Caribbean Area Coastal Zone Soil Survey: Jobos Bay

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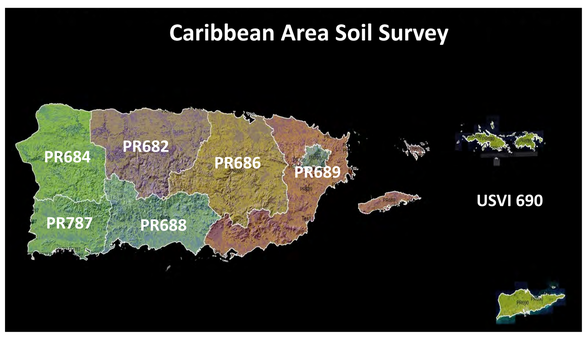
Abstract

Soil information needs have evolved over the past decade, with increasing demands to develop soil interpretations for coastal zone uses and management in the United States and its territories. Advanced mapping and classification protocols were developed by the USDA-NRCS Soils and Plant Divisions and the National Cooperative Soil Survey to standardize coastal zone soil surveys (CZSS). Soil surveys were completed for the U.S. Caribbean: Puerto Rico and the U.S. Virgin Islands in the 1980's and 1990's, with the exception of the San Germán Area soil survey published in 2008. Despite the valuable soil's information available in these publications, there is a lack of soil data for low coastal areas where soils are influenced by tidal changes or are submerged. Several sites in the U.S. Caribbean were evaluated to establish a CZSS pilot project, and the Jobos Bay National Estuarine Research Reserve (JOBNERR) was selected. Jobos Bay provides an excellent example of tropical estuarine and marine systems and is ideally suited for research and as the starting point for coastal zone soil survey update work in the Caribbean Area. The CZSS initiative in the Caribbean Area will not only address soil data needs for NRCS conservation planners and engineers, it will also focus on emerging issues such as climate change, coastal resiliency, estuary restoration, blue carbon assessments, small- and large-scale watershed use planning, and environmental literacy. Therefore, there is an imperative need to update coastal zone soil surveys and develop initial subaqueous mapping in the Caribbean Area.

Introduction

Caribbean Area Soil Survey data needs along the Coast continues to evolve and is becoming of high interest for restauration efforts, planning and management. Soil Survey worked done through the National Cooperative Soil Survey (NCSS) dates back to early 1980's with the exception of San German SSA published in 2008. Since the 1990s, sparse USDA-NRCS mapping projects and continuous ongoing research by Northeastern U.S. Universities has developed considerable advanced mapping and classification protocols in coastal zone areas. It has even provided some new official update soil survey information along the coast. There are completed and ongoing projects in the Northeast with a counterpart initiative supporting projects in New York, New Jersey, Connecticut and Rhode Islands. These projects are been completed with established cooperative agreements that included Environmental Protection Departments, Soil and Water Conservation Districts and Universities. Most of the USDA Caribbean Area (CA) coastal zone soils are distributed within the Humid Coastal Plains and of the Semiarid Coastal Plains. Coastal zone soils are very important for the sustainable function of agriculture and ecological systems. They play an essential role over water retention, sedimentation, and biogeochemical cycling of nutrients. They provide a rich habitat for large and diverse biological communities. The recognition, identification, and management of coastal zone soils helps preserve and a keep good balance between environmental health and humans activities. In the CA approximately 1.28% or 29,434 acres have been identified with the need to be updated under the Coastal Zone Soil Survey Initiative.



Potential CZSS acreage in the CA

- PR684 Mayaguez Area Soil Survey (1975): 1,588 acres
- PR689 Humacao Area Soil Survey (1977): 20,767acres
- PR686 San Juan Area Soil Survey (1978): 865 acres
- PR688 Ponce Area Soil Survey (1979): 2,726 acres
- PR682 Arecibo Area Soil Survey (1982): 850 acres
- USVI 690 USVI Area Soil Survey (2002): 1,091 acres
- PR787 San German Area Soil Survey (2008): 1,547 acres

Total 29,434 acres

Jobos Bay Description

The Jobos Bay National Estuarine Research Reserve is part of the National Estuarine Research Reserve System, established by Section 315 of the Coastal Zone Management Act. Jobos Bay is located in the southeast coast of Puerto Rico, the smallest island of the Greater Antilles. Located between the U.S. Virgin Islands and the Dominican Republic, Puerto Rico has a land area of approximately 9,000 square kilometers, 75 percent of which consists of a series of mountain ranges. These mountains, which divide Puerto Rico along an east-west axis, descend into coastal plains. The south coastal plain, considerably narrower, and drier than the north coast, has fewer and smaller rivers that are characterized by intermittent flows. Jobos Bay is a semi-enclosed water body on Puerto Rico's southeast coast . The estuarine area is subject to surface water inflows primally from the alluvial coastal riverine systems. The Jobos Bay contains mangrove islands and coral reefs within the boundaries of the reserve. Other ecosystem are mangrove forest, lagoons, salt flats, dry forest, and seagrass beds.

Jobos Bay National Estuarine Research Reserve (JOBNERR) lies along south-central coast, east of Ponce, between the municipalities of Salinas and Guayama. The entire reserve covers an total area of 10,994 acres. Approximately 2,800 acres of inland soils and 8,194 acres of subaqueous soils reaches depths of 6 meters. The reserve is composed of two major areas: Mar Negro, mangrove-wetlands forest complex, located on the land side at the mouth of Jobos Bay, and; Cayo Caribe, a linear formation of 15 tear-shaped, reef fringed, mangrove island extending westward from the south tip of the mouth of Jobos Bay. The Reserve is a very important habitat for endangered species. Estuaries are scattered along the shores of all the oceans and vary widely in origin, type and size. Jobos Bay can be classified as a coastal plain estuary formed approximately 18,000 years ago when sea levels rise as a result of the melting of glacial ice at the end of the last ice age. During this process the sea entered lowlands and river mouths forming drowned river valleys or coastal plain estuaries. Water covered the lowest plains as evidenced by the large amount of shell deposits found in the upland adjacent to Jobos Bay, and the coral reef fossils found in the hills immediately to the northwest boundary of the Bay.

These ecosystem provide habitat for a great diversity of flora and fauna including several rare and endangered species, as well as a variety of species of tropical fish. It is this wealth of biological diversity, which makes Jobos Bay an excellent example of tropical estuarine and marine system ideally suited to research and education, as well as to development and implementation of management practices that contribute to informed and environmentally sound decision making. Jobos Bay is the second largest estuary in Puerto Rico and have three times as much shoreline as any other estuarine zone on the Island. The tide dynamic of Jobos Bay conforms to the USFWS criteria (1979) of an intertidal estuarine system dominated by aquatic beds and coral reefs.

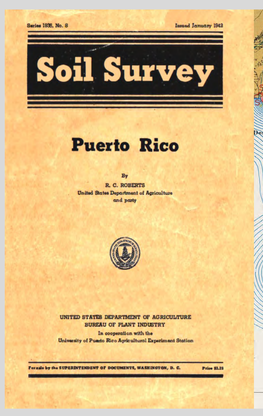
Project Objectives and Goals

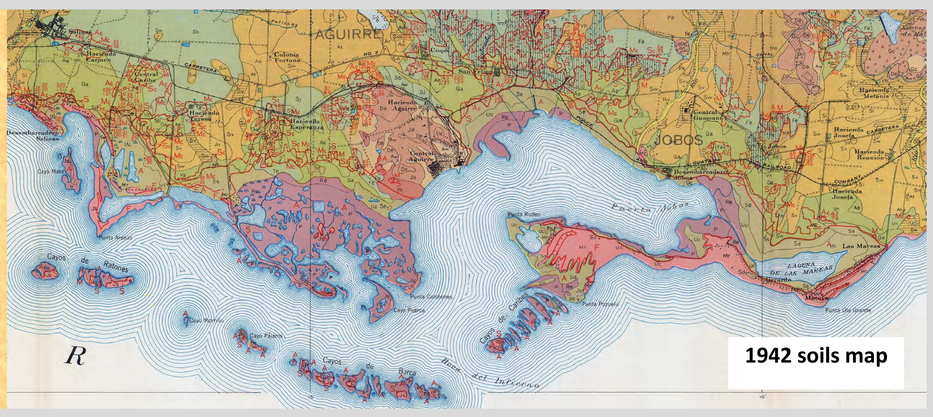
Soil Survey data needs along the Caribbean Islands coast continues to evolve and is becoming of high interest for coastal planning and management. We are learning that there is a need for more refined and detailed scientifically based soil mapping, data, and interpretations. In the Caribbean area, a high percentage of cartographic units along the coast were identified as miscellaneous areas without soil information which hinders the creation of important soil interpretations. This initiative will inventory and map coastal zone areas in accordance with NCSS standards. To achieve this initiative, we support rigorous scientific content from field data gathering and research; diverse and uniquely effective partnerships; and modern techniques to produce a spatial and tabular seamless soil survey. Detailed maps and information of these coastal and nearshore areas are vital tools for sustainable development and increasing resiliency of these important ecosystems and population centers. This collaborative, goal-oriented initiative will not only address the soil data needs of conservation planners and engineers for NRCS programs, it also confronts emerging issues such as climate change, coastal resiliency, estuary restoration, blue carbon assessments, small and large scale watershed use planning, and environmental literacy. Increasing the focus of soil survey on coastal zones provides valuable information for planning and managing these areas that have high development value, high hazard potential, and significant ecological values. The Caribbean Region is requesting that the Soil and Plant Science Division coordinate a coastal and subaqueous soil survey within Puerto Rico, St. Croix, St. John and St. Thomas islands. Soil Survey Offices could complete or oversee the collection of data, document and propose soil series and data map units, complete initial or update mapping to improve spatial data, update tabular data, conduct full characterization lab sampling as needed, assure perfect joins, and provide quality control and the Regional Offices provide quality assurance. The main goal of this initiative is to complete a coastal zone soil survey encompassing portions of MLRA 272 (Humid Coastal Plain) and MLRA 273 (Semiarid Coastal Plain). The goal of a Coastal Zone Soil Survey is to create a seamless dataset of soils information that encompasses terrestrial and shallow subaqueous soils.

Prioritized Goals:

1. Update spatial and tabular data of upland soils within the coastal area through separate raster based Soil Survey Office MLRA projects by soil catena concepts.
2. Start initial mapping of subaqueous soils in the Caribbean.
3. Distinguish between the various types of tidal marsh soils (incorporate salinity class, update fiber content).
4. Identify coastal flood hazard zones and areas of sea salt spray in the soil survey.
5. Quantify soil carbon content (including blue carbon content) and sequestration potential.
6. Identify and documented the presence of acid sulfates.
7. Develop ecological sites in coastal areas.
8. Update current and develop new coastal zone interpretations (habitats and hazards).

Historical Data





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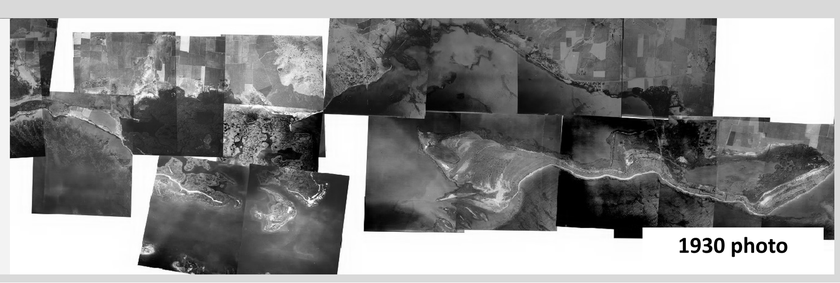


Soil Survey of Puerto Rico by R.C. Roberts 1942 recognized 3 major groups

1. The well drained sandy soils:

Mr – Meros sand; consists of loose single-grain igneous sand intermixed with an small sea shell fragments.

Js – Jaucas sand; is a mixture of white coral sand size fragments, sea shells and a small portion of igneous sand, underlain by soft coral limestone.

2. The imperfectly and poorly drained mineral soils:

Uc - Ursula clay: Ursula clay consists of calcareous gray marine clays that are salty and have a high water table. Most of the area are forested with mangroves or support other halophytic vegetation. This soil typically has a 2-inch layer of black ooze material.

Se - Serrano clay: Serrano soils occurs in lower positions.

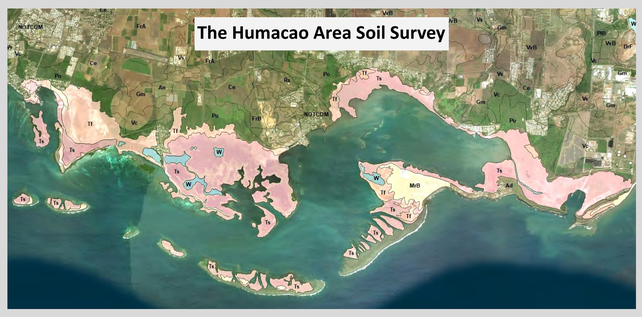
Sd - Serrano sandy clay loam: This soil is similar to Serrano clay subsoil but have around 8 to 10 inches of sandy clay loam on the surface over gray plastic calcareous substratum.

3. The poorly drained organic soils of the coastal low lands

P - Peat: Most of the Peat areas are in mangrove swamps. In general has coarsely fibrous surface material about 10 inches thick. In most places the top two inches of the surface layer is black sticky tidal ooze. Peat is acid in all layers and very salty unless drained.

Re - Reparada clay: Occurs in areas where the climate is dry, and is more alkaline in reaction. In most places have 12 to 18 inches dark gray plastic clay or silty clay surface soil that is underlain by fibrous peat. The peaty subsoil extends to a depth from 30 inches to several feet.

Roberts recognized 3 major soil groups with 7 map units in the Jobos Ba Area. Actually the Meros, Jaucas, Serrano and Reparada concept remai active through the semiarid region. Ursula is an inactive soil series.



The Humacao Area Soil Survey recognized 3 major map units

Tf – Tidal Flats consists of low areas, slightly above sea level, that are affected by seawater during high tide.

Ts – Tidal Swamp consists of areas that are covered with a thick growth of mangrove trees and are under salty water most of the year. These areas are along the seacoast and inlets. The sandy or clayey soils are light colored and saline; and contain organic material from decaying mangrove trees. They are underlain by coral, shells, and marl at varying depths.

MrB – Meros sand, 0 to 2 percent slopes consists of deep soils that are excessively drained and rapidly permeable. These soils formed in fine sandy sediment derived from sand-sized volcanic rock fragments, seashells, and coral. They are on benches along the coast slightly above sea level.

Humacao recognized 3 map units in the Jobos Bay two of them miscellaneous areas

The information collected is very valuable but brief in order to develop soils concepts, soil map units and interpretations. Therefore in order to provide the detailed and accurate soil information that is needed, gather field soil documentation is imperative.

Field Documentation and Results

Collected 75 site/pedon descriptions. Core data analyses include:

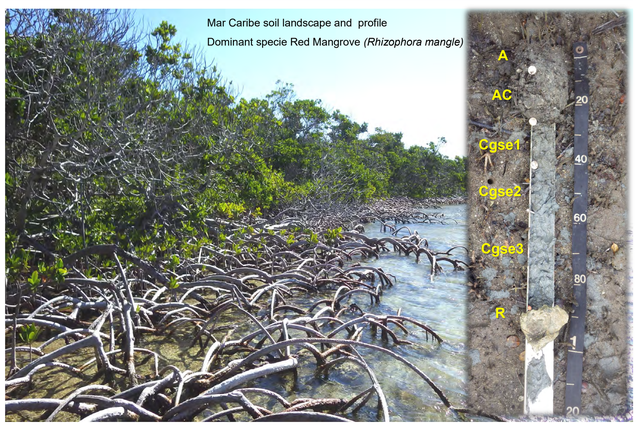
- Horizon and layers designation
- Color, odor and texture
- Redox features
- Species and conditions of vegetation
- Water levels observations (above/below the surface)
- Landscape and landform
- Parent Material


Abdiel Santana; USDA/NRCS Soil Scientist and Ian Matias; USDA/NRCS Pathway student collecting samples of Mar Negro soil (*Typic Sulfiwassists*)


Abdiel Santana; USDA/NRCS Soil Scientist describes Ursula clay (*Typic Sulfaquents*)


Landscape of San Felipe-Mar Negro complex, 0 to 2 percent slopes, very frequently flooded . Red Mangrove *(Rhizophora mangle)* and White Mangrove *(Laguncularia racemosa)* association


Mar Negro soils



Jobos Bay Soils Series and Map Unit Concepts

Correlated Soil Series

- **Teresa** (*Sodic Haplusterts*)
- **Boquerón** (*Vertic Fluvaquents)*
- **Reparada** (*Tapto-Histic Fluvaquent*)
- **Manglillo** (*Terric Sulfihemists*)

New Soil Series

- **Ursula** (*Typic Sulfaquents*)
- **Mareas** (*Sapric Sulfiwassists*)
- **Mar Negro** (*Typic Sulfiwassists*)
- **El Indio** (*Aeric Endoaquent*)
- **Mar Caribe** (*Typic Endoaquent*)
- **San Felipe** (*Terric Sulfisaprists*)

Map units concept

- Teresa clay, 0 to 2 percent slopes, frequently flooded
- Ursula muck, 0 to 2 percent slopes, very frequently flooded
- Mareas muck, 0 to 2 percent slopes, very frequently flooded
- Mar Negro mucky peat, 0 to 2 percent slopes, very frequently flooded
- San Felipe-Mar Negro complex, 0 to 2 percent slopes, very frequently flooded
- Mar Caribe sandy loam, 0 to 2 percent slopes, very frequently flooded
- El Indio sand, 0 to 5 percent slopes, rarely flooded
- Manglillo muck, 0 to 2 percent slopes, very frequently flooded
- Boquerón clay, 0 to 2 percent slopes, frequently flooded
- Reparada clay, 0 to 2 percent slopes, frequently flooded

On-going Related Project

Identification and Determination of Spatial Distribution of Coastal Lowlands Acid Sulfate Soils in Puerto Rico and the US Virgin Island of St. Thomas and St. Croix

Purpose

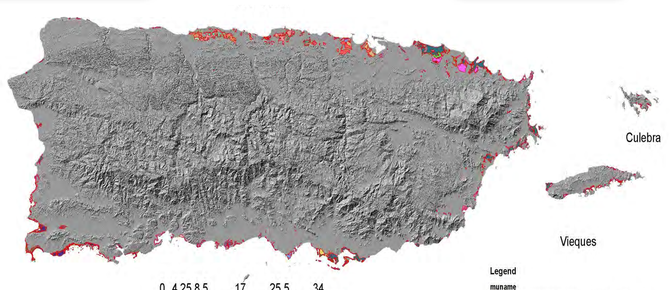
Coastal Lowlands Acid Sulfate Soils (CLASS) are naturally occurring soils and sediments containing significant amounts of reduced sulfur compounds. When oxidized, these minerals oxide and produce sulfuric acid and increase sulfurization. Large amounts of acidity and potentially toxic elements can be exported to nearby waterways potentially inducing massive fish kills, degradation of ecological sensitive areas and water channeling infrastructure. The validation of the presence of acid sulfate soils in Puerto Rico introduces a whole new set of priorities into the natural resource management efforts on Puerto Rico and the U.S. Virgin Islands.

Objectives

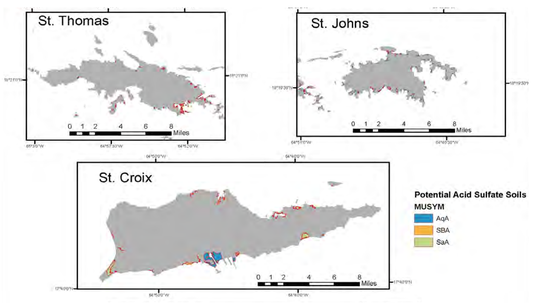
The main objective is to validate the CLASS predicting model by assigning weight and other predicting covariates in Puerto Rico and in the US Virgin Islands of St. Thomas and St. Croix.

1. Develop a probability map of potential CLASS occurrence in Puerto Rico and in the US Virgin Islands of St. Thomas and St. Croix.
2. Describe the spatial relationships between soil properties of CLASS soils occurring in Puerto Rico and the US Virgin Islands of St. Thomas and St. Croix, and spatial covariates using geostatistical methods (regression kriging).
3. Characterize the basic chemical properties, and the spatial and temporal variability of soil profiles from selected coastal lowlands acid sulfate soils in Puerto Rico and the US Virgin Islands of St. Thomas and St. Croix.
4. Characterize the chemical composition of export loads (base and storm flow) from selected acid sulfate soils under varying climate conditions.
5. Develop CLASS educational material in collaboration with USDA-NRCS. The education information will define and describe CLASS, map their potential extent/distribution, describe potential CLASS ecological impacts, and discuss how that impact is affected by land management practices.

Potential Acid Sulfate Soil Map of Puerto Rico and USVI



Mapunit Symbol	Mapunit Name	Acres
Ba	Bajura silty clay, saline	259
BhB	Bahia Salinas sand, 0 to 5 percent slopes, rarely flooded	558
Ga	Garrochales muck	905
HS	Hydraquents, saline	326
Hy	Hydraquents	1,903
Hz	Hydraquents, saline	4,208
Ja	Jareales clay	1,856
JBA	Joyuda, Atolladero, and Bajura soils, very frequently flooded	653
MDA	Manglillo, Boqueron and Serrano soils, very frequently flooded	3,258
Mp	Martin Pena muck	2,217
OrA	Olivares muck, ponded	341
Pa	Palmar muck	538
Pn	Pinones silty clay	901
Sa	Salt flats, ponded	1,252
Sb	Salt pits	297
Se	Serrano sand	852
Sm	Saladar muck	4,415
Tb	Tiburones muck	3,495
Td	Tidal swamp	595
Tf	Tidal flats	1,871
TfA	Teresa clay, ponded	183
Ts	Tidal swamp	14,558
Vg	Vigia muck	1,581
Wa	Wet alluvial land	3,506
	Total Acres	50,527.05



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