UNIVERSITY OF PUERTO RICO
MAYAGÜEZ CAMPUS
COLLEGE OF AGRICULTURAL SCIENCES
AGRICULTURAL EXPERIMENT STATION

ANNUAL REPORT OF ACCOMPLISHMENTS AND RESULTS

Planning Option: This Annual Report of Accomplishments and Results is prepared for our Institution's individual functions, as is our 1999-2004 Five Year Plan of Work.

Reporting Period: October 1, 2003 to September 30, 2004.

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University of Puerto Rico

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General Overview

The University of Puerto Rico's Agricultural Experiment Station (AES) conducts basic and applied research to promote an economically viable agricultural sector and to stimulate rural development in Puerto Rico and the Caribbean region. Research also promotes the conservation and enhancement of natural resources and the environment, supports established and newly developed industries that process agricultural raw materials, and provides technical assistance to farmers and private and public institutions. The Agricultural Experiment Station coordinates its academic activities with the teaching and extension Faculty of the College of Agricultural Sciences in an ongoing effort to implement the strategic plan that defines our programmatic goals. AES scientists also participate in several advisory boards of the Puerto Rico Department of Agriculture (PRDA), providing technical expertise for public policy decisions made by the PRDA. To advance regional goals, the AES participates in both multiState research and Special Grants from USDA-CSREES that target agriculture in the Caribbean Basin of the United States.

Five goals, consonant with both federal and local priorities, drive our research program:

1. To develop technology for achieving sustainable agricultural production systems that are socioeconomically viable and competitive.
2. To develop technology for processing traditional and new agricultural products and for achieving a safe food and fiber system.
3. To provide direct services and technical expertise to farmers, agro industries, and public agencies that lack specialized personnel or research facilities available at AES-UPR.
4. To develop agricultural technology compatible with the preservation and enhancement of our natural resources and environment.
5. To provide the socioeconomic research needed to formulate alternatives that can potentially improve economic opportunities and the quality of life in rural areas.

Research efforts at the Agricultural Experiment Station are concentrated on goals one and four of the national goals, whereas other goals are covered by the Agricultural Extension Service of the College of Agricultural Sciences. In

addition, many of the projects carried out under goals four and five of this Plan of Work are focused on the mountainous central coffee producing region of Puerto Rico, a sensitive ecological region of the island, vital for the preservation of its natural resources and where the majority of farmers are located. Our research program is still organized following commodity lines, but we now have ten commodities[1] instead of the original eleven. Since FY 2002 the sugarcane commodity group was eliminated, given the practical disappearance of sugar plantings in Puerto Rico and the retirement of researchers with expertise in that commodity.

Core funding for the Agricultural Experiment Station's research program is provided by various sources. State funds are primarily to cover salaries of academic and support personnel. USDA funding is crucial for directly financing the research program. Formula-funds include Hatch Regular, Hatch Regional, McIntire-Stennis and Animal Health, although during FY 2004 we had no active Animal Health project. Special Grants such as the Tropical and Subtropical Agriculture Research (T-STAR) support targeted areas of research. Along with federal and state funding, there are extramural research grants and contracts such as those from the Natural Resources Conservation Service, Environmental Protection Agency, and USDA-ARS, Puerto Rico's Department of Agriculture, Puerto Rico's Department of Natural Resources and other agreements with US-Universities.

Executive Summary

Goal I. An agricultural system that is highly competitive in the global economy

Overview: Agriculture is of strategic importance to Puerto Rico both in terms of its present and its potential contribution to the economy. Although it is the smallest of the primary economic sectors its broader economic impact is significant, given the high multiplier effect of its activities. Puerto Rico has a large food import bill, much of which could be competitively produced locally if appropriate technology and marketing strategies were devised, disseminated among farmers and processors, and emerging problems are researched to formulate viable solutions. Moreover, through its research and extension programs the island's land grant system could also make a significant contribution towards stabilizing and expanding our current agricultural exports. Approximately 50% of our federally funded research projects are ascribed to this goal. These projects are in line with

[1] Current commodity groups are: dairy, coffee, plantains and bananas, vegetable crops, fruit crops, ornamentals, meat production, roots and tubers, basic grains and environment and natural resources.

the furtherance of agricultural production, the long-term critical issue targeted by this goal.

Plant breeding research has historically been an important component of the AES and CAS program. Many of our breeding programs have focused on the improvements of traditional food crops such as tropical pumpkin, pigeonpea, yautia, sweetpotatoes and green shelled beans. Most of these variety improvement programs are unique in the U.S. land grant system and help to preserve the agricultural heritage of Puerto Rico. Because small-scale farmers produce many of these crops, the plant breeding programs benefit those who are in the greatest need of assistance. Plant germplasm introduced, evaluated and maintained in our collections has been equally vital for the development of pest and disease resistant crops adapted to local conditions and with greater yield potential.

Bean breeding lines with enhanced levels of disease resistance (bean golden mosaic virus, bean common mosaic virus and rust) have been developed. Morales, one of the white seeded bean cultivars developed under this program, has become the most popular cultivar in Puerto Rico. During the year, over 7,000 lb of bean seeds of cultivars Morales and Arroyo Loro were produced at the Isabela Substation. The seeds sold at this Substation are sufficient to plant 175 acres which should generate more than $420,000 in income for farmers.

Calabaza or tropical pumpkin (*Cucurbita moschata*) is one of the most important vegetable crops in Puerto Rico, occupying second place in terms of the amounts of revenue generated by vegetable crops. It is very important in the growing Hispanic market of the United States, as well as throughout the Caribbean and Latin America. In recent trials, two advanced open-pollinated populations (PRShortvine-1 and PRLongvineSLR) exhibited the best field performance, good fruit quality and ability to produce ample seed of economic value. If variety PRShortvine-1 is released, it has the potential to be planted on 1,000 to 1,500 acres of land in Puerto Rico and to generate from $2 to 5 million/year in income at the farm gate level.

After mango, orange is the most important fruit crop of the island in terms of value of production. The presence of the citrus Tristeza virus, detected in Puerto Rico in 1992, presents a serious problem for our local industry, since the only rootstock commercially utilized with resistance to this virus is now the Cleopatra Mandarin. Studies are under way to evaluate several scion-rootstocks combinations and their performance in different ecological regions. In a recent study, cultivars Rhode Red Valencia and Hamlin were the most yielders in rootstocks Swingle, Carrizo, Cleopatra and Sun Chu Cha at three different sites. It is important to have more than one rootstock for

citrus varieties, in order to make appropriate recommendations to the citrus growers at the different geographic regions of the island.

The dairy industry is the most important agricultural enterprise in Puerto Rico. Revenues from milk sales exceed $190 million annually and contribute 27% to the agricultural gross income. While the industry faces several problems, most are related to the feeding and management systems used in dairy farms. The study of feeding strategies to maximize the efficiency of local forage resources and imported concentrates for milk production remain a high priority in our research program. Data from an experiment conducted last year showed that increasing the level of concentrate supplementation resulted in a reduction of grass hay intake in early and late lactation, but in an increase in total dry matter intake and milk production, even for cows in late lactation. As a result, feeding a high level of concentrate supplementation increased income over feed costs for cows in early lactation, thus lending support to this common practice in order to maximize milk yield and farm income in Puerto Rico.

Plantains and bananas are the most important crops of Puerto Rico, from an economic point of view. In 2004, plantains contributed with $56.8 million to the agricultural gross income (AGI) and bananas with $17.5 million. At present, local plantain production supplies 100% of the island's demand and there is no fresh plantain production for export. The sector's growth depends largely on the industrialization of part of its output. Results from an economic study of plantain processors suggested that to be competitive the industry must be reorganized and deliver a continuous supply of produce at reasonable prices. Puerto Rico has the potential to develop a price-competitive processed plantain industry, both for local consumption and for export, if there is an expansion in the acreage planted to the crop.

Hatch funds under this goal:	$1,949,300	SY FTE: 19.4
State matching funds:	$2,790,802	

Goal II. A safe and secure food and fiber system

Overview: When our current Plan of Work was originally prepared research efforts under this goal were concentrated in the areas of food safety (analysis of pesticide residues) and post-harvest storage and processing of crops. Most of these activities were carried out in the Food Technology Laboratory located in the AES facilities at Río Piedras. In recent years research activities have been limited by the retirement of the majority of food scientists associated to this laboratory, and by the transfer of remaining

projects and facilities to the Mayagüez Campus, where the program's emphasis has shifted away from research to the formal training of students in food science. At the AES new activities are being developed in the areas of emerging plant and animal protection issues, and food system research with an emphasis in alternative food production, alternative marketing, and food accessibility.

Under the activities of a Multi-state Hatch project, research on the restructuring of food retailing in Puerto Rico and the emergence of farmer's markets continued during this year. Informal interviews with some of the participants in the farmer's markets were conducted to assess the progress of these initiatives. Research on food retail restructuring and farmer's markets is expected to contribute to our understanding of the forces that motivate the formation of place-based food systems and of the impact these forces are having in communities nationwide. Information from this project has been used by the local Department of Agriculture in their initial implementation of the WIC Farmers Market Nutrition Program which in FY 2004 injected $2,333,613 to the local economy.

Hatch funds under this goal:	$5,108	SY FTE: .10
State matching funds:	$6,451	

Goal III. A healthy, well nourished population

The current Plan of Work of the AES did not contemplate any research activities under this goal and no project have been developed in this area during this period. The Agricultural Extension Service conducts all the work performed in the CAS under this goal.

Goal IV. Greater harmony between agriculture and the environment

Overview: The principal objective of the Natural Resources and Environment commodity area--the program under which most the projects contributing to this goal are administered--has been since its inception to develop and support the scientific research carried out in the CAS on the interface of agriculture, natural resources and the environment. During this fiscal year work has continued to be focused on the following priorities: (1) Developing land use databases and technologies for the management of soil erosion, (2) Developing technologies for the management of organic residues, (3) Developing integrated management systems for different crops, and (4) Establishing pollution biological indexes. Emphasis has been given to water pollution control, management of soil erosion and forest resources, and

integrated weed and pest management. Close linkages have been maintained with personnel from the Natural Resources Conservation Service (NRCS), USDA Forest Service International Institute of Tropical Forestry, the Department of Agriculture, the Environmental Quality Board, and the Department of Natural Resources, to guarantee that research results contributing to sound management practices are included within these agencies' programs.

Developing a watershed management plan is an important aspect in the solution of soil erosion problems for urban, industrial and agricultural lands. Through one of our McIntire-Stennis projects, quantifiable and specific recommendations are being provided to reduce the risk of soil erosion and siltation of reservoirs. This project has monitored over 40 extreme runoff events in five selected sub-watersheds within the larger Rio Grande de Arecibo one in north central Puerto Rico. A continuous simulation model of the erosion-sediment transport processes was calibrated and validated by using historical data from 1995 to 2001. Findings of this study indicate that agricultural lands produced the highest total sediment losses, corresponding to 54% of total soil losses. The rate of soil erosion from barren lands (sand mines and domestic landfill) was 210 times greater than that from herbaceous areas.

The soil erosion and soil quality research conducted under this goal also promises to provide valuable information for the development of environmentally safe practices to prevent soil and fertilizer losses. Under McIntire-Stennis grants experiments are being conducted with the use of tree species as shade for coffee, evaluating if the accumulation of soil organic matter can enhance the adaptability of the crop to acid soil conditions. The species *Pithecellobium carbonarium* is a leguminous tree that has good potential as a shading species for coffee because of its fast growing habits, low density canopy and its capacity to fix nitrogen. Results indicate that Pithecellobium leaf litter has an acidification effect on the soil and increases available phosphorus content of Alonso soil. Management practices to promote the accumulation of leaf litter under coffee trees should be encouraged to maximize the litter's beneficial effect on reducing levels of exchangeable aluminum.

Research is also being conducted to address the erosion problems of mountainous areas, such as those in northern and central Puerto Rico, caused primarily by deforestation. The use of mycorrhizae and soil-improving polymers may be an excellent strategy to accelerate the recovery of ground cover species and adapted trees on highly eroded soils. Results from a survey to identify the presence of indigenous communities of arbuscural mycorrhizal fungi (AMF) associated with germplasm growing at

two representative sites in central and northern Puerto Rico indicate the presence of endomycorrhizae fungi in all plant species studied. These results will be used to develop management guidelines for the restoration of highly eroded soils in the tropics.

Finally, research geared towards establishing integrated weed management systems is one of the objectives addressed by other projects under this goal. In the tropics, weed control becomes more difficult and costly than in temperate zones because of heavier weed infestations. A single weed control method such as mechanical weeding or herbicides is usually insufficient to prevent yield losses. Non-chemical means of weed control need to be explored to develop new and effective weed management strategies for our cropping systems. The new strategies may become essential components of integrated weed management systems that need to be developed for the individual crops. Coffee is the second most important crop in Puerto Rico in terms of income. Coffee plantations, as secondary forests, are also vital for the preservation of local watersheds. Results of an experiment established to evaluate four frequencies of trimming for pond peanut (*Arachis kretschmeri*) and dalisgrass (*Paspalun dilatatum*) in coffee groves concluded that trimming applied to living mulches every 4 to 12 months reduced weed cover two years after mulch establishment, without significantly interfering with coffee growth. Suppression of weeds by living mulches could be recommended as an alternative practice to reduce the use of herbicide applications, lowering production costs and potential contamination of chemicals in upland agro-ecosystems.

Hatch funds under this goal:	$1,755,909	SY FTE: 17
State matching funds:	$2,682,786	

McIntire-Stennis funds under this goal:	$105,000	SY FTE: 1.6
State matching funds:	$192,863	

Goal V. ***Enhanced economic opportunity and quality of life for Americans***

Overview: High unemployment rates and chronic poverty are long term critical issues affecting Puerto Rico´s population, particularly in rural areas. Changes in the global economy since the mid-1970s, with the concomitant restructuring of major local economic sectors, have exacerbated these adverse conditions. Official statistics confirm that nutritional subsidies and welfare payments are highly important for the livelihood strategies of more than half of the island's families. Although the contribution of agriculture to the Gross Domestic Product is stagnant or declining, because of its high

multiplier effect, the continued viability of farming is critical for maintaining and improving the quality of life in the island, particularly in the central mountainous region where alternative employment opportunities do not abound.

Coffee production is vital for the economy of the central region of Puerto Rico. Studies conducted in the late 1990s showed that access to an adequate labor supply was the most important problem identified by farm operators. To explore the existing mismatch between coffee growers' and agricultural laborers' needs a survey was mailed to 600 coffee growers, and personal interviews were conducted with over 100 agricultural laborers participating in Work Investment Act training programs. A 21% response rate was obtained in the mail survey of growers. This study provides alternatives, recommended by both workers and growers, on how to improve the labor market situation in the coffee region. If linkages can be established between the needs of growers and workers, an expansion in employment and in the size of coffee plantations could be achieved, having a measurable multiplying effect in many rural areas of Puerto Rico.

Hatch funds under this goal:	$	32,192	SY FTE: .7
State matching funds:	$	40,703	

Planned Programs:

Goal I. An agricultural system that is highly competitive in the global economy

I. Key Theme – Plant Production Efficiency

A. (Under Hatch Funds). In Puerto Rico, disease often reduces seed yield and quality of beans. Been cultivars need greater levels of resistance to the most common diseases such as bean golden yellow mosaic (BGYMV), bean common mosaic necrotic (BCMNV) and rust. Resistance to these diseases is available but needs to be incorporated into white and pink beans adapted to Puerto Rico. The winter nursery established in Puerto Rico under this regional project provides collaborators with an opportunity to advance generations and increase seed of promising bean breeding lines. Been breeding lines with enhanced levels of disease resistance have been developed. During last year, greenhouse white-seeded bean lines were screened for resistance to BCMNV, using mechanical inoculations. DNA samples were taken from the BCMNV-resistant plants and evaluated for the

presence of molecular markers linked to disease resistance genes. Seven lines were selected that have resistance to BGYMV, BCMNV and rust. Molecular markers were used to screen white-seeded lines for BGYM and common bacterial blight (CBB) resistance. The presence of the molecular marker for CBB resistance was associated with lower levels of infection in the field. Sixty-three $F_{4:6}$ light red kidney lines were evaluated in a field trial. Almost all of the lines reached maturity within 80 days after planting. Seed yields were excellent. The BGYMV- resistant pink bean line PR0129-1 has a commercial seed type and a mean seed yield of 3456 kg/ha.

B. Impact – Cultivar 'Morales' has become the most popular white-seeded bean cultivar in Puerto Rico. During the past year, > 7,000 lbs of bean seed of the white-seeded cultivars Morales and 'Arroyo Loro' was produced at the Isabela Substation. The seed sold at the Isabela substation is sufficient to plant about 175 acres which, when harvested as green-shelled beans, should generate more than $420,000 in income for farmers. Been growers greatly benefit from a reliable supply of high quality seed. Demand for bean seed continues to exceed the amount produced at the Isabela Substation. Also, BGYM-resistant and heat-tolerant light red kidney breeding line PR9920-171 will be released.

C. Source of Federal Funds: Hatch (Multistate) $ 159,692 SY FTE: 1.9

D. Scope of Impact: Multistate: PR, FL

II. Key Theme – Plant Germplasm

A. (Under Hatch Funds). Tropical pumpkin or calabaza (Cucurbita moschata) is one of the most important vegetable crops in Puerto Rico, occupying second place in terms of the amounts of revenue generated by vegetable crops. It is consumed throughout the Caribbean and Latin America, as well as in the United States mainland where it is important in the growing Hispanic market. The carotenoids that give tropical pumpkins its orange or yellow color are an important source of vitamin A. From a series of trials with six new tropical pumpkin genotypes on the basis of yield, quality and pest resistance of the standard cultivar 'Soler', two advanced open-pollinated populations (PRShortvine-1 and PRLongvineSLR) exhibited the best field performance, good fruit quality and ability to produce economical amounts of seed. PRShortvine-1 is rated as very highly in informal tests and its cooking quality is excellent. The smaller fruit size of PRLongvineSLR makes this population more attractive to a supermarket clientele, where cultivar Soler is considered too large. As a result, these two populations appear to have immediate promise for possible formal release.

B. Impact – If the tropical pumpkin variety PRShortvine-1 is released, it has the potential to be planted on 1,000 to 1,500 acres of land in Puerto Rico and to generate from 2 to 5 million dollars/year in income at the farm gate level. This variety would also most likely be adapted to production areas in the Southern United States.

C. Source of Federal Funds: Hatch Funds $191,895 SY FTE: 1.7

D. Scope of Impact: MultiState: PR and Southern United States

III. Key Theme - Animal Production Efficiency

A. (Under Hatch Funds). In the Caribbean tropics, milk production is being transformed from an extensive pasture-based system into a more intensive one. Traditional recommendations to farmers for efficient milk production in the tropics have been to limit concentrate supplementation and to maximize pasture forage intake. Income over feed costs at the lower level of supplementation (1:2 above 10 kg of milk) gave the best results, irrespective of milk production. It was determined in this study that increasing the level of concentrate supplementation improved daily milk production by 1.3 and 2.9 kg for cows in late and early lactation, respectively. Dairy farmers commonly feed high levels of concentrate supplementation to maximize their milk production and income over feed costs.

B. Impact – Increasing the level of concentrate supplementation resulted in a reduction of grass hay intake in early and late lactation but in an increase in total dry matter intake and milk production, even for cows in late lactation. As a result, feeding a high level of concentrate supplementation improved income over feed costs for cows in early lactation, thus lending support to this common practice in order to maximize milk yield and farm income in Puerto Rico.

C. Source of Federal Funds: Hatch $177.000 FTE: 1.3

D. Scope of Impact: State Specific, PR

IV. Key Theme – Agricultural Competitiveness

A. (Under Hatch and State Funds). From an economic point of view plantains and bananas are the most important crops among the starchy

crops of Puerto Rico. During 2004 plantains contributed with $56.8 million to the Agricultural Gross Income (AGI)--20% of the income generated by all crops--and bananas with $17.5 million. Processed plantains for local consumption, a growing segment of the market, are nevertheless mostly imported from foreign countries. At present, a processing plant has been established in San Sebastián, Puerto Rico. Production and marketing of their products is being conducted with relative success in several supermarkets. The processed plantain industry is an alternative to increase the demand for plantains and strengthen the local economy but, to be able to compete with imports, the industry should be reorganized, expanding its acreage and programming its plantings. To inform this process a survey of plantain processors was conducted to determine the importance for the industry of each of these components: producers, distributors, and consumers. Preliminary results suggest that, to be successful, initiatives most count with a competitive organization, a continuous supply of produce and reasonable prices. Quality and sales prices should compete with those of imported products.

B. Impact – Study results suggest that Puerto Rico has the potential to develop a price-competitive processed plantain industry, both for local consumption and for export, if there is an expansion in the acreage planted to the crop. At present, local plantain production supplies 100% of the demand and there is no fresh plantain production for export. Although results of a supermarket survey indicated a preference for fresh (92%) over processed plantains (36%), 94% of those interviewed would back a local processed plantain industry and consider the quality of supermarket processed plantains as good (44%). A reorganization of the processed plantain industry would be in order. Consideration should be given to competition from imports, quality of the processed products, marketing, costs, and possibly, a vigorous promotion.

C. Source of Federal Funds: Hatch $800 FTE: 1.8
State matching funds: $6,495

D. Scope of Impact: State Specific, PR

V. Key Theme – Plant Germplasm

A. (Under Hatch Funds). Plant genetic resources important for local agriculture have been collected, conserved, evaluated and distributed in Puerto Rico and the United States through the collaborations established under this project. With the detection of the citrus Tristeza virus in Puerto

Rico, for example, there was a need to find new citrus rootstocks. Tristeza virus attacked severely the citrus trees in rootstock Sour Orange. The discovery of this virus in Puerto Rico is a serious problem for the industry, since the only rootstock commercially utilized with resistance to this virus is the Cleopatra Mandarin. An inadequate rootstock for determined soil type or rootstock variety could be the difference between success and failure of the orchard. Several experiments were established at the Adjuntas, Corozal and Isabela Substations in order to evaluate different scion-rootstocks combinations. The germplasm was introduced from the USDA-ARS in Orlando, Florida. Rootstocks used were Swingle, Carrizo, Cleopatra and Sun Chu Cha. Cultivars Rhode Red Valencia and Hamlin produced the best yields in all the rootstocks at all sites, being the Corozal site the best.

B. Impact – The plant genetic resources introduced and evaluated through this project have contributed to the development of pest and disease resistant crops adapted to local conditions and with greater yield potential. Puerto Rico presents a great diversity of soil types throughout its different geographic regions. In the case of the citrus industry, plagued by the spread of the citrus Tristeza virus, it is important to have more than one rootstock for citrus varieties, in order to make appropriate recommendations to growers at the different ecological regions of the island. The crop technology being developed offers alternatives for maintaining a healthy citrus industry in Puerto Rico.

C. Source of Federal Funds: Hatch (Multistate) $ 408,859 FTE: 5.6

D. Scope of Impact: MultiState, PR, NC, HAW, FLA, VI

Goal II. A safe and secure food and fiber system

I. Key Theme – Food Accessibility and Affordability

A. (Under Hatch and State Funds). Research on the restructuring of food retailing in Puerto Rico and the emergence of farmer's markets continued during this year. Informal interviews with some of the participants in the farmer's markets were conducted to assess the progress of these initiatives. The picture emerging from preliminary analyses is one of increasing difficulties faced by those working to construct alternatives to the mainstream food system, as some of the conflicts between producers and consumers which were contained during the initial formative years, reemerged when the organizations began to consolidate.

B. Impact - Research on food retail restructuring and farmer's markets is

expected to contribute to our understanding of the forces that motivate the formation of place-based food systems and of the impact these forces are having in communities nationwide. If duly institutionalized the farmers' markets that have emerged in Puerto Rico in recent years hold great promise for both farmers and different classes of consumers. Information from this project has been used by the local Department of Agriculture in their initial implementation of the WIC Farmers Market Nutrition Program which in FY 2004 injected $2,333,613 to the local economy.

C. Source of Federal Funds: Hatch $5,108 FTE: 0.1
State matching funds: $6,451

D. Scope of Impact: Multistate PR, NY, CA, IA, MN, WI

Goal III. A healthy, well nourished population

The current Plan of Work of the AES did not contemplate any research activities under this goal and no project have been developed in this area during this period. The Agricultural Extension Service conducts all the work performed in the CAS under this goal.

Goal IV. Greater harmony between agriculture and the environment

I. Key Theme – Soil Erosion

A. (Under McIntire-Stennis and State Funds). Tropical watersheds in Puerto Rico are subject to intense rainfall precipitation during the hurricane season from June to November each year. The energy associated with these storms generates important amounts of soil detachment and transport to streams and eventually to reservoirs and coastal valleys around the Island. This project has monitored over 40 extreme runoff events in five selected subwatersheds within the larger Rio Grande de Arecibo in north central Puerto Rico. A continuous simulation model of the erosion-sediment transport processes was calibrated and validated by using historical data from 1995 to 2001. As calculated with bathymetry data from a downstream reservoir, sediment yield at the lake was 3.34 ton ac-1 yr-1. The model was able to account for 1.60 ton ac-1 yr-1, or about 48% of the sediment coming into the reservoir. The remaining 52% (1.74 ton ac-1 yr-1) was not accounted for, but it sheds light on the shortcomings embedded in typical erosion-transport process models that cannot account for stream bank and stream bed erosion. Partial findings of this study indicate that agricultural lands produced the highest total sediment losses, corresponding to 54% of

total soil losses. The rate of soil erosion from barren lands (sand mines and domestic landfill) was 210 times greater than that from herbaceous areas. Soil loss per land use type in the study area was 0.03 ton ac-1 yr-1 for forest lands, 0.31 for herbaceous lands, 4.49 for agricultural lands, 1.59 for urban areas, 70.14 for barren areas and 0.31 ton ac-1 yr-1 for pasture lands.

B. Impact – Tropical watersheds can be steep and have shallow soil depths, features that make them respond very quickly to typical intense precipitation events. As a result, soil detachment and transport could be a severe problem that endangers life and infrastructure projects. The area studied provides potable water to nearly 50% of the island population, concentrated in the metropolitan area of San Juan, Puerto Rico, through a recently installed aqueduct with maximum yield capacity of 100 million gallons per day (MGD). The sustainability of this infrastructure project relies entirely on the capacity of the watershed under study to continue to supply potable water. This project is providing quantifiable and specific recommendations for watershed management to foster urban/industrial and agricultural development, and recommendations for places where preservation is suggested to reduce the risk of soil erosion and sedimentation of this important water-producing system.

C. Source of Federal Funds: McIntire-Stennis $30,000 SY FTE: .50
State matching funds: $36,622

D. Scope of Impact: State Specific (PR)

II. Key Theme – Soil quality

A. (Under McIntire-Stennis and State Funds). In Puerto Rico coffee is grown on highly weathered soils, where production and accumulation of organic matter is essential for maintaining soil fertility and productive crop environment. In plantations under shade, the shading species as well as the coffee crop will contribute to soil organic matter. The incorporation of plant residues often results in an increase in soil pH, a decrease in soil exchangeable aluminum and more favorable conditions for plant growth. Although the use of shade in coffee plantations has been extensively evaluated with regard to coffee yield and quality, the effect of this agroforestry practice on soil chemical and physical properties needs further evaluation. The species *Pithecellobium carbonarium* is a leguminous tree that has good potential as a shading species for coffee because of its fast growing habits, low density canopy and its capacity to fix nitrogen. This species appears to adapt well to the mountain region of Puerto Rico. Results of field experiments conducted indicate that *Pithecellobium* leaf litter had an

acidification effect on the soil and increased the available phosphorus content of Alonso soil.

B. Impact – Addition and incorporation of coffee leaf litter to acid soils can significantly reduce toxic levels of exchangeable aluminum, thus contributing to a better environment for root development. A better root system will result in a healthier coffee plant that will produce higher yields and last longer. Management practices to promote the accumulation of leaf litter under coffee trees should be encouraged to maximize the litter's beneficial effect on reducing levels of exchangeable aluminum.

C. Source of Federal Funds: McIntire-Stennis $35,000 FTE: .4
State matching funds: $70,364

D. Scope of Impact: State Specific PR

III. Key Theme – Forest Resource Management

A. (Under McIntire-Stennis and State Funds). Mountainous areas in the tropics such as those in northern and central areas of Puerto Rico show acute erosion problems, caused primarily by deforestation. The exacerbation of this situation is due to inefficient land use associated with human intervention, such as land development and cropland, rather than use for pasture and forest management. This study showed the special role of ground cover species to reduce soil erosion. Results suggest that the best strategy for the restoration of highly eroded soils is the integration of ground cover species in association with tree species. The use of mycorrhizae and soil-improving polymers may be an excellent strategy to accelerate the recovery of ground cover species and adapted trees on highly eroded soils. The survey to identify the presence of indigenous communities of arbuscural mycorrhizal fungi (AMF) associated with germplasm growing at two representative sites in central (Corozal) and northern (Vega Baja) Puerto Rico was completed. Results indicate the presence of endomycorrhizae fungi in all plant species studied. The predominant AMF belongs to the genus *Glomus spp*. The percentage of root parasitized in the different species varied from 5 to 46%. The effect of dosages and concentrations of synthetic polyacrylamide solutions (PAM) on soil structure and erosion rate was evaluated.

B. Impact – Information obtained is useful in the determination of the effectiveness of arbuscural mycorrhizal fungi (AMF) and synthetic soil conditioners (SSC) in enhancing the adaptation potential of selected germplasm on highly eroded soils in the Caribbean. Results will be used to

develop management guidelines for the restoration of highly eroded soils in the tropics.

C. Source of Federal Funds: McIntire-Stennis $40,000 SY FTE: .75
State matching funds: $85,877

D. Scope of Impact: State specific (PR), VI, Caribbean, other tropical areas

IV. Key Theme- Integrated Weed Management

A. (Under Hatch Funds). In the tropics, weed control becomes more difficult and costly than in temperate zones because of heavier weed infestations. A single weed control method such as mechanical weeding or herbicides is usually insufficient to prevent yield losses. Non-chemical means of weed control need to be explored to develop new and effective weed management strategies for our cropping systems. In the case of coffee, evaluation of living mulches for weed suppression and soil erosion control has shown that although weed suppression ranged from 83 to 93% with living mulches, these mulches interfered with coffee growth. Researchers believe that trimming the living mulches at a particular frequency may reduce their interference with coffee groves. Results of an experiment established to evaluate four frequencies of trimming for pond peanut (*Arachis kretschmeri*) and dalisgrass (*Paspalun dilatatum*) in coffee groves showed that trimming living mulches every 4 to 12 months reduced weed cover two years after mulch establishment. Plant height and canopy diameter of coffee groves did not show significant differences after one year of trimming. Weed density decreased in all trimmed living mulches by May 2004.

B. Impact – Local researchers estimate that weed management accounts for more than 25% of total production expenses in the island's principal crops. Coffee is the second most important crop in Puerto Rico in terms of income, but is farmed by more than 50% of the island's farmers and employs 26% of its farm workers. Coffee plantations, as secondary forests, are also vital for the preservation of local watersheds. After Hurricane George in 1998, all the components of the coffee industry of Puerto Rico have experienced a decline in profits. Increases in the cost of inputs and an inadequate labor supply are an important component of the sector's problems. Suppression of weeds by living mulches may be an alternative practice to reduce the use of herbicide applications, thus lowering production costs and lessening potential contamination of chemicals in upland agro-ecosystems.

C. Source of Federal Funds: Hatch $545,097 SY FTE: 4.3

D. Scope of Impact: State specific PR

Goal V. *Enhanced economic opportunity and quality of life for Americans*

I. Key Theme – Jobs/Employment

A. (Under Hatch and State Funds). Coffee is the crop with the highest socio-economic and environmental importance in Puerto Rico. It generates over 6,000 direct jobs, accounting for 26% of total agricultural employment. Labor scarcity, particularly during harvest, is, however, a major constraint faced by farm operators. It is largely responsible for a decline in the sector's farm income since 1998, and has prompted a downsizing in the scale of operations from medium to smaller farms. To explore potential solutions to the mismatch between coffee growers' labor demands and the available labor supply a mail survey of 126 growers was conducted, and personal interviews with 102 potential agricultural laborers attending Work Investment Act programs were carried out. Nineteen municipalities were represented. Results from the grower's study showed that the average farm land under production was 27 acres, the average value of coffee sold was $17,987 (median $7,850), and the average number of hired farmworkers was three. Fifty-five percent said they would have needed more workers during the year. Responses from the workers' interviews showed that prospective workers were on the average 50 years old, had 8.5 years of schooling, and all were participants of the Nutritional Assistance Program. The most important aspect considered at the time of selecting a job was "to be treated with respect" and flexibility. Having an employer with a good attitude towards laborers was considered more important by the majority of interviewees than having a higher wage.

B. Impact – Maintaining a vital coffee industry in Puerto Rico is important from an environmental perspective, given that farm owners are still custodians of a significant part of the natural resources of the region, and important from a social point of view, because the industry includes more than 50% of the farmers of the island and employs the majority of agricultural laborers. If linkages can be established between the needs of growers and demands of workers, an expansion in employment and in the size of coffee plantations could be achieved, all of which would have a measurable multiplier effect in many rural areas of Puerto Rico. This study provides alternatives, recommended by both workers and growers, on how to improve the labor market situation in the coffee region.

C. Source of Federal Funds: Multi-State Hatch $21,607 SY FTE: .5
State matching funds: $27,347

D. Scope of Impact: State Specific, PR

STAKEHOLDER INPUT PROCESS

Last year the AES began an internal and external evaluation process of current priorities to identify other critical issues that should be targeted by our research program, and to incorporate stakeholders input on these issues and on the setting of research priorities. Two types of meetings held in different locations of Puerto Rico were instrumental for achieving these goals.

First, we have continued to celebrate an annual meeting with all the researchers, extension faculty, farmers and other public interested in the work performed under each commodity area. In these meetings the progress of currently active projects is discussed, preliminary results are shared and further input is sought for updating the commodity's research needs and priorities. The meeting is usually celebrated in the Research Center or Substation closest to where the main nucleus of the commodity producers are located, and coordinated with the Agricultural Extension Service commodity specialist and agricultural agents of the region. Both the commodity leader and the extension personnel identify and invite interested stakeholders from producers associations, individual farmers, faculty and students, government officials and community organizations with an interest in the commodity's work. The input received in these meetings from all the stakeholders present is summarized, evaluated and presented in a concluding meeting of commodity leaders and research administrators, where final decisions are taken. The list of priorities assembled through this process guided this year's call for proposals for new Hatch and Special projects.

Second, several commodity leaders and directors of integrated academic departments have organized thematic workshops, seminars, or field days in which research results on particular topics have been shared and alternative views on the subject--including further research and extension needs, or public policy determinations--have been discussed. The feedback received in these activities was incorporated into the revised statement of issues prepared under each goal for the FY 2004-2006 Plan of Work (POW) update.

PROGRAM REVIEW PROCESS

There had been no significant changes in our Program Review Processes since our Five-Year POW was submitted. We are now, however, in the middle of a review of our entire research program and changes are underway which will be reported in next year's Annual Report. This annual

report includes the same description previously presented, with minor revisions.

Every AES proposal or request for extension, formula funded or otherwise, goes through a thorough merit review process following the *Administrative Manual for the Hatch* (*Experiment Station*) *Act as Amended* (see section C.3, page 7, Projects Supported with Regional Research Funds). The review committee is made up of AES Assistant Dean for Research, the concerned Department Chair[2] and the concerned commodity Leader or Leaders, or, in the case of these last two, their representatives. Each individual evaluates and rates the various proposals before they are submitted to the proper authority for approval. If any of the members of the review committee are collaborating in the proposal being submitted, they do not participate in the evaluation process, but send the proposal to a qualified scientist, in some instances to external reviewers.

More specifically, the scientific peer review process of proposals according to the source of funding is the following:

a) Matching Commonwealth Research Funds:

Proposals are submitted to the Assistant Dean for Research with the pre-approval of the respective Department Head and Commodity Leader. The Assistant Dean for Research discusses and evaluates the proposals in a meeting with the 10 commodity leaders. Once the proposal goes through this process and is accepted, the project is included in the AES research program.

b) Formula Hatch Research Funds:

Proposals are submitted to the Assistant Dean for Research with the preliminary endorsement of the respective Department Head and Commodity Leader. The Assistant Dean for Research sends the proposal again to the corresponding department head, commodity leader and external reviewers—if needed--for their written comments on the scientific merit of the proposed research and compliance with the AES strategic plan. Proposals and their reviewers' input are discussed, evaluated, and a final decision is reached in a subsequent meeting of the Assistant Dean for Research with the ten commodity leaders and seven departments' heads. These proposals are then sent to the USDA-CSREES Office of the Administrator, where the respective specialist reviews them. Once the proposals are approved in

[2] The College of Agricultural Sciences is made up of seven Integrated Departments: Animal Industry, Horticulture, Crop Protection, Agronomy and Soils, Agricultural Economics and Rural Sociology, Agricultural Engineering and Agricultural Education.

Washington, the new or revised projects are included in the AES research program.

c) Special Grant Research Funds:

A letter of intent with an abstract of the proposed project is submitted to the Assistant Dean for Research and to the Manager of the Special Grants Program in the University of Florida, with the pre-approval of the respective Department Head and Commodity Leader. Full proposals are submitted to the Assistant Dean for Research and are forwarded, after reviewing them for compliance with local and federal procedures, to the program manager. The program manager sends them out for external review to the pre-arranged panels. These panels of 3 to 4 reviewers rank each proposal and make written comments on the scientific merit, scientific preparation of the principal investigator, and the potential success and impact of the research. This information is then gathered, distributed, and discussed among the technical committee members of the special grant fund at an annual spring meeting in Washington. This committee is composed of representatives of the universities of Florida, Puerto Rico, and the US Virgin Islands (Dean and Director, Associate Dean and/or Assistant Dean for Research), CSREES staff, and USDA-ARS representative. This group and the Program Manager decide which proposals will be accepted for funding and included in each of the participating universities research program.

Evaluation of the Success of Multi and Joint Activities:

The Agricultural Experiment Station of the University of Puerto Rico actively participates in Multi-State Research. There were six projects within Multi-State Research last fiscal year. Research covers disciplines such as plant breeding, pesticide detection and assessment, irrigation management, and rural sociology. While the impact of some of these studies appears to be state specific, when results from the participant states are put together, conclusions about the impact of a particular program and nationwide variations can be reached. This has been the case with MultiState projects in the area of rural sociology, for example. The exchange of information and disciplinary discussions taking place in these projects annual meetings have contributed to the improvement of our research program.