ANNUAL REPORT
OF
ACCOMPLISHMENTS AND RESULTS

Agricultural Research Center

College of Agriculture and Home Economics

Washington State University

Pullman, Washington

Submitted to USDA/CSREES

APRIL 18, 2002

Period Covered

Federal FY2001
October 1, 2000 to September 30, 2001

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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, 2000 – September 30, 2001) are for ARC only.

During the period of this report CAHE was well over mid-way through 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 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 from several of the disciplines are located at the off-campus units.

Reports relating to the federal FY2001 CSREES Budget can be obtained by searching using key themes or keywords.

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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 FY2001, the ARC received and expended $2,038,092.00 in Hatch funds and $1,463,433.00 in Hatch Multistate Research funds. Of those amounts, $1,938,489.46 in Hatch funds was expended on projects contained in the POW. Expenditures of Hatch Multistate Research funds on projects in the POW total $1,406,137.32. *The remaining amounts ($99,603 for Hatch and $57,296 for Hatch Multistate Research) were expended on new or revised projects not included in the POW.*

Hatch and Hatch Multistate Research funds constitute 6.43% and 4.67%, respectively, of the total funds expended on projects included in the POW. State appropriations are 34.5% of the total with all grants totaling 54.38%.

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 Projects Included in the POW – Federal FY2001

Funding Source	CSREES Goals					Total	% of Totals[c]
	1	2	3	4	5		
Hatch Funds	1,425,587	72,620	1,863	426,786	11,633	1,938,489a	6.43
Hatch Multistate Funds	1,023,398	191,615	1,632	189,492	0	1,406,137b	4.67
Federal Research Grants	5,745,885	481,455	57,917	1,818,895	122,885	8,227,037	27.30
State Appropria-tions	6,817,714	723,452	232,803	2,381,479	251,998	10,407,446	34.53
Other Grants	5,858,006	478,253	42,956	1,732,432	49,490	8,161,137	27.08
Totals	20,870,589	1,947,395	337,170	6,549,083	436,006	30,140,243	–
Percent of Total $	69.24%	6.46%	1.12%	21.73%	1.45%	100.00%	–
FTEs	258.68	22.45	4.61	83.08	4.63	373.45	–
Percent of Total FTEs	69.27%	6.01%	1.23%	22.25%	1.24%	100.00%	–

[a] Total does not include remainder of the $2,038,092 Hatch fund allocations which are expended on new, revised, and other research projects not included in the POW. Funds are used in partial support of faculty/staff salaries, goods and services, and travel.

[b] Total does not include remainder of the $1,463,433 Hatch Multistate fund allocation which are expended on new, revised, and other research projects not included in the POW. Funds are used in partial support of faculty/staff salaries, goods and services, and travel.

[c] Percent of total for projects included in the POW.

SECTION II

EXECUTIVE SUMMARY

The majority of research performed by faculty having appointments in the WSU Agricultural Research Center supports the first national goal, an agricultural system competitive in the global economy. Certain impacts and outcomes achieved in 2001 were particularly noteworthy. Briefly, some of these highlights include: Employment of integrated pest management and the establishment of biocontrol agents in the Pacific Northwest agriculture has increased. Economic studies of agricultural production have resulted in greater understanding of effective machinery management, economics of product quality, supply chain management of fresh fruit, the cost of alternative agricultural transportation systems and estimation methods and model design. Market opportunities for Northwest beef producers have increased and predictive models have been established to optimize feeding regimens maintaining productivity in cattle while reducing the environmental load of phosphorous, selenium and zinc. Widespread use of biocontrol agents by livestock producers has lowered herbicide inputs, reduced land management costs, increased forage plant productivity, enhanced floral biodiversity, and diminished environmental degradation on thousands of acres.

A technology roadmap for tree fruit production has been established which advances precision agriculture techniques to tree fruit production. Improved varieties of cereals have been released, and new plant varieties have increased production. Pesticide inputs have been reduced and alternative crops in combination with reduced tillage practices have increased efficiency of crop production. Researchers have investigated new thermal and non-thermal processes to produce safe, value added food products. A new understanding has been developed of the physical and microbiological changes that food and food components undergo during value-added processing. Research has been conducted in breeding, management and production of tree fruit, small fruits and vegetable crops. New potato cultivars evaluated by the Tri State and regional variety trials have added $240 million to the economy of the Pacific Northwest. Changes in irrigation management practices have resulted in reduced water use and in improved yields. There has been an increase in the number of farmers who are practicing organic or integrated management of crops. Grower's approaches to disease management of fruit trees resulted in reduced fungicide inputs and have hastened the adoption of fungicide resistance management strategies.

Basic research in plant biochemistry has resulted in the improvement and enhancement of wood products, understanding the genetic and biological mechanisms of plants, and has improved the yields of various crops. The molecular basis of sapwood and heartwood formation has been clarified, half of the enzymes of the taxol pathway have been cloned, and a new polyketide synthase for the synthesis of polyunsaturated fatty acids has been discovered which may lead to more nutritious edible oils. New pathways by which plants defend themselves from opportunistic pathogens were elucidated, and the biochemical basis of stress in plants was investigated.

With regard to the safety and security of our food and fiber system (Goal 2), quarantine treatments of cherries and apples were developed utilizing a combination of heat and radiofrequency to replace the use of methyl bromide to eliminate insect pests to meet export requirements. Good Laboratory Practices Magnitude of Residue Trials were completed last year on eleven chemicals used on cherries, potatoes, apples, pears, potatoes, asparagus, hops and grasses. Research has produced engineering refinements to avoid bruising potatoes and other vegetables during processing which are amenable to growing conditions present in Washington.

In order to ensure a healthy, well-nourished population (Goal 3), our researchers made several important discoveries, including the discovery that the Diabetes Quality of Life Survey has great potential for monitoring patient self-management of type II diabetes. Also, the observation was made that the new recommended low level of vitamin B-6 for adolescent diets may too low.

Our researchers have also conducted projects, which ensure that there is an agricultural system, which protects natural resources and the environment (Goal 4). Important new observations were that: (a) Leaching of soils can be effectively managed by controlling irrigation scheduling; (b) Newer pesticides such as the neonicotinoids can rapidly dissipate when used for aquatic pest control or in chemigation; (c) Drip chemigation is most effectively managed by use of soil sensors to monitor irrigation scheduling. Also contributing to the accomplishments under goal 4, studies of biodiversity of arthropod taxa resulted in designating the Hanford Site a National Monument.

Research in several departments has resulted in enhanced economic opportunity and a better quality of life (Goal 5). Research includes: (a) developing better survey techniques with emerging web-based technologies; (b) identifying factors related to family well-being; (c) exploring the implications of globalization and social and demographic changes for local communities; (d) designing interiors more conducive to productivity and employee well-being; and (e) examining issues related to concern for the environment.

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

GOAL I

AGRICULTURAL ECONOMICS

GOAL 1: OVERVIEW

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

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, vineyard management options, wine consumption projections, the economics of product quality, reputation, and labeling, promotion and supply chain management of fresh fruit, pitfalls of financing cooperatives through patron demand deposits, costs of alternative agricultural transportation systems, estimation methods and model design.

Outcomes That Have Resulted in Significant Changes

1. Documentation of financial and legal problems associated with a financing practice that was once common among Washington cooperatives has resulted in its being rapidly curtailed.
2. Evidence that the Washington Apple reputation is declining has contributed to industry discussions about establishing minimum quality standards.
3. Promotion evaluation has led to changes in promotion efforts by the Washington Apple Commission.
4. Supply chain findings provide evidence that the pear industry will increase profits by narrowing the size range of fruit shipped to the fresh market.
5. GIS transportation analysis has enabled Washington policy makers to more accurately target roads that will require maintenance and/or upgrading and anticipate resurfacing costs.
6. Based on preliminary results for Washington dryland grain producers, the USDA Risk Management Agency is exploring alternative revenue insurance plans to protect farmers from price and yield uncertainty more effectively than yield insurance and futures market investment.
7. Documentation that frugal machinery management makes no-till production economic was partially responsible for a nearly doubling of no-till acreage in the Pacific Northwest between 1998 and 2002.

Benefits to Clientele (Stakeholders)

1. Fruit growers increase profits by exercising appropriate promotion and supply chain management.
2. Identifying the cause of likely increases in road damage leads to public policy that can reduce road damage and also assure adequate resources to keep highways maintained. This improves the efficiency of the agricultural marketing chain, thereby increasing prices to growers and decreasing prices to consumers.
3. Revenue insurance can reduce risks with less expense than a combination of yield insurance and futures market investment.
4. 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.

Accomplishments based on Department/Unit POW for 2001

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. Eight 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, 39.
5. Documented improvements possible from alternative decisions through increased profits and/or decreased risks include: (A) Average production costs for no-till winter wheat are 10% lower than typical tillage, (B) Market power in the wine industry is shifting toward wineries and away from grape producers, and (C) Grape producers in Washington have a strong economic incentive to use only certified potted plants resistant to winter kill and phylloxera when planting vineyards.

Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$18,000
Hatch Multistate Research	$45,000
Federal Research Grants	$126,000
State Appropriations	$470,000
Other Grants	$230,000

Total Faculty/Staff FTEs: 11.2

KEY THEME: Agricultural Profitability

Research Program: Production Economics
CRIS projects 0269, 0275, 0303, 0347, 0378

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) vineyard management options, 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.
   2. No-till practices implemented on dryland grain farms frequently increase profit to the farmer while reducing health risks to state residents. This mutually beneficial result is due to frugal machinery management and corresponding improvements in soil, air, and water quality.
   3. The financially devastating spread of phylloxera in wine grape producing areas of Washington that experience winterkill can be largely avoided by purchasing only certified potted plants.
   4. Improved accuracy in estimating the impact of changing policies on agricultural production result from careful attention to aggregation procedures.

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, 0301, 0343, 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) pitfalls of financing cooperatives through patron demand deposits, (4) costs of alternative agricultural transportation systems, and (5) estimation methods.

B. Impacts
   1. Fruit growers can increase profits by making appropriate promotion investments and carefully managing the supply chain.
   2. International non-price generic promotion efforts should be curtailed because benefits from the increased demand are insufficient to cover their cost.
   3. Identifying the cause of likely increases in road damage leads to public policy that can reduce road damage and also assure adequate resources to keep highways maintained. This improves the efficiency of the agricultural marketing chain, thereby increasing prices to growers and decreasing prices to consumers.
   4. Declining reputation of the Washington Apple warrants industry action to establish minimum quality standards.
   5. Supply chain findings provide evidence that the pear industry can increase profits by narrowing the size range of fruit shipped to the fresh market.
      Improved econometric estimators being developed provide more precise estimates of demand, supply, market equilibrium, and other quantitative economic modeling objectives.

A. 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.

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 conducted 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

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

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 based on 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 FTEs

Total Expenditures for all projects:

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

Total Faculty/Staff FTEs: 19.67

KEY THEME: Animal Production Efficiency

Research Program: 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
   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.

A. USA and international scientists, commercial biotechnology companies, and livestock producers interested in improving reproductive efficiency.

Allocated Resources

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

Faculty/Staff F.T.E. 2.44

Research Program: 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
   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. 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

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

Faculty/Staff F.T.E. 6.50

Research Program: -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
   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. USA and scientists worldwide working on the Wagyu breed, livestock producers, meat packers, and consumers of beef.

Allocated Resources

Source of Funds	Amount
Hatch	$2,978
Hatch Multi-State Research	$**0**
Federal Research Grants	$0
State Appropriations	$**36,**449
Other Grants	$0

Faculty/Staff F.T.E. .68

Research Program: 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.

A. 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.

A. 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

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

Faculty/Staff F.T.E. 4.30

Research Program: 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 IHNV infection in trout.
2. Using cloned trout, specific genes were identified which were 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.

B. Impacts
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

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

Faculty/Staff F.T.E. 3.76

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

2. 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.
3. New dietary recommendations for selenium, cobalt, and zinc levels in the diets of dairy cattle and swine.
4. 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.
5. Development of a restructured steak product to create a value added product from the low valued round of beef.
6. 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.
7. The identification of different varieties of barley and wheat as improved sources of animal feeds.
8. 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. Basic science components are long-term and may take a longer time to reach industry.

CENTER FOR PRECISION AGRICULTURAL SYSTEMS

GOAL 1: OVERVIEW

The Center for Precision Agricultural Systems at WSU has been in operation since its funding in July, 1999. The Center director arrived in September 2000 and proceeded to develop research programs in 2001. Research projects, outcomes, and impacts associated with the Center are highlighted as follows:

The most important accomplishment for the Center in 2001 was the development of the Technology Roadmap for Tree Fruit Production and the associated funding received from the IFAFS program to advance precision agriculture in tree fruit. The first complete draft of the technology roadmap is completed and available for distribution and comment at web site for the WA Tree Fruit Research Commission at www.treefruitresearch.com. This effort is in its infancy but will in time make the tree fruit industry more competitive in a global marketplace. There has been complete acceptance of the roadmap process by all sectors of the tree fruit industry and their current efforts are focused on developing the funding and infrastructure to bring the R&D priorities outlined in the roadmap to fruition.

Another success has been in the development of new technologies for crop estimation and for the deployment of site-specific weather networks. Center sponsored research has led to the development of a real-time sensor that relates trellis load tension to crop load in wine and juice grapes. Crop load prediction and management and predicting in-season fruit load are high priority research items listed by the Washington Wine Advisory Board. This research is critical to advancing the development of this technology in grapes and should lead to commercially available crop load sensors for vineyardists. Another research effort has developed telemetry based data loggers and weather sensors that are research grade but affordable. The new systems will 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. Benefits to growers will be found in irrigation scheduling and pest and frost forecasting.

Through private donations of equipment, Center support, and industry funding, a micro-environment field laboratory and technology showcase has been established 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. The site has been soil sampled on a geostatistical grid and the linear move irrigation system installed. This facility has already received the support of the Washington potato industry with the potato cropping system as a major target for technological development.

Working with the support of the wheat industry and conservation groups, Dr. James Cook, WSU, and Dr. David Huggins, USDA-ARS in collaboration with a number of WSU scientists, have developed a major field research program in the Palouse region of Eastern Washington. 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 2001 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.

Source of Funding and FTEs

Total Expenditures for all projects: $285,346.35

Source of Funds	Amount
State Appropriations	$246,105.73
Other Grants	$39,240.62

Total Faculty/Staff FTEs: 0.4

KEY THEME: Precision Agriculture

Research Program: Plant Production Systems

1. Maintaining the Competitiveness of Tree Fruit Production Through Precision Agriculture**.**
   a. 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 program in late 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. The project was recently funded and is just getting underway. However, precision agriculture has not been adopted as rapidly for horticultural fruits and vegetables as for agronomic crops, but potential benefits may be even greater.
   c. This is a joint project with FL, WA, and OR

2. Technology Roadmap for Tree Fruit Production
   a. This effort is lead by James McFerson, Manager of the WA Tree Fruit Research Commission and Francis J. Pierce, WSU. The purpose of this project is to develop the research and development priorities needed to meet the vision of the Roadmap stated as: “for the Pacific Northwest Tree Fruit Industry to compete globally, it must reduce the cost of production of its highest quality fruit 30 % by the year 2010”.
   b. The roadmap process is in its infancy but has received full support from all factions of the tree fruit industry in Washington State. Funding for the needed research is being solicited but the WA Tree Fruit Research Commission has already allocated significant resources to this effort.
   c. The project was initiated in Washington State but already has support in OR, MI, and NY.

3. A Micro -Environment Field Laboratory and Technology Showcase
   a. This project is led by Francis J. Pierce in collaboration with C. W. Fraisse and M. Williams, WSU, and H. Collins, A. Alva, and R. Boydston, 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. The

site has been soil sampled on a geostatistical grid and the linear move irrigation system install. The 2002 cropping season will be the first year for research on this project.
   b. The potato industry is a major target for technological development here and has approved support for research in 2002.
   c. No other states but Washington are involved in this project.

4. Site-Specific Management in a Wheat Cropping System.
   a. This research is lead by James Cook, WSU, and 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 2001 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.

Research Program: 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 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 2001 revealed 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.

2. Site-Specific Weather Networks
   a. This research program is led by Francis J. Pierce. The goal of this research is to develop telemetry based data loggers and weather sensors that are research grade but affordable.
   b. The new systems will 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. Benefits to growers will be found in irrigation scheduling and pest and frost forecasting.
   No other states but Washington are involved in this project.

CROP AND SOIL SCIENCES

GOAL 1: OVERVIEW

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

1. Improved varieties of cereals have been released. Cool season food legumes and alternative crops with improved quality and yield have been identified. A gene encoding barley stem rust resistance in barley has been studied, and breeding value has been added to barley.
2. New technologies have been developed using advanced scientific information on the genetics, molecular biology, physiology, and biochemistry of crops and weeds 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. Outcomes That Have Resulted in Significant Changes

1. Transgenic malt or mature grain containing the thermostable (1,3-1,4)-alpha-glucanase from barley can be used for chicken feed as an alternative to corn grain. Corn grain is 30 to 40% more expensive than barley and is primarily food for the human population.
2. Isolation and characterization of a durable stem rust resistance gene from barley has shown that this gene will provide information on what constitutes a durable resistance and will also be useful in development of durable resistance in other species, for example, wheat.
3. Wide and traditional crosses have been used to incorporate novel sources of disease resistance and end-use quality into advanced breeding lines of winter wheat.
4. New lines of Perennial wheat offer new solutions to soil erosion and degradation of conventional annual small grain cropping systems.
5. The WSU Wheat Quality Lab has developed testing procedures that will increase effectiveness of testing cereal quality that will increase the marketability of WSU wheat varieties.
6. Plant variety protection (PVP) status for Scarlet was approved. Scarlet was the first variety release to be PVPed and will be the number one hard red spring variety in WA production in 2002.
7. Identifying genotypes for hop powdery mildew resistance in the USDA male hop germplasm collection has been successful as a first step towards incorporating this resistance into future cultivars. The next step is to find whether the resistant genotypes are successful in transmitting resistance alleles to offspring.
8. Using a combination of above-canopy digital images, computer and visual symptom analysis, and full spectrum leaf reflectance, digital images have been successful at documenting the location and extent of blackleaf/chocolate leaf/brown, a serious disorder within vineyards.
9. To utilize excess bluegrass straw, a conceptual design has been completed for a transportable, fluidized bed gasifier-boiler-steam turbine-electricity generator that can be connected to a local grid at approved locations for net metering by the local electric utility.
10. Organic and integrated apple production systems are not only better for the soil than their conventional counterpart, but have comparable yields, although they usually have higher production costs.
11. 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.
12. Knowledge of plant genome information and fundamental biochemical and physiological traits have allowed scientists to identify and preserve valuable germplasm and to develop end use qualities for local, international, and niche markets.
13. Fundamental knowledge of ecological principles has permitted weed scientists to better understand how weeds interact in the soil environment and with crops to develop economical weed control strategies that are more compatible with the environment and consumers.

A. Benefits to Clientele (Stakeholders)

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. 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.

A. Accomplishments based on Department/Unit POW for 2001

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 outreach programs.

3. Grower acceptance of our programs has been excellent as determined from the audiences at numerous functions conducted by Crop and Soil Sciences.

A. Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$212,106
Hatch Multistate Research	$9,256
Federal Research Grants	$713,734
State Appropriations	$920,405
Other Grants	$1,133,916

Total Faculty/Staff FTEs: 43.03

KEY THEME: Plant Germplasm

Research Program: Plant genome, genetics, and genetic mechanisms
CRIS projects 0196, 0232, 0251,1006, 1790, 1851, 3251, 6106, 6197

A. Basic studies:
This area includes the plant geneticists and plant breeders who focus on: 1) introducing Cephalosporium resistance and other resistant traits into winter wheat varieties; 2) developing Hessian fly and Russian wheat aphid resistance and identifying potential gene donors for Rhizoctonia resistance in spring wheat 3) studying diploid barley species producing recombinant enzymes for increased production of protein; 4) participation in the North American Barley Genome Mapping Project involving QTL mapping molecular assisted selection for increased grain yield and improved quality; 5) selection for improved hop cultivar traits for improved yield and aroma; 6) selection for disease resistance, winter hardiness, and quality traits in peas, lentils, chickpea; 7) selection for improved varieties of sugar beets and dry beans; and 8) release of improved varieties 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.

B. Impacts
1. Transgenic malt or mature grain containing the thermostable (1,3-1,4) alpha glucanase for chicken feed provides an alternative to the use of corn grain, which is more extensively used and needed as food for humans than barley. Corn grain is also at times 30-50% more expensive.
2. Isolation and characterization of a durable stem rust resistance gene from barley. Studies with this gene will provide information as to what constitutes a durable resistance and will also be useful in development of durable resistance in other species, for example, wheat.
3. Identification and introduction of traits for *Cephalosporium* resistance in winter wheat varieties will reduce the quantities of pesticides required in crop production and improve quality and yield.
4. *Rhizoctonia*-resistant spring wheat varieties will improve crop productivity and economic return, reduce our dependence on pesticides and improve crop performance under reduced tillage conditions. The wheat variety “Zak” was released as the “Wawawai” replacement and is expected to become the primary spring wheat in commercial production in the region within 3 years.
5. New genetic knowledge of barley will enable researchers to release new varieties in the new two years for improved productivity and quality traits.
6. Improved hop varieties with greater yield potential will enable growers to become more competitive.
7. Newly released varieties of pea, lentil, chickpea, sugar beets, and beans have enabled growers to maintain or increase production and while improving quality for economic advantage while reducing their cost of production.

C. Scope: The breeding program focuses on the PNW (WA, ID, OR), but its application is nationwide.

KEY THEME: Plant Germplasm

Research Program: Plant genetic resources and biodiversity
CRIS projects 0282, 1134

A. This research program encompasses: 1) collection, preservation, evaluation, and utilization of plant germplasm; 2) enhancement of genetic regeneration protocols of DNA techniques by RAPDS, RFLPS, and SSRs; 3) utilizes GIS and GPS systems to identify sampling sites; 4) understanding of fungal endophyte diversity and biochemical traits of ryegrass, fescues, and wheatgrass; 5) evaluation of diverse Kentucky Bluegrass germplasm for alternative residue management systems; and 6) evaluation of agronomic and horticultural genera for ornamental potential.

B. Impacts
1. Irreplaceable plant bio-diversity and genetic resources for a strong and competitive U.S. agricultural industry have been preserved.
2. The genetic base of existing crops to reduce genetic vulnerability has been identified that provides new alternative crops for U.S. farmers.
3. Identification of host resistance genes from germplasm will allow producers to reduce reliance on pesticides to resist pests and environmental stress.
4. Technology for eliminating seed borne viruses in large seed collections is now used by international germplasm centers around the world.
5. Identifying the genotypes for resistance to hop powdery mildew in the USDA male hop germplasm collection is a first step towards incorporating this resistance into future cultivars. Future research will discover how resistant genotypes are successful in transmitting their resistance alleles to their offspring**.**

C. Application of this work covers the PNW (WA, ID, OR), but has application nationwide.

KEY THEME: Plant Production Efficiency

Research Program: Plant biological efficiency and abiotic stresses affecting plants
CRIS projects 0182, 0196, 0232, 0242, 0250, 0251, 0277, 0281, 0309, 0332, 0358, 0664, 0688, 1006, 1790, 1851, 3669, 4703, 6106

A. Projects that cover the efficiency of crop production and their response to stress include: 1) improved variety selection for resistance to diseases and environmental stress; 2) carbohydrate type and allocation of carbon under water stress; 3) understanding the mechanisms of producing recombinant enzymes in barley for increased energy in seed; 4) improve our understanding of weed ecology for reducing competition with crops; 5) identify soil quality criteria that are favored under certain crops and cropping systems; 6) evaluation of turfgrass cultivars, and 7) development of perennial wheat on highly erodible land.

B. Impacts
1. Wide and traditional crosses are now used to incorporate novel sources of disease resistance and end-use quality into advanced breeding lines of winter wheat.
2. Transgenic barley lines now will be used to produce varieties high in energy for feed grains.
3. Selection of barley and wheat for fructans will reduce impact of soil water stress.
4. Biotic factors have been identified in which models can predict weed pressure and suggest appropriate management.
5. Reduction of tillage in crops and organically managed orchards improve soil quality.
6. Adverse environmental impacts are reduced in turf grass through species, cultivar, and germplasm evaluation.
7 New lines of perennial wheat offer a new solution to soil erosion and degradation of conventional annual small grain cropping system**s.**

C. Scope: Application covers the PNW (WA, ID, OR), but has application nationwide.

KEY THEME: Plant Production Efficiency

Research Program: Plant production quality and utility (preharvest)
CRIS projects 0110, 0175, 0250, 0334, 0359, 1006, 1851

A. Projects involve: 1) improving genetic lines and varieties for improved quality traits; 2) using molecular markers for identifying useful quality traits; and 3) modifying tillage and cropping systems with key environmental conditions that promote better crop quality; and 4) collecting alternative crop plant germplasm from central and northern China, Korea, and Japan for evaluation of agronomic characteristics.

B. Impacts
1. The WSU Wheat quality Lab has developed testing procedures that will increase the effectiveness of testing cereal quality and that will improve the marketability of WSU wheat varieties.
2. Plant variety protection status for Scarlet was approved as the first variety release PVPed. Scarlet will be the number one hard red spring variety in WA production in 2002.
3. New genetic knowledge on the inheritance of quantitatively inherited economically important traits that affect productivity and quality have been introduced into varieties.
4. Reduction in summer fallow acreage though minimal tillage has reduced soil erosion, improved air quality, and increased crop water use efficiency.
5. Alternative crop production has been promoted in the mass media, extension bulletins, research journals and monographs.

C. Scope: Application covers the PNW (WA, ID, OR), but will be important nationally and internationally.

KEY THEME: Other- Cropping Systems

Research Program: Plant production management systems
CRIS projects: 0110, 0175, 0242, 0250, 0277, 0309, 0329**,** 0358, 0376, 3669, 3776, 4703

A. Projects covering production systems include: 1) adopting new cereal, forage, seed legume and alternative crop varieties to reduced tillage systems 2) identifying tillage and cropping systems that reduce soil, water and air pollution; 3) determining the ecological significance of shifts in weed populations under different tillage and cropping regimes; 4) identifying alternative crops that expand the cropping options and improve the economic return in the annual rainfall and wheat-fallow; 5) investigating production and marketing of East Asian alternative crops for economically viable production in the Pacific Northwest; 6) measuring changes in the physiological status of grapes; 7) generating electricity from bluegrass biomass; 7) mapping genes in grass and seed crops.

B. Impacts
1. Using a combination of above canopy digital images, computer and visual symptom analysis, and full spectrum leaf reflectance, digital images have been successful at documenting the location and extent of blackleaf/chocolate leaf/brown, a serious disorder within vineyards. The spectral wavelengths specifically associated with water and UV-B stress have been documented .
2. To utilize excess bluegrass straw, a conceptual design has been completed for a transportable, fluidized bed gasifier-boiler-steam turbine-electricity generator that can be connected to a local grid at approved locations for net metering by the local electric utility. The entire system would be contained in three trailers.
3. To reduce opposition to burning in ryegrass seed cropping, reduction of volunteer annual ryegrass stand densities by using sheep for grazing and by herbicide row spraying are effective methods to reduce the effects of excessively high seedling populations and to improve yield potential. Row spraying was most beneficial in the absence of grazing.
4. Adaptable alfalfa varieties are available to commercial breeders that lead to new varieties to PNW growers.
5. Through research and education programs in STEEP, cropping systems and tillage practices using direct seeding/no till has increased.
6. Integrated programs in weeds, pathogens, and insects have resulted in beneficial effects of direct seeding on improving soil quality and water-use efficiency in crops.
7. Organic and integrated apple production systems are not only better for the soil than their conventional counterpart, but have comparable yields, although they usually have higher production costs.
8. Alternative crops for PNW production and export to overseas markets are being developed.

C. Application covers the PNW (WA, ID, OR), but application is nationwide.

KEY THEME: Diversified/Alternative Agriculture

Research Program: Basic plant biology CRIS projects 0245, 0296

A. Projects address: (1) changes in microbial activity and soil quality under conventional and direct seed practices

B. Impacts
   1. Surface residue and old root and earthworm channels are maintained from the lack of disturbance under direct seeding that increases water infiltration and crop water use efficiency.
   2. Higher levels of soil organic matter, microbial activity, soil nitrogen release, and soil test phosphorus and potassium under direct seeding increase the prospects for higher yields under direct seeding conditions.

C. Application covers the PNW (WA, ID, OR), but has application nationwide.

ENTOMOLOGY

GOAL 1: OVERVIEW

The research program of the Departmental 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: Apiculture

Research Program: Insects, mites, and other arthropods affecting plants.
CRIS projects 0244, 0342, 3335

Molecular Genetics of Honey Bee Subspecies and Assessment of Populations in North America. The honey bee is a potential model to examine many levels of genetic differentiation, from populations within a subspecies (including different geographic scales) to subspecies within a "lineage" (group of subspecies sharing paths of geographic dispersal), to subspecies from different evolutionary lineages. The key to testing these ideas experimentally relies on the fact that honey bee queens store sperm for their lifetime and the fact that queens can be artificially inseminated with sperm from selected males. Preliminary experiments were conducted in 2002 to test this hypothesis.

Varroa mites. We assisted Ava Chemicals in submitting a sub-label to EPA for the use of sucrose octanoate as a potential new "soft" chemical for the control of *Varroa* mites, important parasitic mites of honeybees. With regard *Varroa* control, we also submitted and received an IFAFS grant with Cornell totaling $1.8M. These funds will be used to establish a germplasm and breeding center (here and at Cornell) and to develop IPM workshops to promote the adoption of IPM principles for mite and disease control in honey bees

Allocated Resources:

Total Expenditures for all projects:

Source of Funds	Amount
State Appropriations	$70,808.87
Other Grants	$12,007.16

Total Faculty/Staff FTEs: 0.8

KEY THEME: Invasive Species

Research Program: Biological Control of Pests Affecting Plants.

CRIS projects 0272, 0337, 4362

Biological Management of Yellow Starthistle in Washington. In 2001, an extensive natural enemy collection/relocation effort was directed against yellow starthistle (*Centaurea solstitialis*) in WA to expand the distribution of extant bioagent populations. The highly damaging, capitulum-infesting weevil *Eustenopus villosus* was moved into six eastern Washington counties. A total of 26,800 adult insects were liberated at 250 new locations during June and July. *E. villosus* has become the dominant control organism in most locations. Surveys conducted in southeastern WA revealed the widespread occurrence of the introduced seed destroying tephritids *Chaetorellia australis* and *C. succinea*, with the latter species being preponderant. Dissection studies revealed that the larvae of both flies destroy 100% of the achenes in infested capitula.

Since 1985, the establishment of six biological control agent species against yellow starthistle in Washington has diminished this highly invasive plant's abundance by 50 to 75% in impacted wildland and rangeland ecosystems. Eleven counties each now have two or more *C. solstitialis* arthropod bioagents present. The widespread utilization of biocontrol by livestock producers and others has lowered herbicide inputs, reduced land management costs, increased forage plant productivity, enhanced floral biodiversity, and diminished environmental degradation on thousands of acres. The long-term management of yellow starthistle populations is best achieved by integrating preventive, chemical, cultural, and biological methods.

Biological Control of Aphid Pests. A number of different Old World aphid-attacking wasp parasites, selective for certain aphids, including green peach aphid in potatoes, have been introduced over the last several years into eastern Washington to strengthen the existing pool of indigenous aphid-parasites. Three species have emerged as dominant aphid biocontrol agents in potatoes: *Aphidius ervi, Aphidius matricariae*, and *Diaeretiella rapae*. *A. matricariae* is the premier parasite of the three against green peach aphid. In 2001, it eliminated aphids completely in selected potato fields in Grant and Yakima Counties. Presently, this parasite is not distributed in all potato producing areas in Washington, but it is spreading. *A. ervi* and *D. rapae* are long-established parasites, and though widely distributed, are not found in all fields of potatoes. Further work is needed to reveal the intertwining factors in the environment influencing parasite movement in and out of potatoes. In addition to the Washington studies, work on the aphidiid parasites of Guam was summarized and published. All of the Guam aphidiids are introduced, as are the aphids they attack. Aphid parasites can be highly effective as biocontrol agents. Steps have and are being taken to ensure their presence in small grains, potatoes, and selected other crops attacked by aphids.

Allocated Resources

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$134,171.43
Fed. Res. Grants	$8,453.39
State Approp	$37,483.02
Other Grants	$114,707.76

Total Faculty/Staff FTEs: 4.3

FOOD SCIENCE AND HUMAN NUTRITION

GOAL 1: OVERVIEW

Research Results From Research Projects Supported by Hatch Formula funds

The overall purpose of this research is to continue to investigate new thermal and non-thermal processes to produce safe, value added, food products and to develop better understanding of the physical and microbiological changes that food and food components undergo during value added processing. During the period under review the Department of Food Sciences and Human Nutrition conducted basic and applied research related to wine

grapes, wine, cheese, legumes, cereals, fish, along with studies on proteins, lipids, carbohydrates, and beneficial and detrimental microbes.

Outcomes That Have Resulted in Significant Changes

Researchers developed an alternate method to improve fermentation rates of wine musts. Their research confirmed that exposure of wine grapes to UV light influenced the biochemical composition of grapes ultimately leading to improved quality in the final product. Studies on the formation of lactic acid crystals in aged cheddar cheese led to an understanding of this important defect in cheese which costs the dairy industry millions of dollars a year. It was demonstrated that legumes could be used for extruded snack products, potentially opening up new markets for these nutritious foods.

By analyzing early generation wheat breeding lines for various end-use parameters, poor lines were eliminated, increasing the efficiency of the breeding programs and the production of wheat varieties better suited to markets. As a result of our researchers developing new non-destructive method for analysis of salt and water in expensive fish roe and muscle products, processors now can meet legal limits without loss of valuable product.

A unique process of exposing whey proteins to high hydrostatic pressure has conferred new functionality to this protein and will open new markets for whey protein. Legume proteins were shown to have functionality that could increase their value and thus expand their markets. Investigations of the discoloration problems in processed barley may lead to increased incorporation of barley into human food products, thus increasing the value of this important cereal product.

Source of Funding and FTEs

Total Expenditures for all projects: $744,481.00

Source of Funds	Amount
Hatch	$48,023.83
Hatch multistate research	$98,537.25
Federal Research Grants	$87,620.03
State Appropriations	$276,155.42
Other Grants	$234,144.47

Total Faculty/Staff FTEs: 10.53

KEY 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

Enological and Viticultural practices on Fermentation, Microbiology, Chemistry, and Quality of Wines. The use of synthetic grape juice in wine fermentation studies indicated that yeast growth and fermentation are more dependent on available nitrogen than biotin or pantothenic acid, but that the presence of these vitamins greatly affects the production of hydrogen sulfide.

Potential Outcome: These results will yield an alternate method to improve wine fermentation rates and the overall quality of wine.

Factors affecting the quality of Washington wine and wine grapes (*Vitis vinifera*). Anthocyanin and phenolic profiles of berry skins, must, and wines from *Vitis vinifera cv*. Merlot in the Yakima valley of Washington were influenced by sun exposure and temperature. Decreased total monomeric anthocyanin concentrations in berry skins from west-exposed clusters were due to temperature and not due to UV-radiation. Exposure to solar radiation, particularly UV, increased concentrations of several key compounds, while temperature had no effect on these concentrations.

Impact: Based on these results, growers and winemakers are reassessing canopy management practices on west facing sides of north-south oriented rows and south facing sides of east-west oriented rows in order to reduce exposure of fruit to sun in the afternoon.

Microbiological and chemical factors affecting the flavor and textural quality of cheddar cheese. Results showed that the formation of at least 50% of one form of lactate during cheese fermentation stimulated the formation of calcium lactate crystals in cheddar cheese.

Potential Impacts: The results of this research will lead to an understanding of, and a means to eliminate, a quality problem which costs the dairy industry millions of dollars each year.

Genetic improvement of beans (*Phaseolus vulgaris L.*) for yield, disease resistance, and food. Legume extrusion studies were continued in 2001. The expansion ratio was maximum for products obtained from 100% split pea flour with 20% starch addition and minimum for products obtained from 100% split pea flour. Addition of sugar and salt resulted in small increases in expansion attributed to the binding of free water. Addition of selected flavors did not affect the expansion ratio.

Potential Impacts: Legumes have not been considered good ingredients for extruded snack food products because of the perception that legumes will not expand well in the extrusion process. Extruded products obtained from this study, however, with added selected ingredients and flavors, are flavorful and acceptable legume snack food products. These results will allow the use of legume flours in the snack food market, thus opening up a new market for these nutritious foods.

Milling and flour quality characteristics of wheat selections. For the crop year 2000-2001, 3457 samples were received from Washington wheat breeders. Samples were analyzed for various end-use parameters, as appropriate for stage of development and intended market class. Data generated plus interpretive summaries, were provided directly to the breeders.

Impacts: By performing this work on early generation lines, poor quality lines were eliminated quickly and were not carried to later generations. In this way, efficiency of breeding programs was greatly increased. The net result was producing wheat varieties better suited to existing and new markets.

Non-invasive method for predicting safety and quality of foods. Experiments with various cured and smoked salmon roe and muscle foods have shown that linear and non-linear chemometric models could be developed to predict moisture and salt in fish roe and muscles. These predictive models had transferability to hot or cold smoked products from several species of fish.

Potential Impact: Development of non-invasive and non-destructive methods for salt measurement will improve food safety while maintaining a saleable product. These are very expensive products and are currently lost when destructive sampling is required to ensure that regulatory limits are met. These newly developed NIR methods have accuracy approaching that of current destructive methods.

Surface hydrophobicity and functionality of proteins in the molten globular state. The molten globule is an intermediate protein structural state between native and fully denatured states, possessing unique hydrophobic molecular structures with potential functionality. High hydrostatic pressure (600Mpa) induced whey protein into hydrophobic molten globule structures stabilized by disulfide bonds. The new structure, however, did not improve affinity for some selected flavor compounds or ligands. Other changes in function were demonstrated.

Potential Impacts: The improved functionality of whey protein due to high hydrostatic pressure is expected to improve utilization of whey proteins as emulsifiers, foam stabilizers, and flavor binders or release agents in foods. This process will reduce available surpluses and improve utilization of whey proteins.

Research Program: Quality maintenance in storing and marketing food products

CRIS Projects 0128

Marketing and delivery of quality cereals and oilseeds. Recent results from this project are: (a) a proposal for the mechanism of chick pea curd formation; (b) identification of xylose as a common sugar in legume fiber; (c) a finding that galactose and cellobiose make up significant portions of legume soluble fiber; and (d) basic color information as well as identification of barley components affecting discoloration in this key cereal crop.

Outcomes: Results of this research have provided ways to enhance the functional properties of legume proteins, expanded the uses of legumes which could increase their value, helped the food industry to utilize barley for human consumption and to select the best barley to avoid the serious discoloration problem.

Scope of Impact: National

HORTICULTURE AND LANDSCAPE ARCHITECTURE

GOAL 1: OVERVIEW

Research Programs of the Department of Horticulture and Landscape Architecture are: (1) Breeding, management, and production of tree fruits and small fruits, and (2) Breeding, management, and production of vegetable crops.

Research Results From Research 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) The identification of new crop varieties in vegetables that have the potential to improve the competitiveness of Washington agriculture; (2) The impacts of volunteer potatoes on subsequent year crop yields; (3) The causes of stem-end splitting in apple; (4) The physiological and biochemical mechanisms that explain the occurrence of sunburning in apple; (5) The suitability of conventional, organic, and integrated orchard management systems; (6) The identification and cloning of genes that encode for calmodulin-binding proteins that control growth and development in plants; (7) The suitability of wine varieties for cool maritime climate.

Outcomes That Have Resulted in Significant Changes

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 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. 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 occuring, 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.

Benefits to Clientele (Stakeholders)

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; (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.

Accomplishments based on Department/Unit POW for 2001

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.

Source of Funding and FTEs

Total Expenditures for all projects: $1,408,960.65

Source of Funds	Amount
Hatch	$102,619.39
Hatch Multi-State Research	$0
Federal Research Grants	$475,048.70
State Appropriations	$356,777.94
Other Grants	$474,514.62

Total Faculty/Staff FTEs: 19.60

KEY THEME: Agricultural Competitiveness

Research Program: Breeding, management, and production of tree fruits and small fruits
CRIS projects: 0201, 0210, 0377, 0480, 0519, 0937, 1639

A. Basic and applied research resulted in new information and a better understanding of: 1) The causes of stem-end splitting in apple; (2) The physiological and biochemical mechanisms that explain the occurrence of sunburning in apple; (3) The suitability of conventional, organic, and integrated orchard management systems; (4) The suitability of wine varieties for cool maritime climate.

B. Impacts
   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. 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: 0168, 0321, 0044, 0239, 910, 1984, 6046

A. Basic and applied research resulted in new information and a better understanding of: (1) The identification of 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
   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. WA, ID and OR scientists and other scientists working in many research institutions and organizations worldwide.

IMPACT CENTER

GOAL 1: OVERVIEW

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 agriculture 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.

Research Results From Research Projects Supported by Hatch Formula funds

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

- A survey of consumers in Japan and Norway about their attitudes towards genetically modified food products. The survey of Japanese consumers suggests that they are willing to pay a 60 percent premium for tofu made from non-GM soybeans. Initial results of the survey of Norwegian consumer preferences for non-GM bread appear to vary significantly by age group with some age groups willing to pay more than an 80 percent premium for non-GM bread.
- The potential for Wagyu (Japanese domestic) beef trade with Japanese consumer cooperatives was assessed. The results of the study indicate that the Japanese cooperatives find it difficult for U.S. beef to compete with lower-priced Australian beef and higher-quality Japanese Wagyu beef. Direct sourcing of lower-priced U.S.-produced Wagyu may be possible if specific production practices, such as refraining from the use of growth hormones, are followed. However, a survey of Japanese consumers suggests that they have dramatically reduced beef consumption in response to recent mad-cow outbreaks.
- 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.
- Wood frame building codes in South Korea and China have been revised. The revisions will encourage the use of wood-based housing in these countries and increase exports of Washington timber products.

To evaluate methods of variegation and quality enhancement of forest foliage as an alternative crop, experiments were established at numerous sites in SW Washington. Rates and timings of norflorazon were evaluated on salal, sword fern and evergreen huckleberry. Variegation created by norflorazon on these species was minor and of too poor visual attractiveness to warrant commercial marketing. Research was also conducted to evaluate the use of fertilization and fungicide application to improve the market quality of regular salal.

1.2 Solving technical impediments to exports of Washington State agricultural products

- 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.
- The use of controlled atmosphere storage in combination with other gases (MCP) on the storage life of cranberries was assessed. The storage life of three cranberry varieties was assessed under various combinations of atmosphere and gas treatments. The combination was found to help marketing life, but the results were not consistent across varieties and storage parameters.

1.3 New products and New processes

- Processes to prepare bean curd from chickpeas, peas, and lentils were developed. The optimal texture of the curd was evaluated and compared to commercial soybean tofu. Methods to improve the texture of the product, including heat-induced gelation and introduction of lipids, were evaluated. The heat induced gelation process resulted in curd that was comparable to soybean tofu. The soluble and insoluble fiber content of chickpeas, peas, and lentils was determined and a modified fractionation process was developed to isolate insoluble cotyledon fiber.
- 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. - Organic apple production was assessed. The project was conducted in conjunction with an ongoing study of organic, conventional, and integrated apple production systems in the Yakima Valley. The project is designed to enhance technology transfer of organic and integrated production processes to increase alternative marketing options for exported fruit, enhance competitiveness, and overcome potential trade barriers in markets that prefer integrated production practices. Organic products command premium prices and, as a result, organic and integrated production practices are being rapidly adopted. The results of the study show that organic and integrated apple production systems in Washington State are better for the soil and environment and have comparable yields. The organic system resulted in higher profits and greater energy efficiency. The organic system ranked first in environmental and economic sustainability, the integrated system second and the conventional system last.
- Edamame (edible soybeans) and azuki bean cultivars continue to be selected to develop uniformity for the Japanese market and identify strains that are best suited to be grown in the PNW.
- 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.
- 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 be an alternative to traditional thermal pasteurization of skim milk to extend shelf life.
- 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.
- 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.

- 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 B_6.
- 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.

Outcomes That Have Resulted in Significant Changes

Assessing consumer attitudes towards GM products provides industry with insights into potential markets and consumer acceptance of biotech products. Japanese and Norwegian consumers do not appear to be willing to accept GM products without substantial discounts.

The objective of the ongoing Wagyu beef project at WSU has been to assess the production of high quality Wagyu beef in the U.S. for export to Japanese consumers. The production side of the project has led to the creation of the U.S. Wagyu Association and the widespread use of Wagyu genetics by PNW cattlemen. While the goal was to establish a strong Wagyu beef production capacity, a side benefit was the discovery of the calving and quality enhancement of Wagyu crossbreds in the U.S. market.

Assessments of the likely effect of WTO disciplines on China's wheat, rice, and corn trade with the U.S. suggest that China will import additional wheat from the U.S., while rice and corn trade will not change significantly. Changes in China's agricultural policies under WTO will encourage a shift from wheat to corn production in response to increased demand for feed grains by the livestock sector. 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.

The European and Asian export markets were appraised for potential foliage products that could be grown on cranberry beds. Based on the foliage products present at the wholesale Munich flower market, bear grass foliage and scouring rush were two additional export items that could have production potential.

Organic apples were found to demonstrate firmness comparable to conventional fruit and to have a higher ratio of soluble solids (sugar) content to acidity, making them taste sweeter. Edible films will help the fruit maintain its integrity and better withstand shipping and handling, delivering a better product to markets, including international destinations.

The use of HHP-treated whey protein in low-fat processed cheese resulted in improved firmness and meltability. Biosensors were found to reduce blanching time and result in savings in energy and improved product quality.

Benefits to Clientele (Stakeholders)

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 engery 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.

Accomplishments based on Department/Unit POW for 2001

IMPACT researchers have assessed the implications of WTO and other trade agreements on PNW agriculture. These results have been communicated to industry and policymakers. Apples and cherries exported to Japan require fumigation using chemicals that will be banned as greenhouse gases in the near future. IMPACT researchers have developed alternative treatments to replace these chemicals. Edemame, and other crops have been developed as alternative crops targeted at the Japanese market. New technologies have been developed to

process fruits 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 pitfalls in the international marketplace.

Source of Funding and FTEs

Total Expenditures for all projects: $605,701.00

Source of Funds	Amount
Hatch	$0
Hatch Multistate Research	$0
Federal Research Grants	$295,102.00
State Appropriations	$310,599.00
Other Grants	$0

Total Faculty/Staff FTEs: 9.28

KEY THEME: Agricultural Competitiveness

Research Program: Enhancing Competitiveness of Pacific Northwest Agricultural Exports
CRIS Projects: 00171, 00971, 00972, 00974, 3171, 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. 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.
3. 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.

1.1 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.

5. A study of organic and integrated apple production systems in Washington State indicates that they are not only better for soil and the environment than their conventional counterpart but have comparable yields and, for the organic system, higher profits and greater energy efficiency. Thus, the organic system ranked first in environmental and economic sustainability, the integrated system second, and the conventional system last.

B. Impacts

1.2 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 from the barley extrusion study will provide valuable information regarding material selection, milling and processing to produce puffed cereals and help to increase utilization of barley for food products.

1.3 Many of the new products that have been developed have now been commercialized by growers and processors. Work on new processes has provided processors with local expertise to help them remain competitive.

1.4 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.

1.5 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.

1.6 Results of the organic and integrated apple production systems will provide producers with a better understanding of the costs and marketing opportunities for each system.

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

INSTITUTE OF BOLOGICAL 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 from plants and (4) improve the yields of various crops including forests.

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. Advances have been made in identifying how lignin is biochemically initiated at the so-called "lignin initiation sites", and down-regulation steps of a tobacco peroxidase reduced lignin contents by up to 50% of the original content. The mechanism of heartwood formation continues to be identified; starch reserves are utilized in the biosynthesis of the different heartwood constituents, these being metabolized into the oligomeric lignans that are largely responsible for the color, texture and durability of the pine and cedar heartwood. Many of the enzymes and genes have now been identified, and their temporal and spatial patterns of deposition identified. The molecular basis of sapwood and heartwood formations, from a biochemical perspective, is thus coming to hand.

In the Croteau research group, genes for Taxol biosynthesis continue to be isolated to improve production yields of this anticancer drug, i.e., additional transacylases and hydroxylases of the Taxol pathway were discovered. Approximately half of the pathway has now been cloned. Additionally, the product outcome of abietadiene synthase has been altered by mutagenesis, providing proof of concept that rosin composition can be modified by this approach.

The Browse research group and collaborators at Monsanto discovered a new, polyketide synthase pathway for synthesis of polyunsaturated fatty acids. These studies of lipid metabolism in oilseeds now identify ways in which we can improve the nutritional quality of edible oils. The Browse group's discovery of the *FAD2* gene is the basis of new cultivars of high oleate soybeans grown nationwide by DuPont Co.

The Croteau laboratory has shown the small subunit of geranyl diphosphate synthase is the regulatory unit for controlling terpenoid chain length, providing an important new tool for pathway engineering. Additionally, diffraction grade crystals of bornyl diphosphate synthase have been obtained, and a crystal structure will soon be available, the first for this enzyme class. Transgenic peppermint with enhanced oil yield and composition was performed successfully in first year field trials; these plants will almost certainly provide the basis for commercialization.

The Kahn research group was a collaborator in description of whole genome DNA sequence of *Sinorhizobium meliloti*, a major milestone in symbiotic nitrogen fixation research. They also developed new methods of bacterial genetics for sequenced genomes, and an improved assay for nitrogen fixation effectiveness that is a significant advance for laboratory assessment of productivity and which may be applicable to legume breeding. Additionally, they defined properties of an organic acid transporter important in bacterial nutrient uptake during symbiotic nitrogen fixation.

The Kramer research group has made progress in understanding how plants balance the essential need for primary photosynthetic productivity with the equally important need to down-regulate photosynthesis to prevent reactive side products that can kill the plant. One practical result has been the development of a new portable instrument that monitors changes in the conductivity of the ATP synthase. It is capable of detecting the early stages of drought and heat stresses in crop plants.

The Okita research group now has transgenic Arabidopsis and rice plants expressing an allosterically up-regulated ADPglucose pyrophosphorylase. Ongoing studies indicate that these transgenic plants have increased ability to accumulate leaf starch and have increased photosynthetic capacity readily evident under elevated CO_2 conditions. Implementation of this novel strategy for sustaining maximum photosynthesis may lead to enhanced plant productivity and crop yields.

Additionally, ongoing studies during the year have identified the "zip code" RNA sequences responsible for the targeting of prolamine RNAs to the protein body endoplasmic reticulum. Two zip code sequences are required for restricted localization to this ER subdomain. In addition to the regulated prolamine RNA transport pathway, two additional RNA pathways to the cisternal-ER have been identified. RNA movement in real time has been observed. RNA moves at up to 1-2 microns per sec with movement properties suggesting the role of the cytoskeleton.

Transgenic rice plants expressing sense and antisense RNA binding protein 120 RBP were also generated and are currently being studied. Preliminary studies indicates that reduction of the 120 RBP results in a reduction in prolamine accumulation suggesting a role for this RNA binding protein in the processing, transport, or localization of prolamine transcripts. A GFP-120 RBP fusion protein is observed localized to the cortical ER and cytoplasmic strands believed to be cytoskeletal in nature.

The Rogers laboratory is establishing how plants store often valuable components in their vacuoles, e.g. protein storage in the vacuole of seeds. They have found that these vacuoles contain an internal time bomb. During seed development when storage proteins must be deposited and kept safe within the PSV, digestive enzymes can accumulate in the same vacuole but are packaged away from the storage products. This "vacuole within a vacuole" model probably also pertains to packaging of complex metabolic products in vacuoles — anthocyanins, for example, which are concentrated within an internal, membrane-bounded vacuole within central vacuoles. Thus, the basis of how plants store and turnover their components is now becoming explicable.

The Ryan research group has made significant progress in their studies of signaling polypeptides and their receptors in plants, which are of fundamental importance in optimizing their defense systems to improve the vigor and targeted plant species for both agriculture and in ecology. Additional work in identifying hydrogen peroxide as a second messenger in defense gene regulation provides a new perspective, whereby natural defense responses in agricultural crops can be strengthened and hence plant vigor enhanced.

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; and in identifying the underlying biochemical processes involved in heartwood and sapwood formation.

Outcomes That Have Resulted in Significant Changes

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

Benefits to Clientele (Stakeholders)

Accomplishments of the department/unit POW 2001 (Detailed below).

Source of Funding and FTEs

Total Expenditures for all projects: $5,798,847.70

Source of Funds	Amount
Hatch	$134,831.76
Multistate Research Funds	$722.68
Federal Research Grants	$2,931,446.06
State Appropriations	$2,931,446.06
Other Grants	$1,499,034.62

Total Faculty/Staff FTEs: 67.27

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, 3967, 6204

Metabolic Compartmentation During (Heart)Wood and Seed Coat Development – The promoter regions for each dirigent multigene member in western red cedar were obtained by genome-walking, with *Arabidopsis* being subsequently transformed to express each promoter fused to the -glucuronidase (GUS) reporter gene. In this way, we established that a sophisticated monolignol radical-radical coupling network exists in plants which has been highly conserved throughout vascular plant evolution. Each component of the network is differentially expressed in individual tissues, organs and cells at all stages of plant growth and development.

Phenylcoumaran benzylic ether reductase (PCBER) catalyzes the 7-*O*-4 reduction of 8-5 linked lignans, such as dehydrodiconiferyl alcohol in (oligo)lignan biosynthesis in heartwood of loblolly pine (*Pinus taeda*). In this reporting period, we have obtained PCBER crystals diffracting strongly up to 2.2 Å. The PCBER molecule shows an / dinucleotide-binding motif; a -sheet surrounded by helices known as the Rossmann fold, which is found in many NAD, NADPH, and FMN binding proteins.

Pinoresinol/lariciresinol reductase (PLR) is involved in two post-coupling transformations of coniferyl alcohol in oligomeric lignan (plicatic acid) formation in western red cedar heartwood. Diffraction quality crystals have been obtained and the PLR crystal belongs to the monoclinic space group P2.

Additionally, the application of stable and radioisotope precursor/tracer experiments has resulted in the identification of various phenylpropanoid, monolignol, and lignan metabolites involved in the biosynthesis of the cancer chemopreventive secoisolariciresinol diglucoside (SDG)-containing ester-linked "polymer(s)" in flax (*Linum usitatissimum*) seed. Individual analysis of size-segregated flax seed capsules at five early stages of their development provided a metabolic profile of intermediates leading to "biopolymer" biosynthesis. The use of ^{1}H and ^{13}C NMR and HRMS data, resulted in the identification of 6a-HMG (hydroxymethyl glutaryl) SDG and 6a, 6a -di-HMG SDG as the two major components of the ester-linked "biopolymer(s)". Based on metabolic tracer analyses and relative radio-isotopic incorporations throughout each of these five stages of seed development, a biochemical pathway is proposed from phenylalanine to SDG, with subsequent mono- and di-substitutions of SDG with HMG CoA. These metabolites then serve as precursors for formation of the SDG-HMG ester-linked "oligomers". Because of the health beneficial value of the SDG pathway, results from this study will facilitate future isolation and characterization of the proteins and enzymes involved in biosynthesis of the SDG-HMG ester-linked "oligomers" in flax seed.

Impacts
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. Additionally, the metabolic processes associated with seed coat development, involving deposition of phenolic substances (e.g., secoisolariciresinol diglucoside in flax which accounts for about 3-4% of the total weight) needs to be established.

Molecular Basis of Heartwood Formation – Various methodologies were developed to study the actual biochemical processes during formation of western red cedar (*Thuja plicata*) and loblolly pine (*Pinus taeda*) heartwood, since these are very recalcitrant tissues.

In situ hybridization of the 18s rRNA riboprobe, confirmed the presence of fixed mRNA in the parenchyma cells of all western red cedar tissues tested. The amounts of 18s rRNA observed correlated with the anatomical ontogeny expected for each tissue type; the greatest signal was observed in the apical meristem, the least in heartwood. A gradient of 18s rRNA signal was observed across four growth rings of a transverse section of heartwood and was apparently inversely correlated to the amount of resin deposition. No chromogenic signal occurred in the oldest growth ring which contained heavy resin deposits in both radial and axial parenchyma cells. Two parenchymous rays in the youngest growth ring of the sample contained chromogenic label for 18s rRNA. No chromogenic label was observed in axial parenchyma of any growth ring. *In situ* hybridization of a general riboprobe for dirigent protein also showed a relative decrease in signaling from the apical meristem to the heartwood. The mRNA for dirigent protein was found in the parenchyma cells of the sapwood but not in the heartwood.

Secoisolariciresinol dehydrogenase enantiospecifically converts secoisolariciresinol into matairesinol, and both are intermediates on the pathway to plicatic acid via 7 -hydroxymatairesinol. Because of the inherent difficulties in using *T. plicata* as an abundant source of enzyme, *F. intermedia* tissue was initially used, in order to obtain the corresponding gene and recombinant protein for further analysis of the organization of the lignan pathway in *T. plicata*. Thus, the ~32 kDa NAD-dependent secoisolariciresinol dehydrogenase (SDH), which catalyzes the enantiospecific conversion of (–)-secoisolariciresinol into (–)-matairesinol in *Forsythia intermedia* and *T. plicata*, was purified >6,000 fold to apparent homogeneity. The corresponding cDNA clone was next obtained from a library constructed from *F. intermedia* stem tissue, together with the fully functional recombinant protein, expressed in *E. coli*. Polyclonal antibodies to SDH were also raised in rabbits against the purified recombinant protein, and these recognized only one band (~32 kDa) in a *F. intermedia* stem crude extract and cross-reacted with the purified recombinant SDH. These were used to determine the cellular and tissue specificities of SDH. SDH was found to be associated with the vascular cambium region as well as the axial and radial parenchyma cells.

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. 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. Additionally, the metabolic processes associated with seed coat development, involving deposition of phenolic substances (e.g., secoisolariciresinol diglucoside in flax which accounts for about 3-4% of the total weight) needs to be established.

Two graduate students are associated with these projects and several patents are pending.

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.

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 –Several early oxygenase steps in the Taxol pathway have been defined, and two of the responsible cytochrome P450 oxygenase genes have been isolated. The aminomutase and putative epoxidase steps of Taxol biosynthesis have been demonstrated. Yeast and *E. coli* have been engineered to produce taxadiene, the committed intermediate in the biosynthesis of Taxol. Genetic engineering of cultivated yew cells has been initiated to increase the production yields of this anticancer drug. Mutagenesis studies have been employed to dissect the two active sites of abietadiene synthase from grand fir. The second site is responsible for the production of three olefin precursors of resin acid biosynthesis. Redesign of this second site allows the possibility of controlling rosin composition for improved viscosity and polymerization characteristics. Two graduate students are associated with this project.

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.

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

Defense Reactions in Conifers – **Oleoresinosis** - Bark beetle infestation and associated fungal infection represent the most serious disease problem in conifer species. Conifers defend against attack by the mobilization of stored oleoresin or the induced production of this material at sites of injury. Oleoresin is a mixture of turpentine [monoterpenes (C10) and sesquiterpenes (C15)] and rosin [diterpenoid (C20) resin acids] that is toxic to invaders and forms a physical barrier to infection. Manipulation of this natural defense system represents an ideal means of disease control but it has yet to be exploited for this purpose because oleoresinosis is biochemically complex, and regulation of this process, that underlies susceptiblity and resistance, is not well understood. Using fir and pine saplings as model systems, the pathways of oleoresin biosynthesis and the responsible enzymes have been elucidated and most of the corresponding genes have been isolated. These genes, and antibodies directed to the encoded enzymes, were employed as tools to define the organization and regulation of resin production in grand fir stem tissue. Regulation of inducible resin production in response to insect and pathogen attack was shown to reside at the level of gene expression. These experimental tools were also utilized to examine the genetic basis of the broad variation in the resinosis response that determines susceptibility and resistance to infection in a grand fir population.

Impact: Completion of these objectives has allowed a comprehensive description of the dynamics, regulation and location of oleoresinosis, and provided the tools and strategies for transgenic manipulation of oloresin-based defenses. The understanding of oleoresinosis at the molecular level has far reaching implications for bark beetle control in commercial forests, since the ecological relationships between conifers, beetle pests, beetle predators, and fungal pathogens present several possible avenues for manipulating oleoresin composition to improve tree resistance, for example, by chemically disguising the host, by adding insecticides and fungicides, and by altering the levels of pheromone precursors, predator attractants, or hormone analogs to disrupt insect development.

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

KEY THEME: Biotechnology; Plant Health; Precision Agriculture; Plant Genomics; Global Change and Climate Change; Medicinal Plants; Nutriceuticals; 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, 0235, 0253, 0262, 0268, 0590, 0773, 1791, 3252, 3589, 3775, 4119, 4589, 5197, 6236, 6773, 7795)

Lipid Biosynthesis in Leaves & Seeds –The chloroplast membranes of all higher plants contain very high proportions of trienoic fatty acids. The characterization of *Arabidopsis* mutants with alterations in chloroplast fatty acid composition has provided four examples of mutants that grow well at 22° C but not at low temperatures (2° -5° C). The chloroplast degradation and death observed in the *fab1* mutant at 2-5° C is the most extreme phenotype. By contrast, the *fad5* and *fad6* mutants are much less affected by low temperature treatments. In these mutants, only tissue that develops in the cold shows chlorosis; existing leaves remain green and chloroplasts in them retain a normal ultrastructure. In several respects, the *fad3 fad7 fad8* triple mutant presents a distinct low-temperature phenotype.

The fundamental question in cold acclimation is how plants perceive low temperatures to activate cold acclimation responses. New findings in the last year suggested that changes in membrane fluidity, cytoskeleton rearrangement, and calcium influxes are among the earliest events in plants upon the exposure to low nonfreezing temperatures. In the cyanobacterium Synechocystis PCC6803, temperature change is detected by at least two separate sensors – one of which measures membrane fluidity using a classical two-component system involving histidine kinases and a response regulator in a His-to-Asp phosphorelay. Although these results may not be directly relevant to cold acclimation, they can guide our thinking as we search for the biological thermometers in higher plants.

An improved understanding of temperature responses is important for enhancing plant growth and crop yields in temperate climates.

Impacts
These 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.

Scope of Impact: National/International.

Genetic and Molecular Approaches to Modifying the Composition of Seed Oils; Biochemistry of Oil Seeds – This project is designed to provide new genes and other tools for the modification of plant oils. cDNAs encoding 16:0 desaturases from *C. elegans* (*fat-5*) and cyanobacteria (*desG*) have been transformed into plants under control of a seed specific promoter. Biochemical analysis of seed lipid metabolism of the transformants indicates that modest synthesis of 16:1 is achieved with a concomitant reduction in saturated fatty acids. This project will be completed in 2002. These experiments demonstrate a successful strategy for generating more healthy plant oils low in saturated fatty acids.
Polyunsaturated fatty acids (PUFAs) are essential membrane components in higher eukaryotes and are the precursors of many lipid-derived signaling molecules. In collaboration with scientists at Monsanto, we have discovered pathways for PUFA synthesis that do not require desaturation and elongation of saturated fatty acids. These pathways are catalyzed by a polyketide synthase mechanism. Generation of *cis* double bonds probably involves position-specific isomerases; such enzymes might be useful in the production of new families of antibiotics. It is likely that PUFA synthesis in cold marine ecosystems is accomplished in part by these PKS enzymes.

Impact: In terms of producing very long chain PUFAs in transgenic oilseeds, these novel PKS-like ORFs potentially represent an attractive alternative route. For example, introducing and regulating the three *Schizochytrium* PKS-like ORFs in a transgenic plant is relatively simple compared with the more than five desaturase and elongase genes required for the previously characterized aerobic pathway.

Scope of Impact: National/International.

Genetic Analysis of Plant Virus Infection – Host proteins that interact with plant viral proteins were isolated. One of these, translation factor eIF4E, was examined in detail and shown to interact with the TEV NIa protein in a strain-specific manner. The functional significance of this interaction is now being investigated. Two *Arabidopsis* genes (RTM1 and RTM2) required for a novel form of virus resistance were cloned using map-based cloning procedures. The RTM1 gene encodes a lectin-like protein that resembles several other proteins involved in defense against insects and fungi. The RTM2 gene encodes a unique small heat shock-like protein. These genes were shown to control a TEV-specific virus restriction mechanism in *Arabidopsis* that is distinct from well-characterized antiviral or defense systems. The biochemistry and function of these proteins in vivo are the subjects of current investigation. In addition, a large scale mutagenesis study to recover loss-of-susceptibility mutants of *Arabidopsis* was initiated. Five mutants that had lost susceptibility to turnip mosaic virus were isolated and analyzed by complementation studies. At least two complementation groups were identified, suggesting that the mutants represented defects in at least two distinct loci. The isolation of these genes is now a high priority.

Impact: This research is providing a basic understanding of how plants interact with pathogens. This will assist local and regional breeders produce more resistant varieties of crops. Accomplishments in relation to plan of work: The identification of genes involved in resistance to pathogens enables development of approaches to limit the effects of biological predation.

Scope of Impact: This research impacts agricultural producers in the State of Washington and the Pacific Northwest.

Host Responses to Potyviruses – This project investigates the basis for gene silencing and silencing suppression that occurs during infection of plants by viruses. The virus-encoded HC-Pro was shown to inhibit a gene silencing maintenance function, as delivery of HC-Pro into silencing cells was sufficient to turn silencing off. It is likely that HC-Pro disables the silencing mechanism during infection, allowing prolonged replication and systemic movement. A series of 25 alanine-scanning mutants with defects in HC-Pro were also tested in the silencing suppression assay. A tight correlation between the ability of HC-Pro to suppress silencing and the ability to stimulate movement and replication of tobacco etch virus was found. A new series of assays was developed to allow initation and analysis of gene silencing using transient gene delivery systems. This enabled demonstration of the strong silencing inducer activity of double stranded RNA. We also extended our investigation of responses of *Arabidopsis* to different potyviruses. One potyvirus, turnip mosaic virus, was shown to induce infection phenotypes that resembled floral homeotic mutations. This feature is due to the HC-Pro silencing suppressor, and may reflect interference of silencing processes that occur during normal plant growth and development. Affymetric gene chip experiments were done to determine the global effects of HC-Pro on gene expression during *Arabidopsis* development.

Impact: This research is providing a basic understanding of how plants interact with pathogens. This will assist local and regional breeders to produce more resistant varieties of crops. The identification of mechanisms such as gene silencing involved in resistance to pathogens enables development of approaches to limit the effects of biological predation.

Scope of Impact: This research impacts agricultural producers in the State of Washington and the Pacific Northwest.

Regulation of Photosynthetic Processes – Funds from this project were used to support the travel of the principal investigators to attend the annual meeting of the Hatch NC-142 Regional Project which was held on November 17-18 in Raleigh, NC. A summary of recent developments from the PI's laboratories relevant to "Regulation of Photosynthetic Processes" was presented. Ongoing collaborative interactions with other members of the NC-142 project were discussed.

Impact: This project enables the PI's to keep abreast of some of the latest developments in the field of photosynthesis especially with regard to carbon partitioning and enzyme regulation.

Scope of Impact: National/International.

mRNA Sorting in Plants , mRNA Targeting to Subdomains of the Endoplasmic Reticulum – In previous studies, we have demonstrated that the prolamine RNAs are targeted to the surface of the prolamine protein bodies (PB-ER) by an RNA-based mechanism although translation initiation was apparently required. By analyzing the intracellular location of a GFP hybrid RNA containing prolamine or glutelin RNA sequences position at the 3' untranslated region, it was demonstrated that localization of this RNA to PB-ER was not dependent on translation initiation of prolamine RNA sequences. These properties enabled a detailed study to determine the location and nature of the RNA signal determinants within the prolamine RNA. Analysis of a series of 5' and 3' deletions of the prolamine RNA indicated the presence of two signal elements, one located in the coding sequence and the other located in the 3'UTR. The presence of both signals is required for faithful localization to the PB-ER, whereas the presence of only a single element resulted in localization of the RNA to both the PB-ER and cisternal-ER. Further studies are being conducted to substantiate this initial view. RNA transport in situ is also being analyzed. RNA movements of up to 0.7 um/sec have been observed.

Impact: These studies are the first demonstration that RNAs are targeted to specific locations in plant cells. Results from this research will not only add to our basic understanding on how plant genes are expressed at the cellular level but will lead to new approaches to increase protein production in plants.

Scope of Impact: National/International.

mRNA Targeting to Subdomains of the Endoplasmic Reticulum: The Role of RNA Binding Proteins An antisense 120 kD gene was constructed and transformed into rice. Over 30 independent transgenic lines were obtained and are currently being analyzed for 120 kD RNA binding protein levels by immunoblot analysis. Several lines showed significant reduction of the 120 kD protein. Using standard molecular approaches, a GFP reporter was fused in-frame to yield a hybrid protein under the control of a seed-specific promoter. This DNA construct has been transferred into rice and more than 20 independent transgenic lines obtained. Second generation transgenic plants are currently being grown and will be ready for analysis. Efforts were also made to identify Arabidopsis knockout mutants for the 120 kD RNA protein. A search of the current database of the Arabidopsis genome project indicates that this

plant has a highly homologous counterpart to the rice 120 kD RBP containing the same structural motifs, i.e., SN folds, Tudor domain, etc., present at a single gene copy. Screening of the University of Wisconsin T-DNA insertional library showed the existence of a line containing a T-DNA insertion in the coding sequence of the gene encoding the 120 kD RNA binding protein. Unfortunately, this Arabidopsis line was not detected in the second round of screening. This apparent discrepancy between the positive results in the primary screen and negative results in the second screen has not been resolved. More recently, a search was made of the Arabidopsis T-DNA collection at the Torrey Mesa Research Institute. Several promising lines have been identified and a formal request to obtain these lines will be made.

Impact: The studies proposed here will determine the possible roles of RNA binding proteins in prolamine RNA transport and/or anchoring using a variety of molecular, biochemical, genetic and cellular approaches. Information from these studies will be invaluable in efforts to increase the quality and quantity of seed proteins as a food and in using plants as phytofactories for the manufacture of novel proteins.

Scope of Impact: National/International.

Control of Photosynthetic Electron Flow in the Steady State – The productivity of crop plants depends greatly on the proper photosynthetic function. Inefficient light capture will directly decrease primary productivity, while strong light excitation of the photosynthetic machinery, in excess of that the plant can utilize or dissipate, will lead to the production of toxic byproducts (usually reactive oxygen species), which will damage the plant. Thus, a productive plant balances the need for primary productivity with photoprotection. Much of our research is directed towards understanding how this balance is achieved. We have focused on the dual role of the transthylakoid proton gradient, or proton motive force (*pmf*), which not only drives photosynthetic ATP synthesis, but is also the key signaling intermediate for the initiation of photoprotection.

The first accomplishment in our research was to define for the first time, the range of *pmf* and chloroplast lumen pH values held under in vivo, steady-state conditions. Contrary to the textbook view, we have demonstrated that thylakoid *pmf* is stored both as a pH gradient and as a transmembrane electric field, a critical discovery in understanding the relationship between *pmf* and both ATP synthesis and photoprotection. This change in view fundamentally affects photosynthetic regulation, and thus impacts our understanding of how plants acclimate and adapt to changing environments.

Our recent work continues to build on these data, showing that plants can adjust the amount of energy stored as electric field of pH gradient, thus altering the sensitivity of photosynthetic down regulation. We have recently demonstrated an important new step in photoprotection by showing that the conductivity of the ATP synthase to protons modulates the sensitivity of down-regulation. This system, which we are just beginning to understand, allows the chloroplast to adjust down-regulatory sensitivity to such environmental cues as atmospheric CO_2 levels.

We have also impacted the understanding of the function of the key photosynthetic proton pump, the cytochrome b6f complex. First, we published the first ever observations of steady-state proton and electron fluxes in vivo, showing that the pump is continuously engaged. Second, we demonstrated that certain metals specifically inhibit the domain movements of the iron-sulfur protein subunit of the complex. This work has demonstrated the functional importance of domain movements that have only been observed structurally, and has led to detailed study of the key molecular processes of the proton pump.

We have also made strides in finding practical applications for our instrumentation in the field of precision agriculture by demonstrating that our new field-portable instrument is capable of detecting drought and heat stresses in crop plants. We have now deployed portable versions of this instrument to address questions of photoprotection and plant productivity under field conditions.

We have also initiated establishment of an Electron Paramagnetic Resonance (EPR) center at WSU. Such facilities are essential for advanced research in many fields and WSU critically needs them. We now have two fully-functional EPR spectrometers together with ancillary equipment.

Impact: Understanding of response of the photosynthetic apparatus to changing environmental conditions is critical for improving crop productivity and range. The ability to probe these processes directly, using newly-developed instrumentation, should allow us to detect and remedy plant stresses at early stages, thus improving yield and decreasing the impact of farming on the environment.

Scope of Impact: National/International.

Photosynthetic Electron Transfer in Cold-tolerant and Cryophilic Algae –Environmental extremes such as chilling, heat, drought, etc., account for the largest fraction of crop losses. For this reason, the study of environmental stress effects is a major research focus in plant and agricultural sciences. Many environmental stresses, in particular chilling, directly or indirectly impact photosynthetic competence. Our approach is to study Antarctic algae that have evolved to live at low temperatures with the goal of characterizing the adaptations to the photosynthetic machinery that allow certain algae to grow at these low temperatures. Our research had identified two electron transfer processes with dramatically different temperature-dependencies in psychotrophic green algae (compared to mesophilic species). The first of these is the exchange of plastoquinol and plastoquinone at the phytosystem II Q_B site and probably reflects major differences in membrane lipid composition. The second of these is the rereduction of P680+ by the recox-active tyrosine, YZ. In mesophilic species, low temperatures accentuate and dramatically slow the longer phases of P680+ rereduction, whereas these phases remain relatively rapid and small in the Antarctic species. This result is particularly interesting because recent advances have shown that YZ acts to extract hydrogen from bound water, making it a central player in the process of photosynthetic oxygen evolution. Very recent reports have shown that the slower phases of P680+ rereduction are likely related to proton flux through channels in the PS II protein. Since the movement of protons through protons likely involves the movement of protonatable amino acid side chains, the relatively rapid P680+ reduction could be advantageous to these organisms since it would prevent back reactions with PS II that would normally lead to the production of chlorophyll triplets and eventual photodamage.

Impact: This research has begun to provide insights into relationships between protein structure, lipid properties, and photosynthetic electron transfer reactions. Extension of these studies should give us an understanding of the adaptations necessary for life at low temperatures, with potential applications for crop engineering in the US and the world.

Scope of Impact: National/International.

Sorting of Proteins to Vacuoles in Plant Cells – 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 that contains lytic enzymes.

Impact: This will have profound implications for understanding how storage proteins in seeds are protected during seed development, but are rapidly degrading during germination. Our model suggests that the lytic components of the globoid are likely to have very rapid access to the storage components during germination, possibly by disruption of the globoid membrane as the seed dessicates.

Scope of Impact: National/International.

Plant Metabolic Engineering – Enhance Productivity – Efforts to complement the mutation of the starch deficient Arabidopsis line TL-46 with a Arabidopsis ApL1 promoter-ApL1 cDNAs were unsuccessful, indicating that one or more regulatory elements controlling gene expression was present in the gene itself and not in the promoter and coding sequences. Therefore, the effect of the UpReg-1 and UpReg-2 mutations in the Arabidopsis LS (a leaf form) on the resulting enzyme was directly studied. Co-expression of the Arabidopsis AGPase subunits resulted in the formation of an enzyme with catalytic and allosteric regulatory properties similar to that reported for the native enzyme. UpReg-1 and UpReg-2 forms of the Arabidopsis LS rendered a heterotetrameric enzyme with up-regulated responses to 3-PGA activation and Pi inhibition comparable to the potato mutant enzymes. The adg2 gene encoding the Arabidopsis ApL1 was isolated, subjected to site-directed mutagenesis to incorporate the UpReg-1 and UpReg-2 mutations and used to transform Arabidopsis. Transgenic Arabidopsis TL-46 plants expressing the WT and UpReg-1, UpReg-2, and UpReg-1/2 versions of the ApL1 gene were readily identified by their enhanced capacity for leaf starch accumulation. As predicted, transgenic lines expressing the WT rApL1 gene accumulated near WT levels of leaf starch during the 12 hour photoperiod whereas lines expressing the UpReg ApL1 genes accumulated elevated starch levels, which were turned over during the dark. Initial photosynthetic measurements indicate that several UpReg lines grown at elevated CO2 exhibited higher CO2 assimilation rates than wildtype plants.

Impact: These studies will aid in efforts to increase our understanding of carbon partitioning during plant development and may lead to novel approaches to significantly increase plant productivity to levels not attainable by traditional breeding programs.

Scope of Impact: National/International.

Structure, Evolution and Function of Plant Proteinase Inhibitors – 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. Seven serine isoinhibitor forms were isolated and characterized from pepper that are induced via the octadecanoid pathway. Two mRNA species contain three copies each of the isoinhibitors that are post-translationally processed to yield the array of isoinhibitors found in leaves. Two tobacco systemins were isolated from leaves that are 18 amino acids in length. The two exhibited significant differences in amino acid sequence but were equally active as inducers of proteinase inhibitor synthesis in tobacco leaves. A cDNA was isolated that coded for a preprotein from which both systemins are processed.

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. We are currently isolating the receptor gene for studies of the structure and function of the receptor in tomato cells. New polypeptide signaling molecules are being isolated to determine their precursors, the mode of release and action, and their localization in plants. We will continue to identify and isolate the receptors of these polypeptides and begin to learn the broad fundamental principles that underlie polypeptide signaling in plants.
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.

Scope of Impact: National/International.

Biochemistry of Plant Terpenoids – Using genes isolated from the peppermint oil gland EST project, and sense and antisense technologies, transgenic peppermints with improved essential oil yield and composition have been prepared. Studies with prenyltransferases have revealed the function of the geranyl diphosphate synthase in the control of chain-length specificity. The stereochemistry of the monoterpene cyclization reactions leading to bornyl diphosphate and cineole were determined. The kinetic mechanism of limonene hydroxylase was determined and site directed mutagenesis allowed modification of the regiochemistry of this enzyme. Site directed mutagenesis of several monoterpene and sesquiterpene synthases have revealed structural features responsible for product diversity. Crystallographic data to 2.05A have been obtained for bornyl diphosphate synthase. A method was developed for screening herbicide activity toward the mevalonate-independent pathway of isoprenoid biosynthesis.

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.

Scope of Impact: National/International.

Nutrient Exchange and Metabolism in the Rhizobium-Legume symbiosis – Bacteria associated with legume roots can provide these plants with a source of nitrogen and contribute to the supply of nutrients available to the agricultural ecosystem. Understanding the way in which bacterial metabolism is coupled to that of the plants is essential to understanding the dynamics of this interaction. During the last year we have made progress in determining the role of key enzymes in the bacterial processing of carbon compounds obtained from the plant, in developing new methods for measuring the productivity of the interaction and in characterizing the genetics of the bacterial symbiont. We are trying to identify steps in this process where the efficiency could be improved, to permit higher yield of crops that can use symbiotic relationships to improve their growth. Significant advances during the last year include contributions toward integrating information available from the *S. meliloti* DNA sequence into a more complete picture of the capabilities of the organism and the improvement of a new method for measuring nitrogen fixation using electrospray mass spectrometry, which could have implications for legume breeding and make it possible to incorporate symbiotic efficiency as a selectable trait in variety development.

Impact: The description of the *S. meliloti* genome provides for the first time a complete look at the metabolic potential of the organism and tools under development will allow us to expand on this understanding and provide a model for genetic analysis of bacteria. The new method of measuring nitrogen fixation should affect strategies for legume improvement if it can be applied in the field.

Scope of Impact: National/International.

Bacterial Dicarboxylate Transport in Symbiotic Nitrogen Fixation – The dicarboxylic acid transport protein, DctA, is essential for a functional, nitrogen-fixing symbiosis. In free-living growth, DctA can transport a number of physiologically important compounds, including malate, fumarate, succinate, aspartate and oxaloacetate. It is unclear how important each of these is in symbiosis. We are isolating DctA mutants of *Sinorhizobium meliloti* bacteria that have altered specificity or affinity for the different substrates in order to discover more about the transport properties of DctA. Various mutant isolation strategies are being used, including isolation of functional mutants resistant to a toxic DctA substrate, mutants with higher transport rates with dicarboxylic acids for which DctA has low affinity, and mutants able to compete well for limiting amounts of dicarboxylic acids. Transport properties of the mutants will be determined and, in addition, the mutants will be tested on their alfalfa host plants for the ability to support symbiotic nitrogen fixation. In this way we will use the mutants as *in vivo* probes of nodule function.

Impact: There are no significant changes or immediate benefits to agriculture unless some of the mutants lead to increased productivity.

Scope of Impact: National/International.

Genetics of Symbiotic Effectiveness in Legumes – Breeding more effective crop plants has been hampered by the complexity of using nitrogen fixation as a quantitative trait. The number and location of plant genes involved in determining effectiveness in symbiotic nitrogen fixation is unknown. Two developments could change this situation: a better assay for nitrogen fixation and improved methods of genetic analysis. We have taken the first steps toward developing a more rapid and more reproducible way to measure nitrogen fixation using a new electrospray mass spectrometry method and are using this method routinely to evaluate effectiveness. We plan to use the method to analyze the heritability of symbiotic effectiveness of recombinant inbred lines of *Medicago truncatula*, a relative of alfalfa, in order to associate the gene(s) responsible for phenotypic variation in effectiveness with quantitative trait loci. Recently we identified two bacterial strains that discriminate between the parents of a new set of RILs and are in the process of increasing seed for these lines so that we can determine their symbiotic properties.

Impact: 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 recombinant inbred lines should give some insight into how many plant genes might be involved in determining this trait.

Scope of Impact: National/International.

KEY THEME: Integrated Pest Management, Biotechnology; Nutrient Management, Sustainable Agriculture

Research Program: Plant and Pathogen Controls in Crops (3153)

Role of Wound-Inducible Polygalacturonase of Plant Leaves – H_2O_2 has been found to be a 'second messenger' in the signaling pathway for inducible plant defense against herbivores. The wound-inducible systemic accumulation of both H_2O_2 and activation of defensive proteinase inhibitor genes and polyphenol oxidase genes were inhibited by NADPH oxidase inhibitors. Wound-inducible genes that encode signal pathway components were not inhibited. When excised plants were supplied with an H_2O_2 generating enzyme through their cut petioles, the defense genes were expressed but not the signaling genes. Our cumulative results indicate that the wound hormone systemin activates the synthesis of methyl jasmonate in vascular bundles, which then activates the synthesis of polygalacuronase (PG). The PG then partially degrades cell walls, producing oligogalacturonide fragments that produce H_2O_2. The H_2O_2 acts as a "second messenger" by diffusing into mesophyll cells where it activates genes for the synthesis of proteinase inhibitors.

Impact: Research performed under this project has demonstrated that hydrogen peroxide is a second messenger for the regulation of defense genes in response to wounding (herbivore attacks). Hydrogen peroxide is produced by the cell wall fragments released by a wound-inducible leaf polygalacturonase. This enzyme is synthesized in response to jasmonic acid that is produced by the wound response. This finding introduces an entirely new scenario for the pathways that cause defensive chemicals to be produced in response to herbivore and pathogen attacks, and provides new approaches for the strengthening of natural defense responses in agricultural crops.

Scope of Impact: National/International.

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 CO_2 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.

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 and 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 UV-B radiation and CO_2 levels in the atmosphere are affecting these same trees. Although few changes in land management have resulted to-date from the ongoing UV-B 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 it 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 UV-B and CO_2 in the atmosphere.

D. Accomplishments based on Department/Unit POW for 2001

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 FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$0.00
Hatch Multistate Research	$0.00
Federal Research Grants	$52,257.09
State Appropriations	$70,721.85
Other Grants	$1,679.92

Total Faculty/Staff FTEs: 3.09

KEY THEME: Biotechnology

Research Program: Ecophysiology and intensive culture of forest trees.
CRIS Projects 0113, 4113, 0307 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; and (6) biomass accumulation in these different clones at the same level of nitrogen nutrition.

B. Impacts
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 Impacts:
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, and (3) Detection of disease-causing organisms and control of plant diseases.

Research Results From Research 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 pollen transmission of the cherry isolate of *Cherry Leafroll Virus*; (2) Improved diagnostic methods for *Rupestris Stem Pitting-Associated Virus* in grapevines; (3) Identification of three genetically distinct groups of *Ascochyta rabiei* in the Pacific Northwest; (4) Isolation of fungi from galleries of bark-boring beetle in aspen and willow; (5) Completion of the first phylogeny of *Tilletia* sp. based on DNA sequence data of the nuclear large subunit ribosome; (6) Greater understanding of the taxonomic and chemotaxonomic relationships among several pyrenomycete fungi; (7) Demonstration that management of grape powdery 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) Establishment of a 100 acre direct-seed, precision agriculture project that is farmed with commercial-size equipment; (9) Demonstration that the previous season's thinned fruit on the orchard floor is a significant source of *B. cinerea* inoculum; (10) Demonstration that frequency of *Tapesia acuformis* has increased nearly 10-fold from surveys conducted 10 years ago; (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) Evaluation of several bacteria for biological control potential of crown gall of grapevines; (13) Demonstration that *Prunus Necrotic Ringspot Virus* of hop consists of a continuum of hop and Prunus isolates rather than single discrete populations; (14) Identification of progeny lines from a wheat x wheatgrass cross with highly effective resistance to *Cephalosporium gramineum* contain a small terminal translocation of wheatgrass chromatin; (15) *Verticillium dahliae* isolates from VCG 2B but not VCG 4A interact with the root lesion nematode *Pratylenchus pene*trans to cause disease in mint; (16) Accurate prediction of stripe rust of wheat and barley epidemics in the western U.S. based on trap plots and field surveys; (17) NRSP-5 received 66 non-proprietary, 61 patented, and 44 varieties of pome and stone fruit clones form foreign countries and distributed over 12,000 buds of 359 varieties, 5,000 buds of 87 patented clones, and 3200 buds of 132 foreign clones; and, (18) Detection of *Cherry leafroll virus* from orchard samples collected in Washington, but not California or Oregon, was positive; most positive samples were from trees 12 to 25 years old, but very few were from trees 6 years old or less.

Outcomes That Have Resulted in Significant Changes

Results of these studies have resulted in significant changes including: (1) Identification of distinct populations of *A. rabiei* resulted in modification of methods of screening for disease resistance to this pathogen to ensure the full range of virulence is included; (2) Altered growers' approach to disease management of fruit trees that reduce fungicide input and hastened adoption of fungicide resistance management strategies; (3) Improved understanding of sources of inoculum that will help reduce disease in stored apples and other tree fruits; (4) Altered methods of screening wheat for resistance to eyespot to account for *T. acuformis* and ensure cultivars with highly effective resistance; and (5) Demonstrated that existing ELISA protocols provided reliable virus testing for Ilarviruses of hops, which did not require changes in testing protocols.

Benefits to Clientele (Stakeholders)

Ascochyta blight will improve the ability of scientists to develop chickpea cultivars with stable disease resistance; (2) Adoption of biorational fungicide resistance management strategies by tree fruit growers results in fewer pesticide applications and reduces potential for development of resistance in pathogens, which reduces production costs and prolongs the commercial life of fungicides; (3) The NRSP5 program distributes virus-free germ plasm nationally and internationally, which enhances productivity of pome and stone fruits; (4) New detection techniques for RSPaV resulted in suspension of germ plasm distribution and destruction of the infected vines, which protected the industry from spread of this pathogen; (5) Reliable detection and identification of *Tilletia* sp. helps reduces the impact of these pathogens on export of wheat from the PNW; (6) Mycological studies enable scientists to better understand biodiversity issues in plant pathogens and their host plants, as well as identifying potential targets for pharmaceutical and chemical industries; (7) Assisted growers in the high-rainfall area of the PNW in making the transition to continuous a direct-seeding system; (8) Highly effective resistance to *Cephalosporium gramineum* is now present in a hexaploid wheat background and is being exploited by breeding programs; and (9) Growers

receive essential information that enables them to implement control methods to reduce yield and quality losses associated with stripe rust of wheat and barley.

Accomplishments based on Department/Unit 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.

Source of Funding and FTEs

Total Expenditures for all projects: $2,632,756.22

Source of Funds	Amount
Hatch	$147,545.58
Multistate Research	$55,102.33
Federal Research Grants	$374,017.83
State Appropriations	$1,015,773.19
Other Grants	$1,040,317.29

Total Faculty/Staff FTEs: 26.375 (Prosser, Pullman, & Wenatchee)

KEY THEME: Plant Health

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

A. **Activities**

Basic studies of plant pathogen biology have resulted in: (1) Greater understanding of pollen transmission of the cherry isolate of *Cherry Leafroll Virus*; (2) Improved diagnostic methods for *Rupestris Stem Pitting-Associated Virus* in grapevines; (3) Identification of three genetically distinct groups of *Ascochyta rabiei* in the Pacific Northwest; (4) Isolation of fungi from galleries of bark-boring beetle in aspen and willow; (5) Completion of the first phylogeny of *Tilletia* sp. based on DNA sequence data of the nuclear large subunit ribosome; and (6) Greater understanding of the taxonomic and chemotaxonomic relationships among several pyrenomycete fungi.

B Impacts

1. Transmission of CLRV via pollen is important to certification programs and limiting spread of this pathogen locally, nationally, and internationally.
2. New detection techniques identified RSPaV in the Grapevine Foundation Block, necessitating suspension of germ plasm distribution and destruction of the infected vines. These measures will protect the industry from spread of this pathogen.
3. Identification of distinct populations of *A. rabiei* resulted in modification of methods of screening for resistance to this pathogen, which will ensure growers have access to cultivars with effective resistance.
4. This work contributes to the global understanding of relationships between fungi and fungus-beetle associations in trees, which enhance understanding of wood decay, wood staining, and insect-vectored diseases.
5. Understanding the phylogenetic placement of important smut pathogens of small cereal grains will enable development of diagnostic and detection techniques, which may help limit their impact on the U.S. wheat export industry.
6. Mycological studies enable scientists to better understand biodiversity issues in plant pathogens and their host plants, as well as identifying potential targets for pharmaceutical and chemical industries.

C. **Scope of Impact of Each Project in Part A:**

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 Projects: 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 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) Establishment of a 100 acre direct-seed, precision agriculture project that is farmed with commercial-size equipment; (3) Demonstration that the previous season's thinned fruit on the orchard floor is a significant source of *B. cinerea* inoculum; (4) Demonstration that frequency of *Tapesia acuformis* has increased nearly 10-fold from surveys conducted 10 years ago; and (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. Assist growers in the high-rainfall area of the PNW in making the transition to a continuous direct-seeding system both agronomically and economically feasible.
3. Improved understanding of sources of inoculum may help reduce disease in stored apples and other tree fruits.
4. Alter methods of screening wheat for resistance to eyespot to account for *T. acuformis* and ensure cultivars with highly effective 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 Projects: 185, 248, 292, 390, 670, 678, 823, 1262, 1844, and 5263.

A. **Activities**

Studies on the detection of plant pathogens and control of plant diseases resulted in: (1) Evaluation of several bacteria for biological control potential of crown gall of grapevines; (2) Demonstration that *Prunus Necrotic Ringspot Virus* of hop consists of a continuum of hop and Prunus isolates rather than single discrete populations; (3) Identification of progeny lines from a wheat x wheatgrass cross with highly effective resistance to *Cephalosporium gramineum* contain a small, terminal translocation of wheatgrass chromatin; (4) *Verticillium dahliae* isolates from VCG 2B but not VCG 4A interact with the root lesion nematode *Pratylenchus penetrans* to cause disease in mint; (5) Accurate prediction of stripe rust of wheat and barley epidemics in the western U.S. based on trap plots and field surveys; (6) NRSP-5 received 66 non-proprietary, 61 patented, and 44 varieties of pome and stone fruit clones form foreign countries and distributed over 12,000 buds of 359 varieties, 5,000 buds of 87 patented clones, and 3200 buds of 132 foreign clones; and (7) Detection of *Cherry leafroll virus* from orchard samples collected in Washington, but not California or Oregon, was positive; most positive samples were from trees 12 to 25 years old, but very few were from trees 6 years old or less.

B. Impacts

1. Demonstration that biological control agents can colonize, move systemically, and persist within plants offers a new approach to control this disease.
2. Confirmation that existing ELISA protocols provide reliable virus testing for Ilarviruses.
3. Highly effective resistance to *Cephalosporium gramineum* is now present in a hexaploid wheat background.
4. Demonstration that control of Verticillium wilt of mint depends on managing *V. dahliae* VCG 2B and *P. penetrans*.
5. This project provides essential information to enable implementation of control methods to reduce yield and quality losses associated with stripe rust of wheat and barley.
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. Demonstration that CLRV occurs in Washington and that this disease will have greater negative impact on orchard productivity as trees age.

C. **Scope of Impact**

1. This research has multistate impacts: WA, OR, ID, CA.
2. This research has multistate impacts: WA, OR.
3. This research has multistate impacts: WA, OR, ID.
4. This research is state specific: WA.
5. This research has multistate impacts: WA, ID, OR, CA, CO, TX, KS, LA, LS, ND, MN.

6. This research has multistate impacts: WA, PA, WV, CO, CA, MI.
7. This research has multistate impacts: WA, CA, OR.

WESTERN WASHINGTON RESEARCH AND EXTENSION CENTER

GOAL 1: OVERVIEW

Research programs at the 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.

Research Results From Research Projects Supported by Hatch Formula funds

1. **Western Washington Farm and Food Systems**
Basal rot control during hot water treatment of daffodil bulbs: Hot water formaldehyde treatments have been used since the 1930's to control a number of important insect pests, nematodes, and fungi associated with harvested bulbs, especially basal rot disease. Agricultural uses of formaldehyde have been severely restricted in the U.S. by the Environmental Protection Agency and will have a major impact on commercial daffodil growers. Chlorine dioxide was shown to be as effective as controlling basal rot disease as formaldehyde treatments. A procedure using chlorine dioxide for this purpose was developed that, in addition to showing good efficacy, avoids disposal problems resulting from use of formaldehyde or traditional fungicides.

2. **Environmental Quality**
Environmental/cultural factors on water stress resistance/growth/cold hardiness of landscape plants: Tests involving several planting media, rooted cuttings of *Fuchsia alba* and *Pelargonium* x *hortorum* 'Americana Light Pink' and plug-grown seedlings of *Impatiens wallerana* 'Accent Cranberry' and differing fertilizer treatments were done to assess effects on plant growth. Results showed that growing plants in compost and using nitrogen compost as fertilizer produced good quality plants and reduce the amount of water needed.

3. **Environmental Quality**
Beneficial use of organic amendments in agricultural and urban soils. The composition and variability of yard trimmings was characterized, estimates N availability were determined, and guidelines developed for agronomic use of yard trimmings.

Outcomes That Have Resulted in Significant Changes

1. **Western Washington Farm and Food Systems**
Research showed that chlorine dioxide treatments are an effective alternative to traditional hot water formaldehyde treatments for controlling basal stem rot in daffodil. The new process avoids the use of formaldehyde, a known carcinogen which will no longer be available for this use. In addition, using chlorine dioxide enables growers to avoid the disposal problems associated with formaldehyde and other fungicides.

2. **Environmental Quality**
   Results showed that plants grown in growing media composed of recycled yard debris compost (rydc) or a 50% rydc: 50% bark medium were larger and of higher quality than plants grown in other media. This finding shows that growers can cut production costs and enable them to use less water than traditional procedures for producing bedding plants.

3. **Environmental Quality**
   Corn grown with yard trimmings had equal or greater yield than corn grown with inorganic N fertilization. Soil organic matter, P, and K increased with yard trimmings application. Nutrient content of different yard trimming mixes were determined. Results indicated that because of variability in the amount of plant-available N supplied by yard trimmings, a conservative application rate is appropriate where nitrate leaching is a concern. Soil nitrate testing approximately 30 days after yard trimmings application to cropland is recommended to fine tune application rates.

Benefits to Clientele (Stakeholders)

1. **Western Washington Farm and Food Systems**
   This research enables Washington bulb producers to comply with new restrictions on the use of formaldehyde while controlling a significant bulb disease. The new procedure also enables them to avoid disposal costs associated with use of traditional fungicides. This findings are a significant contribution to the long term health of the Washington bulb industry.

2. **Environmental Quality**
   This research provides producers of container and bedding plants with procedures to cut production costs, improve efficiency of water use, and to produce superior plants for sale. It contributes significantly to the economic health of the nursery industry in the state.

3. **Environmental Quality**
   This research provides composters and farmers with essential information for using minimally processed yard trimmings in crop production. One local composter has estimated hundreds of thousands of dollars in savings because his yard trimming composting operation has been able to reduce peak flows to the composting facility. Resulting management guidelines for use of crop trimmings protect water quality while ensuring that proper nutrient levels are available to crops.

Accomplishments based on Department/Unit POW for 2001

1. **Western Washington Farm and Food Systems**
   Our plan outlined efforts to enhance farming practices in western Washington. The research outlined a new procedure for basal rot control that does not involve use of a newly restricted traditional chemical agent.

2. **Environmental Quality**
   Our plan outlined efforts to enhance cultivation of plants in urban settings. The research outlined effective procedures for producing bedding/container plants that reduced grower costs and reduced water use.

3. **Environmental Quality**
   Our plan outlined efforts to minimize the negative impacts of human activity on the environment. The research provided composters and growers with effective procedures for using minimally processed yard waste in crop production. The research enhanced the economic performance of composting facilities, and provided procedures that protect water quality.

E. Total Faculty/Staff FTEs: 13.48

GOAL II

BIOLOGICAL SYSTEMS ENGINEERING

GOAL II: OVERVIEW

A safe and secure food and fiber system

Research Results From Research Projects Supported by Hatch Formula funds

The Department of Biological Systems Engineering is reporting activity in three Research Problem Areas under Goal 2: Engineering Systems and Equipment; New and Improved Food Processing Technologies; Quality Maintenance in Storing and Marketing Food Products. Research results include developing techniques used in processing and storage to reduce bruising or to improve processing equipment to reduce bruising. A project is investigating the use of oscillating magnetic fields as a nonthermal method of preserving foods by killing certain microorganisms. The project on application of finite element modeling techniques to agricultural processing has turned its attention to the study of grape trellis wires and possible measurements that could be used for making production decisions. In other food processing research, major progress has been made in the use of microwave and radio frequency energy to process foods. Studies on the use of radio frequency energy have determined essential engineering principles necessary to proceed with research on the use of radio frequency systems to kill insects in fruits and nuts for export.

Outcomes That Have Resulted in Significant Changes

Research results on nonthermal technologies show promise in some areas that are under continuing study for application to food processing. Using microwave and radio frequency energy for insect control and drying has been demonstrated and fundamental engineering principles in these areas have been determined. The project on applying finite element modeling to agricultural processes has selected sites and collected preliminary data for the work on measurements along grape trellis wires as an aid to making production decisions. 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 and has resulted in specific recommendations on conditioning some fruits and vegetables to prevent their bruising. Growers and packers are making use of these recommendations.

Benefits to Clientele (Stakeholders)

Food processors and exporters have new technologies available for processing food and for killing insect pests before export with no harm to the environment. They also now have available storage and shipping techniques that will reduce bruising.

Accomplishments based on Department/Unit POW for 2001

The departmental plan of work is focused, in part, on improved techniques for food processing. Research efforts are aligned with important developments of the previous year. The department is focused on its research objectives and directing its resources toward the accomplishment of stated objectives.

Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$18,308.39
Multistate Research	$52,882.12
Federal Research Grants	$436,579.60
State Appropriations	$279,364.67
Other Grants	$226,421.89

Total Faculty/Staff FTEs: 10.50

KEY THEME: Food Quality

Research Program: Engineering Systems and Equipment

A. 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 has shown that turgor conditioning and, for some commodities, temperature conditioning, can improve tissue strength and elasticity, thereby raising bruise threshold and reducing bruising. The research has also developed and refined mathematical models that can be used to guide future research in this area. Work on measuring thermal properties of bruised and sound apple tissues has determined 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. Impacts
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. This information is integrated into section b above. Accomplishments based on department plan of work: 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.

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$1,650.45
Multistate Research	$0.00
Federal Research Grants	$37,124.44
State Appropriations	$41,712.30
Other Grants	$0.00

KEY THEME: Food Quality

Research Program: New and Improved Food Processing Technologies

A. The purpose of this project is to develop new or improved methods for processing foods. The specific techniques under study are the use of oscillating magnetic fields as a nonthermal method of preserving foods and the application of finite element modeling techniques to the processing of food. The magnetic fields project has examined the use of this technology for killing microorganisms that are common contaminants of food. Other nonthermal processing technologies (high hydrostatic pressure and pulsed electric fields) are under study, especially with regard to processing milk and milk products. The mathematical modeling project has identified research sites and gathered preliminary data for an analysis of load measurements on grape trellis wires as an aid in management of grape crops. A project on the use of high intensity magnetic fields to preserve foods has shown that this energy is not effective in inactivating microorganisms common in food contamination.

B. Impacts
The magnetic fields project has determined that some possibilities for the use of this technology will not work and is exploring other methodologies (impact in all states where food is processed). The mathematical modeling project is developing an understanding of the relationship between single cell properties and tissue properties that will allow for more precise growing and storage practices (impact in all states where unprocessed fruits and vegetables are stored, especially WA, OR, ID, MI). Real time estimations of crop loads is a critical factor in the continuing development of precision agriculture techniques applied to grapes with important implications in states where grapes are important crops (CA, WA, OR, ID, NY, NJ). Possible use of magnetic fields in food processing is continuing along with efforts to use other alternatives to heat treatment. This overall area of research is changing the way that food is processed to produce processed foods more suitable to consumer tastes.

C. This information is integrated into section b above. Accomplishments based on department plan of work: The Center for Nonthermal Processing of Food is fully functional. Several projects are contributing money based on recovery of facilities and administration costs at the department level. Industrial collaborators, especially Avista Utilities, are very interested in the results of research. Mathematical modeling is contributing to a better understanding of agriculture and food processing.

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$10,498.07
Multistate Research	$1,410.61
Federal Research Grants	$48,226.15
State Appropriations	$113,641.04
Other Grants	$185,032.29

KEY THEME: Food Quality

Research Program: Quality Maintenance in Storing and Marketing Food Products

A. Major progress has been made in the use of microwave and radio frequency energy to process foods. The research focused on microwave sterilization technologies for single-meal trays and radio frequency sterilization technologies for group military rations. The project has developed computer simulation models to guide system and process design. It has demonstrated that radio frequency energy can be used to produce much better egg products than the retorted product. Other studies on the use of radio frequency energy have determined essential engineering principles necessary to proceed with research on the use of radio frequency systems to kill insects in fruits and nuts for export. Research on the improvement of the stability and useful life of electrochemical sensors for use in enzymatic assays in the food industry has measured important parameters necessary to model the performance of these sensors and developed laboratory techniques for improving the electropolymerization process that is important in improving the stability of the enzyme-based sensors.

B. Impacts:

The work might change the food canning industry dramatically, providing much better shelf-stable foods in a much cleaner production environment with systems that are highly automated and very energy-efficient. These process can be used to produce better military rations and better processed food available to consumers. This work is important in all states where food is processed. The research on radio frequency energy to provide heat treatment for postharvest pest control in tree fruits and nuts is crucial instates where tree fruits and nuts are grown for export, especially WA, CA, MI, FL, OR, ID. Research on electrochemical sensors is working on improving these sensors, especially their useful life, with impact in all states where food is processed using electrochemical sensors.

C. This information is integrated into section b above. Accomplishments based on department plan of work: This research is developing new technologies in the area of the use of microwave and radio frequency energy in food processing and improved sensors for food processing. As part of this research, investigators are developing improved mathematical and computer models for processing of foods. The research is working toward improvements in on-line sensors for food processing.

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$6,159.87
Multistate Research	$51,471.51
Federal Research Grants	$351,229.01
State Appropriations	$124,011.33
Other Grants	$41,389.60

ENTOMOLOGY

GOAL II: OVERVIEW

The research program of the Departmental 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: Food Safety

Research Program: Integrated Pest Management. CRIS projects 0122, 0246

A National Agricultural Program to Clear Pest Control Agents for Minor Uses.
USDA/IR-4 is a federal/state/private cooperative that aspires to obtain clearances for pest control chemistries on minor crops. All IR-4 research, both field and laboratory research, is carried out according to Good Laboratory Practice (GLP) requirements as mandated by EPA. The process is inspected by IR-4 quality assurance personnel to validate compliance.

GLP Magnitude of Residue Trials completed in 2001

Test Substance	Crop
Bifenazate	cherries
Fenhexamid	pear
Buprofezin	pear
Bifenazate	potato
Fenhexamid	apple
Fluroxypyr	apple
Fluroxypyr	pear
thiocloprid	cherries
flumioxazin	potato
tebuconazole	asparagus
spinosad	grasses
clethodim	hops

Results vary among crop/ chemical registration, however, the Washington State Commission on Pesticide Registration estimates that IR-4 registrations saved over $130 million in crop production from damage by pests.

Development of Crop Protection Chemicals. Acaricides and insecticides have been screened for use on grapes. This program has aided the registration of neonicitinoid insecticides and anti-metabolite acaricides protecting millions of dollars of wine and juice grapes from arthropod pest damage.

Research Program: Ensure Food Products Free of Harmful Chemicals, including residues from agricultural and other sources. CRIS project 0335

Pesticide Information Coordination. Presentations were made to state clientele regarding the status of pesticide registrations. One in-service training on pesticide resources was offered to university personnel. Three regional meetings in the area of pesticide regulation were attended in order to represent WA interests. The Pesticide Notification Network sent 355 notifications comprising 12,328 transmittals to interested parties on changes to pesticide labels and/or regulations. The 20,585 records in the pesticide registration database were updated to include the CY2001 registrations for WA and OR. The tolerance database was updated to include the CY2001 data. The PICOL web site was redesigned as a catalog of WA state pest management resources. An advisory committee of stakeholders was established. Crop profiles are under development; profiles on apples and barley have been published. 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.

Allocated Resources

Total Expenditures for all projects:

Source of Funds	Amount
State Appropriations	$20,896.47
Other Grants	$75,584.22

Total Faculty/Staff FTEs: 1.0

FIELD DISEASE INVESTIGATION UNIT

GOAL II: OVERVIEW

Prevalence and virulence of Shiga-toxigenic *E. coli* (STEC) from dairy, feedlot and range cattle is being examined. Cattle are the main reservoir for Shiga-toxigenic *E. coli* O157:H7, a significant human pathogen. What is not known, however, is the preponderance of other non-O157 STEC in cattle. Preliminary findings suggest that STEC are excreted by cattle more frequently than *E. coli* O157:H7, and virulence characterization of non-O157 STEC suggests they represent a significant public health risk. Ongoing studies on the on-farm risk factors for zoonotic enteropathogens associated with cattle feed and water suggest that they sustain enterpathogens and may be a reservoir and/or fomite of enteric cattle microflora. Feeds may play a significant role in dissemination of hazardous microflora. We are determining the frequency with which resistant bacteria are found in feeds and their ability to multiply in feeds. We plan to determine whether pathogens of the family *Enterococcus* in feeds on farms become part of the intestinal flora of cattle that consume such feeds.

The on-farm ecology of *Listeria monocytogenes* of cattle and sheep is being examined. The focus of this study is to characterize the *Listeria* subtypes of livestock origin and compare those subtypes with isolates of food-borne disease origin, to define the cattle shedding patterns, to define the on-farm ecology of livestock shedders versus non-shedders, and to develop a rapid assay to identify livestock subtypes. We have hypothesized that animals serve as an expansion source of human microflora that carry antibiotic resistance genes. A first study is examining the microflora of sentinel animals, seagulls and cattle, which are exposed to human waste as compared to those that are not. Early findings suggest that there exist resistant organisms in both groups, suggesting exposure is not highly significant. In a second study, the microfloral patterns of dogs fed fresh meat, bones, and visceral components as compared to dogs fed typical diets is being studied. Dogs receiving conventional diets have less antimicrobial resistant microflora than those receiving the fresh diet.

We have examined risk factors associated with mycoplasma mastitis. The number of *S. aureus*, total number of bacteria (SPC), streptococci other than agalactiae (environmental streps), the number of *E. coli*, and the number of *A. pyogenes*, in bulk tank milk, were significantly and positively correlated with mycoplasma counts. The strongest correlation with bulk tank mycoplasma counts was pounds of milk shipped, an estimate of herd size. These data suggest that factors affecting other mastitis pathogens and herd size might be parallel risk factors for mycoplasma mastitis.

Risk factors for the occurrence of lupine induced crooked calf disease have been examined using cows that had borne crooked calves in the 2001 calving season and cows that did not – Both groups having had the same exposure risk to lupine. One study has examined for differences in lupine grazing behavior between the two groups and another study for differences in alkaloid absorption, metabolism, and response as determined by ultrasound examination.

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 out studies will reduce the threat of zoonotic spread of this pathogen. Also, a major focus of our work is transfer of antimicrobial resistance genes. Risk factors associated with this transfer are being addressed in the canine and other species. Lastly, the work in contagious mastitis, specifically *S. aureus* and mycoplasma mastitis, wll impact food safety and milk quality. *Staphylococcus aureus* is a significant form of food poisoning and is of concern to regulatory officials. Both pathogen types can cause significant alterations in milk quality.

Unit Goals:

Definition and resolution of animal and zoonotic disease by the development of on farm emerging control programs

Unit Objectives

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 zoonootic agents such as *E. coli* 0157:h7, *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

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	$65,041,77
Hatch Multistate	$0
Fed. Res. Grants	$0
State Approp	$206,639.38

Total Faculty/Staff FTEs: 3.47

HORTICULTURE AND LANDSCAPE ARCHITECTURE

GOAL II: OVERVIEW

Research Programs of the Department of Horticulture and Landscape Architecture are: Post-harvest quality of fruits and vegetables.

Research Results From Research 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 CA stored fruit increases with consecutive harvest dates until 163 DAFB and during the post storage ripening period. This indicates that flavor can be regenerated after CA storage; (3) 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.

Outcomes That Have Resulted in Significant Changes

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. Other important changes are: (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.

Benefits to Clientele (Stakeholders)

The benefits to clientele result from improved economic efficiency. 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.

Accomplishments based on Department/Unit POW for 2001

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.

Source of Funding and FTEs

Total Expenditures for all projects: $203,811.69

Source of Funds	Amount
Hatch	$0.00
Hatch Multi-State Research	$40,119.87
Federal Research Grants	$13,138.54
State Appropriations	$12,853.55
Other Grants	$137,699.73

Total Faculty/Staff FTEs: 1.67

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) Flavor chemistry studies have found that fruit quality can be maintained with proper post-harvest storage techniques; (2) Volatile production by controlled Atmosphere stored fruit increases with consecutive harvest dates until 163 DAFB and during the post storage ripening period. This indicates that flavor can be regenerated after CA storage; (3) 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. Impacts

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

GOAL III

FOOD SCIENCE AND HUMAN NUTRITION

GOAL III: OVERVIEW

Research Results From Research Projects Supported by Hatch Formula funds

The FSHN department continued to study the nutrition and health aspects and bioavailability of several nutrients including conjugated linoleic acid, leptin, vitamin B-6 and calcium. Research continued on social science methodologies employed to access and facilitate dietary behavior changes and food safety concerns in at-risk and diverse populations.

Outcomes That Have Resulted in Significant Changes

The inaccuracy of some previous methodologies used to measure conjugated linoleic acid consumption in the American diet led to new predicted level of consumption that was lower that previously reported. The current RDA for vitamin B-6 was shown to be too low for young women in the United States and should be raised to 1.5mg/d for optimum health of this group. New understanding about patient adherence and non-adherence to the dietary components of diabetes self-management will impact other research in this important area and will eventually lead to improved self-management of this national health issue.

New expertise was added to the calcium intake research group with a new researcher. Consumption of soybeans or soybean products was shown to be a risk factor for persons at risk for kidney stones. This finding will impact the dietary recommendations assigned to this population sector.

Source of Funding and FTEs

Total Expenditures for all projects: $332,594.93

Source of Funds	Amount
Hatch	$1,862.94
Hatch multistate research	$1,631.95
Federal Research Grants	$53,340.80
State Appropriations	$232,802.76
Other Grants	$42,956.47

Total Faculty/Staff FTEs: 4.61

KEY THEME: Human Nutrition

Research Program: Requirements and function of nutrients and other food components
CRIS Projects: 0118, 0286, 0373, 0905

Conjugated linoleic acid: Dairy enrichment, dietary intakes, cell culture, and cancer prevention. It was demonstrated that three day dietary records and food frequency questionnaires are not reliable estimators for consumption of conjugated linoleic acid (cla) and that intake of cla may be significantly lower that suggested previously by others.

Potential Impact: Results of this study will impact research methodology chosen by future rearchers who study conjugated linoleic acid intakes.

Effect of under or over consumption of serum leptin and food regulation in lean and obese subjects. Leptin and insulin response to macronutrient intake in obese subjects and lean controls suggest that leptin is influenced transiently by feeding and that this effect is exaggerated in obese individuals in response to high carbohydrate feeding. New

relationships among circulating hormones (leptin, insulin, prolactin), maternal adiposity, suckling characteristics and ovulatory function in postpartum women were identified.

Potential Impact: New understanding of leptin and insulin responses in various populations may lead to new hypothesis to the causes and control of obesity.

Nutrition in the treatment of calcium kidney stones. It was demonstrated that consumption of soybeans of soybean products can increase urinary oxalate excretion, a risk factor for kidney stone formation in susceptible individuals.

Potential Impact: This project has national implications with the findings that consumption of soybeans or soybean products may increase kidney stones in populations at risk.

Nutrient bioavailability – A key to human nutrition. The RDA for vitamin B-6 was recently reduced from 1.6 to 1.3 mg/d. The present study demonstrated that young women might require 1.5mg/d.

Impact: This finding has national implications because the current RDA for vitamin B-6 may not be adequate. Lack of vitamin B-6 in the diet of young American women could affect their health status.

Research Program Nutrition Education

CRIS Projects: 0113, 0276

Dietary and psychosocial factors affecting self-management of type 2 diabetes melitis. This project included several multidisciplinary studies aimed at improving self-management for patients with type 2 diabetes. The Diabetes Dietary Quality of Life instrument was shown to have great potential for monitoring quality of life impacts as the patient experiences self-management.

Outcomes: The results of this project added to the understanding about patience adherence and non-adherence to the dietary component of diabetes self management. This knowledge will impact other research concerning patient adherence and will eventually improve self-management of this national health issue.

Factors influencing the intake of calcium rich food among adolescents. A new faculty member, Dr. Miriam Edlefsen, joined the national research team in 2001. Subsequently, the team submitted a joint grant proposal in January 2002. Dr. Edlefsen has brought new expertise to this research on calcium intake in adolescents, and both she and the group benefited from her addition to the team.

Scope of Impact: National

GOAL IV

AGRICULTURAL ECONOMICS

GOAL IV: OVERVIEW

A Research program of the Department of Agricultural Economics is Natural Resource and Environmental Economics.

Research Results From Research 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.

Outcomes That Have Resulted in Significant Changes

Research on resource and environmental economics was particularly important in the policy arena dealing with conflicting agricultural and environmental interests.

Young adults express a willingness both to pay and to change behavior to promote substantive action on global warming. With their demonstrated strong interaction between financial and lifestyle costs, responses foreshadow tougher policies governing activities that contribute to global warming.

Public policy makers were educated about the economics of making prior appropriation doctrine more flexible in order to reallocate water among socially-desired uses.

Research on rights-based fishing has been credited by external sources with changing the course of national seafood policy, specifically modifying the American Fisheries Act, and is being applied in additional fisheries.

Benefits to Clientele (Stakeholders)

The results of resource economics research at Washington State University had important impacts on environmental and water policy decisions at the state level.

Direct, policy-relevant information about conservation practices assists policy-making when agricultural and environmental conflicts emerge.

By continuing to impact federal fisheries policy, research on rights-based fishing is having enormous financial implications for Washington fishers and processors.

Accomplishments based on Department/Unit POW for 2001

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).

Strong acceptance by clientele of resource economics research contributions was also evident in state policy formulation on water and environmental issues.

Five 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.

Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$1,000
Hatch Multistate Research	$6,000
Federal Research Grants	$0
State Appropriations	$205,000
Other Grants	$21,000

Total Faculty/Staff FTEs: 3.4

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. Public policy makers were educated about the economics of making prior appropriation doctrine more flexible in order to reallocate water among socially-desired uses.
   3. Young adults' willingness both to pay and to change behavior to promote substantive action on global warming foreshadows tougher policies governing activities that contribute to global warming.
   4. Research on rights-based fishing has been credited by external sources with changing the course of national seafood policy, specifically modifying the American Fisheries Act. Its financial implications are enormous and it is being applied in additional fisheries.

C. Scope of Impact includes WA, OR, and ID scientists, state and national policy makers, and scientists working in many research institutions and organizations world-wide.

BIOLOGICAL SYSTEMS ENGINEERING

GOAL IV: OVERVIEW

Research Results From Research Projects Supported by Hatch Formula funds

Research results: The department has research in four Research Problem Areas under Goal 4: 112, Water: Watershed Protection and Management, 133: Pollution Prevention and Mitigation; 307: Animal Production Management Systems; and 403: Waste Disposal, Recycling, and Reuse. Research on the protection of soil and water has included a focus on improving the USDA's WEPP (Water Erosion Prediction Project) model as it applies to forest conditions. The project has modified WEPP in its approach to and algorithms for modeling deep percolation of soil water and subsurface lateral flow then applied the modified model to a conceptual Pacific Northwest forest watershed using local data. Experimental results show that the modified model is an improvement over its original focus on farm land. Research has also contributed to reducing erosion from water runoff by showing that no-till farming reduces the formation of rills in agricultural fields. The project on developing better management practices for animal nutrient management has implemented the computer program framework for the decision support system developed during the first project year. The residue sub-model in the CropSyst model has been modified to accommodate application of dairy solid waste.

Outcomes That Have Resulted in Significant Changes

Computer models have proven to be effective in helping producers to manage dairy nutrients and to manage runoff from forests and agricultural land. They are effective in predicting movement of nitrogen and other nutrients through soil. Other research has shown that no-till farming reduces soil erosion from runoff.

Benefits to Clientele (Stakeholders)

The continuing development of computer models for dairy nutrient management and for water runoff will add to efforts to control both nutrients introduced into the soil and soil erosion. Research results on no-till farming will give encouragement to practitioners who are considering using this technique on their fields.

Accomplishments based on Department/Unit POW for 2001

The department's plan of work in this area is focused on improvement in soil and water quality. Research efforts are continuing along these lines with important developments in the previous year. This report makes it clear that the department is focused on its research objectives and directing its resources toward the accomplishment of stated objectives.

Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$58,508.11
Federal Research Grants	$136,161.60
State Appropriations	$305,826.16
Other Grants	$64,027.65

Total Faculty/Staff FTEs: 6.88

KEY THEME: Soil Quality (also Water Quality)

Research Program: Water: Watershed Protection and Management

A. Brief description: Part of this project continues to focus on improving the USDA's WEPP (Water Erosion Prediction Project) model as it applies to forest conditions. WEPP was initially developed to quantify erosion by water from agricultural fields, which are substantially different from forests. The project has modified WEPP in its approach to and algorithms for modeling deep percolation of soil water and subsurface lateral flow then applied the modified model to a conceptual Pacific Northwest forest watershed using local data. Experimental results show that the modified model is an improvement. Another set of experiments was oriented toward comparing no-till and traditional farming methods with regard to runoff. One experiment showed that no-till farming clearly resulted in fewer rills from erosion than conventional tillage, the use of a chisel plow, and the use of a moldboard plow. This work resulted in proposed changes to a soil erosion and sediment transport computer model; the changes are now being verified. The project developed a framework for an integrated watershed hydrological model that includes an overland flow model and a channel routing model.

B. Impacts
The study contributes to the development of reliable computer models for properly predicting flow and sediment discharges from forest watersheds. It is important in states where forests are substantial contributors to runoff and other pollution problems, especially WA, OR, CA, ID, MT. Studies on no-till agriculture show that this method reduces water erosion with an impact on farming in areas with hills that are amenable to water runoff. States affected include WA, OR, CA, ID, MT.

C. Scope of each impact: This information is integrated into section b above.
Accomplishments based on department plan of work: This project is applying existing computer models to the problem of hydrologic modeling.

Source of funding and FTE:

Source of Funds	Amount
Hatch	$15,378.87
Multistate Research	$0
Federal Research Grants	$44,840.64
State Appropriations	$213,269.85
Other Grants	$64,027.65

KEY THEME: Soil Quality (also Water Quality)

Research Program: Pollution Prevention and Mitigation

A. Brief description: This year's research completed a one-year experiment aimed at gathering customized information on crop growth, yield and nitrogen (N) uptake and partition as affected by yield limiting factors (YLF's) distributed over the landscape. Experimental treatments of spring wheat were applied at four different positions in a varied landscape with positions chosen to provide extreme variation across the landscape in terms of both soil type and position. Fixed YLF's were characterized at these sites, including slope, aspect, soil depth, texture, structure, and organic carbon. The treatments of the crops consisted of two water availability levels (irrigated and not irrigated) to quantify yearly maximum yield, both as a function of fixed and long-term manageable YLF's. This research is contributing to changes in the CropSyst computer model for cropping systems.

B. Impacts
The implementation and dissemination of results from this project is contributing to the process of developing site specific crop management based on application of computer technology to the process of growing crops. The specific research will be of particular interest in states with large dryland field crop agriculture, including WA, OR, ID, MT, ND, SD, CO, NE, and KS.

C. Scope of each impact: This information is integrated into section B above.
Accomplishments based on department plan of work: This work is part of the department's efforts to modify existing computer models used for making decisions in agricultural systems. The use of these models will improve production while limiting the environmental impact of agriculture and making crop systems sustainable.

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$43,129.24
Multistate Research	$0.00
Federal Research Grants	$67,995.04
State Appropriations	$92,556.31
Other Grants	$0.00

KEY THEME: Nutrient Management

Research Program: Animal Production Management Systems; and Waste Disposal, Recycling, and Reuse

A. Brief description: The project implemented the computer program framework for the decision support system developed during the first project year. The framework consisted of a biophysical module, an economic analysis module, and a decision support module. Models for ammonia emission from the floor surface of barns and from storage facilities were evaluated and finalized. Denitrification processes in soil as affected by soil temperature, organic carbon concentration, and nitrate concentration levels were studied and associated models were developed. The residue sub-model in the CropSyst model has been modified to accommodate application of dairy solid waste.

B. Impacts
Short impact statement: The results have been published in various forms and have resulted in the modification of widely used computer modeling programs, especially CropSyst. The availability of the information and the resulting decision support tools will help to improve animal waste management practices that protect the environment, especially in states where animal agriculture is very important.

C. Scope of each impact: This information is integrated into section B above.

D. Accomplishments based on department plan of work: This project is crucial in the effort to develop computer models for waste management in farming.

E. Source of funding for RPA 307

Source of Funds	Amount
Hatch	$0.00
Multistate Research	$0.00
Federal Research Grants	$13,250.61
State Appropriations	$0.00
Other Grants	$0.00

Source of funding for RPA 403

Source of Funds	Amount
Hatch	$0.00
Multistate Research	$0.00
Federal Research Grants	$10,075.31
State Appropriations	$0.00
Other Grants	$0.00

CROP AND SOIL SCIENCES

GOAL IV: OVERVIEW

Research Results From Research Projects Supported by Hatch Formula funds

1. Environmental impact of chemicals and soil, air and water pollutants have been minimized through a better understanding of their fundamental reactions in soil using precision application and detection technologies.
2. Through 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.

Outcomes That Have Resulted in Significant Changes

1. Production practices documented by our researchers on organic and integrated apple production and 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.
2. Ion exchange resin technology in grape production has merit for predicting nitrate nitrogen availability in the plant root zone by monitoring soil surface nitrate nitrogen.
3. Variable rate fertilizer application in potato significantly reduces the potential for nitrate leaching below the plant root zone. This technology has the potential to decrease on farm costs and decrease the potential for nitrate contamination of groundwater, while maintaining crop yield and quality in potatoes and grapes.
4. Direct seed and organic fertilization through composting increases the biological activity and other biological parameters of soils compared to conventionally managed soils. This information will ultimately provide growers and scientists with practical advice on soil quality to aid in the development of management practices in order to retain the benefits of improved soil quality resulting from management decisions such as reduced tillage.
5. Grasslands in the western United States provide refuge for wildlife, enhance regional biodiversity, and serve as essential reservoirs for biological control agents of crop pests. Our studies increased our understanding of the relationship between non-crop and crop habitats and our data will help define the specific role of grasslands in agroecosystem biodiversity and the role of grasslands as reservoirs of biological control agents of crop pests.
6. A better understanding of conservation tillage and no-till is being developed in the PNW for protection of land, air, and water resources through the STEEP and PM-10 programs. Continuous cereals may be the best economic option for growers in the low precipitation region.
7. Dissemination of new technology has increased adoption of direct seeding through STEEP educational conferences, trade shows, www sites, bulletins, and case studies.
8. The Columbia Plateau Wind Erosion/Air Quality Project has made significant progress towards understanding the problem and solutions to airborne particulates.
9. We have studied the conditions for movement of contaminants in soils. Colloidal particles can form under conditions representative of potential leakage from the Hanford site. Colloidal particle formation can facilitate the movement of Cesium. Understanding the flow mechanisms in rocks and sediments in order to determine the fate and transport of chemicals and viruses is important.
10. Tools for precise soil sampling and application technologies such as GIS, GPS, and remote sensing will improve the efficiency of fertilizer and pesticide use, reduce environmental impact, and increase economic return.
11. Basic studies in soil chemistry, physics, morphology, and microbiology have improved our knowledge on how pollutants move and interact in soil in agriculture and in remediation of polluted land.
12. Integrated studies on reduced tillage and the identification of new alternative crops have increased the diversity of crops, decreased our dependence on summer fallow, reduced air and soil pollution, and improved economic return to growers.
13. Perennial ryegrass is an excellent rotation crop with potatoes. To enhance seed production Washington state, registration for oxyfluorfen, pendimethalin, S-metholachlor, and diruron have been obtained for established perennial ryegrass for seed.

Benefits to Clientele (Stakeholders)

1. 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 have increased economic return.
2. 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.

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.

Accomplishments based on Department/Unit POW for 2001

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 outreach programs.
3. Grower acceptance of our programs has been excellent as determined from the audiences at numerous functions conducted by Crop and Soil Sciences.

Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$80,603
Hatch Multistate Research	$54,386
Federal Research Grants	290,598
State Appropriations	507,245
Other Grants	318,502

Total Faculty/Staff FTEs: 17.09

KEY THEME: Land use

Research Program: Appraisal of soil resources
CRIS projects 0323, 0598, 0900

A. Projects include: 1) assessing trends in sediment textures and stratigraphic units from eolian deposits on and adjacent to Eureka Flat, WA. 2) using satellite radar imagery as a tool for monitoring the adoption of cover crops in the Columbia Plateau in WA; and 3) developing methods with remote sensing and GIS to map soils in rugged wilderness landscapes.

B. Impacts
   1. We more fully understand the processes by which eolian sediments have been spread across the Columbia Plateau and identifying the variables controlling the eolian system for predictions of response to future global change.
   2. Sonar and GIS have enabled scientists to monitor surface vegetation and to determine the extent to which irrigated soils are maintained in a safe condition for winter erosion.
   3. Remote sensing and GIS technology plus field reconnaissance and sampling will enable the mapping of both wilderness and agricultural lands for determining best use.

C. Application covers the PNW (WA, ID, OR), but is also nationwide.

KEY THEME: Water quality

Research Program: Soil, plant, water, nutrient relationships
CRIS projects 0152, 0182, 0203, 0250, 0257, 0267, 0277, 0325, 0329, 0353, 0385, 0598, 0703, 6703

A. Projects include: 1) characterizing the air-liquid interface for transport of solutes and viruses in porous media; 2) finding a means of cleaning up contaminated waters and soils of the uranium contaminated mines in WA; 3) evaluating soil fertility rates for efficient N use in spring wheat; 4) evaluating precision agriculture and variable rate technology in reducing nitrate leaching in potatoes; 5) comparing the economics, soil quality, and air

pollution of conservation and conventional tillage in a wheat-fallow rotation; 6) comparing organic, biodynamic and conventional farming practices on soil quality; 7) developing site specific approaches for crop management; 8) sustainability of apple production systems; providing alternatives to grass seed burning and 9) identifying soil quality parameters that can be used in the development of best management practices for conserving soil quality and enhancing crop production.

B. Impacts
   1. Colloidal particles can form under conditions representative for leakage at the Hanford Reservation, and these conditions can facilitate movement of Cesium. Understanding the flow mechanisms in rocks and sediments for determining the fate and transport of chemicals and viruses is extremely important.
   2. Addition of apatite to contaminated soils may serve to reduce U(VI) mobility and provide a reactive barrier to remove U(VI) from groundwater.
   3. New fertilizer recommendations promote spring crop adoption in PNW, which has increased in acreage from 10,000 acres to 170,000 acres over the past 10 years.
   4. Variable rate nitrogen management significantly reduces the potential for nitrate leaching below the plant root zone without adversely impacting crop yield or quality.
   5. Minimum tillage systems have reduced air pollution, improve economic return, and offer a "win-win" solution for farmers and the environment.
   6. Direct seed and organic fertilization through composting increase the biological activity and other biological parameters of soils compared to conventionally managed soils. This information will ultimately provide growers and scientists with practical advice on soil quality to aid in the development of management practices in order to retain the benefits of improved soil quality resulting from management decisions such as reduced tillage.
   7. Production practices of organic and integrated apple growers in the Pacific Northwest and in the ability of conventional apple growers to convert to organic production methods adds valuable information to the knowledge base of alternative apple production systems. This information will help expand economic opportunities for farmers and promote reduced use of agrochemicals.
   8. Ion exchange resin technology in grape production has merit for predicting nitrate nitrogen availability in the plant root zone with monitoring soil surface nitrate nitrogen. In potato, variable rate fertilizer application significantly reduces the potential for nitrate leaching below the plant root zone. This technology has the potential to decrease on farm costs and decrease the potential for nitrate contamination of groundwater while maintaining crop yield and quality in potatoes and grapes.

C. Application covers the PNW (WA, ID, OR), but has application nationwide.

KEY THEME: Land use

Research Program: Alternative Uses of Land
CRIS project 0900

A. Methods are being developed and tested to map soils in rugged wilderness landscapes with remote sensing and GIS technology.

B. Impacts: Methods are being developed and tested to map soils in rugged wilderness landscapes with remote sensing and GIS technology.

C. Application covers the PNW (WA, ID, OR), but has application nationwide.

Research Program: Management of Range Resources
CRIS project 3776

A. Project includes: 1) determination of the methods by which shrub-steppe fragment size and adjacent cropping systems affect the productivity, diversity, and composition of species and functional groups of plants within the fragments, and 2) determination of how shrub-steppe fragment size, adjacent cropping systems, and plant community structure affect diversity, trophic structure, and species composition of arthropods within the grassland habitat.

B. Impacts: Grasslands in the western United States provide refuge for wildlife, enhance regional biodiversity, and serve as essential reservoirs for biological control agents of crop pests. Reductions in the quality and quantity of grassland habitats may affect sustainability of regional cropping systems. Results have increased our understanding of the relationship between non-crop and crop habitats and will help define the specific role of grasslands in agroecosystem biodiversity and as reservoirs of biological control agents of crop pests.

C. Application covers the PNW (WA, ID, OR), but has application nationwide.

Research Program: Alternative Uses of Land
CRIS project 0344

A. Project includes: 1) a determination of how shrub-steppe fragment size and adjacent cropping systems affect the productivity, diversity, and composition of species and functional groups of plants within the fragments, and 2) a determination of how shrub-steppe fragment size, adjacent cropping systems, and plant community structure affect the diversity, trophic structure, and species composition of arthropods within the grassland habitat**.**

B. Impact: Grasslands in the western United States are integral components of regional agroecosystems, providing refuge for wildlife, enhancing regional biodiversity, and serving as essential reservoirs for biological control agents of crop pests. Reductions in the quality and quantity of grassland habitats may affect the sustainability of regional cropping systems. Results from the projects will increase our understanding of the relationship between non-crop and crop habitats and will help define the specific role of grasslands in agroecosystem biodiversity and as reservoirs of biological control agents of crop pests.

C. Application covers the PNW (WA, ID, OR), but has application nationwide.

KEY THEME: Sustainable agriculture

Research Program: Pollution prevention and mitigation
CRIS projects 0245, 0250, 0296, 0316, 0329, 0351, 0358

A. Projects include: 1) New tillage and cropping strategies for protection of our soil, water, and air resources and assessment through cooperative grower, industry, NRCS, and university-USDA scientists in the PNW; 2) Integrated approaches in controlling weeds, pathogens, and insects and documenting beneficial effects of direct seeding on soil quality and crop water-use efficiency; 3) evaluation of alternative crops for opening new markets and improving economic returns to growers; 4) economics of conservation tillage in reducing wind erosion and blowing dust on conventionally tilled winter wheat in eastern Washington.

B. Impacts:
   1. A better understanding of conservation tillage and no till is being developed in the PNW for protection of land, air, and water resources through the STEEP and PM-10 programs. Continuous cereals may be the best economic option for growers in the low precipitation region.
   2. Better integrated pest management strategies are being adopted in conservation tillage.
   3. Marked reduction in soil, air, and water erosion has occurred on lands adopting conservation tillage.
   4. Dissemination of new technology has increased adoption of direct seeding through STEEP educational conferences, trade shows, www sites, bulletins, and case studies.
5. The Columbia Plateau Wind Erosion/Air Quality Project has made significant progress towards understanding the problem and solutions to air borne particulates.

C. Application covers the PNW (WA, ID, OR), but application nationwide.

KEY THEME: Biological control

Research Program: Insects, mites, and other arthropods affecting plants
CRIS project 0344

A. Project includes: 1) to determine how shrub-steppe fragment size and adjacent cropping systems affect the productivity, diversity, and composition of species and functional groups of plants within the fragments, and 2) to determine how shrub-steppe fragment size, adjacent cropping systems, and plant community structure affect the diversity, trophic structure, and species composition of arthropods within the grassland habitat**.**

B. Impacts:
Grasslands in the western United States are integral components of regional agroecosystems, providing refuge for wildlife, enhancing regional biodiversity, and serving as essential reservoirs for biological control agents of crop pests. Reductions in the quality and quantity of grassland habitats may affect the sustainability of regional cropping systems. Results from the projects will increase our understanding of the relationship between non-crop and crop habitats and will help define the specific role of grasslands in agroecosystem biodiversity and as reservoirs of biological control agents of crop pests.

C. Application covers the PNW (WA, ID, OR), but has application nationwide.

KEY THEME: Integrated pest management

Research Program: Diseases and nematodes affecting plants
CRIS projects 0232, 0245, 0296, 0316, 0325, 0329, 0351

A. Projects include: 1) Developing Hessian fly and Russian wheat aphid resistance spring wheat varieties with acceptable levels of resistance to stripe, leaf and stem rusts and 2) Using Satellite radar imagery as a tool for monitoring the adoption of cover crops and crop residues over the winter.

B. Impacts
   1. Lines have been investigated for resistance to Hessian fly and Russian wheat aphid.
   2. Satellite radar imagery has identified techniques for distinguishing types of crops and overwintering potential.

C. Application covers the PNW (WA, ID, OR), but application is nationwide.

KEY THEME: Integrated pest management

Research Program: Weeds affecting plants
CRIS projects 0277, 0318, 0715, 0805,4277

A. Work includes: 1) Developing flexible weed management systems for optimal weed control in wheat from common lambsquarters, pigweeds, kochia, downy brome, or wild oats; 2) developing new information on the biology, ecology, and physiology of downy brome, jointed goatgrass, Russian thistle, and wild oat; 3) developing integrated weed management systems for dryland crops; develop practices to reduce pesticide

and tillage use in conservation crop production systems while maintaining or improving profitability; 4) Identifying weed control strategies in volunteer peas and potatoes, beans, grapes, hops, and sugar beets.

B. Impacts
1. Integrated weed management systems for dryland crops have been developed using a combination of tillage and pesticide reduction strategies in conservation tillage while maintaining or improving profitability.
2. Models are being developed to predict weed pressure and the type of management based on other weed and crop species, biotic factors, and abiotic factors such as soil physical characteristics, slope, and aspect.
3. Herbicides have been identified for good sucker control in grapes and hops; microrates of herbicides with oil have controlled weeds in sugarbeets.

C. Application covers the PNW (WA, ID, OR), but application is nationwide.

KEY THEME: Biological control

Research Program: Biological control of pests affecting plants
CRIS projects 0344

A. Work includes: 1) examining the role of the pea leaf weevil on nodulation and nitrogen fixation in peas and lentil; 2) understanding mechanisms of nodule feeding by *Sitona* spp. and 3) cloning the *Bacillus thuringiensis* (*tenebrionis*) gene into rhizobia for control of the *Sitona* spp. weevil.

B. Impacts
1. Nodule feeding by *Sitona* spp. reduces nodulation and N fixation in peas.
2. Gene expression of the delta endotoxin gene, *Cry* III, was achieved in pea and alfalfa nodules.
3. Nodules containing the *Cry* III gene reduced feeding by *Sitona* larvae.

C. Application covers the PNW (WA, ID, OR), but application US wide.

KEY THEME: Air quality

Research Program: Engineering Systems and Equipment
CRIS projects 0250, 0329

A. These studies sought to control of leaf rust and seed production systems in perennial ryegrass in the Skagit Valley of Washington.

B. Impacts
Perennial ryegrass was found to be an excellent rotation crop with potatoes. To enhance seed production Washington, registrations for oxyfluorfen, pendimethalin, S-metholachlor, and diruron have been obtained for established perennial ryegrass for seed.

C. Application covers the PNW (WA, ID, OR), but application is nationwide.

Research Program: Waste disposal, recycling, reuse
CRIS projects 0245, 0250, 0296, 0316, 0351

A. Work includes: 1) New tillage and cropping strategies for protection of our soil, water, and air resources are being assessed through cooperative grower, industry, NRCS, and university-USDA scientists in the PNW; 2) Integrated approaches are used in controlling weeds, pathogens, and insects and documenting beneficial effects of direct seeding on soil quality and crop water-use efficiency; 3) Alternative crops for opening new markets and improving economic returns to growers are being evaluated; 4) Economics of conservation tillage in reducing wind erosion and blowing dust on conventionally tilled winter wheat in eastern Washington are being studied.

B. Impacts:
1. A better understanding of conservation tillage and no till is being developed in the PNW for protection of land, air, and water resources through the STEEP and PM-10 programs.

2. Better integrated pest management strategies are being adopted in conservation tillage.
3. Market reduction in soil, air, and water erosion has occurred on lands adopting conservation tillage.
4. Dissemination of new technology has increased adoption of direct seeding through STEEP educational conferences, trade shows, www sites, bulletins, and case studies.

5. The Columbia Plateau Wind Erosion/Air Quality Project has made significant progress towards understanding the problem and solutions to air borne particulates.

C. Application covers the PNW (WA, ID, OR), but application is also nationwide.

KEY THEME: Global change and climate change

Research Program: Instrumentation and control systems
CRIS project 0323

A. Satellite radar imagery is used as a tool for monitoring the adoption of cover crops to prevent winter wind erosion on irrigated soils of the Columbia Plateau in central Washington.

B. Impact Project will provide a means to monitor the extent to which irrigated soils are maintained in a safe condition for the winter; Landsat data provided a tool to differentiate agricultural soils to improve cropping systems to farmers

C. Application covers the PNW (WA, ID, OR), but application is nationwide.

ENTOMOLOGY

GOAL IV: OVERVIEW

The research program of the Departmental 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, 8131

Managing Agrochemical Behavior under drip irrigation systems. Neonicotinoid insecticides are considered reduced risk pesticides and owing to their systemic properties make good candidates for application through drip irrigation systems. Although drip chemigation has advantages for reducing pesticide runoff, worker exposure, pesticide waste disposal, and adverse effects on insect natural enemies, the high water solubility of neonicotinoid insecticides raises the possibility for excessive leaching. Our research, however, suggests that leaching can be controlled by managing irrigation scheduling. It is especially important to turn on irrigation systems only when the soil matric potential has dropped below optimal plant growth conditions, and then to turn off the system when the optimal moisture level has been attained.

Mechanisms and Mitigation of agrochemical impacts on human and environmental health. Residues from single serving fruit samples are useful for probabilistic exposure assessment, and thus they help regulators estimate realistic pesticide exposure levels. Residues on apple single servings vary at most 3-fold from the average residue level determined on composite samples, but the residues are log normally distributed with most residues occurring significantly below the composite average. Thus, single serving residues actually can lower estimates of pesticide residue exposure.

Reducing the potential for environmental contamination by pesticides and other organic chemicals. Via a recent Federal court order, use of aquatic pesticides has recently come under regulation of the Clean Water Act provisions for obtaining NPDES (National Pollution Discharge Elimination System) permits. Thus, information about potential

environmental impacts must be presented to obtain a permit, and fate of applied pesticides in sediment and water are crucial parameters in making permitting decisions. Our research has shown that newer pesticides like the neonicotinoids can rapidly dissipate when used for aquatic pest control.

Managing drip irrigation to reduce chemical movement in soil. New reduced risk neonicotinoid insecticides can be effective when applied via drip chemigation. The advantages of drip chemigation are reduction in worker exposure, very low impact on pest natural enemies, and elimination of runoff and wastewater generation. Our research suggests that drip chemigation is most effectively managed by the use of soil sensors to monitor when water should be turned on and off.

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. Data generated through our studies were instrumental in the designation of sections of the Hanford Site as a National Monument. We have been asked to continue our studies by The Nature Conservancy with funding through the United States Department of Energy.

Biology and integrated management of insect and mite pests of wine grapes. A release of mealybug destroyers, *Cryptolaemus montrouzeri*, in a Prosser vineyard appeared to suppress a developing mealybug population. A naturally occurring population of *C. montrouzeri* was also observed suppressing mealybugs in a Pasco vineyard. Identification of mealybug species infesting Washington vineyards and understanding natural regulation processes will lead to more appropriate management strategies for these pests. It is likely that chemical intervention for control of mealybugs can be minimized, saving control costs and reducing insecticide inputs in Washington vineyards.

Allocated Resources

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$904.76
Fed. Res. Grants	$83,025.64
State Approp	$68,081.89
Other Grants	$62,109.95

Total Faculty/Staff FTEs: 2.54

KEY THEME: Biological Control

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

Biological Control in Pest Management Systems of Plants. Deployments of host-specific natural enemies have markedly contributed to enhanced exotic weed suppression and have led to documented herbicide inputs of 50-100% in forest, wetland, and rangeland/pasture ecosystems in Washington. Bioagent-induced reductions of diffuse knapweed, yellow starthistle, and purple loosestrife infestation densities have been recorded in Eastern Washington. Significant injury by *M. janthinus* is evident on Dalmatian toadflax but a 2-3 year massive multi-county relocation effort for this insect is warranted.

KEY THEME: Integrated Pest Management

Research Program: Integrated Pest Management Systems.
CRIS projects 0339, 0405, 0711, 00335

Development of Integrated Arthropod Management Systems for irrigated crops in central Washington. New reduced risk neonicotinoid insecticides can be effective when applied via drip chemigation. The advantages of drip chemigation are reduction in worker exposure, very low impact on pest natural enemies, and elimination of runoff and wastewater generation. Our research suggests that drip chemigation is most effectively managed by the use of soil sensors to monitor when water should be turned on and off.

Potential of Insect Growth Regulators for Controlling Insect Pests of the Pacific Northwest. We showed that neonates of the codling moth *Cydia pomonella* (L.) are capable of feeding and development on apple leaves, and identify granulated sugar substitute, Sweet'n Low® (1%, w/v), and monosodium glutamate (0.0025%, w/v) as substances that increase leaf feeding in codling moth neonates. In laboratory trials, addition of Sweet'n Low® or monosodium glutamate to Success®, a pesticide formulation containing Spinosad, increased its efficacy (by factor of 5.97X, and 2.94X, respectively) without increasing the amounts of toxic component. However, our semi-field experiments indicate that a more stable formulation of feeding stimulant/pesticide combination is needed to protect both from being washed from leaves by a rain. We also have preliminary data that characterize glutamate-dependent pharmacology of feeding in codling moth neonates, and improve field persistence of identified feeding stimulators. Our data suggest new strategy for rational pesticide reduction in control of lepidopteran pests. Our formulation increased the amounts of pesticide ingested by stimulation of feeding, thereby showing prospects of decreasing the amounts of toxic ingredients needed in pesticide formulation without affecting its efficacy.

Allocated Resources

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	(-$11.73)
Fed. Res. Grants	$42,664.80
State Approp	$66,792.85
Other Grants	$96,800.06

Total Faculty/Staff FTEs: 4.3

HORTICULTURE AND LANDSCAPE ARCHITECTURE

GOAL IV: OVERVIEW

Research Programs of the Department of Horticulture and Landscape Architecture are: Environmental horticulture and the effect of plants on people

Research Results From Research Projects Supported by Hatch Formula funds

Scientists in the Department conduct research on environmental horticulture and the effects of plants on people. The research results from these studies include: (1) Plant usage can be limited by a number of factors. One of these is the extent of the resources required for their maintenance. In a study published this year, it was shown that mulches, which are known to conserve water when used in the field, also could save water when used on containerized plants under some conditions. (2) 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.

Outcomes That Have Resulted in Significant Changes

It is difficult to point to specific cases where the results of this research have caused changes within the state. In the case of the environmental horticulture work that focuses on mulches, the findings are recent enough that changes in cultural practices in landscape operations are not widespread. In the case of 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.

Benefits to Clientele (Stakeholders)

The benefits to clientele result from improved economic efficiency, reduced environmental impacts, and healthier more stress-free environments. These include: (1) Financial benefits to greenhouse and landscape operators in the form of reduced inputs of irrigation water; (2) Benefits to society generally with regards to improvements in water quality; (3) Benefits to society with regards to a better understanding of the effect of plants on human well-being; (4) Research reported here supports earlier findings that the presence of plants in the workplace results in reduced levels of stress, and lower employee absence.

Accomplishments based on Department/Unit POW for 2001

Scientists in the Department of Horticulture and Landscape Architecture have made significant progress in identifying new approaches to efficient and environmentally sound management of greenhouse crops, and in 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.

Source of Funding and FTEs

Total Expenditures for all projects: $54,055.66

Source of Funds	Amount
Hatch	$2,535.78
Hatch Multi-State Research	$0.00
Federal Research Grants	$1,213.21
State Appropriations	$50,306.67
Other Grants	$0.00

Total Faculty/Staff FTEs: 80

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

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

A. Applied research resulted in new information and a better understanding of: (1) Plant usage can be limited by a number of factors. One of these is the extent of the resources required for their maintenance. In a study published this year, it was shown that mulches, which are known to conserve water when used in the field, also could save water when used on containerized plants under some conditions. (2) 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. Impacts
   1. In the case of the environmental horticulture work that focuses on mulches, the findings are recent enough that changes in cultural practices in greenhouse and landscape operations are not widespread. However, the importance of protecting water resources in the Pacific Northwest would suggest that it is imperative for greenhouse and landscape operators to implement the recommendation of the research.
   2. In the case of 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. Scope of Impact: WA, ID and OR scientists and other scientists working in many research institutions and organizations worldwide.

NATURAL RESOURCE SCIENCES

GOAL IV: 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.

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 eriogonom (i.e., buckwheat) species that could prove beneficial for revegetation of highly disturbed mine spoils and arid landscapes in the Columbia Basin, and (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

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.

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.

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 and 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.

Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$5,714.33
Hatch Multistate Research	$0.00
Federal Research Grants	$77,734.43
State Appropriations	$83,307.16
Other Grants	$67,434.35

Total Faculty/Staff FTEs: 1.96

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 Eriogonom (i.e., buckwheat) species that could prove beneficial for revegetation of highly disturbed mine spoils and arid landscapes in the Columbia Basin, and (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
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.

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.

GOAL V

NATURAL RESOURCE SCIENCES

GOAL V: 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 and 2) natural resource based communities in the era of globalization.

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 and 2) have developed a cost effective inventory technique for noble fir boughs – a non-timber forest product used in the production seasonal greenery products.

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.

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.

Accomplishments based on Department/Unit POW for 2001

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.

Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$0.00
Hatch Multistate Research	$0.00
Federal Research Grants	$63,484.82
State Appropriations	$26,241.35
Other Grants	$0.00

Total Faculty/Staff FTEs: 1.08

KEY THEME: **Impact of Change on Rural Communities**

Research Program: Social and economic dimensions of natural resource sciences
CRIS Projects 0164, 0982, 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, and 2) development of cost effective inventory techniques for noble fir – a non-timber forest product used in the production seasonal greenery products.

B. Impacts
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 NTFPS 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.

RURAL SOCIOLOGY

GOAL V: 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.

Research Results From Research Projects 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 globalization and social and demographic changes for local communities, examining issues related to concern for the environment, and assessing factors related to energy conservation and environmentally sound buildings.

Outcomes That Have Resulted in Significant Changes

1. Research confirmed that personalized correspondence and token financial incentives improve response to surveys and reduce non-response error, and that visual design and layout are important for comprehending self-administered questionnaires.
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.
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.

Benefits to Clientele (Stakeholders)

1. Research on questionnaires modes and formats 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. Policy makers at the county level are becoming more aware of the need to develop 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 ethnic composition help community leaders and decision makers shape more accurate community development plans.

Accomplishments based on Department/Unit POW for 2001

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.

Source of Funding and FTEs

Total Expenditures for all projects:

Source of Funds	Amount
Hatch	$9,097.32
Multistate Research	$2,059.37
Federal Res. grants	$64,522.53
State Approp	$267,492.33
Other Grants	$49,490.02

Total Faculty/Staff FTEs: 2.72

KEY THEME: Community Development

Research Program: Sociological and Technological Change Affecting, Individuals, Families and Communities; CRIS projects: 0127, 0141, 0230, 0280, 0932, 0942, 0981

A. In 2001 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 environmental concern, 5) factors influencing the construction industry to adopt more energy efficient buildings, and 6) the changing racial and ethnic make up of rural communities.

B. Impacts
   1. Personnel in four United States federal agencies, numerous policy makers in other agencies and universities, and policy makers in several other countries have changed the manner in which their self administered questionnaires (both by mail and on the web) are designed and implemented improving 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. Research on environmental attitudes in 24 nations has now documented that citizens in both poor and rich nations are concerned about environmental quality and are of use in international environmental policy making.
   5. Policy makers in western states learned of several methods for encouraging the construction industry to build more environmentally friendly, energy efficient building.
   6. Community leaders, businesses and policy makers have a better understanding of the rapidly changing Hispanic population in their areas.

C. Scope of Impact
   1. National and part of W-183
   2. National
   3. Washington state, national, and part of NE 185
   4. National and international (work with 24 nations).
   5. West Coast (California, Oregon, Washington) and national
   6. Oregon, Washington and part of WCC-84

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