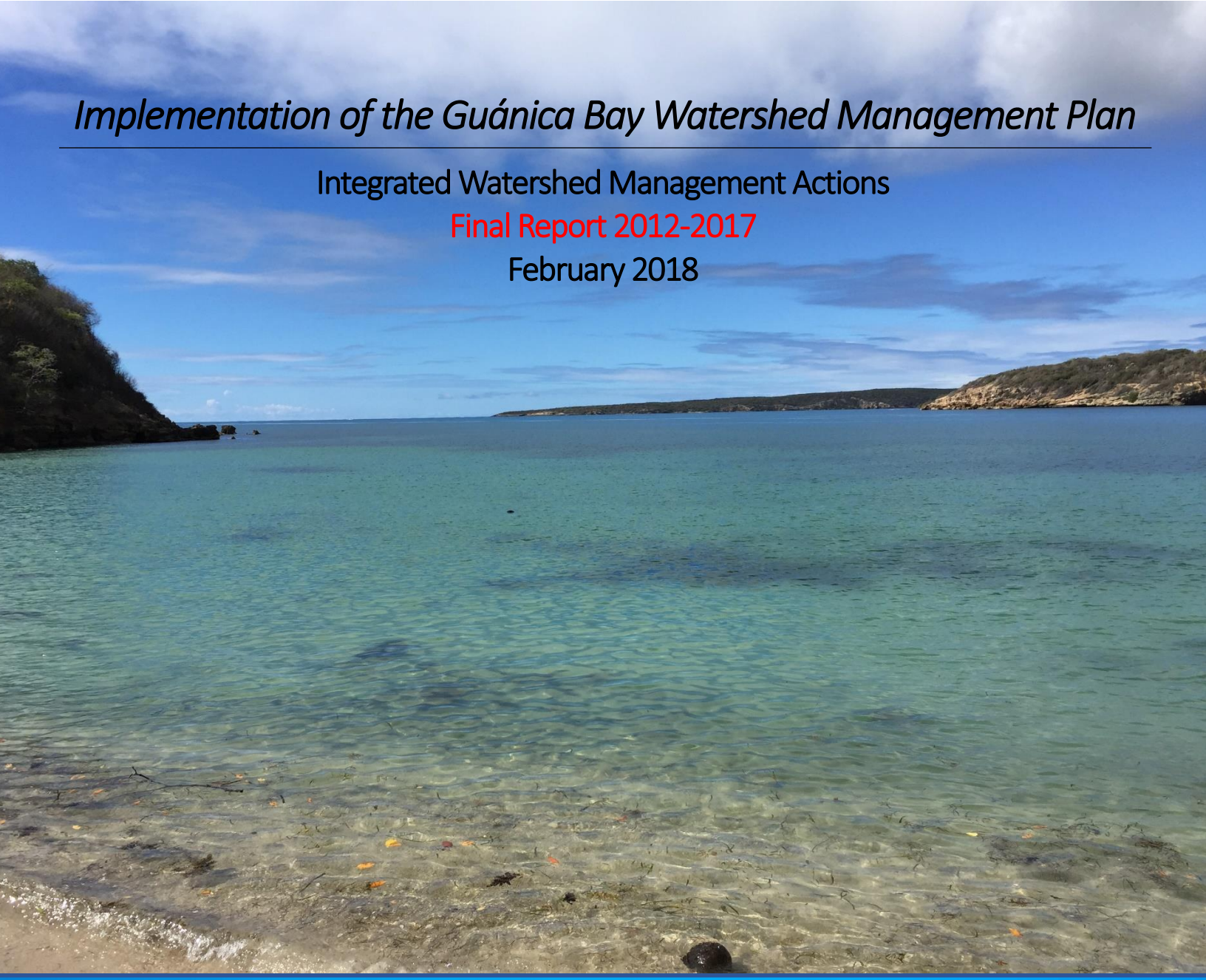
Implementation of the Guánica Bay Watershed Management Plan

Integrated Watershed Management Actions

Final Report 2012-2017

February 2018



Prepared by:

Roberto A. Viqueira Ríos

Executive Director

Protectores de Cuencas, Inc.

Box 1563 Yauco Puerto Rico 00698

February, 2018

Protectores de Cuencas


Café Bajo Sombra De Puerto Rico
CERTIFICADO

TABLE OF CONTENT

PARTNERS AND COLLABORATORS

Yauco Guánica Guayanilla Lajas

Maricao

INTRODUCTION

Historically, the Guánica Bay area was associated with some of the most extensive and healthy reef complexes in Puerto Rico (Figure 1). Unfortunately, coral reefs worldwide have experienced an unprecedented decline over the past 30-40 years, some estimates suggest that in the Caribbean we have lost more than 50% of live coral and over 90% of sensitive and federally listed *Acropora palmata* (elkhorn) and *Acropora cervicornus* (staghorn) species. Meanwhile studies by scientists in Puerto Rico have shown that nutrients and sediment contaminants have increased by 5-10 times pre-colonial levels and several times in the last 40-50 years (Ortiz-Zayas et. al., 2006). 'Coral reefs of Puerto Rico are among the most highly threatened Caribbean reef systems' (Ramos-Scharrón, 2010; Burke and Maidens, 2004). The U.S. Coral Reef Task Force determined that reducing the

Figure 1. Actual coral reef area in Guánica.

contribution from land-based sources of sediment was essential in maintaining the long-term stability of coral reefs (USCRTF, 2000). Even though most soils in Puerto Rico have a high to very high vulnerability to water erosion (Reich et al., 2001) and land erosion is recognized to pose a major threat to both freshwater and marine resources (Torres and Morelock, 2002; Soler-López, 2001), limited actions are generally taken to mitigate its effects (Lugo et al., 1981).

The Guánica Bay/Río Loco Watershed (GB/RLW) area was increased historically to bring freshwater to the dry south coast, almost doubling the drainage areas to approximately 151 square miles through a series of reservoirs, tunnels and hydroelectric plants. Subsequently, the GB/RLW watershed encompasses five manmade lakes and associated reservoirs (Figure 2). The watershed includes the urbanized areas of Yauco, a portion of the Lajas Valley agricultural region, and the upper watershed where coffee farming and subsistence agriculture is practiced on steep often highly erodible slopes. While Guánica Bay receives water directly only by the Rio Loco, the actual total drainage area encompasses much more than just the Loco watershed. This includes the five smaller basins and associated reservoirs: Lago Yahuecas, Lago Guayo, Lago Prieto, Lago Lucchetti, and Lago Loco. Guánica Bay is essentially drained by both the Rio Loco which receives flow from the four reservoirs north and upstream of it as well as by historic Guánica lagoon.

The conversion of upland forested lands to agriculture and man-made channels has altered the natural hydrology of the watershed causing upland soil erosion, in-stream channel erosion, loss of lagoons and the downstream transport of sediment (CWP, 2008). Several studies point to dirt roads and sun coffee within farmlands in the upper watershed as some

of the major elements that contribute to sediment transport to the Guánica Bay and the nearshore reefs.

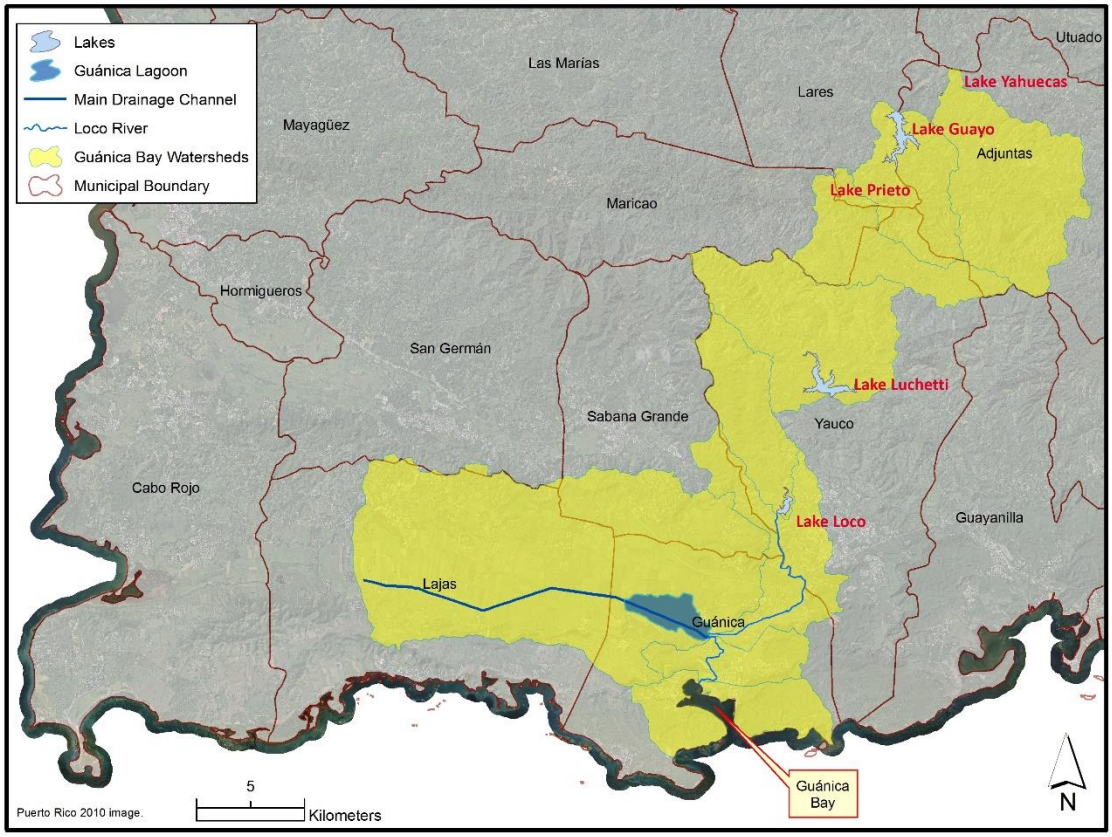


Figure 2. Guánica Bay Río Loco Watershed map.

GUANICA BAY WATERSHED MANAGEMENT PLAN

The ***Guanica Bay Watershed Management Plan: A Pilot Project for Watershed Planning in Puerto Rico*** (Figure 3) was prepared in 2008 by the Center for Watershed Protection in collaboration with federal and state agencies, local NGO's and land users. The Guánica Bay Watershed had been selected as a priority area for coral reef conservation by the Department of Natural and Enviromental Resources (DNER). The primary purpose of this document was to "outline a comprehensive set of actions and an overall management strategy for improving and protecting the Guánica Bay watershed from nonpoint sources of pollution derived from land use alterations, and residential, commercial and agricultural uses." Furthermore, it was intended with this watershed plan to recognize important recommendations, identify partners, and determine the next steps towards implementation. Because of this Plan, a series of projects have been implemented to reduce land-based sources of pollution (LBSP) as well as enhance coordination for community and partner's engagement.

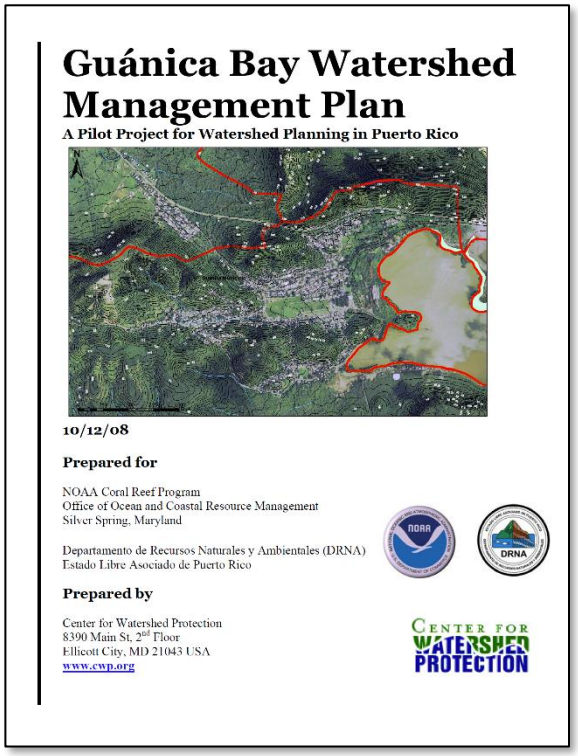

Guánica Bay Watershed Management Plan
A Pilot Project for Watershed Planning in Puerto Rico
10/12/08
Prepared for
NOAA Coral Reef Program
Office of Ocean and Coastal Resource Management
Silver Spring, Maryland
Departamento de Recursos Naturales y Ambientales (DRNA)
Estado Libre Asociado de Puerto Rico
Prepared by
Center for Watershed Protection
8390 Main St, 2nd Floor
Ellicott City, MD 21043 USA
www.cwp.org
CENTER FOR WATERSHED PROTECTION

Figure 3. Front cover of the Guánica Bay Río Loco Watershed Management Plan.

The 2008 Plan required revisions to address the EPA's nine elements of a watershed management plan to the greatest extent reasonable. One of the assigned tasks was to

update the watershed management plan to reflect implemented management actions to date and identify new management actions as a result of addressing EPA's nine criteria.

A series of group meetings were held, with the latest during fall 2015 and spring 2016. During this time frame, 15% of the document was completed. To date, 75% of the updated document has been drafted and a final draft will be completed by the end of March of 2018. Currently, we are updating a watershed characterization based on new develop land use information provided by the Puerto Rico Planning Board and updates from the restoration activities that has been developed. With this information, we expect to update estimated pollutant louds applying the Watershed Treatment Model. The Watershed characterization is a useful tool for describing watershed conditions in the planning process of creating an integrated watershed management plan. By using a watershed approach, information will then be used for the identification of potential threats and possible solutions and for planning for future land uses. The characterization process of a watershed covers the nature of the different components of the watershed, as well as the determination of issues, vulnerability, and opportunities for development restoration interventions.

A combination of Geographic Information Systems (GIS), the use of areal imagery and field assessment has been implemented as tools to describe the different components of the watersheds in the project site. For the land use information, we have use GIS data provided by the Puerto Rico Planning Board including the land use layer from the Land Use Plan (LUP) (2015) (Figure 4). The land use layer from the LUP was updated using actual satellite imagery and corroborated conducting field assessments. A final updated draft of the Plan is expected to be completed by September of 2017.

In 2012, the U.S. Coral Reef Task Force (USCRTF) developed a Watershed Partnership Initiative (Resolution 28.1) to focus the capabilities and capacities of the USCRTF agencies and the U.S. coral reef jurisdictions to reduce Land-based Sources of Pollution (LBSP) from entering into coastal coral reef areas. The intent of this initiative is to facilitate and enhance coordination, partnerships, and contributions of agency resources and expertise to implement geographically specific and integrated activities to reduce pollutant loads to coral reef ecosystems, while also promoting consistent and strengthened application and enforcement of laws and authorities intended to address LBSP. For the past years the Horsley Witten Group (HWG) has been contracted to provide services to the National

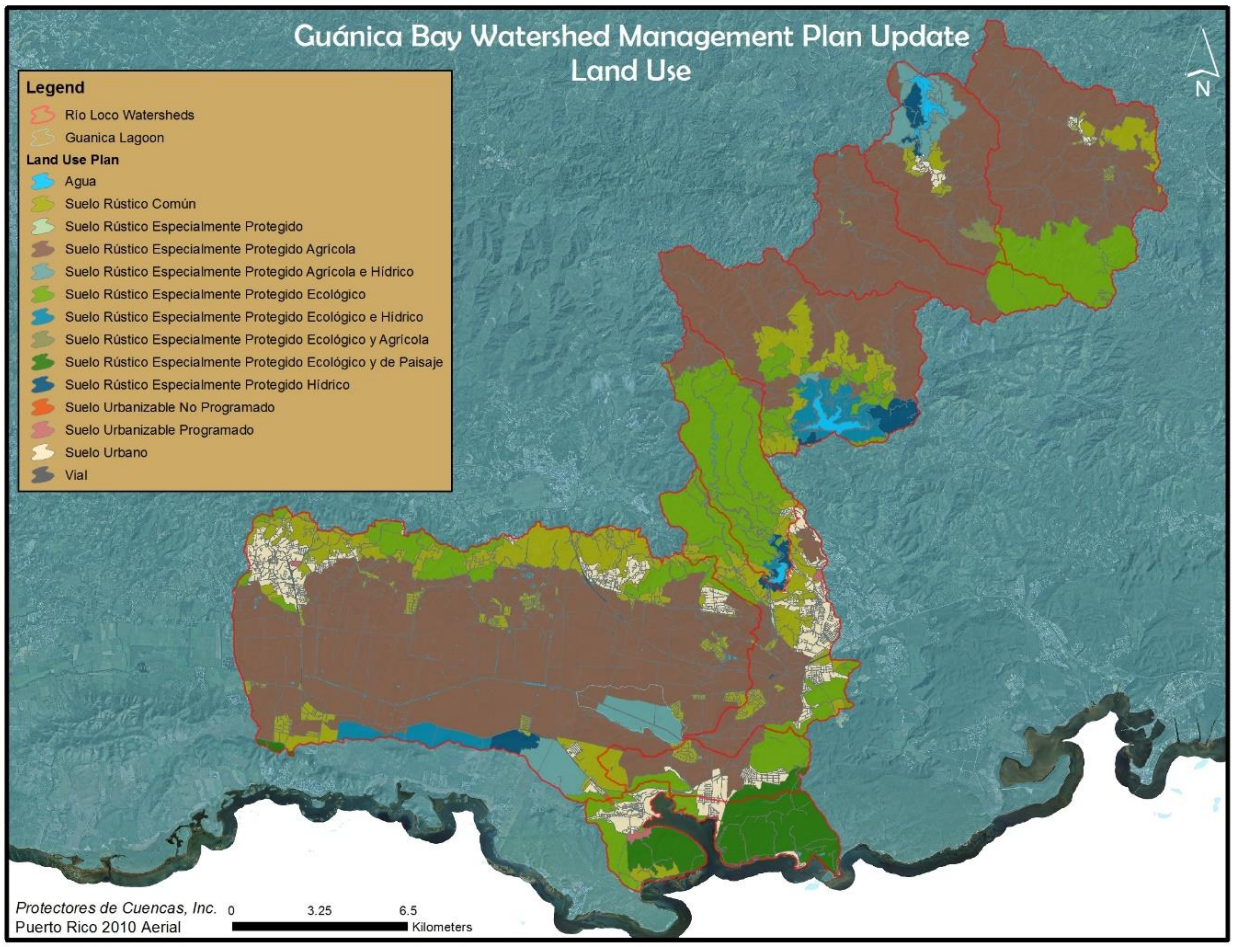


Figure 4. Map of the GB/RL Watershed with actual Land Use Information provided by the Puerto Rico Planning Board.

Oceanic and Atmospheric Administration (NOAA) National Ocean Service (NOS) Office for Coastal Management (OCM) to coordinate state local governments, NOAA and other federal agencies in the delivery of services to targeted watersheds for the protection of valued coral reefs. Services provided include watershed assessments through monitoring and GIS; stakeholder participation, project management, engineering, technical assistance, and capacity development through coordination support; project design and sediment reduction through restoration services; and monitoring to measure restoration impacts and results.

Roberto Viqueira, Executive Director of Protectores de Cuencas, Inc. (PDC), has provided training, consultation, coordination, and implementation in watershed management, planning, restoration, and related technical assistance with appropriate watershed protection practices for the Guanica Bay Watershed in Southern Puerto Rico. These efforts in the Guánica Bay Watershed required developing and sustaining local capacity in order to coherently advance project implementation and partner coordination from both, federal and state levels. Top priorities included: revising the Guánica Bay Watershed Management Plan in order to meet EPA's A-I criteria, continuing support for restoring Guánica Lagoon, conducting community outreach, building local capacity to address the impacts of LBSP, strengthening partnerships between government agencies, academics, agriculturalists, coral reef managers, and other stakeholders. This document summarizes all the coordination activities that have taken place for the past five years.

IMPLEMENTED INTEGRATED WATERSHED MANAGEMENT ACTIONS

The following recommended integrated watershed management actions have been identified in the Guánica Bay Watershed Management Plan as priority areas for implementation with the intent of cataloging potential watershed restoration opportunities through a scientific and participatory stakeholder approach for the area. This initiative was intended to provide direct abatement of Land Based Sources of Pollution (LBSP) threats, which will benefit coastal and coral reef habitats of the Guánica Bay Watershed.

GUANICA LAGOON RESTORATION

Background

Prior to drainage in the 1950's, the Lajas Valley was composed o f a complex of wetlands that included the Guánica Lagoon, El Anegado and Laguna Cartagena. Guánica Lagoon covered an area of approximately 1,200 acres in the east end of the Valley and the El Anegado covered an area of approximately 2,000 acres located in the middle of the Valley. The Guánica Lagoon and El Anegado were connected by a small channel called La Bajura or La Angostura located north of Cuesta Blanca Community (Figure 5).

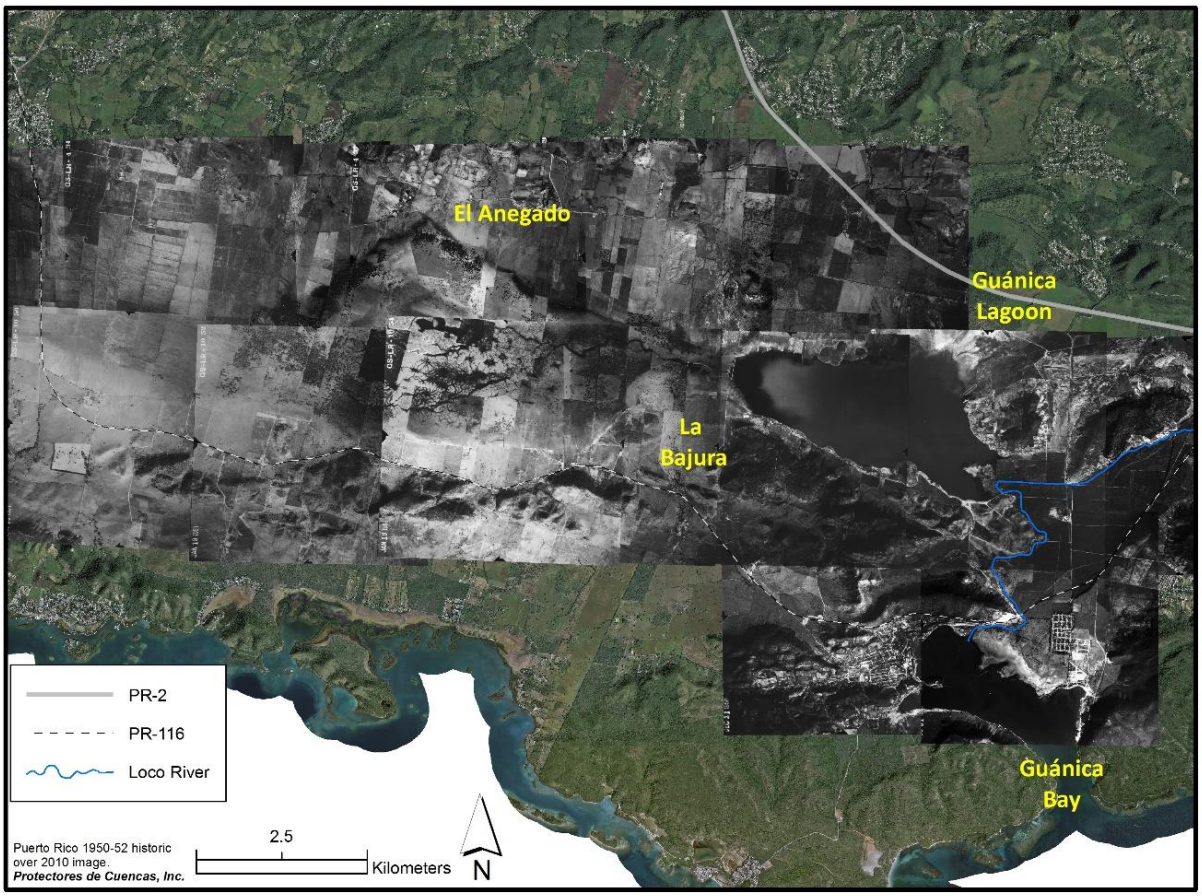


Figure 5. Map showing historic aerial images (1950) of the Guánica Lagoon and the Anegado georeferenced with 2010 aerials.

El Anegado drained into the Guánica Lagoon and then into the Guánica Bay. El Anegado was composed mostly of aquatic vegetation with a web of low depth small channels that converged to the La Angostura, while Guánica Lagoon was mostly composed of open water with some aquatic vegetation in the northeast and northwest portions. Both systems, El Anegado and Guánica Lagoon, depended upon surface water emanating from a series of small creeks mostly from the northern mountain ridge of the Lajas Valley. Water levels were controlled predominantly by evaporation and evapotranspiration processes due to the low permeability of the Lajas Valley soils. Guánica Lagoon was also used for irrigation of adjacent farm land that pumped water with a series of pipes causing the Lagoon to dry

periodically. Guánica Lagoon was also used as a food source for communities who eat fish, shrimps and waterfowl and for other recreation activities and hunting. It also provided habitat for a vast variety of native, endemic and migratory birds.

Guánica Lagoon and El Anegado were drained in 1955 through the construction of a main drainage channel and a series of lateral channels connected to the main drainage channel draining into the Guánica Bay through the Loco River. They were drained as part of the South West Puerto Rico Project that consisted of converting wetlands areas in the Valley to agricultural lands. It also consisted of construction of a series of five lakes in the upper central mountain watershed that carried water for irrigation from one lake to another, connected through underground tunnels, to the Valley through a main irrigation channel from the Loco lake throughout the north side of the Valley with a series of connections for most of the Valley's farms. The irrigation channel has been used more recently as a source for potable water for the municipalities of Yauco, Sabana Grande, San Germán, and Cabo Rojo. This project was also developed to generate electricity with two hydroelectric power plants located in the Yauco municipality (which are currently in use). As a consequence of this action, more than 3,000 acres of wetland in the south of Puerto Rico were lost.

Lands that were claimed from wetland to farm land in the El Anegado Area were most successfully used for agriculture; while lands inside the Guánica Lagoon historic footprint were scarcely used for intense agriculture as intended, mainly because of persistent wetland conditions, frequent inundation, and challenging soil conditions for agriculture. It is important to mention that farming conditions in the Lajas Valley are very dependent upon drainage and rainfall. Farming is almost impossible during the rainy season—predominately

in the months of May and through September and October. The Guánica Lagoon area is partially inundated for most of the year and completely inundated during the rainy season; while the El Anegado area floods during big rain events and stays inundated between one to four months.

The proposed restoration project consists of restoring the Guánica Lagoon as close to its historic levels as possible, with the limiting factor that the impacts stay within the historic footprint of the Lagoon or smaller, without affecting (or negatively impacting) farming in the El Anegado area. A key aspect of any restoration scenario is the construction of a water control structure that can raise water levels iteratively in order to be able to measure impacts at each interval before continuing with inundation. This will also allow the optimal level of lagoon elevation to be determined and managed to effectively support agricultural activity and the native ecology of the area.

The restoration of the Guánica lagoon has been a National issue for the past few decades and has been more actively discussed for the past four years gaining a lot of support from communities, environmental groups, the scientific and academic community, Federal and Puerto Rico agencies, as well as the Executive and Legislative branches of the Puerto Rico Government. It is important to also state that the community of farmers within the Lajas Valley Agricultural Reserve has been historically opposed to the restoration of the Guánica Lagoon project because they have genuine concerns that the Lagoon will negatively affect farm land in the area. The major elements that concern farmers the most are as follows: 1) that having the Lagoon restored will increase the drainage problems that already exist in the Valley where the drainage channels have not been properly maintained for the

past decades; 2) that water uprising will occur in areas that have actively been used for farming, bringing underground salts to the surface, damaging productive agricultural lands, and causing the eventual loss of land dedicated to agriculture.

To be able to answer these uncertainties about the potential impacts of restoring the lagoon, a series of studies were conducted. These include a Farm Inventory (Figure 6), a Hydrologic and Hydraulic Study (Figure 7), a Groundwater and Soil Salinity Study (Figure 8), and a Socioeconomic Study of the Feasibility of the Restoration of the Guanica Lagoon (Figure 9). Through these studies, it was established that more than 95% of the surrounding communities support the restoration of the Lagoon. A restoration design (60% of engineering design) was also prepared.

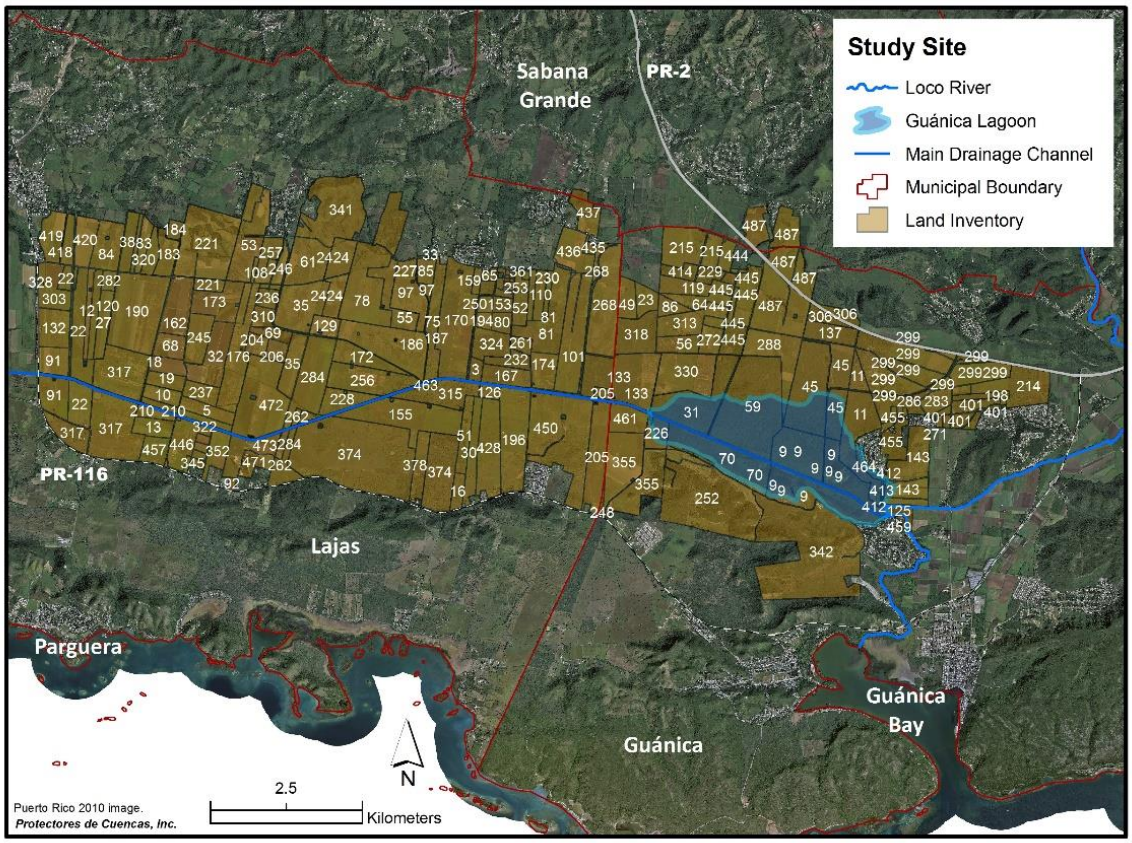


Figure 6. Map of the area of the Lajas Valley that was studied for the Farm Inventory (2011).

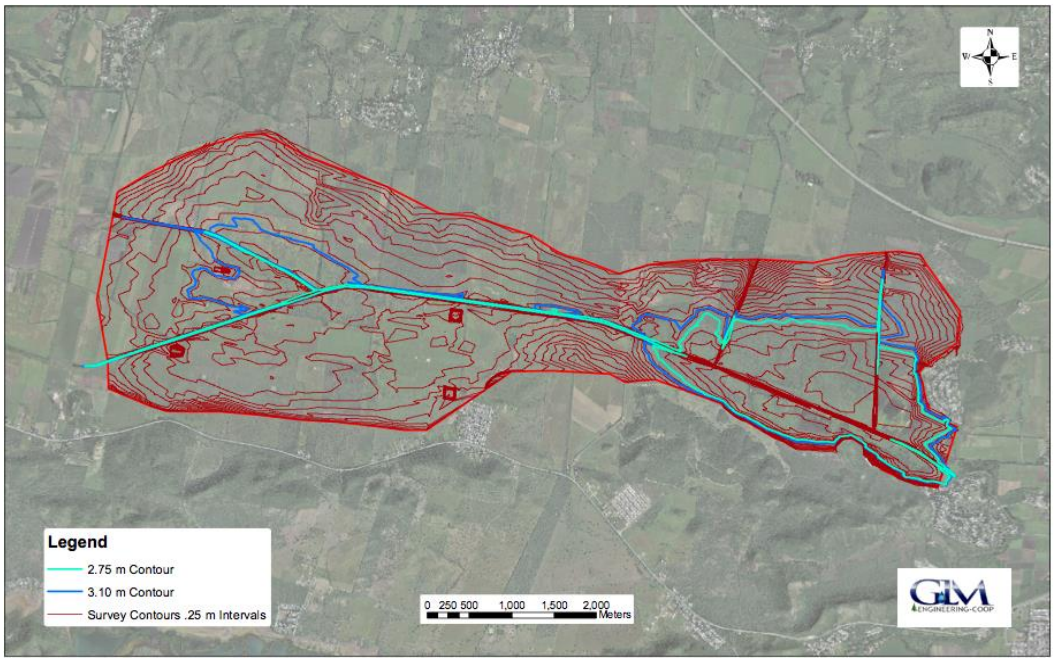


Figure 7. Map of the area covered by the Hydrologic and Hydraulic study (2012)

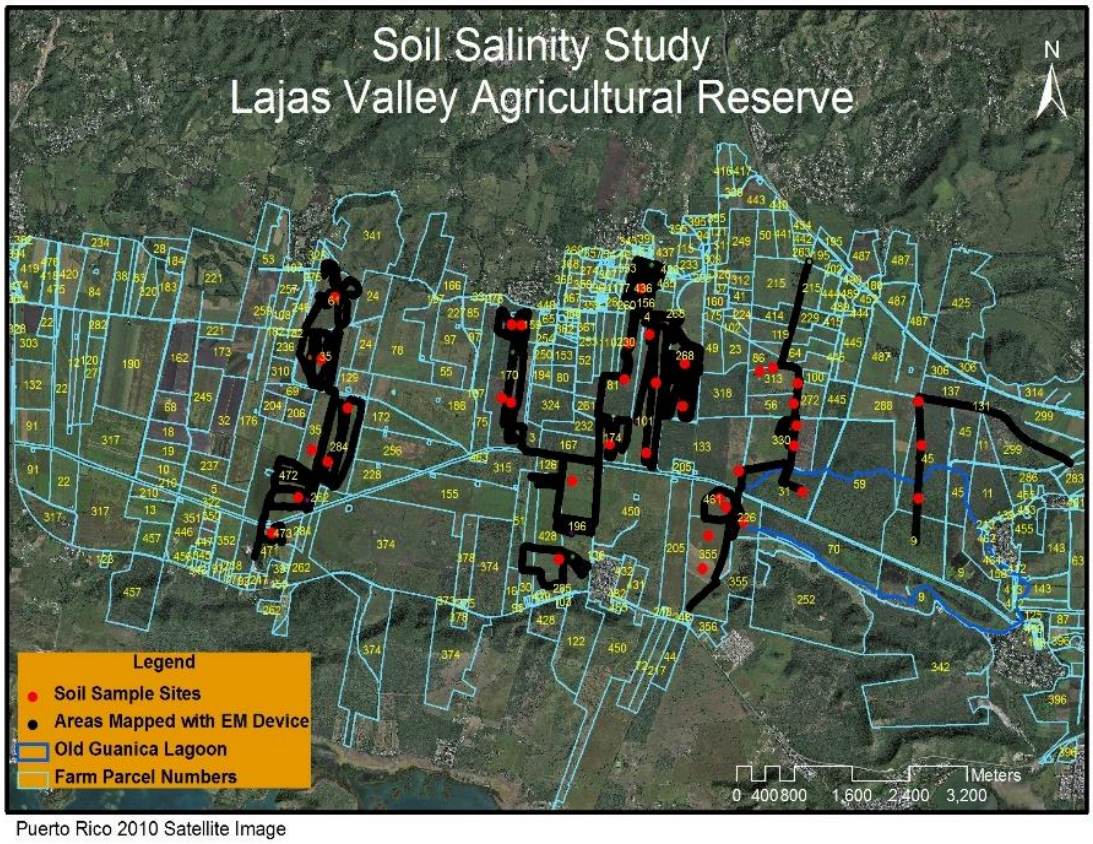


Figure 8. Map of the area surveyed by the Soil and Salinity Study (2012)

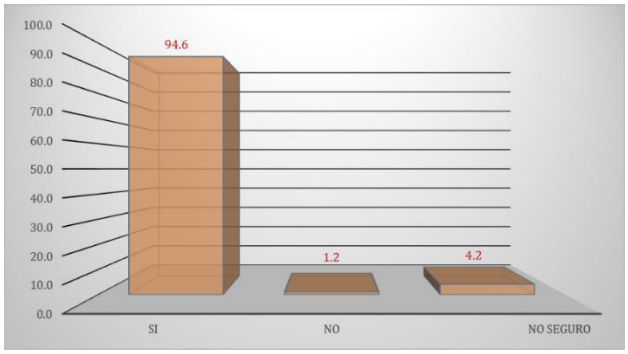


Figure 9. Left: Cover page of the Socioeconomic Study, right; Graph of the community reactions in favor of the Guánica Lagoon restoration (95%)

Recent Efforts

During the last few years, a series of meetings and coordination efforts took place to advance the coordination efforts for the Guanica Lagoon restoration. Some of the most important meetings included meetings the Mayors of Guánica and Yauco, Senators of the District, Head officials from the Department of Natural and Enviromental Resources (DNER), and the Department of Agriculture (DA). A series of outreach meetings with farmers where conducted as well as periodic meetings with the communities surrounding the Lagoon area that helped to reactivate the Committee for the Restoration of the Guánica Lagoon.

As a result of all these efforts, the restoration of the Guánica Lagoon became a very important priority for the Puerto Rico Government, particularly for the DNER, and major improvements were achieved, including the passing of two resolutions in the Puerto Rico Senate and the House of Representatives that where approved unanimously.

An important drawback in the restoration efforts raised because of the intentions of the past Head of the Department of Agriculture to regain farming activities inside the historic footprint of the Guanica Lagoon (Figure 10). During this process, the Puerto Rico Land Authority started clearing wetland areas for farming without any environmental compliance process and public engagement. Because of these actions, most of our efforts where dedicated to protecting the Lagoon area as opposition from the communities became stronger to the point that protests where been carried out periodically on the perimeters of the area. Efforts to protect the area included a series of overflights of the area to ensure that clearing activities here not conducted and to have aerial photographs documenting the clearings (Figure 4). A legal action was taken with the US Army Corps of Engineers (USACE) and the Enviromental Protection Agency (EPA) after several Consent Orders. Thus, the PRLA was fined and a precedent was established that these areas are wetlands and no farming activities can take place without proper environmental compliance process. For the past two years, the footprint of the Guanica Lagoon has remained intact as farming activates have increase in adjacent lands (Figures 11, 12). The other positive action that raised from this process is that recently the Natural Resources Conservation Service (NRCS) has approved funding to implement conservation practices in the subwatershed of the Lajas Valley.

Figure 10. Aerial photo of some of the wetland areas impacted by the Puerto Rico Land Authority.

Figure 11. Recent (August 2016) Google Earth image of the Lagoon area showing the historic (blue) and proposed restoration areas (red)

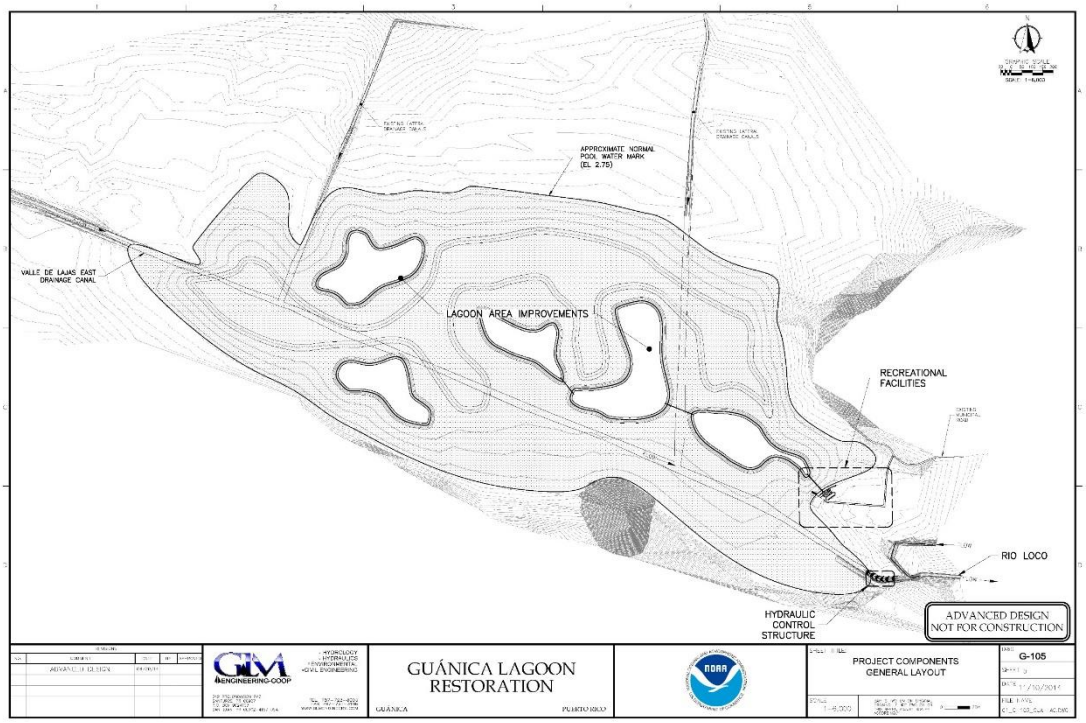


Figure 12. 60% design of the proposed Guánica Lagoon Restoration project.

Next Steps

A series of meetings are being coordinated that will take place in the following months with new Government officials to present the project and gain support from the new Government administration. Another set of meetings will be coordinated with the farming community to ensure their participation in the process and to reopen the possibility of an agreement of the difference in public policy towards the land in the Lagoon area.

An outreach and education campaign will be developed that will start with an event in the community that will invite different other environmental organizations to join the restoration efforts. Other education activates will include the use of bulletins and radio station interviews. Discussions with Dr. William Hernandez from UPR-Mayaguez, Department of Marine Science are taking place for the developing of satellite interpretation of wetland conditions of the past 10 years of the Lagoon area.

RIO LOCO RIVER RESTORATION

Background

Channel erosion on the mainstem of Río Loco was clearly another major issue in the watershed as documented in the stream channel assessments conducted in the process of creating the Guánica Bay Watershed Management Plan. Severe erosion was associated with areas that lacked mature riparian trees, particularly those areas that contained non-native species that seemed to exacerbate erosion as well as areas with historic irrigation infrastructure which created downstream scouring. These low head dams, concrete footers, and other structures continue to act as strainers and constrictions in the channel causing

debris to become lodged and changes in erosive forces to destabilize banks, increasing channel erosion, bed scour and sediment transport.

For the past four years, a series of coordination efforts lead by the Natural Resources Conservation Service (NRCS) have led to the implementation of three major restoration projects on the Río Loco river to restore river banks with bioengineering strategies that included the implementation of a collaborative effort to apply hydroseeding on the restored areas by Protectores de Cuencas, Inc (Figure 13).

Figure 13. Areas of the Río Loco riverbank restoration project hydroseeded by PDC.

During this process, most of the old abandoned irrigation infrastructure inside the river that was identified in the Watershed Management Plan as priority to be removed were taken out of the river. From the total identified structures, there are two sites remaining that we have secure funding from the DNER to remove (Figure 14).

Figure 14. Map of the remaining sites with structures to be removed.

Historic infrastructure on these sites has created downstream scouring and the low head dams, concrete footers, and other structures continue to act as strainers and constrictions in the channel causing debris to become lodged and changes in erosive forces to destabilize banks, increasing channel erosion, bed scour and sediment transport (Figure 15). This removal is critical to the success of the river restoration efforts in the Rio Loco since debris caught in the structures creates large areas of erosion on surrounding farms.

The structures are mostly associated with the past use of surface irrigation that has been replaced by drip irrigation in the Guánica Valley, as a result these structures are in a state of disrepair and inhibit natural flows in the channel and create conditions for excessive erosion.

Figure 15. Pictures of the structures that are going to be removed from the Río Loco, El Tren Site (left and El Puente Site (Right)

NRCS have also, with the collaboration of the Puerto Rico Department of Agriculture, implemented a series of sediment retention basins and conditioned irrigation infrastructure in other areas of the Río Loco flood plains (Figure 16). This project addresses Objective L1.3 of the Coral Reef Conservation Program- Coral Reef Strategic Goals and Objectives 2010-2015, "Implement watershed management plans and relevant Local Action Strategies (LAS) within priority coral reef ecosystems and associated watersheds to improve water quality and enhance coral reef ecosystem resilience". This project also has been described as one of the priority action recommended in the Guánica Bay Watershed Management Plan.

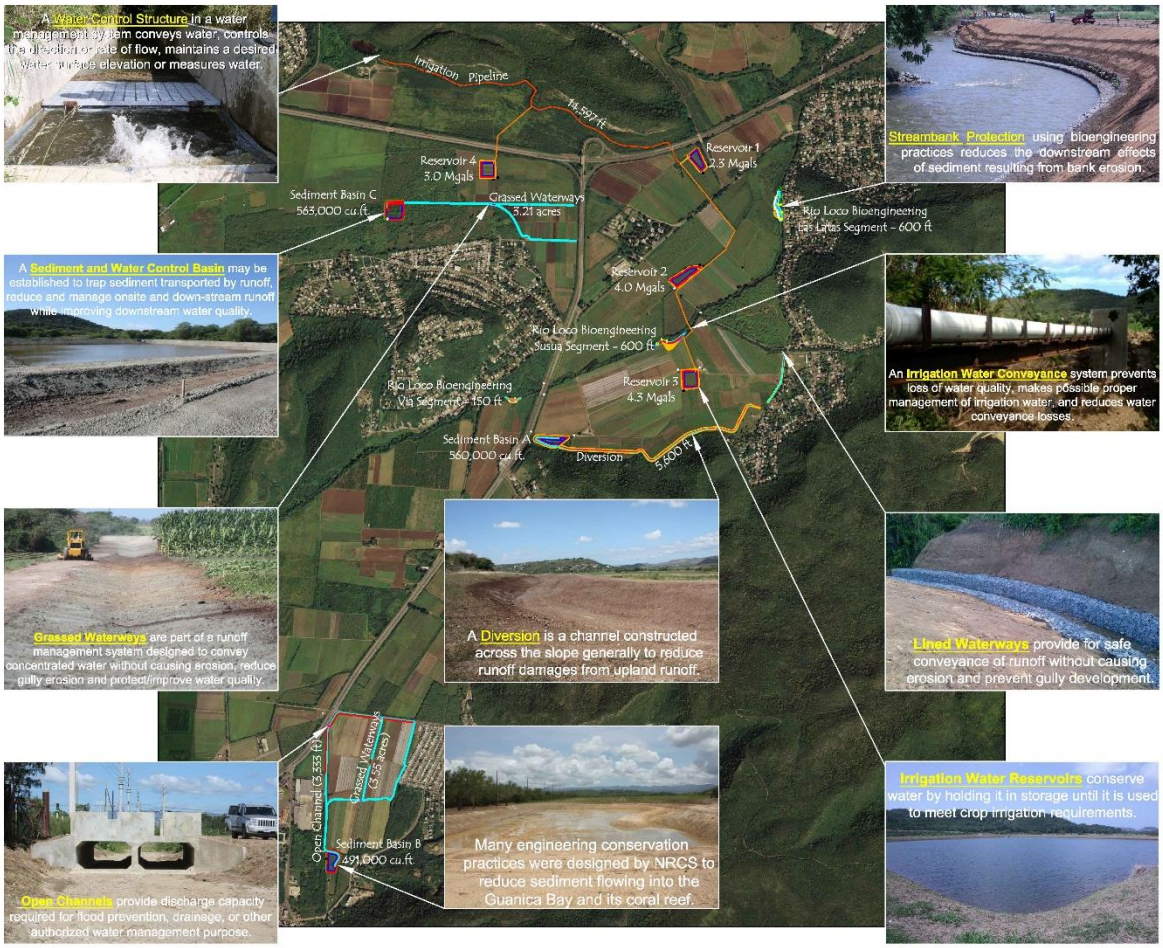


Figure 16. Map of the areas restored by NRCS and the Puerto Rico Department of Agriculture. Provided by NRCS Mayagüez office.

Recent Efforts

Currently, we are in the environmental compliance process to get the necessary permits to remove the abandoned structures with finds provided by the DNER. Protectores de Cuencas has coordinated and led several agency meetings with the purpose to discuss the details concerning the structure removal at the Rio Loco sites. These meetings also served to discuss the necessary permits needed to implement the proposed project. Meetings were held with agency officials from the Department of Natural and Environmental Resources (DNER), the US Fish and Wildlife Service and the US Corps of Engineers. Site visits

with our engineering staff have been conducted at EL Puente and El Tren project sites. A site survey was conducted, and topographic date was collected. A schematic geomorphologic analysis of the project sites will be completed with the date collected. The survey and schematic design generated will be used to make decisions concerning the removal process of the structures at the project sites. State permit process has been initiated with the Oficina de Gerencia de Permisos (OGPe). The permits requested included a description of the proposed tasks and need to complete the project with the purpose to improve the conditions of the sites and prevent the erosion and sedimentation that is taking place in the area. Protectores de Cuencas is currently waiting on a response from OGPe and plan to follow up with the agency within the next couple of weeks. Below is evidence of payment for the requested permits.

Federal permit process was initiated with the US Army Corps of Engineers (USACoE) and we have got a request for additional information from the Agency and are in the process of completing the information requested. Additional coordination has been conducted with the US Fish and Wildlife Service (USFWS), the DNER and the Institito de Cultura Puertorriqueña (ICP)

Next Steps

Table 1. Summarized Work Plan for structure removal in the Río Loco

Task	Task description	Deliverable	Tasks completed	Next Steps	Status	Date
1	Interagency Meeting for Permits needed and Action Plan	Permit Plan as discussed with DNER, ACOE, NOAA, USFWS, ICP and Municipality	• Permit Plan • 3 Meetings with USACoE • 1 meeting with DNER • 1 Call with USFWS • 2 Calls with ICP • 1 Meeting with Guánica Mayor		Completed	9/2017
2	Site Visits with Engineer	Survey and Schematic Geomorphologic Analysis	• Site visits • Survey area completed	• Complete Geomorphologic Analysis	Completed	9/2017
3	Initiate Permit Process	Permits Summited	• Initial Permits submitted to OCPe and USACoE		Completed	9/2017
4	Follow up Permit Process	Comments submitted to Agencies	• Comments submitted to USACoE	• Meeting and site visit with DNER and ICP • Submit additional information requested by agencies	Completed	7/2017
5	Finalized Permit Process	Final Permits approved Preliminary Report		• Submit all final permit authorization to DNER	To be completed	3/2018
6	Kick-off Meetings for Planning Structure Removal	Meeting with Farmers, Soil Conservation District, NRCS and Municipality		• Coordination with all necessary stakeholders and mobilization	To be completed	4/2018
7	Site 1 Structure Removal	Preliminary Report		• Complete removal and disposal of all structures of site 1	To be completed	5/2018
8	Site 2 Structure Removal	Final Report		• Complete removal and disposal of all structures of site 2	To be completed	6/2018

AGRICULTURAL OUTREACH/CONSERVATION

Since the coordination position was created back in 2010 we have been conducting a series of outreach activities with farmers for across the watershed, including coffee farming in the upper watershed as well as crop production in the coastal valleys of Guánica and the Lajas Valley. Efforts in the coffee region have been mostly concentrated in converting sun grown coffee to shade coffee production, a more sustainable and environmentally friendly farming. These efforts have been lead primary by the US Fish and Wildlife Service (USFWS) in collaboration with the NRCS and local agencies. Our coordination efforts have been concentrated in farmer outreach to gain additional farmers to enroll in these efforts and to serve as a point of contact to guide farmers through the process of enrolling in conservation practices with the federal agencies. So far (2010-2016), approximately 99 farms have been impacted and approximately 40,019 native trees have been planted for shade coffee production for a total of 996.8 acres restored by USFWS and NRCS with the support of local farmers, state agencies and local NGO's.

Additionally, the NRCS have obligated 160 conservation contracts with 53 active contracts and 88 completed contracts for a total obligated funding of $3.46 million (2010-2016) of which $1,241,064.00 are on active contracts. Funds have been distributed for implementation of additional conservation practices on farmland across the watershed within the municipalities of Guánica, Yauco, Lajas and Maricao (Table 2).

Table 2. Summarized Conservation Practices Implemented by NRCS

Practice Code	Practice Name	Amount	Units
(310)	Bedding	126	acre
(314)	Brush Management	1,199.8	acre
(328)	Conservation Crop Rotation	91.9	acre
(329)	Residue and Tillage Management No-Till	94.3	acre
(331)	Contour orchard and other perennial crops	60.5	acre
(340)	Cover Crop	8	acre
(342)	Critical Area Planting	18.6	acre
(345)	Residue and Tillage Management Reduced Till	614.10	acre
(379)	Multi- Story Cropping	958.2	acre
(382)	Fence	60,016	linear feet
(383)	Fuel Break	3	acre
(391)	Riparian Forest Buffer	50.32	acre
(430)	Irrigation Pipeline	13,830	feet
(436)	Irrigation Reservoir	4	number
(441)	Irrigation System, Microirrigation	94.20	acre
(460)	Land Clearing	150.10	acre
(490)	Tree/Shrub Site Preparation	797.6	acre
(512)	Forage and Biomass Planting	138.90	acre
(516)	Livestock Pipeline	23,980.5	feet
(528)	Prescribed Grazing	382.90	acre
(533)	Pumping Plant	10	number
(548)	Grazing Land Mechanical Treatment	101	acre
(557)	Row Arrangement	403.4	acre
(561)	Heavy Use Area Protection	1,927	square feet
(580)	Streambank and Shoreline Protection	1,449	feet
(582)	Open Channel	3,720	feet
(601)	Vegetative Barrier	2,300	feet
(638)	Water and Sediment Control Basin	3	number
(660)	Tree/Shrub Pruning	79.7	acre
(737)	Reduced Water and Energy Coffee Conveyance System	3	number
(751)	Individual Terrace	654.1	acre

Additional efforts lead by PDC to implement conservation practices on farmland include; Hydroseeding, shade coffee round table initiative and more recently, stabilization of dirt roads on coffee farms. These initiatives are described in detail in the following sections of this report.

Hydroseeding

Watersheds in Puerto Rico are in deep need of implementation of erosion and sediment control practices to stabilize erodible lands. These techniques can help minimize the amount of sediments and other pollutants entering the freshwater systems and eventually reaching the coastal ecosystems. Protectores de Cuencas, Inc. (PDC) in collaboration with State and Federal agencies, has defined a set of methods to stabilize bare soils on high mountain and dry coastal sites in Puerto Rico. These methods are applicable to other sites across the Caribbean and likely into the tropical areas of the Pacific.

In our efforts to support and implement the Guanica Bay Watershed Management Plan Initiative, we are collaborating with other partner agencies, NGO's and the local community to continue with multiple restoration efforts across the Guánica Bay Watershed. Hydroseeding has proven to be an effective technique for erosion control and sediment stabilization of erodible lands. PDC has recently worked to stabilize approximately 25 acres of bare soils mostly on farmlands within the Guánica Bay Watershed with the ongoing funding support of the NOAA's Restoration Center, the National Fish and Wildlife Foundation (NFWF) and with the local support of local Municipalities and the DNER (Figure 17).

Hydroseeding refers to a process of planting grass using a mulch mixture that is fast, efficient and an economic alternative to restore areas of high slopes with difficult access when compared to other techniques such as turf grass. This process has proven to be more effective than traditional sowing and with lower costs than conventional transplantation. A mulch mixture composed of fibers, seeds, fertilizer and water is added to the tank of the hydroseeding machine. Once the appropriate mulch mixture is achieved, the mixture is

pumped from the tank and applied on the soil. Once the materials come in contact with the soil, they easily adhere and create favorable conditions for seed germination.

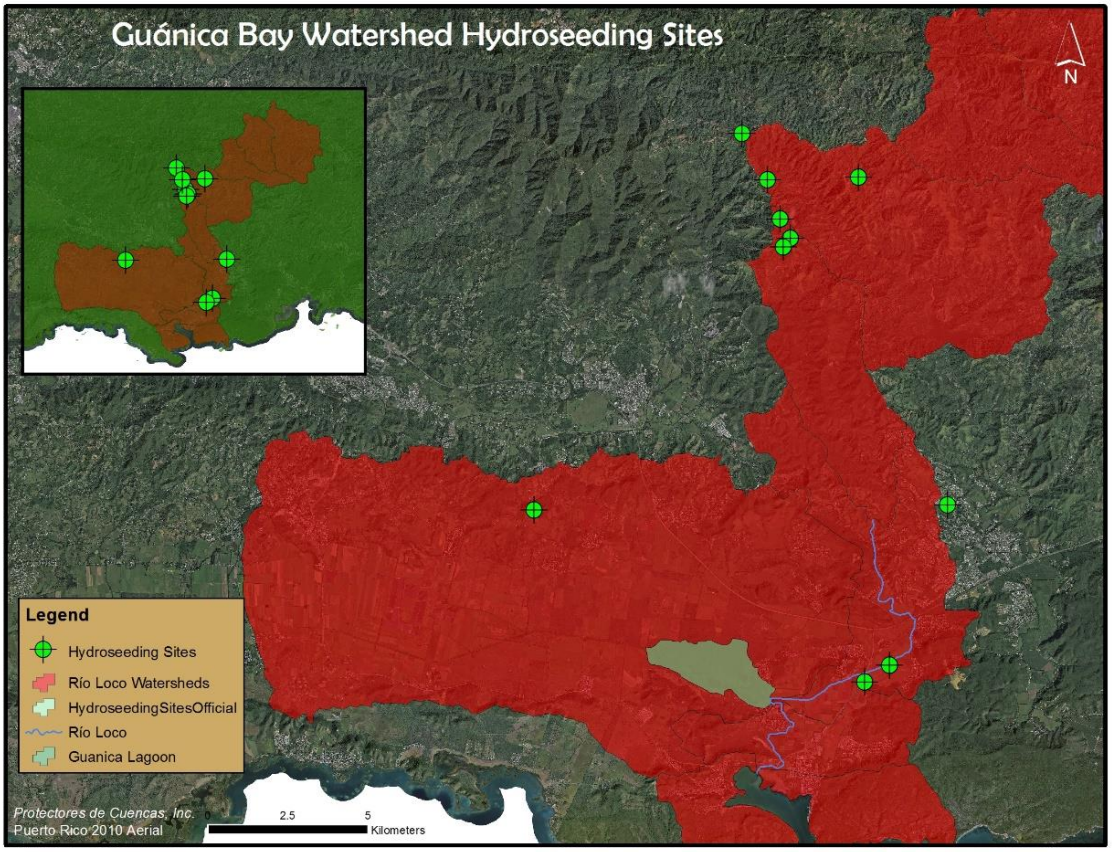


Figure 17. Map of all the areas in the GB/RL Watershed that have been hydroseeded by PDC.

The hydroseeding method is mostly used to restore areas devoid of vegetation affected by erosion processes and sedimentation in order to protect bodies of water and marine ecosystems from the adverse effects of sediment laden runoff. Other common uses of hydroseeding include: at construction sites, cover crops for farm lands, revegetate green areas after road construction, residential and commercial landscaping, as well as extensive areas such as golf courses and stadiums.

A large amount of mulch options are available, from the most inexpensive (composed of 100% recycled paper or a mixture of 50% recycled paper and 50% wood fiber),

intermediate costs (composed of 100% wood fiber), and the most costly, the Bounded Fiber Matrix or BFM (composed of 100% wood fiber with added polymers and other additives that maximize its attachment to the soil). Typically, the mixture chosen depends on the degree of the slope, the available budget and the quality of the desired product. Studies by the University of North Carolina in the United States have shown that the mulch mixture composed of paper fibers results in low quality and poor germination rates. It is for this reason that we have decided not to use paper fiber mixtures for our hydroseeding projects. We've had excellent results using mixtures of 100% wood fiber with the addition of some products found in the BFM, allowing us to reach optimum results with an intermediate budget.

There are different types of machinery or hydromulchers on the market. The main difference between these different options is the size of the machine and its tank capacity. In order to work with wood based mixtures, a specialized machine with greater power is needed. Protectores de Cuencas, Inc. has one of these specialized machines for wood based mixtures, with a water storage capacity of 325 gallons, making it the perfect combination of power and size adequate to reach areas that would be impossible to reach with larger equipment. With this equipment, we can cover an area between 1,200 and 1,500 ft^2 per tank applying close to 10 tanks daily in order to cover one acre of land per day, depending on the slope angle and accessibility to the area. Regular irrigation of restored areas during the first four to six weeks after hydroseeding is necessary to obtain optimum results. We include this service in our projects to guarantee best results. Application should occur during dry periods, where heavy rain is not anticipated during 48 to 72 hours following application to allow

product fixation to the soil. The following pictures are from some example sites that shows the Hydroseeding process (Figure 18).

Figure 18. Hydroseeding process on one of the multiple Hydroseeding sites of the GB/RL Watershed.

Shade Coffee Roundtable Initiative

The Green Revolution was a period beginning in the early 1940s that encouraged efficient production, monocultures, commercial fertilizers and pesticides, an increase in planting density, and the use of heavy machinery. The practice has continued and was widespread in Puerto Rico from the 40s through the present (Figure 19). This form of agricultural production was applied to coffee farming in most of coffee producing countries and the island of Puerto Rico was not an exception. In Puerto Rico, the indiscriminate clearing of farms was done often without proper protection of water bodies. The consequences of this approach led to: soil erosion and acidification, loss of soil fertility, loss of habitat and biodiversity, sedimentation of water reservoirs and has caused the loss of scenic beauty. In order to deal with the many environmental problems associated to these practices and to further support sound economic alternatives of production, a multidisciplinary group established the Shade Coffee Roundtable Initiative in Puerto Rico in 2011. Furthermore, the development of sustainable coffee farming practices was also identified as a priority following the Río Loco/Guánica Bay Watershed Restoration Project

Figure 19. Actual image of a shade coffee farm (left) and a sun grown coffee farm (right).

and watershed plan led by the US Coral Reef Task Force (USCRTF). The rationale was to promote shade coffee farming as a practice that integrates various methods to achieve adequate and sustainable coffee production levels, to sustain the socio-economic wellbeing of coffee farmers and simultaneously help create habitat for biodiversity and wildlife conservation.

The initiative was instigated by Protectores de Cuencas in March of 2011. The first meeting's objective was to introduce the initiative and get feedback from various interested partners and local stakeholders. The past and current participating partners include: the US Fish and Wildlife Service (USFWS), the Natural Resources Conservation Service (NRCS), the Puerto Rico Department of Agriculture, Puerto Rico Department of Natural and Environmental Resources (DNER), US Forest Service (USFS), the National Oceanic and Atmospheric Administration (NOAA), the University of Puerto Rico, Utuado Campus (UPR-Utuado), Experiment Station Agricultural Extension Service of University of Puerto Rico, Mayagüez Campus (UPR-Mayagüez), the Municipality of Yauco, the non-profit organizations of Cafiesencia, Inc., Ridge to Reefs, Inc., Envirosurvey, Inc., Centro para la Conservación del Paisaje, Casa Pueblo, Protectores de Cuencas, Inc., and independent farmers.

The Shade Coffee Roundtable was created with the purpose to develop criteria for shade coffee certification for Puerto Rico; identify incentives for motivating coffee producers to continue to use historical agricultural practices that are sustainable and environmentally friendly; help create economic niches for the coffee produced in the shade that can be marketed separately and that results in greater profits for producers. Some of the most significant benefits of shade coffee are: carbon sequestration, reduction of local

temperatures and climate change resilience; increased organic matter in the soil; recycling of nutrients into deeper parts of the soil into the uppermost part of the soil; reduction of soil erosion; and forage habitat for wildlife. In addition, shade polyculture provides other sources of food and raw materials, the coffee fruit grows healthier and it regulates photosynthesis and plant respiration. Furthermore, some studies suggest better quality of coffee taste, improved grain density, increased longevity of the plant, improved infiltration (90% vs 40%); slower ripeness process; reduced overproduction; and reduced reliance on chemical fertilizer as some shade tree species can fix nitrogen.

The Roundtable partner group identified the need to create a process to certify farmers, intermediaries, roasters and to improve marketing strategies. In addition, the group recognized the need to create an inventory of farmers that are currently growing shade coffee to integrate and organize these individuals into the initiative. Since 2011 the group of interested partners has organized a set of meetings to this date with the purpose of developing the criteria to be used for the certification process. In order to achieve this endeavor, the various partners mentioned above started the process to create the set of criteria for farm certification. After various meetings, the group developed the document entitled, 'Criteria for Shade Coffee Farming'. The criteria were completed and has been approved by the group. The next step will be to define the certification process, establish the necessary committees for farm evaluation, create a Certification Board, and identify marketing opportunities and alternatives to spearhead the certification efforts. It is essential to ensure that conservation efforts included in this initiative result in improved economics for individual farmers who adopt these beneficial practices. We believe that a sustainable

coffee economy will contribute to the protection of coral reefs, biodiversity and drinking water resources, as well as it will help preserve the history and culture of coffee farming areas in Puerto Rico.

This initiative focuses in four critical areas that are necessary to complete a holistic approach to improving both the economic and ecological aspects of coffee farming and to help preserve coffee culture in Puerto Rico. The reality of our Island is that many factors threaten the coffee industry in Puerto Rico. These threats include climate change, increased frequency and duration of droughts and more variable weather patterns. Other external factors include lower cost of coffee production in other countries without strong labor and environmental standards, substitution and mixing of Puerto Rican coffee with lower cost or lower standard imported beans and increased fertilizer and labor costs. Shade coffee and an attention to higher quality coffee, represents a way to provide communities in Puerto Rico with food and economic security while restoring natural functions of the forest and the health of streams, rivers and nearshore coastal habitats.

The four aspects of advancing the shade coffee industry in Puerto Rico include:

1) ***Better trained coffee picking professionals that maintain and harvest coffee to maximize its value.***
2) ***Shade coffee criteria that are supported by government cost-share management practices and funding.***
3) ***Training for coffee growers and those in government institutions that support the "coffee economy".***
4) ***Development of coffee markets supported by advertising both domestically in PR and the US as well as in the greater Caribbean and international markets.***

Together these four aspects make up the critical building blocks to effectively stabilize and grow the sustainable coffee market in Puerto Rico while advancing critical wildlife habitat rehabilitation.

Development

Throughout the development of this initiative we have identified other activities that need to be addressed in order to ensure success and consensus.

- Education and outreach
- Obtain government support
- Public policy
- Market studies
- Funding sources
- Formalizing certification
- Relevant NGOs alliance

To address these needs, we have arranged a set of meetings with relevant partners and NGOs to establish strategies for advancing the Roundtable's goals and objectives. This set of meetings has led to a formal acknowledgement of the initiative in the recently created Model Forest of Puerto Rico.

The Criteria

a. Farm History

i. The operator of the farm needs to know the history of the farm in terms of past uses. For this it is necessary to obtain the history of all parcels within the whole farm.
ii. Another factor to consider is the state of conservation of the parcels in terms of past crops and conservation practices applied and its actual conditions.
iii. The farmer will need to complete a form of the history of the farm.

b. Management Plan (MP)

i. All farms, new and in existence will need to have a MP for the farm.
ii. The MP must be made before carrying out the clearing of the property.
iii. The MP must be prepared by the owner or operator of the property, representatives of relevant agencies (to be determined by the group) and representation of the Certification Board.
iv. The MP should include:
    1. History Form of the Farm
    2. Inventory of the estate or "lay out" of the farm.
    3. Plan for the clearing of the farm (for new farm)
    4. The plan of planting shade trees
    5. Plan for planting coffee trees. The planting of coffee trees must be done following the contour lines of the slope.
    6. New and existing roads. The development of roads within the farm should be constructed in a way that least impacts in terms of preventing erosion and sedimentation and should protect existing roads.
    7. Incorporation of appropriate practices for sediment and erosion control.
    8. Identify water bodies on the farm, both permanent and intermittent and include in the inventory of the farm.
    9. Include the buffer zone to be maintained for water bodies identified on farms, both permanent and intermittent.
    10. Proper management of existing plants and trees during clearing when planting or replacing new coffee trees.
    11. The Plan will include a soil study of the land to be cultivated.

c. Deforestation/Shade Coffee Establishment Criteria

i. This criterion should be applied with special emphasis on new farms and all farms (abandoned etc.) that are in secondary forest as partial deforestation is unavoidable.
ii. Prior to the selection of the site there should be a study of soil in order to determine whether it is appropriate to grow coffee according to their fertility, cation exchange capacity, moisture retention, texture, drainage, external, slope, etc.
iii. Clearing should be done by hand without the use of heavy machinery and selectively to avoid high risks of erosion and water pollution of the environment in the area.
iv. The time for this practice has to coincide with the dry season, so that it can facilitate tasks and reduce the risk of accidents to workers as well as to prevent erosion.
v. The clearing or cleaning of the property must begin by removing weeds, bushes and then finally the trees by size.

vi. Do not use burning as a tool for deforestation. Do not burn leaves, branches or other plant material. These should be left on the ground to decompose and become part of the soil, protect and preserve. If possible, timber can be made for sale.
vii. The result of the dismantling plant material must be handled properly (crushed, compost, etc.). Must be maintained on-farm plant material by placing the coarse material and piling barriers against the slope of the land (the contour).
viii. It is very important to leave a buffer zone (see criteria below buffer zone) between the planting of coffee and water bodies to protect them from leaching of contaminants. This can be done by establishing or leaving a strip of vegetation with no clearing or grading.
ix. It is important to harness the waters of the premises to prevent excessive erosion caused by water currents created by rains. This can be done by building contour ditches according to standards established by the Natural Resources Conservation Service (NRCS).
x. The planting of coffee bushes should be carried out as recommended by the University of Puerto Rico. Agricultural Extension Service Experiment Station.
xi. During the process of renewal pruning or planting of coffee should start by pruning the branches or rods and then the stems or trunks.

d. Restoration Criteria

i. This criteria refers to areas on farms that are identified as critical for restoration because if they are not restored they may cause severe damage to the environment.
ii. Places to restore may include highly pronounced slopes that are devoid of vegetation, buffer zones, water bodies that are not forested, roads with serious problems of erosion and sedimentation, etc.
iii. The restoration must be addressed with appropriate conservation practices for each particular problem.

e. Wildlife Criteria

i. This criteria encourages the farmer promote biodiversity on farms and protect the wildlife that inhabits them.
ii. The operator of the farm and the workers should be aware of protected species and endangered species that live on farms in order not infer with them or impact them negatively.

f. Criteria for Buffer Zones

i. It refers to the buffer zone that should exist in all water bodies identified on farms, both permanent and intermittent.
ii. The buffer area should be forested with trees and shrubs, preferably native.
iii. In the case of permanent water bodies minimum distance of the buffer zone should extend at least 32 feet on each side of the body of water.

iv. In the case of intermittent water bodies minimum distance of the buffer zone should extend at least 16 feet on each side of the body of water.

g. Shade Criteria

i. It refers to all the key elements required to establish a coffee plantation under shade.

ii. The percentage of shade must be between 20% and 40% taking into account that each site may have differences in both its geographical position and inclination and altitude from sea level, which may be decisive factors in the percentage of shadow to establish.

iii. For properties that are proposed to convert to shade coffee, planting of trees should be established in an effective planting plan embodied in the Management Plan (establish distance between trees, type of pruning, maintenance etc.).

iv. The design of the shade coffee planting plan must be made in advance between the operator of the farm and the agencies involved (to be determined) and the Certification Board.

v. Trees should be handled and pruned during the growing period to reach the desired percentage of shade.

vi. For farms that have already reached the desired shade percent; pruning and trimming trees to keep the percentage of shade must be done right at the end of the harvest and before flowering (October to January) or when needed when the percentage exceeds the desired shade. It should be noted that the most active time for breeding and nesting of most birds is during the months of February through summer. It is recommended that pruning be carried out annually to be less damaging to the coffee trees when plant material is pruned from the trees to maintain proper shade levels.

vii. The branches of shade trees should not be less than 6 feet above the coffee bushes.

viii. The plant material resulting from pruning must be kept on farms. It should be left on the ground to decompose and become part of the soil to protect and preserve it.

ix. Layers of shade

1. Partial shade
    a. During the planting of coffee bushes pruning new or renovation of shade coffee the farmer can incorporate planting bananas to protect the soil and planting during the first two years and in turn get an income during the process of establishing the coffee plantation.
2. Lower Strata.
    a. May include muses, citrus and avocados.

3. Principal Strata.
    a. It should be composed mostly of native species.
4. Higher Strata.
    a. It should be composed mostly of native species.

x. Higher and Principal strata are required while the lower layer and Partial shade are optional.

xi. Farmer must maintain species diversity with a minimum of four native species between the Superior and Principal Strata.

h. Habitat Criteria

i. This criteria includes practices that promote and maintain habitat for wildlife on the farm.

ii. Native epiphytes on trees should be maintained as this practice does not affect the planting of coffee or shade.

iii. Keep trees and fallen branches and those that are pruned on the grounds of the farm.

i. Soil Conservation Criteria

i. It is essential to care for and maintain soil fertility and soil conservation.

ii. The soil should be covered all year, either in litter or cover crops.

iii. The base of coffee trees should be clean for the application of fertilizers and pesticides when needed if they are not applied directly to the subsoil.

iv. Maintain a small contour in a half moon around the base of the coffee bushes into the slope to avoid washing away the chemicals applied to the tree.

v. There must be a plan to establish and expand the ground cover and minimize the use of herbicides.

vi. There should be a program to reduce erosion and sedimentation to minimize the risk under the conditions of each site within the farm.

vii. This program should be incorporated into the management plan to prevent erosion of soils, including soil conservation practices such as vegetative barriers, dead trees and shrubs barriers, ground covers, stabilized ditches, roads and sidewalks on the contour, proper planting distances, the use of temporary and permanent shade, liming, the incorporation of organic matter and the proper use and application of fertilizers.

j. Fertility Management Criteria

i. There must be a fertilization plan based on: soil properties, soil analysis and expert opinion.

ii. The farmer must conduct annual soil and foliage nutrient analysis.

iii. Fertilizer applications should be based on the results of these analyses.

iv. Priority should be given to fertilizers made with natural materials of the farm and /or organic fertilizers.
v. Fertilizer should be applied directly in contact with the ground or subsoil.
vi. Fertilizer should be applied as required for each crop and soil properties, without runoff to water bodies.
vii. Farmer must maintain records of all fertilizer applied and provide an appropriate storage area for them.
viii. The use of nitrogen fixing trees (legumes) for shade is recommended.
ix. Material from pruning should be left on the farm.

k. Water Conservation Criteria

i. Buffer zones of vegetation should be established for water bodies on the property as discussed in this document.
ii. Farms must have a water conservation program that includes: map of surface water and discharge of waste into water bodies

l. Criteria for Pest Management

i. Farm must maintain a record of applications and types of pesticides used.
ii. The use of organic-based pesticides is recommended.
iii. There should be an integrated pest management for the farm that includes maintaining records of applications.
iv. Do not use pesticides known as the Dirty Dozen.
v. Farm must apply all regulations and rules in force in Puerto Rico for the use of pesticides.

m. Social criteria

i. In general farm should include programs that promote occupational health and safety, training, fair pay, etc.

n. Traceability Criteria

i. There must be a record of all farm operations for each field including:
    1. Record of operations
    2. Crops record
    3. Production record
    4. Record of management practices implemented

The Shade Coffee initiative is in an advanced state of recognition around environmental discussion fronts in Puerto Rico like the State Technical Committee. We are bringing to fruition the efforts to establish the certification program in Puerto Rico and

beginning to enroll and certify many farms as Shade and Conservation Friendly Coffee. Since Protectores de Cuencas is actively participating in the various working groups developed by the office of the Model Forest, it would bring closer collaboration with farmers and producers to promote their coffee and provide support and training in these efforts. The Round Table will also continue working towards the institutionalization of these practices and programs working together with PR Department of Agriculture, NRCS, UPR Agricultural Extension Service, UPR Mayagüez and UPR Utuado, PR College of Agronomists and the Department of State.

This initiative focuses in four critical areas that are necessary to complete an integrated approach to improving both the economic and ecological aspects of coffee and to help preserve coffee culture in Puerto Rico. Continued threats to the coffee industry in Puerto Rico include climate change and increased frequency and duration of storms, more variable weather patterns, higher temperatures as well as external forces including lower cost coffee production in other countries without strong labor and environmental standards, substitution and mixing of Puerto Rican coffee with lower cost or lower standard beans as well as increased energy, fertilizer and labor costs. Shade coffee and an attention to higher quality coffee represents a way to provide communities in Puerto Rico with food and economic security while restoring natural functions of the forest and the health of streams, rivers and nearshore coastal habitat. A certification Logo was developed to be used on the coffee bags of certified coffee (Figure 20)

The Shaded Coffee Certification process is a constantly increasing challenge. We have had a great number of farmers interested in the certification process and we are

providing the farm enrollment certification sheet. This will enable the Certification Board to fine tune the process and start a greater certification process that can push other farmers to move to more sustainable practices. Throughout the development of this initiative, we have identified other activities that need to be addressed in order to ensure success and consensus.

- Education and outreach
- Sustained government support
- Development of public policy
- Market studies
- Funding
- Coalition of local NGO's with interests in advancing the initiative
- Formalized certification

Figure 20. Shade Coffee Certification Logo.

Dirt road Stabilization on Coffee Farms

The problems of erosion and sedimentation in the Guanica watershed are primarily associated with runoff generated from dirt roads and sun coffee production in the upper watershed farmlands in the central mountain region. Previous studies estimate that highly erodible lands compose much of the high mountain land areas being used for agriculture and these dirt roads in the upper watershed can erode at a rate of 100 times faster than soils with significant mulch cover (Ramos-Scharrón, 2010). Studies point to dirt roads and sun coffee within farmlands in the upper watershed as some of the major elements that contribute to sediment transport to the Guánica Bay and the nearshore reefs.

A 2016 study conducted by Ramos-Scharrón and Thomaz, concluded that unpaved farm roads may account for over 90% of the sediment lost during erosion processes and eventually reaching our water resources throughout the watershed. This publication describes the methodology used where rainfall simulations experiments were conducted to quantify runoff and soil erosion. Results indicated that bare soil dirt roads within farms begin to mobilize and transport sediment with less than 0.1 cm of rainfall within 1 to 2 minutes into the simulations, with an average of 69 g of sediment eroded during 30 minutes of simulation.

Loss of highly erodible soils on steep slopes is clearly a major issue in the Guánica Bay/Río Loco watershed based on GIS analysis, field investigations and data on sediment accumulation in the reservoirs. GIS analysis was used to target the locations of Highly Erodible Lands (HEL) and agriculture, particularly sun grown coffee and other crops being grown at high elevations, roads and homes on or adjacent to steep slopes. Based on the soil

layer, these highly erodible lands were estimated to compose much of the high mountain land areas being used for agriculture in the Lago Lucchetti and Lago Loco drainage areas (CWP, 2008).

As a response to these needs, this project completed the stabilization of 1.7 miles (using ArcGIS tools) of dirt roads in three farms utilizing cost effective BMPs that can be replicable in other locations in the island. The target areas include: San Carlos Farm, Evarista Vélez Farm (Figure 1) and Hacienda Candelaria (Figure 2).

Based on our field evaluations, recommendations from the farmers and technical assistance from site visits and discussions with DNER, NRCS, the Municipality of Yauco and the farmers, we conducted restoration components that are discussed in detail in the next section of this report. The target farms included: San Carlos Farm, Evarista Vélez Farm and Hacienda Candelaria Farm (Figure 21). These three farmers provided their in-kind contributions which included: meetings participation, aid during project design, provided personnel to assist with labor during BMP implementation. In addition, they provided materials for soil stabilization and water for the trees and plants established in each BMP for road stabilization after project completion.

The following components were implemented at each of the three farms selected for this project:

- Dirt Road assessment and BMP design
- Establishment of temporary erosion and sediment control practices
- Dirt Road Stabilization
- BMP training sessions
- Follow up visits to ensure proper maintenance and evaluate functionality
- Research collaboration

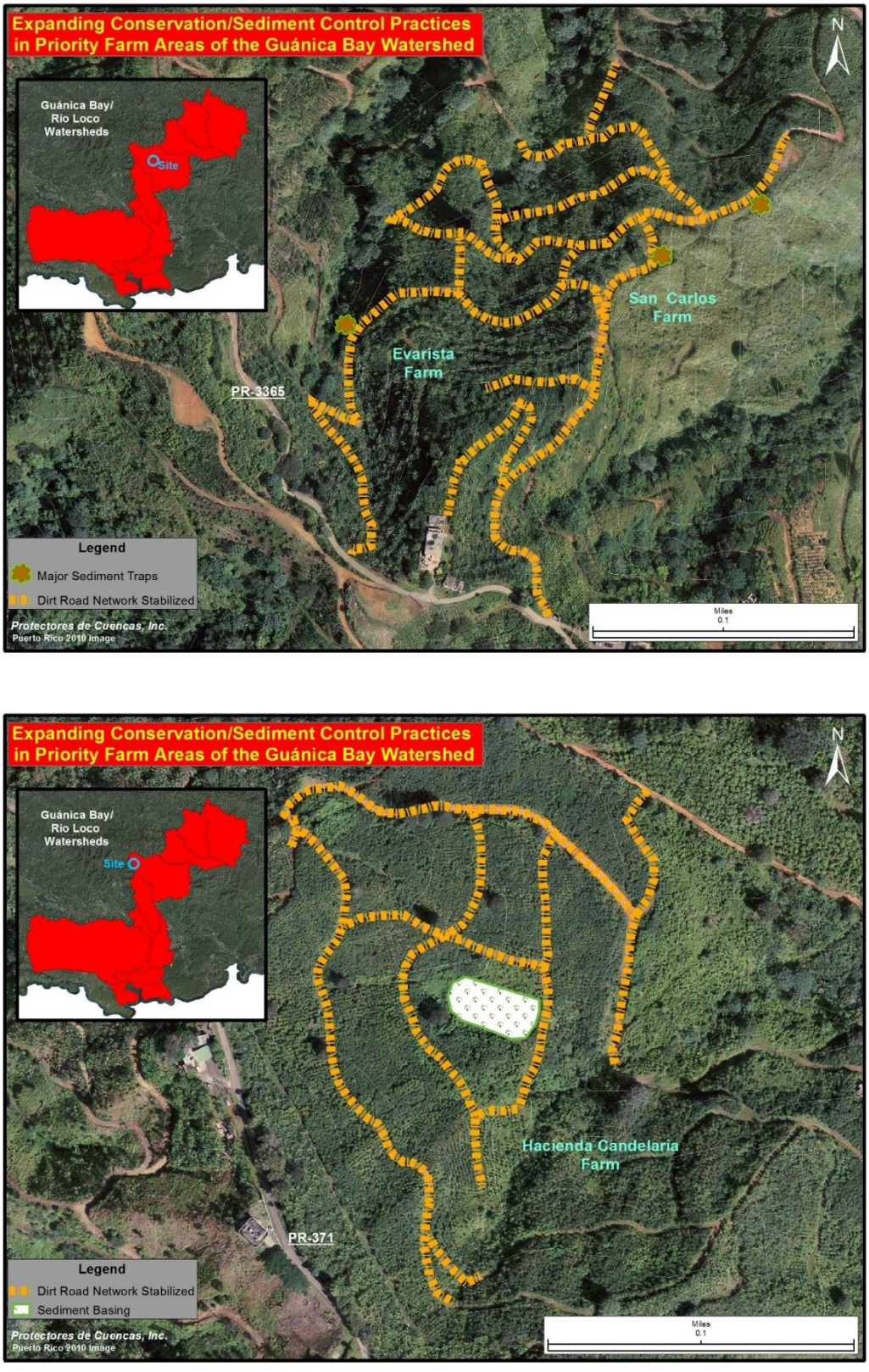


Figure 21. Schematic diagram of the work completed on the three farms selected for the pilot project.

The project assisted farmers in reducing the need for re-grading dirt roads. We also provided them with guidelines for long-term maintenance. The project worked closely with all stakeholders and farm owners to train them in proper installation of temporary and permanent sediment and erosion control practices. We also provided training in construction of stormwater control swales, check dams, creation of infiltration systems with vetiver grass and native trees as well as proper maintenance techniques for Best Management Practices (BMP). By installing these conservation practices, we assisted farmers in reducing the need for re-grading dirt roads that farmers had to do two to three times a year, producing massive sediment runoff. PDC has a partnership with the Natural Resources Conservation Service (NRCS) on these efforts to address this major threat to coastal ecosystems and to work together on creating a set of standard practices to address runoff from dirt roads in the near future.

As part of our ongoing efforts to maintain communication channels with the partners, we presented in the NRCS State Technical Committee meeting. The meeting was led by the Forestry, Wetland and Wildlife Subcommittee in which we are permanent partners. This committee recommends actions to the NRCS director as how to allocate funding and policy towards conservation initiatives. This meeting had participation from DNER, FWS, NRCS, National Wildlife Refuges Association, The Breadfruit Institute, the University of Puerto Rico, and another local NGO's (Figure 22). We presented the dirt roads stabilization project accomplishments and put it into

Figure 22. State Technical Committee Meeting.

perspective of the other state actions needed to advance restoration efforts.

The primary goal of this project was to stabilize bare soils in the upper watershed farms to reduce sediment loads to the Guánica Bay (Figure 23). This will protect and build resilience of coral reef ecosystems in this priority area. Prior to stabilization, in most parts of the dirt road network, runoff was running through the center of the road causing erosion forces to transport sediments into our watershed water resources. After completing the installation of temporary sediment and erosion control measures, PDC stabilized approximately 1.7 miles of dirt roads in three coffee farms. Installed BMPs included sediment traps, check dams, swales, regrading, rip-raps, Vetiver grass and paving with granulate fill material and compacting (Figure 24). A brief description of each BMP is provided here to help understand their function and purpose.

Figure 23. Previous existing conditions of segment of the coffee farms dirt roads.

Sediment traps serve to detain sediments in stormwater runoff to protect receiving streams, lakes, drainage systems, and the surrounding area. An outlet or spillway is often constructed using large stones or aggregate to slow the release of runoff. Check dams are a commonly used practice constructed across a swale or channel. They are used to slow the velocity of concentrated water flows, a practice that helps reduce erosion. Check dams are typically constructed out of gravel, rock, sandbags, logs or treated lumber, or straw bales. Similarly, swales are designed to manage water runoff, filter pollutants, and increase rainwater infiltration and refers to a vegetated, open-channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality volume. As stormwater runoff flows along these channels, it is treated through vegetation

Figure 24. Some examples of the BMP's implemented on the pilot project.

slowing the water to allow sedimentation, filtering through a subsoil matrix, and/or infiltration into the underlying soils.

Regrading is commonly implemented as well. It refers to the process of land grading for raising and/or lowering the levels of land with the purpose of changing drainage patterns and rerouting surface flow. Land grading is applicable to sites with uneven or steep topography or easily erodible soils, because it stabilizes slopes and decreases runoff velocity. Rip-rap is a layer of large stones used to protect soil from erosion in areas of concentrated runoff. Riprap can also be used on slopes that are unstable because of seepage problems.

Based on our experience implementing BMP's, we can recommend that one practice on its own is not enough to observe an improvement. Instead, it is important to implement a series or combination of BMP practices that are best suited for the location, while taking into consideration other factors such as slope gradients, soil type and composition. The different slope gradients found at each farm will help us compare the effectiveness of the different BMPs implemented on the long term. This information will allow us and farmers to better understand which BMPs are best suited to their particular farms. As PDC continues to implement sediment and erosion control practices, this project will help to develop and standardize cost-effective techniques to reduce sediment loads from the upper Guanica Bay watershed.

During the implementation process of this project, several challenges were faced. A series of landslides happened in the farms that interrupted project implementation. Due to the amount of clearing of dirt roads by the farmers, the incline on portions of the dirt roads

are very steep or vertical leading to unstable soil after rain events and frequent landslides. The frequency of rain events in this mountainous area also allowed us to improve and correct certain practices during the process.

Effective stormwater management often occurs by using a holistic system management approach. This approach takes into account the effectiveness of each stormwater practice, the costs of each practice, and resulting overall cost and effectiveness rather than looking at each practice in isolation. Some individual practices may not be effective alone, but when combined with others, it may produce highly effective systems. Our intentions are to continue working towards innovative cost-effective green infrastructure practices that help reduce flows and improve water quality.

The wiliness to implement these types of soil stabilization practices on dirt roads in the coffee production region has increased dramatically as other farmers have seen the work completed in the selected pilot farms. We have identified a series of potential areas for additional dirt road stabilization work in the subwatersheds of Prieto and Luchetti (Figure 25)

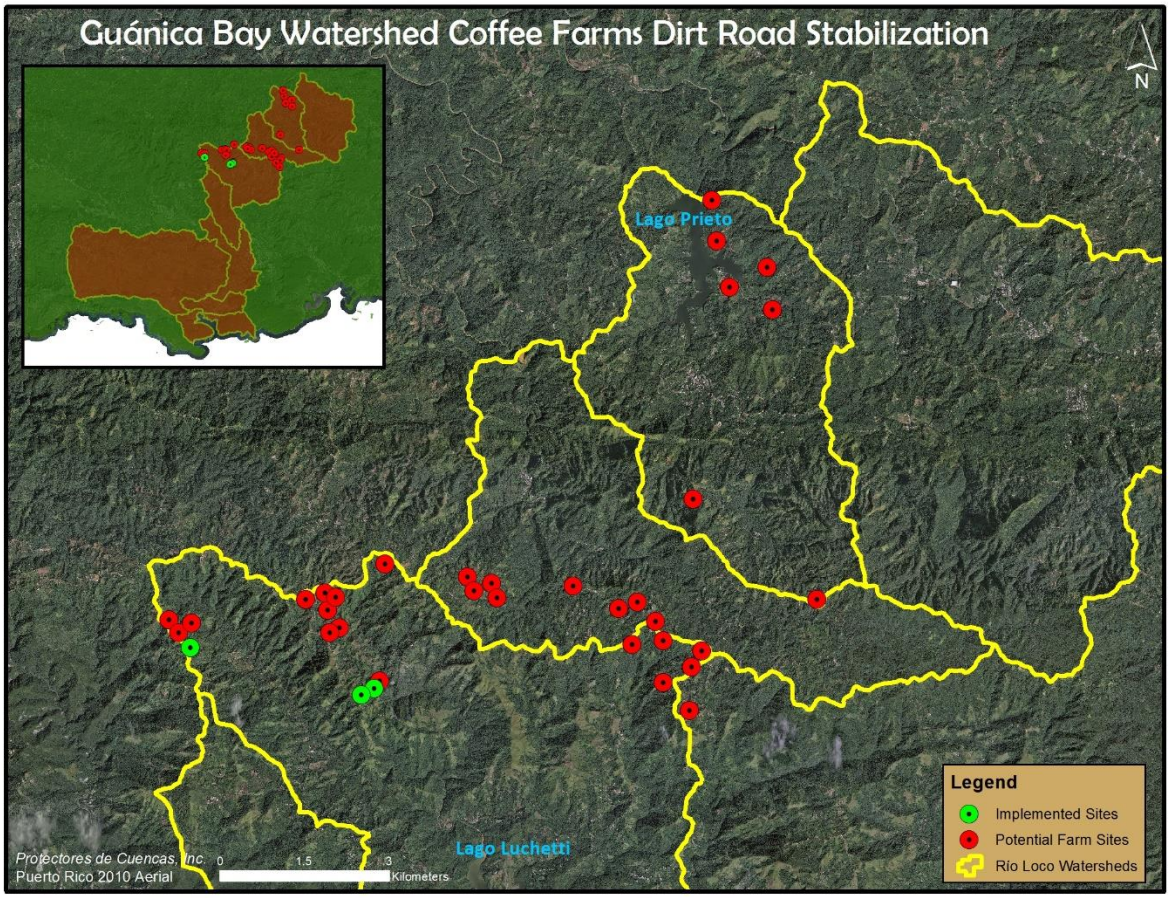


Figure 25. Potential areas for additional dirt road stabilization work in the subwatersheds of Prieto and Luchetti.

After BMPs implementation was completed, PDC conducted training sessions at the San Carlos and Evarista farms (Figure 26). For the training, we worked closely with farm owners, UPR-Sea Grant, Department of Natural and Environmental Resources, NRCS and other NGO's and stakeholders to discuss our experience in proper installation of temporary and permanent sediment and erosion control practices such as the construction of stormwater control swales, check dams, the creation of infiltration systems using vetiver and native trees as well as BMP proper maintenance techniques. By installing these techniques, we assisted farmers in reducing the need for re-grading dirt roads. PDC, NRCS and USFWS is discussing the establishment of a partnership to address this major threat to coastal

ecosystems and to work together on creating a set of standard practices to address runoff from dirt roads.

The efforts undertaken during this project helped gather information that was ultimately used in deciding the best suitable BMP implementation practices for this type of soils and slopes. The take-away message of the BMP training session was that problems caused by land erosion are reflected on coral reefs. Also, that dirt roads are the biggest erosion problems on coffee farms. Upon completing the exercise, participants exchanged ideas about alternatives to minimize the erosion problems generated by dirt roads. An NRCS article discussing some details of the activity can be found at the following link:

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/pr/newsroom/features/?cid=nrcseprd1291489

Figure 26. Images of the workshop conducted with the collaboration of Dr. Carlos Ramos.

These coffee farms are considered heterogeneous landscapes since soil surfaces can be found to have many different surface covers, including cultivated fields with underbrush or weeds, forested hillsides, and uncovered soil. Each type of soil surface has its unique conditions that influence on the amount of erosion generated, such as soil cover, slope, and soil type. It is important to mention that the erosion generated not only impacts on-site but

also downstream. On-site impacts typically include soil fertility, infrastructure to work and move within the farm, while downstream impacts are usually observed in the water quality and consequently the health of rivers, reservoirs, coral reefs, and other coastal ecosystems.

A study published in Land Degradation and Development by Ramos-Scharrón and Thomaz in 2016 describes the methodology used during the BMP training sessions (Figure 31) that took place in San Carlos Farm. Rainfall simulations experiments conducted to quantify runoff and soil erosion from different land surface types, including unpaved roads within farms. Water samples were collected to measure sediment concentration levels and compare them to samples taken in other areas of the farm where bare soils are not exposed. Results of the published 2016 study indicated that bare soil dirt roads within farms begin to mobilize and transport sediment with less than 0.1 cm of rainfall within 1 to 2 minutes into the simulations, with an average of 69g of sediment eroded during 30 minutes of simulation. Authors concluded that unpaved roads account for over 90% of the eroded sediment reaching the watershed (Figure 27).

The research project associated with this effort serves to compare the erosion rates of the different surface covers found at coffee farms. This has helped us identify the surface cover that generates the most erosion and therefore focus our efforts on one specific type of surface. Preliminary data from the rain simulation experiments and sediment traps indicate that bare dirt roads are the primary generator of erosion. To control the erosion and ultimately the water quality, management efforts should focus on the dirt roads. Therefore, it is important to work with all stakeholders to continue with the design, implementation and maintenance of sediment control practices that are focused on farm dirt roads.

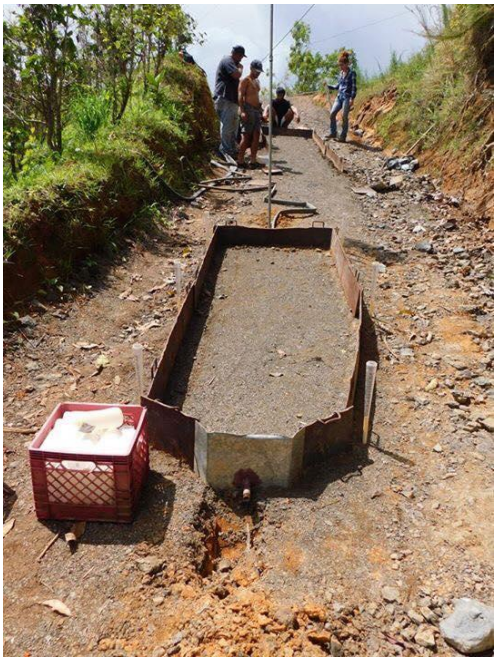


Figure 27. Images of methods of rain simulation implemented by Dr. Carlos Ramos.

GUÁNICA TREATMENT WETLANDS IMPLEMENTATION

Background

The proposed project consists of the construction of a treatment wetland system to reduce nutrient contamination from discharges from the Guánica Sewage Treatment Plant operated by the Puerto Rico Aqueduct and Sewer Authority (PRASA) that discharges to the Guánica Bay (Figure 28). This project is part of the recommendations of the Guánica Bay Watershed Management Plan and the improvement of coastal ecosystems, as discussed with all participating agencies of the Coral Reef Task Force. This plant processes about 2.1 million gallons per day of wastewater from the urban areas of Guánica. The proposed treatment wetlands will be built on PRASA land and are estimated to reduce by 50-80% the total nutrient discharges currently entering the Bay, which would result in a benefit to the marine environment.

The project to be developed on the premises entails the installation of a series of wetland cells for treatment to reduce the concentrations of nutrient effluent from the Plant. The cells will consist of approximately 6 acres in total – each cell will be approximately 1-2 acres and will have a flow depth of approximately 1-3ft – excavated material will be used to construct berms around each cell. Construction includes modifications to the existing flow structure next to the Plant, for the transportation of effluent water to the wetlands through a pipe. The cells will be created by constructing berms around each of the cells and well as engineered conveyance (such as a weir) between each of the cells. Each cell will be stabilized by planting with wetland vegetation or where wetland vegetation already exists

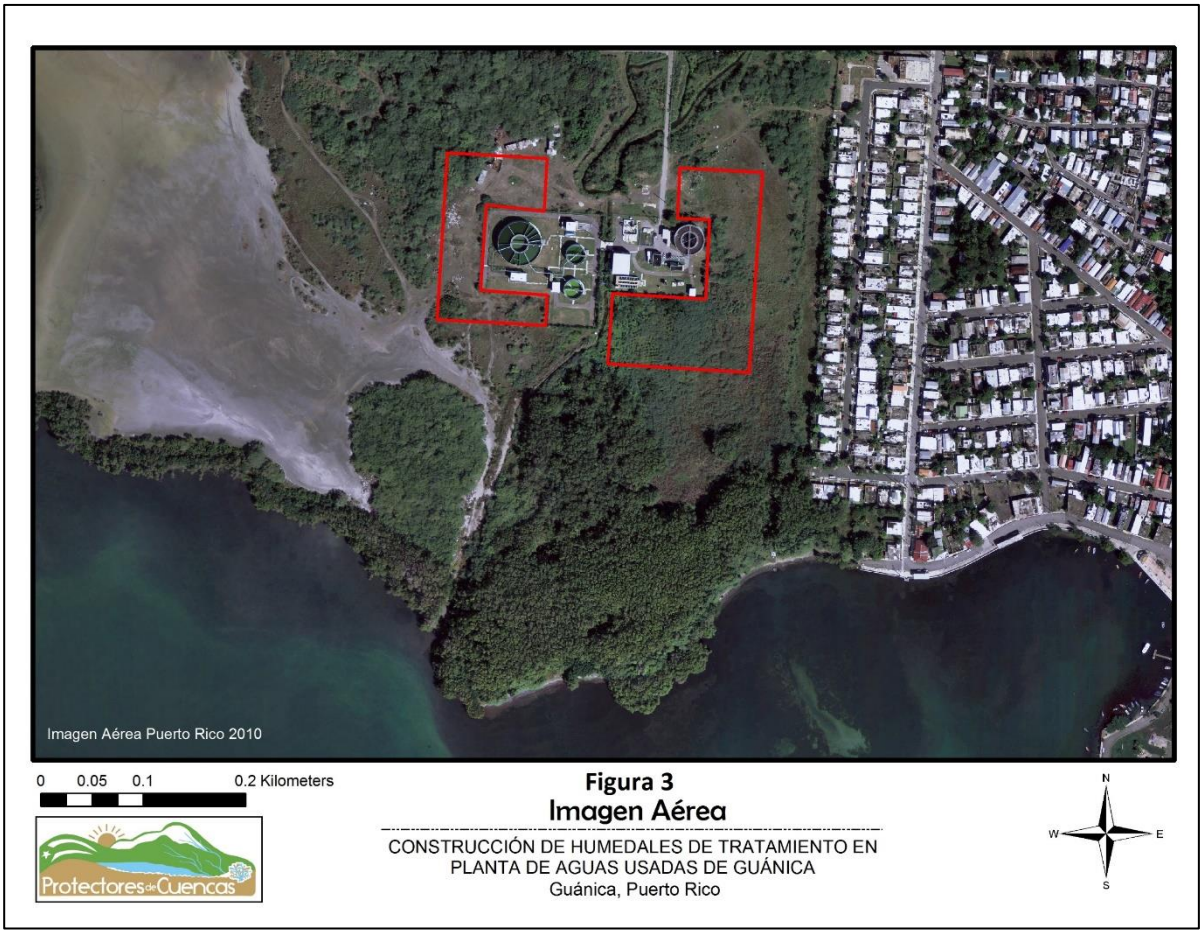


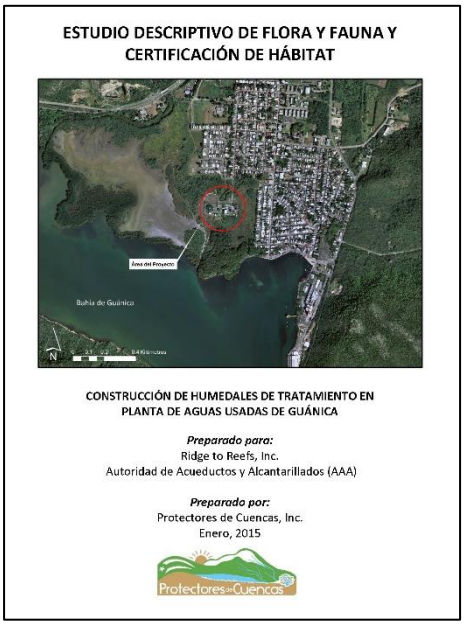
Figure 28. Site map of the proposes treatment wetland project in Guánica Bay.

it will be left in place and supplemented with additional plantings which will also function to uptake nutrients and effluent as well as to create biological conditions for de-nitrification.

The Project will operate by gravity and by wetlands' natural processes in order to treat and improve the effluent from the Plant. It will significantly reduce nutrient loads to the Guánica Bay and near shore coral reefs. The project will effectively take the plant from secondary treatment to tertiary treatment using very little energy and at very little cost to PRASA. It also represents an opportunity for proof of concept for treatment wetlands in Puerto Rico, particularly in regard to plant upgrades.

Recent efforts

Up to date, coordination efforts have been in collaboration with Ridge to Reefs, Inc. to obtain all the necessary environmental compliance process and meetings with PRASA to achieve a signed Memorandum of Understanding. Additional work consisted in evaluating the existing condition of the biodiversity on the project site with a Flora and Fauna study (Figure 29) and getting the survey data for the completed 100% design (Figure 30).


ESTUDIO DESCRIPTIVO DE FLORA Y FAUNA Y CERTIFICACIÓN DE HÁBITAT

CONSTRUCCIÓN DE HUMEDALES DE TRATAMIENTO EN PLANTA DE AGUAS USADAS DE GUÁNICA

Preparado para:
Ridge to Reefs, Inc.
Autoridad de Acueductos y Alcantarillados (AAA)

Preparado por:
Protectores de Cuencas, Inc.
Enero, 2015

Figure 29. Cover page of the completed Flora and Fauna Study.

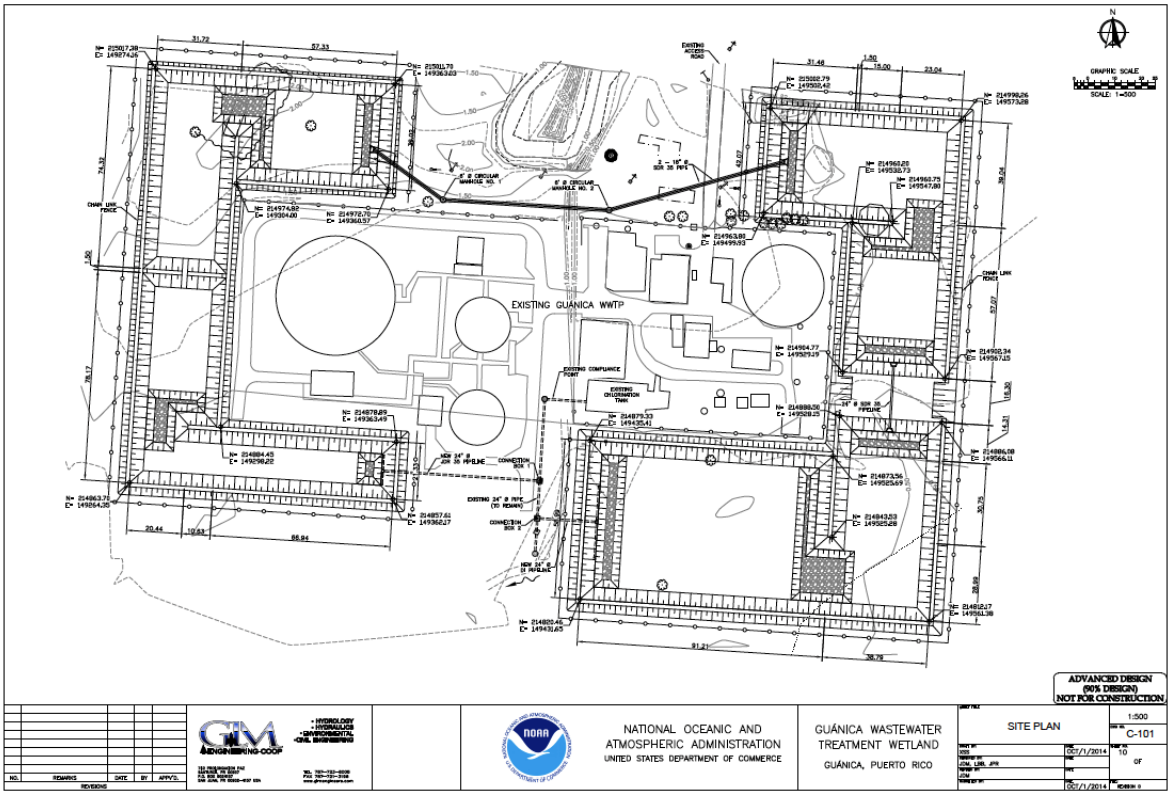


Figure 30. 100% design of the proposed Treatment Wetland Project.

Though the coordination effort we have presented the project to the Guánica Mayor and the Municipal Legislature for approval of a construction tax exemption waiver which have been granted to the project.

Next Steps

Prepare a construction schedule, mark survey points on site and start with construction on April of 2018.

SOURCE AREA POLLUTION

As a direct result of the coordination efforts, a series of pollution source tracking, pollution remediation and elimination as well as education campaigns initiatives have been developed across de watershed. A series of restoration projects have also been implemented to reduce Land Based Sources of Pollution (LBSP) threats for restoring and protecting coastal habitats, ecosystem resiliency and climate change adaptation through community engagement and integrated watershed management actions. Local municipalities and private contractors have been engaged in sediment an erosion control workshops. All these activates have been developed in conjunction with an outreach and education campaign that has impacted more than 1,000 students from local communities across the watershed. Students have participated in classroom presentations as well as in actual restoration work. Implemented projects are briefly described in the following sections.

"Think before you drop it": A Research based Litter Reduction Campaign in Nine Beaches of Guánica, Puerto Rico.

The purpose of this project was to design and implement an education and outreach campaign utilizing social marketing techniques to reduce marine debris in the Guánica/Río Loco Watershed. The project was divided in two stages. Stage one included seven clean-up activities at nine beaches located within the Guánica/Río Loco Watershed. Community members, stakeholders and beach users were invited to take part in these clean-ups. At these events, a Research Team gathered information about the types of marine debris

found in these areas as well as conducted semi-structured surveys to collect sociological and demographic data from participants. Additionally, the research team conducted observations at target sites and unstructured interviews with experienced stakeholders. The research team analyzed the data, organized community events to present findings and designed a strategic campaign for reducing marine debris at the target sites.

Two photography contests in the public schools of Guánica where developed with the incorporation of a Scientific Photography Workshop that encompassed four classroom sessions and two field photography sessions (Figure 31). Arrangements were made for the Scientific Photography Workshop participants to exhibit their photographs at the 'Bienial Municipal de Ponce biannual event where more than 100 well-known local artists exhibit their art work. Regarding the community based social marketing research, PDC successfully defined three research instruments for the research project including: (1) marine debris characterization form-adopted from Ocean Conservancy; (2) beach user's questionnaires; and (3) beach observation forms. These instruments allowed for PDC to collect the necessary information about the type of trash is found in the beaches, sociological and demographic information of beach users, as well as define the type of audience that visited and used the 9 target beaches. During one large beach cleanup event conducted in December 6, 2014, approximately 150 volunteers cleaned these 5 locations. PDC also had the support from the Guánica Municipality, 6 non-

Figure 31. Children that participated in the photography workshop

profit community groups, 3 public schools and various private donors. During this event, we had approximately 11 beach captains in charge of assisting the volunteer groups collect debris data, utilizing the Ocean Conservancy marine debris characterization form. A total of approximately 2,500 lbs. of trash was collected during beach cleanup events.

Stage two focused on the campaign implementation and project evaluation. In this regard, we believe we did have an impact through community empowerment not only to encourage the behavior across Guánica and the region as a whole but also to instill interest in conservation among young children. Through our beach activities with volunteers, children and parents as well as through social media and radio stations we reached out to at least approximately 10,000 people directly (Figure 32).

Figure 32. Part of the volunteer groups that that participated in the campaign.

Continuation of Restoration Efforts in the Río Loco Watershed: Tracking Pollution Sources into the Urbanized Area of Yauco

This project aimed to identify and characterize all point & non-points sources of raw sewage discharges and other contaminants in the main tributary rivers of the Río Loco River in Yauco (Figure 33). Protectores de Cuencas is in the process of providing local and federal partners with recommendations defining problems and solutions and prioritizing specific actions to reduce LBSP to adjacent coral reef ecosystems within the Guánica Bay. The project also is in the process of implementing one restoration pilot project within the target subwatershed. PDC utilized the EPA Illicit Discharge Detection and Elimination (IDDE)

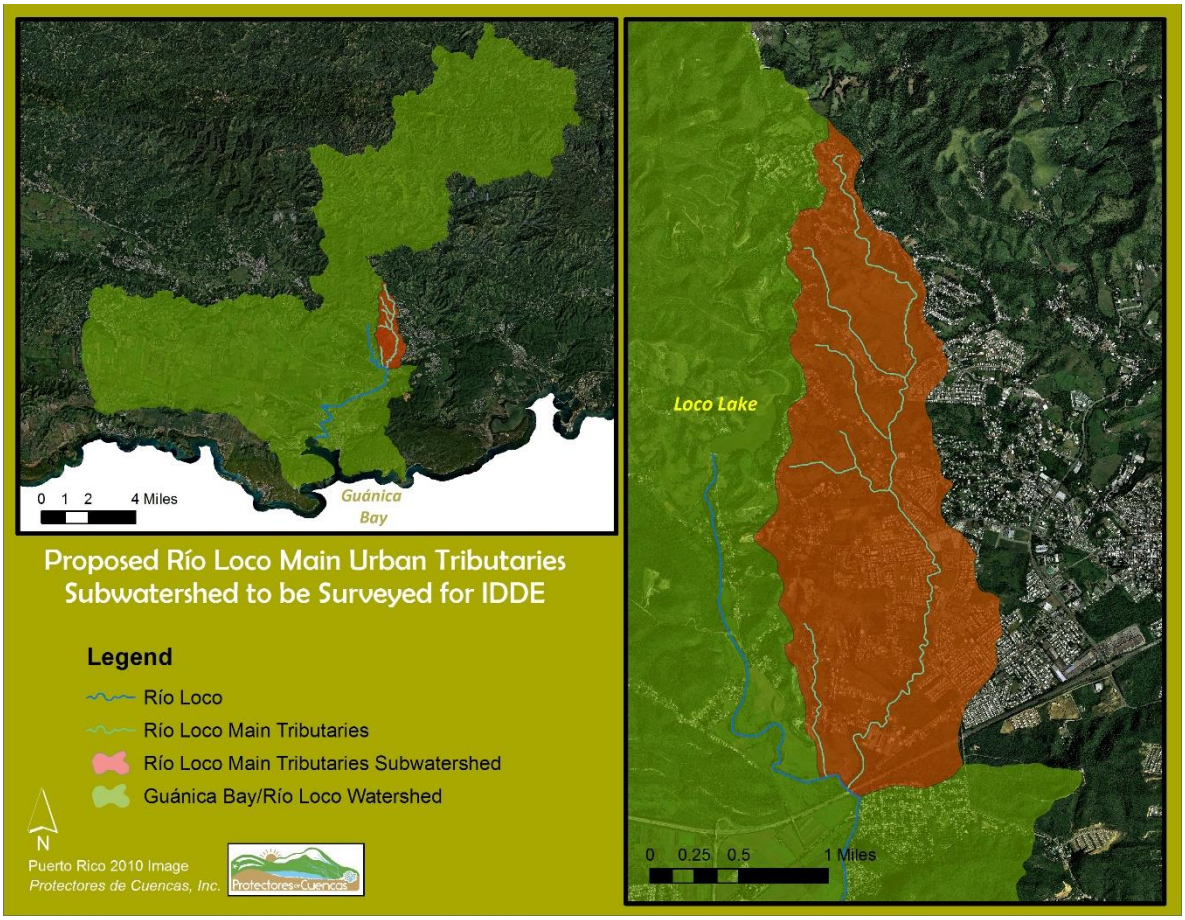


Figure 33. Map of the Río Loco main tributaries surveyed for pollution tracking.

methods. The total area of the subwatershed assessed is approximately 1,900 acres. The total length of all the tributaries studied is approximately 9 miles in length.

These tributaries had not had outfall screening and tracking for pollution sources before, however we are aware that a large segment of these streams pass through Yauco's urban center area collecting a mixture of contaminants and stormwater runoff derived from local industries and dense urban housing development projects. A segment of one of the tributaries also passes through agricultural lands of approximately 200 acres, an area used for cattle grazing.

Water Quality Sampling was conducted in 35 sampling points including outfalls and streams coming in and pollution was further tracked between and upstream of these points using parameters which include total nitrogen, total phosphorus, optical brighteners, ammonia, turbidity, Chlorophyll A, and enterococcus bacteria. The methods utilized are the EPA funded and approved guidelines listed under the document 'Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments'. A series of conceptual restoration strategies are being drafted as well as cost estimates for recommended remediation actions (Figure 34). Data collected in this project is being incorporated in the revised Guánica Bay Management Plan. Training on water quality sampling and illicit discharge detection was incorporated to high school and university students and science teachers.

Figure 34. Part of the site assessments and lab analysis.

Restoring and protecting coastal habitats, ecosystem resiliency and climate change adaptation through community engagement and integrated watershed management actions

A series of nearshore restoration projects have been implemented on coastal areas of Guánica to protect important sensitive coastal and marine ecosystems that include:

Reforestation of coastal forest areas with native vegetation and habitat rehabilitation and forest fire prevention activities.

This task included the design of a reforestation plan for the coastal forest sites that included the conservation of desirable existing trees, shrubs and vines. The plan specified the type of vegetation and at what density was going to be planted; it also proposed management features such as fire break trails. The plan included the preservation of the desired species identified in the surveying process with the technical support of the DNER Forest Management Officer. Boring and drilling activities, fertilization and irrigation of planted trees were thoroughly discussed with the working group. A total estimated area of 7,200 m² of coastal forest (using Arc GIS tools) was restored. The process began by conditioning the area for reforestation activities with the help of DNER personnel (Figures 35).

Figure 35. DNER personnel collaborating with PDC on the site preparation process and our technical advisor Miguel Canals Mora

Invasive grasses as well as other undesirable non-native shrub species where selectively removed from the sites. Bigger non-native trees such as the mesquite tree were left on site pruned for up to 25% so that the new planted trees had enough sunlight to grow. A total of approximately 1,750 native trees were planted with the help of DNER staff, local NGO's and students from schools of the Yauco, Guayanilla and Guánica in the area (Figures 36). Some of the planted species included Sea Grapes (*Cocoloba uvifera*), Almácigo (*Bursera simaruba*), Uverillo (*Coccoloba microstachya*), Roble Nativo (*Tabebuia heterophylla*), Emajagüilla (*Thespesia populnea*), among others as recommended by DNER specialists.

Figure 36. Coastal Forest reforestation process.

We will measure success of the restored areas by assuring the survival of the planted material for a period of 6 months. The chosen tree species require minimal maintenance after proper establishment, however volunteer groups will help with maintenance of the area in the following months.

Forest fires represent a serious threat to the restored area. To deal with this, we integrated management actions to prevent forest fires on the restored sites. This strategy included cutting grasses at ground level and creating fire breakers.

Coastal sand dune and beach berm restoration

Coastal sand dune and beach berm restoration was one of the most important components of this project. The area of critical dune restoration was the sites directly associated with the Sapo Concho breeding pond. These areas were the dune was heavily impacted by erosion and compaction do to the intense public usage (Figures 37) had to be re-nourished in order to protect the breeding pond from marine water intrusion. Endemic sand that was piled up over the years by the management action of creating and maintenance of the fire brakes on the back beach was used for the re-nourishment activities. In this particular sites the sand dune was elevated from 2 to 3 feet. Sand was brought in using a small dump truck and shaped with, first a small skid loader and then finalized by using hand tools. After sand dunes where shaped to the desire tallness and shape they were stabilized by planting four lines of Sea Grapes at two feet intervals in a zig zag pattern for a mean distance between trees of 1.5 feet. This planting process will allow for an accelerated dune vegetated cover stabilization (Figures 38).

Figure 37. Sand dunes prior to restoration.

Figures 38. Part of the sand dune restoration process.

The other areas of beach berms were restored by first selectively removing non-native grasses and reforested with native coastal vegetation following the same procedures and species composition of the coastal forest sites (Figures 39 and 40). A total estimated (using Arc GIS tools) area of 4,100 m² of coastal sand dune and beach berm was restored. Reforested areas where systematically designed to serve as biological corridors. Another important component in this areas was the implementation of Best Management Practices to prevent erosion and sediment runoff to the nearshore environment. Some of these areas where heavy eroded due to vehicular access and concentrated flows from the near paved road. Stone riprap and swales in combination with vegetative buffers were implemented to reduce the energy of the runoff and wooden bollards where installed to delimit vehicular access to the maritime-terrestrial zone.

Figures 39. Coastal areas prior to stabilization.

Figure 40. Coastal berm restoration process.

Delimitation of critical habitat areas and improvement of public access.

Figures 41. Delimitation of critical areas.

The essential coastal habitat in Tamarindo has been seriously impacted by uncontrolled public usage. Based on the field evaluations and with technical recommendations from the Sapo Concho Management Committee we restored the coastal forest, sand dunes and beach berm areas with native vegetation barriers and delineated public access to the beach. This delineation was conducted by installing treated wooden posts buried about 18 inches deep and fixed with concrete at the base leaving about 30 inches of pole exposed to set limits to the area (Figure 41). Wooden posts were placed at a distance of three feet from each other to prevent the passage of small vehicles. Wood fences were built to protect the area re-nourished of sand dunes to prevent pedestrian access through restored sites (Figure 42). Three elevated boardwalks were constructed for public access to the beach without impacting restored vegetation buffers, sand dunes and tadpoles. One boardwalk is 350 feet long and the other two are 30 feet long. These set of boardwalks were built approximately 2.5 feet above the ground to protect terrestrial species and provide ecological corridors connecting the pond and the coastal forest ecosystems (figure 43).

Figures 42. Delimitation of restored areas.

Figure 43. Elevated boardwalks constructed.

Implementation of BMP's for sediment and erosion control and stormwater treatment.

Efforts to reduce the sediment loads to seagrass beds and coral reefs included the implementation of sediment traps, check dams and rip-rap, permeable parking lots filtering systems and bio retentions. A series of coastal dirt road system where stabilized by regrading and compaction activities and stormwater treatment practices (Figure 44-45).

Figure 44. Some examples of the BMP's implemented.

Figure 45. Some examples of dirt road and parking lot stabilization.

Outreach and education

During project implementation PDC visited the María L. Mc Dougall Elementary School of Guánica and the Yauco Technical and Vocational High School in Yauco (Figure 46). We conducted one visit to each school and one large reforestation event impacting a total of 112 students. For the reforestation event alone we counted with the in-kind volunteer work of 46 students from the Yauco Technical and Vocational School who dedicated 6 hours to planting native trees in Tamarindo coastal forest areas (Figure 47). The educational talks were provided by members of our staff Glenis Padilla Plaza and Miguel Viqueira Ríos and these sessions lasted one hour. The topics taught included a full description of the restoration activities done in Tamarindo and their rationale, the biology and management actions of the Sapo Concho, the importance of sand dunes, the role of native trees in the coastal areas, the importance of implementing Best Management Practices and Green Infrastructure, and awareness about climate change impacts and ways to counteract these challenges. In addition, our team, in coordination with local experts and collaborators gave an interpretative tour of Tamarindo Beach with 13 visitors from the University of Puerto Rico,

Figure 46. Educational talks at Escuela Vocacional Técnica in Yauco.

Figure 47. Miguel Viqueira teaching students the importance of native trees.

Rio Piedras Campus and the Puerto Rico Tourism Company (Figure 48). We dedicated six hours to walk within the project site and forest trails describing the different natural elements that make the area unique and ecologically valuable. We also highlighted the importance of native trees, reforestation efforts as well as dune restoration actions for the conservation of the Puerto Rican Crested Toad. In addition, during the "***2nd Symposium of Dry Forests***" that took place from the 26 to the 28 of January 2016 at the Forest's Visitor Center PDC conducted three environmental talks about the importance of coastal ecosystems in Tamarindo to approximately 200 students from the Agripiña Seda Middle School of Guánica (Figure 49). These talks lasted 30 minutes. Throughout the entire project duration PDC reached out directly to approximately 325 students and community members. So far PDC

Figure 48. Interpretative tour in Tamarindo Beach.

Figure 49. Eloy Martínez, Management Officer from the Guánica Dry Forest welcoming volunteers to the Forest.

has reached out to more than 30,000 Facebook users who viewed PDC posts regarding the reforestation events and project progress.

Follow up visits to ensure proper maintenance and evaluate functionality

Monthly visits were conducted to ensure that the practices installed were working properly, particularly after rain events. Problems encountered were fixed during this period. We have also removed any unnecessary temporary measures installed after the site was fully stabilized and restoration activities were completed. During this period plants planted were irrigated and grasses and vines were removed to help in the plant survival. After each planting section was finished a periodically irrigation process begun. A water truck equipped with special irrigation components was used for the irrigation and maintenance component of the project. Any tree with unhealthy growth during the irrigation and maintenance period was replaced. These implementation efforts mark a paradigm shift in the historic usage of the area. In order to ensure the longevity of the practices, proper use by visitors and make it a successful we will maintain a coordinated management and maintenance of the areas with the DNER and local volunteers as part of our Co-management Agreement of the area (Figures 50).

Figure 50. Volunteer groups during maintenance and irrigation activities.

Crested Toad Habitat Restoration for Climate Change Adaptation Playa Tamarindo, Guánica Dry Forest, Puerto Rico

Tamarindo, located in the Guánica State Forest International Biosphere Reserve, is an important coastal ecosystem that faces severe threats, despite it being considered critical habitat to the endangered Puerto Rican Crested Toad or Sapo Concho (*Peltophryne lemur*) that breeds in seasonal ponds formed during the rainy season. For decades, during the dry season, the pond was used as parking lot due to the high visitation and intense public use of the area. During the rainy season, the Department of Natural and Environmental Resources (DNER) closes the parking lot to vehicular access. Threats to the coastal forest and natural sand dunes have been addressed, but the exposure of this natural seasonal pond, mainly associated with intense public usage and the lack of public knowledge, still require attention.

Protectores de Cuencas, Inc. (PDC) with the design of Wetland Expert, Thomas R. Biebighauser and the collaboration and technical assistance from the Puerto Rico Department of natural and Enviromental Resources and the US Fish and Wildlife Service created two artificial breeding ponds distantly located from the path of visitors that will allow additional secure breeding ponds that could be easily accessible for monitoring but distant from everyday visitors, while assuring the species reproduction and juvenile survival. Additionally, with the forecasted rise in sea level as a result of climate change, breeding ponds located farther inland could provide the only accessible breeding location within the Guánica State Forest. Ultimately, these conservation measures will help ensure the species' survival in the long term (Figure 51).

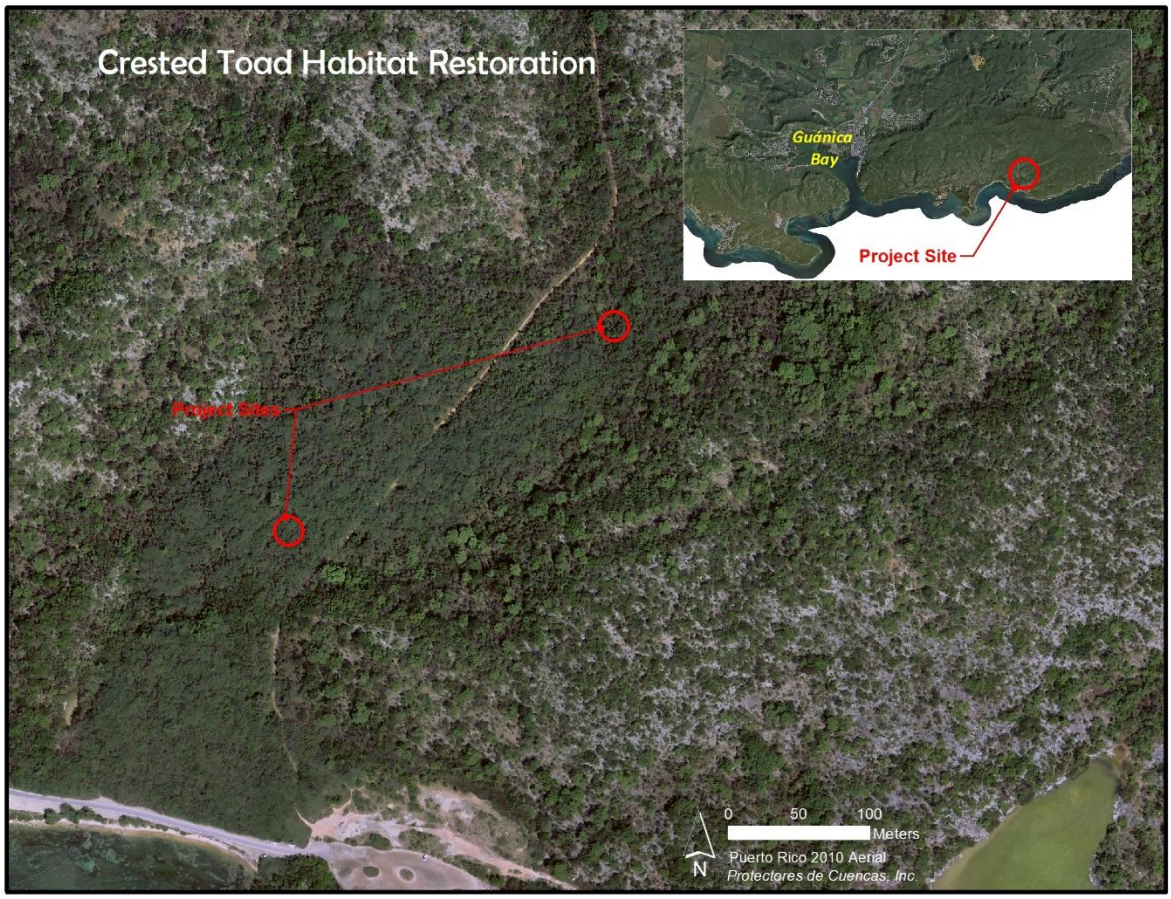


Figure 51. Map of the site locations for wetland construction.

Based on our field evaluations, recommendations and technical assistance from site visits, we conducted the following restoration components at Playa Tamarindo. These are discussed in detail in the following sections of this report. The implemented components are as follows:

1. Conduct a land survey and create a schematic design.
2. Establish temporary erosion and sediment control practices.
3. Prepare site and construct ponds.
4. Reforest with native species vegetation and rehabilitate habitat.
5. Follow up visits to ensure proper maintenance and evaluate functionality.

Tamarindo is located within the jurisdiction of the Guánica State Forest International Biosphere Reserve. Tamarindo is a very important coastal ecosystem that faces severe threats including intense public usage, coastal erosion, deforestation, climate change impacts such as sea level rise and inappropriate solid waste disposal, among others. This area is considered critical habitat to the endangered Puerto Rican Crested Toad or Sapo Concho (*Peltophryne lemur*) that breeds in seasonal ponds formed during the rainy season. There may be over two years between breeding events, depending on the frequency of storms. Tamarindo, together with the adjacent seasonal fresh water lagoons such as Atolladora and Aroma, represent the most critical areas for the reproduction of the only natural population of the Puerto Rican Crested Toad.

Outside breeding events, the Sapo Concho can be difficult to detect as it relies on its ability to camouflage, small holes and crevices to avoid detection. In forested areas, such as the Guánica Dry Forest, the Sapo Concho has been found to climb up trees and rocks to find holes where to hide during the daytime. The Puerto Rican Crested Toad is listed as an endangered species protected under the Endangered Species Act. Additionally, the Guánica State Forest is home to other species protected by the Endangered Species Act, such as the plant *Eugenia woodburyana* and the Puerto Rican nightjar (*Antrostomus noctitherus)*.

Public access to Tamarindo has compromised the natural ephemeral ponds as visitors park in them and hike to the beach. When a reproductive event occurs, most people are not aware of the presence of tadpoles and small toads in the ponds and consequently step on them on their way to the beach, killing potential survivors of this endangered species. Another threat to the survival of this species is the loss of the natural sand dunes caused

by the intensive and unorganized public use, and potentially to sea level rise. The Sapo Concho can tolerate up to 6 PPT of salinity for the eggs to fully develop. During storm events, high swells reach the reduced sand dunes affecting the area by increasing the salinity of the ponds.

Recently, Protectores de Cuencas received funds to restore the coastal forest area of Playa Tamarindo through an educational program and by implementing cost effective green infrastructure techniques to conserve this unique ecosystem. This project was completed in March 2016 and included the reforestation of approximately 7,200 m^2 of coastal forest area, the rehabilitation of over 4,100 m^2 of sand dunes and beach berm, the installation of a series of boardwalks to delimit sand dunes and coastal vegetative zone as well as to protect the Sapo Concho reproduction basin. Before this project was implemented, Playa Tamarindo lacked adequate delineation of the coa stal vegetative zone and the dunes that existed naturally in the area in past decades had been lost due to the use of the area by visitors, forest fires, lack of proper management, among other factors.

This project was made possible thanks to the efforts and funding of US Fish and Wild Life Service, Department of Natural and Environmental Resources, Association of Zoos and Aquariums and the Municipality of Yauco (Figure 52).

Figure 52. Images of work completed during wetland creation activities.

BMP workshops for public workers and local contractors

This project provided for the personnel of the municipal public works departments of the municipalities of Cabo Rojo, Lajas, Guánica and Yauco as well as their respective contractors to be trained in BMP's implementation. For this task, a series of theoretical and practical workshops were held on appropriate practices in the handling of heavy equipment, earth moving and the installation of barriers, both temporary and permanent, for sediment and erosion control (Figure 53).

The workshops were directed to public officials who operate heavy equipment, municipal contractors and employees from other branches such as brigades of ornamental, emergency management, sports and recreation and recycling officers. The main purpose of these workshops was to provide the necessary tools to public officials who carry out the maintenance, preparation and cleaning of areas that involve dirt movement and vegetation removal. These workshops were also open to other people involved in land-disturbing activities and who are agency consultants. The main objectives were to; raise awareness of the impacts of sediments on water bodies and marine ecosystems and the need to implement sediment erosion controls; Develop techniques that involve the use of physical conditions present in the work area to reduce the impact of erosion; Familiarize the participants with the use of economically viable techniques for sediment and erosin control that can be carried out using existing terrain conditions; Familiarize the participants with the correct process of installation of the most appropriate erosion and sedimentation control practices.

Figure 53. Workshop activities on PDC premises in Yauco.

INSTITUTIONAL CAPACITY BUILDING

After two years of the coordination position was created, work began on the idea of building a watershed based community nonprofit organization that would adopt the endeavor of coordinating the implementation of the GB/RL Watershed Management Plan. In January of 2012 Protectores de Cuiencas, Inc. was born. Since its beginning, PDC has adopted the plan as the main guiding document for management in the GB/RL Watershed. PDC has been able to leverage funding and gather partners that have secured additional funding sources to deal with the main sources of pollution in the watershed derived from coffee farms dirt roads as described in the Watershed Management Plan, for monitoring, for BMP implementation, for pollution tracking and implantation of stormwater practices.

With the help of a capacity building grant from NFWF, PDC was formalized, a Board of Directors was created and IRS 501c(3) exempt status was achieved. Late in 2014, also with a grant from NFWF, PDC built three nursery/greenhouses of 100' x 36' to produce native plant materials for the ongoing restoration projects. So far PDC has produced more than 100,000 native plants for restoration projects across the archipelago of Puerto Rico. Nonetheless, (PDC), led by the RL/GB Watershed Coordinator, Roberto Viqueira, has taken the responsibility to implement the plan and to search for new sources of funding to implement the Plan's recommendations. PDC is also working in strengthening and establishing new partnerships with local municipalities, universities, community groups such as the Guánica Lagoon Pro- Restoration Committee and the Coalition Pro-Guanica Dry Forest, and federal agencies like the U.S. Fish and Wildlife Service (USFWS). Furthermore, PDC, have accomplished the establishment of a Co-management Agreement with the PR

DNER for the administration of the Guánica Dry Forest, an important protected area located within the RL/GB watershed's jurisdiction. This initiative represents a big step forward as PDC becomes a stronger and influential stakeholder for conservation and management of natural resources in the watershed and the region.

As a result of the experience gained in the implementation of the GB/RL Watershed Management Plan, PDC have been able to expand the Guánica model to other key priority coral reef conservation areas. Currently PDC is working in the development of several watershed management plans for the Northeast Corridor and Fajardo River watersheds

Acceleration of Watershed Restoration Efforts in Puerto

With a grant from NFWF and the collaboration of the Yauco Municipality, PDC built three nursery/greenhouses of 100' x 36' to produce native plant materials for the ongoing restoration projects (Figure 54). So far PDC has produced more than 100,000 native plants for restoration projects across the archipelago of Puerto Rico (Figure 55). Then main purpose of this project was to be able to accelerate and sustain short and long-term watershed conservation and restoration efforts in Puerto Rico. through the production of a nursery/green house. This project increased capacity building for the sustainability of future conservation efforts. PDC is now able to grow their own plants for restoration purposes and will no longer have to limit restoration efforts upon availability of plant material in the nurseries of the Department of Natural and Environmental Resources (DNER) or other partners. These species of trees are typically very difficult to obtain commercially.

The production of these trees and plants have decreased the costs of all restoration efforts led by PDC. Two years ago, the Municipality of Yauco donated approximately 1 acre for PDC to establish the nursery/greenhouse including water and electric services. Recently, another 2 acres of adjacent grounds were donated by the Municipality of Yauco to expand the available space to grow and store the plants, including a maturation station necessary to acclimate plants to the intense weather conditions found at some of the restoration project sites. Agreements with neighboring schools have helped us gather volunteers that helped with the collection of seeds as this activity is linked to the Environmental Education Program activities. Students also help maintain plant production and plantings.

Environmental Education Program Activities have integrated communities, coffee farmers, and school children in an environmental education program at the nursery/greenhouse and incorporated them in the already mentioned ongoing and new restoration projects.

Figure 54. Google Earth 2014 image (top) of the area donated by the Yauco Municipality before the nursery was constructed and a recently Drone image (bottom) showing constructed nurseries and maturing area.

Figure 55. Images during construction of the nurseries followed with educational activities and actual plant material produced.

Campus Expansion Project Sediment and Erosion Control and Landscaping Installation & Maintenance at Sartorius Stedim Biotech Yauco, Puerto Rico

Protectores de Cuencas, Inc. (PDC) was contracted by the biotechnology company Sartorius Stedim to implement sediment and erosion control practices trough Hydroseeding during construction in their new Plant Expansion (Figure 56). After construction is completed it is expected that PDC will to provide services for Landscaping and long-term maintenance activities and operations.

Figure 56. Images during Hydroseeding implementation of Sartorius Plant Expansion Project in Yauco Puerto Rico.

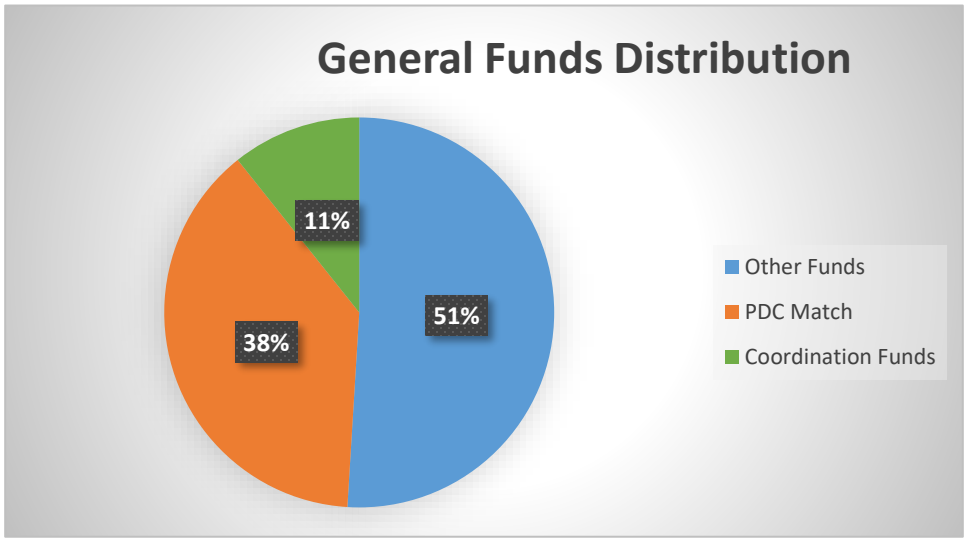
SUSTAINED WATERSHED MANAGEMENT

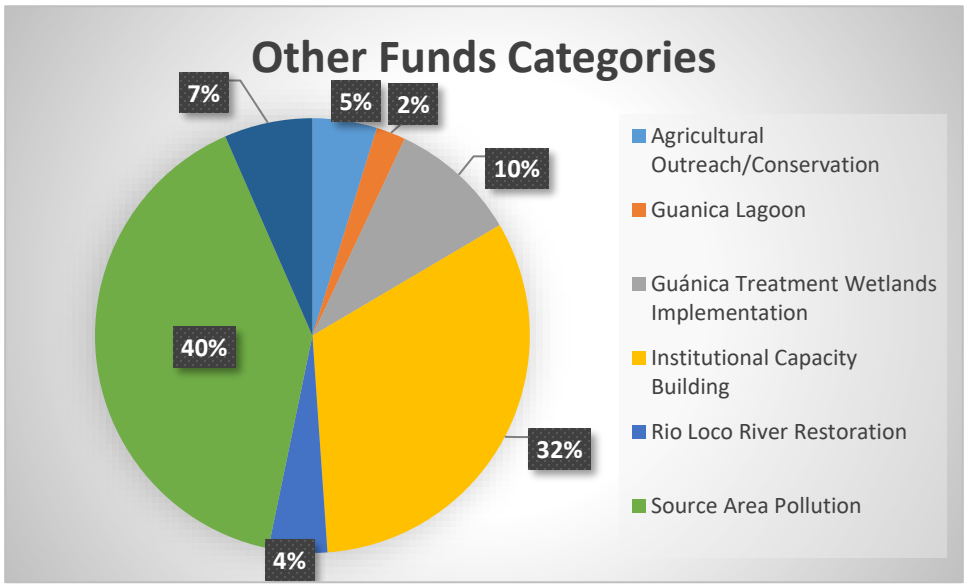
With the help of PDC the Guánica Watershed Coordinator has been able to leverage funding and gather partners that have secured additional funding sources to deal with the main sources of pollution in the watershed derived from coffee farms dirt roads as described in the Watershed Management Plan, for monitoring, for BMP implementation, for pollution tracking and implantation of stormwater practices. From 2012 to 2017 PDC has received from NOAA through different contractual mechanisms a total of $330,500.00 for coordination related activities for the implementation of the GB/RL WMP. With the coordination fuds PDC has been able to secure and additional $1,572,991.92 through efforts that include Federal Grant Funds, State Funds, Foundations, Donations and Private Sector. In addition to this funds PDC estimates and in-kind contribution of $1,017,500.00 from a variety of partners that includes, PDC, Municipalities, private sector, Volunteers, State Government and other non-federal partners (Table 3 and 4 and Graphs 1-3).

Table 3. Summarized PDC's GB/RL Watershed Funding Sources History (2012-2017)

Source	Fed Funds	In-kind
Guanica Watershed Coordination	$ 330,500.00	$ 165,250.00
Other Funds	$ 1,572,991.92	$ 1,017,500.00
Total Funds	***$1,903,491.92***	***$1,182,750.00***

Graphs 1-3. Graph 1 (top) shows distribution of leverage funds compared to Coordination funds. Graph 2 (middle) divides the different categories of funding sources based on Coordination efforts tasks. Graph 3 (bottom) categorizes leverage funds by the entity were funds come from.





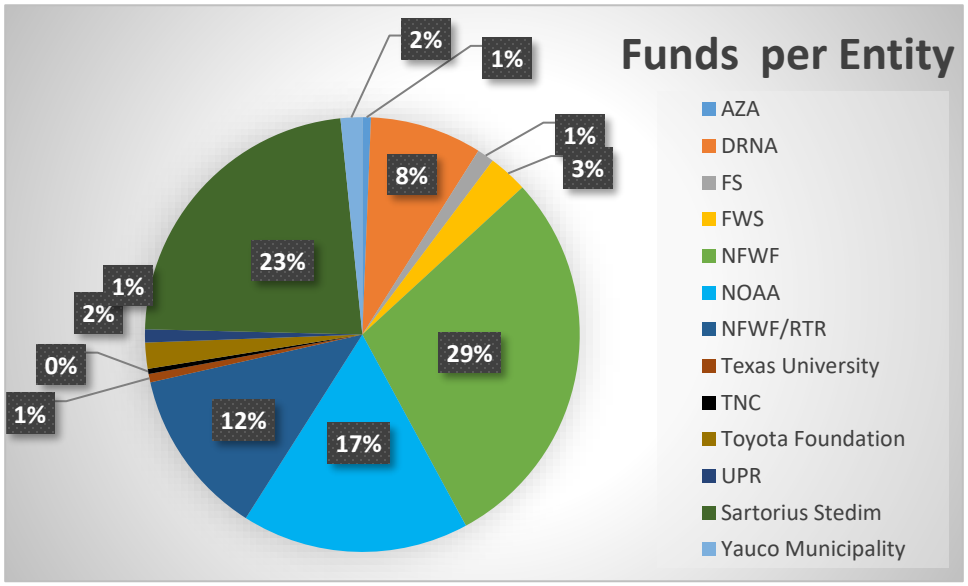


Table 4. Detailed PDC's GB/RL Watershed Funding Sources History (2012-2017)

Project Title	Entity	Funds	Match	Category
"Organizational Capacity Building for Guanica Watershed"	NFWF	$ 78,000.00	$ 78,000.00	Institutional Capacity Building
"Restoration of Vegetation Buffers Along Coastal Areas to Mitigate Erosion and Sediment Discharges into Nearshore Seagrass Habitats in Guánica Bay"	NFWF	$ 150,981.32	$ 96,973.00	Source Area Pollution
"Continuation of Restoration Efforts in the Río Loco Watershed: Tracking Pollution Sources into the Urbanized Area of Yauco, Puerto Rico"	NFWF	$ 70,000.00	$ 70,121.00	Source Area Pollution
"Acceleration of Watershed Restoration Efforts in Puerto Rico"	NFWF	$ 77,985.60	$ 78,350.00	Sustained Watershed Management
"Reduction and Control of Sediment-Laden Runoff at Playa Jaboncillo, Guánica Puerto Rico"	NFWF	$ 77,985.00	$ 78,350.00	Source Area Pollution
"Community Outreach and Coastal Restoration at Tamarindo Beach, Guánica Dry Forest, Guánica Puerto Rico"	Toyota Foundation	$ 15,367.00	$ 12,713.00	Source Area Pollution
	Toyota Foundation	$ 15,100.00	$ 55,715.00	Source Area Pollution
	USFS	$ 20,000.00	$ 12,000.00	Source Area Pollution
	USFWS	$ 20,734.00	$ 21,930.00	Source Area Pollution
"Expanding Conservation/Sediment Control Practices in Priority Farm Areas of the Guánica Bay Watershed"	NOAA	$ 75,400.00	$ 76,610.00	Agricultural Outreach/Conservation
"Rio Loco Structure Removal"	DRNA	$ 68,546.00	$ 34,273.00	Rio Loco River Restoration
"Quantifying Economic Benefits of Guánica Lagoon Restoration Resulting from increased Ecological Services and Benefits to Nearshore Reefs"	DRNA	$ 34,500.00	$ 6,000.00	Guanica Lagoon
"Crested Toad Habitat Restoration for Climate Change Adaptation at Playa Tamarindo"	AZA	$ 10,000.00	$ 3,000.00	Institutional Capacity Building
	DRNA	$ 10,000.00	$ 2,700.00	Institutional Capacity Building
	FWS	$ 25,377.00	$ 18,500.00	Institutional Capacity Building
"Stabilizing highly erodible sites in the Guánica Watershed: Implementation and capacity building"	NOAA	$ 122,000.00	$ 61,000.00	Source Area Pollution
"Think before you drop it: A Research based Litter Reduction Campaign in Nine Beaches of Guanica, Puerto Rico"	NOAA	$ 68,640.00	$ 68,640.00	Source Area Pollution
"Sediment and Erosion control workshop for public workers"	DRNA	$ 18,000.00	$ 9,000.00	Institutional Capacity Building
"Human Impacts to Coastal Ecosystems in Puerto Rico (HICE-PR): A remote sensing, hydrologic, ecologic and socio-economic assessment with management implications"	UPR	$ 15,382.00	$ 7,691.00	Source Area Pollution
"Hydroseeding Recreational and public use areas"	Yauco Municipality	$ 25,320.00	$ 120,000.00	Sustained Watershed Management
"Assessment of Soil Erosion in Coffee Plantations Guánica Watershed"	Texas University	$ 9,868.00	$ 4,934.00	Source Area Pollution
"Guánica Treatment Wetlands"	NFWF/RTR	$ 150,000.00	$ 75,000.00	Guánica Treatment Wetlands Implementation
"Development of a social media educational campaign in Guanica Watershed"	TNC	$ 6,000.00	$ 3,000.00	Institutional Capacity Building
"Campus Expansion Project Sartorius Stedim Biotech Yauco"	Sartorius	$ 361,806.00		Institutional Capacity Building
"Implementation of Stormwater Practices in Guanica"	NFWF/RTR	$ 46,000.00	$ 23,000.00	Source Area Pollution
	Totals	***$1,572,991.92***	***$1,017,500.00***	

RECOMMENDED INTEGRATED WATERSHED MANAGEMENT ACTIONS

If Coordination funds were to be available for the following years we recommend continuing with the following tasks for the selected priority categories. With these priories established, PDC can work with partners to identify additional funding sources for the implementation of the recommended integrated watershed management actions (Table 5).

Table 5. Summarized Recommended Integrated Watershed Management Actions

Category	%	Tasks
Institutional Capacity Building	10%	1. Reincorporation of Coral Farming and coral restoration on the MPA of Guánica. 2. Incorporation of marine restoration activities like seagrass beds restoration and mangrove restoration for coastal resiliency and climate change adaptation. 3. Combine all monitoring efforts in the watershed into a reference data document. 4. Continue efforts with Dr Carlos Ramos Sharon to monitor BMP effectiveness on coffee road stabilization. 5. Restore areas of coastal forest impacted by forest fires to reduce soil erosion and implement coastal stabilization practices.
Source Area Pollution	20%	1. IDDE detection and elimination of illicit discharges and door-to-door surveys of areas where water pollution is persistent to determine whether homes are properly connected to sewer or whether they have failing septic systems. 2. Continue with sediment and erosion control workshops for the municipalities, PRASA, DNER and private contractors. 3. Dirt road stabilization on nearshore hillsides west of Guánica Bay 4. Continue to expand the Coastal Stabilization efforts to other priority areas west of the Guánica Bay. 5. Continue the implementation of soil stabilization trough Hydroseeding techniques. 6. Implementation of stormwater practices un the urban areas of the municipalities of Yauco and Guánica and on the communities adjacent to the Lajas Valley.

Sustained Watershed Management	10%	1. Continue efforts for the implementation of ecotourism activities in the GDF trough h the co-management agreement with the DNER. 2. Continue to foster conservation agreements with the private sector for additional potential funding sources.
Agricultural Outreach/Conservation	20%	1. Coffee Farm Dirt Road Stabilization in the Luchetti and Prieto subwatersheds. 2. Implementation of agricultural BMP's on the main tributaries od Río Loco.
Rio Loco River Restoration	10%	1. River bank stabilization with the implementation riparian buffers. 2. Tributaries restoration and debris removal.
Guanica Lagoon	20%	1. Coordination with the Puerto Rico Government for public policy implementation towards the transfer of the Lagoon lands to the DNER 2. Identify Funding sources for the environmental compliance process
Outreach and Education	5%	1. Implementation of a social marketing campaign trough out the watershed for forest fire prevention, trash prevention of rivers and tributaries, and coral reef conservation importance. 2. Social marketing 3. Foundation of conservation chapters of PDC on various schools on the coastal and mid subwatersheds.
Guánica Treatment Wetlands Implementation	5%	1. Identify funding sources to monitor the effectiveness of the implemented treatment wetlands as well as for maintenance.
	100%	