

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Climate Change: Natural Resources and Environment

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
101	Appraisal of Soil Resources			7%	
102	Soil, Plant, Water, Nutrient Relationships			13%	
103	Management of Saline and Sodic Soils and Salinity			3%	
104	Protect Soil from Harmful Effects of Natural Elements			8%	
111	Conservation and Efficient Use of Water			12%	
112	Watershed Protection and Management			13%	
121	Management of Range Resources			3%	
123	Management and Sustainability of Forest Resources			3%	
133	Pollution Prevention and Mitigation			8%	
136	Conservation of Biological Diversity			17%	
141	Air Resource Protection and Management			2%	
211	Insects, Mites, and Other Arthropods Affecting Plants			7%	
212	Diseases and Nematodes Affecting Plants			2%	
403	Waste Disposal, Recycling, and Reuse			1%	
405	Drainage and Irrigation Systems and Facilities			1%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	3.5	0.0
Actual Paid	0.0	0.0	3.4	0.0

Actual Volunteer	0.0	0.0	0.8	0.0
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2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	549756	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	438035	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	28955	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

The main goal of the Climate Change and Sustainable Energy: Natural Resources and Environment research program (CCSE-NRE) continues to be to develop, perform and support scientific research regarding the impact of agricultural practices on the environment and natural resources of Puerto Rico. The program addresses key Agricultural Experiment Station mission goals by supporting both the Department of Agriculture and the Natural and Environmental Resources Department.

During 2014 soil management research promoting the improvement in soil quality by increasing recalcitrant soil organic matter (RSOM) continued with the quantification and characterization of RSOM in weatherized soils as a function of conservative practices. The integrated soil management system promoted incorporates three soil conservation practices: green manure amendments, compost, and effective microorganisms.

The development of quantitative thresholds of impairment for nutrients continues to be a key priority of our watershed protection and management research program. Studies providing reliable scientific data on the contribution of agriculture in relation to other pollution sources, and promoting a reduction in the amount of nutrients released into soil and water, validated important results for informing regulatory policy decisions. The Environmental Quality Board of Puerto Rico (PREQB) recently modified the island's Water Quality Standards of Rivers and Streams as relates to nutrients. Results from one of our current Hatch projects validated numeric nutrient criteria estimates developed in a previous study using a statistical distribution approach. Confirmation of previous estimates using a biological index component was pivotal in the regulatory effort.

The prevention and control of invasive species through management approaches for biodiversity conservation and restoration also remains an important priority of our program. Both field-and laboratory-based activities were conducted last year to continue identifying and pursuing insights into the role of emerging or invasive insect pest species in Puerto Rico. Digital images were gathered of over 50 common insect species from the Mangrove & Coastal forest plant assemblage. More than 200 high quality digital

images are now available for selection and publication.

Other research priorities identified by program stakeholders, and partially addressed in our projects, are: a digitalized inventory of agricultural land use in crop production and other land uses; appraisal of this resource availability and suitability for specific uses; and development of sustainable agricultural production practices to protect and enhance natural ecosystems. Research results have been disseminated through peer reviewed publications, non-refereed articles, and presentations in trainings, research demonstration activities and meetings with stakeholders.

2. Brief description of the target audience

Extension specialists and agents, Faculty members and students, government partners, producers, consumers, and community-based groups.

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	0	0	0	0

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

Patent Applications Submitted

Year: 2014

Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total
Actual	0	8	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Oral or poster presentations in professional scientific society meetings resulting from program activities

Year	Actual
2014	16

Output #2

Output Measure

- Number of Peer Reviewed publications.

Year	Actual
2014	8

Output #3

Output Measure

- Number of trainings, research demonstration activities and meetings with stakeholders to discuss research results and priorities.

Year	Actual
2014	15

Output #4

Output Measure

- Number of graduate students completing a MS degree and submitting theses under research projects in this program

Year	Actual
2014	4

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of stakeholders gaining knowledge on pollution prevention and mitigation practices for soil and watershed protection and management.
2	Number of persons adopting practices for watershed protection
3	Number of persons gaining knowledge on biodiversity threats and losses, and on prevention practices.
4	Number of farmers adopting methods to increase soil organic matter content
5	Number of stakeholders gaining knowledge of efficient water use and conservation practices.
6	Number of stakeholders gaining knowledge effects on invasive species management practices.
7	Number of stakeholders gaining knowledge on managing approaches for conserving and restoring biodiversity and on the impact of agricultural management practices on natural ecosystems.
8	Number of students (graduates and undergraduates) receiving training and work experience in this research program.

Outcome #1

1. Outcome Measures

Number of stakeholders gaining knowledge on pollution prevention and mitigation practices for soil and watershed protection and management.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Agricultural residues in Puerto Rico have not been considered a manageable resource, but a waste byproduct. Pollution reduction can be achieved through proper organic resource management. Windrow composting offers the possibility of composting large quantities of organic waste that can be managed with relatively low operational cost and low energy consumption.

What has been done

A project was established to validate and demonstrate the use of windrow composting of various agricultural residues. The research conducted also validated the use of microorganisms in the odor control process. To manage large quantities of agricultural residues, a windrow composting and water management design system was adapted to the humid tropical conditions of Puerto Rico. The project was mostly supplied with coffee pulp from various coffee processing plants and occasionally received chicken manure and orange peels from an orange processing plant.

Results

The project's research site, PRAEXS Adjuntas substation, has become a model of proper composting practices. Project results have been widely disseminated to local and international audiences through several videos describing the windrow composting facility and other aspects of the composting process such as the use of temperature to monitor the compost pile. At the time the final report was submitted the audience for the videos numbered more than 900 viewers in Puerto Rico and more than 3,000 in Latin America and the US. Several field visits were also organized to share the project results with local stakeholders.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation
403	Waste Disposal, Recycling, and Reuse

Outcome #2

1. Outcome Measures

Number of persons adopting practices for watershed protection

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Nutrient over-enrichment is highly detrimental to the sustainability of waters. The USEPA has the mandate to develop quantitative thresholds of impairment of nutrients for watershed and reservoirs on the island. The development of biological indicators of stressor conditions is an essential component to implementing regulatory limits or standards to control nutrient over-enrichment in rivers/streams of Puerto Rico. The target audiences for this project are the local regulatory agencies in charge of water quality protection such as the Environmental Quality Board and Department of Natural and Environmental Resources.

What has been done

A project was established to evaluate the relationship between nutrients and recurrent flood events on the growth rate and biomass accumulation of periphyton in moderately to nutrient enriched rivers of Puerto Rico. An opinion poll is being conducted of a particular community (NGO) of river stakeholders to establish what constitutes acceptable/nuisance levels of periphyton biomass for recreational purposes in rivers of Puerto Rico.

Results

The Environmental Quality Board of Puerto Rico recently modified the Water Quality Standards of Rivers and Streams of the island as related to nutrients. Results from our current Hatch project

validated numeric The Environmental Quality Board of Puerto Rico recently modified the island's Water Quality Standards of Rivers and Streams as relates to nutrients. Results from our current Hatch project validated numeric nutrient criteria estimates developed in a previous study using a statistical distribution approach. The confirmation of previous estimates using a biological index component was pivotal in the regulatory effort. Results have been disseminated through seminars. The process of scientific manuscript submission is in progress.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation

Outcome #3

1. Outcome Measures

Number of persons gaining knowledge on biodiversity threats and losses, and on prevention practices.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Invasive species are posing a serious challenge that requires a decision-making framework based on the prioritization of species for control, regulation and public education programs. Methods are needed to identify those non-native species that pose ecological and economical threats in order to prioritize those that should be targeted for regulation, control or both.

What has been done

Both field-and laboratory-based activities were conducted to continue identifying and pursuing insights into the role of emerging or invasive insect pest species in Puerto Rico. In addition to field collections, efforts have been made to secure reliable identification methods using museum reference materials, extant literature, and historical collections. Following our initial model of

constructing pictorial records of known and newly introduced species, digital images were gathered of over 50 common insect species from the Mangrove & Coastal forest plant assemblage. More than 200 high quality digital images are now available for selection and publication.

Results

We have documented the presence of new potential pests. Among these is the first record for the invasive aphid *Greenidea psidii* (Hemiptera: Aphididae) from Asia, a potential pest of guava and other myrtaceous crops. We also found several specimens of the Dynastine beetle, *Gymnetis strigosa*, a northern South America native found feeding on the endangered *Marsdenia woodburyana* (Asclepidaceae). An introduced pit scale, *Planchonia stentae* (Hemiptera: Sternorrhyncha: Asterolecaniidae) was also found attacking the endangered *Mitracarpus polycadus* in Guánica. This scale is another well-known invasive species and a new record for Puerto Rico. Finally, we reported the presence of the croton scale *Phalacrocooccus howertoni* (Hemiptera: Sternorrhyncha: Coccidae) in St. Croix and in Puerto Rico. This invasive scale is likely to become a serious problem in ornamental settings and in urban forests.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources
136	Conservation of Biological Diversity
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Diseases and Nematodes Affecting Plants

Outcome #4

1. Outcome Measures

Number of farmers adopting methods to increase soil organic matter content

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Unsuitable agricultural practices have exacerbated soil degradation worldwide, thus limiting food production. Loss of soil organic matter is a major effect associated with soil degradation. Transition to a sustainable agriculture could be a long-term process that starts with the soil, its health and the environment. Many factors can affect the rate of transition: varied tropical clay soils, compost types, and rainy, humid and changing environments, posing a challenge for sustainable production.

What has been done

Studies were conducted on the transition to sustainable agriculture and the rate at which it can occur. Four important agricultural clay soils of varying characteristics were supplemented with organic amendments in order to quantify and simulate the long-term effects of amendments on crop yield. The frequency and quantity of compost applied to the soil was studied over a four-year period with tomato and onion crop rotations to observe a possible reduction of inorganic fertilizer needs based on soil analysis.

Results

The incorporation of cover crops, compost amendment and application of compost tea increased total soil organic matter and recalcitrant organic matter in tropical soils. The physical, chemical and biological properties of soils were significantly increased by the above-mentioned amendment treatments. The results of this study were shared and continue to be shared on the website compostapr.com. The process of sharing information allows farmers and the general public to prepare individual management plans after a small amount of training through the web page presentations.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
133	Pollution Prevention and Mitigation
403	Waste Disposal, Recycling, and Reuse

Outcome #5

1. Outcome Measures

Number of stakeholders gaining knowledge of efficient water use and conservation practices.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Irrigation is an important factor in areas in which rainfall is limiting crop production. In Puerto Rico, 40% of the groundwater is used for irrigation. Farmers over-irrigate in an attempt to increase yields, resulting in water logging poorly permeable soils, or nitrogen losses in soils with higher permeability, thus contaminating groundwater. Better irrigation management, conservation, and utilization should help to alleviate the dilemma between agricultural production and water for human consumption.

What has been done

A project was established to compare irrigation-scheduling technologies and develop grower-appropriate scheduling products. Best management practices for the application of agrochemicals were also developed.

Results

More farmers and producers have understood the importance of proper management of drip irrigation in fruit trees, vegetables and starchy crops. Proper use of these systems (micro-irrigation or drip irrigation) reduces production costs, increases water use efficiency, and reduces pollution in groundwater. Farmers' trainings in the field were achieved, including a women's group among them. It was proven feasible to use subsurface micro-irrigation to produce vegetables and farinaceous crops in rotation for several years on the south coast of Puerto Rico. The University of Puerto Rico began to play an important role in the Caribbean with the use of remote sensing technology to estimate regional evapotranspiration (ET) and thereby promote better use of irrigation water resources.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
405	Drainage and Irrigation Systems and Facilities

Outcome #6

1. Outcome Measures

Number of stakeholders gaining knowledge effects on invasive species management practices.

Not Reporting on this Outcome Measure

Outcome #7

1. Outcome Measures

Number of stakeholders gaining knowledge on managing approaches for conserving and restoring biodiversity and on the impact of agricultural management practices on natural ecosystems.

Not Reporting on this Outcome Measure

Outcome #8

1. Outcome Measures

Number of students (graduates and undergraduates) receiving training and work experience in this research program.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	15

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Outstanding students at the undergraduate and Master?s levels need training support in order to fill national identified expertise demands in the Agricultural and Natural Resources sciences.

What has been done

Funding from research projects has been allocated for the support of student?s training, work experience and completion of their Master?s degree in priority research areas within the Agricultural and Natural Resources sciences.

Results

Four students completed their master degree during last year. Recruitment and retention of talented students interested in pursuing graduate studies has increased. Students recruited under the program have shown a tendency to continue graduate studies in disciplines and topics related to the research program.

4. Associated Knowledge Areas

KA Code	Knowledge Area
101	Appraisal of Soil Resources
104	Protect Soil from Harmful Effects of Natural Elements
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
121	Management of Range Resources
123	Management and Sustainability of Forest Resources
133	Pollution Prevention and Mitigation
211	Insects, Mites, and Other Arthropods Affecting Plants
403	Waste Disposal, Recycling, and Reuse
405	Drainage and Irrigation Systems and Facilities

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Appropriations changes

Brief Explanation

Budget reductions at the university and increases in the cost of higher education for students may affect the number of scientists and graduate students working under this program.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The input of program participants and stakeholders on the progress of the program continues to be collected in the outreach activities celebrated. Seminars and meetings are among the activities conducted. Methods used to collect information include personal interviews, end section questionnaires, and document review and analysis. Outreach activities have been documented through web videos, web seminars and podcasts. A special seminar series "Colloquio AgroAmbiental" have been developed to discuss major issues regarding the natural resources and environment. In addition, research results have been successfully disseminated through web sites, podcasts and blogs. Reaching these wide audiences has provided us with lots of inputs from concerned parties that came in the form of consultations, comments, and inquiries regarding services and major agricultural

and environmental issues. Evaluation results will be used to improve the research program activities in order to enhance and achieve the stated goals and objectives according to the stakeholders needs.

Key Items of Evaluation

As a result of the gathered data several major issues have been identified; some of them are common ground among the wide number of participants. Among the critical issues are; soil management and erosion control; need for guidelines for quality control and pollution prevention in watersheds; nutrients management; and providing a digitalized inventory of agricultural land for use in crop production and other land uses. Another major concern is the impact of non-native and/or invasive species in agricultural production systems and natural ecosystems. Finally, our audience shows a great interest in sustainable agricultural production in the context of food security. The capacity to comply with these research needs will depend on budget and human resources availability.