 7/1/00
SOCIOLOGY Professor		\$10,908.00	.0909R	87313	Pullman	Eugene A. Rosa, eff. 8/16/01

SAFE FOOD INITIATIVE STATUS

Today's Date: April 2, 2003 ~ Questions, contact Rebecca Armstrong (509) 335-2822, armstro@wsu.edu

SEARCH TITLE	Rank	Current Salary	Appt	POS #	LOCATION	NOTES
COLLEGE OF VET MED Immunogeneticist	2	\$80,000	2.0	84088	CVM/VMP Pullman	Chris Davies, eff. 7/1/00
COLLEGE OF VET MED Infectious Disease Epidemiology	2	\$65-85K	2.0	84090	VCS Pullman	Roland Cobbold, eff. 4/1/01
COLLEGE OF VET MED Molecular Epidemiology	2	\$75,000	2.0	84089	CVM/VMP Pullman	Doug Call, eff. 7/1/00