Maine Agricultural and Forest Experiment Station Annual Report of Accomplishments and Results

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OVERVIEW OF PLANNED PROGRAM AREAS

Goal 1—An agricultural system that is highly competitive in the global economy

Maine farmers are stewards of 1.42 million acres of land. The agricultural system in Maine directly contributes more than $1 billion annually to the state's economy and further stimulates the economy by associated banking, transportation, retail, and service activity. Natural resources are central to the export-based economy. Maine's unique geographic properties with 4,500 miles of tidal coastline, glacial soils and a northern climate ideal for growing a number of plants and crops and yet containing a land base that is nearly 90 percent forested, offer unique challenges. Potatoes, blueberries, lobsters, and specialty food products are all exported to other states and throughout the world. Farming systems must meet market demands for high-quality products and allow agricultural products to be produced profitably, while preserving environmental quality and the health and safety of Maine's people.

To achieve a highly competitive agricultural system, Maine must produce high-quality crops and products. To do this, Maine's producers need better disease and pest prevention strategies, new crop varieties, new harvesting management techniques, new value-added products, and access to new markets. These are all areas in which researchers at the Maine Agricultural and Forest Experiment Station (MAFES) are working for the people of Maine. Following is a highlight of this year's accomplishments:

- MAFES scientists are refining a method to separate maggot-infested blueberries in an IQF processing line using light and NIR wavelengths. Preliminary investigations suggest that it is possible to find differences between maggot and non-maggot berries at the 707, 976, and 1326 nm wavelengths.
- MAFES researchers examined the investment, operating and annual ownership costs of supplemental irrigation systems for wild blueberry. The study estimated the investment, annual operating and ownership costs of four types of supplemental irrigation systems for three different acreage sizes.
- MAFES researchers continued to evaluate methods for controlling weeds in wild blueberry (*Vaccinium angustifolium*) fields and found the Sprout-Less® weeder would provide an additional method to efficiently treat these weeds.
- MAFES researchers have found in several replicated small-plot trials that the 4- and 6-oz rates of propiconazole have given equivalent control of mummy berry disease in lowbush blueberry.
- As part of multi-state project NE-184, MAFES researchers continued evaluating new potato varieties for use in the Northeast. Top performing selections by utilization: table—Eva, AF1758-7, and AF1615-1; chipping—NY112; and russet—Gem Russet.
- MAFES researchers have identified practical and highly sensitive diagnostic tests to confirm the presence or absence of pathogenic agents in potato seed tubers and leaves. Such reliable tests are essential for the best possible methods to certify potato seed for commercial sale.
- MAFES scientists continued their efforts to develop an understanding of how new late blight strains have shifted management needs and the development of seed treatments to prevent transmission have contributed to the recent decline in late blight severity. This research

improves the understanding of how resistance is developing and provides a more realistic assessment of management options.

- As part of multi-state project NE-187, MAFES scientists evaluated cultivars of cool-season turf species. A study to determine the effect of anti-dessicants on winter survival of bentgrass was also conducted during this past year. Preliminary data indicate that certain anti-dessicants were associated with increased numbers of live crowns, higher levels of crown tissue moisture, and generally improved plant viability. This anti-dessicant study could provide information that could help reduce winter loss of turf on golf course putting greens, thus saving these operations significant expense.
- Continuing in multi-state project NE-9, MAFES scientists investigated the reproduction of native plants to help provide needed nursery stocks and to promote the use of native plants in landscaping. The scientists looked specifically at ways to improve the germination rates of *Asarum canadense* and *Gaultheria procumbens* and looked at the effects of cold storage temperature, cold duration, and GA concentrations on percentage of *Comptonia peregrina* root-cuttings.
- The evaluation of apple cultivars continued as part of multi-state project NE-183. Researchers found that taste-testers rated Honeycrisp, Suncrisp, and Arlet the highest for overall quality and for flavor acceptance. Texture was rated highest in Honeycrisp and Suncrisp. Combining consumer preference data with fruit tree performance data, this study has identified several apple cultivars that are suitable for commercial production in Maine.
- MAFES researchers also continued in multi-state project NC-140 to evaluated apple rootstocks to determine their suitability for commercial production. Researchers have identified the rootstocks that can lead to greater yield early in the life of an orchard. High early yield enables growers to get a quicker return on the investment of planting trees.
- MAFES scientists continued their collection and analysis of DNA sequences for multiple chloroplast genes and the nuclear gene granule bound starch synthase I for *Amelanchier* (shadbush) plus many other members of the subfamily to which this genus belongs (the Maloideae). During this past year they completed a study that shows that the Maloideae, which contains apple, pear, and other important plants, evolved from an ancestor that is very close to a group of herbaceous plants of the southeastern United States. This falsifies the long-standing hypothesis that the genesis of the apple subfamily was via hybridization between evolutionarily divergent lineages.
- Testing of an insulated incubator to measure the aerobic stability of semi-micro silage samples continued. External insulation around the 36 incubator cells was doubled from 5 to 10 cm, but this did not change the performance of the equipment. Effects of a new homolactic silage inoculant on fermentation and composition of laboratory-scale corn silage was compared to control non-inoculated silage and to silage made with a market-leading inoculant. Both products improved silage composition and fermentation compared to the control with few differences between the two treatments. A new highly effective inoculant for corn silage will increase competition in the market and provide the producer with an alternate product, which could be competitively priced.
- MAFES researchers measured a number of parameters in lobsters exposed to temperature stress and anoxia from being held out of water, including electrical resistance across the tail membrane, resistance across the body from mouth to anus, pH, and hemolymph, calcium, magnesium and glucose. Hemolymph glucose appeared to be the best indicator of stress, which is the result of an increase in hyperglycemic hormone. Based on these findings, a rapid

technique was developed to measure hemolymph glucose levels using a hand-held glucometer. Monitoring stress is a predictor of future survival of lobsters in shipment and storage.

- Studies continued to evaluate the use of crab-processing by-products in value-added products. Fresh rosemary and other ingredients were added to the crab mince, mixed with durum semolina and water, and extruded through a pasta maker. These studies indicate that Jonah crab processing by-products can be used to produce a good quality crab mince that can be incorporated into newly developed value-added food products. Further research on flavor development is needed to move this prototype pasta product forward.
- Using brook trout, MAFES researchers tested recombinant subunit vaccines for control of infectious pancreatic necrosis virus (IPNV) in cultured fish. MAFES researchers found that sonicated vaccine lysates provided the highest levels of serum response in immunized fish.
- Aquaculture and fisheries businesses in Maine rarely have the resources to provide in-house engineering services or hire consulting engineers, and frequently approach the University for engineering assistance. MAFES scientists continued work on whale-friendly lobster gear, which has resulted in several designs including a weak link. This design was further developed by a commercial plastics maker and is now undergoing field testing.
- Using the wave/tow tank, MAFES scientists completed extensive scale modeling of shellfish upwellers. The scale-modeling research work recently completed answers many questions about flow rate optimization, dispels several myths, and provides a basis for future deigns.
- Additional work on alternative diets for lobster was completed with evaluation of meat quality using diets containing crab-processing wastes. The work with lobster diets is becoming of greater significance with the decline in herring harvests.
- Bonamiasis is a disease of European oysters (*Ostrea edulis*) caused by the protozoan parasite, *Bonamia ostreae*. Presence of this pathogen in Maine oysters was confirmed in 1992. MAFES scientists have successfully isolated and sequenced the entire 18s-ITS 1 rDNA gene and confirmed the placement of this protozoan in the Haplosporidia. They recently developed sensitive molecular diagnostic techniques (PCR and FISH) specific for *B. ostreae,* which will be used to determine growing areas that are free of the parasite and for confirming the absence of *B. ostreae* in oyster seed.

Scientist years:	16.8
Hatch Funds:	$525,000
Reg. Research Funds:	$294,000
State Funds:	$3,106,000
Total Funds:	$3,915,000

Key Theme—Adding Value to New and Old Agricultural Products

a) Cranberry growers in Maine have been devastated by low fruit prices caused by increased supply without growth in demand. Cranberry juice cocktail is required to contain a minimum of 27% cranberry juice, and juice processors are reluctant to increase the amounts of cranberry juice because people may not like the flavor. A MAFES research project, however, asked 50 women to rate cranberry-white grape juice blends containing 27%, 34%, 41%, 54%, and 100% cranberry juice and found no difference in acceptability between the 27% and 34% blends.

b) Impact—This additional 7% cranberry juice in cocktails would help reduce the glut of cranberry juice concentrate in storage. Interestingly, one week later the women were shown information about the health benefits of cranberries and then they re-tasted the juice blends, which this time were labeled with their cranberry juice content. Perhaps because of their knowledge of the benefits of cranberries, the women liked the juice containing 41% cranberry as well as the 27% blend. This research shows that opportunities exist for targeting audiences interested in cranberry health benefits. It is hoped that this study provides juice processors with data to justify development of products containing higher levels of cranberry juice, thus stimulating the cranberry market.

c) Source of Federal Funds—Hatch

d) Scope of Impact—State Specific

Key Theme—Animal Health

a) The Eastern oyster is the primary species of bivalve cultured in the Northeast. Since 1988, however, many producers in this region have lost juvenile oysters (up 90% of total production) due to juvenile oyster disease (JOD). Currently there is no way to predict the impact of JOD or to test for its presence. MAFES researchers are working to change that.

b) Impact—MAFES researchers have isolated a suspect etiological agent for this disease, which (based on sequence analysis of the 16s rRNA gene) is a previously undescribed species of marine alpha-proteobacterium. Confirmation of an etiological agent for JOD will greatly assist in the development of more effective disease management strategies. Now scientists will be able to determine the areal and seasonal distribution of the pathogen as well as its temperature and salinity tolerances.

c) Source of Federal Funds—Hatch

d) Scope of Impact—State Specific

Key Theme—Aquaculture

a) The aquacultural production of blue mussels and eastern oysters is a significant and growing portion of the harvest of these two species in Maine. The continued development of the culture industry, however, is hindered by problems unique to Maine. For oyster culture, there is a need to develop oyster stocks with maximal cold-water growth rates, and the mussel culture industry requires methods for excluding pest species from grow-out facilities, particularly in eastern Maine.

b) Impact—To address these concerns, MAFES scientists are developing an oyster broodstock program, which is expected to result in a selected line of oysters that will grow to market size significantly faster than other oysters under the cold-water growth conditions typical in Maine. These researchers are also studying mussels, *Mytilus edulis* (the preferred species for culture) and *M. trossulus* (considered a pest species), to

determine whether there are species-specific differences in the tolerance of water temperatures between these species. MAFES researchers found that the range of the pest species (*M. trossulus*) extends nearly 100 km further south than previous work had suggested. So far this research indicates that the pest mussel species does not survive as well in the water temperatures typical of the mid-coast region. This information will help mussel producers decide where best to site their blue mussel culture facilities.

c) Source of Federal Funds—Hatch

d) Scope of Research—State Specific

Key Theme—Plant Health

a) Blueberry plants and the fungi that infect them are the target of a MAFES research project whose ultimate goal is to help growers protect their crops. MAFES researchers conducted extensive surveys for stem and leaf diseases in lowbush fields in Maine in 1999, 2000 and 2001. In 2001, 12 of the fields were re-surveyed to determine incidence and persistence of disease over a crop cycle.

b) Impact—The incidence of stem blight in bearing fields was 7.7%, 8% and 3.4% in 1999, 2000 and 2001, respectively, and significantly higher than in nonbearing fields (2%, 4% and 1.6%) for the three years. Researchers found the percentage of stems with leaf spot varied from 35% to 38% in the bearing fields and was significantly higher than the levels found in nonbearing fields (10% to 20%). Bearing fields had more stems with disease symptoms located at the tip, middle and bottom of the stems than the nonbearing fields. From stem and leaf samples collected in 1999 and 2000, more than 128 genera of fungi have been identified, many of which have not been previously described on *Vaccinium.* It appears there may be multiple fungi associated with some disease symptoms suggesting a complex of stem diseases. The most common fungi found on diseased stems in 1999 usually increased in 2000 as measured by percentage of identifications, suggesting that these fungi persist in the fields. The most common fungi found associated with leaf spot in 1999 were not always as common in 2000 suggesting that there may be varying sources of fungal inoculum over the years. In addition to the plant analyses, the team is surveying growers for information about crop management practices. Analysis of management practices have shown a weak trend of less disease incidence in fields that have been burned than mowed fields.

c) Source of Federal Funds—Hatch

d) Scope of Research—State Specific

Key Theme—Plant Production Efficiency

a) Potatoes are one of the leading vegetable crops in the Northeast. Farm value receipts in 1993 for the northeastern states were more than $264 million. A MAFES project is focused on improving the management of potato crops in Maine and the United States.

b) Using soil analyses, the scientists found that the low organic matter inputs and intensive tillage of a potato crop quickly decrease soil structure and organic matter. In an experiment that began in 1996, soil-water-stable aggregate content averaged 14.9% (wt. basis) after potatoes compared to 22.2% after rotation crops. Water-stable aggregate content was highest in the least intensive potato rotation (potatoes every third year). The three-year rotation also had higher soil organic matter than the shorter rotations. Continuous potatoes had the lowest soil water stable aggregate and organic matter content. The researchers were surprised at how quickly extending the rotation to three years and including one year of timothy/clover (which adds organic matter and provides a full year without tillage) improved soil organic matter and structure. The soil management treatments have also resulted in yield differences. The amended treatment or the three-year rotation topped the yield rankings in each of the past five years, with the continuous potato treatment at the bottom of the yield ranking. Relative to the standard two-year rotation, they found an average annual *increase* of 2.1 t/ha in the amendment treatment over the past five years and an average *increase* of 1.57 t/ha for the three-year rotation. Planting continuous potatoes, however, resulted in an average *decrease* of 2.8 t/ha compared to the standard two-year rotation. This information helps potato growers manage their crops so that high quality potatoes are produced while conserving soils and optimizing purchased inputs.

c) Source of Federal Funds—Hatch

d) Scope of Impact—State Specific

Goal 2—A safe and secure food and fiber system

Food production and processing is important in several key sectors in Maine: dairy, fisheries, potatoes, and blueberries and other fruits and vegetables. Food safety in these areas is an important concern to producers and consumers. Researchers in the Maine Agricultural and Forest Experiment Station have continued working on food-handling and processing technologies aimed at extending shelf life of product and preventing food-borne risks. MAFES scientists have continued investigating consumer food preferences and testing crops for pesticides residues. All this work helps ensure that the people of Maine have a high-quality, safe food supply and that Maine growers and producers remain competitive in the face of changing consumer demands.

In the past year to meet Maine's performance goal to develop technologies and methods to assure access to a safe food supply for Maine people, MAFES researchers accomplished the following:

- Experiments testing UV pasteurization for apple cider and like liquid foods continue. Results of the tests show that the UV treatment was effective in reducing *E. coli* counts to below detectable levels and that panelists could not taste differences between UV-treated and non-treated cider.
- Relationships between food products and the measured physical properties are important as new products are being developed. A MAFES scientist assisted graduate students with the design of a plastic tooth for compression tests to simulate the human bite and assisted in the

analysis of their compression test data as it relates to calculating strength and texture of food products.

- MAFES economists completed an analysis of regional differences in consumer potato-purchasing decision using in-person survey data collected in Springfield, Massachusetts, and Hillsborough, North Carolina. Information on regional differences in consumer potato purchasing behavior will be useful in identifying different target markets and marketing strategies.
- Research by MAFES scientists indicate that the benefits of extended storage of Maine potatoes from May until July/August far outweigh the costs. Costs include interest, insurance, shrink and loss, electricity for a refrigeration system, yield losses associated with early vine killing, and annual costs associated with the ownership of refrigeration. The benefits of extended storage are based on the results of a consumer panel that could not distinguish between nearly one-year-old, refrigerated Maine potatoes and new California potatoes. This could imply an average price increase, from April/May until July/August of up to 150 percent.
- General trends and issues in composting were analyzed and an enterprise budget was constructed to analyze the economics of using compost in horticultural production. The case analysis involved the use of compost in the production of watermelons. Although composting is environmentally superior to the landfilling of organic material, the relatively flat trends in landfill tipping fees has slowed the growth in the number of U.S. composting operations. Where landfill tipping fees are higher, and large volumes of compostable waste exist (such as a larger commercial food-processing facility), the economics of composting improves. Results indicate the compost costs $75 per hectare under the scenario with added compost, which increases yields 5%. Returns above specified costs decrease $15 per hectare under the scenario with added compost.
- MAFES scientists are focusing on a number of phytochemicals as well as naturally occurring toxins. MAFES scientists continue to develop tests for glycoalkaloid family of toxins in potatoes and have provided screening services for a number of potato breeders nationwide. The great public interest in phytocompounds led MAFES scientists to develop ELISA and HPLC methods for capsaicinoids in hot peppers and salsas.

Scientist years:	2.8
Hatch Funds:	$107,000
Reg. Research Funds:	$40,000
State Funds:	$355,000
Total Funds:	$402,000

Key Theme–Food Quality

a) There is growing public concern regarding pesticide residues in foodstuffs, drinking water and the environment. Developing new methods for the analysis of residual pesticides in foodstuffs, vegetation, soil and water faster, less expensive, and more efficiently is key to assuring a safe and quality food supply.

b) Impact—The acquisition of a Capillary Electrophoretic system (CE) enabled MAFES scientists to develop several methods for detecting a number of pesticides and their

metabolites in soil, water, and vegetable matrices. The good news is that data shows levels of pesticides in foodstuffs, drinking water and the environment to be quite low.

c) Source of Federal Funds—Hatch

d) Scope of Impact—State Specific

Goal 3—A healthy, well-nourished population

Under Goal 3, the Maine Agricultural and Forest Experiment Station set for itself the performance goal of improving nutrition for all Maine people, especially the elderly and teen population. Improving the nutrition of young people is important because it is during youth that people acquire and consolidate eating patterns and develop lifelong attitudes toward food. Many diseases that affect us later in life are caused in part by poor eating habits. The nutrition of the elderly is important as Maine's population ages and more seniors are living into their eighties and beyond.

In this human nutrition program area, MAFES researchers are carrying out research projects that will lead to the development of a knowledge base that can be used by clinicians, cooperative extension, public school administrators and teachers, and social service agencies to improve the nutrition of all Maine people. Accomplishments this year include the following:

- Twenty-three girls have undergone three data collection points in a study on calcium, Vitamin D, and seasonal bone turnover in adolescent girls. The subjects have also submitted two sets of four-day food and physical activity records, one during winter 2001 and during summer 2001. As expected, the girls are rapidly mineralizing their bones with a 17% gain in bone mineral content of the spine in one year. The mean calcium intake for the group is above 1000 mg per day. An additional study was completed during summer 2001 to validate the physical activity recording method used in the three-year study.
- Considering the higher incidence of cardiovascular disease (CVD) in the United States, elucidating risk factors that cause or promote its development is of utmost importance to public health. MAFES researchers are trying to determine the functional and mechanical properties of the aorta and the interaction of LDL to arterial GAGS using Weanling Sprague-Dawley lab rats. Results from this study will shed light on the role of manganese on the vascular endothelium as well as lipoprotein and GAG metabolism.

Scientist Years:	1.9
Hatch Funds:	$67,000
Reg. Research Funds:	$43,000
State Funds:	$188,000
Total Funds:	$298,000

Key Theme–Human Nutrition

a) A pilot study of the antioxidant effect of wild blueberry consumption was carried out among women between the ages of 60 and 90. Twelve subjects consumed one-half cup of blueberries with breakfast and one-half cup after dinner each for 30 days. Twelve other

subjects acted as controls, consuming no blueberries during the experimental period. Plasma samples were taken for two Oxygen Radical Absorption Capacity (ORAC) tests, and determination of Ferric Reducing Antioxidant Potentials (FRAP) and uric acid levels.

b) Impact—Test subjects maintained their antioxidant protection levels whereas control subjects lost a significant amount of antioxidant protections. Results achieved with small sample numbers appeared to indicate very large effects coming from blueberry consumption. Evidence was found to support a strong antioxidant effect among the elderly from prolonged consumption of wild blueberries.

c) Source of Federal Funds—Hatch

d) Scope of Research—State Specific

a) As part of the multi-state research project NC-219, MAFES researchers are collaborating with nutrition education scientists from thirteen states. One focus was to identify young adults' readiness to change food habits associated with consumption of grain products, vegetables and fruits. In 1999, investigation of grains was discontinued, however, the focus on fruits and vegetables continued. In a 10-state survey (n=1545), for vegetables, the majority of young adults were in pre-Action stages. For fruits, the majority of young adults were in Action or Maintenance. Only 35% were consuming the recommended servings of vegetables or fruits. The second focus was to identify messages and recommend strategies that will promote young adults' progress toward increased consumption of vegetables and fruits. Based on findings from focus groups, newsletters were successful as a channel for receiving information. The subject of vegetables and fruits in newsletters should be approached implicitly, as part of a discussion of other life skills considered critical by young adults.

b) Impact—Young adults who increase their consumption of vegetables and fruits will, by virtue of being role models, transfer this food habit to their children and peers. Higher consumption of vegetables and fruits will provide an economic benefit to producers. An increased consumption of vegetables and fruits will result in increased level of dietary fiber, folic acid and other nutrients in which the typical U.S. diet tends to be inadequate as well as increasing consumption of phytochemicals with disease preventing potential. There is evidence that health habits tend to cluster, suggesting the possibility that adopting healthier eating habits may lead to other positive health habits such as increased exercise or decreased smoking. Early intervention with young adults for improvement in personal health status should lower total costs of health care for the nation over the long-term.

c) Source of Federal Funds—Hatch

d) Scope of Project—Multi-state Research with
IA, KS, MI, NE, SD, WI, AL, ME, NY, OR, RI

Goal 4—Greater harmony between agriculture and the environment

In many ways, Maine people define their quality of life in terms of environmental quality. Indeed, economic development strategies for Maine historically have begun from the premise that quality of life is the foundation on which all else is built. At the same time, natural resources are the driving force behind most of Maine's export-based industries—paper, wood products, potatoes, blueberries, and seafood. The way in which these natural resources are used and conserved has a tremendous impact on the environmental quality by which Maine people measure their wellbeing.

To achieve greater harmony between agriculture and the environment, MAFES scientists are working to protect soil and water quality, to preserve wetlands, to develop ecologically friendly waste management systems, to design sustainable agricultural systems, to develop biological pest controls, and to better manage our wildlife and other natural resources. The following are highlights of this year's accomplishments:

- As part of work on multi-state project W-133, MAFES scientists completed work on groundwater valuation book, designed a survey to value farmland protection using conjoint analysis, completed a study of the effects of proximity to National Wildlife Refuges on sale prices of residential properties and initiated a new project to investigate how public values are affected by different management strategies for private forestland in the southeastern U.S. The study results will result in improved decision making by public agencies involved in protecting groundwater resources and managing open space (public and private, agricultural and forested).
- MAFES researchers examined the effects of crop rotation, residue management, and soil amendments on soil quality and sustainability. This research is designed to help growers utilize nitrogen more efficiently through a wide range of different cover-crop options.
- A MAFES scientist is assisting the Natural Resources Conservation Service in reviewing and editing soil surveys for the state. As part of the project, the scientists and students created a set of monoliths representing soils of the state. These monoliths will be used in classes at the University of Maine and will be available for use by extension educators and local K-12 educators. The monoliths are a great way for people to observe soils and learn about how they form.
- With increased awareness of the role of natural organic matter in the global carbon cycle, tools are needed to evaluate the effects of environmental and soil management perturbations on the distribution of organic matter pools in terrestrial and aquatic ecosystem. A MAFES research project has been using fluorescence spectrometry to examine the effects of crop residue, manure, and biosolids amendment on phosphorus chemistry and bioavailability in soil.
- Harbor and Gray seals were monitored on the coast of Maine through aerial surveys, radio tagging, and observations from shore. Data from these studies has been used to determine the impact of harbor seals on aquaculture sites and has been used to determine the effect of fisheries bycatch of seals on the seal populations.
- MAFES scientists monitored black tern breeding productivity in seven colonies in 2001 and continued a banding study to document adult movements and survival. This research will have important implications for the management of large wetlands in Maine, where this

endangered species (state-listed in Maine) occurs. This information also will form the basis for developing conservation strategies for the recovery of black terns.

- MAFES researchers documented amphibian distribution patterns in wetlands along a continuum from small, isloated wetlands to large, complex wetlands.
- As part of the National Atmospheric Deposition Program, precipitation collections have continued routinely over the past 12-month period. The need for the continued high-quality precipitation data remains high given the federal mandate to document recovery from Clean Air Act legislation and the emerging shift of concern from sulfur only, to nitrogen and other components of deposition from the atmosphere. The Greenville, ME, site data have been critical in regional research efforts as a long-term and high-quality record of precipitation chemistry for interior rural and forested regions of Maine.
- In a MAFES project that is quantifying the effects of highway runoff and nitrogen deposition on macroinvertebrate production and leaf-litter processing, two important ecological processes of headwater streams, researchers completed benthic sampling required to estimate macroinvertebrate production and leaf-detritus processing experiments.
- MAFES scientists collected water samples during spring, late summer, and late fall in three large rivers—Penobscot, Kennebec, and Androscoggin—and two smaller rivers—Sheepscot and Narraguagus—that drain into Maine coastal waters. This study will provide information on regional non-point pollution and transport of terrestrial nitrogen to river ecosystems and coastal waters in Maine. It will also examine how terrestrial carbon and nitrogen potentially contribute to biological productivity in these surface waters.

Scientist years:	10.9
Hatch Funds:	$525,000
Reg. Research Funds:	$134,000
State Funds:	$2,029,000
Total Funds:	$2,687,000

Key Theme—Biological Control

a) Allelochemicals, natural chemicals found in plants, have tremendous potential as alternatives to conventional insecticides in pest management programs. The primary impediment to their acceptance and use is the lack of commercially available, formulated products. To address this issue, MAFES researchers are using limonin (a chemical found in citrus plants) as a way to depress feeding and egg-laying in Colorado potato beetles.

b) Impact—With Colorado potato beetle larvae, the application of pure limonin to potato leaf disks resulted in almost 90% feeding depression with dosages > 30 ug /cm^2, but only in the no-choice bioassay. A maximum of 64% feeding reduction was elicited by limonin in choice tests at dosages up to 100 ug/cm^2, demonstrating the no-choice test was more sensitive than the choice assay procedure. Epilimonol, a limonin derivative, reduced Colorado potato beetle adult feeding greater in the choice assay conditions than in the no-choice bioassays, and 10 ug/cm^2 of epilimonol evoked significant mortality and completely suppressed oviposition for up to 25 days; epilimonol's effectiveness as an antifeedant was maintained for 9 days and as an oviposition suppressant for 25 days. In later laboratory and greenhouse experiments with a crude citrus limonoid extract, adult oviposition suppression was comparable to that found with epilimonol in the earlier

study. In small field plot studies, season-long densities of adult Colorado potato beetles were significantly lower in plots treated with crude grapefruit extract than in untreated, control plots. Citrus limonoid extract applied to the center of field plots, leaving the perimeter rows untreated, resulted in 55% more adults and 82% more eggs in the untreated areas than the limonoid-treated rows; treated perimeter rows, leaving the plot center untreated, resulted in 74% fewer adults and 81% fewer eggs in the center of these plots than in control, untreated plots. Treatment of the entire plot with the citrus limonoids resulted in a 60% reduction in adult density and 50% fewer eggs than the untreated, whole plots. To determine the compatibility and possible synergism of citrus limonoids with *Bacillus thuringiensis* endotoxin, rates of adult beetle colonization and oviposition were significantly lower in plots treated with the endotoxin following treatment with limonoids. Throughout the experiment, densities of early instars in the limonoid and limonoid + endotoxin treatments remained significantly lower than the endotoxin alone and control treatments, but this was probably due to the lower egg densities in limonoid treatments. Conclusions from these experiments indicate that limonoids applied before the endotoxin do not interfere with the endotoxin's insecticidal activity. Rather, disruptive effects of these materials on reproduction are additive. The demonstrated disruptive effects of the citrus limonoids on Colorado potato beetle adult feeding, oviposition, and distribution have established a viable alternative to traditional integrated pest management strategies. Deployment of these and other natural products may have additive, antagonistic, or synergistic effects on a range of insect pests, and therefore, the approach should be the incorporation of an allelochemical into a multi-component system of integrated pest management.

c) Source of Federal Funds—Hatch

d) Scope of Research—State Specific

Key Theme—Hazardous Materials

a) It is estimated that Maine's 39 hospitals produce approximately 111 tons of biomedical waste each month. Most hospitals in the state contract with private firms for disposal service, including transportation of the waste to out-of-state facilities, at an estimated average cost of $685 per ton. With recent consolidation in the waste management industry and closure of some out-of-state incinerators, the hospital industry and environmental regulators are exploring alternative waste disposal alternatives.

b) MAFES researchers examining the issue have found that there are significant economies of size in processing, especially when the biomedical waste must be shredded as part of the processing. Their research reveals options to lower the Maine statewide average cost of handling biomedical waste from $685 per ton to $412 per ton. This information is especially useful for the small and rural hospitals that are experiencing decreased options for their biomedical waste and relatively higher disposal costs.

c) Source of Federal Funds—Hatch

d) Scope of Research—State Specific

Key Theme—Soil Quality

a) Improving our understanding of the process of organic matter decomposition in soils and the factors controlling the rates of decomposition has important implications for agricultural management. The ability of cover crops and crop residues to have a positive agronomic impact on crop yield and nutrient use efficiency and to reduce required chemical inputs, has been extensively documented. Often the mechanisms by which these positive agronomic impacts are achieved are unknown and more basic information is needed. To this end, MAFES scientists examined phosphorus solubility and its relationship to soil properties in both manure-amended soil and unamended soil in a rotational cropping system. Both a two-year rotation study of potato and barley and a four-year rotation study, including barley, forage, soybean, potato, were examined.

b) Impact—Due to manure and compost additions prior to 1999 and to manure additions in 1999 and 2000, amended plots were higher in total C, soil test P, and pH than unamended plots. Amended plots averaged 25.1 g C per kg, while unamended plots averaged 16.2 g C per kg. As expected, soil C content was relatively low in the unamended plots due to the level of soil disturbance associated with potato production and the lack of C additions to these treatments. As well as increasing soil C levels, additions of organic material increased soil test P and pH levels with amended plots averaging 25.8 mg P per kg and pH 6.22, and unamended plots averaging 17.1 mg P per kg and pH 5.83. The pH values are within the range expected for potato production. The optimal range for soil test P is considered to be 7.5 to 20 mg P per kg. The unamended plots were within optimal, while the amended plots were slightly above. Values above 20 mg P per kg are considered 'excessive', and P recommendations reach 0 when soil test P values exceed 25 mg P per kg. A linear relationship was observed between soluble P and soluble C, suggesting involvement of soluble C in P desorption reactions.

c) Source of Federal Funds—Hatch

d) Scope of Research—State Specific

Key Theme—Sustainable Agriculture

a) The MAFES long-term experiment to develop ecological pest and soil management systems for potatoes in Maine has finished its 11^{th} growing season. This project is designed to provide information on the costs, productivity, and environmental impacts of alternative cropping strategies for potato. A pest management system using integrated pest management and synthetic pesticides is compared to a more biologically oriented system. A soil management system centered on chemical fertilizer use is compared with one that relies heavily on manure and soil organic matter. It also compares the following rotation systems: (1) standard, two-year potatoes-barley rotation; (2) four-year extended, potatoes-soybean-barley-timothy/alfalfa; (3) four-year intensive, potato-soybean-potatoes-barley

b) Impact— Results from this experiment are showing that reduced reliance on chemical fertilizers and pesticides does not have to mean reduced yields. Comparing

environmentally friendly pest management tools with synthetic pesticides, researchers found that while both types effectively controlled Colorado potato beetles and leaf diseases, the environmentally friendly system resulted in a 62% reduction in total active pesticide ingredients with no significant reduction in yield. Research on soil management systems found that by amending the soil with manure (90 Mg/ha), they were able to reduce chemical fertilizer rates substantially (N, 59%; phosphate, 100%; and potash, 87), and yields in the plots amended with manure were significantly higher than those in the non-amended plots. Additionally, Rotations, soil management, and pest management system all affected the incidence of rhizoctonia. In 2001, rhizoctonia stem and stolon incidence were 11% and 20% higher, respectively, in the standard rotation than in the extended and intensive rotations. Researchers found significantly lower rhizoctonia incidence on stems and stolons in the amended soil management system when compared to the standard soil management system (stems 16% vs. 32%; stolons 10% vs. 26%). And the incidence of rhizoctonia on stems was also lower in environmentally friendly pest management system compared to IPM system (17% vs. 26%).

c) Source of Federal Funds—Hatch

d) Scope of Impact—State Specific

Key Theme—Wildlife Management, Natural Resource Management

a) Rockweed, *Ascophyllum nodosum*, is the dominant intertidal seaweed throughout much of the North Atlantic Ocean. A long-lived species, which provides shelter or habitat for more than 100 other species of algae and invertebrates, rockweed is harvested for use in many products. MAFES researchers are studying the other species that rely on rockweed to determine just what happens to this ecosystem when rockweed is harvested.

a) The scientists have found that the removal of the seaweed canopy resulted in a short-term (one to two years) loss of habitat and a decrease in associated species. The three (18 cm, 36 cm, uncut) harvest treatments showed that 10 of the 18 most common species were significantly affected by the one-time harvest of *A. nodosum*. These species showed signs of recovery after one to two years. The researchers found that while a one-time harvest of *Ascophyllum* appears to have no long-term negative impacts on the associated community, the intensity (cutting height) of the disturbance is an important factor in the recovery rate of affected species. The researchers have reported their findings and their meaning to private and public groups around the state and in Canada, including the "Maine Seaweed Council," Maine Department of Marine Resources (DMR), Maine Department of Conservation, several small industries that use rockweed in their products, and the Canadian Department of Fisheries and Oceans. They have also assisted the Maine DMR on developing strategies for sustained use and research prior to large-scale harvesting, and advised the Maine DMR staff on possible future regulations for rockweed harvesting. Because of their presentations on their findings at several workshops and meetings, the industries that harvest rockweed have changed their practices, and are now more cautious when removing basal parts of and are restricting cutting heights and annual amounts of biomass removal.

b) Source of Federal Funds—Hatch

c) Scope of Research—State Specific

Goal 5—Enhanced economic development and quality of life for Americans

In our original Plan of Work report, MAFES had no projects that fit under goal 5. Since that time, however, a newly hired faculty member has developed a research project entitled "Employment Change and Industry Growth in Maine." The objectives of this project are to analyze the effects of Maine's business-assistance programs on growth of the establishment of new businesses, to measure the seasonal aspects of jobs located in coastal areas and to analyze the effects of seasonal job reallocation on local unemployment and other measures of community well being, and to examine the factors affecting employment change in Maine businesses, industries and regions. The following are highlights of this year's accomplishments:

- A key determinant of the economic strength and prosperity of an area is the vitality of its local businesses. A MAFES project is analyzing several aspects of business growth in rural Maine communities. The research thus far indicates that local personal property tax rates have a negative effect on the number of business startups, whereas spending on education and total local government spending have a positive effect. Model simulations show that a policy of lower taxes combined with reduced spending on public services would lead to fewer business startups than a policy of higher taxes and more spending on public services. These results are noteworthy because they point out the tradeoffs that policymakers face when deciding to lower taxes (and decrease spending) or increase taxes (and increase spending). Maine policymakers and business leaders used findings from the project in their evaluation of the state's economic development incentive programs.

Scientist years:	0.5
Hatch Funds:	$20,000
Reg. Research Funds:	$0
State Funds:	$67,000
Total Funds:	$87,000

Assessments of Accomplishments

As discussed in the Stakeholder Input Process section, the Maine Agricultural and Forest Experiment Station shares the preproposals for all research projects with the Board of Agriculture and the Forest Resources Advisory Committee and the Cooperative Forestry Research Unit advisory board. In addition, as discussed in the Program Review section, all MAFES research projects are peer-reviewed. We believe that these two steps ensure that our research is good science and is meeting the needs of the state.

STAKEHOLDER INPUT PROCESS

(a) Actions taken to seek stakeholder input and encourage their participation:

Several actions were taken to seek stakeholder input in FY 2001. First, for the second consecutive year, the Maine Agricultural Center (MAC), in conjunction with the University of Maine Board of Agriculture, conducted a survey of all known agricultural groups in Maine to collect input. MAC also worked closely with the Agricultural Council of Maine as it addressed short- and long-term needs of the industry. Researchers and experiment station personnel also attended many meetings with commodity and other agricultural groups in the state to ensure that the Experiment Station was aware of the issues facing the groups and to encourage the groups to participate in the survey. Finally, advisory groups, including the Board of Agriculture, the Forest Resources Advisory Committee (FRAC), and the Cooperative Forest Research Unit (CFRU) advisory committee, met several times during FY2001 to provide input and feedback on research needs and priorities. The CFRU committee is composed of major forest landowners in Maine that provide funding for forest-related research. The FRAC committee is more broadly representative of the forest industry, including small landowners, and wood processors and manufacturers.

(b) Process used to identify stakeholders and to collect input:

For the purpose of the survey, agricultural groups were considered to be the stakeholders. The list of agricultural groups surveyed in 2001 included all that were surveyed in 2000, plus about ten more that were identified through numerous sources. In total, more than 60 groups were invited to participate and sent a copy of the mail survey. The mail survey instrument asked the groups to rate the importance of several major research categories (production, marketing, business planning, etc.) to its members. In addition, the groups were also asked to rate specific research areas within the broader categories identified earlier. For example, under the general category of production, respondents were asked to rate the importance of several sub areas, including reducing production costs, developing new production technologies, new plant varieties and new rotation crops. All groups were contacted at least two times to encourage them to respond to the survey. About 19 of the groups actually responded. Research and extension faculties identified stakeholders through previous work with individuals and groups. The faculties are stakeholders as well, and their expertise is important in identifying needs and establishing priorities. Finally, the advisory groups represent stakeholders, and their input is obtained through the meetings held.

(c) How collected input was considered:

The data obtained through the survey was summarized and presented to the Board of Agriculture. The Board devoted a half day to a discussion of the results and developed a list of high-priority needs found in the survey. Based on the needs identified, the Board of Agriculture worked with extension and experiment station personnel to establish priorities for new extension and/or research positions to address those needs. The highest priority was for an extension/research food science position. Other high-priority positions include an

extension/research farm management position, a teaching/research landscape horticulture position, and a teaching/research quantitative genetics position. The experiment station and cooperative extension administration and other university administrators studied these recommendations. Some of these positions had been approved by the university to be filled, but action has been postponed due to a hiring moratorium at the university. The Forest Research Advisory Committee has offered suggestions on the types of research that need to be conducted to address the issues and concerns related to Maine's forests. This input is being considered currently.

PROGRAM REVIEW PROCESS

The external scientific peer review process used to evaluate all experiment station projects, regardless of funding source, was described in our Plan of Work. That process is still in place and is functioning as described in the Plan of Work. All research preproposals developed for MAFES projects are also shared with the three advisory committees identified in the previous section of this report, and we encourage their comments and input on the relevance and merit of the work proposed.

EVALUATION OF THE SUCCESS OF MULTI AND INTEGRATED ACTIVITIES

This section contains an evaluation of the multi-state projects and the integrated research/extension activities in which the Maine Agricultural and Forest Experiment Station participates. Multi-state research projects are considered first.

Multi-State Research Projects

(a) Do they address key issues, including those identified by stakeholders?

Multi-state projects are important part of the MAFES portfolio of research projects. In fact, multi-state projects contribute to nineteen of the key themes identified in the first section of the report. Furthermore, these projects contribute to many of the key areas of research identified in the stakeholder survey discussed above. For example, stakeholders identified the development of new varieties and improved weed control as priority needs. Two multi-state projects in the area of plant production efficiency supported by MAFES, NE-183, *Multidisciplinary Evaluation of New Apple Cultivars*, and NE-1000, *Improved Weed Control Through Residue Management and Crop Rotation*, address priority production needs identified by stakeholders.

(b) Do they address the needs of under-served and under-represented populations?

Research results are not specific to a given population. It is the position of MAFES that all research results reside in the public domain and can be used by any individual or group. Results of MAFES projects are distributed to anyone who asks for the information. On the other hand, the two multi-state projects in the area of human nutrition supported by MAFES, NE-172, *Nutritional Risk and Antioxidant Status in the Elderly*, and NC-219, *Stages of Change Model to Promote Consumption of Grains, Vegetables, and Fruits*, address nutrition needs of the elderly and young adults, both of which are non-traditional stakeholders.

(c) Do the programs describe expected outcomes and impacts?
New multi-state research projects are written in a format that includes a listing of expected outcomes and impacts. Older multi-state projects are being revised to include expected outcomes and impacts. All of the projects contribute to the outcomes and impacts identified for a program area in the MAFES Plan of Work.

(d) Do they result in improved effectiveness/efficiency?

Improved effectiveness/efficiency is one of the major advantages of multi-state research projects. Having faculty from different states work together generates more information than a person working alone. The information also has wider applicability as the research has been performed under different conditions, such as weather, soil type, or social institutions.

Integrated Research and Extension Activities

All MAFES-supported integrated research/extension activities are managed through the Maine Agricultural Center (MAC). The Center has concentrated on creating more joint research/extension positions and supporting integrated research/extension projects. The Center has developed a process through which MAC members can request special funds for agriculture-related research projects and education programs that address high-priority needs. The funding is intended to support one-time projects that can be accomplished in approximately one year.

(a) Do they address key issues, including those identified by stakeholders?

All of the joint research/extension positions created and the MAC-funded projects are strongly supported by the stakeholders. In terms of the joint positions, the university is responding to a stakeholder recommendation that more joint appointments be created to help develop a more seamless delivery of services to the agricultural community.

All MAC-funded projects must have letters of support from stakeholder groups showing that they address key issues to be eligible for funding. To date MAC has supported 22 projects that address priority issues facing Maine agriculture.

(b) Do they address the needs of under-served and under-represented populations?

All of the joint appointments created have allowed the university to serve groups that were not being served before. For example, creating a joint research/extension position for an animal science faculty member has allowed the University to better serve the red deer and elk industry. This group is considered an under-served population. Projects supported by MAC have also broadened the scope of groups served. For example, one project supports the Maine organic dairy farm industry, an industry that was not well served in the past by the experiment station or cooperative extension.

(c) Do the programs describe expected outcomes and impacts?

Integrated research and extension projects developed by faculty with joint appointments must go through the same program review process used to evaluate all experiment station projects, which

was described in our Plan of Work. That process is still in place and is functioning as described in the Plan of Work. All research proposals developed for MAFES projects discuss the expected outcomes and impacts of the proposed research. These expected outcomes and impacts are submitted with their CRIS forms and are available on the CRIS web site.

Project proposals submitted for MAC funding must show that the research addresses a priority need of Maine agriculture and must include both a research and extension education component, expected outcomes and the method for sharing the outcomes of the project, and proof of industry support for the project. The final result will be a report, product, or finding that can be shared with Maine agriculture and will have a measurable impact.

Examples of outcomes and impacts reported in the termination reports for MAC-funded projects FY2001 are listed below.

- In a project dealing with woody plant species native to Maine, our faculty created a comprehensive list of native woody plant species for use in Maine landscapes.
- In a project dealing with the development of an equine semen facility, scientists taught members of the equine community about the procedures and equipment used in artificial insemination.
- In a study on irrigation investment in lowbush blueberries, scientists calculated investment costs for three field sizes—25, 50, and 100 acres—for two types of irrigation systems.
- In a study on the transport of genetically engineered corn pollen, scientists confirmed that organic crops can be contaminated by wind drift of pollen from transgenic crops. As a result of this study the researchers are recommending that farmers who raise organic crops take special precautions to ensure their crops are free from cross-pollination if genetically modified corn is grown in nearby fields.
- In a study on the integration of Maine's potato and dairy industries, scientists developed a protocol for Maine farmers enabling them to evaluate the feasibility of crop/livestock integration as it applies to their operation.

(d) Do they result in improved effectiveness/efficiency?
We believe that joint appointments are the most efficient way to ensure that research and extension programs are meaningfully integrated. Furthermore, joint appointments allow researchers to get credit for the extension work they perform as well as giving extension personnel credit for the applied research they often perform. Projects that have co-principal investigators (a researcher and an extension educator), such as those funded by MAC, are also an effective way to integrate research and extension activities.

MULTISTATE EXTENSION ACTIVITIES

Not Applicable

INTEGRATED RESEARCH AND EXTENSION ACTIVITIES

The Maine Agricultural and Forest Experiment Station has continued to increase its participation in integrated research and extension activities through the Maine Agricultural Center (MAC). MAC has funded 22 projects over the last two years that include both a research and extension component. Many of the projects have both research and extension faculty working together. MAC will fund additional projects in FY2002.

The Maine Agricultural Center also manages all joint research/extension faculty positions. In FY2001, two new faculty were hired on joint appointments, which brings the total number of faculty with joint appointments to eight and a search is underway for a ninth position. Furthermore, if approved by university administration, a joint extension/research food science position will be advertised in FY2002.

The Maine Agricultural and Forest Experiment Station has met its requirement to spend at least 12.8 percent of its Hatch allocation on integrated research and extension activities. Based on FY 2001 Hatch allocations, our target was about $228,152. We are certifying a total of $243,683 expended on integrated research and extension activities for FY 2001. Form CSREES-REPT (2/00) is attached.

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

Institution Maine Agriculture and Forest Experiment Station
State Maine

Check one: ___ **Multistate Extension Activities**
_X_ **Integrated Activities (Hatch Act Funds)**
___ **Integrated Activities (Smith-Lever Act Funds)**

	Actual Expenditures				
Title of Planned Program/Activity	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Maine Agricultural Center	$229,645	$243,683			
Total	$229,645	$243,683			

Director **Date**

Form CSREES-REPT (2/00)