Human Impacts to Coastal Ecosystems in Puerto Rico (HICE-PR): the Río Loco Watershed (southwest coast PR)
A remote sensing, hydrologic, ecologic, and socio-economic assessment with management implications

Torres-Pérez, Juan L.[1*]; Barreto-Orta, Maritza[2]; Ortiz, Jorge[2]; Santiago, Luis[2]; Setegn, Shimelis[3]; Guild, Liane[1]; Ramos-Scharrón, Carlos[4]; Armstrong, Roy[5]

[1]NASA Ames Research Center; [2]UPR-Graduate School of Planning and Dept. Environmental Sciences; [3]Florida International University; [4]Univ. of Texas at Austin; [5]Remote Sensing Consultants

*E-mail: juan.l.torresperez@nasa.gov

Abstract:

Since the 1960's, Puerto Rico's coastal and marine ecosystems (CMEs), like beaches, coral reefs, mangroves and seagrasses, have suffered the effects of anthropogenic stresses associated with population growth, land use changes and direct extraction of resources. The main goal of the HICE-PR project is to evaluate the impacts of land use/land cover changes on the quality and extent of CMEs in two priority watersheds in Puerto Rico (Manatí and Guánica). Here, we present a summary of our first year of efforts within the Río Loco Watershed (Guánica). We have established collaboration with local agencies in the Guánica watershed and through the Watershed Coordinator now have additional site access and data collection coordination with established projects. The first field campaign (November 2014) focused on the collection of benthic data within the La Parguera-Guánica reef platform and the establishment of sediment traps in Guánica Bay and in the watershed that augment existing sediment sampling stations. Coral cover ranged within and between reefs from 0.2-30%. Cover of additional benthic components (i.e., macroalgae and the encrusting sponge *Cliona*) dominate in most of the reefs sampled, which creates concern about the resilience of these degraded sites to support biodiversity and fisheries and maintain coastal protection. A preliminary assessment of runoff and sediment production from coffee farms located near the headwaters of the watershed was conducted in 2014 through rainfall simulation experiments. Historic and current imagery is being collected for land cover/land use change analysis and cover change of CMEs, and a database of inputs for hydrological modeling is underway. Initial interviews with residents within the watershed were conducted. Second year field activities include: 1) characterization of additional reef sites to increase our temporal dataset, for continuity and to compare with biodiversity estimates from an earlier NASA-funded IDS project (2006-2009), 2) characterizing water optical properties and their possible correlation to the benthic data, 3) bi-weekly collection and analysis of sediment data, 4) development and implementation of surveys for user attribute valuation and environmental concern, 5) further empirical quantification of runoff and sediment yields at spatial scales ranging from hillslopes to the entire watershed, and 6) conduct an advanced SWAT modeling workshop and calibrate the SWAT hydrological model for the watershed.

Project goals:

- To conduct an interdisciplinary study using sound mapping technologies and hydrological modeling to infer how anthropogenic activities related to land cover/land use changes have modified riverine inputs into the coastal and marine ecosystems (CMEs) associated with two priority watersheds in the north and south coasts of PR.
- A secondary goal combines outputs from field measurements within CMEs, ecological modeling and economic valuation methods to assess degradation of CMEs associated with the selected watersheds.
- Additionally, we will demonstrate the use of these remote sensing and modeling tools to stakeholders (local agencies, managers, community) via workshops allowing for technology transfer and future collaboration with the PI's.

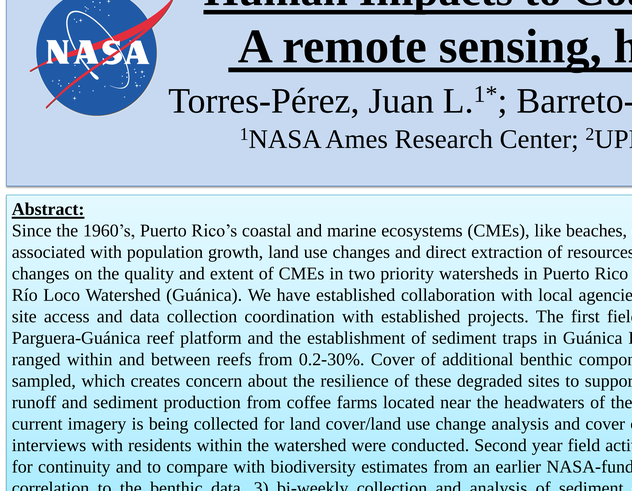
Image analysis Land Cover/Land Use (LC/LU)

Main objective:

•To account for changes in LC/LU within the Río Loco and Parguera watersheds during the past five decades.

This year:

•Acquisition of available aerial and satellite imagery for LC/LU change analysis.
•Land use change maps have been develop for the watershed.
•Results show that agriculture and forest are the major land use categories identified in the watershed for 2010 period. Agriculture areas shift to forest reserve (40%), forest (32%) and rangeland (7%) at Río Loco watershed. Also, there has been an apparent increase in wetlands within the Lajas Irrigation Valley.



Changes in LC/LU within the La Parguera watershed from a relatively unpopulated fishing village in the 1930's to one of the main fully developed tourist areas in the southwest coast of PR.

Next steps:

•Delineation of CMEs within the Río Loco and Parguera watersheds.
•Analysis of mangrove forests cover changes in the past 50 years and evaluation of how LC/LU change has affected these.

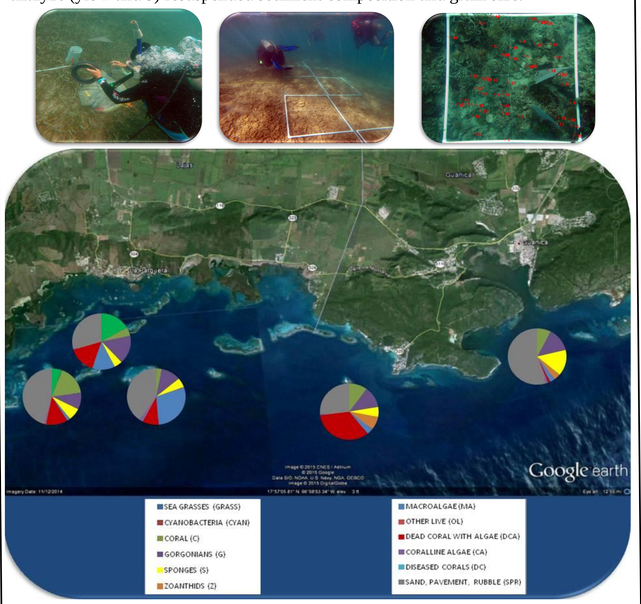
Reef benthic composition

Main objective:

•Provide an updated benthic characterization of selected reefs within the La Parguera-Guánica platform and produce a time series analysis by adding data collected during past NASA-funded efforts. These data will be correlated with bio-optical properties measured in the area (water quality).

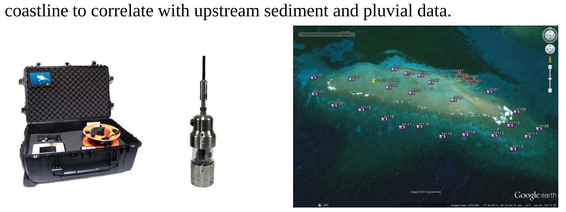
This year:

•Conducted phototransects for reef benthic characterization at multiple reefs in La Parguera and Guánica.
•Generated and analyzed 9,000 random points within each reef with Coral Point Count with Excel extensions (CPCe) for presence of benthic live taxa (identified to the lowest taxonomic level possible) as well as other nonliving benthic components such as sand and dead rubble.
•Conducted reef rugosity analysis at each transect.
•Established a series of sediment traps at each study site and inside Guánica Bay to analyze (yrs 2 and 3) resuspended sediment composition and grain size.



Next steps:

•Characterization of additional reef zones (fore-reef) at the study sites.
•Conduct video transects with a Delta Vision HD Pro drop video camera, additional benthic analysis of selected video frames with CPCe, and produce an Ecological Niche Factor Analysis (ENFA) modeling for habitat suitability.
•Collect bio-optical data (Chl *a*, Kd_λ, total suspended sediments, remote sensing reflectance) for water quality analysis along several transects perpendicular to the coastline to correlate with upstream sediment and pluvial data.

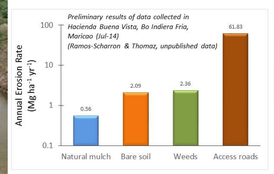


Watershed hydrology

Main objective:

•To assess the effects of intensive historical anthropogenic water and land management in the water and sediment fluxes to Guánica Bay, and quantify runoff, nutrient, sediment yields at scales ranging from the hillslope and headwater stream to the watershed scale.

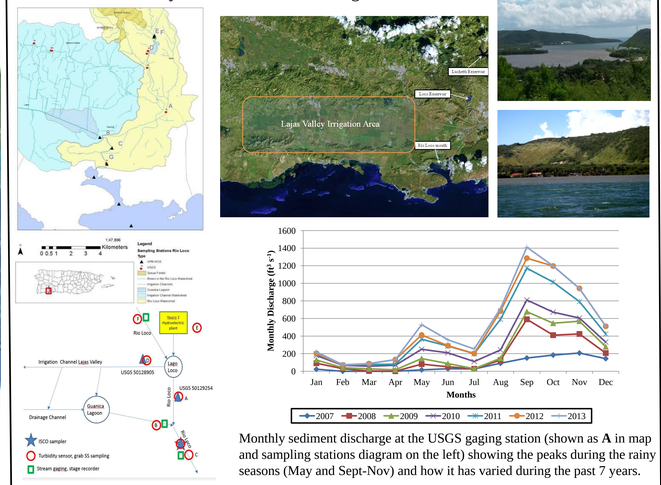
Left photos: Upstream activities within the Parguera and Río Loco Watersheds. Right: Mixing of the hydroelectric plant drainage channel and the Río Loco water.



Annual erosion rates at a coffee farm located on the upper Río Loco watershed showing the impact of unpaved access roads.

This year:

•*Hillslope- & headwater scale*: Rainfall simulation experiments (n = 40; Jun-Jul 2014) were conducted within coffee farms. Results highlight the importance of vegetation cover in maintaining low soil erosion rates and suggests unpaved access roads can be important sources of sediment. These roads are generally ignored by erosion mitigation strategies that only emphasize reforestation practices.
•Established sediment monitoring stations through the watershed and started collecting grab samples for suspended sediment analyses while permanent sampling equipment arrives.
  •Obtained permits from PR Electric Power Authority (PREPA) to sample at hydroelectric plant and irrigation channel, and requested historical data.
•Acquisition of streamflow and water quality data from USGS sampling stations.
•Collection of ancillary data for SWAT modeling.



Monthly sediment discharge at the USGS gaging station (shown as **A** in map and sampling stations diagram on the left) showing the peaks during the rainy seasons (May and Sept-Nov) and how it has varied during the past 7 years.

Next steps:

•Gathering continuous water flow and turbidity data at selected stations in the Río Loco watershed for one year.
•Calibrate the SWAT model for the Río Loco watershed.
•Assess the role of intensive agricultural activities in the Rio Loco and Lajas Valley on the flux of sediments and nutrients to the Guánica Bay.
•SWAT workshop (June 2015) and modeling of the Río Loco watershed.
•*Hillslope- & headwater scale*: Additional rainfall simulation experiments will be conducted in coffee and mixed-use farms, as well as on hydroseeded areas to evaluate its efficiency (Jun-Jul 2015).
•*Sub-watershed & watershed scale measurements*- Runoff and sediment monitoring will be conducted in at least two of the ephemeral streams draining towards the La Parguera. In combination with data collected by the USGS at other south coast draining streams, these data will serve to better describe watershed conditions matching the bio-optical data being collected by another component of this study.

Socio-economic analysis

Main objective:

• Compute the environmental economic value of selected CMEs (e.g. mangroves, seagrasses, coral reefs and beaches).

This year:

•Conducted initial fieldwork based on site visits and informal interviews with residents, visitors and key informants in the Río Loco watershed and found large differences in human interactions between the Manatí and Río Loco watersheds. We did not expect to find such a marked difference between watersheds, and as a result we had to consider various methods, not just Choice Experiments, to assess respondent attribute valuation.
•Identified and valued ecosystem services (following the Millennium Ecosystem Assessment framework) and attributes that may be readily apparent to residents and visitors as a result of direct interaction with the watershed, for instance, recreation and cultural services.
•We found that interaction resulting from consumption or enjoyment of cultural ecosystem services, particularly recreation, was rather rare in the Río Loco watershed.
•Provisioning services were more predominant than cultural services in the Río Loco. A significant amount of water use is dedicated to agriculture and power generation. This finding led us to a possible reassessment of the methods used in this watershed for attribute valuation.

Compute the environmental economic value of selected CMEs using Choice Experiments or Direct Market Methods depending on the watershed. Meetings with A) local stakeholders, B) fishermen, and C) the Guánica watershed coordinator.

Next steps:

•We will continue to study Río Loco watershed services during year 2. One of the possible options is to increase the sample size of the Choice Experiment exercise in the Río Grande de Manatí watershed, and once we obtain reasonable estimates at that watershed, we can proceed to apply the Benefit Transfer method to provide estimates of added value if Río Loco locations were more intensively used for cultural ecosystem services such as recreation. The second option is to conduct Choice Experiments on a reduced basis at the Río Loco to compare results with Manatí, and make adjustments based on the diverse characteristics observed in both regions.

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Bay Area Environmental Research Institute
FIU Florida International University Miami's public research university
The University of Texas at Austin