In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Water scarcity or the lack of rainfall uniformity in some regions of Puerto Rico is a problem that requires special attention to maintain or increase yields without jeopardizing the environment. The response of coffee and avocado to drip irrigation and fertilization management on contrasting environments is being evaluated to address that problem. Also, in this project techniques such as remote sensing were used to increase knowledge in Puerto Rico and the Caribbean region on climate change, issues with reservoirs that supply irrigation districts, issues with aquifers, drought monitoring.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Puerto Rico in recent years has been affected by hurricanes that have continued to reduce agricultural production in the island. This project is addressing economically important crops, such as coffee, and fruit trees, such as avocado, that were affected by those atmospheric disturbances. For avocado, farmers mainly use drip irrigation systems, however there are many aspects that could be improved in terms of a more efficient use of water and the application of fertilizers through the system. Another crop greatly affected was coffee. Coffee production is mainly established in the mountainous region of PR, where there is generally high rainfall, but not evenly distributed. Farmers have the false notion that a drip irrigation system on their farms is not necessary. With our project we try to prove the hypothesis that the installation of a drip irrigation system in coffee plantations has benefits for the production, and a better management of fertilizers through the system.

Briefly describe how your target audience benefited from your project's activities.

Farmers, agricultural professionals, and students have been informed about the research results. They have been provided with the skills needed to improve the adoption of these practices on their farms.

Briefly describe how the broader public benefited from your project's activities.

The society must understand that their agricultural sector must be protected and improved so that dependence on food imports from other jurisdictions is reduced.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Training and professional development opportunities - With the implementation of this project, leaders, coleaders, research assistants and graduate and undergraduate students have been given the opportunity to improve their knowledge by attending conferences and obtaining training both in the classroom and in the field.

Dissemination of results (outreach activities) - Results have been disseminated through peer reviewed publications, oral and written presentations, field days and formal and informal teaching.

Plans for next reporting period - We are planning to continue with field research, and prepare oral and poster presentations. A graduate student was hired to work in the avocado project at Lajas and Isabela substation. Three manuscripts are being written regarding research findings in the project, and we are planning to publish them on the incoming year.

Major changes or problems - Despite the fact that in the last 5 years Puerto Rico were affected by three hurricanes, earthquakes and a covid pandemic, work has continued on the project. Some delays and damages to the experiments established in the field were overcomed.

Publications:

Peer reviewed publications

Harmsen,E.W.;Mecikalski, J.R.; Reventos, V.J.; Alvarez Perez, E.; Uwakweh, S.S.; Adorno Garcia, C. Water and Energy Balance Model GOES-PRWEB: Development and Validation. *Hydrology* 2021, *8*, 113. https://doi.org/10.3390/ hydrology8030113

Piasecki, M.; Harmsen, E. Hydrology in the Caribbean Basin. Hydrology 2022, 9, 22. https://doi.org/10.3390/hydrology 9020022.

Román-Paoli, E., J. Ortiz-López, J. Zamora-Echevarría, and F. Román-Pérez. 2021 Fertilization Methods Affecting 'Tahiti' Lime (Citrus latifolia) Fruit Yield and Profitability. J. of Agric. of the Univ. of Puerto Rico. 105(2): 163-177.

Tirado-Corbalá, R., E. Román Paoli, J. Muñoz. 2021. Fertilization and precise irrigation scheduling for mature avocado. J. of Agric. of the Univ. of Puerto Rico. 105(1):73-88.

Tirado-Corbalá, R., E. Román-Paoli A. Segarra-Carmona C. Estévez de Jensen, D. Rivera-Ocasio.2022. Early response of Mexican lime, Fina clementine mandarin and Campbell valencia orange on selected rootstocks grown under fertigation practices in an Oxisol in Puerto Rico. 8(6), 513 https://doi.org/10.3390/horticulturae8060513.

Personal presentations

Román Paoli, E. Evaluación del uso de riego por goteo en la productividad de café (var. Catuaí). Annual Scientific Meeting. Puerto Rican Society of Agricultural Sciences. December 2, 2022, Coamo, PR. Poster presentation.

Irrigation Research Conducted by UPR-AES in Dragon Fruit. August 15, 2022. Homestead Research and Development Center. FL. Oral presentation.

Drip irrigation mangement according to FSM Act. April 31 2022. Lajas Substation, Agricultual Experiment Station, University of Puerto Rico. oral presentation.

Closing Out (end date 01/17/2024)

Forestry Innovation Laboratory and Learning Institute (FILLI): Using Hurricane Maria's lessons and opportunities to support long-term sustainable

Project Director
Mario Flores-Mangual
Organization
University of Puerto Rico Mayaguez Campus
Accession Number
1016450

⭐ **Annual Results-Forestry Innovation Laboratory and Learning Institute (FILLI): Using Hurricane Maria's lessons and opportunities to support long-term sustainable**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Hurricanes affect trees and produce a surplus of vegetative material that can potentially be used (e.g. to produce biochar for growing media and soil amendments). These materials can be used for tree growth in reforestation efforts. In addition, there is the need to restore forests that have been impacted by hurricanes in Puerto Rico.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

1. **The use of vegetative waste to produce biochar and woodchips, and to test these as soil and growing media amendments.** We tested the biochar and woodchips as part of growing media to grow *Tabebuia heterophylla* trees in pots. We also started growing a field experiment applying biochar and chicken manure as soil amendment to grow trees.

2. **Outreach on forest product management and uses** - We did two presentations of some of the results of the project as part of the meeting (date: May 6, 2022) named: Manejo de bosques en sistemas social-economicos de Puerto Rico. The tittles of the presentation were: 1) Uso de biochar de arboles no-nativos en medios de cultivo (The use of biochar produced from non-natives trees as part of growing media), and 2) Hacia un Laboratorio de Manejo de Bosques y Productos Forestales en el RUM (Towards a Forest Management and Products Laboratory at UPR-Mayaguez).

Briefly describe how your target audience benefited from your project's activities.

As part of Conference on May 6, 2022 we presented to farmers, forest managers, extentionists, and the general public the benefits of using forests products that locally may be considered waste. Part of the audience have reached out to us as they are interested in applying some of our results. For example, there is a group that is starting to produce biochar from waste vegetative materials that accumulate in rivers. They are highly interested in collaborating with the University to do research on the use of this biochar for plant growth.

Briefly describe how the broader public benefited from your project's activities.

We are currently working hand to hand with Para La Naturaleza, a NGO dedicated to the conservation and reforestation of protected ecosystems. The results on how to use biochar will directly help on possible new formulations of growing media that include less amount of Promix. In addition the data generated on the test of biochar in the field will help them improve their reforestation strategies. For example, we are testing biochar as soil amendment, in Corozal Experiment Substation, in highly degraded soils that are limiting the reforestation of protected areas. All this information not only benefits Para La Naturaleza, but also all groups, Government Agencies and land owners interested in reforestation and forest products. In addition, we created videos that are available to the general public in internet platforms such as YouTube. In May 2022 we are presenting at a forest conference of UPRM the first experiments testing the biochar as part of growing medium, and this year we will be presenting the results of field experiments.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Training and professional development opportunities - We have trained several farm workers (at least four) in the use of the sawmill. This has been done inviting local sawmill owners, that kindly have provided their time and expertise to participate in these trainings. From these trainings we have generated videos that we hope will teach the general public about the use of sawmills. We also trained one technician and one graduate student on the preparation of biochar. Also, the technician was trained in plant growth and tree nursery management.

Dissemination of results- We posted videos in the SEA-UPRM webpage of an outreach activity where local sawmill owners did trainings on sawmill maintenance and uses. In this activity we invited local landowners, arborists, Natural Resources agents and USDA Forest Services personnel. From these trainings we have generated 3 videos that we hope will teach the general public on the use of sawmills. We also did another video the same day explaining the benefits of biochar. All four videos are done with editing and will be posted on YouTube for the benefit of the general public.

Also, we presented some of the results in a conference on May 6, 2022 that was organized by Agricultural Experiment Station-UPRM named: Manejo de bosques en sistemas social-economicos de Puerto Rico. This conference was online and was open to everyone.

Plans for next reporting period - We are currently performing a field experiment in the Corozal AES testing the biochar as soil amendment for the growth of native trees. We are including chicken manure as part of the treatments to compare the biochar to a common soil amendment. We will monitor plants after the closing date of the project (September 30, 2023) but we will include the preliminary results in the final report.

Major changes or problems - The biggest problem the research has had was the initial lockdown of Covid-19 that caused the research to be behind schedule. Last period we had hurricane Fiona that limited the work at the end of the reporting period. We also lost the data of a second experiment on the use of biochar to grow trees in growing media due to an error on the collection of the growing media samples. We will try to run again this second experiment, but we may not have enough time before the project funding ends. However, I believe that we have enough information from the first experiment to be able to publish the information.

Publications:

Flores-Mangual, M.L., M.A. Pagán-Lopéz and E.A. Román Aponte. (To be submitted). Use of biochar from non-native trees as part of growing media for basil growth. To be submitted, in an internal review process, to: Journal of Agricultures of the UPR.

Abelleira Martínez, O.J., G. Túa Ayala y Rey E. Cruz Aguilar. 2021. Intervenciones de Forestería Análoga en Bosques Secundarios Puertorriqueños. Presentación oral *en-línea* en el XI Simposio Internacional sobre Manejo Sostenible de los Recursos Forestales (SIMFOR) el 26 de noviembrebde 2021 en la Universidad de Pinar del Río, Cuba (vía Zoom).

Abelleira Martínez, O.J., J. Rivera San Antonio, G. Túa Ayala, R. Cruz Aguilar, G. Báez Rivera, A. Marengo Casul, M. del R. Suárez, y A. Pérez Méndez. 2022. Hacia un Laboratorio de Manejo de Bosques y Productos Forestales en el RUM. Presentación oral *en-línea* en el foro Manejo de Bosques en Sistemas Social-Ecolo?gicos de Puerto Rico del Área Programa?tica de Climas Extremos, Recursos Naturales y Energi?a Renovable de la Estación Experimental Agrícola de la UPR llevado a cabo el 6 de mayo de 2022 vía Zoom.

Other Products:

1. Equipment: The project allowed for the purchase of a Thermo Scientific Heratherm oven and a Norwood sawmill for the FILLI's facilities in Finca Alzamora and a Wood-Mizer sawmill at the Corozal Experiment Substation. Both sawmills have been used for outreach activies related to the use of forest products. The Alzamora sawmill has been also used as part of the research objective that explores the used of softwoods from invasive species.

2. Databases: We built a page in Facebook that includes information about the ongoing progress of the research, outreach information, announcements and other information related to forest management and forest products in Puerto Rico.

3. Videos: We produced four videos that were edited and posted last year at the UPRM website. The videos included trainings on the use of a sawmill. And also we did a video on the benefits of producing biochar. The link to the videos are:

4. Forest Innovation: https://www.youtube.com/watch?v=v7joFvfV0IY&list=UULFA8CUw5QzG-LmmttmFiCB6g&index=14

5. Conceptos Básicos del Mantenimiento de un Aserradero Parte 1/3: https://www.youtube.com/watch?v=8uy4KSDa59s&list=UULFA8CUw5QzG-LmmttmFiCB6g&index=13

6. Herramientas Básicas y Equipos de Protección Parte 2/3: https://www.youtube.com/watch?v=OeBgf4sN_XI&list=UULFA8CUw5QzG-LmmttmFiCB6g&index=12

An updated assessment of soil salinity of the Lajas Valley Agricultural Reserve

Project Director

DAVID SOTOMAYOR-RAMIREZ

Organization

University of Puerto Rico Mayaguez Campus

Accession Number

1013206

⭐ **An updated assessment of soil salinity of the Lajas Valley Agricultural Reserve**   Final Result

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Soil salinity and sodicity (saline soils) is a major factor limiting crop productivity worldwide. The areal extent of saline soils in Puerto Rico may be near 2%. The soils are important as most areas have irrigation-drainage infrastructure, and the soils can be quite productive if managed adequately. One important agricultural area is the Lajas Valley Agricultural Reserve which encompasses an area of over 40,000 acres primarily of Vertisols with irrigation-drainage infrastructure. The spatial distribution and extent of soil salinity was evaluated in the 1950s. There is a need to evaluate changes in the magnitude and spatial extent of soil salinity.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Soil samples from 0 to 120 cm depth, were gathered from the Lajas Valley watershed. The major soils of the area are Typic Haplusterts, Sodic Haplusterts, and Typic Calciaquerts. Soil electrical conductivity (EC) and sodium adsorption ratio (SAR) were quantified in saturated paste extracts (ECe and SARe) and in 1:5 (soil:solution) extracts (EC1:5 and SAR1:5). Significant empirical quantitative relationships were established between EC1:5 and ECe and SAR1:5 and SARe. Soil EC and SAR measurements in 1:5 extractions allow for a quick and efficient method to estimate ECe and SARe, respectively.

Soil apparent electrical conductivity (ECa) was determined using electromagnetic induction with EM-38® (Geonics Limited, Ontario, Canadá) in selected poligons encompassing an area of 1,289 ha of the Lajas Valley. GIS-based regressions between ECaV (vertical mode) and ECe, allowed for estimation of ECe and extrapolation of ECe to the area mapped with EM-38. GIS-based maps of saline, sodic and saline-sodic, based on USSL (1954) categorizations, were developed. Categorizations of saline and sodic soils mapped using our technique differed substantially from soil taxonomic classifications in USDA-NRCS (2008)[1].

A regional-based soil salinity-sodicity predictive model was tested using simple, multiple, and artificial neural network (ANN) analysis. A geodatabase was created using multiple layers (polygons and rasters) which included dependent, regression, and extrapolated variables. These included (i) ECe, SARe quantified in this study and ECe and SARe quantified by Bonnet and Brennes (1958) (ii) 1993 aerial photograph, Landsat 8, Sentinel 2A (images from 2015-2020) spectral bands, NDVI, LIDAR; (iii) soil taxonomic classes, elevation, slope, geology, surface curvature, surface water flow, soil cover, subsurface water flow. A raster database with 10m resolution was created. Simple and multiple regression models were run to predict current state soil ECe and SARe. The ANN model was assembled using Python® and Google® Colab. The entrance layer included regression and extrapolated variables. The model was trained to a maximum of 100 iterations until convergence to obtain highest regression coefficient and root-mean square error. The three models predicted current state soil ECe and SARe in 7,723 ha. The ANN showed improved soil salinity and sodicity prediction than traditional simple and multiple regression analysis. The spatial variability of soil salinity (ECe) and sodicity (SARe) to a depth of 0 to 60 and 0 to 120 cm, was described in a spatial GIS-based model for 1958 and 2020 conditions. The current state status was that normal, saline, sodic, and saline-sodic soils occupied 69, 27, 0, and 4.3% of the area surveyed. A comparison of the current state area of each soil class to that in 1958 showed that 42% of the soils were normal and did not change, 7% of the soils that were saline changed to normal, 3% of the soils changed from sodic to normal, 10% of the soils that were normal became saline, and 16% of the saline-sodic soils changed to normal. There was a net increase of 18% of the soil area previously affected by excess salts and sodium to normal status.

Twelve soil patterns distributed in 751 ha located in different positions of the landscape were identified: (i) normal tumors, (ii) pond tumors, (iii) melon hole tumors, (iv) stony tumors, (v) soils with vertical cracking, (vi) depressions, (vii) hay affected by salts, (viii) wetlands, (ix) springs, (x) surface salts, (xi) outcrops plants, (xii) and an anthropic sulfur deposit.

[1] USDA-NRCS. 2008. Soil Survey of San German Area. USDA-NRCS.

Briefly describe how your target audience benefited from your project's activities.

Saturated paste EC and SAR (ECe and SARe) can be effectively predicted using 1:5 soil:water extractions. This reduces the cost and time of analysis. A protocol for measuring ECa using electromagnetic induction was developed, which permitted assaying large land areas by reducing time and efforts. ECa using EMI can be used to predict ECe and SARe using GIS-based tools. The spatial extent and magnitude of soil salinity and

sodicity at a regional scale can be done using ANN analysis. The results can be used to describe the current state soil salinity and sodicity at a spatial scale. Changes in soil salinity and sodicity relative to that in 1958 can be determined.

Briefly describe how the broader public benefited from your project's activities.

The use of EMI can be used at a field-scale to assess ECa and with the tools generated can be used to predict ECe and SARe. Field-scale ECe and SARe can be used to identify areas that need reclamation. The procedures developed to calculate regional scale ECe and SARe are robust and scientifically objective and can be used by other researchers elsewhere to identify saline and sodic soils.

We are not aware of the use and application of ANN to predict saline and sodic soils at regional scales so that the procedures used constitute a novel approach to an old problem that will improve saline and sodic soils identification in Puerto Rico and elsewhere. Quantitative equations can be used to convert EC and SAR (based on the solution concentration of Ca, Mg and K) in saturated paste from that measured in 1:5 solution extract. Soil salinity changes from 1958 to present show that there was an overall improvement in 18% of the studied area of approximately 7,723 ha.

The current state soil salinity and sodicity at a spatial scale of the Lajas Valley can be assessed using existing software or mobile application. The empirically based sampling points have accompanying soil fertility, chemistry data that can be used to further understand the soil conditions in specific geographic locations. The data can be used to further understand the factors causing salinization and sodification of soils.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Training & professional development: Graduate students and undergraduate students were trained in project planning, hypothesis development, laboratory procedures, data reduction and interpretation, and scientific writing, the use of EMP-400 and EM-38 instrumentation. Two students graduated from MSc program. Graduate students and undergraduate students were trained in data representation using GIS tools and data analysis and interpretation. Collaboration between USDA-NRCS-Puerto Rico State and Field Office soils staff, University of Mayaguez, Puerto Rico, NRCS-National Soil Survey Center and USDA-ARS, was done to conduct preliminary salinity surveys using the Profiler EMP-400 sensor manufactured by Geophysical Survey Systems, Inc. (Salem, NH), from 7 to 12 May 2018. Collaboration between USDA-NRCS Mid-Atlantic and Caribbean Area Soil Survey Region (SSR 3) and with scientists, graduate students, and undergraduate students from UPRM College of Agricultural Scientists. The assembled team identified, accessed and collected soil samples from pre-selected geographic sampling points, during a five-day period of July and August 2020. The profiles were described in details and horizons were sampled in the laboratory.

Publications:

1. Sotomayor-Ramírez, D., J.P. Castro Chacón, B. Alvarez-Torres, L. Pérez-Alegría, G. Martínez-Rodríguez, T. DeSutter. 2021. Catastro de suelos salinos y sódicos en el Valle de Lajas, suroeste de Puerto Rico. Foro en Conmemoración del Día Mundial de Suelos. Virtual. 3 diciembre 2021. República Dominicana. Ministro de MedioAmbiente y Recursos Naturales, Sociedad Dominicana de la Ciencia del Suelo, Food Agrculture Organization.

2. Sotomayor-Ramírez, D., J.P. Castro Chacón, B. Alvarez-Torres, L. Pérez-Alegría, G. Martínez-Rodríguez, T. DeSutter. 2021. Los suelos salinos y sódicos en el Valle de Lajas, suroeste de Puerto Rico. ArteSueloSer. Conferencias Educativas. Reserva Natural Las Cabezas de San Juan, Fajardo.

3. J.P. Castro Chacón, D. Sotomayor-Ramírez, B. Alvarez-Torres, L. Pérez-Alegría, G. Martínez-Rodríguez, T. DeSutter. 2021. Gomorphology and soil salinity of Lajas Valley, Southwestern Puerto Rico. Texas A&M AgriLife. Soil Survey and Land Resource Workshop. Virtual. Texas. 4-5 February 2021.

4. Sotomayor-Ramírez, D. 2020. An updated Assessment of Soil Salinity of the Lajas Valley Agricultural Reserve. Caribbean Area Soil Survey Work Planning Conference MS TEAMS Meeting - September 16, 2020 National Cooperative Soil Survey (NCSS)

5. Castro Chacón, J.P., D. Sotomayor-Ramírez, L. Pérez-Alegría, G. Martínez, B. Álvarez-Torres, T. DeSutter. 2020. Geomorphology of the Lajas Valley, Puerto Rico. 2020 ASA-CSSA-SSSA International Annual Meeting. Nov. 9-13. Virtual Mode.

6. Castro Chacón, J.P., D. Sotomayor-Ramírez, L. Pérez-Alegría, G. Martínez, B. Álvarez-Torres, T. DeSutter. 2020. Extrapolation models of apparent electrical conductivity (ECa) in the Lajas Valley, Puerto Rico: From the local to the regional scale. 2020 ASA-CSSA-SSSA International Annual Meeting. Nov. 9-13. Virtual Mode.

7. Álvarez-Torres, B., J.P. Castro Chacón, D. Sotomayor-Ramírez, L. Pérez-Alegría, G. Martínez, T. DeSutter. 2020. Field-scale assessment of soil salinity and sodicity in the Lajas Valley, Puerto Rico. 2020 ASA-CSSA-SSSA International Annual Meeting. Virtual Mode. Nov. 9-13. Virtual Mode.

8. Álvarez-Torres, B., J.P. Castro Chacón, D. Sotomayor-Ramírez, L. Pérez-Alegría, G. Martínez, T. DeSutter. 2020. Alternative methods for the evaluation of soil salinity in the Lajas Valley, Puerto Rico. 2020 ASA-CSSA-SSSA International Annual Meeting. Nov. 9-13. Virtual Mode.

9. Castro Chacón, J.P., D. Sotomayor-Ramírez, L. Pérez-Alegría, G. Martínez, B. Álvarez-Torres, T. DeSutter. 2020. Spatial Artificial Intelligence: Exploring machine learning for soil salinity mapping in the Lajas Valley. SymposSium COHEMIS - PRSYIG. Mayaguez, Puerto Rico. 30 Oct. 2020.

10. Castro Chacón, J.P., D. Sotomayor-Ramírez, L. Pérez-Alegría, G. Martínez, B. Álvarez-Torres, T. DeSutter. 2019. Cartografía regional de suelos salinos y sódicos en la Reserva Agrícola del Valle de Lajas. Primer Congreso de Geografía Eugenio María de Hostos. 1 Nov 2019. Biblioteca Nacional, San Juan, Puerto Rico.

11. Álvarez-Torres, B., J.P. Castro Chacón, D. Sotomayor-Ramírez, L. Pérez-Alegría, G. Martínez, T. DeSutter.2019. Análisis geo-edafológico de suelos salinos y sódicos utilizando inducción electromagnética en la Reserva Agrícola del Valle de Lajas, Suroeste de Puerto Rico. Primer Congreso de Geografía Eugenio María de Hostos. 1 Nov 2019. Biblioteca Nacional, San Juan, Puerto Rico.

12. Álvarez-Torres, B., J.P. Castro Chacón, D. Sotomayor-Ramírez, L. Pérez-Alegría, G. Martínez, T. DeSutter.2019. Análisis geo-edafológico de suelos salinos y sódicos utilizando inducción electromagnética en la Reserva Agrícola del Valle de Lajas, Suroeste de Puerto Rico. Primer Congreso de Geografía Eugenio María de Hostos. 1 Nov 2019. Biblioteca Nacional, San Juan, Puerto Rico.

13. Castro Chacón, J.P., D. Sotomayor-Ramírez, L. Pérez-Alegría, G. Martínez, B. Álvarez-Torres, T. DeSutter. 2019. Initial steps towards assessing soil salinity at regional scale in Lajas Valley. 25 Apr. 2019. Annual Conference SIGMA XI. Mayaguez, Puerto Rico.

14. D. Sotomayor-Ramírez, J.P. Castro Chacón, L. Pérez-Alegría, G. Martínez, B. Álvarez-Torres, T. DeSutter. 2019. Inducción Electromagnética para la evaluación de la salinidad del suelo en el Valle de Lajas, suroeste de Puerto Rico. XXII Congreso Latinoamericano de la Ciencia del Suelo. Montevideo, Uruguay. 7 al 11 octubre 2019.

15. Sotomayor-Ramírez, D. L. Pérez-Alegría, G. Martínez, B. Alvarez, J.P. Castro-Chacón. 2018. An updated assessment of soil salinity of the Lajas Valley Agricultural Reserve, Puerto Rico. USDA-NRCS Soil Survey Planning Conference. 1-Nov-2019. Mayagüez, Puerto Rico.

16. Alvarez, B., D. Sotomayor-Ramírez. 2018. A preliminary approach towards mapping soil salinity in the Lajas Valley, Puerto Rico using electromagnetic induction. Puerto Rico Agricultural Biotechnology Association (PRABIA) 2018 Meeting. 23-Aug-2019. San Juan, Puerto Rico.

17. Alvarez, B., D. Sotomayor-Ramírez, M. Matos, L. Pérez-Alegría, S. Ríos, W. Tuttle. A preliminary approach towards mapping soil salinity in the Lajas Valley, Puerto Rico using electromagnetic induction. Soil Science Society of America International Soil Meeting 2019 (SSSA). 7-Jan-2019. San Diego, CA, USA.

18. Alvarez, B., D. Sotomayor-Ramírez, M. Matos, L. Pérez-Alegría, S. Ríos, W. Tuttle. A preliminary approach towards mapping soil salinity in the Lajas Valley, Puerto Rico using electromagnetic induction. Farm Foundation Round Table. 17-Jan-2019. San Mateo, CA, USA.

Other Products- Two graduate students participated in the project. Two MSc thesis were developed.

Alvarez, B. 2021. Magnitud y distribución espacial de la salinididad y sodicidad del suelo a escala de campo Enel Valle de Lajas, Puerto Rico. MSc Thesis. University of Puerto Rico, Mayagüez Campus. Department of Agro-environmental Sciences. 105 p.

Castro Chacón. 2021. Cartografía regional de suelos salinos y sódicos en el Valle de Lajas, suroeste de Puerto Rico. MSc Thesis. University of Puerto Rico, Mayagüez Campus. Department of Agro-environmental Sciences. 169 p.

Five undergraduate students worked directly under the direction of graduate students B. Alvarez and J.P. Castro. The students were trained in soil sampling, electromagnetic induction instrument operation, ECa spatial analysis, laboratory analysis, data management.

Development of a drone-based sensor approach for monitoring the occurrence and spatial distribution of algae blooms in reservoirs of Puerto Rico

Project Director

Gustavo Martinez

Organization

University of Puerto Rico Mayaguez Campus

Accession Number

1012925

⭐ **Final Report- Development of a drone-based sensor approach for monitoring the occurrence and spatial distribution of algae blooms in reservoirs of Puerto Rico**

<div style="border:1px solid green">Final Result</div>

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

The emergence of hazardous algae blooms has been termed the single most pressing freshwater quality threat of future generations. The detection of blooms through conventional field-monitoring excursions is particularly ineffective due to the fleeting, and spatially heterogeneous nature of algal blooms. Satellite-based sensor technologies are rapidly evolving as efficient forecasting and diagnostic tools to identify/monitor the temporal and spatial distribution of potentially hazardous blooms. Challenges with spatial resolution, low image frequency, and cloud cover impact severely limit the application of satellite imaging to small reservoirs. Alternatively, we proposed the development of a drone-based sensor technology to monitor the incidence of algae blooms in reservoirs of Puerto Rico.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Phytoplankton response studies: Numerous field bioassays were conducted to evaluate the relative effects of different suspected of phytoplankton productivity. Treatments considered were nutrients (nitrogen (both as (NO3- or NH4+)), phosphorus, calcium, magnesium iron, boron, zinc, manganese and organic carbon. Different concentrations of each element (source) were considered, individually as well as in combination with other factors. Studies were conducted at Cerrillos, an oligo-mesotrophic reservoir on the South region of Puerto Rico.

Nutrients (i.e., N, and P) were the most influential drivers of phytoplankton productivity. Phytoplankton responded similarly to both nitrogen and phosphorus, which acted synergistically when combined. There was no significant difference in phytoplankton response to nitrogen source (i.e., NO3- or NH4+). Biomass productivity followed a logarithmic response with saturation values reached at elevated nutrient concentrations. Chlorophyll a increases increased trophic levels from the usually oligo-mesotrophic condition of this reservoir to eutrophic levels. Results reaffirm recent findings (which contradict longstanding beliefs) that both nitrogen and phosphorus are important drivers of phytoplankton productivity in tropical reservoirs, with nitrogen being more influential in most cases. This requires protective measures for preventing enrichment on both nutrients.

Bathymetry study: A bathymetry study of La Plata reservoir was completed. After hurricane Maria (Sept., 2017) government agencies were in need of determining the storage capacity of the island reservoirs as part of the recuperation efforts. La Plata is one of two of the most important reservoirs in the island providing water for a significant portion of the population of the San Juan metropolitan area. Results revealed that the reservoir had a storage capacity of 30.88 Mm3 adjusted to its maximum elevation of 52 m ASL. This value (i.e., 30.88 Mm3) is similar to the storage capacity reported on 2015. Considering that approximately 260,000 m3 of sediments were removed right after the 2015 bathymetry study as part of a dredging effort, we must conclude that a similar amount was deposited as result of hurricane Maria. The fact that the reservoir floodgates were kept open during the hurricane seemed to have prevented greater sediment accumulation. A chlorophyll a map for Cerrillos reservoir based on Sentinel satellite images was produced. Continuous (1hr-interval) temperature and light depth profiles for Cerrillos reservoir (0.5m, 1m, 2m, 3m and 4m) were produced.

Briefly describe how your target audience benefited from your project's activities.

The target audience for this project was the Puerto Rico Department of Natural Resources and Environment personnel. Temperature data from our self-standing buoy (sensors at 0.5m, 1m, 2m, 3m and 4m) was used by the Department of Natural Resources personnel to evaluate the potential effect of changing temperatures on increasing mortalities of adult largemouth bass at Cerrillos.

Also, despite the series of catastrophic events that occurred in Puerto Rico since the project's onset we were able to characterize the limnological status of La Plata and Cerrillos reservoirs. La Plata is a mesotrophic-eutrophic reservoir with highly anoxic conditions at the hypolimnion, whereas Cerrillos is an Oligotrophicmesotrophic reservoir whose hypolimnion only experiences anoxia during a very short time span during the year. Secchi disk transparency is approximately 1m deeper (e.g., 2.5m vs 1.5m) at Cerrillos than at La Plata. Field trials were conducted to evaluate the spatio-temporal (tri-dimensional) variability in primary productivity (Chl-a) in both reservoirs. Both reservoirs exhibit a Chlorophyll a maximum at depths greater than 1m which constitutes a challenge for accurately describing primary productivity through aerial images.

In addition, numerous field bioassays were conducted to evaluate the effects of nutrients, and inorganic constituents on phytoplankton productivity. Treatments considered were nutrients (nitrogen (both as (NO3- or NH4+)), phosphorus, calcium, magnesium iron, boron, zinc, manganese and organic carbon. Among all factors and treatment combinations considered nutrients (both N and P) were the most influential

drivers of biomass production. There was no significant difference between nitrogen source (i.e., NO3- vs NH4+). The combination of N and P resulted in higher productivity than that of each element by itself. Most other elements were relatively innocuous to biomass production, except for boron which hindered productivity.

Briefly describe how the broader public benefited from your project's activities.

Real or near-real time detection of harmful algae blooms HABs is critical to establishing adequate notification guidelines for specific target audiences (nearby residents, recreational users, drinking water plant managers, etc.), and implementing effective management and protective efforts of the resources.

Another major accomplishment of the project was the completion of a bathymetry study at La Plata reservoir. Although not an initial objective of this project, the need for a bathymetry study was deemed critical after hurricane Maria as government agencies were trying to establish the hurricane's impact on water storage capacity. La Plata is one of two of the most important reservoirs of Puerto Rico as it provides water for a significant percent of the population of the metropolitan area. Results revealed that the reservoir had a storage capacity of 30.88 Mm3 adjusted to its maximum elevation of 52 m ASL. This value (i.e., 30.88 Mm3) is similar to the storage capacity reported on 2015. Considering that approximately 260,000 m3 of sediments were removed right after the 2015 bathymetry study as part of a dredging effort, we must conclude that a similar amount was deposited as result of hurricane Maria. The fact that the reservoir floodgates were kept open during the hurricane seemed to have prevented greater sediment accumulation.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Changes/Problems: Access to the reservoirs was restricted since the beginning of the project, initially as result of the catastrophic impact of Hurricane Maria in September 2017, followed by the effect of a series of earthquakes that struck the island at the beginning of 2020, and finally, by the still ongoing impact of the COVID pandemic since the beginning of March 2020. As result, our ability to adhere to the projected schedule and programmed research activities was severely hampered.

Critical Issue

Family well-being

Healthy and Sustainable Families
Project Director
Jaime Curbelo
Organization
University of Puerto Rico Mayaguez Campus
Accession Number
7002470

⭐ **Health, Prevention and Early Detection Breast and Cervical Cancer**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

In Puerto Rico, 1.2 million people are beneficiaries of government public health insurance. Puerto Rico census data indicate that 7.1% of women of all ages do not have health insurance. According to data from the American Cancer Society, the incidence of breast and cervical cancer in Puerto Rico is 98.5 and 12.6 per 100,000, respectively. These diseases are among the leading causes of death in women in Puerto Rico, being the southwestern region the region with the highest number of uninsured women.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

The Family and Consumer Sciences (FCS) program has a collaborative agreement with the Puerto Rico Breast and Cervical Cancer Prevention and Early Detection Program (PRBCCPEDP), which was funded by the Center for Disease Control and Prevention (CDC) and administered by the University of Puerto Rico, Comprehensive Cancer Center (CCC). As part of this collaboration agreement, Extension Educators of the FCS offered educational activities about women's health and early detection of breast and cervical cancer. The CCC supported the activities by providing educational modules with statistical information about the prevalence of cancers in Puerto Rico, the screening survey, and the analysis of interventions.

Non-formal education on breast, cervical, colorectal and other types of cancers was offered to 1,315 people in Puerto Rico. Educational activities included 1) identification and referring of women of 50 years of age or older who have not had a mammogram in the past two years to the Comprehensive Cancer Center and, 2) identification and referring of women of 21 years of age or older who have not had a Pap smear in the past three years; have no health plan; and that they are residents of the municipalities of the southwest region.

Briefly describe how your target audience benefited from your project's activities.

Of the 1,315 people who received non-formal education about breast cancer, cervical cancer, colorectal cancer, and other cancers, 488 women reported to recognize the importance of prevention and early detection of breast and cervical cancer and 15 women without a health plan were referred to the PRBCCPEDP.

Of the audience of the southwest region, 195 were residents of the municipalities: Ponce, Isabela, Sabana Grande, Moca, San Sebastián, Guayanilla, Cabo Rojo, Hormigueros, San Germán, Mayagüez, Rincón, Aguadilla and Peñuelas. From these women: 46 met the criterion of 50 years or older and have not performed a mammogram during the past 2 years; 67 met the criteria of 21 years or older and had not had a Pap test during the last 3 years; and 1 female participant reported not having a health plan. All 195 women received an early detection test.

Briefly describe how the broader public benefited from your project's activities.

Having the collaboration of the PRBCCPEDP contributes to expands Extension non-formal education to populations that lack access to information and educational services for prevention and early detection of cancers. PRAES and PRBCCPEDP have a close communication that has allowed us to expand education through social networks and other mass media. In 2022, 6 short educational videos related to cervical cancer and 4 for breast cancer with access to our audience and the public in general were developed.

Critical Issue

Food safety, science and technology

Controlled Fermentation Studies in the Manufacture of Specialty Coffees
Project Director
Javier Huertas
Organization
University of Puerto Rico Mayaguez Campus
Accession Number
1025450

⭐ **Annual Results-Controlled Fermentation Studies in the Manufacture of Specialty Coffees**

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

This project is focused on the improvement of the aroma and flavor characteristics of specialty coffees made with coffee varieties of Puerto Rico, by using controlled fermentation in combination with available commercial yeast strains as fermenting microorganisms. These techniques will allow better reproducibility of final product characteristics and reduce the possibility of contamination with mold and bacteria that can be detrimental for public health.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Using the protocols established last year, experiments were done to evaluate the capacity of mucilage removal by selected commercial yeast strains. The experiments were carried out under a 12 x 2 experimental design, with twelve yeast strains used in combination with two thermal treatments (that is,coffee fruits with and without previous pasteurization). The idea was to evaluate the performance of yeasts alone, and in the presence of other microorganisms of the natural flora of coffee. From the results obtained so far, it seems that the yeasts used, by themselves, are not able to remove the mucilage, evidencing the need of other microorganisms to perform this function. We understand that microorganisms present on the surface of the coffee fruits (mainly bacteria) break down the mucilage into simpler carbohydrates, which are then used by the yeasts during their metabolic processes. We have expanded the scope of the research to try to isolate and identify the main organisms which are directly responsible for the initial degradation of the mucilage, with the intention of preserving them for further study and use, as part of controlled fermentations. From the experiments carried out, it seems that there are significant differences between treatments of some commercial yeasts, when combined with microorganism of the natural flora, on the capacity of mucilage removal. We also continued the efforts related to the design and evaluation of a controlled fermentation system, as described in the research proposal. Among other things, the cost of materials, the simplicity of the assembly, the easiness of use, and fluidity of fruits and coffee beans were considered. The most promising design consists basically of a conical tank where the separation of suitable fruits is carried out, based on their flotation. The suitable fruits will be discharged, by means of a butterfly valve, towards the fruit pulping unit. The pulped beans will then be introduced by gravity into another larger tank, where fermentation will take place. The fermentation will be carried out in submerged liquid consisting of filtered water mixed with adequate amount of yeast paste inoculum. From the bottom of this tank, by means of a flow divider and a separating grid, liquid will be extracted and pumped to the top of the fermenting vessel, obtaining a recirculation that will gently mix the liquid in contact with the coffee beans. Temperature and pH sensors will be connected to the recirculation pipe, as well as an electric heater, allowing adequate temperature control, by means of a microprocessor controlling unit. An injection point will be included in the recirculation pipe to inoculate the tank with the corresponding yeast paste. The fermentation unit will also have a butterfly valve at the bottom, that will permit the discharge of fermented material into a cannister for the final washing of the coffee beans, to complete the mucilage removal process.

Briefly describe how your target audience benefited from your project's activities.

The project is still in its experimental stages and there are no relevant results to be reported. However, we expect that the project activities will generate methodologies and procedures that will help to improve the quality and marketability of specialty coffees cultivated in Puerto Rico, which ultimately will benefit local farmers by increasing their potential for greater profits.

Briefly describe how the broader public benefited from your project's activities.

The project is still in its experimental stages, and there are no results to be reported. However, we expect that project activities will help to improve the quality and marketability of specialty coffees cultivated in Puerto Rico, which ultimately benefit customers by providing better coffee products, as well as people of rural communities by increasing potential economic growth of those areas where coffee is cultivated.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Training and professional development opportunities - During the reported period, two graduate students and one undergraduate student received training related to the processing of specialty coffees and the experimental methods to be used in their research activities.

Dissemination of results-The project is still in its experimental stages, and there are no results to be reported. However, we are working on the preparation of a Web Page related to the project, that will provide information to farmers and other interested parties related to the harvesting and processing of specialty coffees.

Plans for next reporting period - During the next reporting period, we will continue with the evaluation of the effect in the aroma and flavor characteristics of fermented coffees of the Limani variety using the yeast strains with the better mucilage removal capacity (in fermentations without thermal treatment). In these experiments, the beans with mucilage will be immersed in a solution of 20 L distilled water and 50 mL yeast paste. This solution will be prepared by diluting 5 g commercial freeze-dried yeasts in 50 mL of distilled water. The fermentation will proceed for 48 hours. After this, the beans will be washed to completely remove the mucilage. Once this is done, the beans will be dried, until reaching a grain moisture content of 11.5 %. Parchment coffee will be stored in low relative humidity conditions (< 70 %) and adequate temperature (78 °F) until further evaluation by 3 certified trained tasters (Q-graders), using procedures specified by the Specialty Coffee Association of America (SCAA). Additional analysis of roasted coffee samples (with fermented and non-fermented treatments) will be done using SPME and MS-GC to determine the presence of important aroma compounds typically found in coffee. We will finish the construction and validation of the proposed fermenter, for further evaluation using the most adequate yeasts selected. We will also finish and activate, in coordination with the Agricultural Extension Service, the Web Page with general information related to the production of specialty coffees and the results related to the research project.

Major changes or problems - Due to unusual climatic conditions (mainly low temperatures) in the geographical area around the Agricultural Experiment Station of Adjuntas, very low yields of the Limaní coffee variety were obtained during the harvesting period. This forced us to use another local variety (Fronton) to perform the experiments for the evaluation of the mucilage removal capacity of the yeasts. Also, the growth of some of the coffee plants planted last year (as part of the project activities) seems to be somewhat affected by both, low temperatures, and the impact of hurricane Fiona. We are planning to sow new plants to replace the ones affected during the next reporting period.

Other Products- Oral Presentation:
Huertas, J. (2016). Controlled Fermentations in the Elaboration of Specialty Coffees. Coffee Commodity Annual Meeting, Agricultural Experiment Station, UPR-Mayagüez, Ba. Yahuecas, Adjuntas.

Manufacturing and marketability of valued added products using goat milk
Project Director
Leyda Ponce de Leon
Organization
University of Puerto Rico Mayaguez Campus
Accession Number
1021261

⭐ Annual Results-Manufacturing and marketability of valued added products using goat milk

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

In Puerto Rico, goat's milk is an industry that is emerging, in order to be successful in developing this industry it's important to provide training in how to convert this milk in added value products. Due to the differences in composition, goat milk does not behave similar to cow milk. Dairy products made out of goat do not have the same organoleptical characteristics as cow's milk, thus the importance of learning how to develop dairy products using goat's milk.

Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

Two graduate students of the Food Science and Technology program were recluted to work on the development of different products using goat milk such a cajeta (Dulce de Leche) and yogurt. The work involving the cajeta is almost done, we are currently doing sensory analysis and the proximal analysis of the finished products. An undergraduate was working on the developing of a frozen dessert using goat milk; proximal
and sensory analysis was done during the months of September to December. Working on this project, we had learned that products made with goat's milk tend to have softer texture. So indeed, formulations used for cow's milk may not work for products with goats milk. With the information gathered in this project, we are planning to offer short courses to all the dairy goat farmers that may be interested.

Briefly describe how your target audience benefited from your project's activities.

Any person that wishes to produce goat milk may benefit from the research were are doing. For instance, we obtained data about the composition of goat milk from 5 different farms in Puerto Rico. Milk composition may be different due to climate, nutrition, and breed. Thus the goat milk composition is not the same and this is valuable information that is needed to develop dairy products. Products made out of goat milk do not have the same organoleptical properties as cow's milk thus developing the proper methods to manufacture products is important.

Briefly describe how the broader public benefited from your project's activities.

The broader public may benefit because we are working on the development of different products that at the present time are not manufactured in Puerto Rico, this is a very positive activity because we are helping with the food security of the island.

Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

Training and professional development opportunities -Undergraduate and graduate students working on this project have learned how to manufacture cajeta, yogurt and frozen desserts. Also, how to perform proximal, texture and sensory analysis.

Dissemination of results- A webinar was held on March 29th, 2022. Two conferences were presented "Dairy Products manufactured with goat milk" and "The role of goat milk in human nutrition".

Plans for next reporting period - We are going to start working on the development of a cheese product. A conference is going to be held at the "Colegio de Agronomos of Puerto Rico" on February 18, 2023, the topic is going to be the "Manufacture of yogurt and "dulce de leche" with goat's milk". A short course is going to be held at the end of March about the manufacture of yogurt and dulce de leche at the Dairy Products Laboratory at the University of Puerto Rico at Mayaguez for dairy goat farmers.

Major changes or problems -No major changes in approach but we did have some delays on our work due to students strikes during November 2021 and strikes by non-faculty members on August 2022 that limited the access to the lab during a few days . Huracan Fiona caused that we lost some samples and products due to being without electricity for a week.

Elaboration of flours, extruded products & chips based on apio (Arracacia xanthorrhiza B.) & plantain as alternatives for using local agricultural products & their marketing
Project Director
Rosa Chavez-Jauregui
Organization
University of Puerto Rico Mayaguez Campus
Accession Number
1017621

⭐ **Elaboration of flours, extruded products & chips based on apio (Arracacia xanthorrhiza B.) & plantain as alternatives for using local agricultural products & their marketing** | Final Result |

In 2-3 sentences, briefly describe the issue or problem that your project addresses.

The aim of this proposal will be to produce flours and starch for culinary purposes and snacks (expanded extruded products and chips) from local cultivars of apio and plantain and carry out the sensory quality tests and perform surveys of consumer impressions and acceptance of expanded extruded products, chips and products prepared with flours.