

R I D G E T O R E E F S /  
P R O T E C T O R E S D E  
C U E N C A S

*Restoration and Implementation Efforts in Culebra*



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## Introduction

Culebra is a small island off the northeast coast of Puerto Rico. It is home to 1,900 residents and is 11.6 square miles in area including the small adjacent uninhabited islands of Culebrita, Cayo Norte and Luis Peña. Culebra is a destination for tourism due to its beautiful white sandy beaches, beautiful vistas, coral reefs and marine life reachable from shore. Culebra is home to some of the healthiest coral reefs in Puerto Rico, as well as a significant population of resident and breeding sea turtles. Even today many of the reefs remain in good condition, bolstered by coral farming and restoration efforts. Despite this, impacts to the reefs and marine resources are becoming more pronounced due to increasing global and local stressors. As a result, Culebra is one of the top priorities for coral reef protection and coastal management in Puerto Rico and is a main driver for the watershed planning process (DRNA, 2013) (NOAA, 2009).

In previous studies by Ramos, Hernandez and Amador, unpaved roads have been identified as the major source of sediment transport to nearshore reefs in Culebra, PR as well as other locations in St. John, USVI. As a result the goal of our project is to directly reduce sediment loads by implementing erosion and sediment transport BMPs on high priority unpaved roads and bare soils within Culebra.

This report summarizes our efforts under a NOAA Task Order in 2012-2013 to stabilize bare soils and pollution sources in Culebra. The efforts for the fiscal year have included:

1. the **emergency stabilization of an arroyo channel** that was cleared prior to the rainy season in the Fall of 2012. The clearing by the municipality was close to 2 miles in length and exposed 2.75 acres of bare soil to potential erosion and runoff during storm events. If those bare soils would have been impacted by the rainy season an estimated 10 tons of soils could have been transported to the nearshore waters and then out to the nearshore reefs. The site was stabilized to achieve greater than 95% vegetative cover.

**Landowner:** Municipality of Culebra

**Maintenance Agreement:** with the Municipality of Culebra to maintain the site; cutting the grass to 4-6 inches to promote healthy root growth and full stabilization; also grass cutting helps reduce woody vegetation that can occupy the channel and reduce conveyance during large flows including hurricanes and tropical storms. The Municipality also committed to not clearing the arroyo channel again down to the bare soil.

**Permitting:** No permitting was required for this project as it involved stabilization

2. **Maintenance of stabilization efforts for unpaved roads in Punta del Viento Estates** - Punta de Viento Estates is a large private large lot subdivision in Culebra, PR. Maintenance on approximately one half mile of road including approximately 20 rock check dams, 2 inlet and outlet protection, and 2 cross swales. A large gully was also reinforced in an area where a new channel was being cut through a dirt

embankment and dropping 15-20ft creating downstream sediment transport. Approximately 1/2 ton of sediment was also removed from behind the check dams.

**Landowner:** Punta de Viento Estates Homeowner's Association.

**Maintenance Agreement:** A verbal maintenance agreement was established under a previous project led by Greg Morris Engineering. This was renewed by our team and we spent considerable time educating the HOA president.

**Permitting:** No permitting was required for this project as it was beneath the disturbance thresholds for erosion and sediment control (that said the work involved the implementation of ESC practices on an on-going source of sediment -dirt roads).

3. The **Tamarindo project** stabilized bare soil along the road to Tamarindo Beach as well as in the dirt parking lot at Tamarindo beach and addressed runoff from the adjacent roads and parking lots. The project also created 4 rain gardens at swale crossings and reforested the marine buffer area (the project summary and details is attached in Appendix 1 due to its size). The project resulted in the planting of over 580 native plant species and over 1400 vetiver plants. The project also leveraged over \$45,000 in match in labor, watering and plants and addressed a major sediment source to one of the healthiest coral reef systems in Culebra part of Luis Pena Marine Reserve and home to an important *Acropora cervicornis* coral farming project.

**Landowner:** Puerto Rico Department of Natural and Environmental Resources (DNER)

**Maintenance Agreement:** A maintenance agreement was established with the Municipality of Culebra ACDEC (Development and Conservation Authority).

\*Though the local community has been very active in the maintenance, watering and upkeep and is doing 95% of the work. The community groups and individuals including (Coralations, Abby's School, Culebra Island Adventures and Tomas Ayala) assisted with watering and maintenance for the first two months so that plants could become established. The community continues to perform the maintenance on the project led by Tomas and the Municipality. In addition, four months of adaptive management was performed by the project team, including the planting of over 300 additional vetiver plants to attenuate all runoff from the adjacent parking lot and roads as well as other tweaks. 580 native plants and 1400 vetiver plants total were utilized to minimize the need for long-term maintenance associated with more structural restoration projects.

**Permitting:** The project did not require permits but a MOU was established with the Puerto Rico Department of Natural and Environmental Resources (DNER) in order to construct the project on DNER land. The project was beneath disturbance thresholds for ESC in Puerto Rico and resulted in the stabilization of bare soils and treatment of stormwater using bioengineering techniques. Over 150ft of silt fence was used at the site despite not being mandated and a strong storm passed the first night the project was initiated and we were able to capture all the sediment from the storm.

Implementation Project Summary

<b>Table 1. Project Implementation Summary</b>			
<b>Component</b>	<b>Project 1</b>	<b>Project 2</b>	<b>Project 3</b>
<b>Name</b>	<b>Arroyo Stabilization</b>	<b>Maintenance in Punta de Viento</b>	<b>Tamarindo Project</b>
<b>Landowner</b>	Municipality of Culebra	Private HOA	DNER
<b>Maintenance Agreement</b>	Municipality of Culebra	Verbal	*Municipality of Culebra (ACDEC)
<b>Permitting</b>	Not needed	Not needed	Not needed but MOA established with DNER to construct project on DNER land
<b>Accomplishments /Metrics</b>	2.75 acres of bare soil stabilized in arroyo channel Reducing an estimated 10 tons of soil that could have been lost in the rainy season Restored to >95% vegetative cover	Maintenance on approximately 1/2 mile of road including 20 check dams, 2 cross swales and 2 inlet and outlet protections	Created 4 rain gardens at swale crossings; Reforested 1/2 acre of marine buffer area; Planted over 580 native plant species and over 1400 vetiver plants; addressed runoff from over 0.80 acres Greater than 90% survival rate of plants
<b>Match</b>	\$20,000.00	None	\$46,750.00
<b>NOAA Funds</b>	\$25,628.30	\$2,500	\$43,976.36
<b>Total</b>	\$45,628.30	\$2,500	\$90,726.36

## Project #1 Hydromulching the Arroyo Channel

The effort to stabilize the bare soil associated with the arroyo channel came about as a result of community concern and distress associated with the clearing of the formerly vegetated channel (photo on cover) and the prospects of tons of sediment being transported to the Bay and nearshore coral reefs in Culebra. The work entailed planning the hydromulching of the channel, coordination of water trucks, transport of several tons of material to the island as well as coordination of labor and personnel from the municipality and permission to complete the work. The project resulted in the stabilization and revegetation of over 95% of permanent vegetation with the exception of some side slope areas damaged by chickens.

The project was carried out with the support of the Municipality, the public works department, and PR Sewer and Water Authority (PRASA). The municipality provided its employees and laborers to assist with the project and PRASA supported the project with its water truck and driver and even continued to water after our team left. The support helped us reduce costs to NOAA from \$10,000/acre for hydromulching (does not include travel to a remote island). The partnership also helped to forge a strong relationship between the project team and the municipal employees and also helped to educate the public works and municipal staff on the importance of stabilizing and not creating bare soils.

The following pictures show the sequence of stabilizing bare soils as it took place.



**Figure 1. Precondition -- bare soils and slopes**

Table 2. Arroyo Channel Stabilization Costs		
Cost	Description	Amount
Upfront Coordination	Budgeting; Travel and coordination with municipality, PRASA and NOAA	\$1,838.35
Hydroseeding materials and equipment	hydromulching materials and equipment rental costs	\$7,782.00
Travel	Travel, lodging and per diem	\$1,967.85
*Personnel and Labor	Technical and Labor staff	\$14,050.00
<b>Total</b>		<b>\$25,638.20</b>

**\*Note: personnel and labor costs also reflect the need to keep personnel and equipment in Culebra in order to perform watering (twice a day) and also to return to the island to ensure successful re-stabilization and help direct watering by PRASA and the municipality in this very hot and dry climate (watering often takes place for a full month post hydroseeding)**



**Figure 2. More bare soils and slopes**



**Figure 3. Hydromulching initiation**



**Figure 4. Hydromulching Initiation**



**Figure 5. Hydromulch completion**



**Figure 6. More stabilization: note hungry chickens eating seed**



**Figure 7. Post stabilization -- note challenges with side slopes**



**Figure 8. More post-stabilization**



**Figure 9. More stabilization -- note tire tracks from watering truck as there was not other access to the channel in this location**



**Figure 10. Further downstream - post stabilization**



**Figure 11. Lowest section adjacent to airport**

**Project #2. Maintenance of the Unpaved Road Stabilization Areas in Punta del Viento**

The Feb/March 2013 maintenance work associated with dirt road stabilization in Punta del Viento Estates is follow up from work performed in June of 2012. We have determined that an appropriate maintenance schedule for road stabilization efforts should be 3 times per year (twice in the rainy season and once in the dry season) -- perhaps with some additional checks after major storm events. The work performed entailed excavation of additional storage behind check dams, cleaning out of check dams that retained a lot of sediment, stabilization of existing outfall area with stone, ensuring all check dams were properly formed so that they are focusing flow in the channel as well as retaining sediment and building up a berm that were uncontrolled runoff was flowing down a hillside and creating erosion.

As mentioned this work is follow up from May and June of 2012: 1) a training with machine operators that included a background presentation on sediment and other stressors that impacts reefs with specific examples throughout Puerto Rico and a presentation on the methods to control erosion from unpaved roads; 2) on-site training and implementation of a erosion and sediment control techniques for unpaved roads in the community of Punta del Viento Estates. Participating in the work were 8-10 machine operators, Culebra Public works staff and a major developer on the island with oversight and coordination from GLM COOP, Protectores de Cuencas and Ridge to Reefs.



**Figure 12. Backdrop of road stabilization efforts**

Maintenance of structures including check dams and cross swales are critical to continue sediment reductions in the Punta del Viento Estates subwatershed areas. There were many check dams that were full of sediment and one even was used by a contractor or homeowner to empty/clean out a cement truck. The maintenance effort was focused on reducing the sediment and concrete in one case from behind the check dams. This effort will allow for the further accumulation/storage of additional sediment behind the check dams and also reduces the runoff velocity. An initial verbal agreement was negotiated with Punta de Viento Estates for the on-going maintenance of the practices in the earlier project led by Greg Morris Engineering and a verbal agreement was secured by the project team with the existing president of the homeowner's association. However, a new homeowner's association president was elected after our maintenance project and coordination has been much more difficult as he is seldom on island. In addition, it had taken at least 5 hours of one-on-one education and field visits with the previous HOA president to get him up to speed on the importance of the project and the techniques used. This underscores the issue of dirt roads which needs to be addressed island-wide in Culebra and maintenance procedures and requirements should be established. Long-term maintenance and dirt road standard requirements were a major recommendation in the watershed plan and efforts to improve these programs at the municipal level will be initiated with FY13 funds.



**Figure 13. Discussing the finer points of unpaved road maintenance**



**Figure 14 Illustrates excavation adjacent to a rock check dam**

**Details of original location of BMPs and those BMPs where we provided maintenance**

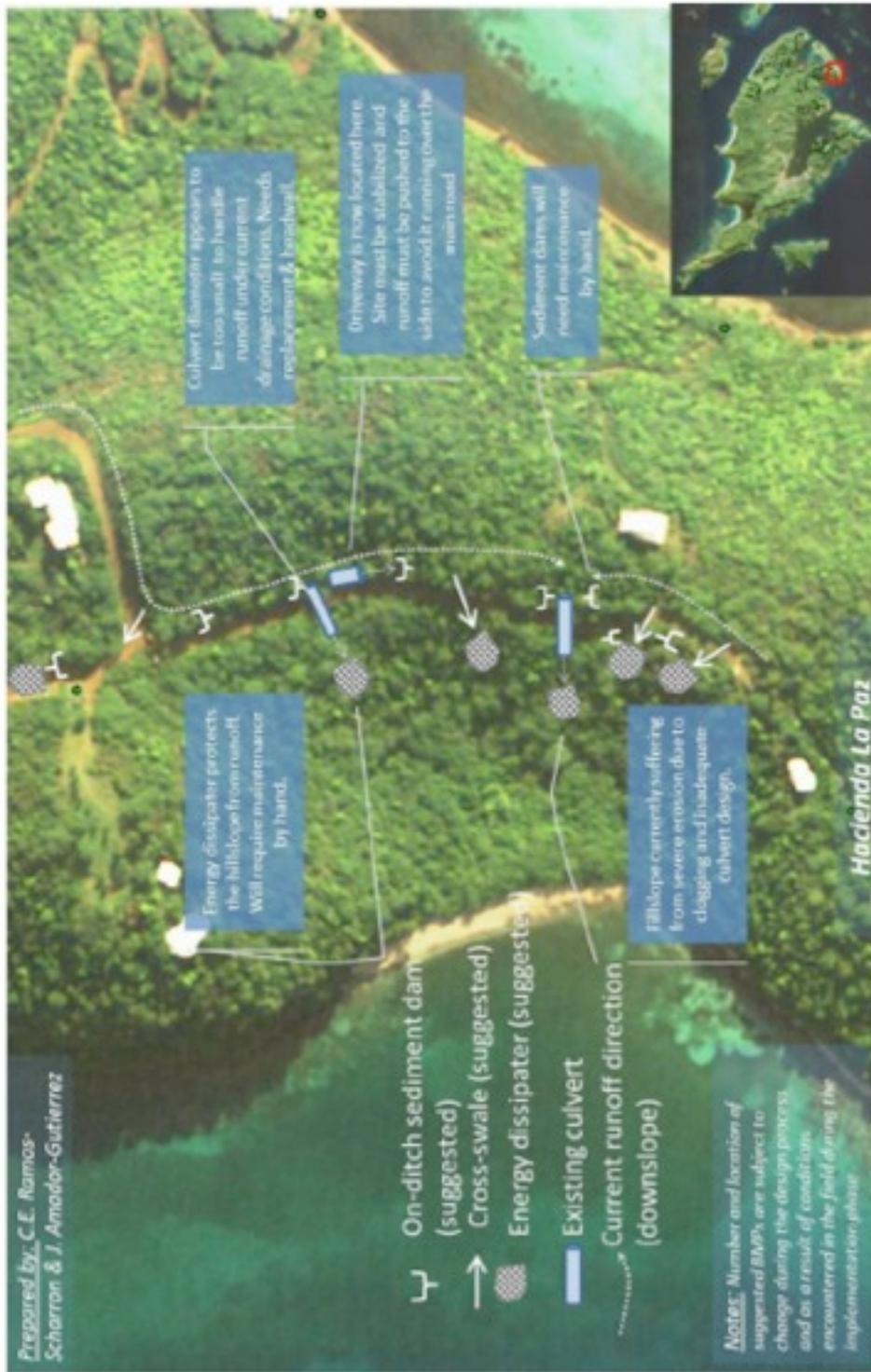


Figure 15. Restoration Site #1 and proposed practices



Figure 16. Restoration Site #2 and Proposed Practices

## **Training and Capacity Building**

- Training of backhoe operators continued as part of the maintenance activities in Punta del Viento
- Public works staff and PRASA personnel participated in the hydroseeding efforts; the restoration project in Tamarindo included over 100 volunteers from the Municipality, the community including schoolchildren their parents and teachers who learned about the importance and composition of coastal buffers and erosion control as well as how and where to plant native and erosion control species
- Tamarindo partners and participants also included local NGOs including Coralations and CESAM (Student chapter of a marine conservation society), Federal Agencies including NOAA and USFWS (provided plants, a green house and on-site coordination assistance) and PR Department of Natural and Environmental Resources staff that supported the effort through providing plants, local housing and coordination

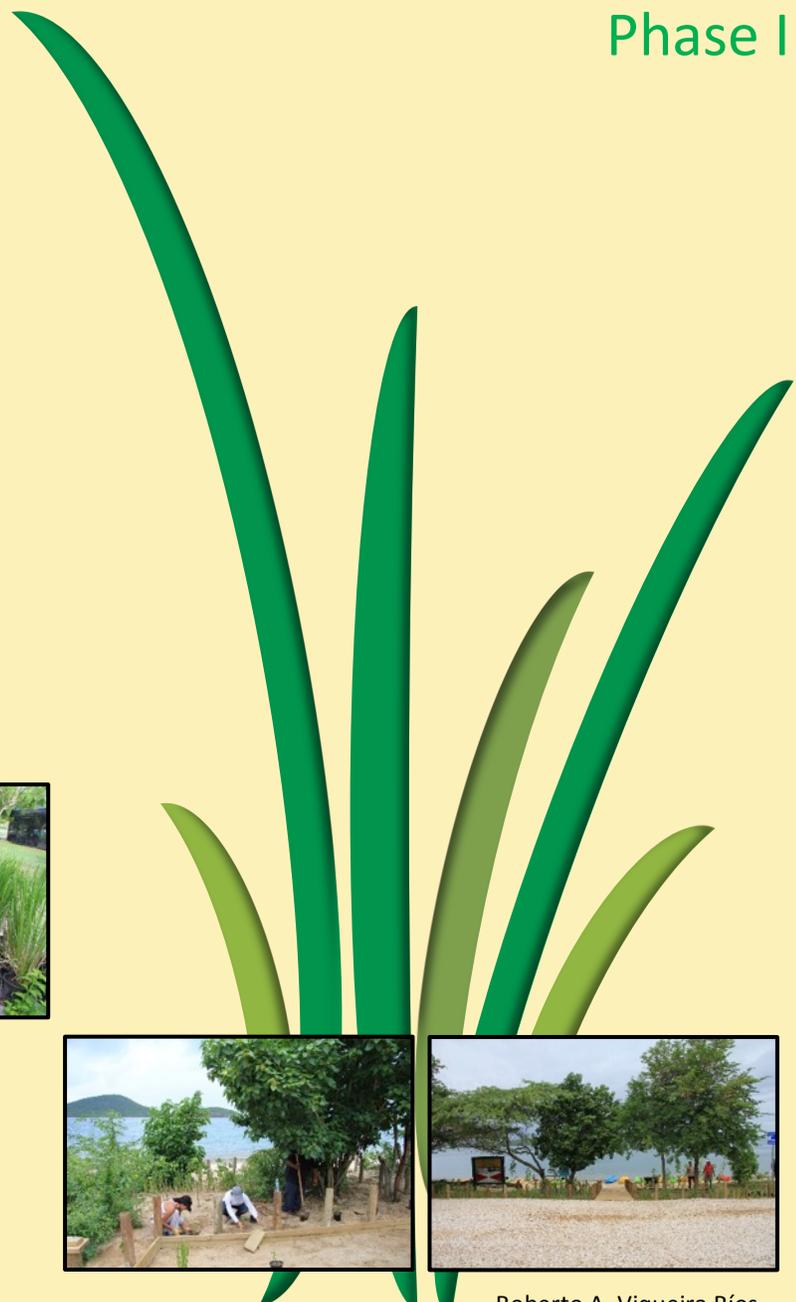
## **Lessons Learned and Challenges**

- Issues with chickens eating the grass seed used to stabilize the arroyo channel using hydroseeding -- particularly a challenge at the apex of the slope into the channel and the steepest parts of the bank where destabilization of the hydromulch material and seed is most vulnerable (over 100 chickens were rounded up with the community to reduce their impact on the restoration project)
- Watering in a dry and windy environment was a challenge in Culebra; often watering had to take place up to twice a day to promote germination and prevent desiccation of seeds.
- the drainage channel 'cleaning' practices such as in the arroyo channel are typical across Puerto Rico and are a very entrenched part of the mindset for municipalities who have suffered from flooding during hurricane season. Protectores de Cuencas and Ridge to Reefs are working with Department of Natural and Environmental Resources to provide training for other municipalities for environmentally sensitive channel maintenance.
- Maintenance standards for dirt roads and a mechanism to train and enforce maintenance and design standards is critical for long-term stabilization of dirt roads in Culebra. We will work to help address this issue in the next fiscal year.

## **APPENDIX 1. TAMARINDO IMPLEMENTATION REPORT**



# Environmental Restoration Project Playa Tamarindo Culebra, Puerto Rico Phase I



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December 2013

## Table of Contents

Contents.....	1
Executive Summary.....	2
Sponsors and Partners .....	4
Acknowledgements .....	5
Introduction.....	7
Project Description .....	10
Costs.....	26

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## Executive Summary

**A** pilot project was carried out from August 19 to August 23, 2013 as part of efforts to develop a ***Watershed Management Plan for the Municipality of Culebra*** (a small island off the coast of Puerto Rico). It is widely known that the degradation of coastal water quality as well as rising sea surface temperatures have caused a decline in the populations of coral reefs. This phenomenon is mainly due to the lack of sustainable management of sediment/bare soil, excess nutrients from agriculture, stormwater runoff and sanitary sewer leaks and overflows which are some of the main causes of the degradation of the marine ecosystems.

After several meetings with strong community participation, Playa Tamarindo was selected as the highest priority location due to concerns generated by erosion and sedimentation and impacts to the natural beach berm vegetation and high use. It was also possible for motor vehicles to illegally enter the beach and to impact the beach berm area. The beach berm was no longer vegetated and hence the loss of an important buffer from stormwater runoff. This was resulting in sediment and pollutant transport into this important marine ecosystem. The NGO (nonprofit) CORALations helped to select the site and provided an educational component by coordinating the participation of students from the Ecological School of Culebra in reforestation and coordination of irrigation of the restored vegetation.



Area affected by runoff associated to the parking, previous to the restoration project.



One of the goals was to address runoff from the adjacent roads and bare soil areas prior to being discharged to the marine environment. Another organization that assisted in the project in site selection and prioritization for restoration is the Society of Marine Environment (SAM) and its Student Chapter (CESAM) were able to demonstrate adverse effects on marine sedimentation and reefs from Playa Tamarindo over the years impacting their successful efforts to restore coral reefs in the area through its coral farming and out-planting efforts. In addition, Tamarindo is one of the healthiest reef systems accesible by land in Culebra and part of the Luis Peña Marine Reserve and therefore a high priority for restoration efforts in the watershed planning effort.

This project is also part of the **Sustainable Forestry Network**, Department of Natural and Environmental Resources Bureau coordinated through the Forest Service and Program initiatives Coastal Zone Management of Puerto Rico. The effort also has the endorsements of the Municipality of Culebra Conservation and Development Authority of Culebra (ACDEC). The latter is responsible for maintaining the facilities provided as part of the restoration as the vegetated areas. The project also had the endorsement of the Tourism Company of Puerto Rico. Funding for this project came from the Coral Reef Conservation Program of the National Oceanic and Atmospheric Administration (NOAA). The project was designed and implemented by nonprofit organizations Protectores de Cuencas, Inc. and Ridge to Reefs, Inc., with the cooperation and active participation of the community. Much of the labor for the project came from Culebra. The project received technical assistance from the Department of Natural and Environmental Resources (DNER), the US Fish and Wildlife Service (USFWS) and NOAA. The DNER provided the trees planted as part of reforestation program and provided accommodation for the team in their facilities Culebra.



A group of students from Abby's school in Culebra with their teachers and parents.

## Sponsors and Collaborators

### Sponsors

**Department of Natural and Environmental Resources (DNER)**

**National Oceanic and Atmospheric Administration (NOAA)**

### Contributors

**Municipality of Culebra**

**Authority Culebra Conservation and Development (ACDEC)**

**U.S. Fish and Wildlife Service (USFWS)**

**Natural Resources Conservation Service (NRCS)**

**CORALations**

**CORALations Marine Explorers**

**Tourism Company of Puerto Rico**

**Marine Environment Society, Inc.**

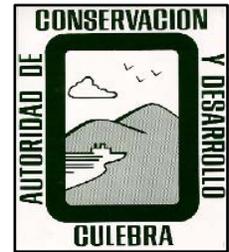
**Student Chapter Society of Marine Environment**

**Center for Applied Tropical Ecology and Conservation, University of Puerto Rico, Río Piedras**

**Culebra Eco School**

**Abby's School of Culebra**

**Municipality of Culebra**



**United States Department of Agriculture  
Natural Resources Conservation Service**



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This project could not have taken place without the active participation of the community of Culebra. In particular we want to acknowledge all the help and support from Omar Villanueva, Alexander Ayala, Thomas Ayala, Julio Figueroa (Apa), Antonio Albert, Paul Aquilina (Poly) and Tyson, who were instrumental in all the work including the use of heavy equipment, transportation of materials to Culebra, labor and carpentry. We also acknowledge the support and assistance provided by the following persons and entities: the Mayor of Culebra, Honorable Ivan Solis, for the support given to the project and their active participation in community meetings and to last ACDEC Director, Ms. Arlene Robles and current

director, Mrs. Sindymar Villanueva, for their part in the initial discussions of this project and to adopt this project as part of the recreational areas managed by ACDEC and for all maintenance post-restoration. We also wish to thank Mr. Miguel Canals Mora, Management Officer for the International Biosphere Guanica Dry Forest Reserve for his technical assistance in planning visits prior to the development of the project and for sharing his experience managing natural coastal areas for over 25 years. To Mr. Ernesto Diaz, Director of the Coastal Zone Management from



Alex, Apa and Tomasito doing carpentry work.



Omar and Tomasito stabilizing the soil.



Hon. Iván Solís Mayor of Culebra in one of his visits to the restoration Project area.



Mary Ann Lucking, Director of Coralatons, with students from the Ecological School of Culebra.



Sindymar Villanueva, Director of ACDEC, taking notes on maintenance needs.



Department of Natural and Environmental Resources for his assistance in project planning and permission and Mr. Edgardo Gonzalez, Natural Resources Administrator for DNER for all the support provided by the Department to make this project successful. Mr. Robert Matos, Culebra Management Officer, for his technical assistance and to coordinate the use of the facilities of the Department in Culebra. Thanks also to Jeiger Medina, NOAA Coral Fellow with the Coral Reef Conservation Program,



Laura and Mary giving an architectonic touch to the planting.

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Lisa Vandiver from NOAA documenting the project.



## Introduction

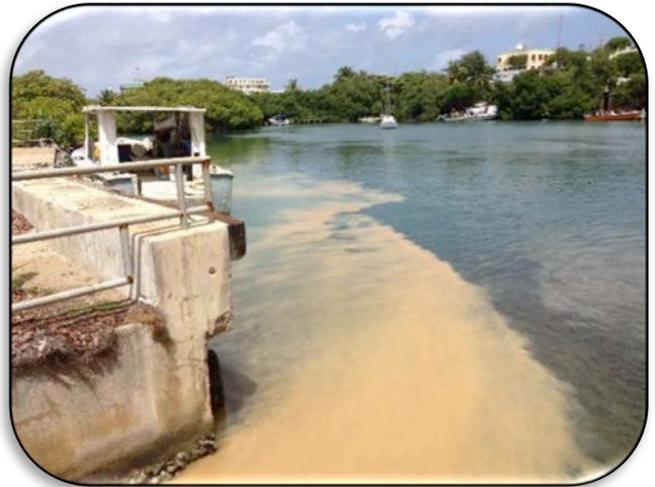
The degradation of coastal water quality in Puerto Rico has caused a decline in the population and health of coral reefs. The ability of these reefs



Drainage channel in Culebra.

to survive is being reduced gradually as discharges increase fine sediment and nutrients from the land to coastal waters of Puerto Rico. From the point of view

of conservation of marine ecosystems, degradation of water quality due to land-based sources of pollution dispersed has negative and sometimes irreversible damage to the integrity of the structures of coral reef communities, sea grasses, mangroves and other coastal ecosystems. High rates of sedimentation, excess nutrients from agriculture and sanitary sewage overflow are the main causes of the degradation of marine ecosystems. This phenomenon is mainly due to the lack of sustainable management from the



Sediment discharge to the Lobina Canal because of erosion from a dirt road after a water tank overflowed in Culebra.



Culebra runoff channel enlarged and devoid of vegetation by the municipal administration of Culebra last before being restored through hydroseeding technique.



One of the many existing dirt roads in Culebra



perspective of integrated coastal watershed management. Erosion is another serious problem for our wetlands, estuaries and coastal waters. In particular the removal of vegetation and the movement of land for the construction of infrastructure and homes, in the absence of good practices to control erosion and sedimentation, marine and coastal ecosystems are impacted and the attractiveness of coastal areas for recreation and tourism is diminished. Playa Tamarindo is one of the busiest areas in the Canal Luis Peña Natural Reserve, managed by the Department of Natural and Environmental Resources. The beach has become the second most visited beach in Culebra, second to the famous Flamenco beach. This rise is mainly due to the great diversity of marine organisms that inhabit the area. The presence of



Photos of coral estates in Playa Tamarindo which show the abundant presence of marine species by Edwin Hernández.

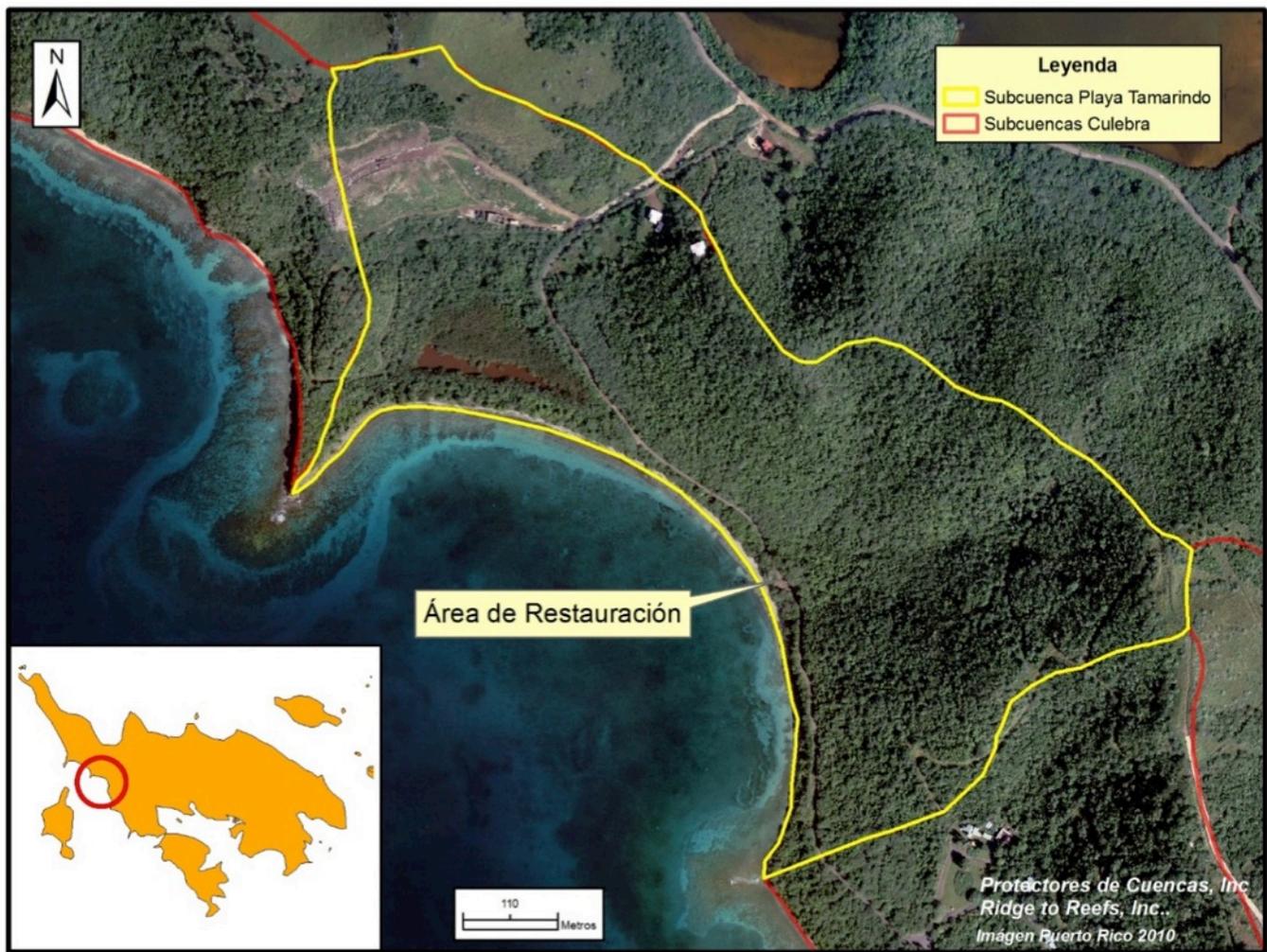
these organisms is partially attributable to a community project of Coral Reef Rehabilitation and Aquaculture which began in 2003 and has been led by the Society of Marine Environment (SAM), in collaboration with the Center for Applied Tropical Ecology and Conservation (CATEC) of the University of Puerto Rico in Rio Piedras.



A kayak tour company providing instructions to the group before the tour.



People around Puerto Rico, as well as other parts of the world, are looking for areas where you can swim with the turtles and see relatively healthy coral reefs. No doubt this is a good resource that contributes to the local economy of Culebra. Currently, there are three companies offering guided snorkeling and kayaking tours. The high visitation in Tamarindo has resulted in increased pressure on natural resources and increased need for implementation of management practices to ensure both the enjoyment of visitors to the area as the protection and conservation of coastal resource.



Map of Culebra delimitating the area of the Project and the sub-basins.



## Project Description

Tamarindo Beach Project consists of the following elements directed towards the conservation and protection of coral reefs and other marine ecosystems; erosion and sedimentation control, reforestation and habitat restoration through dune restoration, restoration of the line permanent vegetation, and through the delineation of vehicular and pedestrian access.



Parking area prior to restoration.



The problems of erosion and sedimentation in Tamarindo beach are mainly associated runoff coming from the dirt parking lot and access road to the beach that is only partially paved and in a critical state of disrepair with lots of exposed soil. The parking lot covers an area of approximately 160 m<sup>2</sup>. Prior to the rehabilitation of the parking area, motor vehicles had direct access to the permanent vegetation areas of the beach and in several places, vehicles could get to the beach area, and sometime traversed the beach in the evenings.



Current conditions to the road leading to Playa Tamarindo.



The procedure was, first, to delineate the parking area above the permanent vegetation zone of the beach. This delineation was conducted by installing wooden posts buried about 18 inches deep and fixed with concrete at base leaving about 30 inches pole to demarcate the area. Wooden posts were placed at a distance of three feet from each other to prevent the passage of small vehicles such as golf carts that have become a major means of transportation in Culebra. Each pole was connected to each other by using 2x6 boards, which in turn, act as a barrier to keep in place the stone used to stabilize the parking lot.



Process of demarcation and delimitation of the new parking area.



Process of creating the new parking area.





Parking stabilization process.



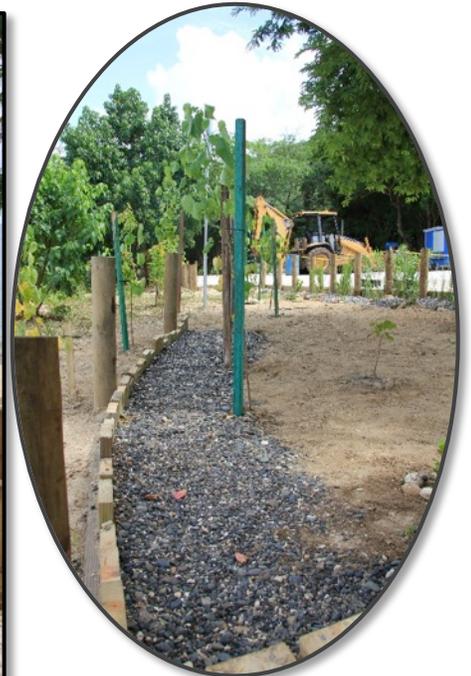
Second, stone was laid in the parking lot to promote infiltration and reduce surface water flows causing erosion during rainy periods. Approximately 60 m<sup>3</sup> were used of A1 washed stone. The material used has the same specifications of the material that was approved by the DNER to stabilize coastal roads and trails in the Reserve International Guanica Dry Forest. The stone was compacted slightly using manual equipment to both maintain a safe walking surface and some degree of infiltration in the area. Prior to the placement of the stones the ground was leveled. Third, erosion control plants and infiltration galleries were added to enhance deposition of sediment from the runoff from the road and parking lot. 600 vetiver plants (*Vetiveria zizanioides*) were planted to reduce runoff and enhance sediment deposition. The vetiver has a dense and deep root system that intercepts surface runoff and reduces energy of the water and traps sediment. Fourth, the shoulder area of the road where most of the runoff was generated and conveyed now intercepts water through cross swales at five locations to break up flow paths and reduce concentrated flow of runoff over the historically dirt parking lot.



Improvements to the road drainage -- attenuation and flow reduction and redirection.



Fifth, we created two small bio-filters/infiltration galleries to treat runoff not infiltrated by the parking lot. The bio-filters were built with wood, sand and gravel. Temporary sedimentation measures (silt fence) controls were installed prior to construction and remained in place for the duration of the implementation.



Images of bio-filters/infiltration galleries been built.



During the last municipal administration there were some attempts to pave the road and only stage culminated with concrete cross swales with exposed bare soil at both ends (which actually worsened sedimentation problems from the access road).

Currently, the Municipal Administration of Culebra is finalizing details to complete the paving of the road. The second phase of the Environmental Restoration project involved the reforestation of the Tamarindo access road and creating rain gardens at many of the cross swales along the road. This final phase of the project was completed in December of 2013. As a precaution, large rocks were placed to prevent the passage of vehicles on the exposed soil areas and areas were created to temporarily trap sediment and extensive planting also occurred in these locations.





Another aspect of our work was to stabilize and block an area sometimes used to access the beach with vehicles which also was an eroding conveyance of runoff from the access road to Tamarindo beach. The work in this section consisted of placing large rocks that surround the vehicular access and stabilizing the eroding access with large stone sized gravel to minimize erosion. The area was reforested with seedlings and emajagüillas. This section was designed and implemented by the Culebrenses, Omar Villanueva, Alexander Ayala and Tomás Ayala, who took part in a workshop on techniques for erosion and sedimentation control that we facilitated about a year ago in Culebra. The Ayala's were also volunteers in the effort providing their technical assistance and expertise to benefit their community. It was great to see the community leading the establishment of erosion and sediment control practices.

Sedimentation and erosion control practices established by the community.



The coastal habitat at Tamarindo beach had been seriously impacted by public uncontrolled public access and was in a very dilapidated state where the soil was compacted and eroding into the near shore waters. In order to restore the coastal vegetated berm and buffer, the team re-planted native species of endemic to coastal areas of Puerto Rico. Over 325 trees and shrubs were planted including a hundred sea grapes (*Cocoloba uvifera*), a hundred emajagüilla trees (*Thespesia populnea*), a hundred cooperwood (almácigo) seedlings (*Bursera simaruba*) and thirty icaco bushes (*Chrysobalanus icaco* L.). Furthermore, the project defined the pedestrian access areas to the beach. Reforested areas were delimited and access restricted primarily to three areas of public access. In two of these areas small elevated boardwalks were constructed for the public to access the beach without impacting vegetation and sand dunes. In the area closer to the coast the sea grapes planted at an average distance of one foot apart, and in two parallel lines



Design process to reforest areas.



with the purpose of accelerating the accumulation of sand trapped by the wind. This process will increase the height and diameter of the sand dune. In the upper berm area, we successively planted emajagüillas and almácigos and between the parking area and division of permanent vegetation zone icaco bushes were planted. All trees planted were a contribution of DNER nurseries including Cambalache in Arecibo and the Mayagüez nursery. The plants and assistance were provided by the nurseries as part of the Sustainable Forestry Network. For irrigation at the restoration site, a 400-gallon cistern was installed in the area and the Municipality of Culebra has been filling it once a week.

In the second phase of the project over 260 trees and 900 vetiver were planted in order to restore 1 acre of native forest to the coastal buffer and to attenuate runoff from flowpaths. Additional large stones, vetiver grass and trees were placed at cross swales to keep vehicles from driving around them and creating more erosion.



Reforestation process.



Boardwalks to delimit the beach access and protect the dunes and vegetation.





Images of the completed project.





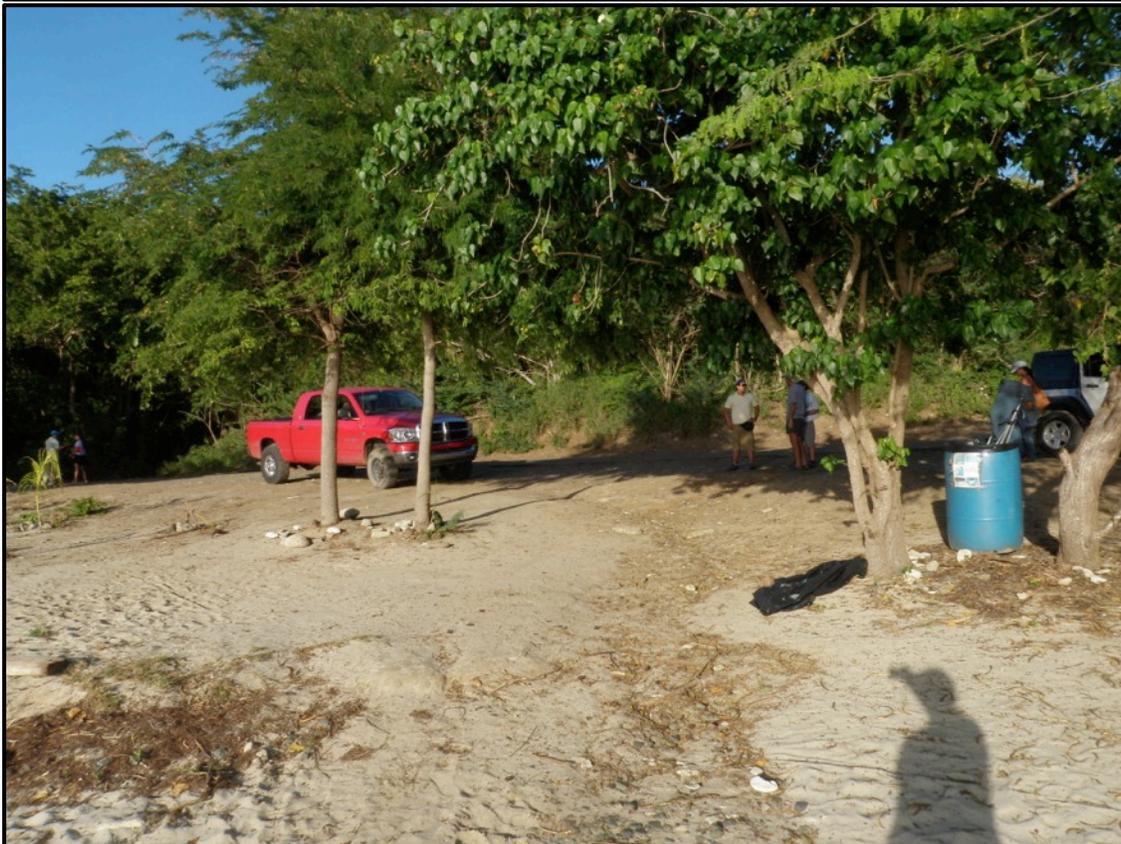
Images of the completed project.





Images from a video camera located in the Project area during the process. From left to right, the pictures show the Project from day one to day five.





Pre-restoration photos: the silt fence in the upper picture was set up the day before we started and a rainstorm occurred that evening transporting the sediment shown; the lower photo shows one of the flowpaths for sediment prior to our work





**Invasive species removal and native forest regeneration – over 260 native trees were planted as part of our follow up effort re-establish a native forest buffer in the coastal buffer areas**





**Invasive species removal and native forest regeneration – over 260 native trees were planted as part of our follow up effort to help re-establish a native forest buffer in the coastal area**



## Costs

The cost of this project and the specific expenses are summarized in the following tables. The first table shows the direct costs of the project and the entity responsible for providing the funds. The second table shows the indirect costs associated with the project and the contributions made by different entities. Indirect costs are estimates based on current market value. The team Protectores de Cuencas and Ridge to Reefs, was composed of ten workers skilled in masonry, carpentry and general environmental restoration, two biologists, an agronomist, an engineer and two landscape architects.

**Table I. Costs summary**

<b>Activity</b>	<b>Entity</b>	<b>Cost</b>
<b>Labor and Manpower</b>	NOAA Coral Reef Conservation Program	\$9,055.00
<b>Rental Equipment and Materials Transportation</b>	NOAA Coral Reef Conservation Program	\$9,326.22
<b>Materials</b>	NOAA Coral Reef Conservation Program	\$8,951.63
<b>Coordination, Design and Engineering</b>	NOAA Coral Reef Conservation Program	\$11,525.00
<b>Gasoline and Transportation</b>	NOAA Coral Reef Conservation Program	\$2,938.22
<b>Per Diem</b>	NOAA Coral Reef Conservation Program	\$2,180.29
<b>TOTAL</b>		<b>\$ 43,976.36</b>

The second phase of the project that included forest regeneration, invasive species management and re-planting and placing large stones at cross swales cost an additional \$10,000. This was matched in an equal amount through volunteer labor estimated at 250 hours, lodging from DNRA, plants from USFWS, and watering from Coralations, USFWS, the Ecological School and Abbie's School and time donated by Ridge to Reefs and Protectores de Cuencas. The project also planted an additional 900 vetiver to stabilize bare soils at the cross swales and to adaptively address flowpaths for runoff at Tamarindo beach. We were able to have our investment matched more than 100% through all the assistance and support we received on the project – a true tribute to the community and the agencies who supported the project.

**Table II. Contributions Summary Indirect Estimates**

<b>Entity</b>	<b>Activity</b>	<b>Quantity</b>	<b>Total Cost</b>
<b>DNER/USFWS</b>	Trees	550 trees/\$20 per tree	\$11,000.00
<b>DNER</b>	Accommodations	12 persons/ one week / \$100 / night + 4 persons -4 nights	\$10,400.00
<b>DNER</b>	Technical assistance	40 hours	\$2,000.00
<b>USFWS</b>	Technical assistance	50 hours	\$2,500.00
<b>TourismCompany of Puerto Rico</b>	Technical assistance	20 hours	\$1,000.00
<b>CORALations</b>	Coordination with Green School for reforestation and irrigation for the first 2 months	90 hours	\$4,500.00
<b>Abby's School Culebra</b>	Assistance maintenance and irrigation	60 hours	\$3,000.00
<b>Municipality of Culebra</b>	Using rolo road roller	\$100 / day/ 2 days	\$200.00
<b>Municipality of Culebra</b>	Labor	2 people 7 days	\$3,150.00
<b>NOAA</b>	Labor and technical assistance	1 person for 7 days	\$3,000.00
<b>Protectores de Cuencas y Ridge to Reefs</b>	Uncompensated work hours	Time donated to the project	\$6,000.00
<b>TOTAL</b>			<b>\$ 46,750.00</b>