

Maine Agricultural and Forest Experiment Station

**Annual Report of Accomplishments and Results
FY 2000**

**Maine Agricultural and Forest Experiment Station
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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:

- Collaborative efforts with the National Turfgrass Evaluation Program continue. Presently, Kentucky bluegrass, creeping bentgrass, perennial ryegrass, high- and low-maintenance fine fescues, and tall fescue are being evaluated at the University of Maine. MAFES researchers are also evaluating winter survival of creeping bentgrass grown on three experimental greens, using six anti-desiccant products, in combination with fungicide. These research findings will help the homeowner, college and high school athletic directors, and golf course superintendents select grass varieties adapted to this region of northern New England.
- An investigation of the impact of leaf spot and stem blight diseases on lowbush blueberry and the effect of management practices on these diseases continues. Higher levels of leaf spot and stem diseases were found in the bearing fields than the non-bearing fields. Preliminary experiments on DNA extraction and use of the AFLP method of fingerprinting isolates has been done. The selected isolates will be used to examine the genetic diversity of *Monilinia* in lowbush blueberry fields. This research will determine whether control measures are economically justified and the information on the genetic diversity of *M. vaccinii-corymbosi* can be used to evaluate and design different control strategies.
- As part of a multi-state research project, the evaluation of apple cultivars continued. Varietal differences in tree growth, fruit coloring, and eating quality have been demonstrated. Consistently high yielding varieties are beginning to become apparent. Information from this project is useful to growers who are looking for new varieties to plant and market.
- MAFES researchers continued investigating the feeding physiology and morphology of three species of fish, cod, haddock, and winter flounder. Results showed that winter flounder larvae develop complex feeding structures at much smaller sizes than cod or haddock. Haddock and cod differ in their rates of swim bladder inflation, and for haddock, swim bladder inflation was the major cause of high mortality rates compared to the relatively lower mortality rates in cod. A significant finding from this research that is directly applicable to

the marine finfish aquaculture industry is that it may be necessary to feed juvenile fish more often throughout the day to maximize growth in juvenile marine fish.

- In an effort to increase the productivity of dairy cows, MAFES researchers continued looking for the reasons that dairy cows are subfertile for the first 60 days postpartum. In doing so, they found that a small but significant percentage of early postpartum dairy cows could produce viable embryos. This information demonstrates that embryos may be recovered, albeit at lower rates, from valuable donor cows during the early postpartum period.
- Infertility in horses is a significant problem in Maine, where horses are a multi-million dollar industry. Failure to conceive or carry a foal leads to great economic losses. MAFES scientists are attempting to improve our knowledge of equine infertility by investigating *Streptococcus* infection of the equine uterus. Early results indicate that strain of *Streptococcus* the horse is infected with may affect the horse's fertility.
- 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. This year MAFES scientists continued work on whale-friendly lobster gear, development of filter foam material for recirculating aquaculture systems. Especially critical now that wild Atlantic salmon have been listed as an endangered species is MAFES work testing experimental net pen materials to replace the current netting with a material that is predator-proof and will prevent escape of farmed salmon.

Scientist years:	15.9
Hatch Funds:	\$542,000
Reg. Research Funds:	\$304,000
State Funds:	\$2,417,000
Total Funds:	\$3,263,000

Key Theme—Agricultural Competitiveness

- a) Usually tablestock potato prices are stable throughout the marketing season until late in the season when they often rise. For Maine growers, however, there are risks of quality loss from storing potatoes so long. MAFES economists, examining the costs of refrigeration together with the prices of potatoes marketed late in the season, have found that refrigeration can extend the quality of the potatoes with little impact on the weekly cost of storage.
- b) Impact—Since releasing these preliminary results, there has been considerable interest in retrofitting storages for refrigeration and several retrofits have already taken place.
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—State Specific

Key Theme—Animal Health

- a) Organic contaminants, such as dioxins and polychlorinated biphenyls, are widespread in Maine watersheds. Monitoring studies, however, have not addressed the effect of these chemicals on the animals living in these waters. In addition, detection of dioxin by high-resolution spectrometry costs approximately \$1,000 per sample. The high cost limits both the numbers of organisms that can be tested and the frequency of sampling. MAFES scientists are investigating the biological effects of these compounds on the health of these aquatic animals and working to develop an in vitro bioassay, which would provide a rapid, sensitive, and relatively inexpensive method to screen for the presence of dioxins and other halogenated aromatic hydrocarbon contaminants.
 - b) Impact—Working with softshell clams, the research indicates that chronic exposure to these contaminants may harm the development of reproductive organs, which could lead to lower population levels. The bioassay may provide an inexpensive alternative for prescreening dioxin toxicity equivalents.
- a) Source of Federal Funds—Hatch
 - b) Scope of Impact—State Specific

Key Theme—Aquaculture

- a) The farming of fish has been around for literally thousand of years, but the culture of cold-water marine fish species is a relatively new idea. Limited ingestion of inert diets by marine larval fish has been a fundamental obstacle to their successful use as a replacement for live food. Supplies of live food, however, are unpredictable and prices for live food are high. MAFES researchers are assessing the factors that affect ingestion of microparticulate diets (MPD) by Atlantic cod larvae and working to develop alternative feeds that will reduce dependency on live food organisms, specifically Artemia.
 - b) Impact—So far, researchers have found that particle size did not appear to affect ingestion of MPD within the size range tested. They have also identified the proper feeding level that resulted in maximum ingestion with the least amount of wasted food. In addition they determined that binder composition had a significant effect on the palatability of these experimental diets. In experiments conducted to determine if good growth and survival could be achieved with reduced quantities of Artemia, the researchers found that growth rates and survival of those larvae receiving 50% and 25% rations were not significantly different from the live food control. Developing inert diets to replace or reduce the use of live food in the culture of marine fish larvae will reduce associated cost of production and improve the economic viability of commercial marine fish culture.
- c) Source of Federal Funds—Hatch
 - d) Scope of Impact—State Specific

Key Theme—Biotechnology

- a) Infectious Salmon Anemia Virus (ISAV) is an emerging pathogen and as such special regulations on fish health certifications and restrictions on trade are imposed on aquaculture companies operating in the affected zones. In the ISAV-affected zones, the Canadian government ordered the eradication of 1,000,000 (+) fish and the fallowing of fish farms. If ISAV is diagnosed in Maine, similar extreme measures would be implemented, which would devastate the aquaculture industry. MAFES scientists are working to help the industry avoid, contain, and control ISAV through (1) ISAV genomic cDNA synthesis and analysis, and (2) ISAV molecular phylogenetics and epidemiology. The information will be essential for structuring fish-health-monitoring strategies, bioregulations, and the design of ISAV DNA vaccines.
- b) Impact—Large-scale culture of the virus in cell-factories, using CHSE-214 cells, has been accomplished. Viral growth in cell-factories (6,000 cm²) has allowed the researchers to purify large quantities of virus and viral RNA. Additionally, two cDNA libraries have been made. The libraries are composed of roughly 2,500 clones. Both the nucleocapsid and matrix genes are now being used to develop nucleic acid and antibody-based diagnostic tools. The nucleocapsid gene is being used to develop a recombinant ISAV vaccine.
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—State Specific

Key Theme—Managing Change in Agriculture

- a) The Maine dairy industry is experiencing unprecedented change. A group of dairy farmers in central Maine has responded to this volatile environment by switching their production to organic milk. Organic milk production is expected to grow by 50% over the next three years if production costs can be controlled. Since the Maine Organic Farmers and Gardeners, the certifying agency, requires that organic milk cows consume organic feeds, the price of organic feeds is crucial to the success of Maine's organic dairy industry. To address these issues, MAFES researchers analyzed the viability of developing an organic grain receiving and milling facility.
- b) Their analysis indicated that a facility would be financially viable if the demand for organic feed extended beyond the dairy industry. Another recognized benefit from such a facility would be as an incentive for local growers to produce organic grains.
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—Multi-State Research
 - With KY, MD, MI, MN, NYC, OH, PA, TX, VT, WI

Key Theme—New Uses for Agricultural Products

- a) MAFES scientists are developing several alternative income-generating methods of handling crustacean processing by-product in the state of Maine. Crustacean processing by-product (CPB) contains calcium, chitin, protein, pigments, and flavor compounds that could be further utilized in the development of value-added products. Two studies have been conducted in the past year to evaluate the use of crab-processing by-products in value-added food products. Previous research indicated that both wet and dried crab processing by-product could be successfully extruded into a snack product. This year's research focused on using wet CPB to develop a calcium-rich, extruded snack and examining efficacy of a chitosan coating on improving the shelf-life stability of refrigerated fish fillet.
- b) Impact—The results indicate that (1) crab processing by-products can be used to produce a crispy, protein-enriched, high-calcium extruded snack product, and (2) that applications of chitosan coating could be an effective method of improving the quality and shelf-life stability of refrigerated fish fillets. Further research will focus on determining appropriate concentrations needed and effects of chitosan coating on sensory quality of fresh fish fillets. The development of value-added food products out of crab processing by-product will help alleviate the problems associated with waste disposal and increase the total value of our natural resources.
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—State Specific

Key Theme—Ornamental Green Agriculture

- a) Most wild plants have great horticultural potential, and many plants currently sold in the trade are taken from the woods. Maine has abundant flora, which provides a source of native plants for horticultural trade. To prevent depletion and possible extinction of wild plants and to produce quantities of native plants for horticultural trade, practical and commercially feasible methods of propagation are necessary. MAFES scientists are conducting research on new Maine plants with commercial potential and natural conservation significance.
- b) Impact—To date, a total of 36 varieties have been identified as potential new garden plants from Maine. Research is being conducted to determine viability and suitability of these new plants. New garden plants that meet criteria will be introduced, along with culture requirements, to local growers for commercial production. The success of this study will save our natural environment, enhance popularity of native plants in our gardens, and increase the sales of plant nurseries
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—Multi-State Research
 - With CTH, CTS, DE, MD, MA, NH, NJ, NYG, NYC, PA, RI, VT, WV, USDA/ARS

Key Theme—Plant Health

- a) Plants subjected to environmental stress exhibit reduced growth in part due to inhibition of protein synthesis. Specific gene messages are selected for protein synthesis from the total message pool. MAFES scientists are working to define the mechanisms by which protein synthesis is reduced, and how specific messages are selected to make proteins under stress conditions. Primary efforts have been to develop sensitive, inexpensive tests for the detection of potato pathogens in leaves or seed tubers. These assays will be used as secondary confirmation tests for phytosanitary certification of the potato seed crop.
- b) Impact—MAFES researchers have developed a multiplex PCR assay to simultaneously screen for potato virus X, potato virus Y, potato virus S, and potato leaf roll virus. They have found that a single assay mix is effective in testing for the presence of any of these individual pathogenic agents, as well as provide an internal positive control (rDNA). This study affirms that the multiplex PCR test is appropriate as a sensitive, independent confirmation of positive ELISA test results. They have recently begun characterization of a molecular padlock strategy, which is more sensitive, cheaper, and easier to perform than the PCR assay. This work has identified practical and highly sensitive diagnostic tests to confirm the presence or absence of pathogenic agents in potato seed tubers. Such reliable tests are essential for the best possible methods to certify potato seed for commercial sale.
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—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. Commercial potatoes lack strong resistance to many common diseases, and several virus-caused diseases are major threats to potato production in the region. In addition, the Colorado potato beetle and several nematodes are important pests in the Northeast. Because of these disease and pest problems, potato production in the region requires a lot of chemical inputs. The potato industry needs new potato varieties that combine excellent quality with high yields and pest resistance. Most of the potato varieties grown in Maine today originated from the public breeding programs conducted in Maine, New York, Wisconsin, Canada, Louisiana, North Dakota, and by the USDA. The most promising lines from these breeding programs are then tested at several locations in Maine and at trial locations in Canada and the eastern United States. Identification of new potato lines that grow well in Maine is important; however, it is also important to identify varieties that will grow well in other eastern areas, since Maine supplies seed to markets all over the eastern United States. This project is developing new potato varieties with improved pest and disease resistance and better fertilizer-use efficiency that also meet consumers' and processors' demands for high quality. Prior to their release as varieties, this project evaluates new potato lines for their chipping potential, french fry quality, and fresh market quality.
- b) Impact—Since 1991, the Maine potato-breeding program has released six potato varieties for public use. MaineChip, released in 1991, has resistance to net necrosis and verticillium wilt, and produces excellent chips. Mainestay, released in 1995, is high yielding with resistance to

net necrosis, verticillium wilt, fusarium dry rot, pink rot, and early blight. Quaggy Joe, released in 1996, has resistance to net necrosis, verticillium wilt, early blight, and bruising. Portage was released in 1992. Prestile, released in 1991, has attractive tubers and resistance to net necrosis, virus X, verticillium wilt, early blight, and common scab. St Johns, released in 1995 and licensed to Hetteme, has very good tuber appearance and resistance to golden nematode, corky ringspot, verticillium wilt, black wart, net necrosis, blackspot bruise, early, blight and late blight. In addition to the new varieties, MAFES researchers have been working hard over the last few years to help bridge the gap between research trials and commercial production and to better understand the growers' needs. They have been working on better ways to get information about the new lines to interested growers (e.g. meetings, published articles, demonstrations, and variety profiles), and have helped arrange initial seed propagation and commercial trials with the most promising lines that are identified in our research trials. This multi-state project received the 1998 Northeast Experiment Station Directors award for excellence in regional cooperation.

c) Source of Federal Funds—Hatch

d) Scope of Impact—Multi-State Research

- With DE, FL, NJ, NYC, NC, NV, OH, PA, PEI, Quebec, VA, WV, USDA/ARS/BARC

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 were initiated. Results of the tests showed 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.
- To develop sensor technology for quantitative measurement of fruit and vegetable properties indicative of quality, MAFES researchers are examining various methods to separate maggot-infested blueberries in an IQF processing line. Maggot identification in the process line is important to Maine wild blueberry producers and processors as they have identified it as one of the top research areas in their 5-year plan for funding support. As a positive show

of support, several producers and processors in Maine have cooperated with the PI to obtain blueberry samples and aid in the research effort.

- MAFES food scientists continued performing sensory evaluations for several projects, and helped a sensor company with correlation of a new sensor for fish smell with human panelists. They are also involved in small clinical studies that evaluate the effects of freeze-dried wild blueberries and spray-dried cranberry juice concentrate on amelioration of Type II diabetes side effects. This sensory testing supports new product development in Maine, and research on health benefits of fruits may stimulate consumption of those commodities.
- MAFES scientists continued analyzing pesticide residues in wild blueberries and potatoes, compiling data that will be extremely important to toxicologists and epidemiologists. They also tested concentrations of several pesticides used on our agricultural crops (blueberries, potatoes, apples, Christmas trees, strawberries, and small grains) in ground and surface waters to determine the impact on people and fish. Hexazinone was the pesticide that was detected most frequently, with most concentrations below 2 ppb.
- An analysis of consumer preferences for key potato attributes and their impact on consumers' purchasing decisions was completed. Results clarify the positioning of Maine potatoes in selected major markets, identify which consumer attitudes need to be reinforced or altered through specific promotion and merchandising, and indicate which modifications to products, marketing actions or pricing strategies would be most effective in extending market share. Addressing questions relevant to consumer preferences and purchase decisions, this project provides the Maine potato industry information useful in planning and executing market strategies.

Scientist years:	3.1
Hatch Funds:	\$163,000
Reg. Research Funds:	\$56,000
State Funds:	\$460,000
Total Funds:	\$679,000

Key Theme—Food Quality

- a) The U.S. Patent Office has assigned a patent to the University of Maine for a new process to preserve the flavor and texture of frozen seafood. The process has been applied to lobsters and may be expanded to other types of seafood as well. The patent is based on research by MAFES scientists.
- b) **Impact**—This process helps businesses that prefer not to handle live lobsters. Now they can use a frozen product that tastes as good as the fresh and has a longer shelf life. Previous attempts at preserving the quality of frozen seafood have been unsuccessful, according to the patent document. The patent notes that in addition to protecting flavor and texture, the UMaine process can promote a steady supply of products, protect public health, and reduce seafood spoilage, thus conserving natural resources.
- c) **Source of Federal Funds**—Hatch
- d) **Scope of Impact**—State Specific

Key Theme—Food Resource Management

- a) MAFES researchers are working with the Maine Gourmet and Specialty Food producers to help the producers improve the web sites. The organization's web site and individual sites of 21 member companies were evaluated through online surveys. Reports of findings were prepared for each company. Various electronic promotional activities were conducted to evaluate their cost effectiveness, with the goal being to increase traffic to the organization's web site.
- b) Impact—Traffic to the Maine Gourmet and Specialty Food Producers' web site has increased approximately 12-fold three months after the beginning of the promotional campaign.
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—State Specific

Key Theme—Food Safety

- a) During the past year MAFES food scientists performed 130 process and product reviews for individuals starting or continuing a home-based food-processing business in Maine and New Hampshire. Home processors must complete the review process before they receive a license from the Maine Department of Agriculture, Food and Rural Resources or the New Hampshire Division of Public Health. These individuals come from all parts of northern New England, and more than 85% are women. Without this review and approval, these processors cannot sell their products.
- b) Impact—Estimating that average sale from each business is \$5,000 to \$10,000, the impact on the economy is \$650,000 to \$1,300,000. In addition to the economic impact, these reviews reduce the chance that unsafe foods will enter the marketplace.
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—Multi-state Integrated Research and Extension
 - With NH

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:

- As part of a multi-state research project (NC219), Maine was one of 10 states to participate in a survey of young adults. Trained students telephoned young adults and conducted interviews, assessing stage of change for fruit and vegetable intakes. Sample size from the 10 participating states was 1545 (61% females; 39% males), and researchers found that less than one-third of the respondents met the recommended daily intake of five fruits and vegetables. This research will help nutritionists design interventions to facilitate behavior change.
- Despite the importance of fruits and vegetables to health of older adults, there are few data on interventions to increase fruit/vegetable consumption in this population. To target appropriate interventions, research is needed on elder food practices, as well as perceptions of barriers and benefits to changing dietary intake. MAFES nutritionists continued their nutrition surveillance on approximately 4000 elderly Maine citizens (two-thirds female) participating in the Older Americans Act Elderly Nutrition Programs. These data on dietary risk of Maine's elderly are being reported to state agencies for nutritional education efforts and other intervention practices.

Scientist years:	1.1
Hatch Funds:	\$33,000
Reg. Research Funds:	\$31,000
State Funds:	\$91,000
Total Funds:	\$155,000

Key Theme—Human Nutrition

- a) Osteoporosis is a significant health problem affecting more than 25 million people in the United States. Because approximately 50 percent of total bone mass is accumulated during puberty, strategies to prevent osteoporosis later in life are now focused on maximizing bone mineralization during adolescence. MAFES researchers are investigating whether there is a seasonal variation in the rate of bone mineralization in adolescent girls. If mineralization rates are slower in the winter, this time of year can be targeted for intervention resources.
- b) Impact—This research will provide further information on the process of bone mineralization during adolescence, specifically the impact of decreased skin synthesis of vitamin D in

winter and other seasonal factors on bone. Evidence might support more aggressive interventions to increase vitamin D intake or physical activity levels in winter during this critical stage of bone mineralization and growth.

c) Source of Federal Funds—Hatch

d) Scope of Project—State Specific

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:

- MAFES researchers examined the hydrologic impacts of different cultural practices for potato cropping systems, focusing on compost- and manure-amended soils versus conventional chemical fertilized potatoes with no organic matter amendments added to soils. Understanding and quantifying movement of nutrients due to farming practices provides farmers with decision-making tools for choosing best management practices.
- Improving understanding of the process of organic matter decomposition in soils and the factors controlling the rates of decomposition has important implications for agricultural management. Although it is recognized that cover crops and crop residues have a positive impact on crop yield and nutrient use efficiency, the mechanisms by which these positive agronomic impacts are achieved are unknown and more basic information is needed. In a two-year rotation study of potato and barley, MAFES researchers found soil from barley plots contained higher phosphatase activity than soil sampled under potato plots. In addition both potato and barley soils that had received additions of organic amendments contained higher levels of phosphatase than soils that had received no organic amendments.
- Domestic wells that provide water with arsenic concentrations that exceed the USEPA's drinking water standard are estimated to occur in 10% of all wells. A MAFES project involves collecting water samples from domestic water wells from Northport, Maine. These samples will be used to assess ground-water geochemistry of an area with high arsenic concentrations in ground water. The investigators are assessing the possible linkages between anthropogenic inputs (herbicides and pesticides), minerals in the bedrock and arsenic

concentrations to test two hypotheses: (1) arsenic is derived from weathering of the bedrock and (2) arsenic originates from the application of arsenic salts used as pesticides in the past.

- MAFES researchers are examining the relationships between selected biological, chemical, and hydrological variables at two raised bog complexes in Maine to predict responses to climate change. So far they have found that production by *Picea mariana*, *Larix laricina*, and *Chamaedaphne calyculata* is strongly influenced by water levels. Although these results have not yet been analyzed in relation to climate change scenarios, they suggest that climate change that causes minor but sustained hydrologic change can have important ecological impacts on peatlands. The effect of climate change on peatlands is of interest, not only because of the likely detrimental effects on peatlands themselves, but also because of the major role that peatlands play in the global carbon cycle.
- Allelochemicals have tremendous potential as alternatives to conventional insecticides in pest management programs. In field experiments, a MAFES researcher investigated the effects of neem extract as the deterring allelochemical and a combination of host attractants and the insecticide permethrin. Colorado potato beetle adult, larval, and egg mass numbers were reduced. To explore potential deployment strategies of beetle attractants and repellents, experiments were conducted using a diverse array of treatment timings and sequences over an entire growing season to disrupt natural field colonization and life stage distributions of the beetle. The results indicate that the “stimulo-deterrent” strategy for attractants and repellents offers significant potential for management of Colorado potato beetle.
- A MAFES researcher is continuing to determine the relative incidence and severity of stem pathogens in a potato cropping study in which long-term amendment with potato compost, beef manure, and green manure has been compared to conventional fertilization. The results so far indicate that an additional year of rotation, or the avoidance of heavily affected areas of a field for one potato crop, would be useful ways of reducing pink rot incidence and pathogen population increases.
- Rockweed is a common intertidal brown seaweed in Maine that is exposed at low tide and stands in a water column at high tide. Its canopy sustains other seaweeds and animal species. Currently there is much interest in harvesting rockweed for use as fertilizer and fodder in animal feed. MAFES researchers are investigating what happens to the other marine species that rely on rockweed for shelter, refuge, and food when rockweed is harvested. The results from this study will be used by state agencies to develop regulations that ensure sustainable harvest levels.
- Maine’s Great Ponds are important ecological, cultural, and economic assets, providing recreational opportunities, commercial opportunities, and drinking water. A project by MAFES researchers examines the economic benefits of water clarity in these lakes. Their research found that people enjoy and use lakes with higher clarity more than they do those with lower clarity and they spend more money when they visit these higher-clarity lakes. These results, published in a MAFES report, suggest that local communities should protect water clarity of their lakes and that increasing the state budget to protect lake-water clarity would have economic benefits to the state.
- Seals are responsible for some 60% of the escapes of Atlantic salmon from aquaculture pens. These escapes are both a loss to the industry and a threat to the wild, endangered Atlantic salmon stocks that spawn in the nearby rivers. MAFES researchers are continuing their work to gather information about harbor and grey seals that would reduce these escapes. Aerial surveys of seals were conducted from January through April. The researchers acquired funding to initiate a review of the seal-aquaculture interactions in Maine and to begin to

capture seals near aquaculture sites. Cooperators include the finfish aquaculture industry, the Maine Department of Marine Resources, and the National Marine Fisheries Service/USDC.

- MAFES researchers are investigating of the genetics of the wood turtle in an effort to better understand the regional genetic variations of this rare turtle. These data also will aid in forensic identification of turtles illegally collected for the pet trade. Results of wood turtle surveys are being used by the Endangered Species Group at Maine Department of Inland Fisheries & Wildlife to monitor this Species of Concern.

Scientist years:	11.2
Hatch Funds:	\$507,000
Reg. Research Funds:	\$121,000
State Funds:	\$2,09,000
Total Funds:	\$2,637,000

Key Theme—Biological Control

- a) With environmental and social pressures demanding biological alternatives to chemical pesticides, the study of insect diseases is one of the most rapidly expanding areas of research for insect pest management. A considerable effort is being directed toward the commercial development of disease-causing agents (pathogens) to be used as microbial insecticides. However, many insect pests have naturally occurring pathogens in their populations, and natural outbreaks of disease occur when the pathogen replicates and infection is spread throughout the population. MAFES scientists are developing and evaluating pathogens for insect pest management programs. These researchers have created a computer model that simulates primary infection of the Colorado potato beetle (CPB) with *Beauveria bassiana*. The model accurately simulates the seasonal incidence of larvae of CPB in control plots, but over estimates large larvae in *B. bassiana*-treated plots. They are investigating the impact of timing of foliar sprays of *B. bassiana* conidia on persistence of activity against CPB larvae and the impact of abiotic and biotic factors on secondary cycling of *B. bassiana* on CPB populations.
- b) Impact—This research suggests that growers using the mycoinsecticide *Beauveria bassiana* for management of insects may have better efficacy with evening applications than early morning applications. Also, their horizontal transmission research suggests a new paradigm for the use of insect pathogens in integrated pest management systems. Instead of only considering the short-term benefit of the pathogen as a bioinsecticide, the long-term benefit of introducing and managing the pathogen within the pest population is being assessed.
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—Multi-state Research
 - AL, AR, AZ, CA, CTH, FL, GA, ID, IL, KY, LA, MS, MN, NJ, NYC, NC, OH, SC, TN, TX, VA, USDA/ARS, USDA/FS

Key Theme—Natural Resource Management

- a) Faced with increasing federal and state regulations, declining stocks of many fish/shellfish, and intense competition, the Maine's fishery industries need to develop innovative ways to

manage their resources. Experiment Station researchers are involved in cutting-edge fisheries management research with the Maine lobster zones project. In an attempt to decentralize and democratize the state's fisheries, this project is looking for incentives for individual fishermen to adopt practices that conserve the resource.

- b) Impact—The lobster zones experiment is on the cutting edge of fisheries management. The *Chronicle of Higher Education*, the *Christian Science Monitor*, *The Economist*, the *Boston Globe*, *Governance* magazine, *Bioscience* and a number of local publications have featured articles on the lobster zones. In August of 2000 a group of private foundations met in Portland, ME, to form a collaborative project titled *The Civic Environmental Renewal Project* and to hear about what was happening in the lobster zones. Invitations to talk about the project were received from the AAAS, the National Academy of Sciences, the Beijing Institute of the Swedish Academy of Sciences, the International Institute for Fisheries Economics and several local colleges and institutes.
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—State Specific

Key Theme—Soil Quality

- a) A MAFES research project is refining current soil- and tissue-testing criteria for use in Maine potato cropping systems and investigating if organic soil amendments, crop rotation, and supplemental irrigation can be effective management tools for enhancing potato quality, productivity, and nutrient utilization in Maine. To do this, researchers are looking at the effects of crop rotation and soil amendment (compost and manure) on potato soils and crop productivity and studying crop rotation effects and the residual effects of compost and papermill sludge on potato soils and crop productivity.
- b) Impact—To date, the researchers have found that soil amendment programs with cull potato compost and beef manure increased yield by 1.8 t per ha when no irrigation was used. Plots that were annually amended with compost and manure since 1992 had significantly greater soil organic carbon levels, light fraction organic matter, water soluble carbohydrates, water stable aggregates, and gravimetric soil moisture. Superior potatoes grown in a two-year rotation with oats were significantly higher yielding when the soils were amended three years earlier with paper mill sludge and cull potato compost. A three-year rotation (potato-grain-green manure) resulted in significantly higher yields than continuous potatoes, but was statistically equal in yield to a two-year, potatoes-grain rotation. Legume green manure crops grown in two-year rotation with potatoes provided 44 to 66 kg/ha of fertilizer N replacement value when compared to a two-year, potato-grain rotation. These crops would prove beneficial in potato production systems with reduced availability of fertilizer N; however, they did not result in improved potato yields compared to crops fertilized with the optimum rate of N fertilizer. This is probably due to their minimal effects on soil physical properties. This project is focused on improving the management of potato crops in Maine and the United States. The information generated 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

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 10th 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.
- 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, and yields in the plots amended with manure were significantly higher than those in the non-amended plots.
- c) Source of Federal Funds—Hatch
- d) Scope of Impact—State Specific

Key Theme—Water Quality

- a) Over the past 20 years water quality in Maine has increased dramatically because of efficient detection and regulation of point sources of pollutants. Research concerning further enhancement of water quality in Maine is being directed toward assessing the effects and sources of non-point pollution. MAFES researchers are looking at effects of atmospheric nitrogen deposition and roadway runoff to determine the consequences of these two widespread forms of non-point pollution to stream communities in southern and eastern Maine, and to provide information required for effective monitoring and mitigation of their effects. The objective of this research is to quantify the effects of highway runoff and nitrogen deposition on two critical ecological processes of headwater streams in Maine—macroinvertebrate production and leaf-detritus processing. Preliminary results are available for the nitrogen deposition study being conducted at the Bear Brook Watershed in Maine (BBWM), which is a long-term experimental research program investigating the response of a forested ecosystem to elevated nitrogen (N) deposition.
- b) Impact—So far these field experiments indicate that the effect of N-deposition on both concentrations of stream water dissolved nitrogen and differences in leaf chemistry influences rates of leaf-detritus processing following its entry into stream food-webs.

However, the apparent strength of the effect of changes in leaf tissue attributes on processing rates is surprising. This finding is significant to both basic and applied aspects of stream ecology because it suggests that elevated N deposition causes fundamental changes in the food quality of autumn-shed leaf litter. Such changes will have consequences for the energy base of stream communities throughout the broad regions of the Northern Hemisphere that receive elevated N deposition. Together with roadway runoff, the atmospheric deposition of nitrogen may have important consequences for stream communities in Maine. Current understanding is not sufficient to provide guidance to local organizations required to maintain the quality of surface waters affected by these forms of non-point pollution.

c) Source of Federal Funds—Hatch

d) Scope of Impact—State Specific

Key Theme—Wildlife Management

a) Just like people, black terns like to build their homes by water. They also like open country with broad vistas. Unfortunately, there's a high price to pay for such prime real estate. Spring storms can raise water levels quickly and flush nests downstream. A lack of cover makes black tern chicks vulnerable to predators. These risks may help explain why New England's black tern population is so small. Only about 75 to 90 breeding pairs are known in Maine, and fewer exist in Vermont, New Hampshire, and Massachusetts. A MAFES project, funded in part by the Maine Department of Inland Fisheries and Wildlife, is attempting to determine why the birds are so rare and whether or not steps can be taken to increase their numbers. The objectives are (1) to determine the annual local survival of breeding adult and nestling Black Terns for the Maine population, site fidelity to individual wetlands, and recruitment rates for major colonies; (2) to conduct a population viability analysis to evaluate the extinction risk of the population in Maine; (3) to determine potential breeding habitat on a statewide basis; and (4) to determine the variation in variation in chick growth rates within broods and among colonies and relate these to food habitats and chick provisioning rates by adults as a basis for assessing habitat quality.

b) Impact—This year eight colonies were surveyed, with approximately 120 nests being monitored for hatching success and 40 broods for fledging success. Nest enclosures were used to measure chick growth, food habits, and provisioning rates for 12 broods. Foraging data also was collected at five colonies by observers in tower blinds. Researchers captured 79 adult terns in 2000 and have banded a total of 140 adult terns overall (approximately 60% of the current population). Initial recaptures or resightings of banded adults indicate high colony fidelity, but some movement between colonies for nesting or re-nesting. An initial population model has been developed and used for setting research priorities. This research will have important implications for water/dam management in large wetlands in Maine where this endangered species (State of Maine) occurs. This information also will form the basis for future conservation strategies for recovery of this species.

c) Source of Federal Funds—Hatch

d) Scope of Impact—State Specific

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 encourage and seek stakeholder input in FY 2000. First, the Maine Agricultural Center (MAC), in conjunction with the Maine Board of Agriculture, conducted a survey of all known agricultural groups in Maine. The list of agricultural groups surveyed was compiled through input from many people, including researchers and extension personnel, state department of agriculture personnel, and agricultural leaders and groups throughout the state. More than 50 groups were identified. Extension and research faculty also collected input and encouraged participation during their meetings with individuals and groups. MAC also worked closely with the Agricultural Council of Maine as it updated its strategic plan for agriculture in Maine. This plan addresses the important issues facing agriculture in Maine. Finally, advisory groups, including the Board of Agriculture, the Forest Resources Advisory Committee (FRAC), and the Cooperative Forest Research Unit (CFRU) advisory committee, each met several times during FY2000 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 method used to identify agricultural groups is described above. The mail survey instrument asked each group to identify its research and extension needs. Groups were also asked to indicate how current research/extension needs were being met and to offer suggestions to better serve their members. All groups were contacted at least three times to encourage them to respond to the survey. About 30 of the groups actually responded. The responses to the survey were analyzed and consolidated into general categories such as plant disease, IPM, etc. 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 presented to the Board of Agriculture. The Board devoted a full day to a discussion of the results and developed a list of high-priority items found in the survey. Based on those priorities, the Board of Agriculture identified five extension/research positions that needed to be filled or created. The experiment station and cooperative extension administration and other university administrators studied these recommendations. The university responded by providing four of the five positions and a promise to try to fill the fifth position in the near future. 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 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 POW. 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 regional projects and the integrated research/extension activities in which the Maine Agricultural and Forest Experiment Station participate. Multi-state research projects are considered first.

Multi-State Research Projects:

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

Multi-state regional projects are important part of the MAFES portfolio of research projects. In fact, regional projects contribute to thirteen 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, multi-state projects related to marketing/consumer demand, IPM, concerns of the growing horticultural industry of Maine, animal health/nutrition, human nutrition, and environmental issues all contribute to key areas 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 health supported by MAFES 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:

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

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 has supported a few integrated research/extension projects. All of the joint positions created and the projects supported 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 joint research/extension projects supported by MAC must have letters of support from stakeholder groups to be eligible for funding.

(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 a food science faculty member has allowed the University to better serve the cottage industry related to home-prepared food for sale. This group is considered to be an under-served population. Projects supported by MAC have also broadened the scope of groups served. For example, one project supports the equine 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?

As faculty with joint appointments develop their research projects and extension education programs, they describe the expected outcomes and impacts associated with their activities. The joint extension/research projects submitted to MAC must include a description of outcomes and impacts.

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

We believe that joint appointments are the most efficient way to insure that research and extension programs are integrated in a meaningful way. 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, such as those funded by MAC, that have co-principle investigators, (a researcher and an extension educator) is also an effective way to integrate research and extension activities.

MULTISTATE EXTENSION ACTIVITIES

Not Applicable

INTEGRATED RESEARCH AND EXTENSION ACTIVITIES

As noted in the MAFES Plan of Work, the Maine Agricultural Center was developed to improve the level of cooperation and coordination between the Maine Agricultural and Forest Experiment Station and the University of Maine Cooperative Extension (UMCE). One of the methods used to improve coordination is the establishment of more joint research/extension faculty positions at the University of Maine. Stakeholder groups have strongly recommended that joint appointments be developed between MAFES and UMCE. Considerable progress was made in FY2000 in creating joint appointment positions. Joint appointments were created for three current faculty who were either 100 percent research or extension before the change. Furthermore, two new positions were defined that represent joint research/extension appointments. These positions will be filled in FY2001.

Integrated activities have also increased through the Maine Agricultural Center grants program. Research and extension faculty are encouraged to submit proposals that include both extension and research components. These projects are given priority in the funding program. MAC is currently funding six projects that have both research and extension faculty contributing to the project.

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 2000 Hatch allocations, our target was about \$225,000. We are certifying a total of \$229,645 expended on integrated research and extension activities for FY 2000. Form CSREES-REPT (2/00) is attached.