Bayamón Series
Puerto Rico Representative Soil

Photo: Chip Clark/Smithsonian Institution

Soil Science Society of America

Introduction

Many states have a designated state bird, flower, fish, tree, rock, etc. Now, all USA states and most territories have selected a soil that has significance because of its use, abundance or other importance as their representative soil. Of the more than 200 different soils in Puerto Rico, the Bayamón was selected to be the representative soil of Puerto Rico. Let's explore how the Bayamón is important to Puerto Rico.

History

The Bayamon soil was first designated as Puerto Rico's representative soil under Law 115 of May 12, 1999 by the Puerto Rico Legislative Assembly. It is found only in Puerto Rico and was first described in 1936 in Manati Municipio (municipality). It was named after Bahamón, a chief of the indigenous Tainos peoples whom Christopher Columbus met when he first came to the island of Puerto Rico on his second voyage in 1493. Bayamón is also the name of one of the main cities in Puerto Rico and the name of one of its rivers.

What is Bayamón Soil?

The first thing you notice about Bayamón is its deep red color which is a typical color for tropical soils (**Figure 1**). They formed in highly weathered, clayey marine sediments eroded from the interior of the island and deposited on top of limestone formed in a marine basin in the Tertiary period (66-2.6 million years ago) and later uplifted.

The climate is humid tropical with a mean annual precipitation of about 1650 mm (65 inches) and mean annual temperature of about 25.5°C (78° F). These conditions contribute to intensive weathering and leaching, resulting in highly weathered, acidic soils.

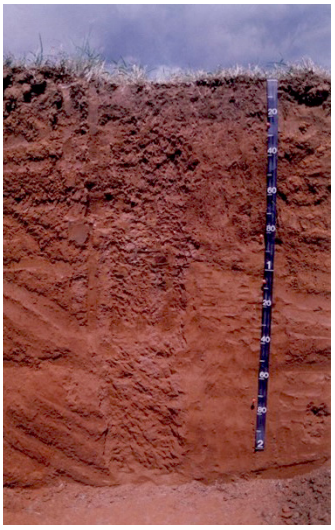

Fig. 1 Bayamón soil profile. Credit USDA-NRCS

Bayamón soils are located in the subtropical moist forest region of Puerto Rico. Only a small fraction of those forests remains, as most were cleared in the 17th and 18th century to produce crops, historically for sugar cane plantations, but now dominantly pasture, pineapple and food crops. Thus, 400 years of crop production may have a greater impact on the soil properties than the original forest.

Bayamón soils are found on 2 to 12 percent slopes on uplands, coastal plains and valleys intermingled among limestone hills (haystacks) (**Figure 2**) and *sinkholes* in the *karst* region of the northern part of the island. This

Fig. 2 Landscape of Bayamón soil in northern Puerto Rico (note the haystacks). USDA-NRCS

series is usually more than 200 cm (80 inches) deep and very strongly acid throughout (pH < 5.0). The *topsoil* (also called A horizon, the layer of soil that we plow or plant seeds in) has a dark reddish-brown color, generally less than 2% *organic matter*, and can be as much as 20 cm (8 inches) thick (Figure 1). The red color gets brighter in the *subsoil* (or B horizon) as the *organic matter* decreases with depth.

Every soil can be separated into three separate size fractions called *sand*, *silt*, and *clay*, which make up the *soil texture*. They are present in all soils in different proportions and say a lot about the character of the soil. In Bayamón soil, the texture throughout the profile has more than 60% clay.

These soils are *well-drained* and do not have a *water table*, but *permeability* of water through the soil is very slow due to the high clay content.

Where to dig a Bayamón

Yes, you can dig a soil. It is called a soil pit and it shows you the *soil profile*. The different horizontal layers of the soil are called soil horizons. If you want to dig a Bayamón soil pit, you will have to travel to the northern coastal plains of Puerto Rico where it can be found on more than 9,300 hectares (23,300 acres) (**Figure 3**). This does not mean other types of soil cannot be found there, but the Bayamón is among the most common. There are more than 200 named soil series mapped in Puerto Rico.

Fig. 4 Pineapple field in Bayamón soil. Photo credit: Taxonomic Classification of the Soils of Puerto Rico, 2017. AES Bulletin 313, p. 67.

Fig. 3 Location of Bayamon in Puerto Rico. Credit: Smithsonian Institution's Forces of Change. https://forces.si.edu/soils/interactive/state-soils/html/index.html

Importance

Bayamón soils are classified as *prime farmland* and were historically used for sugar cane production, and more recently for pineapple (**Figure 4**), which grows better on acid soils. For many decades, the Espanola Roja pineapple was used for lotus juice. Now, other pineapple varieties are grown as fresh fruit for consumption on the island. Also, you will find the Puerto Rican lizard cuckoo (**Figure 5**), Puerto Rican screech owl and Puerto Rican boa.

Fig. 5 Puerto Rican Lizard Cuckoo. Photo credit: By Ron Knight - https://www.flickr.com/photos/sussexbirder/8091097838/, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=51589245.

Uses

Currently, the pineapple production has declined, and these soils are being used for food crops, pasture and hay for livestock. Some producers have even planted coffee. The soil supports native grasslands of Guinea grass, Zarcilla and Tulipan Africano.

Limitations and Management

Bayamón soil series have low to medium fertility and are strongly to extremely acid throughout their profile. The availability of many plant nutrients is limited in soils with pH < 5, so special management is required to manage the pH and nutrients for producing most crops. The soils respond well to applications of fertilizer and lime (to raise the pH). The major soil resource concerns are water erosion (sheet and rill); maintenance of the content of *organic matter*, crusting, and water *infiltration*.

Bayamón Soil Formation

Before there was soil there were rocks and in between, ClORPT. Without ClORPT, there will be no soil. So, what is ClORPT? It is the five major factors that are responsible for forming a soil like the Bayamón series. It stands for **Cl**imate, **O**rganisms, **R**elief, **P**arent material and **T**ime. ClORPT is responsible for the development of soil profiles and chemical properties that differentiate soils. So, the characteristics of Bayamón soil (and all other soils) are determined by the influence of ClORPT. Weathering takes place when environmental processes such as rainfall, freezing and thawing act on rocks causing them to dissolve or fracture and break into pieces. ClORPT then acts on rock pieces, marine sediments and vegetative materials to form soils.

Climate – Temperature and precipitation influence the rate at which parent materials weather and dead plants and animals decompose. They affect the chemical, physical and biological relationships in the soil. The Bayamón soil developed under a humid tropical climate with continually warm temperatures (mean annual soil temperature > 22°C, 72 ° F and less than 5°C change) and abundant rainfall 1650 mm (65 inches). The influence of the two resulted in the depletion of *organic matter* and *leaching* of soluble bases – elements such as calcium and magnesium necessary to decrease soil acidity.

Organisms – This refers to plants and animal life. In the soil, plant roots spread, animals burrow in, and bacteria break down plant and animal tissue. These and other soil organisms speed up the breakdown of large soil particles into smaller ones. Plants and animals also influence the formation and differentiation of *soil horizons*. Plants determine the kinds and amounts of *organic matter* that are added to a soil under normal conditions. Animals breakdown complex compounds into small ones and in so doing add organic matter to soil. Bayamón developed in a subtropical forest with some grasses which deposited leaves, twigs, roots and other plant remains on the surface. But these readily decompose and the resulting *organic matter leaches* through the soil. Bayamón soils, under cultivation, have even less accumulation of *organic matter*.

Relief – Landform position or relief describes the shape of the land (hills and valleys), and the direction it faces which makes a difference in how much sunlight the soil gets and how much water it keeps. Deeper soils form at the bottom of the hill rather than at the top because gravity and water move soil particles downhill. Bayamón soil is *well drained* because it is formed on dominantly stable gently sloping positions of the coastal plains.

Parent material (C horizon) – Just like people inherit characteristics from their parents, every soil inherits some traits from the material from which it forms. Some parent materials are transported and deposited by glaciers, wind, water, or gravity. Bayamón soils developed from highly weathered, clayey marine sediments and strongly weathered clayey sediments eroded from volcanic rocks from the center of the island and transported by water to be deposited along the northern coast on top of limestone.

Time – All the factors act together over a very long period of time to produce soils. As a result, soils vary in age. The length of time that soil material has been exposed to the soil-forming processes makes older soils different from younger soils. Generally, older soils have better defined *horizons* than younger soils. Less time is needed for a soil profile to develop in a humid tropical and warm area with dense vegetative cover where the Bayamón soil is than in a cold dry area with sparse plant cover. More time is required for the formation of a well-defined *soil profile* in soils with fine textured material than in soils with coarse-textured soil material. The Bayamón is an old soil in a tropical environment and started weathering 23 million years ago!

Ecoregions, Soils & Land Use in Puerto Rico

An **ecoregion** represents areas with similar biotic and abiotic characteristics which determine the resource potential and likely responses to natural and man-made disturbances. Characteristics such as climate, topography, geology, soils and natural vegetation define an ecoregion. They determine the type of land cover that can exist and influence the range of land use practices that are possible.

Puerto Rico is cut roughly in half east to west by a mountain range with coastal plains around the perimeter of the island. The elevation ranges from sea level to 700 m (2300 ft). Moving inland, the northern coastal plains grade into *karst* limestone features which account for almost 20% of the island's total land area. In some places, limestone cliffs drop 60m (200 ft) into the sea.

The mountain range is responsible for much of the climatic variability on the island. Most of the temperature differences are associated with elevation, while the mountains intercept the weather fronts resulting in a range of precipitation from

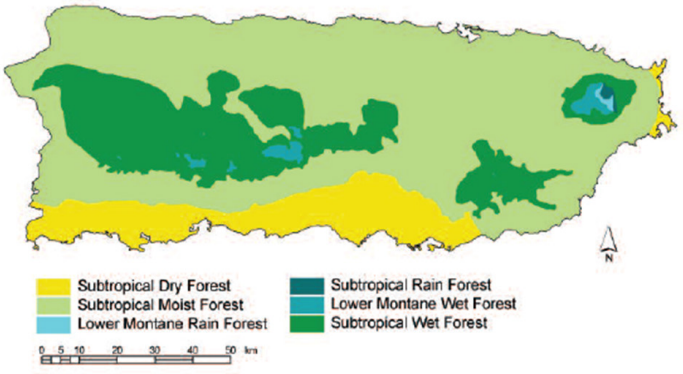

Fig. 6 Forest ecosystems of Puerto Rico. Source: *Jennings et al., 2014*

the Guánica Forest (a tropical rainforest) in the northeast with more than 5,000 mm (200 in) of precipitation to the semiarid southern coast that may only get 250 mm (10 in) in dry years.

Climate, parent materials and organisms combine to create six distinct ecosystems within the tropical forest biome. Notice the similarities between the *ecosystem* (**Figure 6**) and soil orders (**Figure 7**) maps.

Remember ClORPT? All these factors contribute to the many different types of soil that can be found in Puerto Rico. These individual soils are classified into groups based on similarities in their profiles and other characteristics. Soil, like plants and animals, has a classification system. It's called Soil Taxonomy. It has six levels: Order, Suborder, Great Group, Subgroup, Family and Series. Ten of the twelve soil orders can be found in Puerto Rico. Bayamón is in the Oxisol order and has an oxic horizon - a mixture of iron and aluminum oxides and kaolinite.

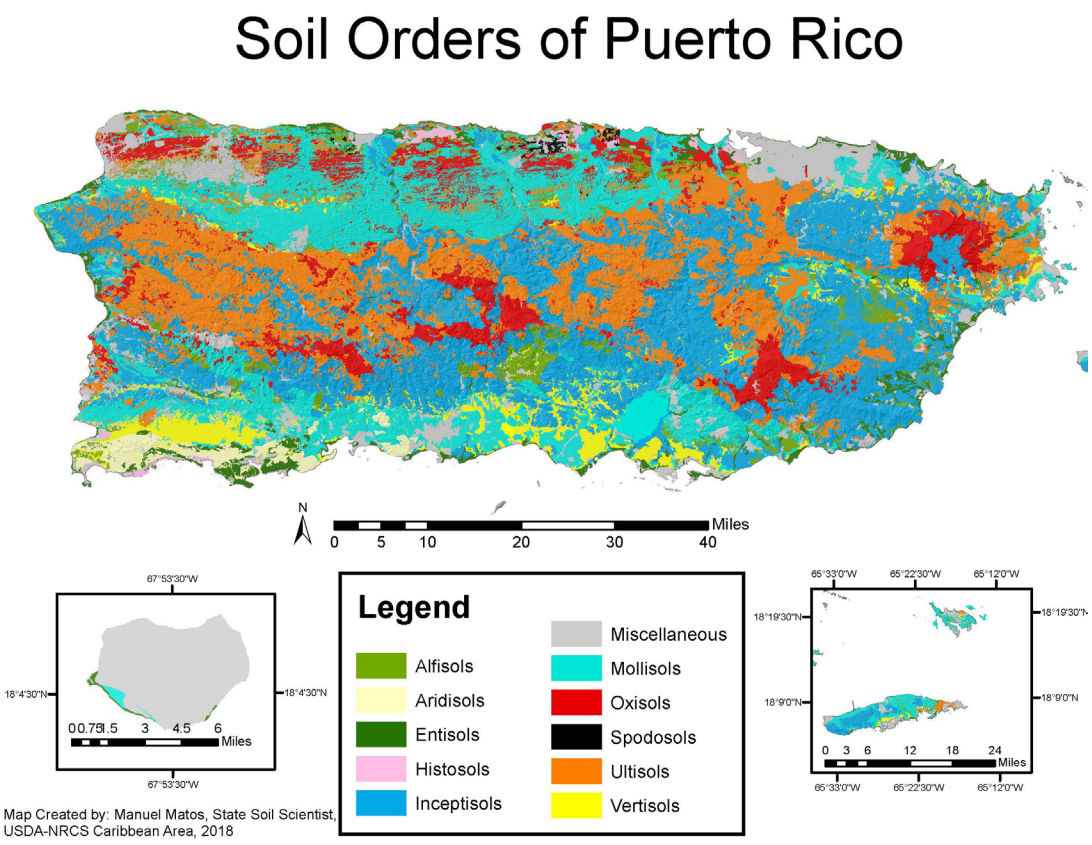

Fig. 7 Soil orders of Puerto Rico. Source: p. 51. Munoz, M.A., W.I. Lugo, C. Santiago, M. Matos, S. Rios, and J. Lugo. 2017. Taxonomic classification of the soils of Puerto Rico, 2017. Univ. of Puerto Rico, Mayaguez Campus.

Glossary

Biome: A large geographic region with a similar environment and distinctive plant and animal community. Biomes often contain several ecosystems.

Clay: A soil particle that is less than 0.002 mm in diameter. Clay particles are so fine they have more surface area for reaction. They hold a lot of nutrients and water in the soil. A clay soil is a soil that has more than 40% clay, less than 45% sand and less than 40% silt.

Ecosystem: A system formed by the interaction of a community of organisms (microorganisms, plants and animals) and its environment (climate, soils and other abiotic factors).

Erosion: The process of eroding or being eroded by wind, water, or other natural agents.

Infiltration: The process by which water on the ground surface enters the soil.

Kaolinite: A highly weathered, low activity clay mineral that does not shrink and swell upon wetting and drying.

Karst (topography)**:** The relief of an area underlain by limestone that dissolves in different degrees, thus forming numerous depressions, or small basins, and even caves.

Leaching: The removal of soluble materials from one zone in soil to another via water movement in the profile.

Organic matter: Material derived from the decay of plants and animals. Always contains compounds of carbon and hydrogen.

Permeability: The ease with which gases, liquids or plant roots penetrate or pass through a layer of soil.

Prime Farmland: Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. It could be cultivated land, pastureland or forest land, or other land but it is not urban or built-up areas or water areas.

Sand: A soil particle between 0.05 and 2.0 mm in diameter. Sand is also used to describe soil texture according to the soil textural triangle, for example, loamy sand.

Silt: A soil particle between 0.002 and 0.05 mm diameter. It is also used to describe a soil textural class.

Sinkhole: A depression in the landscape where limestone has been dissolved.

Soil Horizon: A layer of soil with properties that differ from the layers above or below it.

Soil Profile: The sequence of natural layers, or horizons, in a soil. It extends from the surface downward to unconsolidated material. Most soils have three major horizons, called the surface horizon, the subsoil, and the substratum.

Soil Texture: The relative proportion of sand, slit, and clay particles that make up a soil. Sand particles are the largest and clay particles the smallest. Learn more about soil texture at www.soils4teachers.org/physical-properties

Subsoil: (B horizon) The soil horizon rich in minerals that eluviated, or leached down, from the horizons above it. Not present in all soils.

Topography: The shape of the land surface (different from relief which refers to differences in elevation of different points in a landscape.)

Topsoil: The horizon that formed at the land surface. Mostly weathered minerals from parent material with a little organic matter added.

Water table: The top layer of ground water where the soil profile is filled with water. It can move up or down during different seasons.

Well-drained: One of several drainage classes used by soil scientists to indicate the depth to the water table during the growing season. Well drained means the water table is below 122cm or 4 feet during the growing season.

Additional Resources

Soil! Get the Inside Scoop. David Lindbo and others. Soil Science Society of America, Madison, WI.

Know Soil, Know Life. David L. Lindbo, Deb A. Kozlowski, and Clay Robinson, editors. Soil Science Society of America, Madison, WI.

Web Resources

Resources for Teachers—www.soils4teachers.org

Soils for Kids—www.soils4kids.org/

Have Questions? Ask a Soil Scientist—www.soils4teachers.org/ask

Soil Science Society of America—www.soils.org

USDA-NRCS, Caribbean Area Homepage—
www.nrcs.usda.gov/wps/portal/nrcs/site/pr/home/

USDA-NRCS—www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/

USDA-NRCS, Educational Resources—
soils.usda.gov/education/resources/k_6/

Puerto Rico Dept. of Agriculture—www.agricultura.pr.gov/

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