## V(A). Planned Program (Summary)

**Program # 2**

**1. Name of the Planned Program**

Climate Change

☑ Reporting on this Program

**V(B). Program Knowledge Area(s)**

1. Program Knowledge Areas and Percentage

| KA Code | Knowledge Area | %1862 Extension | %1890 Extension | %1862 Research | %1890 Research |
|---|---|---|---|---|---|
| 101 | Appraisal of Soil Resources | | | 4% | |
| 102 | Soil, Plant, Water, Nutrient Relationships | | | 9% | |
| 112 | Watershed Protection and Management | | | 11% | |
| 123 | Management and Sustainability of Forest Resources | | | 18% | |
| 133 | Pollution Prevention and Mitigation | | | 4% | |
| 135 | Aquatic and Terrestrial Wildlife | | | 7% | |
| 136 | Conservation of Biological Diversity | | | 7% | |
| 203 | Plant Biological Efficiency and Abiotic Stresses Affecting Plants | | | 14% | |
| 204 | Plant Product Quality and Utility (Preharvest) | | | 3% | |
| 211 | Insects, Mites, and Other Arthropods Affecting Plants | | | 3% | |
| 212 | Pathogens and Nematodes Affecting Plants | | | 3% | |
| 213 | Weeds Affecting Plants | | | 3% | |
| 605 | Natural Resource and Environmental Economics | | | 14% | |
| | **Total** | | | 100% | |

## V(C). Planned Program (Inputs)

**1. Actual amount of FTE/SYs expended this Program**

| Year: 2012 | Extension | | Research | |
|---|---|---|---|---|
| | 1862 | 1890 | 1862 | 1890 |
| Plan | 0.0 | 0.0 | 1.4 | 0.0 |
| Actual Paid Professional | 0.0 | 0.0 | 3.9 | 0.0 |
| Actual Volunteer | 0.0 | 0.0 | 0.0 | 0.0 |

**2. Actual dollars expended in this Program (includes Carryover Funds from previous years)**

| Extension | | Research | |
|---|---|---|---|
| **Smith-Lever 3b & 3c** | **1890 Extension** | **Hatch** | **Evans-Allen** |
| 0 | 0 | 222745 | 0 |
| **1862 Matching** | **1890 Matching** | **1862 Matching** | **1890 Matching** |
| 0 | 0 | 293309 | 0 |
| **1862 All Other** | **1890 All Other** | **1862 All Other** | **1890 All Other** |
| 0 | 0 | 318573 | 0 |

## V(D). Planned Program (Activity)

### 1. Brief description of the Activity

Conduct scientific research. Publish peer-reviewed journal articles and other publications. Present findings at professional and public meetings and at other venues. Educate undergraduate and graduate students.

### 2. Brief description of the target audience

Maine natural-resource-based industries, Cooperative Extension staff, other scientists, local, state, and federal policymakers, regulators, and legislators, land-conservation organizations, K-12 teachers, interested members of general public who are concerned about possible effects of climate change.

### 3. How was eXtension used?

eXtension was not used in this program

## V(E). Planned Program (Outputs)

### 1. Standard output measures

| 2012 | Direct Contacts Adults | Indirect Contacts Adults | Direct Contacts Youth | Indirect Contacts Youth |
|---|---|---|---|---|
| **Actual** | 0 | 0 | 0 | 0 |

### 2. Number of Patent Applications Submitted (Standard Research Output)

**Patent Applications Submitted**

Year: 2012

Actual: 0

**Patents listed**

**3. Publications (Standard General Output Measure)**

**Number of Peer Reviewed Publications**

| 2012 | Extension | Research | Total |
|---|---|---|---|
| Actual | 0 | 8 | 0 |

**V(F). State Defined Outputs**

**Output Target**

**Output #1**

**Output Measure**

- Number of other publications

| Year | Actual |
|---|---|
| 2012 | 4 |

**Output #2**

**Output Measure**

- Number of research projects completed

| Year | Actual |
|---|---|
| 2012 | 0 |

**Output #3**

**Output Measure**

- Number of professional or public presentations of research findings.

| Year | Actual |
|---|---|
| 2012 | 15 |

**Output #4**

**Output Measure**

- Number of annual population surveys of Floods Pond Arctic charr and obtained new samples for assessing Arctic charr diversity in Maine

| Year | Actual |
|---|---|
| 2012 | 1 |

**Output #5**

**Output Measure**

- Conducted sturgeon mark-recapture and telemetry study in Penobscot River and other rivers on Maine coast.

| Year | Actual |
|---|---|
| 2012 | 0 |

**Output #6**

**Output Measure**

- Co-hosted international conference BIOGEOMON 2012, involving more than 200 scientists from 20 countries.

| Year | Actual |
|---|---|
| 2012 | 0 |

**Output #7**

**Output Measure**

- Several local library seminar series on changes in Maine forests. Attendance at the first three events ranged from 30 to more than 120.

| Year | Actual |
|---|---|
| 2012 | 0 |

**Output #8**

**Output Measure**

- Amount researchers in this program area received in extramural grants and contracts: $536,379

| Year | Actual |
|---|---|
| 2012 | 0 |

## V(G). State Defined Outcomes

### V. State Defined Outcomes Table of Content

| O. No. | OUTCOME NAME |
|---|---|
| 1 | improvements in federal, state, local and private institutional decision-making with respect to managing public and private lands by reducing risks associated with natural hazards such as fire, invasive species, weather-related natural events, and climate change |
| 2 | Use of new rootstocks that are better suited to Maine's climate for commercial apple production in Maine |
| 3 | Increased profitability for Maine apple growers based on their use of better-adapted rootstocks |
| 4 | Better understanding of the effects of climate change on Maine agriculture |
| 5 | Better understanding of the effects of climate change on Maine salmon |
| 6 | Number of biogeochemical indicators or metrics that have been mapped in Maine watersheds |
| 7 | Development of new knowledge on the response of forest soils to environmental alterations |
| 8 | Development of new knowledge and the transfer of this knowledge to clientele to address the effects of climate variability and change--Improve understanding of how perch traits rapidly respond to changing lake conditions and how perch trait variation in turn influences aquatic ecosystem conditions |
| 9 | Develop new knowledge on shortnose sturgeon wintering habitats |

## Outcome #1

### 1. Outcome Measures

improvements in federal, state, local and private institutional decision-making with respect to managing public and private lands by reducing risks associated with natural hazards such as fire, invasive species, weather-related natural events, and climate change

### 2. Associated Institution Types

- 1862 Research

### 3a. Outcome Type:

Change in Condition Outcome Measure

### 3b. Quantitative Outcome

| Year | Actual |
|---|---|
| 2012 | 0 |

### 3c. Qualitative Outcome or Impact Statement

**Issue (Who cares and Why)**
Natural resource agencies and institutions at the federal, state, and local levels, as well as private landowners, attempt to balance economic growth and environmental quality. Emphasis on environmental quality is evident in provisions of the most recent Farm Bills; in agricultural land preservation programs at the local, state and federal levels; and in legislative mandates to federal agencies to justify their decisions regarding how natural resources are to be managed, including protecting environmental quality, providing wildlife habitat, and providing access for recreation. Federal, state, local, and private institutions face considerable challenges when making natural resource management decisions. Many of these decisions necessitate consideration of tradeoffs between economic growth and environmental quality. Furthermore, although private actions of households mediate the impacts of natural hazards, few households fully understand the risks they face and how their actions influence these risks and those faced by other members of the public. Moreover, institutional decision-makers charged with managing these risks do not fully understand how households make decisions.

**What has been done**
As part of a multistate project University of Maine economists collaborated with scientists in other states in a series of studies of voting behavior with regard to land protection programs, impacts of public lands on property values, urban-rural land use dynamics, and land use policies. The scientists also conducted applied economics research of invasive forest pest management issues in Maine, North Carolina, and Tennessee, which revealed complex management tradeoffs across private and public landscapes and public forest land management objectives. By conducting research on household decision-making in response to arsenic contamination of drinking water, invasive forest pests, and changes in surface water quality, this project improved knowledge of household behavior and disclosed opportunities for improved risk communication and targeted outreach and marketing to public agencies, communities, and private businesses.

**Results**
The results of this research offer guidance to promote changes in action by supporting the development of improved risk communication, prevention, and education programs. For example, Maine-based research on arsenic was shared with staff from Maine CDC and continued collaborations with these staff demonstrate the value of these findings. Research on management options for controlling invasive forest pests on public lands and public land management programs improved knowledge about key aspects of public preferences and emphasized the significance of spatial patterns in the benefits and costs of providing such services. These advances in knowledge can help citizens, policy-makers, and private businesses make informed decisions about land use and land management. Improved knowledge of connections between urban and rural places and the impacts of ecosystem services on these connections will help stakeholders also make more informed regional economic development and natural resource management decisions. For example, Maine-based research in this area was communicated to state and local land use planners through targeted workshops and stakeholder engagement processes, has supported policy efforts intended to revise wetland and land use regulations, and, in combination with results from other related projects, was featured in a public television program.

**4. Associated Knowledge Areas**

| KA Code | Knowledge Area |
|---|---|
| 605 | Natural Resource and Environmental Economics |

**Outcome #2**

**1. Outcome Measures**

Use of new rootstocks that are better suited to Maine's climate for commercial apple production in Maine

Not Reporting on this Outcome Measure

**Outcome #3**

**1. Outcome Measures**

Increased profitability for Maine apple growers based on their use of better-adapted rootstocks

Not Reporting on this Outcome Measure

**Outcome #4**

**1. Outcome Measures**

Better understanding of the effects of climate change on Maine agriculture

Not Reporting on this Outcome Measure

**Outcome #5**

1. **Outcome Measures**

Better understanding of the effects of climate change on Maine salmon

Not Reporting on this Outcome Measure

**Outcome #6**

1. **Outcome Measures**

Number of biogeochemical indicators or metrics that have been mapped in Maine watersheds

2. **Associated Institution Types**

- 1862 Research

**3a. Outcome Type:**

Change in Knowledge Outcome Measure

**3b. Quantitative Outcome**

| Year | Actual |
|---|---|
| 2012 | 0 |

**3c. Qualitative Outcome or Impact Statement**

**Issue (Who cares and Why)**
River and stream ecosystems play a critical role in the Maine landscape as valuable habitats and fluvial connectors, linking upland watersheds with downstream aquatic and estuarine ecosystems through fluxes of water, matter, and energy. Increasingly, rivers and other aquatic ecosystems are facing pressures and threats associated with human population growth, climate changes, land development, invasive exotic species, and non-point pollution. Given these environmental uncertainties, there is a need for research aimed at sustaining and managing the ecological health of these ecosystems.

**What has been done**
University of Maine scientists examined watershed exports of carbon, nitrogen, phosphorus, major solutes, and suspended sediments during five water years in the Penobscot River basin, which forms part of the Gulf of Maine watershed.

**Results**
Mean annual exports of dissolved organic carbon (DOC) in the Penobscot River were 58 kg C ha(-1) year(-1), whereas cumulative yearly watershed flux of DOC during the study period ranged from 8.6 to 16.1 × 10(10) g C year(-1) and averaged 11.7 × 10(10) g C year(-1). Watershed

exports of total soluble N (TN) and total soluble P in the Penobscot River averaged 1.9 and 0.02 kg ha(-1) year(-1), respectively. Extrapolation of results from this investigation and a previous study indicates that estuaries and coastal waters in the Gulf of Maine receive at least 1.0 × 10(10) g N year(-1) and 2.5 × 10(11) g C year(-1) in combined runoff from the four largest Maine river basins. Soluble exports of Ca + Mg + Na minus wet deposition inputs of cations in the Penobscot system were approximately 1,840 mol(c) ha(-1) year(-1), which represents a minimum estimate of cation denudation from the watershed. Based on its low N and P export rates, the Penobscot River watershed represents an example of reference conditions for use as a benchmark in ecological assessments of river water quality restoration or impairment. In addition, the biogeochemical metrics from this study provide an historical baseline for analysis of future trends in nutrient exports from the Penobscot watershed as a function of changing climatic and land use patterns. This research, in collaboration with an NSF-supported investigation of alternative landscape futures, is also providing a valuable interdisciplinary training opportunity for three doctoral students.

**4. Associated Knowledge Areas**

| KA Code | Knowledge Area |
|---|---|
| 112 | Watershed Protection and Management |
| 133 | Pollution Prevention and Mitigation |

**Outcome #7**

**1. Outcome Measures**

Development of new knowledge on the response of forest soils to environmental alterations

**2. Associated Institution Types**

- 1862 Research

**3a. Outcome Type:**

Change in Knowledge Outcome Measure

**3b. Quantitative Outcome**

| Year | Actual |
|---|---|
| 2012 | 0 |

**3c. Qualitative Outcome or Impact Statement**

**Issue (Who cares and Why)**
Studies of the way nutrients, carbon, water, and energy flows through forested ecosystems will enable us to better understand the underlying mechanisms that control the form and function of these ecosystems. This understanding is essential for us to be able to determine the effects of environmental perturbations at the global (e.g., climate change), continental (e.g., acid deposition, regional (e.g., biomass harvesting), and local (e.g., biosolids land spreading) scales. The

ecosystem process research helps us to design better environmental monitoring systems, along with better predictive models to allow us to determine the future effects of the present and emerging environmental stressors.

**What has been done**
University of Maine scientists are focusing on a long-term whole forested watershed study that provides insights unique to understanding the long-term response of forests and streams to a changing chemical and physical climate. In the past year, the long-term record of measurements has continued. Recent studies have shown that base cation depletion continues on both watersheds due to the treatment (on the treated watershed) as well as due to continuing declines in atmospheric deposition of sulfur and nitrogen as a result of the 1990 Clean Air Act Amendments. This past year has seen findings on the use of soil extracellular enzymes in determine nutrient limitations, particularly for phosphorus. We have completed a series of studies on in-stream nutrient stoichiometry, particularly for carbon, nitrogen, and phosphorus interactions.

**Results**
Results show clear and important contributions from in-stream processes for whole watershed nutrient export, and particularly for the importance of phosphorus in nitrogen dynamics. The scientists have also begun a major nitrogen study at the watersheds focusing on nitrogen dynamics after 23 years of whole watershed nitrogen enrichment. This includes the use of stable isotopes of nitrogen with this past year focusing on insights from delta15N natural abundances.

**4. Associated Knowledge Areas**

| KA Code | Knowledge Area |
|---|---|
| 101 | Appraisal of Soil Resources |
| 112 | Watershed Protection and Management |
| 123 | Management and Sustainability of Forest Resources |

**Outcome #8**

**1. Outcome Measures**

Development of new knowledge and the transfer of this knowledge to clientele to address the effects of climate variability and change--Improve understanding of how perch traits rapidly respond to changing lake conditions and how perch trait variation in turn influences aquatic ecosystem conditions

**2. Associated Institution Types**

- 1862 Research

**3a. Outcome Type:**

Change in Knowledge Outcome Measure

**3b. Quantitative Outcome**

| Year | Actual |
|---|---|

| | |
|---|---|
| 2012 | 0 |

### 3c. Qualitative Outcome or Impact Statement

**Issue (Who cares and Why)**
Humans are currently the world's most potent evolutionary agent, drastically reshaping the face of biodiversity in the wake of various forms of disturbance. Indeed, many of our current approaches to the management and conservation of natural resources can alter such genetic diversity for the better or worse. Although the preservation of locally adapted diversity is commonly cited as a central tenet of conservation biology and natural resource management, several factors still limit our ability to implement evolutionarily-informed monitoring and management practices: (1) population resources (genetic and phenotypic) are often poorly characterized, (2) a lack of quantitative insights into the role of evolutionary diversity in the fate of populations and function of ecosystems, and (3) a lack of guidance to managers and the public with respect to why or how genetic diversity and ongoing evolution should be incorporated in resource management.

**What has been done**
University of Maine scientists are conducting empirical research to assess potential reciprocal interactions between evolutionary diversity, ongoing evolutionary processes mediated by humans, and emergent ecological effects on aquatic populations, communities and ecosystems. They are also beginning to develop a synthetic eco-evolutionary framework to problems in ecology and conservation biology, by employing appropriate theory and model systems. Further efforts involve providing resource managers and the public with scientifically based insights into the evolutionary resources that exist in Maine's aquatic ecosystems and the potential consequences of various resource management decisions.

**Results**
Ongoing research on the white perch study system continues to reveal ways in which perch traits rapidly respond to changing lake conditions and that perch trait variation in turn influences aquatic ecosystem conditions. The scientists have expanded their trait considerations to fish stoichiometry (body elemental content) and excretion. Their analyses show that the body and excretion content of white perch varies with lake nutrient state. Subsequent simulation models show that such effects have the potential to influence overall excretion dynamics of fish populations and thus nutrient cycling in lakes. In combination these findings suggest that cultural eutrophication by humans could potentiate the emergence of important eco-evolutionary interactions.

### 4. Associated Knowledge Areas

| KA Code | Knowledge Area |
|---|---|
| 135 | Aquatic and Terrestrial Wildlife |
| 136 | Conservation of Biological Diversity |

**Outcome #9**

**1. Outcome Measures**

Develop new knowledge on shortnose sturgeon wintering habitats

**2. Associated Institution Types**

- 1862 Research

**3a. Outcome Type:**

Change in Knowledge Outcome Measure

**3b. Quantitative Outcome**

| Year | Actual |
|---|---|
| 2012 | 0 |

**3c. Qualitative Outcome or Impact Statement**

**Issue (Who cares and Why)**
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**Results**
Looking at shortnose sturgeon in the Penobscot River, the scientists have discovered that their wintering habitats are likely culturally inherited and that the overwintering site in the Penobscot has moved upstream by several kilometers in recent years. The scientists have also developed a new approach to estimating local sturgeon abundance using sonic-lens-imaging systems. These

new findings that shortnose sturgeon have shifted their wintering habitat will result in new attention and protection for the critical habitat that now represents the wintering site.

**4. Associated Knowledge Areas**

| KA Code | Knowledge Area |
|---|---|
| 135 | Aquatic and Terrestrial Wildlife |
| 136 | Conservation of Biological Diversity |

**V(H). Planned Program (External Factors)**

**External factors which affected outcomes**

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges

**Brief Explanation**

Some projects terminated early or PIs changed focus of their research, which affected our ability to report on all previously submitted state-defined outcomes.

**V(I). Planned Program (Evaluation Studies)**

**Evaluation Results**

Evaluations are currently conducted at the project and program levels. At the project level, all projects are reviewed by an internal research council and external peer reviewers when initiated and again at completion by the research council. During the research council final evaluation, the focus is on determining if terminating projects met their stated objectives, secured extramural funding, and produced peer-reviewed publications. For FY12, 11 projects went through the review process in this program area. As for other measures of successful research programs, faculty in this program area published 42 peer-reviewed articles and secured more than $2,700,000 in extramural funding. Also during this time period, research results published by faculty in this program area were cited by peers more than 900 times in other peer-reviewed journals.

Researchers use a variety of methods to evaluate their own research projects including evaluations retrospectively, before-after, and during the life of the project; case studies; and comparisons between treatment/intervention and nontreatment/nonintervention.

At the program level, external NIFA review teams are asked to review the research programs of schools/departments. These teams provide input on the impact and productivity of research programs supported through the station. The station is working to develop a standard program-level evaluation process, which will be used to evaluate each

station program area. Our current plans include an approach based on use of expert panels as recommended by the federal Government Accounting Office with individual program evaluations occurring every four to five years on a staggered time table.

**Key Items of Evaluation**

Although this program area has only 3.9 SYs, research articles written by these faculty have been cited more than 900 times in other peer-reviewed journals this year.