United States Department of Agriculture
Cooperative State Research, Education, and Extension Service, Office of the Administrator

Self-Review for 2005 Portfolio Review Expert Panel

Portfolio 5.2, Natural Resources: Soil, Air, and Water

Supporting CSREES Objective 5.2: Provide science-based knowledge and education to improve the management of soil, air, and water to support production and enhance the environment

CSREES Goal 5: Protect and Enhance the Nation's Natural Resource Base and Environment

EXECUTIVE SUMMARY

In response to a directive from the Office of Management and Budget (OMB), the Cooperative State Research, Education, and Extension Service (CSREES)-USDA has prepared a set of self-review documents on portfolios of Research, Education, and Extension programs that support its strategic goals. The purpose of these self-reviews is to provide a concise yet comprehensive insight into activities so that the Panel may assess whether CSREES is fulfilling OMB's requirement for Relevance, Quality, and Performance.

This is one of two reports addressing Goal 5 (Protect and Enhance the Nation's Natural Resource Base and the Environment) and was prepared by National Program Leaders of the Natural Resources and Environment (NRE) unit, which is primarily responsible for work under this portfolio. This report specifically focuses on work supporting CSREES Strategic Objective 5.2 (Management of Soil, Air, and Water). The self-review paper on Portfolio 5.1 (Protect the Nation's Forests and Rangelands) has also been prepared by CSREES and will be reviewed by another Panel.

Portfolio 5.2 is composed of 13 related topical Problem Areas (PAs) that integrate research, education, and extension activities, depending on funding line and authority. The portfolio and its related PAs demonstrate the complementary nature of research, education, and extension that is integrated to solve national problems and to ensure that public investment is effective and efficient. This portfolio report provides detailed descriptions of PA activities. Some of the PAs are subject-linked and discussed as one topic area, while others are addressed individually. For example, PAs 101 – 104 focus on soils and are grouped for discussion purposes as Soil Resources. Similarly, PAs 111 – 112 focus on water and are grouped for discussion purposes as Water Resources. The PAs covered by this report are:

- PA 101 Appraisal of soil resources;
- PA 102 Soil, plant, water, nutrient Relationships;
- PA 103 Management of saline and sodic soils and salinity;
- PA 104 Protect soil from harmful effects of natural elements;
- PA 111 Conservation and efficient use of water;
- PA 112 Watershed protection and management;
- PA 131 Alternate uses of land;
- PA 132 Weather and climate;
- PA 133 Pollution prevention and mitigation;
- PA 141 Air conservation and management;
- PA 403 Waste disposal, recycling and reuse;
- PA 405 Drainage and irrigation systems and facilities; and
- PA 605 Natural resource and environment economics.

The conclusion of this self-review is that CSREES efforts under Portfolio 5.2 are relevant, of high quality, and high performance in addressing the national problems, needs, and concerns identified. The resounding theme of all descriptions of the work on Problem Areas in Portfolio 5.2 is that CSREES is engaged, through a unique partnership with agencies, states, institutions and the private sector, in solving soil, air, and water resource problems relating to agriculture, forest, and rangeland activities, while ensuring sustainability of the nation's food and fiber production system. Broadly, land use practices and management decisions determine productivity of agriculture, forest and rangelands that in-turn directly impact the health and well-being of society. For example, soil is a complex and dynamic natural resource on the earth's surface that supports plant growth, affects water and air quality, and helps to clean up natural and man-made wastes. This shows the inter-relatedness among all three natural resources (soil, air, and water) that are the foci of Objective 5.2. Agriculture, forest, and rangeland activities result in production of wastes and residuals that can be applied to the land to improve soil health and quality but if not properly managed based on scientific basis, will result in fouling of the environment. Weather, climate, and environmental degradation have regional and global impacts on agriculture and forestry production and services, hence affecting the health and well-being of society and illustrating the circular nature of these issues.

In general, high quality projects in this portfolio must use science-based knowledge to develop cost-effective technologies, techniques, practices, and strategies that can be adopted and implemented by end-users to ensure high productivity while protecting and preserving environmental quality. End-users can include producers, regulatory agencies, and policy developers in the public and private arenas.

Table of Contents

Section II – Portfolio Overview

Soil, Air, and Water Portfolio

Supporting CSREES Objective 5.2: *Provide science-based knowledge and education to improve the management of soil, air and water to support production and enhance the environment*.

Introduction
Natural resources are a critical issue deserving attention across the nation. In reviewing NRE's effort as a group in this area, it is good to understand what the group's general, but informal, vision and mission are for all their efforts:

Vision
Abundant clean, safe and secure soil, air, and water resources, while supporting production for the U.S.

Mission
To promote and support integrated research, education, and extension programs that improves the management of soil, air and water to support production and protect the environment.

The Soil, Air, and Water Portfolio, although residing primarily within the NRE unit, encompass agency-wide activities, because soil, air, and water are the fundamental natural resources necessary to support agricultural productivity and thriving rural and agricultural communities. It is for this reason that NRE initiated and implemented the *enr* team as discussed above.

The Soil, Air, and Water portfolio has been defined as those research, extension, and education programs aligned with 14 (including one pending) PAs to enhance environmental quality through better understanding of processes that affect the quality of our soil air, and water resources. This portfolio was prepared using the larger *enr* team approach to plan, develop, and implement natural resource and environment related programs.

This integrated systems approach takes into account that the ability to sustain production, while growing our economy, requires more efficient production practices, better management of the resource base and finding uses and markets for raw materials. The Soil, Air and Water portfolio encourages interdisciplinary approaches to address the issues. Many of the activities are integrated in nature, encompassing research, education, and extension components. This portfolio focuses on activities relating to three natural resources, soil, air, and water – how they are affected by human activities, and the socioeconomic implications of human activities on these resources.

Frame of Reference for this Portfolio Review

This portfolio review measures the potential value of investments made in 13 Problem Areas in the area of Natural Resources and Environment during 1999-2003. As explained in Section I, the concept of Problem Areas, based on Research Problem Areas in CRIS, was recently introduced into all agency operations, including education and extension, as well as research. Another of the difficulties in providing documentation for this review is that nomenclature for goals and objectives has evolved significantly within USDA and CSREES since the beginning of 1999 (see the crosswalk chart in Section I for two Strategic Plans). In principle, the USDA CSREES goals and objectives in the two plans have different names but similar focuses. In the Strategic Plan for 1997–2002, Goal 4, Greater harmony between agriculture and the environment (with associated objectives), now Goal 5, Protect and Enhance the Nation's Natural Resource Base and Environment in the current Strategic Plan, also is less defined and so it encompasses a number of elements that are covered under other portfolio reviews, such as that on Objective 5.1, the forestry objective. These shifts and evolutions that have taken place in operational directions and categorization from 1999 until now provide a challenge in providing meaningful tracking of efforts. Nevertheless, a sincere effort is made below.

The Problem Areas covered in this portfolio include:

- 101 Appraisal of soil resources
- 102 Soil, plant, water, nutrient relationships
- 103 Management of saline and sodic soils and salinity
- 104 Protect soil from harmful effects of natural elements
- 111 Conservation and efficient use of water
- 112 Watershed protection and management
- 131 Alternate uses of land
- 132 Weather and climate
- 133 Pollution prevention and mitigation
- 141 Air resource conservation and management
- 403 Waste disposal, recycling and reuse
- 405 Drainage and irrigation systems and facilities
- 605 Natural resource and environmental economics

Each PA discussion is composed of research, education, and extension activities across various units and funding lines within CSREES. A specific program, often conducted by a single program unit or even a single National Program Leader (NPL), may address several PAs and several objectives of the CSREES Strategic Plan (see http://www.csrees.usda.gov/about/offices/pdfs/strat_plan_04_09.pdf). Write-ups on these areas are compressed and do not cover each of the specific activities within a portfolio. Additional information can be found in the Evidentiary Material that will be available at the portfolio review. The CSREES website (http://www.csrees.usda.gov) also contains information on this portfolio's programs.

In order to obtain performance criteria data relevant to Objective 5.2 for the 1999-2003 period, we have drawn upon material available for the previous strategic plan. The objectives, strategies, and performance measures of the 1997-2003 CSREES Strategic Plan are listed below and will serve as the basis to provide data for this portfolio review.

Objective 4.1: to develop, transfer and promote the adoption of efficient and sustainable agricultural, forestry, and other resource conservation policies, programs, technologies, and practices that ensure ecosystems integrity and biodiversity.

Strategies to achieve the objective

- Develop techniques and methods to conserve and enhance the quality of air, soil, and water resources.
- Increase understanding of ecosystem management to conserve and enhance biodiversity.

Performance measures

- Annually increase the research and knowledge base available from CSREES partners and cooperators on environmental sciences and agriculture, including conserving, maintaining, and protection ecosystem integrity and biodiversity.
- Annually ensure ecosystem's integrity and biodiversity.
- Annually increase agricultural producer awareness, understanding, and information regarding the adoption of agricultural production practices that sustain and/or protect ecosystem integrity and biodiversity in which CREES partners and cooperators play an active research, education and extension role.
- Strengthen the capacity of higher education institutions to develop future scientists, professionals, and leaders in environmental sciences and related disciplines who will more effectively contribute to the development of agricultural production practices that sustain and/or protect ecosystems and bring into greater balance agricultural production activities and biodiversity needs of the surrounding ecosystem.
- Meet the annual demand in the market for individuals formally educated and trained as scientists, professionals, and leaders in environmental sciences and related disciplines.

Objective 4.2: to develop, transfer, and promote adoption of efficient and sustainable agricultural, forestry, and other resource policies, programs, technologies, and practices that protect, sustain, and enhance water, soil and air resources.

Strategies to achieve the objective

- Recover and use waste resources through improved agricultural and forestry production systems.
- Develop and disseminate resource policies that value environmental and productivity needs.

Performance measures

- Annually increase producer adoption of agricultural production practices that conserve and/or protect surface and groundwater supplies on or adjacent to agricultural production sites or land uses.
- Annually increase producer adoption of agricultural production "best practices" that conserve, protect, and/or enhance the soil resources on or adjacent to agricultural production sites or land uses.

Objective 4.3: to improve decision making on public policies related to agriculture and the environment.

Strategies to achieve the objective

- Develop resource management decision systems.

Performance measures

- Annually increase the research and knowledge base available form CSREES partners and cooperators on public policy issues affecting agricultural production, the environment, and ecosystems integrity and biodiversity.
- Annually increase the effectiveness of constituent and citizen participation on public policy issues affecting agricultural production the environment, and ecosystem integrity and biodiversity.

USDA and CSREES GOAL 5 – Protect and Enhance the Nation's Natural Resource Base and Environment

Introduction

One of the five goals that USDA has set and that CSREES supports through its unique mission to provide knowledge is the goal of protecting and enhancing the nation's natural resource base and environment. This Section of the self-review begins with an overview summarizing the important issues involved in natural resources and the environment in the U.S. It is followed by brief discussions on natural resources from the USDA, CSREES, and finally from the Water, Soil, and Air portfolio perspectives as framed by current Objective 5.2: *Provide science-based knowledge and education to improve the management of soil, air and water to support production and enhance the environment*. The latter discussion briefly describes overall plans, projects and outcomes for work during the 1999-2003 period. This section also addresses general issues with research, education, and extension work for this portfolio. Finally, this section leads into more comprehensive treatments of the 14 Problem Areas that are included in the agency's' efforts under Objective 5.2.

An Overview of Natural Resources and the Environment for the U.S.

We all need clean air, clean and sufficient water, healthy forests and rangelands and appropriate land use that provides living space, food, fiber, and forage production areas, and wilderness areas. As a nation, we have long benefited from an abundance of natural resources. The relationships between natural resources, environmental sustainability, and human well-being have often been taken for granted.

Today, we recognize that pressures on natural resources and land use are increasing, competing, and more frequently, conflicting. Demographic changes and changing social values bring new challenges. Ecosystems have become increasingly fragmented for production of food and forest products. Urbanization and fragmentation have major impacts on ecosystem structure and function. Public demand for natural resources products and services – timber, recreation, fish and wildlife, soil and water, open space, and the beauty of the land – continues to grow.

The relationship between agriculture and natural resources is changing. Farming is no longer the largest element in the economic base of most rural communities. Natural resource values and income opportunities are becoming more important to farmers, ranchers, other landowners, and communities.

The future sustainability of our natural resources will increasingly depend on the use and management decisions made by individual private landowners, who collectively control more than two-thirds of the nation's land and water resources, as well as public land managers.

Communities need to make land-use decisions based on the best scientific knowledge available – the knowledge that enables them to identify and manage their environmental resources, understand ecosystem processes, and recognize the long-term impact of economic tradeoffs that may erode the quality and quantity of existing resources.

More than ever, people need to understand the issues, the implications, and their options. Research on the use and management of natural resources and extension programs focused on decision-making and consensus-building are critical investments we can make for our future. Agency-sponsored formal education will also help to ensure that a new generation of scientists, educators, and extension personnel will be available to help future generations of Americans with their resource needs.

USDA Natural Resources and the Environment

CSREES programs are based on a dynamic and vibrant relationship with our university and private sector partners. The Soil, Air and Water portfolio demonstrates the linkages, interdependence and connectedness between the federal and state components of a broad-based, national, agricultural research, education and extension system. The agency's mission is carried out through this dynamic partnership. This partner-based system is critical to ensuring performance, relevance and quality of the programs administered and led by the agency to protect and enhance the nation's natural resource base and environment. Program Leadership serves as both the catalyst and focal point for national research, education and extension programs in the natural resources and environment arena that are conducted by our partners.

The Natural Resources and Environment (NRE) team supports strong linkages with the USDA's ARS, the Natural Resource and Conservation Service (NRCS), and Forest Service (FS), and the Environmental Protection Agency (EPA). Strong collaboration, linkage and integration of programs in research, education, and extension amongst our agencies ensure the well-being of not only the American public, but also the larger global community. This partnership works because the ARS in-house research is complementary to CSREES' work; university partners are heavily involved in education and extension activities; FS provides forest-specific efforts, and NRCS provides technical assistance. EPA's role in regulation helps to protect the natural resource base and environment at the local, regional, and national levels. These cooperators extend the knowledge beyond CSREES.

The Evidentiary Materials contain information on Cross-Cutting Programs from the USDA FY 2004 Annual Performance Plan and Revised Plan for FY 2003. This appendix identifies programs or activities that USDA agencies are undertaking with other organizations to achieve a common purpose or objective.

CSREES Natural Resources and the Environment

NRE is a broad emphasis area with major impact on the quality of our world. National leadership integrates research, education, and extension expertise to address contemporary environmental and natural resource problems with science-based approaches that are economically sound, socially acceptable, and environmentally advantageous. NRE programs strengthen the Nation's capacity to address critical environmental priorities and contribute to improved soil, air and water quality. These programs have a positive impact on fish and wildlife management; enhanced aquatic and other ecosystems; the sustainable use and management of forests, rangelands, watersheds, and other renewable natural resources; and a better understanding of global climate change, including its impact on the diversity of plant and animal life. NRE programs also demonstrate the benefits and opportunities of sustainable development, and contribute to the economic viability of agriculture and rural communities realizing the

impact of environmental policies and regulations. Natural resource sustainability depends on the use and management decisions of individual private landowners, who collectively control more than two-thirds of the nation's land and water resources, as well as public land managers. With agriculture no longer the largest element in the economic base of most rural communities, natural resource wealth and income opportunities are becoming more important to farmers, ranchers, other landowners, and communities.

Research to discover new, improved ways to use and manage natural resources and educational programs that teach best management practices will enhance environmental and economic benefits, as well as human well-being. These CSREES activities are critical investments for our future.

Natural Resource and Environment provides leadership to partners, primarily land grant universities, in pursuit of two objectives under Strategic Goal 4 on which the community depends for sustainability and well-being.

Objective 5.1. Provide science-based knowledge and education to improve the management of forest and rangelands *(discussed in a separate portfolio review).*

Objective 5.2. Provide science-based knowledge and education to improve the management of soil, air, and water to support and enhance the environment

The agency supports integrated education, research, and extension programs to fully understand the complex environmental interrelationships affecting agriculture, forest, and range production practices; improve scientific understanding of soil, air, and water to better manage production; and minimize adverse environmental impacts.

CSREES and its partners collaborate with industry and other interested parties to develop and disseminate knowledge and methods to provide and evaluate ecosystem management strategies that generate long-term benefits, including the mitigation of global change through buffering from public and private lands

Stakeholder Input and Feedback to Ensure Relevance

The Soil, Air, and Water Management portfolio addresses critical issues, needs and priorities related to these critical natural resources on the local, regional, and national levels. Extension and education programs are driven by knowledge and information from scientific research. Just as research programs are required to demonstrate relevance, quality, and performance standards, this is also a requirement for extension and education programs. The Natural Resources and Environment Administrator and National Program Leaders (NPLs) have close working relationships and links to various stakeholder partners including research, education, and extension scientists and educators at the universities and colleges, other federal agencies, county agents, advocacy organizations, professional societies, advisory groups, and Congress. NRE Unit leaders also serve in advisory capacities, for example, to various departments at the universities and colleges. It is through these interactions, whether directly or indirectly, that CSREES obtains feedback which is instructive in identifying needs and establishing priorities that are relevant to the mission and to the portfolio.

The agency uses formal and informal processes to gather stakeholder input including, but not limited to, stakeholder listening sessions, workshops, symposia, peer panel recommendations, RFA solicitations, white papers, and Legislative Mandates. NRE was instrumental in developing the *enr* (Environment and Natural Resources) team, which is an agency-wide effort of NPLs, from a number of units within CSREES, whose expertise encompasses the NRE disciplines. Between NRE and *enr* leaders, stakeholder feedback is amplified, ensuring relevancy of programs that address critical needs at the local, regional, and national levels.

The State Plans of Work (POW) covering research and extension programs receiving funding from require documented input from stakeholders. The POW and associated annual progress reports provide a continuous dialogue and interaction with stakeholders nation-wide to ensure that top priority issues are being addressed. Mission-relevant emerging issues are identified and subsequently addressed through this process.

Cross-cutting Programs

The NRE work outlined in this portfolio often cuts across jurisdictional lines – within USDA and CSREES – with other federal agencies, and with state, local and private partners. Table 2.1 lists some of the partnership agencies and organizations that enable CSREES to reach the desired outcomes.

Table 2.1. Primary Internal and External Governmental Partnerships, CSREES.

USDA Primary Agencies	**External Organizations**
Natural Resources Conservation Service	Soil Conservation Districts
U.S. Forest Service	Resource Conservation and Development councils
Farm Service Agency	State agencies
Economic Research Service	Tribal governments
Agriculture Research Service	Environmental Protection Agency
National Agriculture Statistics Service	Bureau of Land Management
	Bureau of Reclamation
	Federal Emergency Management Agency
	U.S. Geological Survey
	National Oceanic and Atmospheric Administration
	National Space Aeronautics Administration
	Fish and Wildlife Service
	Army Corps of Engineers
	National Park Service
	National Commodity Organizations
	Regional Air Quality Planning Organizations

The agency uses formal and informal processes to gather stakeholder input including, but not limited to, stakeholder listening sessions, workshops, symposia, peer panel recommendations, RFA solicitations, white papers, and Legislative Mandates. NRE was instrumental in developing the *enr* (Environment and Natural Resources) team, which is an agency-wide effort of NPLs, from a number of units within CSREES, whose expertise encompasses the NRE disciplines. Between NRE and *enr* leaders, stakeholder feedback is amplified, ensuring relevancy of programs that address critical needs at the local, regional, and national levels.

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Mechanisms for Problem Solving and Funding for Portfolio 5.2

As discussed above in the section on funding authorities, CSREES manages millions of dollars of funds each year. These funds are invested in the three areas of Research, Education, and Extension. Below is a summary of investments and efforts in each of these three areas for the 13 soil, air and water PAs. For each PA, a similar but focused discussion will take place where data are available.

General Investments and Outputs

CSREES' main investments in Portfolio 5.2 are money and expertise. While investments are significant, the agency is not claiming to be the largest contributor to any national effort because other department and agency funding is not included in this analysis. Similarly, there are a variety of outputs, some are a direct result of CSREES efforts, and some are the result of leveraged funding provided to another party. The logic model for the entire portfolio is presented in Chart 2-1, with a text discussion provided with a general list of inputs and outcomes; additional, more specific ones are provided in each PA discussion.

Inputs

The ability to address critical natural resources issues is based on funding. CSREES manages three types of funds:

- Merit funds, both formula and targeted;
- Competitive peer reviewed funds; and
- Congressionally-directed funds, subject to merit review.

Additional funding sources include other federal agencies, states, and non-government grants and contracts.

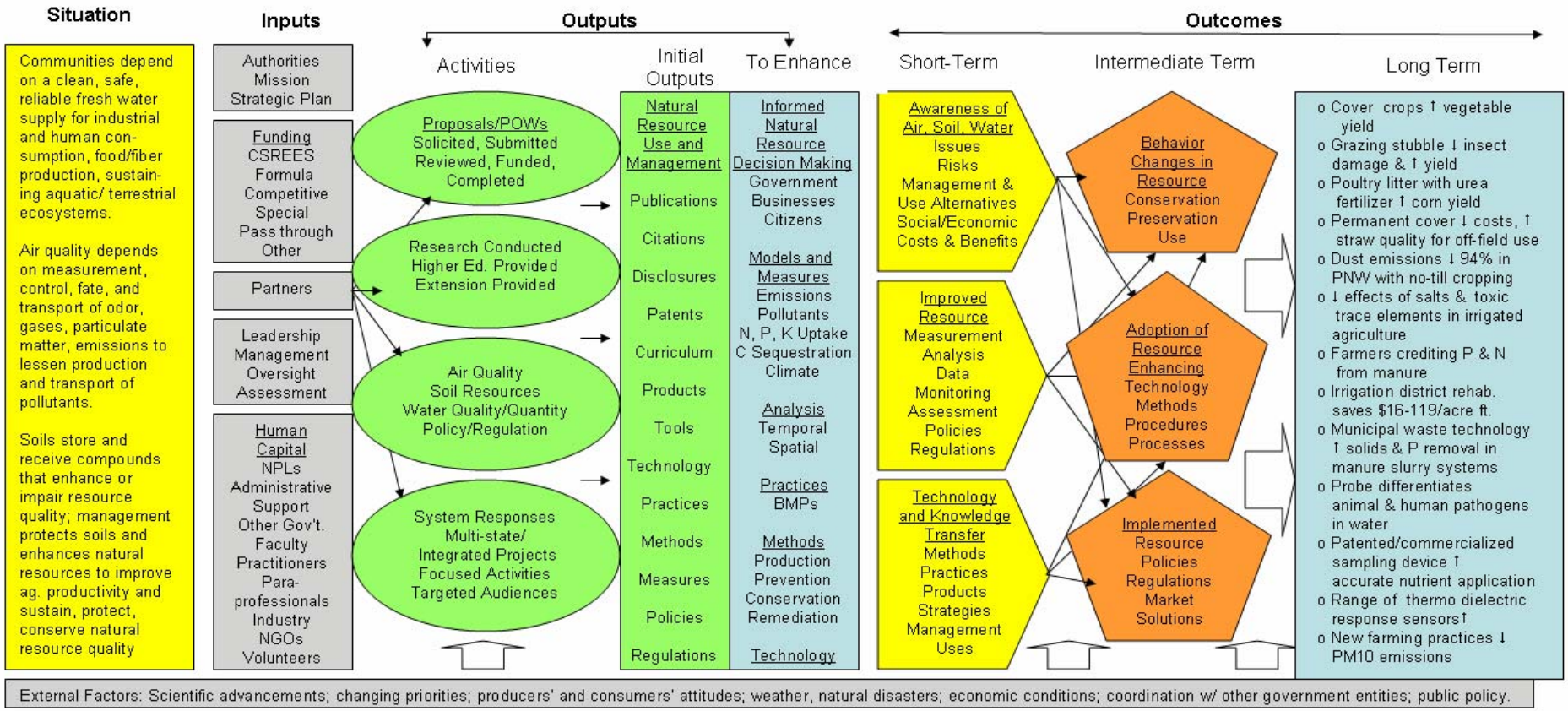
Leadership and management are critical to achieving the CSREES mission. Human resources include CSREES administrators, NPLs, administrators, faculty and staff based at universities, teachers, paraprofessionals, stakeholders (both industry and non-governmental organizations), and volunteers.

Outputs

There are a vast array of direct and indirect outputs from the leadership and management of funds by CSREES. They include:

- Identification of mission-relevant problems, opportunities, and issues requiring federal attention and support;
- Establishment of networks and collaborations with partners and stakeholders to ensure performance;
- Methodologies to evaluate and assess the quality, outcomes, and impacts of programs;
- Programs and activities responsive to existing or emerging problems, opportunities, and issues through the development and application of science-based knowledge, resulting in
    - Publications
    - Patents and products
    - Citations
    - Educational and marketing tools
    - Improved techniques, methods, and best management practices (BMPs)
    - Curricula and courses
    - Trained scholars, scientists, and practitioners
    - Non-formal training and education programs

Chart 2-1. Portfolio 5.2 Logic Model



CSREES Funds, Leads, and Manages Efforts and Funding

NRE manages a complex portfolio of activities and efforts in natural resources. In the PA discussions below, areas will be discussed to the extent that they exist within a PA, and that data are available. Admittedly, it is easiest to track research efforts, and less easy to track education, extension, and integrated efforts for reasons discussed throughout this document. Nevertheless, the following information provides an overview of significant efforts in the Objective 5.2. portfolio.

Research Efforts

Continuous research findings are needed to increase our understanding of the nation's natural resources. New knowledge answers the immediate questions of professionals, policy makers, landowners, and the public. This portfolio provides information pertaining to CSREES' role in addressing Research, Education, and Extension issues nationwide. Details are outlined and presented in individual PAs in this document. Funding sources are summarized in Tables 2.2 through Table 2.4.

Table 2.2. CSREES Research Funding by Source, Portfolio 5.2, Protect and Enhance the Nation's Natural Resource Base and Environment, 1999-2003.

Source	Fiscal Year ($ 000)					Total
	1999	2000	2001	2002	2003	
Hatch	25,433	24,248	24,537	23,179	23,175	120,571
McIntire-Stennis	3,859	3,570	3,239	3,829	3,396	17,894
Evans Allen	4,564	4,455	4,262	4,565	3,560	21,406
Special Grants	6,338	5,487	5,608	8,659	11,597	37,689
NRI Grants	10,559	3,952	15,250	12,498	13,733	55,993
SBIR Grants	1,731	1,020	2,208	2,785	1,940	9,685
Other CSREES	14,226	22,401	35,351	19,051	20,538	111,567
Total CSREES	66,710	65,133	90,457	74,566	77,939	374,805

Table 2-3. CSREES Research Funding, by Problem Area, Portfolio 5.2, Protect and Enhance the Nation's Natural Resource Base and Environment, 1999-2003.

Problem Area	Fiscal Year ($000)					Total
	1999	2000	2001	2002	2003	
101 Appraisal of Soil Resources	4,040	3,248	5,741	4,605	4,544	22,178
102 Soil, Plant, Water, Nutrient Relationships	15,472	13,887	22,402	15,816	17,076	84,653
103 Management of Saline and Sodic Soils and Salinity	596	514	909	464	333	2,816
104 Protect Soil from Harmful Effects of Natural Elements	978	929	2,110	1,887	1,085	6,989
111 Conservation and Efficient Use of Water	4,740	2,384	3,238	6,280	8,746	25,388
112 Watershed Protection and Management	7,229	12,305	18,221	14,624	12,654	65,033
131 Alternative Uses of Land	970	1,328	5,929	1,385	2,825	12,437
132 Weather and Climate	1,574	1,514	1,956	1,509	4,250	10,803
133 Pollution Prevention and Mitigation	17,196	16,999	19,655	16,904	15,047	85,801
141 Air Resource Conservation and Management*	0	0	0	0	0	0
403 Waste Disposal, Recycling and Reuse	8,910	5,635	4,445	5,226	4,498	28,714
405 Drainage and Irrigation Systems and Facilities	958	907	1,295	874	1,144	5,178
605 Natural Resource and Environmental Economics	4,087	5,514	4,843	5,006	5,741	25,191
Total	66,750	65,164	90,744	74,581	77,943	375,181

*This PA 141 was identified in 2004 in response to emerging needs and priorities; data are insufficient to retroactively assign funds.

Table 2-4. CSREES Research Funding, All Sources, Portfolio 5.2, Protect and Enhance the Nation's Natural Resource Base and Environment, 1999-2003.

Source	Fiscal Year ($000)					Total
	1999	2000	2001	2002	2003	
CSREES	66,710	65,133	90,457	74,566	77,939	374,805
Other Federal	42,488	46,548	55,340	67,778	71,421	283,575
State Appropriations	158,493	170,109	167,650	174,383	163,264	833,899
Private or Self Generated	13,425	12,336	12,502	12,073	13,341	63,677
Total	281,116	294,126	325,949	328,800	325,965	1,555,956

Education Efforts

Education efforts are an important part of CSREES operations. There is direct funding for scholarships and funding for projects that contain support for students to continue their education. Unfortunately, CSREES capacity to categorize these investments by portfolio or PA is limited at this time. The following provides some indication of what is happening in the

general area of natural resource education and as close as can be defined, with investments by CSREES into formal education activities.

Educational programs at land grant universities are enhanced by CSREES academic program reviews, multi-state administrative committees, and coordination with National Associations. These programs enhance teaching excellence, as well as support undergraduate and graduate students. It should be noted that the bulk of instructional funding is typically derived from tuition, state appropriations, educational grants, and other federal sources.

Natural Resource Higher Education Programs

The preparation of the next generation of scientists, specialists, agents, and decision-makers is critical to the evolution of our understanding, protection, and appropriate utilization of our natural resources. Nationwide, there are a number of institutions that are training future natural resource personnel. Included in the Evidentiary Materials are data tables outlining what is happening at the national scale for a number of institutions who are reporting to the FAEIS database system. No claims are made by CSREES to any significant funding contributions to these efforts.

CSREES Science and Education Resources Development Funded Projects

SERD is leading USDA's commitment to human capital development. SERD's grant programs strengthen agricultural and science literacy in K-12 education, influence students' career choices toward agriculture, strengthen higher education in the food and agricultural sciences, prepare graduate students, and train master's and doctoral-level students as future scientists. SERD provides national leadership for revitalizing curricula, recruiting and retaining new faculty, expanding faculty competencies, using new technologies to improve instruction delivery, attracting outside scholars, developing research and teaching capacity at minority-serving institutions, and increasing the diversity of the food and agricultural scientific work force. Table 2-5 summarizes projects, funded at nearly $7 mil., in the area of natural resources.

Table 2-5. CSREES Funded Education Projects, Portfolio 5.2, Protect and Enhance the Nation's Natural Resource Base and Environment, 1999-2003.

Fiscal Year	Amount ($)	Title	Institution
1999	90,000	Native Plant Propagation & Land Restoration: Tribal College Curriculum Development	Salish Kootenai College
1999	50,000	Higher Education Multicultural Scholars Program at SUNY College of Environmental Science and Forestry	State University of New York
1999	50,000	Higher Education Multicultural Scholars Program at SUNY College of Environmental Science and Forestry	State University of New York
1999	196,169	Environmental Impact of Land Applied Animal Waste: Biogeochemistry and Using Remote Sensing and Geographic Information Systems	Alabama A&M University
1999	197,475	Agricultural Experiential Waste Management and Regulatory Compliance Program	University of Arkansas
2000	85,686	Internet Based Course on Wetlands and Water Quality	University of Florida
2000	90,000	Senior Undergraduate Capstone Course in Environmental Sciences	Montana State University

Fiscal Year	Amount ($)	Title	Institution
2000	100,000	Curriculum Development: Watershed Management Initiative	Louisiana State University, Shreveport
2000	97,899	Video Course: Ecology and History: Landscapes of the Columbia Basin	Oregon State University
2000	99,534	Experiential Learning in Hydrologic Modeling for Watershed Mgmt.: Closing the Gap Between Undergraduate Training and Professional Practice	University of Washington
2000	237,500	Multi-Media Video Instruction of Soil Science and Environmental Quality	University of Wisconsin, Madison
2000	20,392	Food and Agricultural Science National Needs Graduate Fellowship Grants Program	University of Minnesota
2000	29,217	ditto	University of Minnesota
2000	19,391	ditto	University of Minnesota
2000	69,000	ditto	North Carolina State University
2000	69,000	ditto	North Carolina State University
2000	7,000	ditto	Purdue University
2000	69,000	ditto	Purdue University
2000	69,000	ditto	Purdue University
2000	1,856	ditto	University of Florida
2000	61,174	ditto	University of Florida
2000	58,174	ditto	University of Florida
2000	85,796	ditto	University of Florida
2000	103,500	ditto	Michigan State University
2000	103,500	ditto	Michigan State University
2000	103,500	ditto	Colorado State University
2000	103,500	ditto	Colorado State University
2000	19,391	ditto	Virginia Polytechnic Institute and State University
2000	20,392	ditto	Virginia Polytechnic Institute and State University
2000	29,217	ditto	Virginia Polytechnic Institute and State University
2000	150,000	Educating and Training a Diverse Workforce of Water Professionals	California State University, San Bernardino
2000	150,000	Revegetating Invasive Plant Infested Rangelands in a Single Entry	Salish Kootenai College
2000	140,995	Natural Resources Curriculum to Strengthen Academic Program and Career Choices	North Carolina A&T State University
2000	97,481	Strengthen Graduate Environmental Sciences Program	Florida A&M University
2000	49,742	Indigenous Plant Materials for Phytoremediation of Arid Pollution	Southwestern Indian Polytechnic Institute

Fiscal Year	Amount ($)	Title	Institution
2001	37,736	Global Seminar on Human Sustainability, Agriculture and the Environment	Florida A&M University
2001	100,000	Watershed Management Initiative Enhancement	Louisiana State University, Shreveport
2001	149,726	Geographic Information System for Environmental Sciences	Inter American University, Puerto Rico
2001	149,670	Ecological Role of Indigenous Functional Groups and a Nonindigenous Invader in a Rangeland Ecosystem	Chief Dull Knife College
2001	149,670	Navajo Watershed Research Project	Dine College
2001	285,750	Monitor Biological Endpoints of Pesticide Exposure in Blood of Farm Workers	Kentucky State University
2001	179,947	Geographical Information System: Curricula Development and Student Experiential Learning	Virginia State University
2001	123,071	Bio-Environmental Geographical Information System	Prairie View A&M
2002	149,999	Enhancing Diversity and Student Experiential Learning in Water Resources	University of New Mexico
2002	300,000	Water-Technology Curriculum for Professional Certification	Santa Fe Community College
2002	299,947	Internships in Agricultural Watershed Conservation: Community Partnerships and Academic Training for the Next Generation of Land Managers	California State University, Monterey Bay
2002	297,315	Evaluating and Modeling Soil Carbon Dynamics in Conservation Tillage Cotton Production Systems	Alabama A&M University
2002	299,780	Development of Low-Cost Water Filtration Systems Using Nutshell-based Activated Carbons	North Carolina A&T State University
2002	300,000	Phosphorus Dynamics in Nutrient-Rich Sediments	Virginia State University
2003	250,000	Experiential Learning via Research in the Red River Basin (Joint Project)	Louisiana State University, Shreveport
2003	227,772	Using the Internet to Teach Market-Based Policies for Water Quality Management: NutrientNet.edu	Texas A&M University
2003	39,963	Growing Aware Institute	Genesee Community College
2003	149,989	Recruit Disadvantaged Students in the Environment Science Program	Inter American University, Puerto Rico
2003	142,038	Provide Experiential Learning Experiences for Environmental Science Students	Inter American University, Puerto Rico
2003	150,000	Multimedia Program to Facilitate Retention and Academic Performance of Minority Students in Entry-Level Math and Science Courses	Pontifical Catholic University of Puerto Rico
2003	199,806	Remote Sensing and Geographic Information System Technologies for Improving Teaching Agriscience, Environmental and Natural Sciences	Virginia State University
Total	6,906,660		

The agency also supports students at land grant institutions to obtain baccalaureate and graduate degrees in the natural resources and the environment science disciplines. Between 1999 and 2003, twenty-seven students received scholarships for this purpose from the Higher Education Multicultural Scholars Grants Program. During the same period, sixty-eight students received scholarships from the Food and Agricultural Sciences National Needs Graduate and Postgraduate Fellowships Program.

Extension Efforts

Various state and federal government agencies have outreach agendas but their capacity to deliver programs is extremely limited or nonexistent. The CES retains its comparative advantage for delivering science-based, consumer-driven programs providing knowledge to help individuals and communities adopt new practices and respond to change.

The extension system is built on a unique infrastructure that includes on-site local educators, agents, and specialists in rural, urban, and suburban communities, faculty specialists at land grant universities[1] and partnership with local, state, and federal government. Hamilton and Biles (1998) reported that 268 of 644 full-time positions[2] devoted to Renewable Resources Extension Act programming (RREA, see http:www.csrees.usda.gov/nea/nre/in_focus/forests_if_rrea.html) between 1992 and 1997 were focused on forestland, resulting in improved management practices on nearly 90 million acres.

CSREES plays a key role in the land-grant extension mission by distributing annual congressionally appropriated formula funding and targeted competitive funding for extension work. The agency affects how these funds are used through NPLs to help identify timely national priorities and ways to address them. This is accomplished through NPL guidance to, and merit review of POWs, Requests for Applications (RFAs) for competitive peer-reviewed extension programs, and through the merit review of proposals for targeted programs. While CSREES collaborates as a full partner with state CES', outcomes and impacts reported here are only partially attributable to CSREES funding, but typically CES' derive the majority of their funding from state and local funding. The reporting of this information, however, demonstrates the value of leveraged, matched and blended funding approaches that result in greater impact than what would be accomplished without the federal contribution. Reporting these data demonstrates that the agency and its partners are establishing monitoring and evaluation systems that facilitate the dissemination of knowledge in a timely manner to inform policy and decision-makers and the public. Due to the fact that extension funds are not currently disaggregated by PA or portfolio, or are not tracked in a manner that validly describes extension funding during the portfolio review period, no overall budget estimates are available for extension investments in Objective 5.2.

Summary of Short, Medium, and Long-term Extension Outcomes for Objective 5.2

As discussed in the section on funding authorities, CSREES manages millions of dollars of funds each year. The expected outcomes[3] of land grant university agriculture and natural resources extension efforts include, but are not limited to:

[1] Most land grant colleges of agriculture and forestry faculty have joint appointments in research, teaching and/or education.

[2] According to the most recent (December 2003) salary analysis of Cooperative Extension Service professionals (http://www.csrees.usda.gov/about human_re/pdfsreport2003.pdf), there were 5,643 specialists (4,170.2 full-time equivalents (FTE)) and 8,987 (8,789.8 FTE) agents/educators in the country responsible for local, state and regional programs.

[3] As per the 1997–2002 Strategic Plan.

Short Term

- Increased awareness of soil, air and water quality issues within the research, education and extension communities;
- Increased knowledge through publication of information gained through research activities that will subsequently impact natural resources; and
- Better understanding of trade-offs in adopting alternative technologies and conservation policies.

Medium Term

- Improved resource planning and sustainable land use that protect land from flood damages;
- Improved monitoring, measuring and mapping of land use and land-cover, projecting future atmospheric pollutant (e.g. CO_2, NH_3, CH_3) concentrations and changes in land-based carbon sinks; and
- Better treatment processes that mitigate environmental problems.

Long Term

- Better use of available land to maximizes yield of crops despite adverse conditions (e.g. salinity and drought);
- Better irrigation techniques and equipment to conserve water quantity;
- Increased economic benefits for adopting management strategies and practices that will enhance productivity while negating soil, air and water pollution;
- Improved models that incorporate socioeconomic factors and ecosystem function to determine contemporary impacts of land-use and land-cover change; and
- Better decisions leading to enhanced crop and animal production under various environmental conditions.

Integrated Efforts

Integrated efforts include those that have all three aspects of CSREES – research, education, and extension. In this portfolio, only the water and air components had integrated efforts. It is difficult to extract isolated funding data for integrated efforts, so what is available is included in the tables in this document in the category "Other CSREES."

CSREES Comprehensive Reviews of Natural Resources and Environment Academic Departments and Programs

One of the unique assessment services that CSREES engages in leading expert peer reviews of departments and programs at land grant institutions. When comprehensive review requests are submitted to the agency by our land grant partners[4], usually at the Departmental or College level, the CSREES Deputy Administrators assign appropriate NPL to lead the review team, generally comprised of eminent faculty from other institutions and USDA scientists with expertise in the program that is slated for review. The review encompasses research, education (undergraduate and graduate), and extension activities as they relate to the particular academic department. The

[4] CSREES Comprehensive Reviews are voluntary, undertaken at the request of the institution, and are typically scheduled about every five to seven years.

external team reviews a self-study document prepared in advance by the institution, and typically spends approximately four days on site interviewing and listening to presentations by administrators, faculty, students, and staff. The team subsequently prepares a comprehensive report that documents the strengths and weaknesses of the programs and identifies opportunities for growth or improvement. This allows the agency to gain fuller insight into the research, education, and extension programs at participating land grant institutions, helps identify emerging trends and issues, and, in the aggregate, provides a comprehensive overview of state-of-the art research, teaching and extension around the Nation. The institutions gain from having their programs peer reviewed from a national perspective.

The Portfolio 5.2 Logic Model

The logic model, a conceptual tool for planning, accountability, and evaluation, is a systematic and visual way to present the relationships among the resources to operate a program, the activities, and the changes or results expected to be achieved (*W.K. Kellogg Foundation Logic Model Development Guide, see* http://www.wkkf.org/Pubs/Tools/Evaluation/Pub3669.pdf). It displays the programmatic sequence of events that take place in the development and execution of a program. Each section is comprised of a series of actions that generate a result which feeds into or serves as a substrate for the next sequence. The framework demonstrates the extent to which elements of the logic model are tied into a problem or a situation for which there is a legislative or administrative authority, resources obligated, and specific program activities including performance measures and performance indicators have been identified. These activities are then implemented and result in the generation of data that demonstrate the extent to which meaningful progress is taking place, leading toward eventually solving the problems for which funds were obligated.

While every attempt has been to follow the conceptual framework of the logic model, readers are reminded that this portfolio assessment is conducted for activities that took place from 1999 through 2003. As such, CSREES is attempting to map its program outcomes retrospectively against a robust framework that was not used as a programming tool during the assessment period. Future programming efforts will be based on this conceptual framework and to that extent it would be much more useful for assessments to be conducted in the next cycle.

CSREES, through its unique partnership with universities, federal and non-federal agencies, and state partners, sponsors and support research, education, and extension work that focuses on protecting and enhancing the nation's natural resource base and environment.

The logic model for Objective 5.2 (Figure 2.1) depicts how CSREES and NRE achieve works with partners to achieve this objective. The remainder of this document discusses the specific PAs following the specific logic model framework

Situation

Management decisions and practices inherent to agriculture-related activities can lead to impaired soil, air, and water quality, three of the main natural resources. Soil receives a variety of inputs (organic and inorganic) to improve its health and quality for production purposes, but some of these inputs can also result in pollution, not only of soil, but also water and air. Agricultural and non-agricultural users of water require a safe supply for production of food,

feed, and fiber, and to ensure the health and well being of society. Similarly, air resources are needed and shared by all of society, yet production of food and fiber can result in emissions and particulates becoming airborne and negatively impacting water and air qualities. Therefore, it is imperative that science-based knowledge is generated, disseminated, adopted and implemented to improve soil, air, and water to support production and enhance the environment.

General Assumptions
CSREES has the funds, personnel and facilities to accomplish this objective. There is a need to collaborate with lateral partner organizations and agencies.

This portfolio utilizes an interdisciplinary, integrated approach.

CSREES personnel have established solid networks and support to conduct comprehensive research, extension, and education programs.

Inputs
CSREES provides human capital and funding to address Objective 5.2-related issues.

Outputs
- Mission-relevant problems, opportunities, and issues requiring federal attention and support are identified;
- Networks and collaborations with partners and stakeholders are in place;
- Programs and activities respond to existing or emerging problems, opportunities, and issues through the development and application of science-based knowledge;
- Programs and activities are administered and managed in order to develop and apply science and knowledge; and
- Methodologies are being developed to evaluate and assess the quality, outcomes, and impacts of these programs.

Short-Term Outcomes
- Allocated funds result in new research findings, improved teaching and continued extension.
- Research findings are used to guide further research, extension and education programs.
- Grantees and partners have increased awareness, knowledge, and skills.
- Increased scientific understanding and dissemination of knowledge makes it possible to sustain and enhance the nation's soil, air and water resources.
- National Program Leaders are connected to research, extension, and education activities nation-wide.

Mid-Term Outcomes
- Scientific knowledge base is continually recharged and expanded.
- Research findings, through extension and education programs, result in management or behavioral change opportunities for producers, agencies, and the interested public
- Science based information is delivered to policy makers and decision makers.

Long-Term Outcomes

- Adopted better management decisions and practices increase agricultural productivity and environmental quality;
- Use of improved techniques, technologies and equipment increase agricultural productivity and environmental quality; and
- Better models, guidelines, and policies reduce environmental degradation of soil, air and water resources.

Specific Accomplishments and Success Stories

CSREES, through its partners have made significant strides in managing soil, air and water resources to enhance the environment. Examples of the numerous success stories generated through these efforts are described for each PA in Section III.

Future Directions and Emerging Issues

Emerging issues for each of the PAs that were identified through stakeholder involvement are discussed in Section III. They include but are not limited to the need to:

- Target drought preparedness and mitigation;
- Focus on water conservation;
- Find innovative approaches to quantify, model and project natural and human drivers of land-use and land-cover change;
- Focus on methods to analyze associated implications for wildlife habitat, for carbon sequestration, for climate change mitigation and for biodiversity, and other ecological and economic impacts;
- Determine the source, fate and transport of atmospheric pollutants arising from agriculture-related activities;
- Identify and develop new and alternate uses of agriculture-generated wastes and by-products;
- Define the bioavailability to plants and animals of nutrients and other components (health risks) in wastes and by-products;
- Assess multiple benefits, such as carbon sequestration, flood protection, water quality improvement, energy conservation, wildlife habitat, or rural vista and create institutional mechanism to compensate producers for the environmental benefits they deliver;
- Define economic values and costs of bio-technology and bio-energy development in a global-trading settings; and
- Evaluate economic impact of global climate change and design potential mitigation policies.

Section III – Problem Area Discussions

A: PROBLEM AREAS 101 – 104
Soil Resources

Overview

Soil is a complex and dynamic natural resource on the Earth's surface. It supports plant growth, affects water and air quality, and helps to clean up natural and human-made wastes. We depend on soils for the food we eat, the water we drink, and the environment in which we live and play. CSREES is involved in a diverse range of research, education, and extension activities that will ultimately lead to development of practices, techniques and methodologies that will enhance productivity, while also protecting environmental quality.

Soils profoundly affect agricultural productivity and sustainability, ecosystem stability, and global change. Soils provide physical support, water, air, and nutrients for plants, and they receive natural and man-made materials and wastes. At the same time, soils contain an immense diversity of microorganisms, plants, and animals. This dynamic combination of organisms, water, nutrients, and minerals can remove and transform harmful products while storing and recycling water, nutrients, and other elements needed for life on Earth.

Soil science is an interaction of the biological, physical and chemical sciences that influences management practices for addressing food and fiber productivity while also preserving and conserving environmental quality. The major soil related problem areas addressed by CSREES are: Appraisal of Soil Resources (PA 101); Soil, Plant, Water and Nutrient Relationships (PA 102); Management of Saline and Sodic Soils and Salinity (PA 103); and Protect Soil from Harmful Effects of Natural Elements (PA 104).

For the purpose of this review, PAs 101-104 will be addressed as Soil Resources because of cross-cutting and inter-relatedness of the Problem Areas.

Situation

Soil is the recipient of numerous organic and inorganic inputs (fertilizers, agricultural and non-agricultural residuals, by-products and wastes). Some products are incorporated to alter the biological, physical and chemical characteristics of the soil so as to improve soil health and quality and subsequently crop productivity. Residuals, wastes, and by-products are often incorporated into soil to enhance population density and diversity of organisms, increase organic matter content, enhance tilth, improve water holding capacity, improve bulk density, and subsequently, increase crop productivity. Soil inputs also affect nutrient cycling and storage (e.g. carbon (C) storage/sequestration, and C and N cycling). Human activities generally have positive impact on soil resources, but sometimes can also have negative outcomes. Therefore, soil resources are intimately related to land cover, land use and land change, which then affect water and air quality, and ultimately, will impact the health and well-being of society. The goal of CSREES Soil Resources portfolio (PA 101–104), then, is to “provide science-based

knowledge and education to improve management of soil to support production and enhance the environment."

Excess nutrients like N and phosphorus (P) can enter water bodies causing degradation of ground and surface water and the ecosystem. Research has shown that proper rates and timing of nutrients to coincide with plant demand can reduce the risk of environmental degradation. Similarly, efficient methods of nutrient application and soil conservation practices can reduce erosion and runoff. Understanding the processes controlling retention and transport of nutrients can improve guidelines and recommendations for managing soil inputs based on soil type, crop species and external factors. CSREES addresses these concerns through activities focusing on PA 101, Appraisal of Soil Resources.

Nutrient availability varies considerably from soil to soil depending on numerous internal and external factors and processes. Under a given situation, the system of farming, soil management and soil amendment practices influence productivity of soil and crop yields. Uptake and utilization of nutrients, especially the macro nutrients (N, P, and potassium (K)) are tied to crop species grown, which are in turn affected by soil and external environmental factors. We depend on soils for the food we eat, the water we drink and the environment in which we live and play. This vital resource sustains all live forms. PA 102 focuses on Soil, Plants and Water to Enhance the Environment.

Saline and sodic soils can significantly reduce the value and productivity of affected land. Soil salinity and related problems generally occur in arid or semiarid climate where rainfall is insufficient to leach soluble salts from the soil. In general, insufficient water or irrigation water, which contains salts, can also lead to accumulation of salts. It is estimated that the salinity of more than 25 percent of irrigated land in the United States is higher than normal. Saline and sodic soils fall into three distinct groups (saline, sodic and saline-sodic). Understanding these differences is critical to designing strategies for management and reclamation. This is the focus of PA 103 (Management of Saline and Sodic Soils and Salinity).

Population growth and climatic variations continue to impact societies' health and well-being. The dust bowl of the 1930's is an example of climatic variation that had global impact. Without proactive measures, it is conceivable that a similar event related to soil management and practices could occur in the future. Arid and semiarid regions of the southwestern United States are amongst the most sensitive regions to changes in climate and land use, yet, the interactions between land use and climate change are largely unknown. To Protect Soil from Harmful Effects of Natural Elements (PA 104) while enhancing crop productivity, it is important to understand how past climate changes affect soil processes. CSREES and it partners are involved in research, education and extension activities that are tackling this issue.

Inputs

CSREES invested a total of $116 mil. in Soil Resources between 1999 and 2003. Of this total, Hatch funds accounted for approximately $45 mil., while the NRI program accounted for nearly $24 mil. Funding for Special Grants has increased steadily from 1999, with the largest increase in 2003. In 2003 funding for Soil Resources increased by 8.5 percent compared to 1999. The

breakdown of funding by source is presented in Table 3-1. In general, NRI funding for Portfolio 5.2 was consistently modest for all PAs.

Table 3-1. CSREES Funding by Source, PA 101-104, Soil Resources, 1999-2003.

Source	Fiscal Year ($ 000)					Total
	1999	2000	2001	2002	2003	
Hatch	9,912	9,369	9,036	8,541	7,924	44,782
McIntire-Stennis	1,570	1,355	1,093	1,051	1,222	6,291
Evans Allen	2,250	1,946	2,088	2,324	1,904	10,512
Special Grants	712	1,259	1,320	1,498	3,291	8,080
NRI Grants	4,739	1,224	6,011	5,685	5,849	23,508
SBIR Grants	625	0	60	189	262	1,136
Other CSREES	1,282	3,424	11,285	3,485	2,586	22,062
Total CSREES	21,090	18,577	30,891	22,773	23,038	116,371

From 1999 through 2003, over 700 projects focusing on PA 101 were funded at $21.9 mil.; approximately 2,300 PA 102 projects were funded at $84.7 mil.; less than 200 PA 103 projects were funded at $2.8 mil.; and about 270 PA 104 projects were funded at $7.0 mil. Results presented in Table 3-2 show that in each year, total funding by CSREES exceeded other federal and non-federal sources, accounting for about 43 percent of funds invested in Soil Resources. However, this also shows the importance of leveraging funds to address soil resource issues that are critical to the well-being of society.

Table 3-2. CSREES, Other Federal and Other Non-Federal Funding, PA 101–104, Soil Resources, FY 1999-2003.

Fiscal Year	Source ($ 000)				
	CSREES	Other Federal	Other Non-Federal	Total 101-104	CSREES % of Total
1999	21,090	12,273	11,337	44,700	47
2000	18,577	18,364	10,328	47,269	40
2001	30,891	21,642	10,051	62,584	49
2002	22,773	23,829	10,041	56,643	40
2003	23,038	28,094	11,372	62,504	37
Total	116,369	104,202	53,129	273,700	43

For each PA and within each year, the main Subject of Investigation (SOI, see CRIS, http://cwf.uvm.edu/cris/revman/manvi_si.htm) for Soil Resources was Soil and Land, except in 2003 when emphasis was placed on Trees, Forests and Forestry in PA 103. Across PAs in 1999, total funding averaged 62.3 percent for Soil and Land, compared to an average of 56.4 percent in 2003. Other SOIs that were funded above 10 percent included Trees, Forests and Forestry (PA 103 in 1999 – 36.9 percent); Water (PA 103 in 1999 – 23.8 percent); Grain Crops (PA 104 in 1999 – 15.8 percent); and Grain Crops (PA 104 in 2003 – 10 percent). These data are indicative of the diversity of natural resources and environment related subject matter of the Soil Resources portfolio.

Performance Criteria

The health and well-being of society is tied to the three major natural resources: soil, air and water. Soil directly or indirectly influences the quality of air and water. Therefore, science-based research, education and extension activities must improve productivity and sustainability, while addressing environmental quality. High quality activities encompassed by PA 101–104 must:

- Develop and disseminate management practices and strategies that maintain or enhance soil resources while ensuring sustainable production and environmental quality;
- Increase the knowledge-base and understanding of soil processes that impact agriculture and the health and well-being of society; and
- Develop techniques and technologies that will enhance nutrient application and utilization and protect the environment.

Performance Indicators

- Adoption and implementation of science-based knowledge by end-users (e.g. nutrient management plans, regulatory policies)
- Designed effective management strategies for soil that increase productivity and reduce environmental damage
- Increased awareness of agricultural management practices and their impact on soil resources and environmental quality (e.g. land application of residuals and wastes); and
- Designed strategies for reclamation and restoration of degraded and contaminated soils

Outputs

- Nutrient management plans that have been developed and or refined to reduce environmental degradation
- Guidelines that have been developed and implemented for land application of residuals to improve soil processes and characteristics
- Cost-effective measures that have been identified for remediation of contaminated soils
- Hazards associated with land applied residuals have been identified

Outcomes

Short Term

- Increased knowledge of scientists, educators, extension personnel, practitioners and producers through sharing of information in various formats and media (e.g., fact sheets, journal articles, guide books, on-line resources)

Medium Term

- Better strategies, plans and guidelines for managing soil resources that lead to
    - Reduced risks of land applying wastes and residuals
    - Cost effective remediation and restoration of degraded soils

Long Term

- Better or new crop varieties that can tolerate salinity and drought conditions
- Improved productivity and reduced environmental degradation

- Improved soil resources (including quality) that lead to
    - Degraded soils restored
    - Improved environmental quality (including cleaner and safer air and water resources)
- Improved productivity and reduced environmental degradation through land application of wastes and residuals

Accomplishments/Outcomes

Multistate projects generally have regional reference but participants are drawn from across the nation and the world depending on the topic's relevance to the investigators' locale. In addition, participants include not only academic institutions, but the private and public sectors and NGOs. Examples of several multistate projects that are currently addressing topics relevant to Problem Areas 101–104 are listed in Table 3-3. Project activities are generally integrated, that is, encompass research, education and extension. Academic participants may hold extension appointments, whether exclusively or partially. In addition, some participants may be producers or end users, thereby ensuring that results are transferred and where appropriate, adopted or implemented in a timely fashion. As indicated in Table 3-3, selected multistate projects address not only Problem Areas 101–104, but related PAs like 133 and 403, demonstrating the cross-disciplinary approach that is being taken to address soil resource-related issues.

In general, these projects evaluate 1) risks posed by applying residuals to baseline soils, 2) the impact of residuals on chemical, biological and physical characteristics and processes in the soil environment, 3) availability and impact of nutrients on water quality remediation of contaminated land, 4) ecosystem restoration. and 5) soil management effects on C sequestration, productivity and quality. Education and extension components are included through management of research sites by farmers, which translate into immediate application of results and knowledge obtained from participating in the projects. Specifically, the involvement of EPA in W-1170 also addresses education and extension because EPA regulations and public policy decisions are based on scientific knowledge obtained through collaboration with the land grant system. Some of the results can be seen in EPA's regulatory policies regarding use of residuals for land application. Further, the group works closely with several private sector entities (e.g., Water and Environment Federation, and the Northwest Biosolids Management Association), ensuring that findings are reported directly to industry cooperators. In each of these projects, several investigators are involved in extension**,** so that communication and interaction with stakeholders and user groups is built in at all levels.

Table 3-3. Selected Multistate Projects, PA 101-104, Soil Resources.

Multistate Project PAs	Title	Participants
W1170 (PA 101, 102, 104 124, 133, 403)	Chemistry, bioavailability of waste constituents in soils	AR, CA, CO, FL, GU, HI, IA, IL, IN, KS, MI MO, MT, NM, NY, OH, OK, OR, PA, TX, VA, WA, WY, US EPA, US Army, ARS, MWRDGC, N-VIRO, Canada
NC1017 (PA 102, 104)	Carbon Sequestration and distribution in soil of eroded landscapes	GU, IL, IN, IA, MI, MN, MO, ND, OH, PA, SD, WI, ARS
S297 (PA 101, 102, 131 133, 203, 205, 206)	Soil microbial taxonomic and functional diversity as affected by land use and management	AL, AR, CO, DE, FL, GA, ID, KY, MD, NY, NC, OK, TX, VA, WV, WI, US Army, ARS, FL Int'l Univ, Univ. of Saskatchewan
S1014 (PA 101, 102,)	Mineral controls on P retention and release in soils And soil amendments	FL, NC, SC, TN, KY, TX, AL, GA
NC 1018 (PA 101,102,103 131,203,205)	Impact of climate and soils on crop selection and Management	FL, GA, IL, IN, IA, KS, LA, MI, MN, NE, NY, ND, OH, SD, TX
W1188 (PA 101, 102, 103, 104 104,111,120,133,213, 405, 712)	Characterizing Mass and Energy Transport at Different Scales	AZ, CA, CO, CT, DE, ID, IL, IA, MN, MT, ND, PA, TN, TX, UT, WA, WY, ARS, Battelle

Two projects funded by the NRI[5] are outgrowths of the precursor of multi-state project S1014. They address the fate of P in long term manure treated soils and in wetlands. Investigators determined that the soil mineral interactions with soil organic matter and oxidation-reduction potentials strongly influenced P loss from soils and constructed wetlands. The strong association of magnesium (Mg) and P in P released from abandoned dairy fields suggests possible **dietary manipulation for reducing P loss from soils**. Other NRI projects have shown the effects of roots, mycorrhizae, and microorganisms under normal conditions and increased atmospheric CO_2

[5] Hatch-funded multistate research helps to identify emerging issues or changing priorities that are later incorporated into National Research Initiative or other funding requests.

on N cycling. This allows better projections of nitrogen dynamics under different conditions for improved management of forest and croplands, so as to optimize productivity while minimizing environmental damage (PA 102, 104).

Projects funded through the National Integrated Water Quality Program (NIWAQP) are required to address a combination of Research, Education and Extension activities. Similarly, projects funded through the Air Quality Program (a new program that started in 2003 and is discussed in PA 141) have so far included research, education, and extension. Activities within these two programs are integrally related to Soil Resources because combined, these three resources are tied directly to sustainability, environmental health and quality. As such, the education and components of Soil Resources are addressed to some extent, within this framework. This is further demonstrated by activities that are being undertaken by principal investigators through several related multi-state projects (Hatch funded), Special Grants, Small Business Innovation Research (SBIR, see http://www.csrees.usda.gov/funding/sbir_highlights.html) grants, and NRI program grants.

Other examples of successful projects focusing on PA 101–104, Soil Resources, are described below.

A CSREES formula-funded research study in North Carolina found that a **legume cover crop can be an effective N source in vegetable production**. The investigators showed that yield components (fruit number, total yield, dry matter content and net photosynthesis) of bell pepper were similar when grown with N fertilizer or with the legume cover crop. This project, which addressed PA 101, PA 102 and PA 205 (Plant Production Management Systems), has greater implications for improving soil and water quality as well as vegetable yield. The investigators are working to extend this knowledge to Georgia farmers.

In another study, investigators conducted a study to evaluate and extend practical management strategies and systems that **reduce deleterious effects of salts and potentially toxic trace elements in irrigated agro-ecosystems**. In this formula-funded project which addressed PA 101 and PA 103, investigators found that composted organic matter that is rich in nutrients may help alleviate salinity stress in some plants. They also reported that although Pearl millet may not be an effective extractor of arsenic or lead for phytoremediation purposes, it may be grown in contaminated soil without sequestering arsenic in the grain heads. This is important for any group that has limited access to “clean” soils for crop production.

In a NRI funded project, investigators in Montana used **sheep to graze alfalfa residue** and found that weevil numbers were significantly lower than in non-grazed plots. Overall, results showed that sheep grazing may be a viable method for controlling pest insects in alfalfa without negatively impacting hay yields. Similarly, when sheep were used to graze wheat stubble, the mortality rate of stem sawfly was higher than burning the stubble or tilling the field, and also, that this method was beneficial to weed control. Soil compaction was not negatively impacted with the use of this well-managed grazing system. Although an economic analysis of this alternate management system has not yet been completed, it is expected to show that sheep grazing is an economically viable management strategy because the most significant economic problem for Montana wheat producers is wheat stem sawfly. Traditional methods of stem sawfly

control are more expensive than grazing, and more damaging to the environment. This example is illustrative of PA 101 (Appraisal of Soil Resources) and PA 102 (Soil, Plant, Water and Nutrient Relationships).

Several NRI projects have resulted in the development or improvement of methods for measuring soil moisture. In one, a ground penetrating radar device was successfully used to **map soil moisture** down to a 1 cm^2 grid to varying depths in a commercial vineyard. Since the quality of wine grapes is dependent on slight water stress, this has potential to increase both yield and quality, factors often inversely related in wine making. Other projects are extending the range of *in situ* sensors such as Time Domain Reflectometry **thermal dielectric response** to measure plant available water. These projects improve our understanding of basic relationships between various soil properties, available water and water retention in situ to improve our ability to manage spatially variable soils and water resources efficiently and profitably (PA 101 and PA 102).

SBIR funds Soil Resources-related projects in which investigators develop and test technologies and equipment with the ultimate goal of enhancing productivity and while ensuring cost effectiveness and environmental quality. Examples include development **of low cost devices for assessing** soil, plant, water and nutrient relationships (PA 102) - measuring soil moisture, soil temperature and assessing soil fertility at hazardous sites. In one project, a soil moisture sensor (SMRT Probe) was developed, patented and commercialized. In another project, an "on the go" soil sampling device was developed in Ohio by Geophyta, to **increase the accuracy of soil sampling**, (PA 101 and PA 402). The device has been patented, commercialized and is leading to more accurate nutrient applications, thereby protecting the environment.

Through coordinated unique multi-disciplinary partnerships and collaborations. Agency leadership is significantly impacting Soil Resources in the national and international arenas. The agency's efforts have led to discoveries that are improving crop productivity and cost efficiency, enhancing the quality of soil, air and water, and improving the life and well-being of society.

Investigators are collaborating across borders, including Canada and South America, sharing resources and knowledge thereby serving a larger populace. These outcomes and accomplishments would not have been possible without taking an 'integrated approach,' that is, not focusing solely on research but linking research activities to formal and informal education, and extension.

Future Directions:
Future funding and emphasis will be needed to address emerging issues, identified by stakeholders at the International Annual Meetings of the Tri-Societies (Agronomy, Soil Science and Crop Science Societies of America) in October 2004. Stakeholders included federal and state partners, private sector, academia, and NGOs. The emerging issues that were identified encompassed research, education and extension activities and include the following.

- Determine the relationship between soil structure, health and productivity including below ground biodiversity and water relations
- Examine transgenics and their effects on the soil environment
- Study soil chemistry, structure, geomorphology, cycles

- Explore carbon sequestration/cycling; climate change/variability
- Investigate organic agriculture: techniques, effectiveness, soil health, productivity
- Explore energy (fuel input) costs and availability to manage soil
- Study the linkage of process models and GIS; link models to increase understanding on appropriate scales for enhanced assessment, validation and policy making
- Determine environmental impacts of agri-chemicals, wastes, by-products and pharmaceuticals on biological, physical and chemical processes and characteristics and link to air and water cycles
- Assess technology use (Precision Agriculture, GIS, modeling at different scales)
- Develop programs and methodologies to better educate the public about the socio-economic value of soils and soil/environmental processes
- Develop strategies to address the decline of soil science as a discipline, hence availability of future soil science experts

In addition to addressing federally-mandated issues, stakeholder input will help to guide the development of future RFAs. The 2005 RFA for the Soils Program illustrates that the agency values stakeholder input. The program title was changed from *Soil and Soil Biology* to *Soil Processes* and reflects some emerging issues identified at the October 2004 listening session. Through individual program RFAs, CSREES continually seeks input from stakeholders, which in turn, is taken into consideration when developing upcoming program announcements. Stakeholder input is also generated through participation of National Program Leaders in numerous external activities including representation on multi-state committees, attending national and international scientific society meetings, and participating in work groups that include the federal, state, and private sectors.

Some Soil Resources-related issues were also identified through a Manure and By-product Utilization stakeholder workshop conducted by ARS in April 2004. Participants were drawn from the private sector, NGOs, academia, and other federal and state partnerships, further illustrating that other entities also address similar issues in Soil Resources. The leveraging of funds from multiple sources, including CSREES, enhances the impacts and outcomes of those related activities while reducing redundancy.

B: PROBLEM AREAS 111/112
Water Resources

Overview
Cities, communities, and rural areas across the nation depend on a safe, reliable, healthy supply of water for human consumption; the production of food, fiber, and other products; and sustaining aquatic and terrestrial ecosystems. The science and management of water requires consideration of both the quantity and quality of water resources and the land management activities that affect these water resources.

Over the past decade, drought conditions have developed in virtually every state in the nation. These circumstances have resulted in serious impacts to agricultural production, natural resource health and welfare, and rural community development. Due to a combination of drought cycles and impacts of global change, nine Western states are experiencing critical drought – similar circumstances exist in the East. Examples from 2003 include:

- Low water levels in Colorado's reservoirs resulted in lawn watering restrictions for 1.2 million Denver water users.
- Lake Powell in Utah fell to 50 percent of its total capacity.
- Montana experienced its sixth consecutive year of drought.
- Floridians suffered through extreme wildfires brought about by an abnormally dry spring.
- The Georgia Environmental Protection Division announced year-round conservation-based restrictions on outdoor water use.

USDA's Federal Crop Insurance payments alone for drought losses have averaged $462 million annually (33 percent of total payments) since 1989. Over half of the $4.1 bil. in 2002 crop insurance indemnity payments, some $2.5 bil., were for drought-related causes. In 2003, those indemnities were approximately $3.2 bil., and of this amount about 45 percent was attributable to drought-related losses.

On June 5, 2003, Interior Secretary Norton and Agriculture Secretary Veneman signed a Memorandum of Understanding (MOU) aimed at promoting improved water management and rapid response to emerging water supply shortages in the West. This MOU highlights the need for expanding the research, education and extension programs focused on better management of water resources. The MOU sets the stage for improved cooperation between the departments.

Similar concerns exist concerning the quality of the Nation's waters. The EPA is responsible for tracking the number of impaired water bodies (i.e., water bodies that do not meet the states' designated use: drinkable, swimmable, fishable) across the Nation and the reason for impairment. While point source pollution (e.g., discharges from pipes and factories) generally has been controlled, non-point source pollution (e.g., pollution from agricultural fields, suburban developments and managed forests) continues to be a serious threat to the quality of the Nation's water resources.

Non-point source pollution is addressed in the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977 this became the Clean Water Act. EPA is authorized to establish allowable guidelines for pollutant levels in streams, rivers, lakes, and groundwater primarily

through regulations for the Total Maximum Daily Load (TMDL) of that water body. EPA considers agriculture to be the leading source of non-point source pollution. As a consequence, agriculture is the focus of many TMDL studies and the TMDL program may result in the first nationwide regulatory programs for agricultural non-point source pollution control if voluntary non-point source programs fail to achieve water quality standards. Examples of TMDLs reported and developed include:

- 29,184 impairments to water bodies (e.g., pollution from sediment, nutrients, pathogens, etc.) were reported by the states since 1998;
- 13,255 TMDLs have been approved by EPA since January 1996;
- 2,623 TMDLs were approved for pathogens, 1,724 for nutrients, and 1,300 for sediment/siltation.

Within the broad context of Water Resources, CSREES funds research, education, and extension work that address Water Conservation (PA 111) and Watershed Protection (PA 112).

PA 111. Conservation and Efficient Use of Water

Projects related to this problem area focus on improving the storage, movement, use and reuse of water in agricultural and rural watersheds. Individual projects may address improving infiltration or soil water storage, plant breeding and selection to conserve water, improved conservation practices to retain or improve soil moisture content, and strategies to conserve or replenish groundwater resources. The spatial scale of projects related to this PA range from plot to field-scale analyses.

PA 112. Watershed Protection and Management

Projects addressed by this problem area focus on water quality and quantity at the full watershed scale. Critical issues addressed in this problem area include erosion control practices, sediment transport and deposition by wind and water, land cover management to improve the quantity and quality of water delivered from agricultural and rural watersheds, and management and storage of water to reduce impacts of flooding and maintain stable, healthy streams and rivers. Land reclamation that improves the quantity and quality of groundwater and surface water delivered from watersheds also is addressed in this PA.

Situation

CSREES is addressing water resources issues through a broad array of programs and funding sources. Several Problem Areas focus on activities related to water quantity and water quality, including PA 102, 111, 112, 133, and 405. This section, however, focuses on activities listed under PA 111 Conservation and Efficient Use of Water and PA 112 Watershed Protection and Management. Readers are directed to PA 133 for related discussions regarding pollution prevention and PA 405 for discussions related to drainage and irrigation systems and facilities. The Water Program is an outgrowth of the President's Water Quality Initiative of 1989. This was established to evaluate the impacts of agricultural pesticides on drinking water supplies in rural and agricultural communities. Three sets of projects were established through this initiative: the Management Systems Evaluation Area (MSEA) projects and the subsequent Hydrologic Unit Area (HUA), and Demonstration (DEMO) Area projects. Overall, the research, education, and extension activities of these projects demonstrate that the impact of sediment and

nutrient contamination on surface water quality was greater than the impacts of agricultural pesticides on surface and groundwater quality.

In 1999, research, education, and extension funding for water resources consisted of formula funds for research (Hatch) and extension (Smith-Lever 3d), competitive research grants in the NRI Watershed Processes and Water Resources program, directed research and extension projects administered outside competitive programs (including congressionally or non-competitive directed projects) and limited funding provided through SBIR and Higher Education Programs.

The implementation of Section 406 of the Agricultural Research, Education, and Extension Reform Act (AREERA) of 1998 led to the elimination of Smith-Lever 3d funds for water quality and the consolidation of agency directed research and extension projects within a single, competitively awarded funding source - the NIWQP in 2000. This competitive grant program now forms the cornerstone of the research, education, and extension efforts in water resources funded by the agency.

Agency efforts cover a broad range of activity on water quality and water quantity through research, extension and education. Research funded by CSREES provides the basic knowledge needed to address water quality and quantity issues in rural and agricultural watersheds. Extension and other outreach programs apply this knowledge to protect and improve water quality and assure the continued supply of safe and healthy water resources to communities across the nation. Education activities provide state-of-the-science learning opportunities for future leaders who will be addressing water resource issues.

The research, extension, and education programs funded by the agency also form the nexus for partnerships with other federal, state, and local agencies and organizations working cooperatively to protect and improve the Nation's water resources. Through these partnerships, scientists, educators, and extension specialists combine their knowledge and expertise to address locally defined water resource issues supported through the Water Resources program.

Input

Funding for PA 111 and 112 comes from a number of sources (Table 3-4). Formula funds support basic research and other non-competitively funded projects also provide key research and extension activities that address issues in water conservation and watershed protection. Competitive grants funded through the National Research Initiative Watershed Processes and Water Resources program, the SBIR program, and the NIWQP, established by Section 406, AREERA, provide funding for research, developmental research, and integrated research, education, and extension, respectively.

Data in Table 3-4 show an increase from 1999 to 2003 in the funding provided for PA 111 (water quantity issues). The same pattern exists for PA 112 from 1999 to 2001 (Table 3-5). However, in 2002 and 2003, the total funding for PA 112 drops – reflecting a likely shift in the problem areas being addressed from traditional water quality studies to water quantity studies. This time period coincides with a dramatic increase in the prevalence of drought across the nation. In 2002-2003, drought was recorded in 48 States. This shift in focus is most apparent in the NIWQP

where funding shifted from a strong water quality emphasis (2001) to a more balanced portfolio of water quantity and quality (2003). These changes show programmatic shifts in the emphasis of national programs and shifts in university or institutional commitments to water quantity issues. Non-competitive merit reviewed projects reflect the same tendencies. Interpretation of data in Tables 3-4 and 3-5 suggests that congressionally-directed projects shifted from a water quality focus in 1999 to 2001 to a water quantity focus in 2002 and 2003.

Table 3-4. CSREES Funding by Source, PA 111, Conservation and Efficient Use of Water, 1999-2003.

Source	Fiscal Year ($ 000)					Total
	1999	2000	2001	2002	2003	
Hatch	1,399	1,330	1,129	1,248	1,459	6,565
McIntire-Stennis	30	29	69	98	88	314
Evans Allen	128	84	85	89	0	386
Special Grants	374	222	846	1,177	2,013	4,632
NRI Grants	595	30	422	78	993	2,118
SBIR Grants	295	0	0	0	0	295
Other CSREES (inc. NIWQP)	1,920	688	688	3,590	4,194	11,080
Total CSREES	4,741	2,383	3,239	6,280	8,747	25,390

Table 3-5. CSREES Funding by Source, PA 112, Watershed Protection and Management, 1999-2003.

Source	Fiscal Year ($000)					Total
	1999	2000	2001	2002	2003	
Hatch	1,856	1,886	1,970	1,983	2,192	9,887
McIntire-Stennis	677	739	634	1002	862	3,914
Evans Allen	248	206	231	47	409	1,141
Special Grants	2,181	465	958	1530	827	5,961
NRI Grants	1,556	1,226	4,664	3,363	2,482	13,291
SBIR Grants	130	265	372	148	0	915
Other CSREES (inc. NIWQP)	581	7,517	9,390	6,550	5,878	2,9916
Total CSREES	7,229	12,304	18,219	14,623	12,650	65,025

Data presented in Table 3-6 show the percentage commitment by CSREES to PA 111, which ranged from 37 percent to 60 percent. The trend is an indication that research, education, and

extension funded by CSREES is among the leading contributor (particularly within USDA) to the effort to expand knowledge on water availability.

Table 3-6. CSREES, Other Federal, Other Non-Federal Funding, PA 111, Water Conservation, 1999-2003.

Fiscal Year	Source ($000)			Total PA 111	CSREES % of Total
	CSREES	Other Federal	Other non-Federal		
1999	4,740	1,739	2,016	8,495	56
2000	2,384	1,583	2,489	6,456	37
2001	3,238	1,785	2,177	7,200	45
2002	6,280	3,064	2,078	11,422	55
2003	8746	3693	2154	14593	60

By contrast, results in Table 3-7 show strong increases in funding from 1999 through 2001 and then a decreasing trend from 2001 through 2003. These numbers probably reflect the overall shift from water quality focused research, education and extension (1999-2001) to a focus on water availability (2001-2003). CSREES continues to provide over 40 percent of the total funding tracked in PA 112.

Table 3-7. CSREES, Other Federal, Other non-Federal Funding, PA 112, Watershed Protection, 1999-2003.

Fiscal Year	Source ($000)			Total PA 112	CSREES % of Total
	CSREES	Other Federal	Other non-Federal		
1999	7,229	5,798	5,270	18,297	40
2000	12,305	5,742	5,800	23,847	52
2001	18,221	7,432	5,503	31,156	58
2002	14,624	9,146	8,329	32,099	46
2003	12,654	10,022	7,547	30,223	42

A comparison of data for PA 111 and PA 112, in 2000 for example, shows that funding for water quantity (PA 111) was approximately 19 percent of the funding for water quality (PA 112). However, by 2003, water quantity funding reached approximately 69 percent of the amount allocated to water quality. These changes in funding show the responsiveness of the agency and its partner institutions to shift attention to those issues of greater societal concern (e.g. drought and water availability).

Performance Criteria

Ninety percent of the human body is water. This fact points to the importance of this critical natural resource, showing that it ultimately controls the health and well-being of society. Water plays a crucial role in every aspect of society and the environment. Activities addressing PA 111 and PA 112 are deemed of high quality if they result in:

- Developing improved technology for on-site detection of viable pathogens and other bacteria in water;
- Developing best practices for reducing the amount of nutrient pollutants entering water bodies from cattle feedlots;
- Improving the ability of farmers and ranchers to prepare for drought and to mitigate the response to drought;
- Reducing soil erosion from agricultural lands, forest lands, and rangelands;
- Reducing the net loss of wetlands due to agricultural production; and
- Improving irrigation management on agricultural lands.

Performance Indicators

Appropriate measures of success or performance indicators should describe and reflect the creation of knowledge and the pathways and linkages necessary to put knowledge into action. Indicators include:

- Increased and improved the knowledge base for water resource policy discussions;
- Established strategic partnerships and alliances to increase research and education;
- Transfer of water resource knowledge to appropriate target audiences;
- Improved environmental regulations (policies for water quantity and quality);
- Expanded environmental monitoring to detect improvements in the quality of water resources; and
- Improved financial incentive packages for landowners and land managers to protect or restore watersheds.

Outputs

- Generated scientific data from projects detailing changes in water quality
- Changed municipal regulations regarding management of suburban storm water
- Developed strategies for controlling aquatic invasive species in rivers, streams, and lakes
- Developed ground-penetrating radar tools to detect soil moisture in vineyards
- Developed strategies for reducing selenium in western rives
- Expanded knowledge-base for effective riparian buffer strip development and implementation
- Developed a national website and 10 regional websites that disseminate knowledge and best management practices for improving water quality (www.usawaterquality.org).

Outcomes

Short Term

- Increased scientific knowledge to document changes in water quality
- Raised the awareness and inclusion of water quality issues in the research, education, and extension community through increased funding for the water quality research
- Increased knowledge regarding the management of suburban storm water

Medium Term

- Documented the presence of pharmaceuticals in stream waters
- Identified protocols for reducing stress tolerance in important crops
- Reduced aquatic invasive species in rivers, streams, and lakes
- Documented state and regional water policies and their impacts on water quality.

Long Term

- Reduced selenium in western rivers
- Developed drought stress tolerance in important crops
- Developed and implemented effective riparian buffer strips that reduce pollutants (such as sediments and nutrients) entering waterways
- Adoption and implementation of better irrigation techniques within the Rio Grande river basin

Accomplishments/Outcomes

To illustrate the accomplishments achieved by this portfolio for the period covering 1999-2003, examples of success stories are presented below. These are just examples of numerous projects within the portfolio and show the interdisciplinary nature of the research, education and extension activities funded by CSREES, where PA 111 and PA 112 (Water Resources) were identified being a significant subject of the investigation.

Success Stories for PA 111 (Conservation and Efficient Use of Water)

A Hatch Multi-state project focused on **assessing the impact of agricultural technologies and practices** on crop yields, water quality, and profitability. Analyses of 15 proposed irrigation district rehabilitation projects in the Lower Rio Grande Valley found that 49,392 acre feet of water could be conserved each year. Costs of saving water ranged from $16 to $119 per acre foot. Savings ranged from $79 thousand to $5.9 mil. based on the potential cost of saved water. These studies are providing conceptually correct and empirically accurate estimates of the economic value of water and the information necessary to obtain funding for South Texas irrigation district rehabilitation projects. These studies are essential for resource owners and decision makers to make informed choices in water and rehabilitation projects. Survey results of farmers' responses to conservation practices and barriers are being used to identify more effective incentives to increasing irrigation efficiency and to compare reported conservation practices with those actually implemented during severe drought. Alternative water management policies were evaluated and found to have substantial positive economic and water efficiency gains, increasing yields and reducing water loss. Field studies of ultra-narrow rows on corn and grain sorghum showed increased yields compared to conventional tillage over a wide range of

weather conditions. Yields increased 56 to 60 lbs./acre compared to typical 40 inch rows. They also determined the optimum poultry litter application rate to increase yields and profit. Economic assessment of poultry litter application to corn found that small quantity applications (2 tons/acre) to a urea-based fertilizer program resulted in the greatest increases in profit and yields.

For more than ten years Georgia has faced **critical water resource management** issues resulting from increasing population and economic growth in needs for water. The number one priority for the CSREES non-competitively-funded Agriculture Water Policy project's Coastal Rivers Water Planning and Policy Center's research program is the development of data required for the design of basin water plans. The research will assist in the formation of basin plans and new legislation to protect and preserve water resources and water supply in southeast Georgia's 24 county region. Scientific and empirical studies will provide much needed information to Georgia to help determine available water supply. The research will create methods to help measure available water quantities, water use, especially agricultural water use and water needs, help farmers address irrigation, cropping and water conservation under drought conditions, assess drought effects on fisheries and other agribusinesses, and help to implement protective legislation for water resources by providing assistance to government officials and regional stakeholders. The academic program will provide a graduate level certificate and Master of Public Administration (MPA) to educate new water policy professionals.

Success Stories for PA 112 (Watershed Protection)
USDA has a long history of research, education and extension activities related to water quality. Efforts in this section of the portfolio deal with improving our understanding of how agricultural pollutants and practices impact the quality of our Nation's water resources. Two key activities in this portfolio include the development and implementation of the NIWQP, and the activities of the Multi-State Committee S-1004.

National Integrated Water Quality Program
The NIWQP was established in 2000 and provided funding through competitive grants for four types of projects: National Facilitation projects, Regional Coordination projects, Extension/Education projects, and Integrated Research, Education, and Extension projects. The NIWQP brings university scientists, instructors, and extension educators into more effective and efficient partnerships with federal interagency priority programs to address water quality issues in U.S. agriculture. A key emphasis of the program is integration of extension, research, and education resources to solve water quality problems at the local level.

Through a collaborative effort with representatives from land-grant universities and colleges, eight key "themes" were identified that represent critical challenges affecting the quality of our nation's water resources in agricultural and rural watersheds. These themes are:

- Animal manure management;
- Drinking water/Human health;
- Environmental restoration;
- Nutrient and pesticide management;
- Pollution assessment and prevention;
- Water management and conservation;

- Water policy and economics; and
- Watershed management.

NIWQP is guided by the CSREES Committee for Shared Leadership for Water Quality (CSL-WQ). This committee is a unique model for shared leadership which includes representatives from each of the 10 regional coordination projects, representatives from 1890 and 1994 institutions, and the NPL for Water Quality.

A key accomplishment of the NIWQP was establishment of a **national network of extension water quality coordinators** funded through a Regional Coordination component of the program. This network allowed expertise and knowledge to be shared between states, within regions, and between regions across the nation. Regional Coordination projects use state water quality coordinators to promote regional collaboration, enhance delivery of successful programs, and encourage multi-state and multi-regional efforts to protect and restore water resources in 10 regions consistent with the EPA regional structure. Activities include:

- **Annual national water quality conferences** enabled strategic planning and national program coordination organized around the eight key water quality themes listed above. The conference serves as a forum for discussion in water quality. All research, education, and extension projects funded by CSREES water programs are invited to attend this meeting. This conference has expanded each year since the first meeting in 1999; in 2003, over 200 persons attended the conference;
- **The national web site** (www.usawaterquality.org) was used to provide a single, coordinated information site for water quality concerns;
- **Regional water quality** coordination meetings and conferences facilitated resource sharing and technology transfer;
- **Regional water quality databases** were developed to share information and resources across state and regional boundaries; and
- **Partnerships** were formed and strengthened with federal and state agencies and organizations to enhance program delivery.

CSREES funded three other project types in the NIWQP:

- Integrated Projects implement a focused research effort along with outreach education to address a watershed concern;
- Extension Education Projects deliver outreach programs into target watersheds; and
- National Facilitation Projects coordinate and support implementation of successful programs that are relevant across the U.S.

Antibiotics have been found in many watersheds throughout the U.S., but it is not clear whether the source is urban wastewater or animal feed lots. This project investigated the occurrence of several classes of compounds in the Cache la Poudre watershed, Colorado, and determined the source and fate of these compounds and the degree of spatial and temporal variability in the watershed. The study identified antibiotics in waterways that come from both human and animal uses. It is the first study to **identify the presence of drugs specifically from animal sources in stream sediment.** One key result from this study is that the concentration of antibiotics was 20 to 1,000 times greater in sediment than in the surrounding water.

The Public Radio Reporting by the Great Lakes Radio Consortium (GLRC) explores the **relationship between the agricultural sector and water quality** in the Great Lakes Region to increase awareness about the issues of the Great Lakes Watershed among policymakers and the general public. This project not only educates, but also promotes informed decision-making on water quality issues throughout the Great Lakes Region. The GLRC is a primary source of environmental news in the region with more than 140 member stations. Through the regular broadcast of environmental stories, the GLRC affects issues on the public's and policymaker's "radar screen." GLRC regularly gets calls and emails from regional, state and local leaders requesting more information about reports. As GLRC informs policymakers about water quality issues in the Great Lakes Region, they will be in a position to use that knowledge to positively impact public policy and shape resource stewardship. People in the Great Lakes Region have come to trust the GLRC as a reliable source for environmental news.

Fresh water resources are stressed by municipal, agricultural and industrial demand. Managing resources is particularly difficult in the western U.S. where there are chronic shortages, but all regions struggle to maintain water quality during droughts. Surface water and ground water are a single resource within linked reservoirs, but the rates, causes, and impacts of water flow between streams and aquifers are not well understood. Tools developed to **assess the dynamics of streambed seepage** will be used by researchers, water managers, water district personnel, and other stakeholders to assess the nature of surface water - ground water interactions. Studies help determine how stream and ground water management can be optimized to limit negative impacts of nitrate loading associated with agricultural activity, as well as impacts from other potentially-harmful solutes. Methods developed during this project will be applied to wetlands, estuaries, ponds, lakes, and other terrestrial and near-shore environments.

Future Directions

Accessing and providing water of the appropriate quantity and quality for food, fiber and human consumption is the leading environmental issue around the globe. The agency is providing a key part of the knowledge base for water resource management in this global context. Water resource research, extension, and education funded by CSREES will form the foundation of the knowledge needed to answer water resource challenges of the next decade and beyond.

On September 9-10, 2004, the USDA-Research Education, and Economic (REE) Agencies conducted an Agricultural Water Security Listening Session in Utah. The goal was to determine the relevance of current REE efforts and develop the basis for an expanded research, education/extension, and economics program within USDA to take advantage of partnerships with federal and state agencies. Representatives from agencies, universities and colleges, non-profit and private sector firms and local municipalities identified six key topic areas for REE involvement:

1) Targeting drought preparedness and mitigation;
2) Enhancing irrigation efficiency,
3) Focusing on general water conservation;
4) Targeting urban and rural water reuse;
5) Application of biotechnology to PA 111 and PA 112-related activities; and
6) Investigating economics, marketing, and institutions.

Participants identified 19 "Bold Steps" that USDA and particularly the REE mission area can take to move closer to solutions for agricultural water security. A report summarizing the activities and findings of the listening session is being prepared and is expected to be available for comment in December, 2004.

The agency is addressing some of these issues and will use these issues in current and previous RFAs. CSREES water resources programs will likely fund "cohorts" of projects over two years that provide critical knowledge to solve water quantity and water quality problems. The focus will be agricultural and rural watersheds particularly where strong pressures exist from urban/suburban development. In addition to federal mandates and input from stakeholders, future CSREES plans over the next five years include:

- Present a unified RFA for its water resource programs – "One stop shopping for water;"
- Develop a new program focused on Agricultural Water Security that addresses water supply, management, distribution, economics and social impacts;
- Emphasize the social dimensions of water resources issues;
- Emphasize a seamless coordination between research, extension, and education in water resources program linking Competitive, Formula, and non-competitive funding sources;
- Sponsor highly developed "cohorts" of projects funded through competitive, formula, and directed funding mechanisms that focus on timely, appropriate water resource issues; and
- Sponsor a national conference where project cohorts meet with stakeholders and other interested parties to identify knowledge gaps, outreach/education needs and opportunities for collaboration or partnerships.

Population growth across the U.S. and around the world will be accompanied a growing demand for safe, reliable sources of water to meet the needs of the expanding population. Farmers, ranchers, and rural communities are particularly susceptible to the mounting pressures to provide more water to urban areas at the expense of water supplies in rural and agricultural communities. The term "agricultural water security" describes the need to maintain adequate water supplies to meet the food and fiber needs of the expanding population—maximizing the efficiency of water use by farmers, ranchers, and rural communities.

Drought and the reliability of water supplies for agriculture and rural communities historically have been linked to the Western states. Issues surrounding agricultural water security have expanded beyond the West and represent a national crisis. Water supplies for irrigated agriculture in south are being consumed by expanding urban populations. Shifts in the allocation of these water resources could have dramatic impacts on the long-term supply of food and fiber. Water security will become a major topic in the future.

C: PROBLEM AREA 131
Alternate Uses of Land

Overview
According to the Economic Research Service (ERS), the U.S. has 2.3 bil. acres of land, 97 percent of which is classified as rural, and 3 percent is classified as urban. Major land uses include forest (28 percent), pasture and range (26 percent), cropland (20 percent), special use such as parks, wilderness and wildlife refuge (13 percent) and other miscellaneous lands such as deserts, wetlands, barren land (10 percent). The amount of land converted to urban use rose steadily from15 mil. acres in 1945 to 66 mil. in 1997. Forest land declined 10 percent since the 1950's. Federal agricultural commodity policies produced peak cropland acreage in the 1990's and new conservation programs have removed cropland, through programs like the Conservation Reserve Program (CRP), by 36 mil. acres.

Improvements are needed in process models of land use and land cover change spatial and temporal dynamics, combining field-level case studies for analysis of processes, statistical studies for large regions, and empirical analyses using remote sensing change detection. Process-level understanding of land use and cover dynamics will aid analysis of land use and land cover change across scales. Work will be required to understand how one agent or cause of change influences another. Comprehensive understanding of land use and cover change processes considers interactions between socioeconomic and biophysical factors, including synergies between land use dynamics and climate change and variability.

Evolving public and private land management questions call for new data and knowledge, and improved scientific bases for decision making. They require long-term continuity in data collection, and acquisition from local, regional, and national scales. While progress has been made in mapping land cover characteristics, ability to accurately map the wide range of landscape attributes, including land use and biomass, requires effort especially in acquiring data and algorithms for detection of local changes and their characteristics. Data integration is a particularly important research strategy so that *in situ*, remotely sensed and other forms of data can be merged to derive needed land use and land cover information. As scientific demands and needs for land use and land cover information change, parallel innovation in resulting data products and means to communicate knowledge are essential components of this portfolio.

Situation
CSREES has funded research, education and extension on evaluation of alternative uses of land to determine short- and long-term consequences of how changes in land use, management and cover affect local, regional and national environmental and socioeconomic conditions. Changes in response to population growth, urban and suburban growth, recreational needs, and other factors affecting the supply of land are included in this portfolio. Knowledge gained from scientific inquiry educates industry, scientists, students, policy makers, managers, and specialists in the state of science and technology help maintain the balance of providing goods and services in agriculture, forest, range and urban ecosystems. Extension integrates science and educational resources into clear and effective decision support systems and communicating knowledge in a timely, user-friendly manner.

Addressing issues and making science useful requires a focused portfolio that includes mapping, measurement, and monitoring of land use and land cover change from local to global scales; identification of forces driving change; capability to model and project change; and assessment of implications of land use change. Research collaboration with other portfolios is necessary to understand the impacts of land use and cover change on the environment, and combined effects of land use and climate change on ecosystems and hydrological and biogeochemical cycles. Projects have a complimentary relationship to other PAs in NRE as land use and land cover change is linked to the environment and society in complex ways. Changes in the environment and natural resources alter land use practices differently in different climatic regions. Changes in land use affect ecosystems and goods and services they provide on a long-or short term basis.

Input

Funded projects in this PA increased from 85 in 1999 to 180 in 2003 with an increased investment from $970 mil. in 1999 to $2,825 mil. in 2003. (Tables 3-8 and 3-9). While investments from Hatch, McIntire-Stennis, and special grants remained level over this time, NRI funding increased from $148 mil. to $565 mil., and other grants jumped from $23 mil. to $1.4 bil. The focus on research shifted from primarily soil and land in 1999 to a combination of soils, watershed, communities, and rangeland/pasture in 2003. No Evans-Allen or SBIR funds were invested in this PA.

Table 3-8. CSREES Funding by Source, PA 131, Alternative uses of Land, 1999-2003.

Source	Fiscal Year ($ 000)					Total
	1999	2000	2001	2002	2003	
Hatch	418	373	386	473	531	2,181
McIntire-Stennis	278	268	222	148	204	1,120
Special Grants	101	94	101	165	124	585
NRI Grants	148	291	0	80	565	1,084
Other CSREES	23	303	5,185	372	1,400	7,283
Total CSREES	948	1,329	5,894	1,238	2,824	12,233

In 1999, thirty-three states were funded, especially those with more urbanized areas. Topic ranged from arid to wetlands, watersheds, forest, range, cropland management, farm land preservation and open space protection, as well as controlling urban growth. Several projects used emerging technologies in GIS and remote sensing to conduct spatial analysis and link it to systems or models to project future scenarios. Four projects were part of multi-state committees and three addressed land use practices of limited resources farmers, ethnic minorities, and Native Americans.

By 2003, 42 states were funded, including one 1890 institution and 6 tribal colleges funded by SERD, and the Initiative for Future Agriculture & Food Systems (IFAFS) Program. Multi-state projects included 9 more regional projects and the Northeast Regional Rural Development Center. In a contributory relationship with other PAs, more multi-state and regional projects that included this PA were reported as part of the Water Quality and other IFAFS Programs.

Table 3-9. CSREES, Other Federal, Other Non-Federal Funding, PA 131, Alternative Uses of Land, 1999 and 2003.

Fiscal Year	Source ($ 000)							Total	CSREES % of Total
	CSREES	Other USDA	Other Federal	State	Self Generated	Individual Grant	Other Non-federal		
1999	970	286	870	3,652	285	222	795	6,795	14
2003	2,825	806	3,069	3,921	242	1,055	1,382	13,300	21

Performance Criteria

This problem area addresses the critical issues related to the following:

- Identifying methodological advances to improve land use and land-cover change analyses, including strategies for integrating ground-based data, socioeconomic statistics (e.g. census information), and remotely sensed measurements;
- Identifying the current areas of rapid land-use and land-cover change at local, regional, and national scales;
- Assessing how environmental, institutional, political, technological, demographic, and economic processes determine temporal and spatial distribution of land use and land cover over the next few decades;
- Characterizing how different scenarios of land-use change stress or enhance the productivity of our natural resource base and the industries that depend on it, especially agriculture and forestry; and
- Determining how land-use and land-cover changes affect the form and functioning of ecosystems, including the ability to provide essential goods and services and levels of ecosystem biodiversity, and what are the ecological, economic, public health, and social benefits and costs of the changes.

Performance Indicators

- Created maps of areas of rapid land-use and land-cover change and location and extent of fires; this includes national land-cover database for the U.S. that includes attributes of land cover and vegetation canopy characteristics
- Quantified and projected possible drivers of land-use change for a range of economic, environmental, and social values
- Reported social, economic, and ecological impacts of urbanization on other land uses; this includes reports on the social, economic, and ecological impacts of different scenarios of land-use change on agriculture, grazing, and forestry
- Identified to the extent possible the regions in the U.S. where land use and climate change may have the most significant need for land management
- Identified to the extent possible past trends in land cover or land use attributed to changes in agricultural or forest practices (e.g., changes in forest type, changes in specific agricultural crops, or changes in the presence or absence of agriculture)

Outputs

Research, education and extension activities from this portfolio have accomplished, among other things, the following.

- Quantify and verify the composition and configuration of various state landscapes under historic and present conditions and quantify the changes over time
- Assessed the relative impact of land-use patterns – residential, commercial and industrial growth- upon farm families and the economic development of various states
- Examined the extent of agricultural land loss in various states using an integration of remote sensing, geographic information systems and global positioning systems
- Produced or developed various environmental and socio-economic models to simulate and explain various factors that alter stable demographic and economic land use patterns
- Determined the necessary data to detect significant change in vegetation structure and to predict vegetation change
- Develop new analytical tools and information systems on land conservation and sustainable land management for stakeholders and industry professionals
- Assembled GIS data layers needed to assess fragmentation and forest conservation/restoration potential including private land conservation, easement/program enrollment, forest/non-forest land cover and landscape context fragmentation indices
- Developed new computer tools to assist decision makers in utilizing the best science to assess the consequences of alternative land use and rate the relative value of importance of such consequences
- Improved interdisciplinary collaboration between the social and natural scientists studying land use planning and policy
- Developed regional Cooperative Extension System education and training programs to provide an in-depth understanding of how public land policies affect economic and social activities in rural communities dependent on public lands
- Develop new and better tools for water resource planning and sustainable land-use that both restore nature and protect land from flood damages.
- Develop user-friendly, cyber-based systems that would easily and quickly transmit to stakeholders decision support systems for risk assessment and decision making processes.
- Develop coupled climate and land use/cover models that incorporate socioeconomic factors and ecosystem function to determine contemporary impacts of land-use and land-cover change and calibrate impacts on the sustainability of ecosystem goods and services.

Outcomes

Short Term

- Improved use of satellites for monitoring forest and natural systems to determine land cover and land use through the increased availability of imagery and ground truthing methods
- Increased use of geographical information systems computer mapping techniques with housing and demographic data to geographically define the urban/rural fringe and estimate how different fringe landscape characteristics impact urban sprawl
- Developed maps showing the level of fire potential for regions of the U.S. that identify where efforts are most needed to limit the impact of wildfires

Medium Term

- Combine satellite-based land-cover data and ground-based agricultural census data to derive global, spatially explicit data sets of agricultural land cover land-use practices
- Define how successional vegetation changes affect water, carbon and other biogeochemical cycles over historical land cover changes in response to fires
- Determine the amount of gross area changes in land use and land cover to provide a baseline against which future changes in agricultural, rangeland and forest cover can be assessed by creating new baselines and identifying changes in baselines of information

Long Term

- Quantify, understand, model, and project natural and human drivers of land-use and land-cover change
- Improved characterization of regional land-atmosphere interactions, including the water cycle associated with land use and land cover
- Project land use changes, especially deforestation, due to pressures to develop rural land as the human population expands

Accomplishments/Impacts

To illustrate the accomplishments achieved by this portfolio for the period covering 1999-2003, examples of funded projects and success stories are presented below. Most of the projects described are research based, however they all have included as part of their objectives strong educational and extension activities associated with their specific scientific objectives. A few projects are more directly involved with extension and education, especially those that focus on developing analytical tools or management systems for economic or urban planning. These examples show the diversity of funded topics and the interdisciplinary nature of the research, education and extension activities conducted by CSREES where PA131 (Alternative Uses of Land) was an identified problem areas under investigation.

Success Stories

Land Use Change and Agricultural Competitiveness in the Midwest

This research explored how agriculture adjusts and adapts to changing land uses, particularly urbanization. The hypothesis was that as development occurs, agriculture remains competitive by adapting with a range of options (e.g., changing crops, renting land, adjusting capital intensity, adjusting cash rents). Objectives were: 1) assess how crop choices in the Midwest are affected by urbanization; 2) develop a model that predicts crop choice and land use simultaneously; 3) explore the effect of non-farm ownership on farming practices and explore how capital-land ratio changes at different distances from urban centers and different land rental rates. The research has successfully provided a richer understanding of how **crop choices are affected by development pressures, how crop choices affect development, and how land tenure affects crop choice and capital intensity decisions**. Given widespread changes in land use that have occurred within the U.S. over the past 20 years, the results will help policy makers understand the potential implications of future development, and shifts in population, on the agricultural sector. This is particularly important for the Midwestern U.S., which has experienced large increases in population in recent years. The research impacts farmers' choices of capital investment and crops affect the marginal productivity of cropland and hence, land-use

change, and that land-use change affects the choice of capital investment and crops. The models will show how cropping choices are affected by urbanization pressures; how crop and capital intensity decisions influence the marginal productivity of land and hence land use change; and how land tenure affects crop choices and capital intensity decisions.

Land Cover Change in Rhode Island from 1972 to 2002 and the Impact on Forest Ecosystems

This project obtained quantitative information of land-cover changes and the impact of human induced disturbance (e.g., urban sprawl) on forest ecosystems and natural resources. Land-cover changes involved major transitions of forested land to urban land-classes. About 14,986 hectares of forested land were converted into urban land between 1972 and 1985 resulting in a 21 percent increase in urban land-cover. Likewise, 6,551 ha. of forested land and 4,806 of deciduous forest were converted into urban land between 1985 and 1999 resulting in an 18 percent increase in urban land-cover. As forested land declined in spatial extent, it declined in connectivity as the number of forest patches increased in the state. Forests in open space and areas defined as rare and endangered species habitat were impacted by urban development between 1972 and 1999. Urban development increased by 36.6 percent, resulting in an increase of discrete forest patches from 8,509 to 33,040, and a decrease from 5.10 to 1.34 ha. in the average size of forest patches. Surprisingly, the entire forested landscape did not decline in spatial extent, but instead increased 2.4 percent. This research provided valuable insight into the **extent and rate of land-cover changes in Rhode Island and the impacts of human activity on forest landscape** characteristics over the last three decades. This project makes the power of remote sensing technology and the map products accessible and useable to decision makers and land managers in planning and development activities. The dataset and analyses are easily interpretable for use by the general public. Output data are valuable for education and research in regional and statewide studies.

A Planning Model for Assessment of Agricultural Potential in Appalachia Using Information Technology Tools

This research models a planning process for rural areas that makes use of digital data to address land use issues. Evaluation factors such as soil quality, slope, and climate and water availability were considered, with factors such as location relative to transportation, availability of agricultural infrastructure, and other contextual conditions included. This project successfully organized data through modeling the information needs and decision processes for predicting the suitability of land for a particular use, e.g. the prototype land use modeled was vegetable production. The land use suitability criteria and decision processes will be formalized within an Expert System, which will query a GIS database to assess the attributes of particular locations and determine the suitability of those locations for specific land uses. This Expert System will be an interactive program which will guide users through the land evaluation process. The model will then be expanded to address the potential for other agricultural endeavors. The project continues to evaluate newly available data and to explore structuring the data to be most useful in assessing regional potential to impact vegetable production in the region. As an output of this project, the Expert System provides a useful tool for farmers and land use managers in assessing the agricultural potential of various crops as suitable for various regions given current technological information and observations systems.

Portfolio Impacts

Research, education, and extension activities in this portfolio for the period 1999-2003 have made major impacts documenting and understanding changes in land use in response to population growth, urban and suburban growth, and recreational needs. The impacts have mostly been regional in application which is what can be expected given the current state of information and modeling. Disturbances to the land-based ecosystem, such as fires, crop damaging pests, climate change, and soil erosion are some drivers of land use change studied under this portfolio. Well developed education and extension activities have contributed to increased awareness of the drivers of land use change as well as the impacts of change on the environment and humans. Socioeconomic issues have become important components of research, education, and extension activities and will continue to be future. Some documented impacts of the work in this portfolio are outlined below.

- Studies of forest fires show that the high-risk areas in the Southwestern U.S. are public forests, urban-forest interface locations, and young pine and mixed stands. Maps have been developed showing the level of fire potential for these areas. This information helps identify where efforts are most needed to limit the impact of wildfires.
- Several projects have improved our ability to use satellites for monitoring forest and natural systems. Satellites record the amount of reflected radiation from a target. Using this information and ground truthing, classification algorithms are developed to identify objects on the ground. Improving the classification algorithms is important to make more accurate maps and have more accurate data for making intelligent management decisions.
- Riparian agricultural lands in California face the dual problem of high exposure to flood risk and low availability of natural habitats to sustain a healthy ecosystem. Research on the pre-historic, historic, and on-going environmental conditions present at a representative area are being used for water resource planning and sustainable land-use that restore nature and protect land from flood damages.
- Michigan State University CES United Growth for Kent County is helping develop elementary students into tomorrow's land use leaders. The organization released a curriculum to educate students to address problems associated with poor land use planning. This Land is Your Land curriculum targets 3rd through 5th grade students. Nearly 500 educators use the curriculum in classrooms and MSU extension activities. The curriculum uses activity-based, service learning to help students begin involvement by working with their parents. Activities include conducting neighborhood surveys, participating in planning commission meetings, and planning imaginary cities.
- Researchers at Clemson University combined GIS computer mapping with housing and demographic data to 1) geographically define the urban/rural fringe in the Piedmont Region counties of Pickens, Oconee, Anderson, Greenville, and Spartanburg; 2) estimate the value of living in the urban/rural fringe using hedonic analysis; and 3) estimate how different fringe landscape characteristics impact housing values. This research provides knowledge to developers of residential subdivisions, rural development experts interested in the relationship between economic development, environmental amenities, and quality of life, and government officials interested in learning what landscape amenities residents' value for improved regulation of growth, development, and natural resource management.

- National projections of changes in land use and land cover were updated as part of a national renewable resources assessment, designed in part to support global climate change analyses. Projected land use changes include deforestation due to pressures to develop rural land as the human population expands—a larger area than that converted from other rural lands (e.g., agriculture) to forestry.

Future Directions

Societal demands for land in residential, commercial, and industrial uses are expected to continue to increase with growing populations and rising incomes. The agency has several methods for engaging stakeholders in identifying directions of its programs. States' POWs require universities to engage stakeholder input in developing planned activities. NPLs review academic programs at land grant institutions. The Global Change and Climate NPL has been engaging stakeholders for input in developing planned activities in relation to the U.S. Climate Change Science Program. NPLs participate in national and international scientific meetings, and engage others including state, federal, NGOs and academic personnel all in an effort to ensure that programs are relevant and of high quality.

Future funding directions call for research to develop and evaluate methods for analyzing associated implications for wildlife habitat, timber supplies, carbon sequestration for climate change mitigation, biodiversity, and other ecological and economic impacts. Spatial econometric studies need to be conducted to focus on forest-cover changes, with expanded use of ecological and economic theories to guide model development and enhance robustness of projected changes.

With remotely sensed data, researchers are able to map global land cover consistently from space. Remotely sensed data do not yet have the ability to distinguish between characteristics of agricultural land use. While they distinguish croplands from other land cover, they are as yet unable to distinguish between different crops, identify irrigated land, or the amount of fertilizer applied. This information is available only from ground-based sources, such as census data and land surveys. Satellite-based land-cover data and ground-based agricultural census data will be used to derive global, spatially explicit data sets of agricultural land cover (croplands, pastures, natural ecosystems) and land-use practices (cropping systems, irrigation, fertilization). These data sets are critically important for study of ecosystem consequences of global agricultural land-cover change, including trade-offs between ecosystem goods and services.

An innovative approach is needed to quantify, understand, model, and project natural and human drivers of land-use and land-cover change. Research is needed to understand and project the interactions of economic, social, and environmental choices on land use and management policies and decisions. New techniques and tools that integrate understanding of human behavior, opportunities, consequences, and alternatives are needed for improved decision making and policy making.

Other portfolios at CSREES provide complementary information about the environmental and biophysical forces that influence potential land uses (e.g., atmospheric chemistry and processes, climate variability and change, water resources, nutrient flows, ecological processes) and the anthropogenic pressures that will give rise to various land uses and processes (e.g., human

contributions and responses). Development of coupled climate-land use/cover models that incorporate socioeconomic factors and ecosystem function will be emphasized. The challenge is to use contemporary impacts of land-use and -cover change to calibrate impacts on ecosystem goods and services; biogeochemical, water, and energy cycles; and climate processes. Research requires multidisciplinary cooperation to develop land-use and land-cover projections that address spatial and temporal scales, and include physical, biological, and social factors of interest to ensure that projections can be incorporated into models of impacts. Integrated knowledge in a user-friendly, cyber-based system is transmitted to stakeholders for risk assessment and decision making.

D: PROBLEM AREA 132
Weather and Climate

Overview
Land-based systems, such as agricultural fields and forests, interact in a dynamic manner with both short- and long-term changes in regional and global climate. Environmental change may affect water cycles, atmospheric transport and deposition of pollutants, biogeochemical cycles, vegetation quality, and harmful radiation. Understanding how these changes affect food, fiber, and forestry production in agricultural, forest, and range ecosystems is critical to the competitiveness and sustainability in agriculture.

One of the most pressing issues faced by plant and animal producers is to adapt to ever-changing conditions and impacts of climate on their specific crop or animal production. A second critical issue is a need for various scientific and technical information for planning and decision making in order for agricultural producers to sustain an economically viable commodity. Historic plant and animal production levels point toward some impacts of climate or environmental change on their growth and development. The modern producer must determine how to use the different sources of information to increase profits and conserve resources. Decisions on most appropriate species type, cultivar or breed, planting or breeding time, tillage, feeds and fertilization, pesticide or vitamin application, irrigation, harvest, storage, and sale of the product must be made. These factors must adapt in one form or another, or be chosen with respect to, changes in the environment brought about by weather and climate parameters. Scientific information on weather and climate and its impacts on soils, water, air, plant and animal biology and the general environment enables our development of robust simulation models to provide guidance on the relative benefits and outcomes associated with agronomic decisions.

Conversely, agriculture and forests affect the environment, including impacts on global warming through the production of greenhouse gases. In 2004, EPA estimated that agriculture contributed approximately 7 percent of the U.S. greenhouse gas emissions, primarily as methane and nitrous oxide. While agriculture represents a small but relevant source of greenhouse gas emissions, it has the potential, with new practices, to also act as a sink, tying up or sequestering CO_2 from the atmosphere in the form of soil carbon. This and other agricultural and forest practices provide a partial solution to the problems associated with greenhouse gases. Estimates of the potential for agricultural conservation practices to enhance soil carbon storage range from 154-368 million metric tons carbon equivalents (MmtCE), which compare favorably to the 345 MmtCE of reduction proposed for the U.S. under the Kyoto Protocol. Thus, agricultural systems can be manipulated for the benefits of reducing greenhouse gas emissions and enhancing carbon sequestration.

Situation
CSREES had funded research, extension and education projects addressing issues on weather and climate since the inception of the agency in 1994 and even before that. It was in 2004, however, that a separate and distinct program on Global Change and Climate with its own National Program Leader was established. This program uses an interdisciplinary approach to address the impacts of global change and climate (including weather) and mitigate their adverse effects on agricultural production, and the forest and rangeland resources.

CSREES weather and climate projects focus on determining the effects of global change and climate on land-based systems and the global carbon cycle and on identifying agricultural and forestry activities that can help reduce greenhouse gas concentrations. Research can help identify, describe, and quantify processes involved in the cycling of organic and inorganic carbon in soil. Global change extension programs focus on 1) technologies and practices to reduce carbon in the atmosphere and 2) risk management practices to anticipate natural and human impacts on agricultural ecosystem dynamics. Education and extension activities provide robust scientific information for learning and decision support systems for citizens and public officials to evaluate the environmental and socioeconomic impacts of policy options for sustainable resource management.

For example, the agency supports research to determine the influence of irrigation practices and water management on carbon storage in land-based systems. Irrigation schedules and best practices are then communicated to stakeholders for implementation. Contributions from research programs include new tools for accurately measuring greenhouse gases, methods for measuring and estimating carbon in ecosystems at different scales, and effective ways to sustain productivity in a changing environment. Mitigation steps to reduce carbon dioxide or methane emissions are then taught to industry professionals and education specialists to achieve national goals of greenhouse gas reductions. To achieve a true holistic view of global change and climate impacts, future research, education and extension projects will occur on an integrated level. This type of thinking brings together the natural sciences, engineering, mathematics, business, social and political sciences, economics, and education to achieve a system science view of agricultural and forestry production and sustainability. This approach provides reliable knowledge for decision-making processes on regional and national levels.

In order to address issues of adapting agriculture to varying climate conditions, the following major topics have been undertaken:

- Develop an improved understanding of seasonal climate variability and climate predictability at local to regional scales;
- Characterize the contributions of climate variability to risks in management of agricultural, forestry, and water resources;
- Develop information and decision aids based on the use of seasonal climate forecasts, historical climate data, and other climate analyses that help decision-makers and industry professionals identify management options to reduce risk and increase profits while sustaining the ecosystems;
- Design and implement appropriate vehicles for disseminating climate and decision support information, including an Internet-based learning and decision support system; and
- Develop partnerships needed to build socially equitable extension and outreach programs for farmers, forest managers, water resource managers, homeowners, and policy makers to enhance users' familiarity with these new seasonal climate forecasts and decision aids and to provide mechanisms for users to give feedback to researchers.

The major themes include:

- Assess the current situation regarding the global warming contribution of various farming systems;
- Develop strategies for changing the farming practices to maximize global warming mitigation; and
- Evaluate the potential and actual mitigation through computer modeling and demonstration sites.

The focus areas do not represent the entire universe of projects under this portfolio. They do, however, represent the general direction of the research, education and extension activities conducted with climate and weather identified as a major problem area or a component area under investigation.

Input

Funding to support this program area through CSREES was made available through a mixture of Hatch, McIntire-Stennis, special grants, competitive grants through the National Research Initiative and from other grants comprised of federal administrative programs; homeland security, capacity building projects, etc. (Table 3-10). The majority of CSREES funds for this program were formula-based, i.e. Hatch, about 10 percent were through the competitive grants, and the rest through special and other grants. A comparison of projects funded through these programs indicates a decrease from 1999 (131 projects) to 2000 (102 projects). From 2000-2002 the number of projects remained fairly steady and then dramatically increased to 161 in 2003 due to a significant influx of special grants and a higher success rate in the NRI. For the most part, however, special grants and other grants come and go year after year while formula funds and, to a certain extent NRI funds, remain pretty steady.

Table 3-10. CSREES Funding by Source, PA 132, Weather and Climate, 1999–2003.

Source	Fiscal Year ($ 000)					Total
	1999	2000	2001	2002	2003	
Hatch	1,347	988	1,005	929	845	5,114
McIntire-Stennis	51	30	39	119	147	386
Special Grants	0	239	0	243	1,365	1,847
NRI Grants	141	111	160	93	227	732
Other CSREES	34	146	753	125	1,664	2,722
Total CSREES	1,573	1,514	1,957	1,509	4,248	10,801

Combined funding for this program from federal sources was approximately $5.5mil. comprising 36 percent of total funding in 1999 while state funded projects contribute almost half of the funding (Table 3-11). In 2003, CSREES and other federal funding each increased by about 10 percent while state funding decreased by the same amount. Special grants were responsible for the almost three fold increase in agency funding between 1999 and 2003.

Table 3-11. CSREES, Other Federal, Other Non-Federal Funding, PA 132, Weather and Climate, 1999 and 2003.

Fiscal Year	Source ($ 000)							Total	CSREES % of Total
	CSREES	Other USDA	Other Federal	State	Self Generated	Individual Grant	Other Non-federal		
1999	1,574	608	3,293	7,003	447	777	1,398	15,100	10
2003	4,250	1,013	5,848	6,190	667	720	860	19,548	22

Performance Criteria

This problem area addresses the critical issues related to weather and climate with an emphasis on atmospheric composition, climate variability, carbon cycling, hydrological and nutrient cycles, economic and social policy, and land use. The research areas of this program focused on measuring and understanding the processes and dynamics that shape the physical, chemical, and biological environment of the land, atmosphere, and water pertinent with an emphasis on agricultural, range, and forest ecosystems. The education and extension activities focused on disseminating information on technologies and practices to adapt to the ever changing conditions and impacts of climate on their specific crop or animal production and provide risk management practices to anticipate natural and human impacts on agricultural ecosystem dynamics. Examples of performance criteria are:

- Identifying the mechanisms and processes responsible for the maintenance and variability of the water cycle, how the characteristics of the cycle change and to what extent are human activities responsible for those changes;
- Discovering how climate variability and change affect land use and land cover, and identify the potential feedbacks of changes in land use and land cover to climate;
- Characterizing the effects on carbon sources and sinks of past, present, and future land-use change and resource management practices at local, regional, and global scales.
- Establishing the options for sustaining and improving ecological systems and related goods and services, given projected global changes; and
- Determining the magnitudes, interrelationships, and significance of the primary human drivers of, and their potential impact on, global environmental change.

Performance Indicators

- Achieved an interdisciplinary program of regional and global climate variability to characterize the complex sources, sinks, transformations, and fluxes of biologically important elements in relation to climate;
- Developed coupled models of climate variability and biogeochemical cycles to predict the impact of changes at multiples scales and improve predictions of climate variability from extreme events to gradual changes, and from annual to decadal time scales;
- Designed and implemented appropriate mechanisms for disseminating climate and decision support information to stakeholders and policy makers; and
- Built solid partnerships for extension and outreach programs for farmers, forest managers, water resource managers, homeowners, and policy makers to enhance the full and proper use of climate forecasts and decision aids and to provide mechanisms for users to give feedback to researchers.

Outputs

Research, education and extension activities from this portfolio have accomplished, among other things, the following:

- Improved management strategies for major crops in various states;
- Improved crop models representing and forecasting the growing conditions of North Central Region and potentially other states;
- New, more precise forecast techniques based on improved representation of climate conditions from combined datasets;
- New planting and irrigation scheduling techniques for managed systems;
- Improved representation of historic and current atmospheric and soil moisture conditions;
- New web application to display and serve data to more users; and
- New partnerships with state, county and federal institutions to share data and information gathered from different parts of the U.S.

Outcomes

Short term

- Better decision-making tools and management practices for irrigation and water use including new drought monitoring and early warning products;
- Soil moisture climatologies for various soil types in different climatic regions of the continental U.S.;
- New atmospheric moisture climatologies detailing moisture conditions in spatial and temporal scales;
- Better access to disparate data sets including weather and soils data in combination with crop yield histories; and
- Landscape-scale estimates of carbon stocks in agricultural, forest, and range systems and unmanaged ecosystems from spatially-resolved carbon inventory and remote sensing data.

Medium Term

- Model physical/biological and socioeconomic processes to facilitate efficient water resources management;
- Improved monitoring, measuring, and mapping of land use and land cover, projecting future atmospheric carbon dioxide and methane concentrations and changes in land-based carbon sinks;
- Web based decision support packages composed climate forecast tools and a crop yield tools for industry professionals;
- Improved observation systems at all scales for the analyses of bio-geochemical cycles and climate variability and change and understanding how ecosystems are organized, function, and change;
- Models to evaluate the consequences of human perturbations on essential nutrient cycles in soils, sediments, water, and other ecosystems; and
- Better comprehension of the impact of land-use change and resource management practices on carbon sources and sinks.

Long Term

- Prediction of precipitation and evaporation on time scales of months to years and longer.
- Identification and quantification of the human drivers of land-use and land-cover change;
- Projection of land-cover and land-use change under various scenarios of climate, demographic, economic, and technological trends;
- Social options to ensure that desirable ecosystem goods and services will be sustained under a changing climate;
- New decision making strategies and institutional approaches that effectively combine analytical, deliberative, and participatory approaches to environmental choices; and
- New decision making tools focusing on conditions of significant complexity and uncertainty of crop and animal production under various climatic conditions.

Accomplishments/Outcomes

To illustrate the accomplishments achieved by this portfolio for the period covering 1999-2003, examples of funded projects and success stories are presented below. Most of the projects described are research-based, however they all have included as part of their objectives strong educational and extension activities associated with their specific scientific objectives. A few projects are more directly involved with extension and education, especially those that focus on developing decision support or management systems and the traditional mechanisms or web based tools used to present them.

The selected research, education and extension projects active during 1999-2003 show the diversity of funded research topics and the interdisciplinary nature of the activities conducted by CSREES where PA132 (Weather and Climate) was one of the identified problem areas under investigation.

Success Stories

Southeast Climate Consortium

SECC was formed in 2002 with funds from CSREES and National Oceanic and Atmospheric Administration. This group's mandate is to develop a climate information and decision support system for the Southeastern U.S. that contributes to improved quality of life, increased profitability, decreased economic risks, and more ecologically sustainable management of agriculture, forestry, and water resources. SECC developed **regional climate models** to explore use the El Nino Southern Oscillation (ENSO) forecast system to provide tailored output for socioeconomic sectors in small regions, primarily the Southeast U.S. and South America. Research at SECC includes integration of weather generators with climate models; the assessment of agricultural impact through the analysis of historical crop yields and simulated yield potentials; understanding forestry risk and its minimization; water quality assessment and policy analysis; and the development of crop management optimization toolkits and programs to explore optimal management options under different ENSO conditions and optimization criteria. SECC includes scientific experts in climatology, agriculture, hydrology, marine and atmospheric sciences, and economics. These experts work in close collaboration with each other and with clientele to improve our understanding of climate, how climate affects our daily lives, and to develop teaching and decision aids from climate information. The current six member

institutions are Florida State University (lead institution), University of Florida, University of Miami, University of Georgia, Auburn University, and University of Alabama, Hunstville.

The consortium's biggest success has been the development of a web based **Agriculture Climate Tools package** composed of a climate forecast tool and a crop yield tool. The SECC Climate Forecast Tool provides county level 1) Monthly climate forecasts of average precipitation and min/max temperatures; 2) Probabilities for these variables to help analyze risk; and 3) Observed values for the past five years. The **SECC Crop Yield Tool** analyzes yield potential based on climate forecast and planting dates. The results are based on crop model simulations and are only available for a limited number of counties, depending on the crop selected. Crops under implementation are 1) Peanut (selected counties in Alabama, Georgia, and Florida); 2) potato (Suwannee County, Florida); and 3) fresh tomato (South Florida).

Climate Friendly Farm

This is a project from Washington State University's Center for Sustaining Agriculture and Natural Resources and is funded by CSREES through a Special Grant. The focus of the project is on dairy production, irrigated crop farming, and dry land grain farming, three farming systems of importance for Washington and the world. The project goals are: 1) assess the current situation regarding the global warming contribution of dairy farming, irrigated crop farming and dry land farming; 2) develop strategies for changing farming practices to maximize global warming mitigation; and 3) evaluate the potential and actual mitigation through computer modeling and demonstration sites. The project approaches include technology research and development, socioeconomic analysis and systems modeling, on-farm implementation of demonstrations, and educational outreach.

Key project tasks include development of an **improved anaerobic digester** for treating dairy waste, development of whole farm nutrient management strategies and an associated decision support system for dairy farms, integration of **reduced tillage and residue management to increase soil carbon storage**, irrigation **water management to improve N cycling**, and outreach and education. Expected impacts of the project include the documentation of new technology, farm practices, and systems that can mitigate multiple environmental problems and lead to measurable improvements in natural greenhouse gas storage (in soil), water use, and nutrient cycling on farms.

Impact of Climate and Soils on Crop Selection and Management

This multi-state project has been in existence for nearly fifty years. It works on research activities related to the impact of weather and climate on agriculture in the North Central Region and other member states. The project helped move forward several major agro-climatological innovations, including some of the first successful efforts to collect and electronically enter data for agro-climatological studies. The project proposed and championed the formation of **regional climate centers** that have now successfully provided data to the general public and performed research activities on regional climate for almost 20 years. It has also conducted research activities on regional climate and its impact on agricultural production and resource use. Recent innovative work has resulted in a temporally and spatially consistent dataset for climate, soils, and crops over the North Central Region. At a county level, daily information for climate and

annual cropping is available from a single, comprehensive database. The most recent research has evaluated methods to estimate daily solar radiation totals from existing climate information.

The project database now includes most of the basic input information needed to run a variety of **crop simulations** for various applications, including regional yield prediction. That has been part of the goal from the existing plan of work. Crop simulations for several counties and soil types in each state have been run and inter-compared for model comparison and model consistency with observed data. Another outcome from the data compilation has been a unique publication, the North Central Region Agricultural Climate Atlas. This collection of pertinent climate, soil and crop information derived from the existing database. A web site under development will allow users to access and analyze the data set on-line. This would be the first web site of its kind to analyze agriculture in that region.

Members of this multi-state project are land-grant universities in Florida, Georgia, Illinois, Indiana, Kansas, Michigan, Minnesota, Montana, Nebraska, New York, North Dakota, Ohio, South Dakota and Texas.

Portfolio Impacts

Research, education and extension activities in this portfolio for the period 1999-2003 have made major impacts towards documenting and understanding changes in land-based ecosystems in response to various global change and climate influences. The impacts have mostly been regional in application but directly focused on the agricultural or forest industry of the region or state. The effects of climate change on agriculture and forest product productivity are just some of the issues that have been studied under this portfolio. The socioeconomic impacts and human dimensions of climate related events have been well documented. In addition, well developed educational and extension activities have contributed to an increase in awareness of the influence of climate as well was the impacts of environmental change on biological systems and human societies. Socioeconomic policies and decision support mechanisms have become important components of research, education and extension activities and will continue to be so in the future.

Some of the documented impacts of the work in this portfolio are outlined below.

- Improved yield forecasts have improved marketability of crops and ultimately lead to better economic decision-making based on better information;
- Better decision-making for irrigation has improved profitability for farmers using irrigation. It will continue improve the use efficiency of water especially during droughts;
- Decision tools for better water management particularly in hard-hit drought areas have made the most efficient use of scarce water resources;
- Developments of soil moisture climatologies fill a critical gap in understanding crop production and the dynamic changes in soil moisture over time and during the growing season;
- Atmospheric moisture climatologies have provided improved understanding of moisture conditions in spatial and temporal detail, which are necessary for improved pest forecasts and ultimately more precise use of chemicals and improved profitability;

- Climatologies of new climate variables have improved the crop modeling capability by filling unknown information across regions;
- Better access to disparate data sets and comparison techniques for comparing them have allowed for more detailed comparison and representation of the current weather and climate situation local to national scales;
- Better access to weather and soils data in combination with crop yield histories for model testing has resulted in improved crop model capabilities;
- Landscape-scale estimates of carbon stocks in agricultural, forest, and range systems and unmanaged ecosystems from spatially-resolved carbon inventory and remote sensing data have provided enhanced capability for estimating the future capacity of carbon sources and sinks and will guide full carbon accounting on regional and continental scales. These results are a prerequisite for planning, implementing, and monitoring carbon management practices in North America; an
- New drought monitoring and early warning products based on improved measurements of precipitation, soil moisture, and runoff, and data assimilation techniques have improved drought mitigation planning.

Future Directions

The portfolio continues its current efforts to provide leadership in dealing with the critical issues faced by agricultural producers and the forestry industry to maintain its natural resources, sustain productivity of their respective products, and understand the feedback impacts of agriculture, forest and rangelands on climate. The Global Change and Climate Program at CSREES, which oversees this portfolio, will be working towards implementing the strategic plan of the US Climate Change Science Program which describes a strategy for developing knowledge of variability and change in climate and related and human systems and for encouraging the application of this knowledge. The portfolio aims to address the issues surrounding climate and global change in the following areas.

Global Water Cycle

Research on the global water cycle will focus on how natural processes and human activities influence the distribution and quality of water within the Earth system, whether changes are predictable, and on the effects of variability and change in the water cycle on human systems. Specific areas include identifying trends in the intensity of the water cycle and determining the causes of these changes (including feedback effects of clouds on the global water and energy budgets as well as the global climate system); predicting precipitation and evaporation on time scales of months to years and longer; and modeling physical/biological and socioeconomic processes to facilitate efficient water resources management.

Land-Use/Land-Cover Change

Research on land-use and land-cover change will focus on: 1) the processes that determine the temporal and spatial distributions of land cover and land use at local, regional, and global scales, and how and how well, land use and land cover can be projected over time scales of 5 to 50 years; and 2) how changes in land use, management, and cover may affect local, regional, and global environmental and socioeconomic conditions, including economic welfare and human health, taking into consideration socioeconomic factors and potential technological change. Specific foci will identify and quantify the human drivers of land-use and land-cover change;

improve monitoring, measuring, and mapping of land use and land cover, and the management of these data; and develop projections of land-cover and land-use change under various scenarios of climate, demographic, economic, and technological trends.

Global Carbon Cycle
Research on the global carbon cycle will focus on identifying the size, variability, and potential future changes to reservoirs and fluxes of carbon within the Earth system; and providing the scientific underpinning for evaluating options to manage carbon sources and sinks. Specific programs and projects focus on North American and oceanic carbon sources and sinks; the impact of land-use change and resource management practices on carbon sources and sinks; projecting future atmospheric carbon dioxide and methane concentrations and changes in land-based and marine carbon sinks; and the global distribution of carbon sources and sinks and how they are changing.

Ecosystems
Research on ecosystems will focus on: 1) how natural and human-induced environmental changes interact to affect the structure and function of ecosystems (and the goods and services they provide) at a range of spatial and temporal scales, including those ecosystem processes that in turn influence regional and global environmental changes; and 2) what options society may have to ensure that desirable ecosystem goods and services will be sustained, or enhanced, in the context of still uncertain regional and global environmental changes.

Human Contributions and Responses
Research on human contributions and responses to global change focuses on the interactions of changes in the global environment and human activities. The current focus of this research is on the potential effects of climate variability and change on human health and welfare; human influences on the climate system, land use, and other global environmental changes; analyses of societal vulnerability and resilience to global environmental change; decision making under conditions of significant complexity and uncertainty; and integrated assessment methods.

E: PROBLEM AREA 133
Pollution Prevention and Mitigation

Overview

Pollution from agriculture first became a national issue in the 1930's with the air pollution effects of the Dustbowl. Soil erosion by wind and water were severe enough to lead to the formation of a new USDA agency, the Soil Conservation Service (now Natural Resources Conservation Service (NRCS)). However, NRCS has no research authority to study the problem or develop control methods. Universities and the USDA Agricultural Research Service (ARS) have continued to develop new tillage, crop rotation and engineering measures to prevent pollution from soil erosion. Sediment continues to be the biggest pollutant by volume, in rivers and lakes according to the U.S. Geological Survey.

The publication of *Silent Spring* by Rachel Carson in the 1960's drew attention to pollution effects of agricultural pesticides such as DDT and its impact on ecosystems and wildlife. Research and education to substitute safer pesticides and non-chemical methods of pest control have restored many ecosystems, but some pesticides continue to exceed drinking water standards or are implicated in ecosystem effects on frogs and wildlife.

The Clean Water Act of 1977 regulates water pollution from "point sources" such as pipes coming from industrial and sewage plants, as well as "non-point sources" which come from many points including agriculture such as cropland and livestock operations. Some EPA estimates are that 60 percent of non-point pollution is from agriculture. Pollutants such as sediment, fertilizer, pesticides and manure can be mitigated through research and adopted by farmers through extension outreach. New enforcement measures under this Act include setting limits of TMDLs of pollutants and new permit requirements for Concentrated Animal Feeding Operations (CAFOs) and some aquaculture operations.

The Clean Air Act of 1990 originally regulated industrial smokestacks, but some remaining air pollutants come from agriculture as fertilizer and pesticide volatilized into the air, dust from tilled soil and harvest operations, gases and dust from poultry and livestock operations, smoke from agricultural burning, and diesel exhaust from pumps an tractors. Additional agricultural pollutants such as fuel or solvent spills are covered by the Toxic Substance Control Act of 1977. Research can develop new methods of mitigating soil contamination such microorganisms that clean up oil spills or plants that can remove heavy metals.

Situation

Recent agricultural pollutant violations and lawsuits have resulted in substantial fines, operation closures, state or regional bans on agricultural expansion, and the inability to sell property or secure loans if violations are found. Some operations such as large livestock and poultry farms will be required to obtain EPA operating permits to monitor pollution controls. Pollutants such as N and P are impairing drinking water, recreation use of water, and affecting habitat for fish and wildlife. Nitrogen can also escape into the air as ammonia and NO_x where it becomes a health hazard for breathing or combines with other air pollutants to create smog, and can be re-

deposited as acid rain in forests and ecosystems. Pollutants such as pesticides are exceeding drinking water standards and affecting the growth of fish and wildlife.

CSREES supports a diversified portfolio of research, education and extension activities addressing PA 133. Pollution arising from agricultural and forestry-related activities affects soil, air, water, plants, animals, and humans. Potential pollutants include organic pesticides, radio-nuclides, fertilizer chemicals, growth regulators, animal and crop wastes, mulching materials, pathogenic microorganisms, heavy metals, salts, allergens, airborne particulates, dust, ozone, volatile compounds, gases, combustion products, smoke and smog.

At the 2004 International Meetings of the Tri-Societies of America (Soil Science, Agronomy and Crop Science Societies of America) including the US, Canada, Japan and other countries, nearly one third of the sessions focused on reducing pollution from agriculture through nutrient management plans, precision conservation and effective practices to reduce pollutants, toxicological remediation, reducing hazardous chemicals in fertilizer, mitigation of greenhouse gases, and reducing agricultural pharmaceuticals and hormones in the environment.

Inputs

In 1999, CSREES invested approximately $17.2 mil. in pollution prevention research, which dropped to $15 mil. in 2003. The priority in 1999 was primarily focused on water and watershed pollutants with 40 percent of the budget and 30 percent on soil pollutants. By 2003, the focus shifted to approximately 33 percent on agricultural water and watershed pollutants, 23 percent on soil and land pollutants, and 8 percent focused on air emissions. New teaching curriculum emerged on soil carbon sequestration to reduce air emissions and on environmental livestock production web-based modules for air, water and soil protection. Extension outreach in water quality is delivered through all 50 states and US territories through local delivery and a national annual conference. An Extension pilot project in Environmental Management Systems for livestock and poultry is documenting continuous improvement in pollutant reductions in 9 states.

Hatch funding remained flat at approximately $6 million/year from 1999–2003, as well as McIntire–Stennis funds at $300,000 per year. SBIR grants on pollutants rose steadily from $0.2 mil. in 1999 to $1.3 mil. in 2003 (Table 3-12.).

Table 3-12. CSREES Funding, by Source PA 133 (Pollution Prevention and Mitigation), 1999 - 2003

Source	Fiscal Year ($ 000)					Total
	1999	2000	2001	2002	2003	
Hatch	6,187	6,035	6,158	5,945	5,902	30,227
McIntire-Stennis	305	361	343	347	312	1,668
Evans Allen	1,164	1,495	1,082	1,207	747	5,695
Special Grants	534	859	1,267	1,905	1,455	6,020
NRI Grants	2,364	508	3,213	2,652	2,195	10,932
SBIR Grants	237	306	908	1,555	1,289	4,295
Other CSREES	6,366	7,404	6,668	3,278	3,149	26,865
Total CSREES	17,157	16,968	19,639	16,889	15,049	85,702

Several multi-state research committees share Hatch research funds across multiple states on joint research efforts on PA 133 including:

W-82 Reducing the potential for environmental contamination by pesticides and other organic chemicals,
S-291 Systems for controlling air pollution emissions in poultry, swine and dairy
W-170 Chemistry and bioavailability of waste constituents in soil
S-297 Soil microbial diversity affected by land use and management
S-1000 Animal manure and waste utilization
S-1004 Evaluation of Total Maximum Daily Load assessment tools
S-1007 Science and engineering for a bio-based industry and economy
NRSP-3 National Atmospheric Deposition Program (every state participates)
W-188 Micro irrigation technologies for protection of natural resources
NC-230 Functions of riparian systems for management practices.
W-45 Mitigation of agro-chemicals on human and environmental health

Results in Table 3-13 show that CSREES has accounted for a minimum of 45 percent and a maximum of 52 percent overall on the total spent on PA 133, or approximately half of all agricultural pollutant research including other federal and non-federal.

Some states like California are taking the lead with nearly 10 percent of all projects, or 56 of 660 research projects in PA 133. Topics range from biological substitutes for pesticides to laser sensors for ammonia emissions to selenium, salinity, and mercury remediation.

Table 3-13. CSREES, Other Federal, Other Non-Federal Funding, PA 133, Pollution Prevention and Mitigation, FY 1999-2003.

Fiscal Year	Source ($ 000)			Total	CSREES % of Total
	CSREES	Other Federal	Other Non-Federal		
1999	17,196	10,719	5,451	33,366	52
2000	16,999	10,228	6,538	33,765	50
2001	19,655	9,938	5,896	35,489	55
2002	16,904	15,381	4,993	37,278	45
2003	15,047	13,213	4,934	33,194	45

Performance Criteria

Problem Area 133 addresses the critical issues related to prevention of agricultural pollution and mitigating existing pollutant contamination.

- Identifying the agricultural pollutant locations, sources and transport mechanisms in soil, water and air
- Evaluating spatial impacts of pollutants on the landscape as they affect soil, water, air, ecosystems and human health
- Prioritizing risks from various pollutants to determine action plans
- Developing affordable alternatives and policies to control pollutants and remediate or clean up existing pollution cost effectively
- Motivating producers to identify and prevent pollution or clean up existing contamination

Performance Indicators

- New sampling and testing instruments
- New computer models to forecast pollutant trends and interventions
- Cost/benefit analyses to address priority pollutants
- New methods of clean up or controls of pollution
- Educational programs, websites and curricula are developed to teach producers methods of pollutant control

Outputs

Research, education and extension activities from this portfolio have accomplished the following:

- Improved sampling equipment and genetic tracing methods of pollutant sources;
- Improved pollutant prediction models that show fate and transport of pesticides, nitrogen and sulfur through air and water movement; and
- New and more user friendly curricula that can be accessed through the web.

Outcomes

Short Term

- Education curricula for youth and adults were developed to protect soil, water and air from fertilizer, pesticide, manure and other toxic contaminants such as fuel spills
- Testing methods with new instruments that can locate pollutants faster and at lower costs
- Data collection on pollutants that can be used to develop a spatial history of pollutant sources and loading

Medium Term

- Behavior changes such as farmers keeping records on manure and fertilizer applications and reducing excess loading that can lead to polluted water and air
- Practice changes to divert storm water
- Policy changes to protect ground water supplies from storm water recharge and pesticide contamination

Long Term

- Cleaner water from reduced nutrient loading of manure and proper crediting of nutrients to reduce excess fertilizer applications
- Increased economic benefits from environmentally superior products for consumers
- Number of young people that are trained for careers in environmental and pollution prevention disciplines

Accomplishments/Outcomes

National Research Special Project 3 (NRSP-3), the **National Atmospheric Deposition Program** provides the only national scale data, geographic distribution and trends in wet chemical deposition in the U.S. This Hatch funded project includes all states as one of the few nationally coordinated research programs. Short term outcomes include data collection for spatial distribution of pollutant deposition of pollutants such as nitrogen and sulfur that can cause acid rain effects. Medium term outcomes include models that can predict the concentration of atmospheric-deposited chemicals of agricultural crops, forestry, rangelands, surface and ground water estuaries. It serves as an **early warning device for potential airborne bio-terror agents**. Long term outcomes have provided the data to support policy decisions for reductions in acid deposition for the Clean Air Act of 1990 from sulfur dioxide and nitrogen oxide emissions.

Environmental Management Systems (EMS) was funded under the Initiative for Future Agriculture and Food Systems (IFAFS) as an integrated research/extension/teaching program to develop livestock and poultry systems that will develop continuous improvement plans for pollutant reduction in animal systems. Short term outcomes include curriculum development and training for pilot programs in nine states for beef, dairy and poultry farmer pollutant prioritization and remediation. Worksheets and record-keeping documentation for producers were developed to reduce air emissions, nutrients, and other potential pollutants while coming into compliance with current regulations. Medium term outcomes include one pilot program in Iowa with 19 producers who have developed policy statements and documented nutrient management improvements, built clean water diversions and constructed new storage facilities for operations ranging from 600 to 8000 animals each. An additional 19 farmers are

participating in training. The Idaho pilot featured a web-based nutrient plan that was completed by all 846 dairies in the state to meet regulatory requirements, with intensive follow-up on 11 farms in a regulated watershed to affirm implementation. The dairy EMS pilot was presented at a national conference attended by more than 200 dairy farm advisors. The Georgia and Pennsylvania poultry pilot projects resulted in the identification of pollution risks and strategies for nutrients, petroleum storage, septic systems, mortalities, biosecurity and pathogens, dust and odor, pesticides, noise pollution, and emergency spill response. Long term outcomes include producers who **avoid violations and fines** while improving farm management and saving costs through evaluation of their whole production system. Some producers can continue to certify under ISO (International Standards of Operation) 14000 (environmental certification) that becomes a "green label" for international exports and premium prices for greater profits.

A Special Grant, the **Delaware Institute of Soil and Environmental Quality**, is developing comprehensive graduate and undergraduate **education curricula** for soil and environmental scientists and conducts public policy education regarding soil environmental issues.

W-82 regional research committee **Reducing the Potential for Environmental Contamination by Pesticides and Other Organic Chemicals** uses Hatch funds in multiple states to reduce pesticide pollution by characterizing pesticide movement in soil, water and air for spatial and process models. Short term outcomes document the movement of pesticides and other organic chemicals under various climatic and management methods. Medium term outcomes include the development **models to predict pesticide movement** and management measures to reduce pesticide impacts. Long term outcomes include regional policies and guidelines to reduce pesticide loading and movement from crop fields as a pollutant.

A Small Business Innovation Research (SBIR) grant project conducted in Florida has resulted in the development of a **molecular PCR-based probe** to detect human vs. animal *E. faecalis*. It can detect distribution of isolated genetic species, such as *E. faecium*, *E. casseliflavus*, *E. flavescens* and *E. durans*. The short term outcome is a new instrument that can produce quick detections of pathogens and their sources at a low cost. It can detect distribution of isolated genetic species such as *E. faecium*, *E. casseliflavus*, *E. flavescens* and *E. durans*. The medium term outcome is that sources of pathogens between agriculture, wildlife and human origin can be identified to target appropriate remediation and prevention methods. Long term outcomes include **reductions of pathogen loadings** for cleaner water supplies.

New Jersey used Smith Lever Extension funding to develop a **storm water management** education and outreach program for all 566 municipalities of the state that are required to meet new pollutant runoff regulations. Short term outcomes include curriculum development and workshops to train employees that could be replicated in other states. Medium term outcomes include development of a Section in the State's policy manual on pretreatment requirements for storm water before use in ground water recharge to protect drinking water supplies and protect aquifers from pollutant contamination. Long term outcomes result in safer ground water supplies for drinking water state-wide. State scientists have also used Smith Lever funds to conduct 4-H Adventures in Environmental Science for career development and community strategies on pollution prevention for 300 youth in grades 7-12, and also "Caring Keepers of Our Planet Earth" for 350 youth in grades 5-7 along with 81 adult leaders. Short term outcomes include

curricula and trained youth that will teach their parents and families about methods of local pollution prevention. Medium term outcomes include local families that will identify local pollutants and implement prevention measures to protect local communities. Long term outcomes include development of new career professionals in environmental sciences that will become the next generation of pollution prevention specialists.

Michigan Extension used Smith Lever funds in conjunction with Sustainable Agriculture Research and Education (SARE), state, and county funds in **phosphorus pollution prevention** through improved manure management strategies. Short term outcomes include training 29,500 farmers, agribusiness and agency staff to develop nutrient management plans. Medium term outcomes resulted in the average producer reporting nearly $7,000 each in fertilizer savings by crediting phosphorus and nitrogen from manure, and stopped adding manure to fields testing high in phosphorus that could become a pollutant source. Long term outcomes include **farmers keeping records of manure application** that will keep them in compliance with new regulatory inspections, while reducing pollutant loads of P and N to local drinking water supplies and recreational waters.

Future Directions

The Experiment Station Committee on Policy Science (ESCOP) Science Roadmap for Agriculture has designated environmental stewardship as one of the top seven priorities for the future, based on stakeholder input. The 1990 and 2002 Farm Bills substantially increased funding and priorities for pollution prevention through EQIP (Environmental Quality Incentive Program). Funding has reached $1 bil. annually, with 60 percent of the funds prioritized for animal agriculture pollutant remediation. The CRP has also been authorized to remove 43 million acres of land from production that pose an environmental risk. Additional incentives remove land next to streams to protect water quality. The USDA Air Quality Task Force was re-authorized for an additional 2 years by the Secretary of Agriculture as an official Federal Advisory Committee to address priority issues of particulate matter (dust), ammonia, ozone, volatile pesticides, and odor from agriculture. Record recent EPA enforcements have targeted drinking water protection, cleanup of contaminated soil and water, and enforcement of air quality violations.

The CSREES Portfolio PA 133 has responded to these priorities in 1999 by focusing 40 percent of its budget on water pollution and 30 percent on soil pollutants. By 2003, a shift in the funding went to 33 percent water, 23 percent soil, and 8 percent air quality. The emergence of air quality issues has resulted in the designation of a new competitively funded Air Quality program (discussed under PA 141 – Air Resource Protection and Management) that also focuses on PA 133-related issues.

F: PROBLEM AREA 141
Air Resource Protection and Management

Overview

Agricultural producers face a growing array of regulatory pressures, including those related to air quality. The Air Resource Protection and Management problem area seeks to provide sound science that protects the environment while maintaining a viable agricultural production system. This problem area focuses on developing emission data for agricultural production practices and improving what we know about the measurement, control, fate, and transport of odor, gases, and particulate matter. This research also studies emissions and reduction of other greenhouse gases, such as nitrous oxide and methane. Its outreach activities include transferring technologies and best practices to producers and the regulatory community to lessen the production and transport of air pollutants and greenhouse gases.

Agricultural operations can be significant sources of odors, gases and particulate matter. Title V of the 1990 Clean Air Act (CAA) requires owners of all major sources of air pollution to obtain an operating permit describing each source's pollution control obligations under the Act. "Major sources" are those with potential emissions of specific air pollutants that exceed certain minimum levels. EPA has compiled a list of pollutants and emission thresholds associated with agricultural production. Farmers are receiving citations and fines for air violations based on limited U.S. research data.

Because of the lack of relevant research and monitoring of these pollutants from agricultural production facilities, thresholds from other industries form the basis of enforcement. To address these concerns, CSREES has created and funded a comprehensive, integrated air quality program to provide the research and outreach necessary to assist regulatory authorities in developing and implementing appropriate permit options for agricultural producers under the Clean Air Act and other legislative authorities. The research should enable the development and evaluation of emission control technologies that are both effective and economical for producers.

Developing sound research needed for agriculture in an increasingly regulated environment is a particularly challenging opportunity. The immediacy of policy and laws to protect people and resources contrasts with the much slower process of problem solving based on hypothesis testing and technology transfer. The mission of this problem area--to foster sound science, enhance stakeholder education and competencies, and transfer this knowledge through high-impact extension programs – is critical in developing effective agricultural air quality policies.

Problem Area 141 is new in CSREES classification and was developed to address an emerging issue that is critical to protecting the environment, while enhancing productivity and sustainability. Problem Area 141 is closely linked to and overlaps with others discussed in Objective 5.2 Portfolio, including PA 101,112, 132 and 133. This information is being presented to demonstrate that CSREES and its partners are proactive in identifying and addressing critical agricultural-related problems.

Situation

The agricultural community is increasingly coming under scrutiny for practices that can potentially degrade air quality. A number of trends in agriculture are driven by economic incentives and competitiveness that have serious environmental ramifications. For example, the adoption and widespread use of nitrogen fertilizers and the concentration of animal feeding operations have led to dramatic increases in emissions of reactive forms of nitrogen to the atmosphere (NH_3, N_2O, and NO_x). Because agriculture tends to be "leaky" and inefficient with respect to nitrogen, these reactive forms of nitrogen can build to unsustainable levels in air, soil and water by forming greenhouse gases, aerosols/fine particulates and, through wet deposition as NO_3 and NH_4. Additionally, fine particulate matter ($PM_{2.5}$) and coarse particulate matter (PM_{10}) can be emitted from controlled burning to manage crop residues, from pre- and post-production practices such as tillage and cotton ginning, and from livestock production facilities. Odors from agricultural production and processing can also have serious consequences not only as a public nuisance but odor can contain compounds that are regulated as hazardous substances.

The immediacy of the subject matter contained in this problem area is driven primarily by regulation and legislative authority. Federal and state agencies are being sued by citizen groups to enforce regulation that may or may not have targeted agriculture and forestry. Legislation that created reporting requirements for hazardous substances and the Superfund to clean up those hazardous substances probably did not have agriculture in mind. Nevertheless the authorities are now being used to regulate agriculture and precedence is being set successfully in many states. Agriculture, to a certain extent, has been a victim of its own success. Research has demonstrated the need for fertilizer to increase crop production but the relationships that were developed to determine the rates were based on production not on environmental consequence. Similarly research has demonstrated the economic production advantages for concentrating the feeding of livestock but has mostly neglected the impacts of waste streams on the environment. The research community now understands the need to protect the natural resources that underpin agricultural production and USDA is responding to those externalities. In this context, policy and legislation are the primary drivers of this program and not the pursuit of basic knowledge.

The major themes that are being tackled by CSREES are:

- Emissions: the determination of fluxes of particulates, gases and odors from agricultural and forestry related production practices;
- Fate and Transport: the physical and chemical fate of agriculturally related air emissions and the mechanisms of transport to, through and from the atmosphere;
- Measurement and Monitoring Methods: the development and improvement of methods for the measurement and monitoring of fluxes of particulates, gases and odors and how the methods relate to federal standard references;
- Mitigation Practices: technologies and practices that reduce emissions or protect the atmosphere from emissions; and
- Environmental Effects: impacts of agriculturally derived atmospheric pollutants on ecosystems.

With the increasing threat of environmental regulation, agriculture needs to respond to these air quality challenges. CSREES is involved in a number of research, education and extension

activities that are responding to the challenges of Air Resource Protection and Management (PA 141).

Input

Although CSREES' Air Quality Program was initiated in 2003, subject matter related to PA 141 was already being addressed through other related PAs (e.g., PA 101, 112, 132, 133). Data presented in Table 3-14 are a compilation of funds spent on Air Quality-related PAs and not directly on the proposed PA 141. In 1999, CSREES had limited investments ($2.8 mil.) in programs directly tied to air quality from agricultural production practices. Several multi-state research committees were in place in 1999, but air quality inside livestock facilities was the primary research focus and its impact on animal production rather than air quality impacts on the surrounding environment. Two special research grants were in place studying emissions from tillage and post-production practices. Formula as well as competitive research dollars have grown over this five year period. Funds for the National Atmospheric Deposition Program (NADP) that are reimbursed through CSREES to the University of Illinois from other federal agencies have remained relatively constant through this five year period. Due to the freshness of this PA, comparative data for other USDA funding, other federal funding, and funding generated elsewhere are not available.

Table 3-14. CSREES Funding, Air Quality Related Research, 1999-2003.

Source	Fiscal Year *($ 000)*					Total
	1999	2000	2001	2002	2003	
Hatch Grants	661	1,002	1,323	1,637	1,577	6,200
Other Grants*	817	1,133	2,979	2,495	2,326	9,750
NADP	1,361	1,308	1,315	1,274	1,657	6,915
NRI Grants	0	0	0	0	5,100	5,100
Total	2,839	3,443	5,617	5,405	10,660	27,965

*NRI, SBIR, Special Research Grants

The USDA Agricultural Air Quality Task Force (AAQTF) was formed in 1996 because of increasing concerns of agricultural emissions and the lack of sound scientific data to quantify the emissions and measure their impact on the environment. Agency staff attended the AAQTF and advised the task force on USDA research investments. Research recommendations of the task force were crafted into CSREES budget recommendations as early as 1998, but with little success until FY 2000 when an animal manure management program was created in IFAFS. Several projects were funded under IFAFS that dealt directly with animal emissions and methods to measure and mitigate those emissions. Unfortunately the program only ran for two years. Finally in 2003, a dedicated integrated air quality program was created in the NRI when increases became available for IFAFS-like integrated programs. The first awards were made late in 2003 with a total of $5.1 mil. and thirteen projects funded. A third special research grant was added in 2002 focused on air quality from beef cattle feedlots. From 1999 to 2003 expenditures on air quality increased from $2.8 mil./yr to approximately $10.7 mil./yr.

The NRI air quality program has emphasized four of the five main themes: emissions, measurement and monitoring, fate and transport, and mitigation practices. All but the fate and transport topic are viewed as research, education, and extension issues that can have meaningful

impact for producers in the short-term. The fate and transport topic is viewed as more basic research that requires long-term investment to significantly advance the science. As agricultural emissions are understood and can be accurately measured, less emphasis will be placed on these topics and more on fate and transport and in understanding how to best implement practices that can reduce emissions. As fate and transport are better understood more emphasis can be placed on environmental effects. Eleven projects were funded in 2004 ($5.0M) and $5M should be available in 2005 to continue to work on these topics.

Performance Criteria

Improving knowledge, understanding and management of emissions, measurement methods, fate and transport of emissions, the impact of emissions on the environment, and practices to mitigate agricultural and forestry emissions are the performance criteria for this problem area.

Examples of performance criteria are:

- Developing improved emission inventories for agriculture and forestry practices;
- Developing new spectroscopic techniques for continuously measuring ammonia fluxes;
- Characterizing the fate and transport of particulate matter from controlled burns;
- Determining the response of the environment to elevated levels of nitrogen from wet deposition; and
- Developing best practices for reducing particulate emissions from cattle feedlots.

Performance Indicators

Examples of performance indicators are:

- Reduced emissions of hydrogen sulfide below national ambient air quality standards for concentrated beef cattle operations and pose no deleterious effects to the environment;
- Implemented minimum tillage practices in continuous wheat production areas that will greatly reduce dust emissions below national ambient air quality standards;
- Improved monitoring and detection systems for regional trends of atmospheric deposition critical to agricultural productivity; and
- Improved detection and characterization of volatile organic carbon compounds attributed to the formation of ozone from large dairy operations.

Outputs

Research, education and extension activities from this portfolio have accomplished, among other things, the following:

- Data products detailing the regional trends in the wet deposition distribution of major cations and anions across the U.S.;
- A state-of-the art best management practices document to control windborne dust from small-grain production in the Pacific Northwest; and
- Emission factors for dust emissions from nut harvesting in the Central Valley of California.

Outcomes

Short Term

- Hundreds of peer-reviewed journal articles have increased the knowledge base of this portfolio
- Raised the awareness of air quality issues in the research, education, and extension community through increased funding for air quality research
- Development of dozens of websites across the country that disseminate best management practices for reducing agricultural air emissions

Medium Term

- Research documenting the economic advantages of no-till cropping systems for controlling dust emissions
- Wide-spread adoption of direct-seeding technology to reduce wind borne dust
- Creation of a grower led direct-seeding association as a result of extension programs

Long term

- Identification of regional trends in atmospheric deposition of agriculturally important compounds that potentially degrade the environment

Accomplishments/Outcomes

The following are examples of research, education and extension projects active during 1999-2003 and shows the diversity of topics and the interdisciplinary nature of the activities conducted by CSREES where Air Quality was identified as a dominant theme under one of the prominent problems areas contributing to this portfolio.

Success Stories

Monitoring and Environmental Effects

A number of projects were indirectly monitoring agricultural emissions such as NRSP-3 (National Research Support Project) which contributes to and manages the federal monitoring budget for the National Atmospheric Deposition Program (NADP). The National Trends Network (NTN) of NADP monitors the **chemistry of precipitation** at over 250 locations across the U.S. This program has been actively monitoring wet deposition for more than 25 years and has been integral to the U.S. acid rain program. NTN was created by the Agricultural Experiment Stations with Hatch multi-state research money. The multi-state research committee then became NRSP-3. Now eight other federal agencies and numerous state and private entities contribute more than $3 mil./yr to support this important monitoring activity while USDA's contribution through the experiment stations is approximately 25 percent of that amount. NTN has played a significant role in documenting the impact of the CAA on sulfur emissions. Results indicate that **sulfate emissions have significantly decreased** over the past twenty years in the Northeast primarily from regulating sulfur emissions from coal-fired power plants. This project has also had an extensive outreach objective. The project collects wet deposition data and disseminates data and derived data products to the research community and to the general public. Over the past five years, more than 100 research publications per year have appeared in scientific

journals documenting the impacts of acid precipitation and the environmental effects of that deposition.

Mitigation Practices and Fate and Transport

Two special research grants were dealing with particulate matter emissions in 1999. One of the projects in Washington was and is still studying the impact of farming practices such as tillage on PM_{10} emissions. This CSREES-funded research in the Columbia Plateau has demonstrated that **continuous annual no-till cropping can significantly reduce predicted dust emissions** during severe winds. Results to date have shown that continuous annual no-till cropping can reduce predicted dust emissions by 94 percent during severe wind events, compared to conventional wheat-fallow. Research continues on measuring dust emissions from fields in the Columbia Plateau, a 50,000-square-mile region in Washington, Oregon, and Idaho containing one of the driest, yet most productive, rain-fed wheat regions in the world. Not only is the project determining PM_{10} emissions, but it is seeking to understand basic transport mechanisms. Wind velocity profile analysis from a 20-acre field site during two high-wind events in 2002 indicated that direct suspension (not saltation) is the major process by which soil is lost and dust is emitted from this field site. A major effort continues **in modeling regional transport of windblown dust**, and particulates derived from field burning. This project has also had a significant outreach component. Research updates are provided to growers through annual regional conferences. Numerous publications are available including the second edition of Farming with the Wind: Best Management Practices for Controlling Wind Erosion and Air Quality on Columbia Plateau Croplands just recently published. This publication is a compilation of management recommendations for controlling dust emissions and soil erosion by wind on the Columbia Plateau and has been very popular with producers.

Portfolio Impacts

Research, education and extension activities in this portfolio for the period 1999-2003 have made major impacts towards the following:

- Identification of soils likely to produce dust when disturbed. Dust can be reduced if soils are cultivated at soil water contents above the dust threshold. Conservation tillage reduces dust in the field;
- Biofiltration at livestock facilities is a cost effective means of air pollutant control. The ongoing work helps extend the range of contaminants and situations for which biofiltration can be used. Also, through better understanding of the biological and physical-chemical processes involved, increased efficiency can be achieved;
- Measured emission rates of odor, hydrogen sulfide, particulate matter, ammonia, methane and non-methane hydrocarbons from swine and poultry buildings will provide needed information about air pollution source strength and will be utilized by individuals and organizations throughout the United States;
- Increased understanding of the ecological basis for greenhouse gas fluxes to the atmosphere. The role of agriculture in these fluxes - whether source or sink – is important to know in order to develop effective greenhouse gas mitigation strategies at a national level. The development of carbon credit trading depends on a sound scientific understanding of these issues;
- Studies document the degree to which non-urban areas downwind of pollution sources are affected by emissions from urban, transportation and agricultural sources. In

particular these areas often experience concentrations greater than in the urban areas themselves as they are exposed to the accumulation of all emissions along the traveled trajectory. Greater knowledge of sources of pollutants, transformations and dispersion and deposition into sensitive ecosystems are the first steps to reduce these impacts; and

- The development of an electronic nose to evaluate odors and development of systems for controlling air pollutant emissions and indoor environments of poultry, swine and dairy facilities through improvement in monitoring systems which support changes in design to reduce pollutants.

Future Directions

CSREES solicits stakeholder input through various mechanisms including request through individual program RFAs, and through participation of NPLs in numerous external activities including representation on multi-state committees, attending national and international scientific society meetings, and participating in work groups that include federal, state, and private sector personnel. It is through stakeholder involvement that and Protection and Management of Air Resources (PA 141) in general and specifically Air Quality based on agricultural emissions of ammonia was identified as an emerging issue. The agency's Air Quality program, which requires that all funded projects integrate research, education and extension activities, is funded through the NRI.

It is estimated that agriculture accounts for almost 90 percent of U.S. ammonia emissions (EPA, 2004). The bulk of these emissions come from livestock operations and inefficient use of nitrogen fertilizers on crop lands. Ammonia emissions are not currently regulated under the Clean Air Act (CAA) but environmental groups have been successful in using hazardous substance release reporting rules such as CERCLA and EPCRA to require agricultural operations to report ammonia emissions when emissions exceed 100 lb./day. Ammonia could potentially be regulated in the future in air quality non-attainment areas because ammonia can form fine particulate matter in the atmosphere resulting in increased loading of $PM_{2.5}$ and PM_{10} which are criteria pollutants regulated under the CAA.

The NTN has demonstrated an increasing trend in ammonium ($NH_{4)}$ wet deposition which implies that ammonia emissions are increasing. The agricultural source contributions need to be better understood so that appropriate strategies can be put in place to reverse this trend. As fate and transport of ammonia in the atmosphere from agricultural sources is better understood, source/receptor models can be developed to identify key areas and practices that are contributing to regional excess ammonium concentrations. These areas can be targeted to implement control technologies that will then lead to decreasing concentrations over time.

G: PROBLEM AREA 403
Waste Disposal, Recycling and Reuse

Overview

Waste is generated by every segment of society, which is causing a disposal dilemma and creating challenges for those concerned at the local, regional national and international levels. Production agriculture creates large volumes of animal and plant wastes. In addition, society must contend with municipal and industrial wastes including sewage sludge and biosolids. As the system copes with this deluge of waste, those concerned are focusing on the benefits of reusing and recycling waste products for use in the urban and rural landscape. There has been an increasing interest in the concept of recycling and reuse in all aspects of the U.S., both in the private sector and in the industrial sector. This is due to a general concern about protecting the environment and conserving our natural resources. There are many programs to encourage citizens to conserve and recycle, such as community recycling programs for newspapers, cans, bottles, and plastic. There are national programs to use recycled paper products and converting plastic into building materials. It is likely that citizens will continue to support recycling and reuse activities and even expand such programs. It has been common for several years that schools emphasize recycling and reuse so that most children are sensitive and knowledgeable about the benefits of these activities for the long term.

The following are a couple of examples where environmental concerns have caused a major shift in policies and practices. In 2003 EPA promulgated a new rule for CAFOs. The major change for the CAFO operator is that now he/she will be required to submit a nutrient management plan in order to get a permit. Prior to this rule there were many operators who over applied either nitrogen or phosphorous to their cropland, resulting in potential runoff problems. Another example is from the urban setting where cities did not want to dispose of sewage sludge (biosolids) in landfills because it occupied too much volume. Many cities across the U.S. now transport the biosolids to cropland and apply it as a nutrient source for the crop.

At the 2004 International Meetings of the Tri-Societies of America (Soil Science, Agronomy and Crop Science Societies of America), three four-hour long Symposia were held to address this topic (waste disposal and reuse). The Symposia were titled Organic Waste to Resource: Recycling Wastes. There were also posters and other related oral sessions including Environmental Aspects of Biosolids and other Wastes Applied to Soils. Presenters were drawn from the private and public sectors from countries including the U.S., Canada and South Korea, demonstrating the magnitude of the issue.

CSREES is involved in a diverse range of research, education, and extension activities that focus on collecting, storing, transporting, treating, recycling and utilizing agricultural, non-agricultural and forestry generated waste products. PA 403 is primarily research oriented, but there are some extension and education stand alone projects, or extension and education are a part of the research project. Extension projects in PA 403 have not been as well documented as the research projects. Approximately 50 percent of FY 2003 projects relate to animal manure management. NPLs interact with the land grant universities thru multi-state projects, special grants, and competitive grant programs. The NPLs also communicate with other agencies and organizations regarding policies, proposal reviews, and joint committees.

Situation

Many waste products are generally applied to soil to improve the biological, physical, and chemical characteristics and processes. As such, waste management is now viewed from the perspective of resource recycling and reuse to enhance productivity and sustainability. While there are environmental benefits to recycling and reusing wastes, environmental degradation is also taken into consideration because of the potential for pathogen, metals, and other types of contaminants. If not properly handled, this leads to soil contamination and eventually to air and water pollution, which ultimately affects the health and well-being of society. In PA 403, CSREES funded projects address the development of value-added or alternative products, such as bio-fuels from biomass and development of granular activated carbon made from peanut shells and corncobs, as well as modifying a livestock facility to flush water in manure management.

In the forest industry new techniques have been developed to collect/harvest timber. In the storage of waste products there are new modifications of lagoons with liners and use of dry storage in deep stacks for poultry operations. There has been minimal development in new technology for transport of waste products, based on the results of a CRIS search. Numerous projects have focused on treatment technologies (e.g., anaerobic, aerobic, lagoons, composting, constructed wetlands, and land application). Recycling and reuse includes projects including use of biogases and kenaf, sawmill waste, land applied biosolids, conversion of municipal solid waste, recovering fiber from dairy manure solids. CSREES, through its unique partnership with public and private sector organizations, works to explore and develop techniques and methodologies to solve the waste disposal problem in ways that are sustainable, environmentally friendly and cost-effective.

Major Themes

- Development of management tools, strategies and systems for land application of wastes to enhance productivity and sustainability while also protecting and conserving environmental quality
- Development, evaluation, and refinement of physical, chemical and biological treatment processes
- Development of methodologies and technologies to reduce odors, gases, microbes and other emissions from animal production systems
- Development and evaluation of feeding systems to alter excretion of environmentally sensitive nutrients from livestock
- Investigation of alternate strategies for collecting wastes that are environmentally friendly and cost effective

Inputs

CSREES invested $29 mil. for Waste Disposal, Recycling and Reuse between 1999 and 2003, of which Hatch funds accounted for $9 mil. and Special Grants funds accounted for $6.5 mil. In general, funding was highest in 1999 ($8.9 mil.) and has remained flat through 2003 (Table 3-15). The funding trend is reflected in the total number of projects (206 in 1999 compared to 216 in 2003) indicating that work in PA 403 has been relatively stable.

Table 3-15. CSREES Funding by Source, PA 403, Waste Disposal, Recycling and Reuse, 1999-2003.

Source	Fiscal Year ($000)					Total
	1999	2000	2001	2002	2003	
Hatch	2,118	1,734	2,086	1,468	1,606	9,012
McIntire-Stennis	27	63	106	223	73	491
Evans Allen	380	420	528	532	266	2,126
Special Grants	1,754	1,568	402	1,359	1,379	6,462
NRI Grants	302	70	208	263	273	1,116
SBIR Grants	307	324	525	746	276	2,178
Other CSREES	4,020	1,456	590	636	629	7,331
Total CSREES	8,908	5,635	4,445	5,227	4,501	28,716

Results presented in Table 3-16 show that CSREES has consistently accounted for a minimum of 52 percent, and an average 63 percent overall, of the total spent on PA 403.

Table 3-16. CSREES, Other Federal, Other Non-Federal Funding, PA 403, Waste Disposal, Recycling and Reuse, 1999-2003.

Fiscal Year	Source ($ 000)			Total	CSREES % of Total
	CSREES	Other Federal	Other Non-Federal		
1999	8,910	2,866	999	12,775	70
2000	5,635	1,333	1,158	8,126	69
2001	4,445	1,579	1,392	7,416	60
2002	5,226	2,152	1,214	8,592	61
2003	4,498	2,949	1,286	8,733	52
Total	28,714	10,879	6,049	45,642	63

Performance Criteria

As the population continues to grow, so will the volume of waste products, which result from everyday agricultural and forestry-related activities, since these activities affect every member of our society. CSREES is involved in addressing waste issues via several related Problem Areas, but activities are concentrated in PA 403, Waste Disposal, Recycling and Reuse. Activities conducted through PA 403 are deemed to be high quality if they lead to:

- Better methods of collecting, storing, moving, treating, and disposing of organic wastes.
- New value-added products from organic wastes;
- Improved methods and practices for recycling wastes;
- Reduced negative environmental effects of wastes; and
- Utilization of combined efforts of research, education, and extension to address the above criteria.

Performance indicators

- Developed and implemented new management strategies for handling wastes;
- Increased the knowledge-base of the principles of waste recycling and reuse;
- Developed curricula and supporting education tools that help producers and advisors;
- Developed scientific knowledge that is used in formulating regulatory policies and guidelines; and
- Built solid partnerships for extension and outreach programs that reduce adverse impacts on environmental quality.

Outputs

- A GIS system that is used to optimize locations of industrial user facilities to minimize delivered cost of straw
- The use of coagulants for nutrient removal in waste water is a technology that has the potential to greatly assist the livestock grower by lengthening lagoon life, reducing land application cost, and dramatically decreasing the environmental risk to both surface and ground water
- A national curriculum and supporting educational tools developed for U.S. livestock and poultry industry advisors, who in turn, help producers acquire certification and/or achieve environmentally sustainable production systems
- Input from National Center for Manure and Animal Waste Management on the content of the 2003 CAFO rule to positively influence public policy

Outcomes

Short term

- Increased knowledge regarding waste product utilization for agricultural and forest-related food and fiber productivity

Medium Term

- Improved feeding systems that alter excretion of environmentally sensitive nutrients from livestock
- Better treatment processes that mitigate environmental problems

Long Term

- Increased economic benefits for adopting management practices and strategies that are environmentally friendly
- Cleaner air, water and soil resources because of adopting and implementing science-based knowledge

Accomplishments/Outcomes

The source of funding for projects focusing on Waste Disposal, Recycling and Reuse include NRI, Special Grants, SBIR, Hatch (including multi-state projects), and Evans-Allen programs.

The following are examples of PA 403 projects to indicate the type, scope and specific activities that have taken place.

Harvesting and Handling Rice Straw for Off-field Utilization

A Special Grant project focuses on the management of rice straw from a rice production region in California, where growers need alternatives to field burning of straw because this method of disposal has been severely curtailed by state legislation. The project investigates improvements **to straw handling for off-field utilization**. Field equipment modifications and new equipment designs potentially offer reduced costs and improved quality and yield for off-field uses as alternatives to the primary method of soil incorporation. Sixteen publications have resulted from this project and a GIS system was developed for rice straw has been used to optimize locations industrial user facilities to minimize delivered cost of straw. Results indicate that permanent cover using pole barns or metal buildings tends to **reduce overall cost and improved straw quality for longer term storage** compared with lower capital cost systems such as tarping and uncovered storage. Rice straw yields of 3 tons/acre lead to maximum productivity and minimal cost. Time motion studies of actual harvesting showed that yields were more commonly 2 tons/acre.

A Hatch funded project, **Increasing Solids and Phosphorus Removal from Flushed Dairy Manure Slurry Systems Using Coagulants and Flocculants** demonstrated that use of proven municipal waste technology (coagulation/flocculation/solid separation) can **increase the solids and phosphorus removal efficiencies from animal manure slurry** systems. Overall, compared to current field practices, polymers in combination with coagulants dramatically increase total solids (TS) and total phosphorus (TP) removal from animal slurries, removing 90 percent of TS and 98 percent of TP. This technology has the potential to greatly assist the grower by lengthening lagoon life, reducing land application cost and dramatically decreasing the environmental risk to both surface and ground water.

In the late 1990's, as state regulations for animal feeding operations were being modified and EPA was preparing for new legislation, there was a tremendous need for educational materials for producers. The Livestock and Poultry Environmental Stewardship (LPES) project delivered a national curriculum and supporting educational tools to U.S. livestock and poultry industry advisors, who in turn, will **help producer's acquire certification and achieve environmentally sustainable production systems**. Producers will also benefit directly from the information and assessment tools that the curriculum provides. The LPES educational materials were developed with support from CSREEES, EPA's National Agriculture Assistance Center, and University of Nebraska CES at Lincoln. Educational materials developed for the LPES curriculum were nationally developed and regionally piloted. The curriculum included 26 lessons grouped into six modules. The modules included: animal dietary strategies, manure storage and treatment, land application and nutrient management, outdoor air quality, and other related issues. As part of each module there were environmental stewardship and/or regulatory compliance assessment tools for most lessons; and PowerPoint presentations for each lesson. It was a collaborative effort of individuals representing 15 land-grant institutions, Midwest Plan Service, EPA Ag Center, and USDA. The educational materials were targeted for the following groups:

- Mandated environmental certification programs for producers and advisors;
- Voluntary Cooperative Extension programs for producer education programs;
- Proactive educational programs for commodity associations;
- Clientele training for NRCS EQIP and related stewardship programs; and
- Training for industry employees and contract growers.

The **National Center for Manure and Animal Waste Management** was a unique multi-disciplinary program that addressed a wide variety of environmental, economic and social concerns. It consisted of 16 universities across the U.S. and a Policy Advisory Committee. The Center was supported for a 4-year period under the Fund for Rural America Program. Using a systems approach that integrated technologies across species and regions, Center efforts supported **sustainable animal production practices that reduce environmental risks and meet public needs and concerns**. Center efforts emphasized the development and dissemination of knowledge and technology that support sustainable, profitable and internationally competitive animal production and also protect community interests and environmental quality. Working with producers, agribusiness and policy makers, the Center fused interdisciplinary research, extension and education activities to produce a holistic understanding of animal waste and manure production and management.

Center members developed 20 white papers on a range of waste management topics. These papers describe the state of knowledge about each topic and list research and knowledge needs related to the topic. The full set of the white papers is available on a CD. Some research was sponsored based on the needs identified in the white papers.

The members, along with collaboration with other scientists and engineers, responded to requests for feedback on the draft EPA CAFO rule. Nine separate responses were prepared and sent to EPA. EPA stated that the input from the National Center had a direct affect on the content of the final rule. It was an excellent example how science-based information can positively influence public policy.

Investigators in these projects have academic and extension appointments, ensuring that research results are adopted by end-users, thereby directly linking research activities to education and extension.

Future Directions

There will be a continuing need to manage wastes from the agricultural, residential, and industrial sector. As livestock and poultry waste management has been nearly fifty percent of PA 403 effort, and wastes from these sources continue to be of concern, the research, education, and extension efforts will continue. Treatment and recycling, pre- and post-use, will be emphasized more in the future. No longer will there be emphasis solely on waste disposal, but also on developing value-added products that will improve productivity but will not degrade the environment.

The USDA Agricultural Research Service conducted a customer workshop on the Manure and Byproduct Utilization program. In general, this workshop focused on nutrient, emissions, pathogens and by-products. Although not exhaustive of the list generated during the workshop, stakeholders indicated that there was a need to:

- Identify and develop new and alternate uses of byproducts, biosolids and manures;
- Validate new technologies and practices, particularly on a whole system view;
- Investigate the fate and transport of pathogens associated with waste products;
- Determine the long term post application health risks of byproducts (including animal health and worker safety);

- Develop research methods on land application of byproducts that may have specific benefits to water, air emissions, soil tilth, odor and pathogen control measures;
- Quantify BMP effectiveness at long term field and watershed scales; and
- Define the bioavailability to plants and animals of nutrients and other components (health risk) in byproducts.

There are several multi-state committees which have are already addressing some of these and PA 403-related issues including:

S-1000	Animal Manure and Waste Utilization, Treatment and Nuisance Avoidance for a Sustainable Agriculture
W-1170	Chemistry and Bioavailability of Waste Constituents in Soils
NE-1001	Application of Sewage Biosolids to Agricultural Soils in the Northeast: Long Term Impacts and Benefits
S-1007	The Science and Engineering for a Biobased Industry and Economy
W-195	Water Quality Issues in Poultry Production and Processing

Numerous other activities are underway nationwide that are tackling similar issues.

Investigators participating in PA 403 and related projects also hold full or partial extension appointments, so that results obtained are used in educating and, where appropriate, implemented by end-users. Multistate projects are cross-disciplinary in nature and in the case of S-1000, participants includes microbiologists, agricultural engineers, animal scientists agricultural economists, soil scientists and agronomists. As a result, the outcomes have far reaching implications and have significant impact on a large number of end users of a diverse background and interest, as exemplified by W-195 which is a water quality-related project. This is because wastes are typically land applied, which then has implications for soil, air and water quality. The CSREES Integrated Water Quality Program dictates that successful grant proposals address research, education and extension. Similarly, projects funded through the Air Quality program (managed in PA 141) must address a combination of research, education and extension. In addition, participation of private sector groups like the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) in W-1170 ensures immediate implementation of results, thereby fulfilling the education and extension requirements.

H: PROBLEM AREA 405
Drainage and Irrigation Systems and Facilities

Overview
The U.S. water supply available for commercial, agricultural and residential use is dwindling due to extended periods of drought in the west and the south, expanding urban regions and a lackluster human response to water conservation. Currently, the U.S. is facing a water crisis because of limited supply. Competition for this resource has become more intense, especially between the agricultural and residential communities. Increasing population and a blurring of the line between the rural and urban landscapes will only continue to drive problems associated with this critical natural resource.

With water availability being such a crucial part of every society's existence, agricultural and forestry-related users must practice efficient and wise use of water. Constraints on water quantity and water quality are being imposed by federal, state and local regulations. Drainage is equally as important because of its contribution to replenishing water supply by recharging the groundwater.

PA 405, Drainage and Irrigation Systems and Facilities, focuses on water management, including surface and subsurface drainage and all irrigation systems. Specifically, this involves drainage and irrigation equipment, system design, theory, modeling, installation, operation and maintenance for more efficient use of land, water and capital resources. Example topics are theory of water flow for more efficient water management system design, methods of automated water management systems to reduce labor and increase efficiency, and improved technology to measure and control losses of agri-chemicals from irrigated lands.

Situation
Each year, 25 percent of the nation's water supply is withdrawn, 80 percent of which is used for agricultural purposes. Irrigated acres constitute 15 percent of total farmland, but produce 38 percent of farm revenue. Due to advancing irrigation technology, farmers have the ability to increase the effective use of water from less than 50 percent to more than 90 percent. The number of irrigated farms and ranches fell 2 percent in 2003, and total land irrigated was down 3 percent compared with USDA National Agricultural Statistics Service (NASS) irrigation survey data collected in 1998. Some states, primarily in the southeast, have seen an increase in irrigated lands. Leading in total acreage of irrigated land in 2003 were California (16 percent of U.S. total), Nebraska (14 percent), and Texas (9 percent). The total quantity of water applied via irrigation in 2003 was down 11 percent from the 1998. Irrigators estimate a total of 87 million acre-feet of water were applied to the 53 million acres irrigated in 2003 for an average of 1.7 acre-feet per acre.

Stakeholders, especially in the Southern U.S. list irrigation as a top 10 priority for which research to meet projected growing water demands. When done efficiently and effectively, benefits of irrigation include reduced soil erosion and subsequent nutrient and pesticide pollution of ground and surface water because there is more precise delivery of inputs to crops. Proper drainage is also important to ensure that point source pollution is controlled. Improved irrigation systems and facilities ensure water conservation so that more water will be available for other uses.

CSREES is involved in research, education, and extension activities that improve drainage and irrigation systems and facilities to benefit agriculture and forestry-related practitioners. The ultimate goal is to more efficiently and effectively utilize irrigation and drainage systems to improve productivity of agriculture, forest, pasture and rangelands while also conserving and protecting the environment.

Input

CRIS data show that between 1999 and 2003 there were 120 projects conducted under PA 405. The number increased steadily from 4 in 1999 to a total of 65 in 2003. It is important to note that over the years, the focus on drainage has been deemphasized because appropriate technologies have been developed and are in use in the agricultural and forestry communities. PA 405 related activities are also being addressed through other Problem Areas (e.g., PA 102, 103, 111, 112), and the Water Quality Program.

CSREES invested $958,000 in PA 405 in 1999 and approximately $1.1 mil. in 2003. Hatch funds accounted for 56 percent of the 1999 total, followed by the NRI which accounted for 35 percent (Table 3-17). In 2003, Special Research Grants accounted for 35 percent of total expenditure and 26 percent was realized from Hatch funds. Total funding of approximately $5.1 mil. was invested in PA 405 for the 5-year period.

Table 3-17. CSREES Funding by Source, PA 405, Drainage and Irrigation Systems and Facilities, 1999-2003.

Source	Fiscal Year ($000)					Total
	1999	2000	2001	2002	2003	
Hatch	540	489	380	291	299	1999
McIntire-Stennis	0	0	0	0	0	0
Evans Allen	0	0	0	0	0	0
Special Grants	83	196	139	271	403	1,092
NRI Grants	334	195	386	23	155	1,093
SBIR Grants	0	0	309	0	75	384
Other CSREES	0	28	81	289	212	610
Total CSREES	958	907	1,295	874	1,144	5,178

Compared to other federal and non-federal sources, over the review period CSREES invested 39 to 48 percent of total funds (Table 3-18) in PA 405. The agency spent almost equally as much as other federal agencies combined on PA 405, and in 2001-2003 spent more money than other federal agencies.

Table 3-18. CSREES, Other Federal, Other Non-Federal Funding, PA 405 Drainage and Irrigation Systems and Facilities, 1999-2003.

Fiscal Year	Source ($000)			Total	CSREES % of Total
	CSREES	Other Federal	Other Non-Federal		
1999	958	962	450	2,370	40
2000	907	1,053	382	2,342	39
2001	1,295	954	443	2,692	48
2002	874	648	336	1,858	47
2003	1,144	795	467	2,406	48

At this time, most funding for PA 405 is allocated for research purposes. SERD funds a number of curriculum development projects geared toward natural resources and hydrology that involve irrigation and drainage principles, but the extent and depth of these programs are unknown. Integration among research, education, and extension is demonstrated in multi-state projects. Three projects with multiple state partners are addressing irrigation concerns affecting various areas throughout the U.S.

W1128 Reducing Barriers to Adoption of Micro-Irrigation
WERA202 Climatic Data Applications in Irrigation Scheduling and Water Conservation
S1018 Irrigation Management for Humid and Sub-Humid Areas

Other participants for the projects include USDA agencies, usually ARS or the NRCS.

Performance Criteria

This problem area addresses the critical issues related to drainage and irrigation. High quality activities are those that:

- Developed coupled models that advance irrigation efficiency;
- Increased understanding and knowledge of irrigation performance parameters; and
- Assessed economic measures for valuing irrigation and drainage systems.

Performance Indicators

- Adoption and implementation of practices and strategies that improve irrigation efficiency;
- Designed strategies to improve water quality leaving irrigated fields; and
- Adoption of irrigation measures that reduce water quantity used for crop irrigation.

Outcomes

Short Term

- Increased knowledge through publication of information gained through research activities
- Extending knowledge through extension activities
- Increased awareness, knowledge, attitude, and skills of producers and other end-users

Medium Term

- Better use of irrigation systems that conserve water

Long Term

- Increased knowledge of average irrigation amounts
- Adoption of practices that reduce the quantity of water needed to irrigate crops
- Adoption of fertigation techniques that limit over use of fertilizers
- Enhanced knowledge of the functionality of nutrient and pesticide application systems for uniform application
- Improved environmental quality because of reduced point source pollution
- Refined models that improve agricultural productivity and sustainability

Accomplishments/Outcomes

Highlights from four of the many successful projects from 1999-2003 are provided below.

Drought is perhaps the single greatest threat to agriculture. **Efficient water conserving alternatives** for agricultural production are needed to protect regional water resources and maintain productivity. A project was funded through the Special Research Grants program to determine the **feasibility of subsurface drip irrigation** and other alternative irrigation systems in western Kansas. Over a fourteen year period, the investigators found only small fluctuations (less than 5 percent) in flow rates, and concluded that it is economically feasible to irrigate lower value crops like corn. Also, over a four year period, they found that drip line depths ranging from 8 – 24 inches had no appreciable effects on corn yields, so that producers can apply less water to their crops. Because of the direct involvement of extension, the results have been shared with producers through publications and oral discussions. It is expected that these practices will be adopted by end-users.

Another Special Research Grant funded project is targeting **efficient irrigation** in Texas and New Mexico, since the waters of the Rio Grande River are a critical resource for the region. The major problem is that total water management does not exist, so that water is released on demand. Excessive ground water pumping increases salinity and the potential for crop damage. Research progress is having significant impact in the region, including: 1) **seepage loss tests** have formed the basis for irrigation districts' guidelines for canal lining, noting that for every mile of canal lined, the region may save about 400 acre-feet of water; 2) five native and one introduced shrub's soil water extraction and pattern of transpiration formed the basis for a Web site detailing native shrub water use; 3) a model to estimate the **economic values of water in alternative uses and locations** in New Mexico river basins, useful for projecting the consequences of different management plans, was developed; 4) larger numbers of homeowners are now willing to assume responsibility for selecting **climate appropriate landscapes**. Work is continuing and will determine the extent to which homeowners are engaging in these practices.

Conventional center pivot irrigation management treats the field area as a homogenous unit in terms of irrigation requirements and water application. The same is true for application of N, but spatial variability in water and N requirements develop throughout the growing season. Enhancements to center pivot irrigation which enable **site-specific in-season water and nitrogen management** have the potential to increase production efficiency through increased

water and N use efficiency. Researchers developed, field tested and implemented the use of equipment and a control system to implement conjunctive, in-season, site-specific water and nutrient management with center pivot irrigation systems. The system achieves a high level of **uniformity in both chemical and water application**. The investigators are documenting the economic and environmental benefit of the technology, which will spur commercialization and adoption by producers. The system will reduce over application of N and water which results in ground water contamination and increase production efficiency, by increasing the precision of chemical and water application.

The goal of one formula-funded project is to provide irrigation **water and cultural management** information and tools for the production of high value crops, including wheat, in North Dakota. The scientists are finding that furrow planting has not increased the occurrence of disease or green tubers and has not affected yield components of potatoes. It is expected that planting configuration will significantly increase yield and water conservation in drought-sensitive situations.

Future Directions

CSREES gathers stakeholder input for this PA through participation of National Program Leaders in numerous multistate projects, attendance at local, regional and national meetings, review of land grant programs and other external activities. Research, education and extension successes in the fundamentals of irrigation and drainage are substantial as evidenced from the accomplishments in this document. However, with a growing human population that is living longer, water availability demand and quality needed by multiple users is at an all-time high. Funds are needed to address irrigation and drainage issues in the agricultural and forestry-related sectors.

Participants at the September 2004 USDA Water Security Listening Session for the topic area Irrigation Efficiency and Management specified the strengths of USDA for improving the advancement of research, education and extension in PA 405. Major strengths included educational linkages through extension, infrastructure encouraging interdisciplinary activities, a broad and inclusive customer base, partnerships between universities and industry, regional collaborations, expertise, and dissemination of information.

The pertinent needs, issues and policy concerns of irrigation efficiency and management were also identified at session by participants drawn from academia, NGOs, state, federal and the private sector. Program attention is required to:

- Alert, motivate, and educate the agricultural community about the importance of irrigation efficiency;
- Maximize/optimize socioeconomic return to consumed water in agricultural and urban landscapes and the environment;
- Promote proper management and effective use of irrigation systems to extend the use of current water supplies;
- Enhance the transfer of irrigation technologies and management alternatives emphasizing economic and environmental benefits;
- Address the concerns associated with losing water rights, particularly for landowners in the western U.S.;

- Collect data on water use;
- Understand irrigation performance parameters and water delivery systems;
- Develop educational programs that meet future irrigation needs;
- Implement long-term studies of irrigation systems and technologies;
- Establish basin-wide water management protocol;
- Study water marketing;
- Collect economic data about water values and different uses;
- Construct improved technologies for water for field level application and management; and
- Assess water accounting and assessment measures (Improvements in terms, better measurements and tools, consumptive use with satellite technologies, affordable/accurate soil-water sensors, water use efficiency and comparable terms for urban/environment).

CSREES and others are already addressing some of these issues. The agency continues to fund projects classified as addressing PA 405, and related Problem Areas, and it also funds related projects through the Water Quality program.

I: Problem Area 605
Natural Resource and Environmental Economics

Overview

Economists examine tradeoffs in allocating limited resources for producing goods and services that will meet individual, community, and societal needs. In the agricultural sector, farmers and ranchers use natural resources, such as land, soil, air, and water, for producing food, fiber, and timber. Not only do farmers and ranchers have limited access to these natural resources, the economy as a whole has various activities besides agriculture that compete for their uses. With population increase and economic growth, these natural resources have become increasingly depleted over the last few decades. Agricultural production, while generating some positive benefits, may simultaneously create negative impacts on the environment.

Agricultural economists design tools to illustrate effective allocation of natural resources. They develop methodologies to estimate the economic values of environmental attributes. They also evaluate decision-making processes among alternative or completing uses so as to protect and minimize negative effects on natural resources and the environment. Traditionally, tools developed or suggestions made by economists have been most helpful to individual producers in understanding the potential effects and consequences of alternative management strategies to the environment. However, a better approach is for economists to collaborate with biophysical scientists to study long-term cumulative and multi-generation effects on a broader scale (e.g. watersheds or river basins). Failure to incorporate economic perspectives in policy decision-making has inadvertently reduced the effectiveness and efficiency of public policy in addressing natural resource and environmental issues.

Situation

PA 605, Natural Resource and Environmental Economics, is built around an interdisciplinary philosophy by integrating economics with biophysical sciences to understand natural resource and environmental issues. CSREES involves agricultural economists at the land-grant universities in research, education, and extension activities to address complex natural resource management and interrelationship of that management with the environment. Agricultural economists combine mathematical and statistical tools with economic principles and other biophysical sciences to design and implement innovative solutions for managing natural resources that are economically viable, socially acceptable, and environmentally responsible.

PA 605 encompasses a broad scope of subject areas, including, but are not limited to, the economics of water resources, wildlife and fisheries, land use and management, agro-environmental policies, and valuation methodologies. For example, agricultural economists develop methodologies to measure economic values of water for competing uses among irrigation, aquatic animals, recreation, or urban water supply. They estimate the important value of public goods and services, such as flood or erosion mitigation, wildlife habitat, scenic vista, and clean air or water, delivered by agriculture. They apply various mathematical and statistical tools to examine how choices made by people in private or public sectors may affect land or water resource allocations or the quality of the environment.

Agricultural economists explore costs and benefits to help farmers, ranchers, and communities make informed decisions for achieving efficiency and sustainability in managing their natural resources. They calculate on-site and off-site benefits resulting from conserving natural resources and protecting the environment. They evaluate trade-offs, risks, and unintended consequences on public sector's agro-environmental policies designed to minimize negative impacts on the environment. They investigate conflicts between economic development and environmental quality, and develop strategies to resolve such conflicts. They may also analyze and design various institutional incentives or procedures to enhance the distribution of natural resources. A few examples will be presented in the section of Accomplishments/Outcomes below.

Inputs

Through various funding mechanisms, CSREES investments in Natural Resource and Environmental Economics increased from $4 mil. to over $5 mil. during FY 1999 to 2003, to a total of more than $25 mil. over those 5 years. In general, Hatch funds remained flat with a total of less than one-half (43 percent) of all CSREES funds dedicated to this area of work. Competitive grants, i.e., NRI, dipped down from a modest $380,000 in FY99 to a low in FY 2001 of $187,000, yet in FY 2003 increased substantially to approximately $1 mil. Funds from Special and other CSREES Grants increased only slightly over that 5-year span. Table 3-19 shows funding breakdown for PA 605 by source.

Table 3-19: CSREES Funding by Source, PA 605, Natural Resource and Environmental Economics, FY 1999-2003.

Source	Fiscal Year ($ 000)					Total (%)
	1999	2000	2001	2002	2003	
Hatch	1,656	2,044	2,387	2,302	2,416	10,805 (43)
McIntire-Stennis	921	725	734	841	489	3,710 (15)
Evans Allen	394	304	248	366	234	1,546 (6)
Special Grants	599	584	576	511	740	3,010 (12)
NRI Grants	380	297	187	260	994	2,118 (8)
SBIR Grants	137	125	0	0	38	300 (1)
Other CSREES	0	1,435	711	727	826	3,699 (15)
Total CSREES	4,087	5,514	4,843	5,007	5,737	25,188

Table 3-20 reveals that between FY 1999 and 2003, while CSREES investments in the area of Natural Resource and Environmental Economics were comparable to that of other Federal agencies, it was much less than that of non-Federal organizations. Overall, CSREES funds accounted for only an average of 19 percent of the total funding received by scientists working on projects that have components related to natural resource and environmental economics.

Table 3-20. CSREES, Other Federal, Other Non-Federal Funding, PA 605, Natural Resource and Environmental Economics, FY 1999-2003.

Fiscal Year	Source ($ 000)			Total	CSREES % of Total
	CSREES	Other Federal	Other Non-Federal		
1999	4,088	3,278	15,348	22,714	18
2000	5,514	3,526	14,782	23,821	23
2001	4,843	4,349	14,836	24,028	20
2002	*5,006	6,027	17,733	28,767	17
2003	*5,741	5,244	18,917	*29,907	19
Total	25,192	22,424	81,616	129,237	19

* Total from CRIS print out directly. Minor discrepancy exists due to rounding.

Table 3-21 summarizes the broad scope of SOIs for PA 605. Funding for Trees, Forests, and Forestry ranked No.1 in FY99 (37 percent of total CSREES PA 605 funding). Watershed and River Basin ranked second (11.6 percent); followed by Soil and Land (9.7 percent) and Water (9.3 percent). In FY03, Trees, Forests, and Forestry remained No. 1 (23.7 percent). However, Watershed and River Basin (No. 7) fell below Soil and Land (No. 2) and Water (No. 6), at 5.9, 11.6, and 6.8 percent of the total funding, respectively. Despite changes in ranking, these SOI accounted for about 80 percent of total agency funding in Natural Resource and Environmental Economics. Other SOIs, such as rangelands and grasslands, wildlife and fisheries, or pasture and forage crops, accounted for the rest of the 20 percent PA 605 funding.

Table 3-21. CSREES Funding, by Selected Subjects of Investigation, PA 605, Natural Resource and Environmental Economics, 1999 and 2003.

Fiscal Year	Subject of Investigation[1] ($ 000) (%)							Total[2]
	Trees, Forests, and Forestry	Watershed and River Basin	Soil and Land	Water	Recreation Resources	People and Communities	Economy	
1999	1,511 (37)	475 (12)	396 (10)	380 (10)	286 (7)	282 (7)	181 (4)	3,511 (86)
2003	1,362 (24)	339 (6)	667 (12)	390 (7)	597 (10)	645 (11)	561 (10)	4,561 (79)

[1]Other SOIs include, but are not limited to, pasture and forage crops; rangelands and grasslands; plants, (general); wildlife and fisheries; swine; poultry; beef cattle; animals, in general; cultured aquatic animals; weeds; structure, facility, and equipment; and micro-organisms.

[2]Total CSREES PA 605 funding was $4.087 mil., and $5.741 mil., for FY99 and FY03, respectively.

Performance Criteria

To ensure long-term economic growth and environmental sustainability, economic perspectives will have to be incorporated into research, education, and extension activities when addressing the interrelationship between agricultural production and the environment. High performance for PA 605 requires:

- Understanding the economic implications of adopting alternative technologies;

- Evaluating at multiple scales the short- and long-term economic impacts of public policies;
- Quantifying environmental benefits and designing incentive programs to compensate producers for the public goods produced; and
- Developing market-based mechanisms for mitigating pollutants.

Performance Indicators

- Increasing awareness of economic implications by producers and policymakers;
- Adopting efficient technologies for protecting and conserving natural resources;
- Improving the effectiveness in conservation program and policy implementation; and
- Creating markets or institutional mechanisms for pollutant trading.

Outcomes

Short Term

- Increased integration of economics in research, education, and extension activities when addressing environmental issues attributed to agriculture; and
- Better understanding of trade-offs in adopting alternative technologies and conservation policies.

Medium Term

- Improved modeling approach in quantifying environmental benefits;
- Increased knowledge of cumulative benefits on a larger scale; and
- Better strategies, policies, and program designed to encourage resource conservation.

Long Term

- Increased effectiveness of agro-environmental policy implementation based on performance, instead of practice;
- Reduced needs for regulatory approaches with more incentive-based policies; and
- Enhanced environmental quality and improved efficiency of natural resource utilization by
  - Protecting high-quality productive and environmentally sensitive lands; and
  - Minimizing potential conflicts among alternative user groups.

Accomplishments/Outcomes

Partnering with CSREES, agricultural economists in the land-grant system have collaborated with physical and biological scientists to address natural resource and environmental problems. They generated knowledge, trained future scientists, and directly or indirectly assisted producers and private and public policymakers in managing natural resources and mitigating environmental problems for sustainable growth.

Multiple Benefits of Carbon-Friendly Agricultural Practices: Empirical Assessment of Conservation Tillage. (Hatch funded project).

Agro-environmental policies, such as the Conservation Reserve Program (CRP), tend to be designed based on least-cost measures that maximize acres enrolled. However, they may not gain the most environmental benefits due to performance results varying from different land and

soil characteristics. A more efficient conservation policy ought to target subsidies to environmental sensitive areas where producers can provide the highest amount of environmental benefits per dollar spent. A Hatch funded project addressed this issue through a project Multiple Benefits of Carbon-Friendly Agricultural Practices: Empirical Assessment of Conservation Tillage. Study results show that the environmental benefits generated by farmers in Iowa are relatively homogeneous from their adoption of conservation tillage. Namely, **practice-based policy can provide high proportions of the environmental benefits studied relative to that of performance-based policy**. It implies that should there be ample conservation funding in Iowa, there would be no need to implement performance-based policy of which measuring and monitoring costs could be higher. This study is expected to provide an in-depth knowledge for conservation policy decision makers to establish strategies in achieving greater environmental benefits. Applying similar methodologies in this study to different conservation objectives and to a regional or national scale, especially to areas with considerable variations in natural resource characteristics, will enhance better understanding of tradeoffs between alternative policies.

The Impact of Open Space and Potential Local Disamenities on Residential Property Values in Berks County, Pennsylvania. (Hatch and special grant-funded project)
Increased attention is being focused throughout the Northeast on how land use is changing over time. Concerns over urban "sprawl," with its patchy, diffuse pattern of development, include the loads placed on the transportation infrastructure, the costs of delivering local services, the impacts on natural systems, and the effects on the aesthetic and cultural value of the landscape. Local authorities that manage and regulate growth and development need information on both the relative desirability of alternative land use patterns, and on the forces generating those patterns. Researchers are investigating the "Impact of open space and potential local disamenities on residential property values in Berks County, Pennsylvania." They focused on: 1) developing a GIS database on land use and residential property values in Berks County, Pennsylvania; 2) estimating an implicit price function to explain variations in single family residential properties; and 3) characterizing the pattern of recent residential development to determine whether spatial interactions among parcels were an important factor of new home construction location. Results indicate that 1) spatial interactions among parcels do impact residential property values; 2) within 400 meters of a house, open space is the most desirable surrounding land use, followed by large-lot residential use; 3) between 400 and 1600 meters from a house, commercial is the most attractive land use, followed by large-lot residential, and then open space; 4) specific to large-scale animal production facilities, there is a significant impact within 1600 meters from such facilities, but not farther than that; and (5) an analysis of the spatial pattern of development showed a) that larger lots are more likely to be developed as are lots located near existing residential areas, and b) proximity to government-owned open space has a small positive impact on probability of development. Overall, the project demonstrated the utility of using GIS analysis to investigate issues of spatial interaction in land use, both interactions that affect house prices and the pattern of development that occurs over time. Key findings provide Berks County officials with science-based knowledge to support their land use decisions. The approach used in this study needs to be expanded to a larger region so as to better distinguish the relative impacts of different scales of animal operation and species.

Economic Linkages between Coastal Wetlands and Water Quality. (Hatch-funded project). Coastal wetlands are increasingly recognized as essential to natural systems and human activities because of the environmental services that they provide. However, this recognition has not resulted in capitalized economic value for landowners. Non-market wetland benefits may be important society, but the lack of a market value for the services means that they are often de-emphasized relative to physical loss or the private economic gains that can arise from conversion of wetlands to other land uses. While the search for quantitative measures of wetland values is challenging due to the diversity, socioeconomic context, and complex hydro-biological functions of wetlands, informed policy requires that both market and non-market wetland values be incorporated into the decision making process. Scientists are evaluating the "Economic Linkages between Coastal Wetlands and Water Quality: A Review of Value Estimates Reported in the Published Literature." They set out to: 1) document the current status of knowledge concerning the economic value of the water quality services generated by coastal and other wetlands; 2) provide a brief overview of the theoretical economic linkages between wetland ecosystems and water quality as a basic framework for understanding why specific variables and measurement methods are of interest; and 3) outline common methods used to value the water quality services of wetlands, along with their major advantages and disadvantages. An output of the project is a systematic and concise compendium of theoretical and technical information on estimating the economic value of wetlands' environmental services for water quality. The importance of geographic location, and the specific use demand, on water quality service value suggests that coastal wetland benefits should be carefully examined within a spatially disaggregated context. This comprehensive information will help enrich policymakers about the relative benefits and costs of different strategies in natural resource management such as to restore or preserve wetlands for improving water quality. However, the complexity of interrelationships between natural resources and the environment demand in-depth evaluation.

Future Directions

More emphasis and support for PA 605 is required to enable a systems approach and to strengthen the integration of socioeconomic perspectives with biophysical sciences. Only then can agriculture-induced natural resource and environmental issues be adequately comprehended. CSREES has yet to plan a direct stakeholder input or listening session on natural resource and environmental economics. However, based on Plan of Work reports submitted by States, scientific papers presented at regional and national conferences (e.g., American Agricultural Economics Association), reports from nationally renowned organizations, such as Farm Foundation, NASULGC and ESCOP (2001), and National Research Council (Robertson, et. al., 2004), a few significant issues for the 21st century (not in priority order, nor inclusive) that require further attention are:

- Design economic incentives for conservation technology implementation;
- Develop comparative studies on performance- and practice-oriented conservation policies for achieving optimal environmental goals;
- Enhance biophysical modeling with economics to measure short- and long-term economic benefits of conservation practices at the watershed or regional scale;
- Estimate cumulative economic effects of air and water pollution for downwind and downstream communities;

- Assess multiple benefits, such as carbon sequestration, flood protection, water quality improvement, energy conservation, wildlife habitat, or rural vista; and create institutional mechanisms to compensate producers for the environmental benefits they deliver;
- Define economic values and costs of bio-technology and bio-energy development in global-trading settings;
- Evaluate economic impact of global climate change and design potential mitigation policies;
- Explore market-based mechanisms for water, soil carbon, and greenhouse gas emission trading;
- Measure risks and costs to human health and the society from polluted air and water;
- Estimate damages to producers and society attributed to invasive plant and pest species;
- Compare agro-environmental policy implications between voluntary and enforcement programs and design effective policies; and
- Understand costs and benefits on the ecological landscape with competing uses of land and water from demand for rural, urban, agriculture, aquatic animals, and recreation.

Currently, several on-going multi-state projects are focused on some issues listed above. For example, W1190 (Interfacing Technological, Economic, and Institutional Principles for Managing Inter-sector Mobilization of Water) has multi-discipline participants from AZ, CA, CO, HI, KS, NE, NM, ND, OR, TX, UT, WA, and the Economic Research Service (ERS). W1133 (Benefits and Costs of Natural Resources Policies Affecting Public and Private Lands) has land-grant participants from AL, AZ, CA, CO, CT, GA, IA, KY, LA, ME, MD, MA, MI, NH, NY, ND, OH, OR, PA, TX, WA, WV, and WY, along with partners from ERS, Forest Service, and Bureau of Land Management. Through these multi-disciplinary collaborations, economists have developed and disseminated knowledge and information to producers and policymakers for achieving their environmental objectives.

To address socioeconomic implications of interactions between agriculture and the environment at multiple scales with a long-term perspective, however, more multi-state work ought to be encouraged. Multi-state research helps strengthen collaborations among multi-disciplinary scientists across the nation as well as to expand research to a larger scale and for a longer term. Increase in integrated projects between research and extension will ensure more stakeholder input in designing research projects and deliver practical research results. Moreover, stakeholder input will be taken into consideration in designing CSREES competitive program RFAs, by incorporating human dimensions to address the interaction between agriculture and the environment.

Section IV Criteria and Dimensions of Panel Review

Frame of Reference for this Portfolio Review and Limitations

This portfolio review is a first attempt at measuring the potential value of investments made in 13 PAs in the area of Natural Resources and Environment during 1999-2003.

Criteria and Dimensions of Panel Review

The work of the Portfolio described in Sections II and III should be reviewed using the following criteria. A scoring sheet will be provided to the panel to facilitate ratings.

Relevance

Scope

The evolving system of environmental and natural resource research encompasses the programs of SAES, colleges and departments of forestry, 1862, 1890, and 1994 land grant institutions, HSIs and other cooperating institutions, including state and private colleges and universities and USDA intramural agencies. These programs are closely linked to and complement the teaching and extension activities of the land-grant and other institutions. At the university level, research programs also are integral to graduate education, through which scientists are prepared to address future scientific natural resources and environment challenges. The agency uses a unique partnership of federal and non-federal, private and public sector and NGOs partners to address issues relating to Objective 5.2 (Management of Soil, Air and Water) to ensure the health and well-being of society. Coordination, joint planning and priority setting are accomplished through various national and regional mechanisms to ensure the efficient use of resources, while enhancing productivity and protecting soil, air and water resources quality.

Accomplishments and outcomes described in individual PAs in Section III illustrate where CSREES is contributing to timely, relevant research directed to solving critical problems of national significance. For example, water and air are among the most critical natural resources that are inherent to the health and well being of society. The water quality program at CSREES was implemented because of stakeholder identification of this emerging issue. More recently, water quantity/water security is recognized as being equally important. CSREES is already taking steps to address this issue. Similarly, the air quality program at CSREES was implemented in 2003 because it was identified as a priority emerging issue that demanded immediate action. These two examples clearly show that programs in Objective 5.2 are current, relevant, timely and of high quality and productivity. Further, PA descriptions also point to the interdisciplinary nature of the portfolio and that activities in Objective 5.2 are interlinked with almost all other portfolios in the agency, including plant production and protection, food safety, animal production and protection and others.

CSREES funding mechanisms for Objective 5.2 portfolio includes formula funds, the NRI, Integrated, special and administrative grants, SBIR and to some extent, McIntire-Stennis funds. The agency invested approximately $67 mil. in 1999 and approximately $78 mil. in 2003, and a total of $375 mil. during the 5-year review period. During this time, other Federal agencies

invested a total of $284 mil., while State appropriations accounted for $834 mil. The grand total invested in Objective 5.2 for this 5-year period from all sources was approximately $1.6 bil. This demonstrates that extensive leveraging of Federal funds and sharing of resources is critical to maximizing the outcomes and impacts of management of soil, air and water resources.

CSREES SERD is leading USDA's commitment to human capital development. Section II, Table 2.5 shows that between 1999 and 2003, SERD invested $6.9 mil. in Objective 5.2-related education programs, nationwide.

It is important to note that the funds reported (except for SERD's education programs) in this document represent investments on research activities and does not include extension activities. This is a weakness of the current CSREES database reporting system. The agency is addressing this short-coming, including modification of the CRIS database so that education and extension activities will be readily accessible in the next 5 years.

The summaries presented are based on federal and state research activity as documented in USDA CRIS, land-grant university plans of work, and the USDA Science and Education Impact database (see http://www.csrees.usda.gov/newsroom/impacts/impacts.html).

Portfolio Ability to Remain Focused on Critical Needs

CSREES peer review of formula-funded research and competitive grant proposals, state Cooperative Extension plans of work and annual reports ensure that programs and activities supported by CSREES funds focus on critical scientific issues. National planning activities and listening sessions (such as the Soil Science Society of America-CSREES Soil Stakeholder Listening Session and the USDA-Research Education, and Economic (REE) Agencies' Agricultural Water Security Listening Session), help to guide state and regional level research, education and extension programming to contribute to meeting national needs. The competitive review process especially encourages innovative ideas that are likely to open new research approaches to enhancing agricultural and natural resources management. A proven mechanism for stimulating new scientific research, the process increases the likelihood that investigations addressing important, relevant topics using well-designed and well-organized experimental plans will be funded. Each year, panels of scientific peers meet to evaluate and recommend proposals for funding based on scientific merit, investigator qualifications, and relevance of the proposed research to the mission and goals of USDA.

For this report, priorities are based on USDA CSREES Strategic Plan of 1997-2002, and identified as Objective 5.2 in the 2004–2009 Strategic Plan. In addition, priorities and emerging issues are identified through the broad network of relationships that NRE's Deputy Administrator and NPLs have established. Themes outlined in the PA descriptions (Section III) illustrate how CSREES contributes to timely, relevant research directed at solving critical soil, air and water resources problems of national significance.

Identification of Emerging Issues Relevant to the Portfolio

Setting priorities is an important means of facilitating the scientific and technological advances needed to meet the challenges facing U.S. agriculture and natural resources management. Congress set the budgetary framework by providing funds to CSREES. Members of Congress

also make recommendations for the scientific and programmatic administration through appropriation language and through their questions and comments during Congressional hearings. Input into the priority-setting process is sought from a variety of customers and stakeholders. AREERA formally requires that formula-funded projects reflect stakeholder priorities. The scientific community provides direction through the competitive grant proposals it submits each year as well as through the proposal evaluation and funding recommendations of individual peer-review panels (see Evidentiary Materials).

Participation by NPLs in review panels for competitive programs, federal interagency working groups, and stakeholder listening sessions are important mechanisms for the agency to identify emerging issues for Objective 5.2. NPLs also attend professional and scientific meetings to stay current on scientific trends that should be reflected in programs and in the coordination of priority setting with other federal agencies. The Deputy Administrator and NPL have established close working relationships and networks with various stakeholder partners including research, education and extension scientists and educators at the universities and colleges, other federal agencies, county agents and educators, advocacy organizations, professional societies, advisory groups, environmental groups and Congress. Through these interactions, NPLs learn of stakeholders' current priorities, identify emerging issues and solicit comments and suggestions on ways that the agency can assist in meeting their needs. In this portfolio, emerging issues are described as "new directions" individual or groups of PAs (See relevant sections of PA descriptions – Section III).

Integration of CSREES Education, Research and Extension efforts in the Portfolio

Integration refers to the linkage of the functions of research, education, and extension in programs and activities to produce products which reach a wide variety of audiences and stakeholders in appropriate formats. These products might otherwise be disjointed and more narrowly defined. Although the agency is dedicated to integrative efforts in all its programming areas, there are some challenges to accomplishing this, caused chiefly by outside factors. For example, some legislative authorizations are so specifically defined that they preclude meaningful integration. Similarly, some stakeholders have interests which are similarly fixed on single purposes. These situations require that NPLs take the initiative to stimulate and accomplish integration in otherwise focused program areas. While this has been somewhat problematic in the past, significant progress has been made. The agency also has competitive grant programs that specifically require or encourage integrated programming. The NRI, for example, is authorized to allocate up to 20 percent of annual funding for integrated projects, and within it, certain programs are identified as appropriate. A specific NRI program that is integrated is the Air Quality program; projects must show integration of research, education and extension activities. Others like Soil Processes (formerly Soil Biology) and the Managed Ecosystem programs can allocate funds to projects that integrate research and education. The Water Quality program (Section 406) includes sections that require integration of research, education and extension activities (see Evidentiary Materials).

Multidisciplinary Balance of the Portfolio

Both mission-linked research and fundamental research are supported by CSREES formula- and competitively-funded research. Mission-linked research targets specific problems, needs, or opportunities. Fundamental research involves the quest for new knowledge about important

organisms, processes, systems, or products and opens new directions for mission-linked research. Mission-based and fundamental research is essential to the sustainability of agriculture and Management of Soil, Air and Water resources. Review of formula-funded projects in the Objective 5.2 portfolio reveals that the vast majority typically combine fundamental and applied approaches. Although single-investigator projects remain the norm, increasingly these types of research are taking multi- and inter-disciplinary and multi-investigator formats. Additionally, CSREES competitive grant programs are encouraging multidisciplinary research. Moreover, the agency requires that 20 percent of the research formula funding that it provides to states be devoted to multi-state activities, which at least indirectly promotes multidisciplinary approaches. In turn, the regional SAES use the funds to support multi-state research projects and committees. At any given time, several such projects have objectives related to Objective 5.2 and CSREES NPLs serve as advisors to them (see Evidentiary Materials).

From the extension perspective, multidisciplinary approaches, and involvement of end-users in the conduct of research experiments are well established practices in many states. This is especially true for multi-state projects, where producers and other end-users are integrally involved in the projects. Some competitively funded programs (National Integrated Water Quality Program, Air Quality Program) require integration of research, education, and extension in all funded projects. Specific examples of integrated projects and outcomes are discussed below.

Quality

Significance of Portfolio Outputs and Findings

At the Agency level, all federal funds are leveraged at least by a ratio of $2 of non-federal funds for every $1 of federal funding. This leveraging provides expanded fiscal resources to address programs that are partially funded by CSREES.

Every individual and every segment of society is directly impacted by the quality of soil, air and water, the three natural resources that are the foci of this report. These resources are shared by urban populations and agriculture, forest and rangeland production sectors. Society is aware that agriculture-related activities can contribute to the degradation of these natural resources, and this fact is not lost on the agriculture community, which uses science-based knowledge to increase productivity while protecting the environment. CSREES through its partnership with universities, other federal and state agencies, and private organizations, are contributing to this bank of science-based knowledge through research, education and extension activities. Included in this report, are examples of some of the thousands of CSREES-funded projects that are having significant positive impact on improving “the management of soil, air and water to support production and enhance the environment.”

All approved projects, competitive and formula-funded, must address topics and issues that are in keeping with the agency’s mission. CSREES funded projects, whether wholly or in part because of leveraging, have resulted in the production of hundreds of Baccalaureates, Masters and PhD degree holders in natural resources and environment related disciplines. (See Evidentiary Materials for examples). This is significant evidence CSREES is contributing to the training of the next generation of natural resources scientists, specialists, agents and decision-

makers while simultaneously expanding the knowledge base. Research results and findings have significantly contributed to the accomplishments related to Goal 5, Objective 5.2. (See also PA descriptions in Section III).

CSREES investment in natural resource-related research is highly effective and beneficial. For example:

- North Carolina researchers found that a legume cover crop can be an effective nitrogen (N) source in vegetable production, in that bell pepper yield (fruit number, total yield, dry matter content and net photosynthesis) was similar when grown with N fertilizer or with the legume cover crop. This project improves soil and water quality as well as vegetable yields.
- SBIR funded a project that led to the development of low cost devices for measuring soil moisture, soil temperature and assessing soil fertility at hazardous sites. A soil moisture sensor (SMRT Probe) was developed, patented and commercialized.
- A project funded through the Water Quality program was the first to identify the presence of drugs specifically from animal sources in stream sediment. Increased funding of the Water Quality program is resulting in increased public awareness of water quality and quantity issues, and adoption and implementation of best management practices that conserve water for agriculture-related activities, such as crop irrigation.
- In Washington, dust emissions from agriculture–related activities have been reduced by 94 percent, simply by adopting no-till cropping practices.

Research activities are geared to the needs of CSREES' stakeholders and the science-based knowledge resulting from these activities is used by policy-decision makers and others, and the end result is the protection of the health and well-being of society.

Stakeholder/Constituent Inputs to the Portfolio

The NPLs and Deputy Administrators have effective networks and mechanisms that assist them in establishing priorities and assuring program relevancy.

Formula fund (Hatch, Evans-Allen, McIntire-Stennis and Smith Lever) recipients are required by the1998 Agricultural Research, Education and Extension Reform Act (AREERA) to obtain stakeholder input every year and to describe the process used to identify individuals or groups as stakeholders. Also each institution needs to describe how these inputs relate to Plans of Work, priority setting, immediate needs and long-term goals, guidance on monitoring, and proposed research activities.

CSREES and ARS, the USDA in-house research component, conduct many stakeholder listening sessions, nation-wide, in order assess program effectiveness, for program development, and to identify new and emerging issues, and program directions. NPLs from both agencies participate in these listening sessions, thereby reducing redundancy of programs. Several examples of listening sessions are discussed in Section III – Problem Area discussions - including the CSREES-Soil Science Society of America soil listening session and the Water Security listening session. Stakeholder input is critical to directing RFAs and program directions.

Alignment of Portfolio with Current State of Science-Based Knowledge and Previous Work
All funded projects complement CSREES goal of providing "science-based knowledge and education to improve the management of soil, air and water to support production and enhance the environment." The outcomes and accomplishments of funded projects could not be achieved without application of modern and advanced scientific methodologies and techniques. For example, the SBIR program funds projects that will develop devices and technologies that are used for increasing production and managing soil, air and water resources. Investigators are using molecular tools and techniques to track and identify pathogens and determine their source, fate and transport in soil, air and water. Technologies are being used for weather forecasting, because environmental conditions directly affect crop production activities such as planting, irrigation schedule and timing of pest control measures. Similarly, GIS is being used in precision agriculture to target application of nutrients to crops which subsequently leads to reduced negative environmental impacts.

The peer and merit review processes that are employed by the agency ensure that this Portfolio is aligned with current state of science-based knowledge and previous work. Each proposal that is submitted must address previous work that has been done on that topic or issue. Further, for competitive projects, there is an intensive and extensive peer review system, and success hinges on meeting this criterion, among others. The process is somewhat problematic for formula-based projects, however, since alignment is typically dictated by the desires of individual academic institutions that receive the funds.

Appropriate Methodology of Funded Portfolio Projects
All proposals submitted to CSREES must undergo a rigorous review process at several levels. Competitively funded projects are reviewed by an external peer panel of experts drawn from universities, other federal and state partners, and the private sector. Non-competitively funded proposals, including formula funds, are reviewed at the university level prior to submission to CSREES, where they are further reviewed by NPLs. NPLs ensure that the proposed projects are in keeping with the mission of the agency, fit the intent of the legislative act, and have measurable potential outcomes and impacts. Proposals submitted for congressionally-directed funding are also reviewed by NPLs, who subsequently schedule site visits to monitor the progress of these projects. Similarly, NPLs serve as liaisons to all multi-state projects for reasons previously discussed.

The quality, outcomes, outputs and impacts of projects are significantly influenced by experimental methodologies. Overall, appropriate methodology correspondingly produces appropriate results and appropriate procedures produce data that are suitable for analyses. Therefore CSREES

Performance
Assessment of the performance of the programs funded in this portfolio suggests that the programs are providing science-based knowledge and education for improving management of soil, air and water resources.

Portfolio Productivity

Each Problem Area discussion (See Section III) indicates various research, education, and extension outputs, outcomes and accomplishments in Goal 5, Objective 5.2. However, assessing overall portfolio productivity is problematic, for several reasons:

- Specific measures of productivity have not been established, with the result that current trends over time cannot be tracked.

- Assessing the productivity of competitively funded programs, including education, is relatively straightforward, in that project directors are required to submit annual and termination reports for each funded project. In addition, NPLs routinely schedule site visits to assess progress of projects that receive congressionally-directed funds. The assessment is more difficult, however, with formula-funded programs, particularly extension, in that states exercise wide latitude in what they report. This is based in part, on the fact that CSREES contributes only a small percentage of the funds in some states. The result is that some states report only those programs that are "touched" by CSREES funds, while others report the entire state program. In both cases the amount and quality of annual reports vary widely from state to state. The result is that at the national level, there is a mixed and incomplete picture of the results that emerge from CSREES-funded programs.

- State extension annual reports most often report only program inputs, audiences reached and outputs. Evaluating outcomes requires more resources, particularly time, professional evaluation, and money. If program evaluation efforts are not budgeted for, they are unlikely to occur, and if evaluation specialists are not available at the institutions to assist with the design and execution of the evaluation, some extension educators simply must do what they can without the benefit of experts.

Despite these limitations, several observations and conclusions can be drawn from a review of the accomplishments of the university partners. (See "Outcomes and Accomplishments in Section III):

- Each PA previously described (See Section III) demonstrates various research, education, and extension outputs, outcomes and accomplishments, thereby pointing to portfolio productivity.

- Project productivity can be measured in part, by the number of publications that are produced (Output), the number of patents (Output), and the actual or potential impacts when new practices are adopted and implemented (Outcome). These productivity measures exist for several programs (e.g. Soil Processes, Air Quality and Water Quality), as outlined in Section III.

- Through the mechanism of CSREES Program Reviews led by NPLs, Goal 5 Team Members have observed and studied programs at universities and have documented the quality and productivity of the programs (partially funded by CSREES) in Program Review Final Reports.

Overall, it is the assessment of the Portfolio Team, that this portfolio of work is productive, despite several short-comings including those that have been previously outlined.

Portfolio Comprehensiveness

Programs in this portfolio meet their intended outcomes at the individual project level as well as at state and institution levels. In the case of formula funds where broad guidelines are provided to states, "completeness" is largely evaluated by stakeholders who provide input as to what the research and extension programs need to address. Competitively funded projects result from funding recommendations from Peer Review Panels which make selections on a proposal by proposal basis and do not necessarily consider "completeness" in the suite of proposals recommended for funding. In the case of competitively funded programs, NPLS who serve as Program Directors are responsible for reviewing final reports and comparing the proposed objectives against what was actually accomplished. Timely reviews and feedback from NPL-directed project reviews ensure that proposed objectives are being addressed so that they are aligned with outcomes and potential impacts.

Portfolio Timeliness

Assessing the timeliness of the work in this portfolio is largely done by monitoring the submission of annual and final reports or requests for renewal, extension, or budget carryover. These determinations are relatively easy to track for competitive and special grant projects that require submission of formal proposals, annual and termination reports. Assessing the timeliness of the work accomplished through formula programs, particularly extension programs, has inherent challenges. Research projects have discreet start and completion dates[6], but extension and education programs may have semi-discreet start and completion dates because of the nature of education, which is rarely "completed." For example, because there is continual turnover in personnel (natural resource professionals, forest and rangeland owners/managers, agriculture producers and policy makers) the "timeliness" criterion becomes harder to assess. What can be assessed, in place of timeliness, is extension program evolution. As issues change and new knowledge is gained, extension programs are continually evolving in order to incorporate new considerations. This is monitored, in part, through the state Annual Reports which are reviewed by NPLs.

Agency Guidance Relating to the Portfolio

The agency provides guidance in the conduct and assessment of program through several mechanisms:

- Requests for Applications - Project Directors of funded projects are expected to fulfill the project objectives and to submit annual progress and termination reports, which are logged into the CRIS database. The requirements that must be fulfilled by the Project Director are clearly spelled out in the Terms and Conditions of the award document that is sent to the performing institution. NPLs, if needed, are also available to provide timely answers to the Project Directors on an individual basis. In this way, CSREES ensures that funding recipients clearly understand their obligations.

[6] Multi-state committees coordinate multiple discrete research projects that, in the aggregate, may continue for extended periods of time as projects are renewed, terminated, and replaced.

- NPL Management and Leadership - NPLs are responsible for portfolios of work within specific disciplines, funding sources and functions. NPLs interact with multi-state research committees, ad hoc program committees, strategic planning efforts and other venues with the university community. Part of this interaction involves conveying agency needs and expectations regarding the funding that is being provided. This is usually more relevant to formula-funded programs, as competitive grant recipients have formal obligations to complete project objectives for which they were funded.

- Plan of Work Guidance – CSREES provides guidance for the preparation and annual updating of research and extension plans. To ensure that guidance is followed, these plans are reviewed by two-person teams of NPLs. If plans are deficient, they are deferred until the deficiencies are corrected.

Examples of the various forms of agency guidance are contained in the Evidentiary Materials.

Portfolio Accountability

The work accomplished in this portfolio is monitored by NPLs who are either program directors for competitive grants programs, agency contacts for special grants, or state annual report reviewers. The CRIS system is an informational resource that allows NPLs to track the progress of research and, more recently, education programs. The CRIS database is accessed by NPLs to determine if projects were completed as funded, requests for extensions and budget carryovers are justified, and progress reports were submitted prior to approving requests for renewals. Research and Extension formula-funded programs submitted as POW reports are evaluated on a state-by-state basis by a two-member NPL Review Team. These reports are evaluated for completeness, evidence of impacts, and stakeholder involvement. A written assessment is completed and returned to each institution. In the event that a report has deficiencies, the lead NPL communicates those deficiencies to the Experiment Station or Extension Director, and awaits additional documentation before proceeding with the review. The review is completed upon receipt of a satisfactory report. This system, however, does have a drawback in that topic or issue-related information on a national basis can only be accessed by reviewing each of the 50 annual reports.

CSREES is in the process of designing new processes and tools, particularly monitoring and evaluation systems and will train the agency's partners in their use. In an environment in which funding is becoming tighter, any activity that strengthen accountability and impacts will likely have greater funding support. This is true of the President's Management Agenda and OMB's results-based budgeting processes.

Potential Improvements for this Portfolio

One of the outcomes of this effort has been identifying areas that could be improved to allow for even greater impact of program inputs. The recommendations of the Review Panel will further inform portfolio improvements. Suggestions from the NPLs include:

Research

- Could be made better if data matrices and criteria for success were more transparent
- Could be made better if socio-economic issues were incorporated into projects
- Could be better if research, education and extension activities were uniformly integrated across PAs and programs

Education

- Could be made better if the reporting system within the agency mirrored that of the research programs[7] (i.e. database reporting such as CRIS)
- Could be made better if there was more active coordination and collaboration among CSREES units and programs
- Could be made better if there was more alignment between research, education and extension activities and programs

Extension

- Could be made better if the reporting system within the agency mirrored that of the research programs[8] (i.e., database reporting such as CRIS); and
- Could be better if research and education activities were truly integrated with extension.

[7] Integrated data collection improvements currently under development allowed inclusion of higher education grant performance and accomplishment data beginning in FY 2004. All Higher Education Program funded grants are now logged into the CRIS system, including annual performance and termination reports. Due to the multi-year nature of most funding, it will take several more years until the database is sufficiently populated to provide education data specific to CSREES Problem Areas that are inclusive of research, higher education and extension work.

[8] CSREES is developing a comprehensive reporting system for funded activities to systematically collect data to be used in assessing project, activity, and program progress in achieving goals and objectives. The system will use a common coding for Problem Areas inclusive of research, higher education, and extension work. Integrated data collection improvements allow inclusion of performance and accomplishment data for extension beginning with the next Plan of Work cycle (2007-2012) that begins in FY 2006.

Concluding Remarks

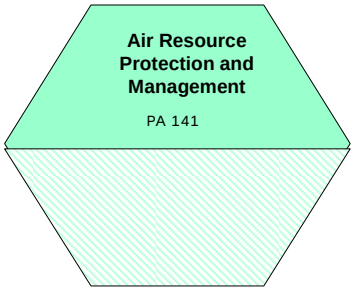
Strategic Goal 5, Protect and Enhance the Nation's Natural Resource Base and the Environment, is the primary responsibility of the NRE unit. However, the range of topics covered in this Goal is not confined to NRE , but also cuts across units within the agency. It is largely for this reason that the CSREES' agency-wide Environment and Natural Resource group was formed in 2003, and it is the within this framework that this report was prepared. Prepared primarily by the NRE National Program Leaders, the report contains Problem Area write-ups done by NPLs in Plant and Animal Systems, and Economic and Community Systems units. The information on the education component of the report was provided by NPLs in the Science, Education and Resources Development unit.

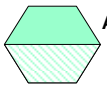
The authors strived to provide the review panel with a comprehensive yet broad view of the research, education, and extension activities in Objective 5.2, but are cognizant that there may be issues that remain unanswered or statements that require clarification. The authors request that in addition to reviewing the report, the panel also refer to the evidentiary materials and other documents that will be provided to them to help answer and questions and clarify issues during the meetings in Washington, D.C. In addition to the report and other documents provided, the NPLs will make short presentations on the Problem Area descriptions.

The NRE unit and the *enr* team thank the panel for its invaluable input in assessing this portfolio.

Appendix of Honeycomb Models

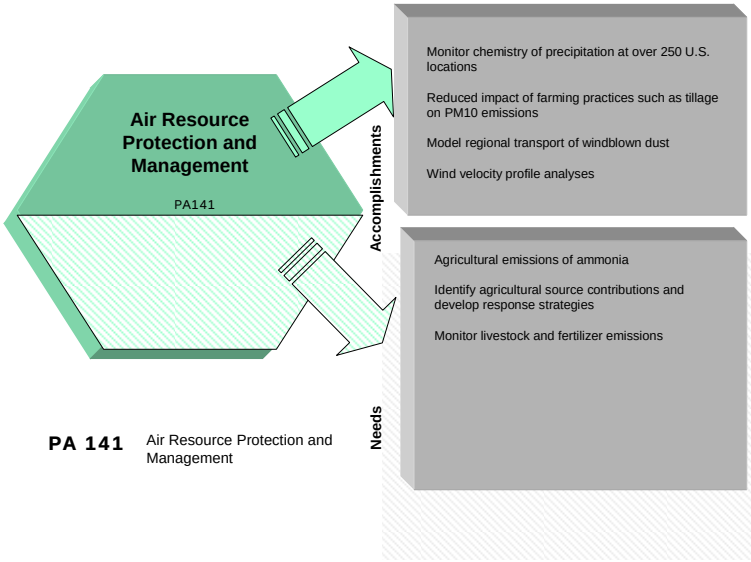
CSREES Air Resource Protection and Management Portfolio





Accomplishments

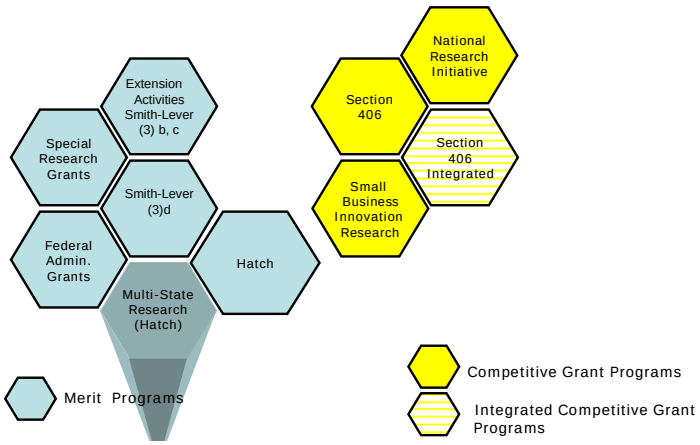
Needs



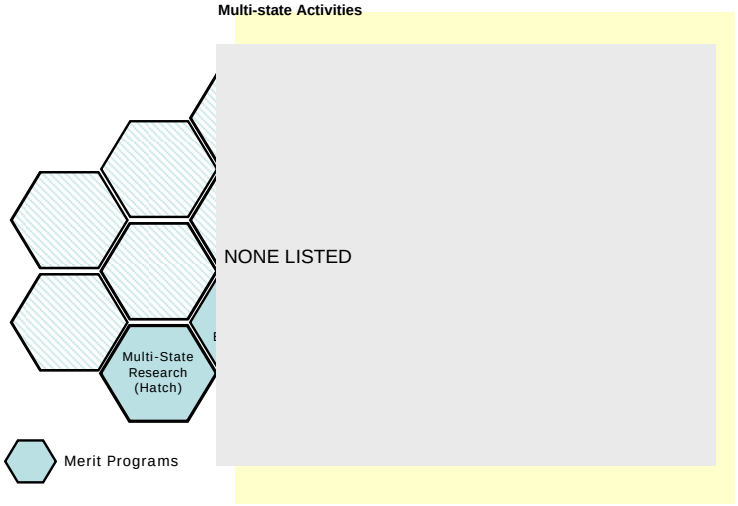
PA 141 Air Resource Protection and Management

Objective 5.2... to improve the management of soil, air and water to support production and enhance the environment.

CSREES Air Resource Protection and Management Portfolio (PA 141) By Funded Program

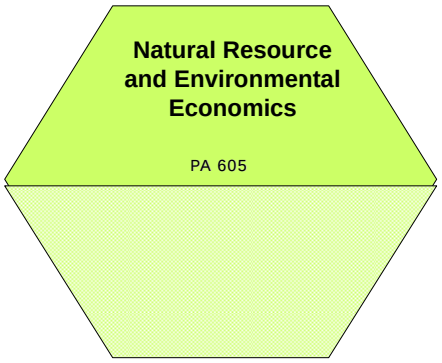


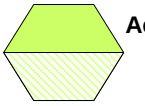
CSREES Air Resource Protection and Management Portfolio (PA 141)
Multi-state Activities



Objective 5.2... to improve the management of soil, air and water to support production and enhance the environment.

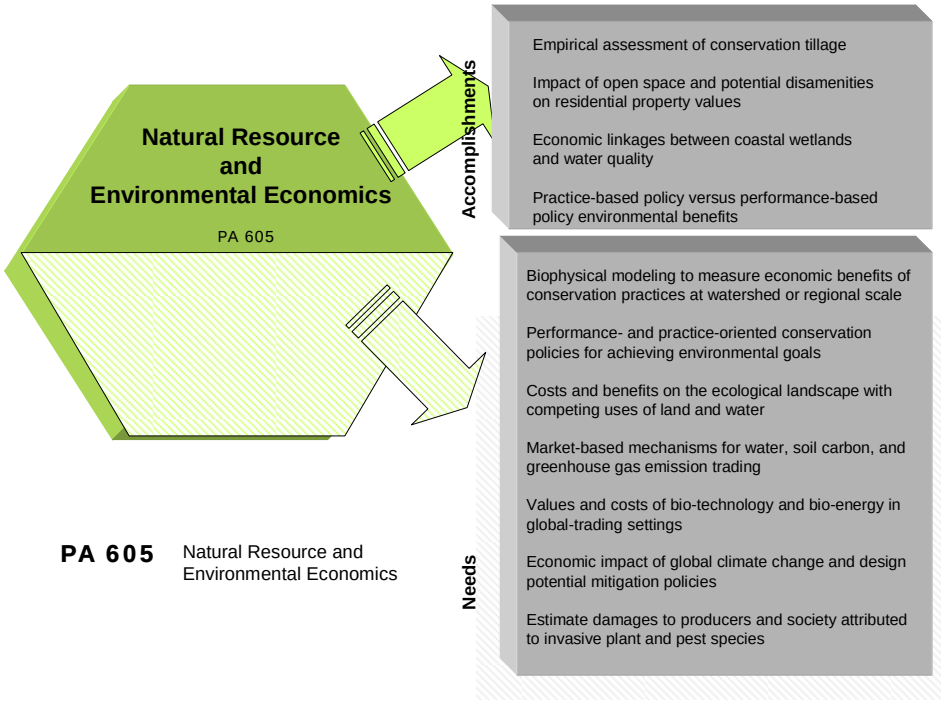
CSREES Natural Resource and Environmental Economics Portfolio





Accomplishments

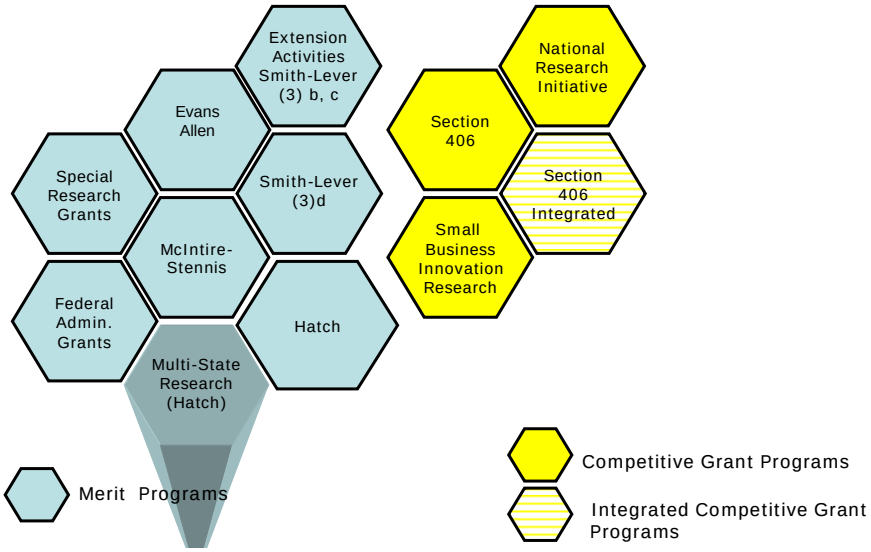
Needs



PA 605 Natural Resource and Environmental Economics

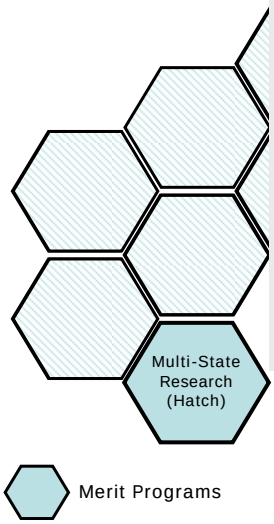
Objective 5.2... to improve the management of soil, air and water to support production and enhance the environment.

CSREES Natural Resource and Environmental Economics Portfolio (PA 605) By Funded Program



CSREES Natural Resource and Environmental Economics (PA 605)

Multi-state Activities



W1190 Interfacing Technological, Economic, and Institutional Principles for Managing Inter-sector Mobilization of Water

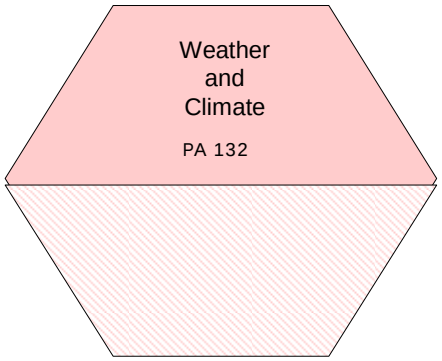
W1133 Benefits and Costs of Natural Resources Policies Affecting Public and Private Lands

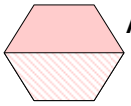
SERA 30 Southern Natural Resource Economics Committee

WERA 55 Rangeland Resource Economics and Policy

Objective 5.2... to improve the management of soil, air and water to support production and enhance the environment.

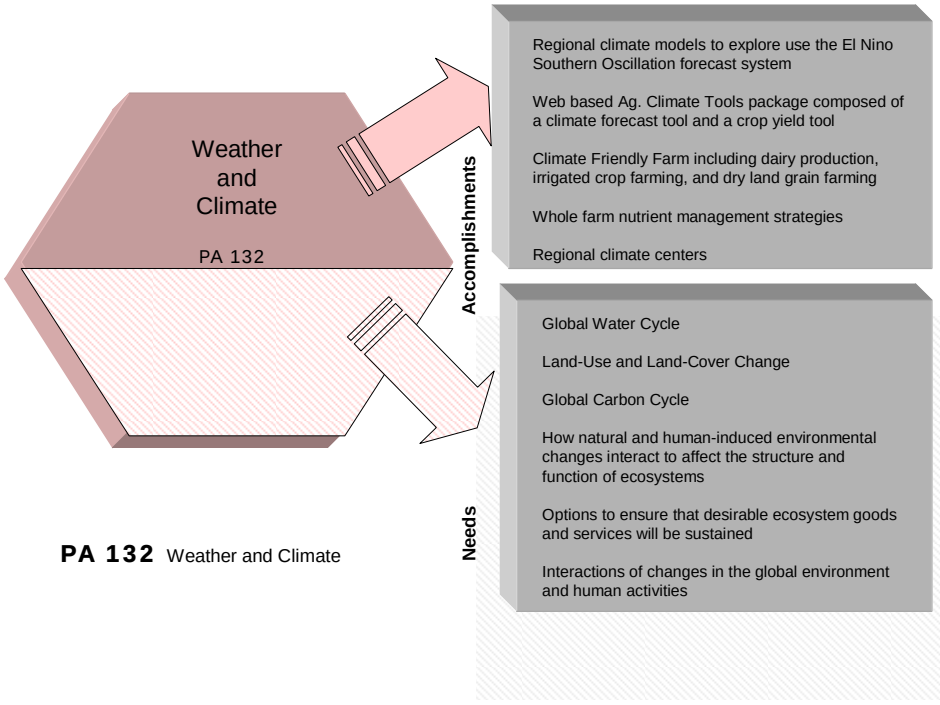
CSREES Weather and Climate Portfolio





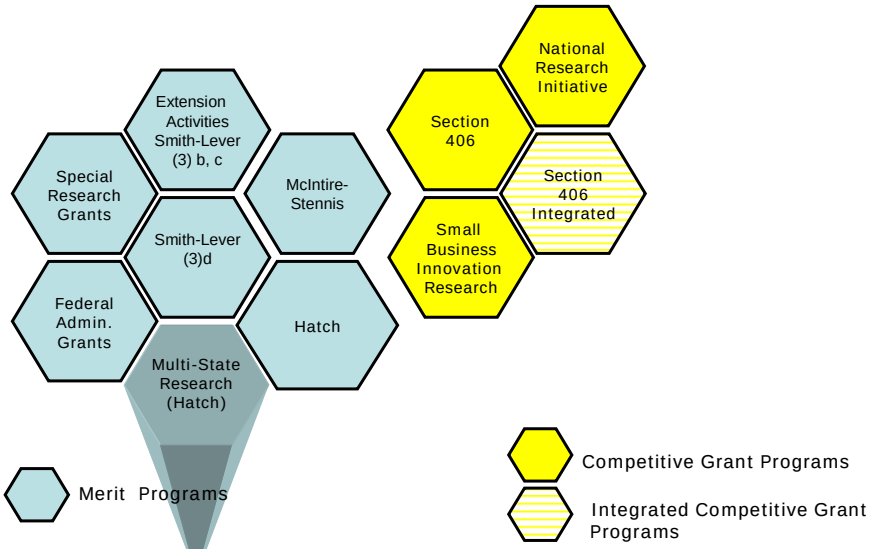
Accomplishments

Needs

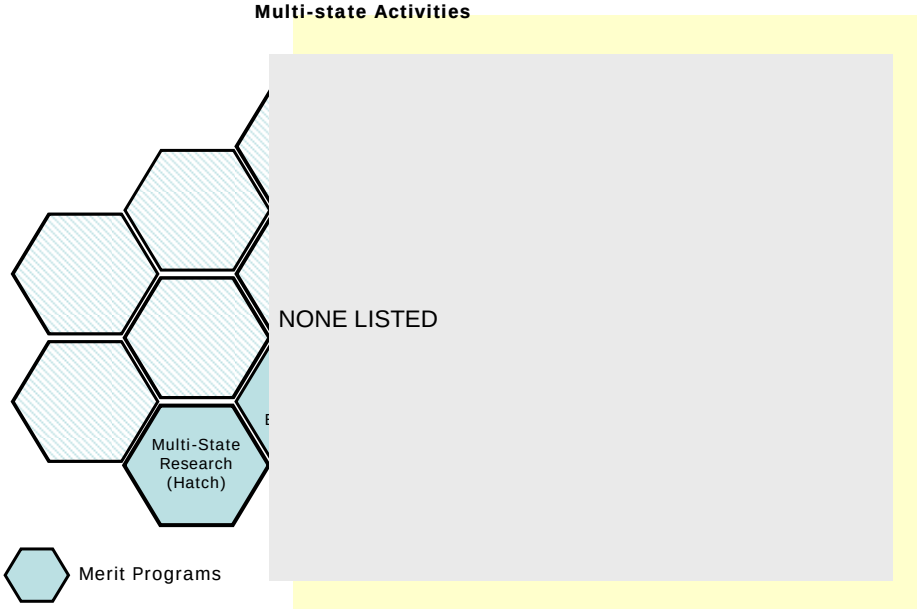


PA 132 Weather and Climate

CSREES Weather and Climate (PA 132) By Funded Program



CSREES Weather and Climate Portfolio (PA 132)
Multi-state Activities



Objective 5.2... to improve the management of soil, air and water to support production and enhance the environment.