United States Department of Agriculture

Natural Resources Conservation Service

In cooperation with the United States Department of Agriculture, Forest Service, Southern Region and Southern Research Station; the International Institute of Tropical Forestry; and the University of Puerto Rico, Agricultural Experiment Stations

Soil Survey of Caribbean National Forest and Luquillo Experimental Forest, Commonwealth of Puerto Rico

How To Use This Soil Survey

General Soil Map

The general soil map, which is a color map, shows the survey area divided into groups of associated soils called general soil map units. This map is useful in planning the use and management of large areas.

To find information about your area of interest, locate that area on the map, identify the name of the map unit in the area on the color-coded map legend, then refer to the section **General Soil Map Units** for a general description of the soils in your area.

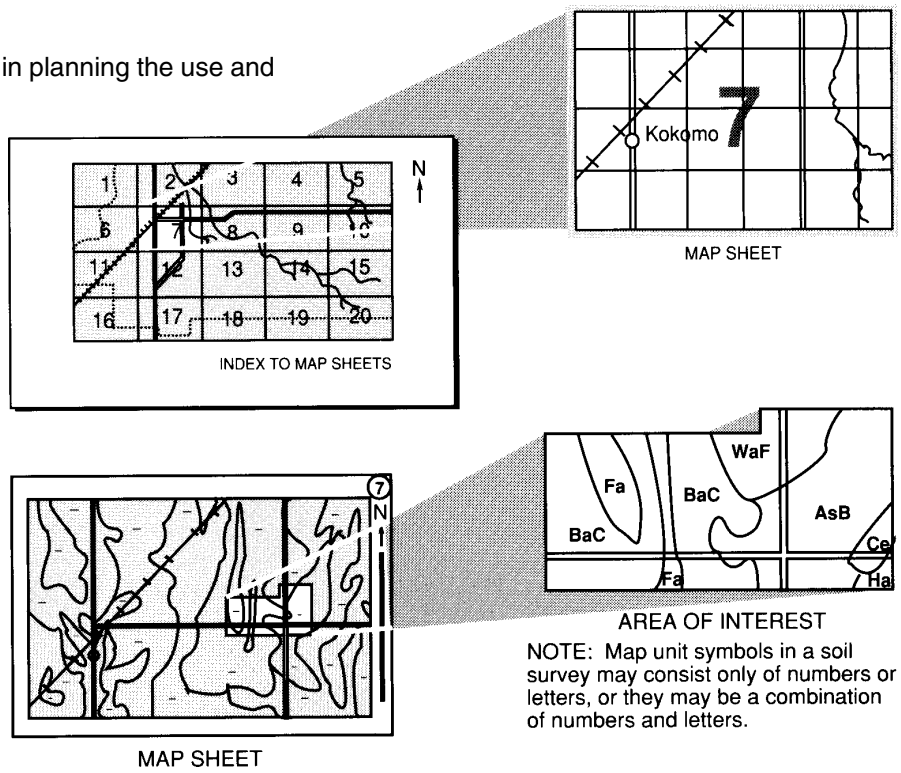
Detailed Soil Maps

The detailed soil maps can be useful in planning the use and management of small areas.

To find information about your area of interest, locate that area on the **Index to Map Sheets**. Note the number of the map sheet and turn to that sheet.

Locate your area of interest on the map sheet. Note the map unit symbols that are in that area. Turn to the **Contents**, which lists the map units by symbol and name and shows the page where each map unit is described.

The **Contents** shows which table has data on a specific land use for each detailed soil map unit. Also see the **Contents** for sections of this publication that may address your specific needs.



NOTE: Map unit symbols in a soil survey may consist only of numbers or letters, or they may be a combination of numbers and letters.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (formerly the Soil Conservation Service) has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in 1992. Soil names and descriptions were approved in 2000. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 2001. This survey was made cooperatively by the Natural Resources Conservation Service and the USDA Forest Service, Southern Region and Southern Research Station; the International Institute of Tropical Forestry; and the University of Puerto Rico, Agricultural Experiment Stations. The survey is part of the technical assistance furnished to the USDA Forest Service, Southern Region.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

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Cover: A pair of juvenile Puerto Rican parrots *(Amazona vittata)* in the Caribbean National Forest. Much effort is going into maintaining and increasing the population of this endangered species (photo courtesy of Francisco Valenzuela, USDA Forest Service).

Additional information about the Nation's natural resources is available online from the Natural Resources Conservation Service at http://www.nrcs.usda.gov.

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Foreword

This soil survey contains information that affects land use planning in this survey area. It contains predictions of soil behavior for selected land uses. The survey also highlights soil limitations, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Foresters, land use planners, and researchers can use it to evaluate the potential of the soil and the management needed for maximum use and production. Planners, community officials, engineers, and builders can use the survey to plan land use, select sites for construction, and identify special practices needed to ensure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Various land use regulations of Federal, Commonwealth, and local governments may impose special restrictions on land use or land treatment. The information in this report is intended to identify soil properties that are used in making various land use or land treatment decisions. Statements made in this report are intended to help the land users identify and minimize the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Natural Resources Conservation Service, the Forest Service, or the Cooperative Extension Service.

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Soil Survey of Caribbean National Forest and Luquillo Experimental Forest, Commonwealth of Puerto Rico

By Loren Huffaker

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Fieldwork by Loren Huffaker and by Edward O'Brien, Lawrence F. Baldwin, Linda O'Brien, and Pete Kleto, consultant team

United States Department of Agriculture, Natural Resources Conservation Service,
In cooperation with
the USDA Forest Service, Southern Region and Southern Research Station; the International Institute of Tropical Forestry; and the University of Puerto Rico, Agricultural Experiment Stations

The Caribbean National Forest, locally known as El Yunque or "the Forest," is in the Luquillo Mountains and dominates the northeastern corner of Puerto Rico (fig. 1). It is one of the most popular recreation sites in Puerto Rico. Annually, almost one million tourists visit the Forest from Puerto Rico, the United States, and abroad. Puerto Rico, an island, is associated with the Greater Antilles chain of the Caribbean and is located at the southeastern end of the chain (Mitchell, 1954). The survey area includes all 27,846 acres (11,268 hectares) of the Caribbean National Forest.

The "Soil Survey of the Humacao Area of Eastern Puerto Rico" (Boccheciamp and others, 1977) was published by the Soil Conservation Service in 1977. An inservice report, "The Soils of El Yunque—An Order III Soil Resource Inventory of the Caribbean National Forest," (Ford, 1981) was completed in 1980. Other soil studies of specific areas in the Forest have been conducted (Soil Survey Staff, 1995). They can be valuable supplements to this soil survey. This report updates the previous surveys and provides additional information concerning the soils and their management.

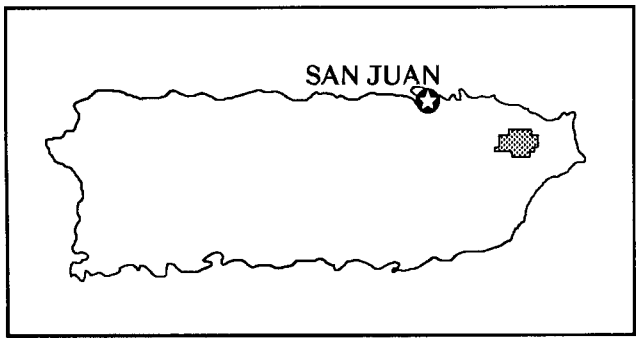

Figure 1.—Location of the Caribbean National Forest in Puerto Rico.

General Nature of the Survey Area

The mountainous terrain of the survey area is due to its location within the rugged Sierra de Luquillo Mountains. Relief within the area can be characterized as extreme and includes numerous dissected, steep to very steep slopes that are broken by narrow ridges. Elevations range from about 100 feet at the northern boundary to 3,533 feet at El Toro Peak (30 to 1,077 meters). The main drainage systems for the Forest are the Mameyes, Fajardo, Espiritu Santo, Río Grande, Río Sabana, and Icacos watersheds. The headwaters of these drainage systems originate in the survey area and provide water to over 200,000 people (Brown and others, n.d.; Wadsworth, 1951).

History of Land Use

Before the arrival of Columbus in 1493, Taino Indians lived in the Forest and throughout Puerto Rico (fig. 2). At one time, the Spanish Crown managed

Figure 2.—Petroglyphs inscribed by Taino Indians on a large boulder in Río Icacos. The boulder is in an area of Sonadora-Caguabo complex, 25 to 40 percent slopes. The Taino Indians of Puerto Rico numbered more than 60,000 during pre-Columbian times.

approximately 12,384 acres (5,018 hectares) of the Forest. Parts of the Forest have been in a protected status since the 1870s. In 1898, Puerto Rico became a territory of the United States and the Forest became the property of the federal government. Most of the original "Crown Lands," except for some lands that were used for high-grade logging, are the same today as when Columbus first visited the island (Robinson, 1997).

By the early 1900s, a large portion of the lower slopes of the Luquillo Mountains was used for subsistence cropland and pasture. Small, scattered plots were cultivated to produce food crops for the local population. Coffee plantations were also widespread in the foothills. Much of the lower Tabonuco Forest was cut or cleared for agricultural purposes. Most of these areas proved marginal for commercial crops.

The Forest was proclaimed a federal reserve in 1903 and has been managed by the USDA Forest Service since 1917. In 1931, the Weeks Law and the Clarke-McNary Act of 1924 were extended by Congress to include Puerto Rico. Under these laws, the Forest Service was able to acquire many of the exhausted, eroded agricultural lands on the periphery of the Forest and make them productive again (Scatena, 1989). The "parcelero" program aided this effort. It maintained a local labor force for onsite restoration. Each farmer residing on Forest land planted both food crops and timber. The program ended in 1960, but many of the plantations developed during this program remain today.

Current Land Use

Today, agriculture is not practiced in the Caribbean National Forest. Most of the land is considered unsuitable for modern agriculture, and no permanent private residences remain. Except for a few landslide areas, virtually all of the lands within the Forest contain native forest types or plantation forest types. Many stands of timber that originated with land purchases in the 1930s and 1940s now contain mature sawtimber. Occasionally, some timber is extracted for research or for other limited purposes. Since 1978, approximately 1,200 acres (480 hectares) of the degraded secondary timber stands have been planted (called enrichment plantings) to mahogany (Brown and others, n.d.).

Currently, the Forest is managed under the multiple-use concept that is common to the National Forest system. The greatest impact on the land base comes from recreation and the associated trails and areas for picnicking, swimming and other water play, and camping (fig. 3). The change in Puerto Rico from an agrarian society to a manufacturing society has increased the general availability of leisure time and has resulted in an increased number of visitors to the Forest.

Another important use of the Forest is as a site for research into the physical and biological processes of tropical ecosystems. The association between the Commonwealth of Puerto Rico and the USDA Forest Service has provided a combination of stability and infrastructure not commonly found in the tropics. This association has facilitated the establishment and continuation of many long-term ecological studies into tropical forest systems.

Biophysical Setting

Biodiversity has been defined as “the variety of life in an area, including the variety of genes, species, plant and animal communities, ecosystems, and the interactions of these elements” (USDA–FS, 1986 and 1997). The forests on the island of Puerto Rico are characterized by a great diversity of plants (although they are somewhat less diverse than continental tropical forests). More species of trees grow in the Caribbean National Forest than in all other 155 U.S. National Forests combined, and none of these species grow in any other U.S. National Forest.

The diversity of animals in the Caribbean National Forest is significantly less than that in similar continental forests (fig. 4). This is primarily because Puerto Rico is located a long way and upwind from the closest continental land masses, making it difficult for new species of animals to arrive. Nevertheless, about 134 vertebrate species are known to live within the Forest.

Biodiversity generally is threatened by such factors as human-caused habitat change, toxins, and pollution; the overuse of plant and animal populations; habitat fragmentation; climate change; the simplification of ecosystems; reduction in genetic variation; and the spread of exotic species. Puerto Rico, including the Caribbean National Forest, are or have been influenced by many of these factors.

The threats to biodiversity commonly have a greater impact on the animals and plants on small islands than on larger land masses. Many species of plants and animals are unique to Puerto Rico. These small, isolated populations—which cannot be reestablished from elsewhere—are inherently more prone to extinction than the more common, widespread continental species.

Figure 3.—The Yokahú tower, which is in an area of Cristal-Zarzal complex, 5 to 40 percent slopes. The tower provides a spectacular view of the survey area and the Atlantic Ocean to the northeast.

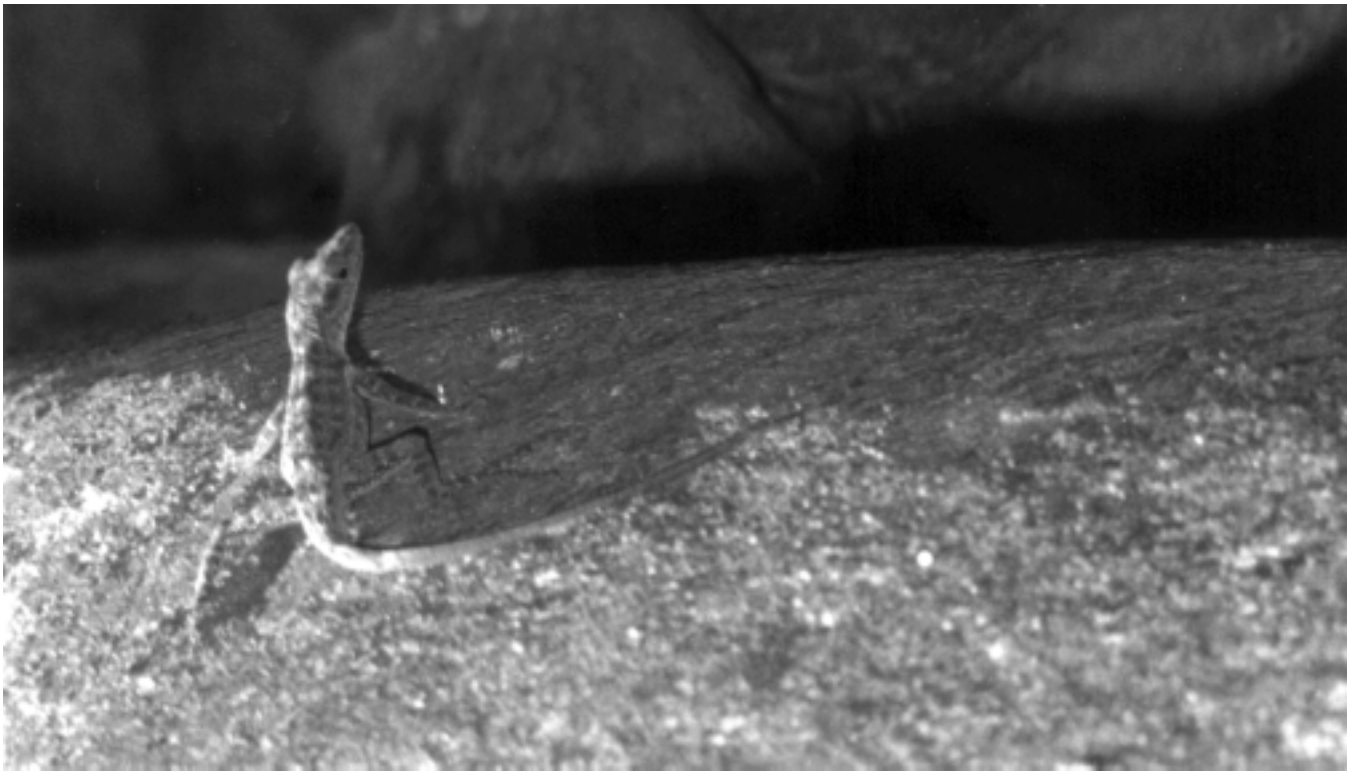

Figure 4.—A small lizard near Río Icacos. The animal population in the survey area is dominated by birds and reptiles.

Vegetation

By Luis Rivera, USDA Forest Service.

The Caribbean National Forest contains five ecological life zones: subtropical wet forest, subtropical rain forest, lower montane wet forest, lower montane rain forest, and a small area of subtropical moist forest. Figure 5 shows the distribution of the four major forest types in the survey area. They are the Tabonuco, Colorado, Palm, and Dwarf forest types (USDA–FS, 1989, 1986, and 1997; Ford, 1981; Ewell and Whitmore, 1993).

The four major forest types have their nearest allies in the Lesser Antilles. Nearly one-third of the tree species in the Caribbean National Forest are unique to Puerto Rico and the Virgin Islands, and 10 percent are unique to the Caribbean National Forest itself.

The Tabonuco forest type, named for the dominant tree *Dacryodes excelsa,* occurs on foothills and slopes below elevations of 2,000 feet (610 m). It is the most extensive forest type in the survey area, covering about 13,800 acres (5,585 hectares), which is about 49 percent of the Forest. The Tabonuco forest type also has the richest flora, containing at least 175 tree species. One hundred and fifteen of these species occur less commonly than 1 tree per 2.5 acres (1 tree per hectare). Two prominent species in this forest type are *Sloanea berteriana* (motillo) and *Manilkara bidentata* (bulletwood or ausubo). Significant impact from human activities, such as farming and pasturing, has occurred on about 80 percent of the acreage covered by this type, leading to a variety of successional stages.

The Colorado forest type, named for the common *Cyrilla racemiflora L.* (swamp cyrilla or palo colorado), is associated with the lower montane wet forest ecological life zone and typically occurs above 2,000 feet (610 m) on gentle slopes and in valleys. This forest type borders the Tabonuco forest type. There is an overlapping vegetative transition between the two forest types. The Colorado type provides nesting habitat for the endangered Puerto Rican parrot *(Amazona vittata vittata).* The abundant moisture in this forest type supports a host of herbaceous plants, including epiphytes representing many plant families. Over 50 species of trees grow in this forest type. Fifteen of these species occur less commonly than 1 tree per 2.5 acres (1 tree per hectare). Other abundant species include *Ocotea spathulata* (nemocá), *Micropholis chrysophylloides* (caimitillo), and *Micropholis garciniaefolia* (caimitillo verde). The

Colorado forest type covers 8,200 acres (3,318 hectares), which is about 30 percent of the Caribbean National Forest. At least 80 percent of this acreage is essentially unmodified by human activities.

The Palm forest type is dominated by a single species: *Prestoea montana* (Sierra palm). This forest type is a component of all five ecological life zones in the Caribbean National Forest. The Palm forest type occurs chiefly on steep slopes and along stream beds at about 1,500 feet (457 m). This forest type indicates unstable soils. It covers about 4,800 acres (1,942 hectares), which is about 17 percent of the Caribbean National Forest. This acreage is essentially unmodified by human activities. A few small areas are used as recreational sites.

The Dwarf forest type, also known as the "elfin woodland" or "cloud forest," is associated with the lower montane rain forest ecological life zone. This forest type occurs only on the higher peaks and ridges that are above 2,500 feet (762 m) and are subject to extreme exposure. Trees in this forest type are stunted and twisted. The largest trees are about 15 feet (4.6 m) tall and 12 inches (30.5 cm) in diameter. The average diameter is about 2 to 4 inches (5 to 10 cm). The exposed environment in this forest type supports a smaller number of species per unit area than the other types. A higher percentage of these species, however, are endemic to Puerto Rico. Common trees include *Ocotea spathulata* (nemocá), *Eugenia borinquensis* (guayabota), and *Tabebuia rigida* (roble de sierra). Some of the species in this forest type grow only in the Caribbean National Forest. The Dwarf forest type covers only about 1,000 acres (405 hectares),

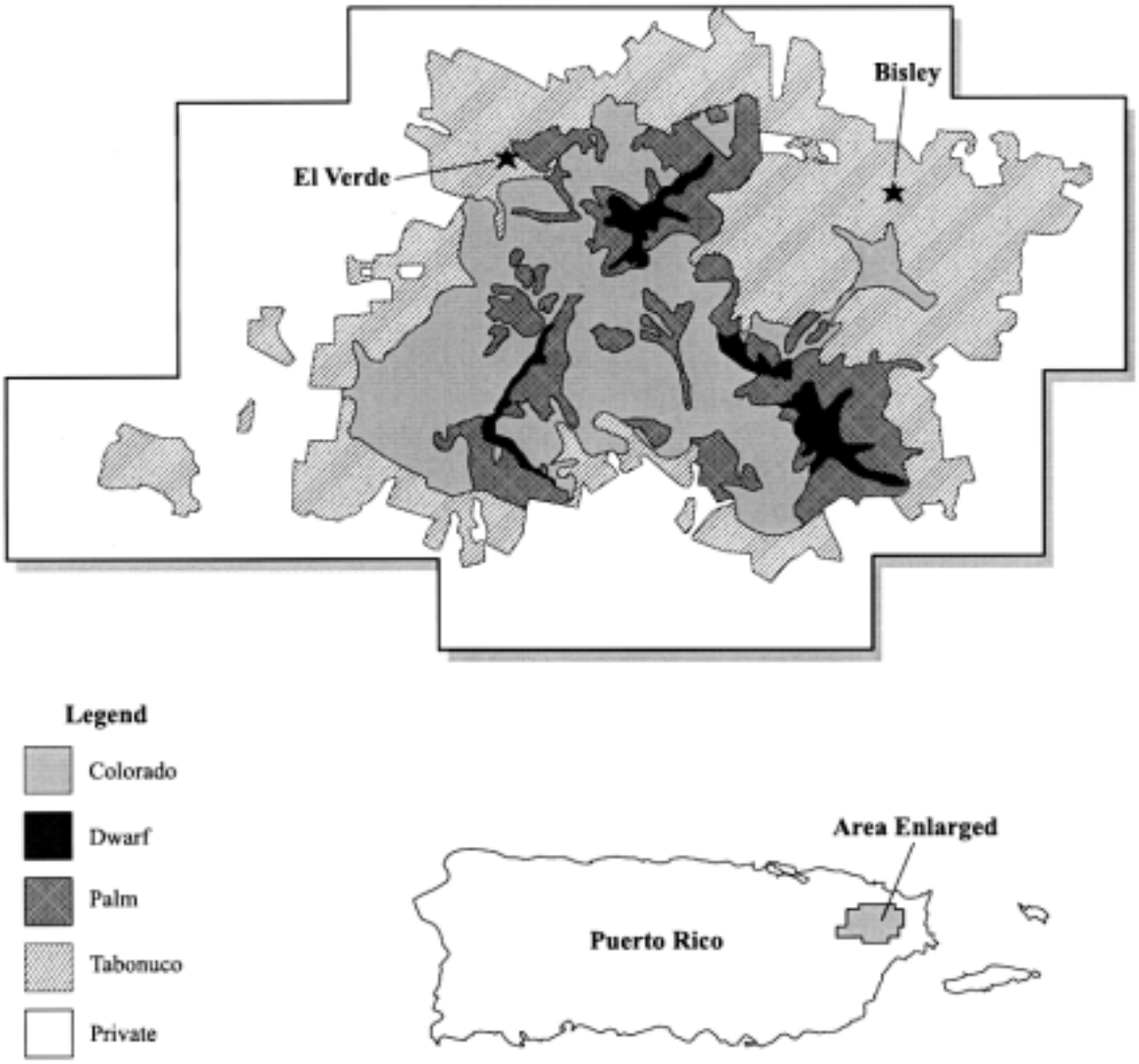

Figure 5.—The four major forest types in the Caribbean National Forest.

Figure 6.—Rockslides and landslides are hazards along roadbanks where the soil has low bearing strength.

which is about 4 percent of the Caribbean National Forest. Most of this acreage is unmodified by human activities. A few areas on the peaks have been developed as sites for electronic equipment and have access roads.

A zone of riparian vegetation about 200 feet wide (61 m) occurs along perennial streams. This zone totals about 2,200 acres (890 hectares).

Primary Forest

The core of the Caribbean National Forest remains in primary condition without significant human modification. This primary forest is the largest remnant of the forest that covered virtually the entire island at the time of Columbus's arrival 500 years ago. At least 85 percent of Puerto Rico was cleared for agriculture, resulting in the disappearance of nearly all of the forest.

The primary forest presents a unique window into the past. It also provides a natural control against which changes to tropical forests in Puerto Rico and elsewhere can be measured. It provides the only currently suitable habitat for many endemic plant species and for the endangered Puerto Rican parrot. The biological values of the primary forest remain incompletely known, but are certainly unique.

Construction of Puerto Rico Highway 191

through the Caribbean National Forest and construction of access roads to electronic sites on El Yunque Peak and East Peak opened up the primary forest to vehicular traffic (fig. 6). El Toro-Trade Winds Trail traverses the primary forest for about 5 miles (8 km), providing the main walking access into the primary forest. Tree harvesting for charcoal in the Colorado forest type during World War II also impacted some primary forest. Timber sales that began in 1931 never entered the Dwarf and Palm forest types and were discontinued in the Colorado type about 40 years ago. Despite these impacts, nearly 50 percent of the Caribbean National Forest, about 13,700 acres (5,544 hectares), remains in pristine condition.

Climate

Precipitation

The climate in the Caribbean National Forest is dominated by trade winds. The constant trade winds, punctuated by occasional remnant fronts from the northwest during the winter, bring moisture on a daily basis against the Luquillo Mountains. Tropical storms and hurricanes impact the forest, primarily in August and September (Robinson, 1997).

The Luquillo Mountains are the wettest area in Puerto Rico, with rainfall generally increasing with elevation. Table 1 shows the mean rainfall for nine stations in or adjacent to the Forest. The stations are arranged according to elevation from the lowest (Río Blanco 1) at 100 feet (30.5 m) to the highest (Pico del Este) at 3,448 feet (1,051.0 m). The mean annual rainfall ranges from about 97 inches (246 cm) annually at the lower elevations to over 150 inches (381 cm) at the higher elevations.

Peak rainfall occurs in May, particularly at the higher elevations. Minimum rainfall occurs in March (Robinson, 1997). The mean monthly rainfall ranges from about 6 to 12 inches (15 to 30 cm) at Río Blanco 1 and from about 8 to 22 inches (20 to 56 cm) at Pico del Este.

At the higher elevations, about 250 rainy days and 1,700 showers occur annually. The average precipitation from each shower is a little over 0.1 inch (3 mm). The rainfall at the higher elevations includes about twice as many rainy days and three times as many showers as on the northeast coast. The south and west sides of the Forest receive less precipitation than the north and east sides due to the mountain barrier. Hurricanes occur on a periodic basis and are expected to hit the Forest directly once every 50 to 60 years (Mount and others, 1992; Robinson, 1997; USDA–FS, 1986; Wadsworth and Englerth, 1959).

Temperature

Soil temperatures in the Luquillo Mountains, on a year-round basis, are 8 to 12 degrees F (4 to 7 °C) cooler than on the coast and are about equal to those of the central mountain ranges of Puerto Rico. The monthly mean soil temperature is about 70.3 degrees F (21.3 °C). The extreme maximum temperature in the geographic center of the Forest, at the El Yunque Recreation Areas, is 90 degrees F (32 °C), and the extreme minimum is 52 degrees F (11 °C).

Soil Temperature Regimes

Temperature is an important soil property. In classification, soil temperature is used to differentiate soil taxon at the family level. On a practical level, biological processes are largely controlled by soil temperature. For example, soil temperatures between 32 and 41 degrees F (0 and 5 °C) restrict root growth of all but the most highly adapted species. Temperature also strongly influences the biological, chemical, and physical processes of the soil. These processes are reflected in the plant community that occupies a particular landscape.

As is common in mountain landscapes, the vegetation in the Caribbean National Forest changes with increasing altitude. The changes in vegetation are an expression of changes in temperature and moisture; the landscape is cooler and wetter upslope and is dryer and warmer downslope. In the mountainous parts of the western United States, such changes in vegetation commonly are used to identify changes in the soil temperature regime, which is then used for soil classification. This same principle was used to classify the soils of the Caribbean National Forest.

According to “Soil Taxonomy” (Soil Survey Staff, 1999), “Soil temperature often can be estimated from climatological data with a precision that is adequate for the present needs of soil surveys. If we cannot make reasonably precise estimates, the measurement of soil temperature need not be a difficult or a time-consuming task.”

Soil Taxonomy further states, “If the temperature of a soil is measured at a depth below the influence of the daily cycle of fluctuations, such as a depth of 20 inches (50 cm), four readings equally spaced throughout the year give a very close approximation of the mean annual temperature. For example, the average of readings taken at a depth of 20 inches (50 cm) at Vauxhall, Alberta, on January 1, April 1, July 1,

and October 1, 1962, differs from the average of two readings each day of the year by only about 1.8 degrees F (0.3 °C)."

Soil temperature was measured at seven locations either entirely within or near the fringes of the dominant vegetation types in the Caribbean National Forest. These sites were at 430 and 760 feet (130 and 230 m) for the Tabonuco forest type, at 1,080 and 1,380 feet (330 and 420 m) for the fringe between the Tabonuco and Palo Colorado types, at 1,720 and 2,400 feet (525 and 730 m) for the Palo Colorado type, at 2,710 feet (825 m) for the fringe between the Palo Colorado and Dwarf types, and at 3,220 feet (980 m) for the Dwarf type. Readings were taken at a depth of 20 inches (50 cm) between the 14th and 29th of each month for the 20 months between April, 1985, and November, 1986. Unfortunately, the station at 1,380 feet (420 m) was vandalized after three months of readings. It was not replaced. Table 2 gives the data from the temperature study. These data were used to help define the soil climate regions of the Caribbean National Forest.

An "average for one year" is included in table 2 because the data do not include two complete years. The averages for the 20-month totals are skewed towards the warm side because they include two summer readings and only one winter reading. The readings for the 3,220 foot (980 m) sample represent the first recognized isomesic (47 to 59 °F, or 8 to 15 °C) soil temperatures in Puerto Rico. The data also support the use of the "iso" modifiers because the spread between mean summer and mean winter temperatures is less than the maximum allowed, which is 10.8 degrees F (6 °C).

How This Survey Was Made

This survey was made to provide information about the soils within the Caribbean National Forest. The information includes descriptions of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Observations were made concerning the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of native plants; and the kinds of bedrock. Many holes or pits were sampled to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biologic activity.

The soils in the survey area are in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each type of soil is associated with a particular kind of landscape or with a segment (landform) of the landscape. Concepts, or models, of how the soils formed were developed by observing the soils in the survey area and relating their position to a landform of the landscape. During mapping, these models were used to predict with considerable accuracy the kind of soils that occur at a specific locations on the landscape (Steers and Hajek, 1979).

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, the boundaries between the soils must be determined. Only a limited number of soil profiles can be observed, and not all boundary lines can be verified by onsite investigation. Nevertheless, these observations, supplemented by an understanding of the soil-landscape relationship, are sufficient to determine the boundaries. The types of soil and their percent composition within each mapped area were determined by random transects of individual mapping units.

Profiles were studied and soil characteristics were recorded in descriptions. Soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, acidity, and other features were noted. After the soils in the survey area were described and their properties were determined, the soils were then assigned to taxonomic classes and map units. Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The system of taxonomic classification used in the United States is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soils in the survey area were classified and named, comparisons were made with similar soils in the same taxonomic class in other areas in order to confirm the classification and to assemble additional data based on experience and research (Soil Survey Staff, 1996).

Predictions about soil behavior are based on soil properties and such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, predictions can be made with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but predictions cannot be made that a high water table will always be at a specific level in the soil on a specific date.

After the significant natural bodies of soil in the

survey area were located and identified, the boundaries of these bodies were drawn on aerial photographs and each was identified as a specific map unit. Aerial photographs show trees, buildings, clearings, roads, and rivers, all of which help in locating boundaries. These are the original and most accurate maps. For reproduction, the lines were transferred to 1:20,000 USGS quadrangle topographic maps. These are the maps contained in the publication and the base for any further use in geographic information systems (Soil Survey Staff, 1996).

The soil maps for this survey have been produced in digital format that meet Soil Survey Geographic Database (SSURGO) standards. The digital data can be acquired from the USDA Forest Service.

General Soil Map Units

The general soil map in this publication shows broad areas that have a distinctive pattern of soils, relief, and drainage. Each map unit on the general soil map is a unique natural landscape. Typically, it consists of one or more major soils and some minor soils. It is named for the major soils. The components of one map unit can occur in another but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general or Forest-wide land use and planning. Areas of broad suitability can be identified on the map. Likewise, areas where the soils are not suitable for certain uses can be identified. For example, the land in the isohyperthermic zone (commercial timber area) may be contrasted against the areas that do not have commercial potential. Areas derived from volcanic sandstone and breccia may be contrasted against those of plutonic origin.

Because the amount of rainfall increases with elevation, hydric soils are generally more common at the higher elevations than at the lower.

Because of its small scale, the map is not suitable for planning the location of recreation areas, roads, or other projects that require onsite evaluation. The soils in any one map unit differ widely from place to place in slope, depth, drainage, and other characteristics that affect use and management.

Soils of the Isohyperthermic Region

The soils of this group correspond to the Tabonuco forest type (fig. 7). The mean annual soil temperatures are greater than 72 degrees F (22 °C), and the difference between the mean summer temperature and the mean winter temperature is

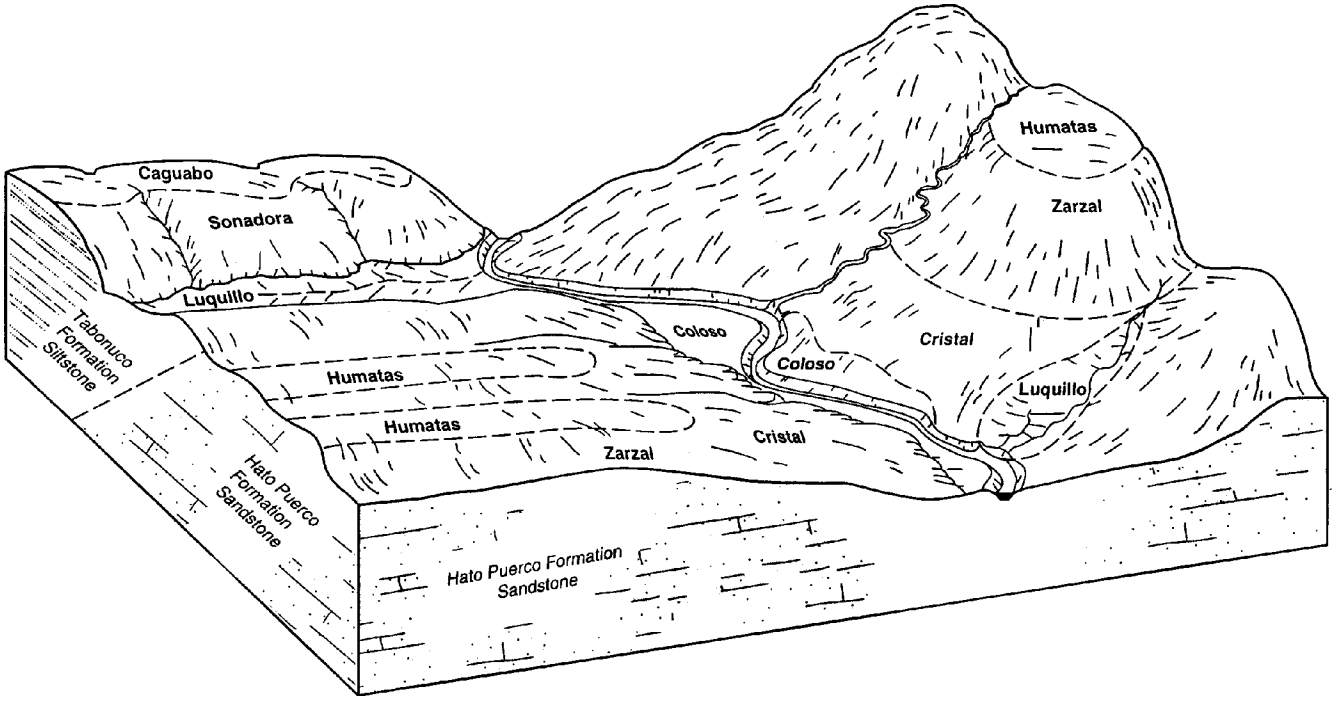

Figure 7.—Typical pattern of soils in the isohyperthermic temperature regime.

less than 9 degrees F (6 °C) at a depth of 20 inches (50 cm) (Boccheciamp and others, 1977).

1. Zarzal-Cristal-Humatas Association

Very deep, well drained and somewhat poorly drained clayey soils that formed in residuum that weathered from volcanic sandstone and mudstone of the Hato Puerco, Tabonuco, and Fajardo Formations

This association is dominantly on the north side of the survey area in a band that runs east to west from the boundary of the survey area to about the contour line at 1,970 feet (600 m). Isolated areas are also around Gurabo and in the southeastern part of the survey area. The association covers about 35 percent of the survey area.

The Zarzal soils are very deep and well drained. They are on convex parts of mountain side slopes and footslopes. Typically, the surface layer is dark reddish brown clay about 1 inch (2 cm) thick. The upper part of the subsoil, to a depth of 35 inches (89 cm), is yellowish brown clay. The lower part of the subsoil, to a depth of 82 inches (209 cm), is strong brown clay. It has mottles in shades of red and, below a depth of 56 inches (143 cm), gray. The underlying material, to a depth of 91 inches (230 cm) or more, is strong brown, weathered sandstone having a texture of very gravelly clay.

The Cristal soils are very deep and somewhat poorly drained. They are in concave parts of coves, on lower parts of side slopes, and in drainageways. Typically, the surface layer is dark brown clay loam about 2 inches (5 cm) thick. The upper part of the subsoil, to a depth of 15 inches (38 cm), is pale brown clay that has mottles in shades of brown, red, and gray. The next part of the subsoil, to a depth of 26 inches (66 cm), is yellowish brown gravelly clay that has mottles in shades of brown, red, and gray. The lower part of the subsoil, to a depth of 39 inches (99 cm), is strong brown clay that has mottles in shades of yellow, red, and brown. The substratum, to a depth of 60 inches (152 cm) or more, is yellowish red clay loam that has mottles in shades of brown and yellow.

The Humatas soils are very deep and well drained. They are on ridgetops and side slopes. Typically, the surface layer is dark brown silty clay about 4 inches (10 cm) thick. The upper part of the subsoil, to a depth of 12 inches (30 cm), is yellowish brown silty clay. The next part of the subsoil, to a depth of 19 inches (48 cm), is yellowish brown clay that has red mottles. The lower part of the subsoil, to a depth of 38 inches (97 cm) is clay mottled in shades of red and yellow. The substratum, to a depth of 60 inches (152 cm) or more, is red clay that has mottles in shades of yellow.

The minor components in this association include Coloso and Luquillo soils on flood plains. The Coloso soils are somewhat poorly drained. The Luquillo soils have a stony substratum. Also included are small areas of very steep Zarzal soils.

Most areas of this association were once used for extensive logging, for charcoal production, or for both. Some areas were used for intensive agriculture, subsistence agriculture, or both. Currently, the association supports second-growth native forest or plantations and is used as a site for recreation, research, wildlife habitat, and watershed protection.

Most areas of this association have moderate or severe limitations affecting timber management and dispersed recreational activities, such as hiking and bird watching. Onsite investigation is needed to locate facilities and to plan development for recreational areas.

2. Sonadora-Caguabo-Prieto Association

Moderately deep and shallow, well drained and poorly drained clayey soils that formed in residuum that weathered from volcanic mudstones and conglomerates of the Hato Puerco, Tabonuco, and Fajardo Formations

This association is in isolated areas in the extreme northwestern and southern parts of the survey area and south of the Río Cubuy. The association covers about 5 percent of the survey area.

The Sonadora soils are well drained and moderately deep. They are on the lower side slopes and footslopes. Typically, the surface layer is dark reddish brown clay loam about 1 inch (3 cm) thick. The upper part of the subsoil, to a depth of 16 inches (41 cm), is dark brown to dark yellowish brown clay. The lower part of the subsoil, to a depth of 21 inches (53 cm), is grayish brown clay. The substratum, to a depth of 36 inches (91 cm), is clay loam mottled in shades of brown. The underlying material, below a depth of 36 inches (91 cm), is dark gray mudstone.

The Caguabo soils are well drained and shallow. They are on side slopes on uplands. Typically, the surface layer is dark grayish brown gravelly clay loam about 3 inches (8 cm) thick. The subsoil, to a depth of 7 inches (18 cm), is brown very gravelly clay loam. The substratum, to a depth of 11 inches (28 cm), is brown very gravelly clay loam. The upper part of the underlying material, to a depth of 16 inches (41 cm), is weathered, gravelly mudstone. The lower part of the underlying material, at a depth of 16 inches (41 cm) or more, is hard, gravelly mudstone.

The Prieto soils are poorly drained and moderately

deep. They are in concave positions in mountain coves, on side slopes, and in drainageways. Typically, the surface layer is gray very cobbly clay loam about 4 inches (10 cm) thick. The upper part of the subsoil, to a depth of 13 inches (33 cm), is dark gray cobbly clay that has mottles in shades of brown. The next part of the subsoil, to a depth of 25 inches (64 cm), is greenish gray cobbly clay that has mottles in shades of yellow and brown. The lower part of the subsoil, to a depth of 35 inches (89 cm), is light gray cobbly silty clay that has mottles in shades of brown and gray. The underlying material, below a depth of 35 inches (89 cm), is hard, volcanic mudstone.

The minor components in this association include the well drained Luquillo soils. They are on narrow flood plains and stream terraces and have a very stony substratum.

Most areas of this association were once used for intensive agriculture, subsistence agriculture, or both. A few areas were used for timber and charcoal production. Currently, the association supports second-growth native forest or plantations and is used as a site for recreation, research, and wildlife habitat.

Except for the areas in the south-central part of the survey area, this association generally has moderate limitations affecting timber management and dispersed recreational activities, such as hiking and bird watching. The areas in the south-central part are dominated by the Prieto soils and have severe limitations.

Soils of the Isothermic Region

The soils of this group correspond to the Palo Colorado forest type. Soil temperatures range from 59 to 72 degrees F (15 to 22 °C), and the difference between the mean summer temperature and the mean winter temperature is less than 9 degrees F (6 °C) at a depth of 20 inches (50 cm) (Boccheciamp and others, 1977).

3. Yunque-Los Guineos-Moteado Association

Very deep and deep, moderately well drained, well drained, and poorly drained clayey soils that formed in residuum that weathered from volcanic sandstone and mudstone of the Hato Puerco, Tabonuco, and Fajardo Formations (fig. 8)

This association is in an arc that starts east of Pico del Oeste, where the arc roughly corresponds to the contour band at 1,310 to 2,950 feet (400 to 900 m), and then continues northwest to La Coca falls and west to Quebrada Jimenez. From Quebrada Jimenez, the arc rises transitionally up the land mass in response to a warming microclimate and roughly corresponds to the contour band at 1,800 to 3,120 feet (550 to 950 m). The arc crosses southwest to El Negro and then circles to the east to La Mina. The association covers about 35 percent of the survey area.

The Yunque soils are very deep and moderately well drained. They are on mountain side slopes and convex ridgetops on strongly dissected uplands. Typically, the upper part of the surface layer is a root mat about 2 inches (5 cm) thick. The lower part of the surface layer, to a depth of 7 inches (18 cm), is dark yellowish brown cobbly clay or clay having mottles in shades of brown. The upper part of the subsoil, to a depth of 30 inches (76 cm), is yellowish brown clay that has mottles in shades of red, yellow, gray, and brown. The middle part of the subsoil, to a depth of 51 inches (130 cm), is yellowish red to strong brown silty clay to silty clay loam having mottles in shades of brown and gray. The lower part of the subsoil, to a depth of 62 inches (157 cm), is silty clay loam mottled in shades of red and brown.

The Los Guineos soils are very deep and well drained. They are on mountain side slopes. Typically, the surface layer is dark yellowish brown clay about 1 inch (3 cm) thick. The upper part of the subsoil, to a depth of 18 inches (46 cm), is yellowish brown to brownish yellow clay. It has red mottles below a depth of 9 inches (23 cm). The next part of the subsoil, to a depth of 43 inches (109 cm), is red clay that has mottles in shades of brown. The lower part of the subsoil, to a depth of 93 inches (236 cm), is strong brown to yellowish red clay that has mottles in shades of brown and red.

The Moteado soils are deep and poorly drained. They are in concave areas on ridgetops and side slopes on uplands. Typically, the upper part of the surface layer is a root mat about 1 inch (3 cm) thick. The lower part of the surface layer is grayish brown to dark grayish brown clay about 13 inches (33 cm) thick. The upper part of the subsoil, to a depth of 22 inches (56 cm), is dark grayish brown clay that has mottles in shades of brown and gray. The next part of the subsoil, to a depth of 41 inches (104 cm), is yellowish brown to light olive brown clay that has mottles in shades of brown, gray, and, below a depth of 27 inches (69 cm), red. The lower part of the subsoil, to a depth of 54 inches (137 cm), is olive gray clay that has mottles in shades of brown. The underlying material, below a depth of 54 inches (135 cm), is unweathered, volcanic sandstone bedrock.

The minor components in this association include

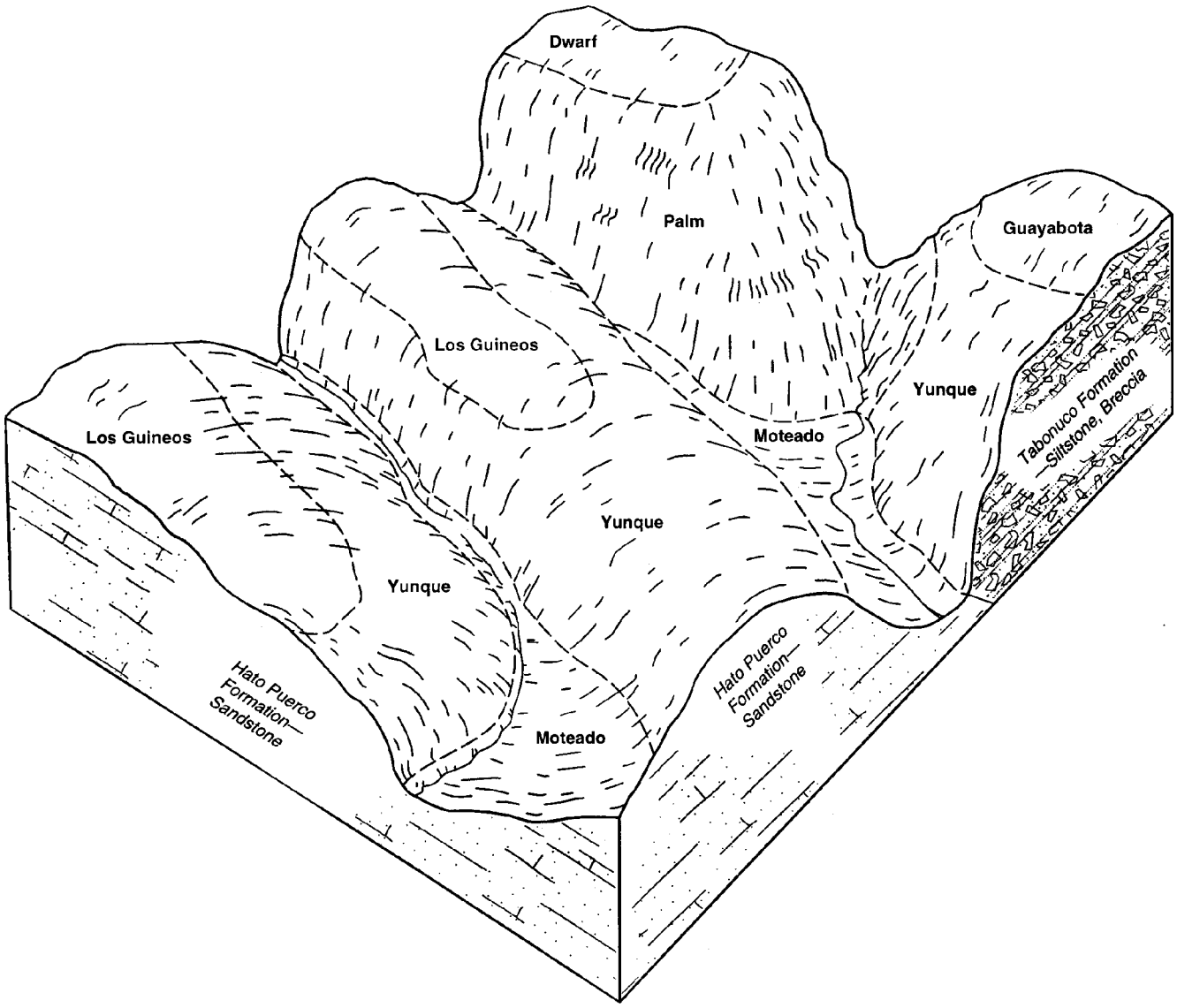

Figure 8.—Typical pattern of the soils that are derived from volcanic sandstone and siltstone in the isothermic temperature regime. (The Dwarf soils are at the highest elevations and are in the isomesic temperature regime.)

Palm and Guayabota soils. They are on wet, unstable, rocky side slopes. The poorly drained Guayabota soils are shallow to bedrock. The poorly drained Palm soils are very deep and have more than 15 percent rock fragments in the subsoil.

Most areas of this association support native forest. Some areas were harvested for timber before coming under the administration of the USDA Forest Service. Old access roads are still discernible in some areas, especially in the northern and northwestern portions of the survey area.

Because of high rainfall, steep slopes, and a high content of clay in the soils, this association has moderate or severe limitations affecting most uses. It is currently used as a site for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

4. Picacho-Utuado-Ciales Association

Very deep, somewhat poorly drained and poorly drained loamy soils underlain by granitic saprolite; formed in residuum weathering from intrusive rocks of the Rio Blanco Formation in the plutonic uplands (fig. 9)

This association is in the south-central part of the survey area. It corresponds generally to an area bounded by the Pico del Este on the east, Mt. Britton

on the north with El Cacique, and La Mina on the west. This association covers about 20 percent of the survey area.

The Picacho soils are very deep and somewhat poorly drained. They are on strongly dissected, plutonic uplands. Typically, the upper part of the surface layer is a root mat about 3 inches (8 cm) thick. The lower part of the surface layer, to a depth of about 4 inches (10 cm), is reddish brown sandy loam that has mottles in shades of brown. The upper part of the subsoil, to a depth of 10 inches (25 cm), is brown sandy clay loam that has mottles in shades of brown and gray. The next part of the subsoil, to a depth of 15 inches (38 cm), is reddish yellow sandy clay loam that has mottles in shades of brown. The lower part of the subsoil, to a depth of 27 inches (69 cm), is yellowish brown sandy clay loam that has mottles in shades of brown. The substratum, to a depth of 63 inches (160 cm) or more, is cobbly sandy loam mottled in shades of red, brown, and yellow.

The Utuado soils are very deep and somewhat poorly drained. They are on middle and lower side

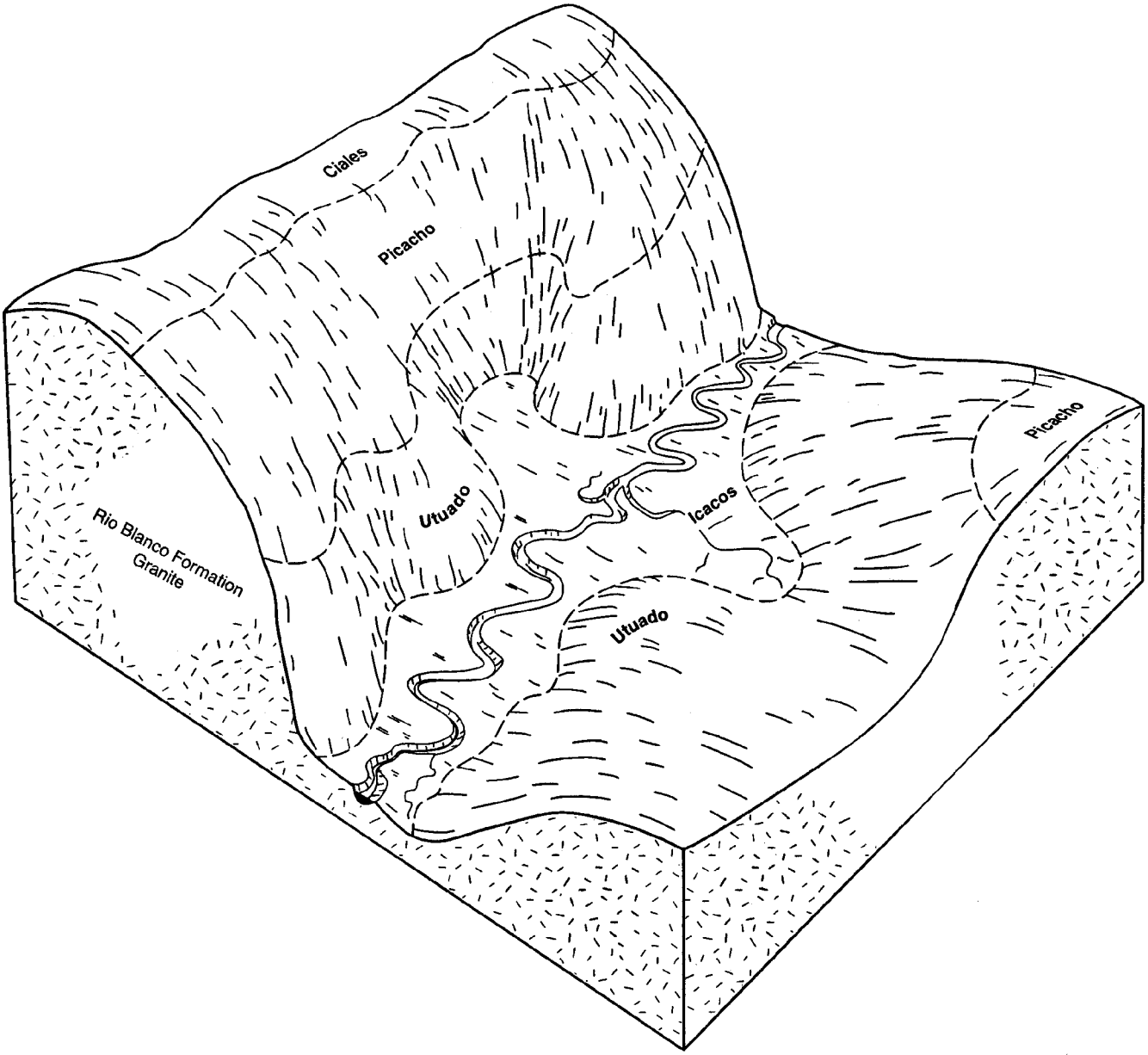

Figure 9.—Typical pattern of the soils that are derived from granodiorite of the Rio Blanco Formation in the isothermic temperature regime.

Figure 10.—A landscape showing Dwarf soils at the highest points in the survey area, the Yunque-Los Guineos-Moteado association on the side slopes, and the Zarzal-Cristal-Humatas association on the lower slopes.

slopes of strongly dissected uplands. Typically, the upper part of the surface layer is a root mat about 1 inch (3 cm) thick. The lower part of the surface layer, to a depth of about 2 inches (5 cm), is dark brown gravelly loam. The upper part of the subsoil, to a depth of 7 inches (18 cm), is dark brown loam that has mottles in shades of brown and gray. The lower part of the subsoil, to a depth of 13 inches (33 cm), is dark yellowish brown loam that has mottles in shades of gray. The upper part of the substratum, to a depth of 28 inches (71 cm), is yellowish brown sandy loam. The lower part of the substratum, to a depth of 61 inches (155 cm) or more, is saprolite mottled in white, black, and brown and having a texture of loamy sand.

The Ciales soils are very deep and poorly drained. They are in concave positions on lower side slopes and footslopes of dissected mountains. Typically, the surface layer is dark reddish brown mucky clay loam about 9 inches (23 cm) thick. The upper part of the subsoil, to a depth of 25 inches (64 cm), is dark gray to olive gray sandy clay loam that has mottles in shades of black and brown. The next part of the subsoil, to a depth of 39 inches (99 cm), is strong brown to yellowish brown sandy loam that has mottles in shades of brown. The lower part of the subsoil, to a depth of 56 inches (142 cm), is stratified yellowish brown and dark brown loam. The substratum, to a depth of 73 inches (185 cm) or more, is stratified dark yellowish brown, strong brown, yellowish brown, and dark red sandy loam.

The minor components in this association include the somewhat poorly drained Icacos soils on flood plains. Also included are very narrow, extremely bouldery areas along drainageways.

Most areas of this association support native forest. In the past, the largest Palo Colorado trees were removed by high-grade logging for charcoal

production and sphagnum moss was harvested from the wetter areas.

Because of high rainfall, steep slopes, and the instability of cutbanks, this association has severe limitations affecting most uses. It is currently used as a site for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

Soils of the Isomesic Region

The soils of this region correspond to the Dwarf forest type (fig. 10). Soil temperatures range from 47 to 59 degrees F (8 to 15 °C), and the difference between the mean summer temperature and the mean winter temperature is less than 9 degrees F (6 °C) at a depth of 20 inches (50 cm) (Boccheciamp and others, 1977).

5. Dwarf

Very deep, poorly drained clayey soils that have an organic surface layer, are on summits and ridges of mountains, and formed in residuum that weathered from metamorphosed andesitic to basaltic, marine-deposited, volcanic sandstone of the Hato Puerco, Fajardo, and Tabonuco Formations

This association is at elevations of more than 2,950 feet (900 m) around the highest major peaks in the survey area. It corresponds roughly to the areas identified on vegetative maps as dwarf forest or Bosque Enano. It covers about 5 percent of the survey area.

Typically, the upper part of the surface layer is very dark grayish brown muck about 4 inches (10 cm) thick. The lower part of the surface layer, to a depth of 9 inches (23 cm), is dark brown mucky sandy loam that has mottles in shades of brown. The upper part of the subsoil, to a depth of 26 inches (66 cm), is dark grayish brown to olive gray silty clay loam to silty clay having mottles in shades of brown and olive. The next part of the subsoil, to a depth of 35 inches (89 cm), is olive silty clay that has mottles in shades of olive, brown, and gray. The lower part of the subsoil, to a depth of 43 inches (109 cm), is olive brown clay loam that has mottles in shades of brown and gray. The upper part of the substratum, to a depth of 52 inches (132 cm), is olive silt loam that has mottles in shades of brown and gray. The lower part of the substratum, to a depth of 60 inches (152 cm) or more, is strong brown silty clay loam that has mottles in shades of brown.

The minor components in this association include Palm soils on unstable and rocky slopes. The Palm soils have more than 15 percent rock fragments in the subsoil.

Most areas of this association support native forest. Because of high rainfall and the low bearing strength of the topsoil, this association has severe limitations affecting most uses. In some areas, however, it has been used as a site for electronic equipment because it is at the highest elevations. It is also used as a site for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

Detailed Soil Map Units

The map units delineated on the detailed soil maps in this survey represent the soils in the survey area. The map unit descriptions in this section, along with the maps, can be used to determine the suitability and potential of a unit for specific uses. They also can be used to plan the management needed for those uses.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. The contrasting components are mentioned in the map unit descriptions. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Many of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Zarzal very cobbly clay, 40 to 80 percent slopes, is a phase of the Zarzal series.

Some map units are made up of two or more major soils. These map units are complexes. A *complex* consists of two or more soils in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils are somewhat similar in all areas. Zarzal-Cristal complex, 20 to 60 percent slopes, is an example.

Table 3 gives the acreage and proportionate extent of each map unit. Other tables give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils or miscellaneous areas.

112—Zarzal-Cristal complex, 20 to 60 percent slopes

This map unit consists of the very deep, well drained Zarzal soil and the very deep, somewhat poorly drained Cristal soil. The soils are on mountain side slopes dominantly at the lower elevations (<1,970 feet, or 600 m, Tabonuco zone). In the far southwestern part of the survey area, this map unit reaches elevations of up to 2,460 feet (750 m). Generally, the slope is convex in areas of the Zarzal soil and concave in areas of the Cristal soil. Individual areas of the map unit are irregular in shape and range from 20 to more than 500 acres (8 to 202 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Zarzal soil makes up about 50 percent of the map unit, and the Cristal soil makes up about 25 percent.

The soils in this map unit are isohyperthermic. Rainfall is moderate: 80 to 90 inches (203 to 229 cm). The isohyperthermic soil temperatures and moderate rainfall result in moisture competition in areas that do not receive additional water from runoff. Relief within the map unit is extreme, causing a wide range of growing conditions.

The Zarzal soil is generally on upper and middle side slopes. Typically, the surface layer is dark reddish brown clay about 1 inch (2 cm) thick. The upper part of the subsoil, to a depth of 35 inches (89 cm), is yellowish brown clay. The lower part of the subsoil, to a depth of 82 inches (209 cm), is strong brown clay that has mottles in shades of red, and, below a depth of 56 inches (143 cm), gray. The underlying material, to a depth of 91 inches (230 cm) or more, is strong brown weathered sandstone having a very gravelly clay texture.

Important properties of the Zarzal soil—

Permeability: Moderately slow
Available water capacity: High
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Depth to seasonal high water table: More than 6 feet (1.8 m)
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

The Cristal soil is on the lower side slopes and in small drainageways. Typically, the surface layer is brown clay loam about 2 inches (5 cm) thick. The upper part of the subsoil, to a depth of 15 inches (38 cm), is pale brown clay that has mottles in shades of brown, red, and gray. The next part of the subsoil, to a depth of 26 inches (66 cm), is yellowish brown gravelly clay that has mottles in shades of brown, red, and gray. The lower part of the subsoil, to a depth of 39 inches (99 cm), is strong brown clay that has mottles in shades of yellow, red, and brown. The substratum, to a depth of 60 inches (152 cm) or more, is yellowish red clay loam that has mottles in shades of yellow and brown.

Important properties of the Cristal soil—

Permeability: Slow
Available water capacity: Medium
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 12 to 36 inches (30 to 91 cm) from January through December, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

Included in mapping are small areas of Humatas and Luquillo soils. The well drained Humatas soils are on higher and more stable ridgetops and shoulders than the Zarzal and Cristal soils and have less clay in the subsoil. The well drained Luquillo soils are on the lower adjacent flood plains. Also included are narrow drainageways on bedrock substratum and small areas of Zarzal soils that have slopes of more than 60 percent. The inclusions make up about 25 percent of the map unit and are generally less than 10 acres (4 hectares) in size.

Most areas of this map unit are used for dispersed recreational activities, such as hiking and bird watching, and for wildlife habitat, watershed protection, and research.

This map unit is poorly suited to commercial timber production. The major management concerns are the hazard of erosion and the restricted use of equipment. Disturbed and compacted sites are susceptible to high rates of erosion and the loss of productivity in future stands. Scheduling timber operations for the dry season, using cable-yarding systems, and restricting timber operations to the less sloping areas help to reduce the hazard of erosion. This map unit is poorly suited to the use of rubber-tired skidders or crawler-type equipment for timber harvesting. Using this equipment on this map unit damages the surface layer and litter layer. Seedling mortality is moderate in areas of the Zarzal soil. It is high in areas of the Cristal soil

due to the high water table. The most economical method of reestablishing the trees is natural regeneration through coppice or an existing seed source.

This map unit is poorly suited to recreational development. The major management concerns are restricted permeability, the high content of clay in the subsoil, wetness in the Cristal soil, and the slope. Locating facilities in the less sloping areas and cutting and filling help to minimize the slope limitation. The design and installation of alternate sewage disposal systems and the use of suitable fill material from an offsite location help to overcome low percolation rates and the shrink-swell potential. Selecting the drier parts of the map unit helps to overcome the wetness.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are clayey surfaces, wetness in the Cristal soil, and the slope. Locating trails on ridges or in the less sloping areas, applying gravel to the trails, and selecting areas that do not include the Cristal soil help to minimize these limitations.

This map unit is poorly suited to the construction of local roads. The major management concerns are wetness in the Cristal soil, the slope, landslides, and slumping. These limitations can be partially overcome by surfacing roads and constructing lined ditches. Selecting the drier parts of the map unit helps to overcome the wetness. Because of the slope, water should be drained away from the roadbed such that the water does not flow back to the roadbed farther downslope. If possible, roads should be constructed on the narrow ridgetops or in the less sloping areas. Unshaped cutbanks should be less than 6 feet (1.8 m) in length because of the hazard of slumping. Roads built in areas of this unit entail steep grades, switchbacks, and cutbanks over 6 feet (1.8 m). The cutbanks are susceptible to slumping and landslides. The design and implementation of cuts that have proper slope ratios, the use of rip-rap to support the lower parts of the slope, and the use of benching help to minimize the slumping and landslides.

113—Cristal-Zarzal complex, 5 to 40 percent slopes

This map unit consists of the very deep, somewhat poorly drained Cristal soil and the very deep, well drained Zarzal soil. The soils are on mountain side slopes at the lower elevations (<1,970 feet, or 600 m, Tabonuco zone). Generally, the slope is convex in areas of the Zarzal soil and concave in areas of the Cristal soil. Individual areas of the map unit are irregular in shape and range from 20 to 200 acres (8 to 81 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Cristal soil makes up about 55 percent of the map unit, and the Zarzal soil makes up about 40 percent.

The soils in this map unit are isohyperthermic. Rainfall is moderate: 80 to 90 inches (203 to 229 cm).

In general, most areas of this unit were used for extensive logging, for charcoal production, or for both. Some areas were also used for intensive or subsistence agriculture. Most areas have been reforested with native and/or naturalized species. A few areas still need silvicultural treatment to be fully productive.

The Cristal soil is generally in the concave, lower positions. Typically, the surface layer is brown clay loam about 2 inches (5 cm) thick. The upper part of the subsoil, to a depth of 15 inches (38 cm), is pale brown clay that has mottles in shades of brown, red, and gray. The next part of the subsoil, to a depth of 26 inches (66 cm), is yellowish brown gravelly clay that has mottles in shades of brown, red, and gray. The lower part of the subsoil, to a depth of 39 inches (99 cm), is strong brown clay that has mottles in shades of yellow, red, and brown. The substratum, to a depth of 60 inches (152 cm) or more, is yellowish red clay loam that has mottles in shades of yellow and brown.

Important properties of the Cristal soil—

Permeability: Slow
Available water capacity: Medium
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 12 to 36 inches (30 to 91 cm) from January through December, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

The Zarzal soil is generally in the convex, higher positions. Typically, the surface layer is dark reddish brown clay about 1 inch (2 cm) thick. The upper part of the subsoil, to a depth of 35 inches (89 cm), is yellowish brown clay. The lower part of the subsoil, to a depth of 82 inches (209 cm), is strong brown clay that has mottles in shades of red, and, below a depth of 56 inches (143 cm), gray. The underlying material, to a depth of 91 inches (230 cm) or more, is strong brown weathered sandstone having a texture of very gravelly clay.

Important properties of the Zarzal soil—

Permeability: Moderately slow
Available water capacity: High
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Depth to seasonal high water table: More than 6 feet (1.8 m)
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

Included in mapping are small areas of Humatas and Luquillo soils. The well drained Humatas soils are on the higher and more stable ridgetops and shoulders. The well drained Luquillo soils are on the lower adjacent flood plains. Also included are small areas of narrow drainageways on bedrock substratum and Zarzal soils that have slopes of more than 40 percent. The inclusions make up about 5 percent of the map unit and are generally less than 10 acres (4 hectares) in size.

Most areas of this map unit are used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is poorly suited to commercial timber production. The major management concerns are the hazard of erosion and the restricted use of equipment. This map unit is poorly suited to the use of rubber-tired skidders or crawler-type equipment for timber harvesting. Using this equipment in areas of the Zarzal soil, which has a high content of clay and steep slopes, damages the surface layer and litter layer. Disturbed and compacted sites are susceptible to high rates of erosion and the loss of productivity in future stands. Scheduling timber operations for the dry season, using cable-yarding systems, and restricting timber operations to the less sloping areas help to reduce the hazard of erosion. Seedling mortality is moderate in areas of the Zarzal soil. It is severe in areas of the Cristal soil due to the high water table. The most economical method of reestablishing the trees is natural regeneration through coppice or an existing seed source.

This map unit is poorly suited to recreational development. The major management concerns are restricted permeability, wetness in the Cristal soil, and slope. Locating facilities in the less sloping areas and cutting and filling help to minimize the slope limitation. The design and installation of alternate sewage disposal systems and the use of suitable fill material from an offsite location help to overcome low percolation rates and the shrink-swell potential. Selecting the drier parts of the map unit helps to overcome the wetness.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are clayey surfaces, wetness in the Cristal soil, and the slope. Locating the trails on ridges or in the less sloping areas, applying gravel to the trails, and selecting areas that do not include the Cristal soil help to minimize these limitations.

This map unit is poorly suited to the construction of local roads. The major management concerns are wetness in the Cristal soil, the slope, landslides, and slumping. These limitations can be partially overcome by surfacing roads and constructing lined ditches. Selecting the drier parts of the map unit helps to overcome the wetness. Because of the slope, water should be drained away from the roadbed such that the water does not flow back to the roadbed farther downslope. Roads built in areas of this unit entail steep grades, switchbacks, and cutbanks over 6 feet (1.8 m). The cutbanks are susceptible to slumping and landslides. The design and implementation of cuts that have proper slope ratios, the use of rip-rap to support the lower parts of the slope, and the use of benching help to minimize the slumping and landslides. If possible, roads should be constructed on the narrow ridgetops or in the less sloping areas.

114—Zarzal very cobbly clay, 40 to 80 percent slopes

This very deep, well drained soil is on mountain side slopes at the lower elevations (<1,805 feet, or 550 m, Tabonuco zone). Slopes are generally complex and convex. Individual areas are irregular in shape and range from 20 to 300 acres (8 to 121 hectares) in size.

The Zarzal soil is isohyperthermic. Rainfall is moderate: 80 inches (203 cm).

Due to the continuous or sustained nature of the slope, runoff is very rapid. The opportunities for infiltration because of breaks or depressions in the slope are few. The Zarzal soil in this map unit is generally dryer than Zarzal soils in other map units. Also, coarse fragments reduce the overall water holding capacity. Stands of trees are characterized by a few large old “wolf” trees that occupy the most favorable microsites and that are surrounded by smaller trees. The smaller trees rarely develop

sawtimber characteristics because of adverse growing conditions.

Typically, the surface layer is dark reddish brown very cobbly clay about 1 inch (2 cm) thick. The upper part of the subsoil, to a depth of 35 inches (89 cm), is yellowish brown clay. The lower part of the subsoil, to a depth of 82 inches (209 cm), is strong brown clay that has mottles in shades of red, and, below a depth of 56 inches (143 cm), gray. The underlying material, to a depth of 91 inches (230 cm) or more, is strong brown weathered sandstone having a texture of very gravelly clay.

Important properties of the Zarzal soil—

Permeability: Moderately slow
Available water capacity: High
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Depth to seasonal high water table: More than 6 feet (1.8 m)
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

Included in mapping are small areas of Cristal, Humatas, Los Guineos, and Luquillo soils. The somewhat poorly drained Cristal soils are in landscape positions similar to those of the Zarzal soil but have a significant increase in content of clay in the subsoil. Humatas and Los Guineos soils are on the higher and more stable ridgetops and side slopes and have mixed mineralogy. Also, the Humatas soils have less clay in the subsoil than the Zarzal soil. Luquillo soils are on the lower adjacent flood plains. Also included are narrow drainageways on bedrock substratum and common rock outcrops, ledges, and surface boulders. The inclusions make up about 25 percent of the map unit and are generally less than 5 acres (2 hectares) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is not suited to commercial timber production, recreational development, or the construction of low-standard access roads. The slope and restricted permeability are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are the slope and clayey surfaces. Locating paths and trails on suitable ridges and along the contour and applying gravel to the pathways help to minimize these limitations.

115—Humatas-Zarzal complex, 5 to 30 percent slopes

This map unit consists of the very deep, well drained Humatas soil and the very deep, well drained Zarzal soil. The soils are on hill summits, ridgetops, and shoulders on mountain footslopes at the lower elevations (<1,476 feet, or 450 m, Tabonuco zone). Slopes are generally short, convex, and complex. Individual areas are irregular in shape and range from 10 to more than 300 acres (4 to 121 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Humatas soil makes up about 52 percent of the map unit, and the Zarzal soil makes up about 45 percent.

This map unit occupies the most stable positions on the landscape. The soils are isohyperthermic. Rainfall is moderate: 80 inches (203 cm).

Nutrient status is low, but the soils respond well to applications of fertilizer. This map unit has few management restrictions, but growth rates for trees may be slower than in surrounding areas due to moisture competition.

The Humatas soil is on hilltops and the lower ridges. Typically, the surface layer is dark brown silty clay about 4 inches (10 cm) thick. The upper part of the subsoil, to a depth of 12 inches (30 cm), is yellowish brown silty clay. The next part of the subsoil, to a depth of 19 inches (48 cm), is yellowish brown clay that has red mottles. The lower part of the subsoil, to a depth of 38 inches (97 cm), is clay mottled in shades of red and yellow. The substratum, to a depth of 60 inches (152 cm) or more, is red clay that has mottles in shades of yellow.

Important properties of the Humatas soil—

Permeability: Moderately slow
Available water capacity: High
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Depth to seasonal high water table: More than 6 feet (1.8 m)
Shrink-swell potential: High
Flooding: None
Hydric: No

The Zarzal soil is on the higher side slopes and shoulders. Typically, the surface layer is dark reddish brown clay about 1 inch (2 cm) thick. The upper part of the subsoil, to a depth of 35 inches (89 cm), is yellowish brown clay. The lower part of the subsoil, to

a depth of 82 inches (209 cm), is strong brown clay that has mottles in shades of red, and, below a depth of 56 inches (143 cm), gray. The underlying material, to a depth of 91 inches (230 cm) or more, is strong brown weathered sandstone having a texture of very gravelly clay.

Important properties of the Zarzal soil—

Permeability: Moderately slow
Available water capacity: High
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Depth to seasonal high water table: More than 6 feet (1.8 m)
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

Included in mapping are small areas of Cristal soils. The somewhat poorly drained Cristal soils have a significant increase in content of clay in the subsoil. Also included are Zarzal soils that have slopes of more than 30 percent. The inclusions make up about 3 percent of the map unit and are generally less than 5 acres (2 hectares) in size.

Most areas of this map unit are used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is suited to commercial timber protection. The major management concerns are the hazard of erosion, the restricted use of equipment, and seedling mortality. The slope can be a limitation in areas where it exceeds 15 percent. Locating roads and trails on the contour, establishing turnouts, and constructing lined ditches help to reduce the hazard of erosion. Using vehicles that have wide tires or tandem axles and restricting timber operations to the dry season help to overcome the equipment limitations.

This map unit is poorly suited to recreational development. The major management concerns are the slope, restricted permeability, the shrink-swell potential of the Humatas soil, and the clay in the subsoil. Locating facilities in the less sloping areas and cutting and filling help to minimize the slope limitation. Using fill material from an offsite location or using special design helps to overcome the shrink-swell potential of the Humatas soil. The use of alternate systems for sewage disposal helps to overcome the restricted permeability.

This map unit is suited to the establishment of paths and trails. The major management concerns are clayey surfaces and the slope. Locating the trails on ridges or in the less sloping areas and applying gravel help to minimize these limitations.

This map unit is suited to the construction of local roads. The major management concerns are the slope, landslides, slumping, the shrink-swell potential, and the low bearing strength of the subsoil. These limitations can be partially overcome by surfacing the roads and constructing lined ditches. Because of the slope, water should be drained away from the roadbed such that the water does not flow back to the roadbed farther downslope. A subgrade of suitable fill material from an offsite location helps to provide a stable base for paving. The design and implementation of cuts that have proper slope ratios, the use of rip-rap to support the lower parts of the slope, and the use of benching help to minimize the slumping and landslides. Locating logging roads and skid trails on the contour, using diversions, and mulching can help to reduce the hazard of erosion. Slumping can be minimized by the design and construction of shaped cutbanks. Unshaped cutbanks should be less than 6 feet (1.8 m) in length because of the hazard of slumping.

121—Sonadora-Caguabo complex, 25 to 40 percent slopes

This map unit consists of the moderately deep, well drained Sonadora soil and the shallow, well drained Caguabo soil. The soils are on mountain side slopes at the lower elevations (<1,640 feet, or 500 m, Tabonuco zone). Most areas of this map unit are in the southern part of the survey area (fig. 11). This map unit is of small extent. Access is typically restricted by map units of less accessibility. Slopes are both concave and convex and are complex. Individual areas are irregular in shape and range from 50 to 200 acres (20 to 81 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Sonadora soil makes up about 60 percent of the map unit, and the Caguabo soil makes up about 25 percent.

The soils in this map unit are isohyperthermic. Rainfall is moderate: 80 inches (203 cm).

The Sonadora soil is on side slopes and footslopes of the lower hills and strongly dissected uplands. Typically, the surface layer is dark reddish brown clay loam about 1 inch (3 cm) thick. The upper part of the subsoil, to a depth of 16 inches (41 cm), is dark brown to dark yellowish brown clay. The lower part of the subsoil, to a depth of 21 inches (53 cm), is grayish brown clay. The substratum, to a depth of 36 inches (91 cm), is clay loam mottled in shades of brown. The

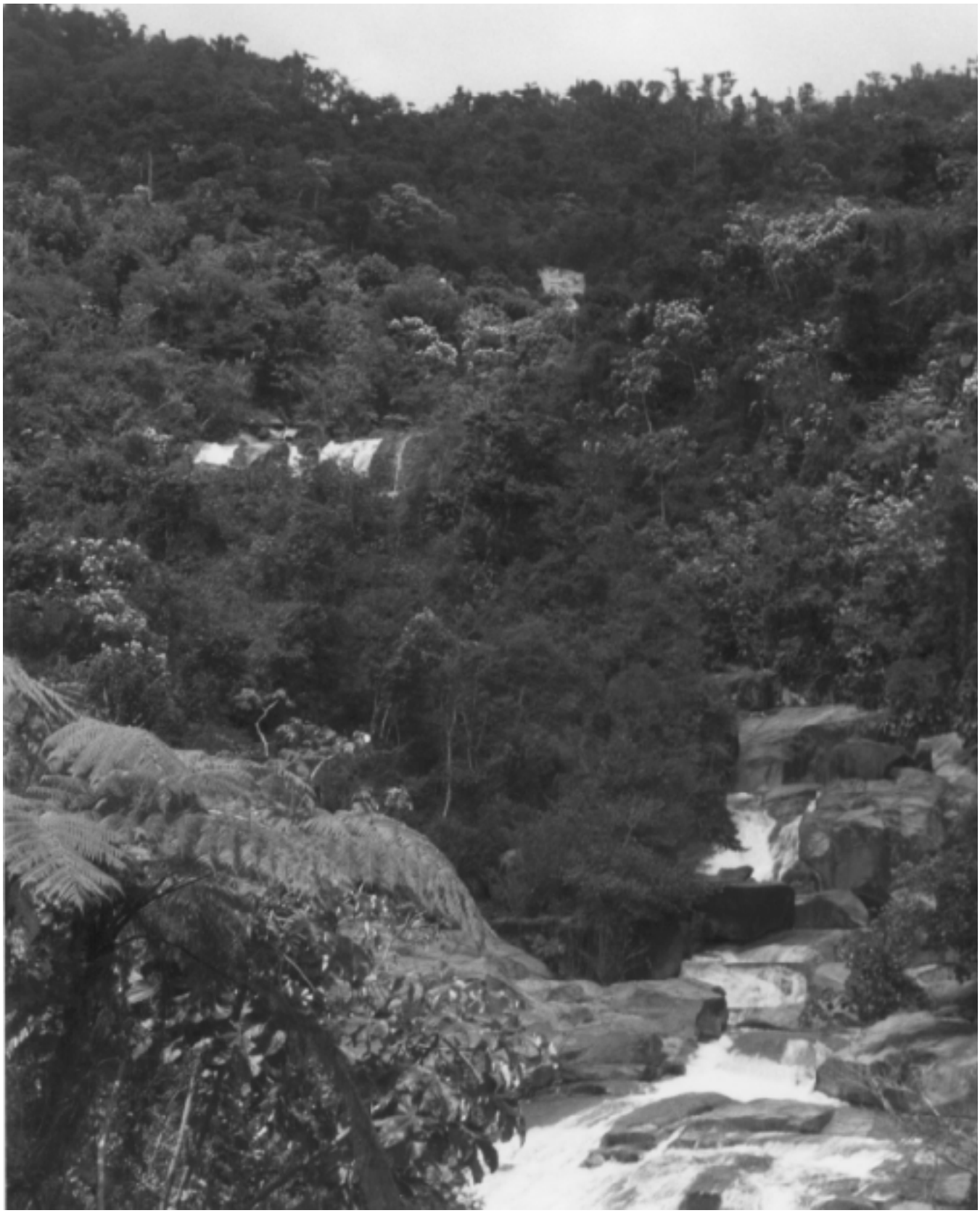

Figure 11.—An area of Sonadora-Caguabo complex, 25 to 40 percent slopes, in the southern part of the survey area.

underlying material, below a depth of 36 inches (91 cm), is dark gray mudstone.

Important properties of the Sonadora soil—

Permeability: Very slow
Available water capacity: Medium
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: 20 to 40 inches (51 to 102 cm)
Root zone: 20 to 40 inches (51 to 102 cm)
Depth to seasonal high water table: More than 6 feet (1.8 m)
Shrink-swell potential: High
Hydric: No
Flooding: None

The Caguabo soil is on side slopes of strongly dissected uplands. Typically, the surface layer is dark grayish brown gravelly clay loam about 3 inches (8 cm) thick. The subsoil, to a depth of 7 inches (18 cm), is brown very gravelly clay loam. The substratum, to a depth of 11 inches (28 cm), is brown very gravelly clay loam. The upper part of the underlying material, to a depth of 16 inches (41 cm), is conglomerate in shades of gray and brown. It crushes into very gravelly sandy clay loam. The lower part of the underlying material, below a depth of 16 inches (41 cm), is mudstone having few fractures.

Important properties of the Caguabo soil—

Permeability: Moderate
Available water capacity: Low
Content of organic matter: Low
Natural fertility: Low
Depth to bedrock: 10 to 20 inches (25 to 51 cm)
Root zone: 10 to 20 inches (25 to 51 cm)
Depth to seasonal high water table: More than 6 feet (1.8 m)
Shrink-swell potential: Low
Hydric: No
Flooding: None

Included in mapping are small areas of Zarzal soils that have slopes of more than 40 percent. The Zarzal soils are in the higher positions and are very deep to bedrock. Also included are rocky, narrow drainageways and areas of soils that formed in colluvium. The inclusions make up about 15 percent of the map unit and are generally less than 10 acres (4 hectares) in size.

Most areas of this map unit are used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is poorly suited to commercial timber production. The major management concerns are the hazard of erosion, the restricted use of equipment, and seedling mortality. Also, windthrow is a hazard in areas of the Caguabo soil. Windthrow can be minimized by proper thinning techniques. Disturbed and compacted sites are susceptible to high rates of erosion and the loss of productivity in future stands. The hazard of erosion can be minimized by locating roads and skid trails on the contour, establishing turnouts, and constructing lined ditches. Restricting timber operations to the dry season, using vehicles that have wide tires, and using rubber-tired skidders or crawler-type equipment help to overcome the equipment limitations. Seedling mortality can be partially overcome by increasing planting rates.

This map unit is poorly suited to recreational development. The major management concerns are the slope, depth to bedrock, large stones, a high content of clay in the subsoil, restricted permeability, the high shrink-swell potential in the Sonadora soil, and accessibility. Locating recreational facilities in the less sloping areas or cutting and filling help to minimize the slope limitation. The use of alternate systems and the use of suitable fill material from an offsite location help to overcome the restricted permeability. The removal of the large stones is recommended. Special design and the use of suitable fill material from an offsite location help to overcome the shrink-swell potential of the Sonadora soil. The construction of roads and trails can help to overcome the restricted accessibility.

This map unit is poorly suited to the establishment of paths and trails. The slope is a management concern. Locating paths and trails in the less sloping areas and along ridges helps to minimize this limitation.

This map unit is poorly suited to the construction of low-standard access roads. The major management concerns are the slope, the hazard of erosion, the low bearing strength of the Sonadora soil, and a high content of clay in the subsoil. Locating logging roads and skid trails on the contour, establishing turnouts, and mulching help to overcome the slope and the hazard of erosion. The use of gravel or road material from an offsite location help to overcome the low bearing strength of the subsoil.

131—Sonadora-Caguabo complex, 40 to 70 percent slopes

This map unit consists of the moderately deep, well drained Sonadora soil and the shallow, well drained Caguabo soil. The soils are on mountain

footslopes at the lower elevations (<1,970 feet, or 600 m, Tabonuco zone). Most areas of this map unit are in the southwest and northwest parts of the survey area. The unit is of small extent. Slopes are convex and concave and are complex. The map unit has a distinctive and repeating toposequence: side slope, bench, and ledge. Individual areas of this map unit are irregular in shape and range from 50 to more than 500 acres (20 to 202 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Sonadora soil makes up about 70 percent of the map unit, and the Caguabo soil makes up about 15 percent.

The soils in this map unit are isohyperthermic. Rainfall is moderate: 80 inches (203 cm).

The Sonadora soil is on side slopes and footslopes of the lower hills and strongly dissected uplands. Typically, the surface layer is dark reddish brown clay loam about 1 inch (3 cm) thick. The upper part of the subsoil, to a depth of about 16 inches (41 cm), is dark brown to dark yellowish brown clay. The lower part of the subsoil, to a depth of 21 inches (53 cm), is grayish brown clay. The substratum, to a depth of 36 inches (91 cm), is clay loam mottled in shades of brown. The underlying material, below a depth of 36 inches (91 cm), is dark gray mudstone.

Important properties of the Sonadora soil—

Permeability: Very slow
Available water capacity: Medium
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: 20 to 40 inches (51 to 102 cm)
Root zone: 20 to 40 inches (51 to 102 cm)
Depth to seasonal high water table: More than 6 feet (1.8 m)
Shrink-swell potential: High
Hydric: No
Flooding: None

The Caguabo soil is on ledges. Typically, the surface layer is dark grayish brown gravelly clay loam about 3 inches (8 cm) thick. The subsoil, to a depth of 7 inches (18 cm), is brown very gravelly clay loam. The substratum, to a depth of 11 inches (28 cm), is brown very gravelly clay loam. The upper part of the underlying material, to a depth of 16 inches (41 cm), is conglomerate mottled in shades of gray and brown. It crushes into very gravelly sandy clay loam. The lower part of the underlying material, below a depth of 16 inches (41 cm), is mudstone having few fractures.

Important properties of the Caguabo soil—

Permeability: Moderate
Available water capacity: Low
Content of organic matter: Low
Natural fertility: Medium
Depth to bedrock: 10 to 20 inches (25 to 51 cm)
Depth to seasonal high water table: More than 6 feet (1.8 m)
Root zone: 10 to 20 inches (25 to 51 cm)
Shrink-swell potential: Low
Hydric: No
Flooding: None

Included in mapping are small areas of Caguabo soils that have slopes of less than 40 percent; rocky, narrow drainageways; soils that formed in colluvium; and Zarzal soils. The Zarzal soils are in the higher positions, have less plastic clay, and are very deep to bedrock. The inclusions make up about 15 percent of the map unit and are generally less than 10 acres (4 hectares) in size.

Most areas of this map unit are used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed management.

This map unit is not suited to commercial timber production, recreational development, or the construction of low-standard access roads. The slope, the high shrink-swell potential in the Sonadora soil, the hazard of erosion, large stones, depth to bedrock, and windthrow in areas of the Caguabo soil are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. The slope is a management concern. Locating paths and trails on the contour and along ridgetops helps to overcome this limitation.

132—Caguabo gravelly clay loam, 8 to 15 percent slopes

This shallow, well drained soil is at the lower elevations (<1,804 feet, or 550 m, Tabonuco zone) on side slopes and footslopes of lower hills and strongly dissected uplands. It occupies both convex and concave positions. Slopes are generally convex and complex. Individual areas are irregular in shape and range from 10 to 50 acres (4 to 20 hectares) in size.

The Caguabo soil is isohyperthermic. Rainfall is moderate: 80 inches (203 cm). The shallow depth, coarse fragments, and low available soil moisture make this one of the least productive units in the Tabonuco zone.

Typically, the surface layer is dark grayish brown

gravelly clay loam about 3 inches (8 cm) thick. The subsoil, to a depth of 7 inches (18 cm), is brown very gravelly clay loam. The substratum, to a depth of 11 inches (28 cm), is brown very gravelly clay loam. The upper part of the underlying material, to a depth of 16 inches (41 cm), is conglomerate mottled in shades of gray and brown. It crushes into very gravelly sandy clay loam. The lower part of the underlying material, below a depth of 16 inches (41 cm), is mudstone having few fractures.

Important properties of the Caguabo soil—

Permeability: Moderate
Available water capacity: Low
Content of organic matter: Low
Natural fertility: Medium
Depth to bedrock: 10 to 20 inches (25 to 51 cm)
Root zone: 10 to 20 inches (25 to 51 cm)
Depth to seasonal high water table: More than 6 feet (1.8 meters)
Shrink-swell potential: Low
Flooding: None
Hydric: No

Included in mapping are small areas of Caguabo soils that have slopes of more than 15 percent, Sonadora soils, Zarzal soils, and soils that formed in colluvium. The Sonadora and Zarzal soils are in the higher positions. The Sonadora soils are moderately deep to bedrock, and the Zarzal soils are very deep. The inclusions make up about 10 percent of the map unit and are generally less than 5 acres (2 hectares) in size.

Most areas of this map unit are used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is poorly suited to commercial timber production. The major management concerns are the restricted use of equipment and the hazard of erosion. Equipment use during wet periods causes excessive disturbance of the soil, rutting, and compaction of the site and thus makes the soil susceptible to high rates of erosion. Restricting timber operations to the dry season, using cable-yarding systems, and using crawler-type equipment help to overcome the equipment limitations. Locating logging roads and skid trails on the contour, establishing turnouts, and mulching help to reduce the hazard of erosion.

This map unit is poorly suited to recreational development. The major management concerns are the depth to bedrock, the slope, restricted permeability, and surface cobbles and stones. Construction of facilities in the less sloping areas and cutting and filling help to minimize the slope limitation. The design and installation of alternate sewage disposal systems, such as mounds or onsite sewage treatment, and the use of suitable fill material from an offsite location help to overcome the depth to bedrock and the restricted permeability. The removal and replacement of the surface layer minimize the limitations caused by the cobbles and stones on the surface.

This map unit is well suited to the establishment of paths and trails. There are no significant management concerns.

This map unit is poorly suited to building low-standard access roads. The major management concerns are the slope and the depth to bedrock. These limitations can be partially overcome by surfacing roads and constructing lined ditches. A subgrade of suitable fill material from an offsite location helps to provide a stable base for paving. If possible, roads should be constructed in the less sloping areas and on the contour.

135—Prieto very cobbly clay loam, 25 to 50 percent slopes

This moderately deep, poorly drained soil is at the lower elevations (<1,970 feet, or 600 m, Tabonuco zone) in concave positions in mountain coves, on side slopes, and in drainageways. This map unit is at the southern boundary of the Forest. It is of small extent. It is characterized by long, continuous, convex slopes dissected internally by numerous small drainageways that are parallel to the slope. Except for short, steeper slopes next to drainageways, this map unit has little internal relief compared to other parts of the survey area. Slopes are generally concave and complex. Individual areas are irregular in shape and range from 150 to 300 acres (60 to 121 hectares) in size.

The Prieto soil is isohyperthermic. Rainfall is high: 130 inches (330 cm).

Typically, the surface layer is gray very cobbly clay loam about 4 inches (10 cm) thick. The upper part of the subsoil, to a depth of 13 inches (33 cm), is dark gray cobbly clay that has mottles in shades of brown. The next part of the subsoil, to a depth of 25 inches (64 cm), is greenish gray cobbly clay that has mottles in shades of yellow and brown. The lower part of the subsoil, to a depth of 35 inches (89 cm), is light gray cobbly silty clay that has mottles in shades of brown and gray. The underlying material, below a depth of 35 inches (89 cm), is volcanic mudstone bedrock.

Important properties of the Prieto soil—

Permeability: Moderately slow
Available water capacity: High

Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: 20 to 40 inches (51 to 102 cm)
Root zone: 20 to 40 inches (51 to 102 cm)
Seasonal high water table: At the surface to a depth of 12 inches (30 cm) from January through December, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: Yes

Included in mapping are small areas of Zarzal soils that have very steep slopes and small areas of rocky, narrow drainageways. The well drained Zarzal soils are in higher positions than the Prieto soil and have few coarse fragments in the subsoil. Also included are soils that are similar to the Prieto soils but are somewhat poorly drained. The inclusions make up about 10 percent of the map unit and are generally less than 5 acres (2 hectares) in size.

Most areas of this map unit are used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is not suited to commercial timber production, recreational development, or the construction of local roads. Wetness, the slope, restricted permeability, the depth to bedrock, erosion, and surface cobbles are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are the slope, wetness, clayey surfaces, and surface cobbles. Locating paths and trails on ridges and on the contour helps to minimize the slope limitation. Applying gravel to the pathways helps to overcome the wetness and the clayey surfaces. The removal of the cobbles or the selection of a site that does not have concentrations of cobbles is recommended.

141—Luquillo stony clay loam, occasionally flooded

This very deep, well drained soil is at the lower elevations (<1,312 feet, or 400 m, Tabonuco zone) on flood plains and low stream terraces along mountain streams and rivers. Slopes are generally smooth and convex. Individual areas are generally long and narrow in shape and range from 20 to 100 acres (8 to 40 hectares) in size.

The Luquillo soil is isohyperthermic. Rainfall is moderate: 80 inches (203 cm). This map unit is dominated by a large amount of surface stones. The stones are fragments larger than 10 inches (25 cm) and hamper most management activities. The unit is flooded an average of twice every 5 years.

Typically, the surface layer is dark yellowish brown stony clay loam about 5 inches (13 cm) thick. The upper part of the subsoil, to a depth of 17 inches (43 cm), is yellowish brown clay. The lower part of the subsoil, to a depth of 35 inches (89 cm), is strong brown clay. The substratum, to a depth of 60 inches (152 cm) or more, is brownish yellow very stony clay that has mottles in shades of red.

Important properties of the Luquillo soil—

Permeability: Moderately slow
Available water capacity: Low
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Depth to seasonal high water table: More than 6 feet (1.8 m)
Shrink-swell potential: Low
Flooding: Occasional; brief; June through September
Hydric: No

Included in mapping are small areas of Coloso, Cristal, and Zarzal soils. The somewhat poorly drained Coloso soils are in the slightly higher, concave areas on flood plains and stream terraces. The somewhat poorly drained Cristal soils have more clay in the subsoil than the Luquillo soil and are on the higher, adjacent side slopes. The Zarzal soils are in adjacent higher positions and have more clay in the subsoil than the Luquillo soil. Also included are areas of extremely stony riverbeds. The inclusions make up about 15 percent of the map unit and are generally less than 5 acres (2 hectares) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is suited to commercial timber production. Plant competition is a management concern. The most acceptable method of minimizing the plant competition is removing the undesirable species by hand. The use of native or naturalized species from natural regeneration of rootstock or seed is recommended for reforestation.

This map unit is not suited to recreational development or to the construction of local roads. The hazard of flooding, a high content of clay in the subsoil, restricted permeability, and large stones on the surface are severe limitations.

This unit is poorly suited to the construction of paths and trails. The major management concerns are the occasional flooding and the clayey surfaces. The flooding is very difficult to overcome on a cost-

effective basis. Applying gravel to the pathways helps to overcome the clayey surfaces.

142—Coloso silty clay loam, occasionally flooded

This very deep, somewhat poorly drained soil is at the lower elevations (<1,312 feet, or 400 m, Tabonuco zone) on flood plains and low terraces along mountain streams and rivers. Slopes are generally smooth and slightly concave. Individual areas are generally long and narrow in shape and range from 50 to 150 acres (20 to 61 hectares) in size. The unit is flooded an average of once every 5 years.

The Coloso soil is isohyperthermic. Rainfall is moderate: 80 inches (203 cm).

Typically, the surface layer is dark yellowish brown silty clay loam about 4 inches (10 cm) thick. The subsoil, to a depth of 7 inches (18 cm), is dark yellowish brown clay that has mottles in shades of red. The upper part of the substratum, to a depth of 35 inches (89 cm), is light yellowish brown clay that has mottles in shades of red and gray. The lower part of the substratum, to a depth of 60 inches (152 cm) or more, is light yellowish brown clay that has mottles in shades of gray.

Important properties of the Coloso soil—

Permeability: Slow
Available water capacity: High
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 24 to 48 inches (61 to 122 cm) from July through September, apparent
Shrink-swell potential: Moderate
Flooding: Occasional; brief; July through September
Hydric: No

Included in mapping are small areas of Cristal, Luquillo, and Zarzal soils. Cristal soils are in the higher adjacent positions and ephemeral drains. The well drained Luquillo soils are in the slightly lower, slightly convex positions on flood plains. The well drained Zarzal soils are in the higher adjacent positions. Also included are areas of extremely stony creekbeds. The inclusions make up about 25 percent of the map unit and are generally less than 5 acres (2 hectares) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is suited to commercial timber production. The major management concerns are equipment limitations, seedling mortality, and plant competition. Restricting timber operations to the drier periods and using vehicles that have wide tires or using crawler-type equipment help to overcome the equipment limitations. The most acceptable method of minimizing the plant competition is removing the undesirable species by hand. Increasing planting rates helps to offset seedling mortality. The use of native or naturalized species from natural regeneration of rootstock or seed is recommended for reforestation.

This map unit is not suited to recreational development or to local roads. The flooding, the slow permeability, the shrink-swell potential, wetness, and a high content of clay in the subsoil are severe limitations.

This map unit is suited to the establishment of paths and trails. The occasional flooding, however, is a management concern. The flooding is very difficult to overcome on a cost-effective basis.

212—Yunque-Moteado complex, 20 to 65 percent slopes

This map unit consists of the very deep, moderately well drained Yunque soil and the deep, poorly drained Moteado soil. The soils are on mountain side slopes at the middle and upper elevations (1,970 to 2,950 feet, or 600 to 900 m, Palo Colorado zone). Generally, the slope is convex in areas of the Yunque soil and concave in areas of the Moteado soil. Individual areas are irregular in shape and range from 10 to more than 1,000 acres (4 to 405 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Yunque soil makes up about 45 percent of the map unit, and the Moteado soil makes up about 25 percent.

The soils in this map unit are isothermic. Rainfall is high: 160 to 165 inches (406 to 419 cm). Relief within the map unit is extreme, causing a wide range of growing conditions.

The Yunque soil is generally on the convex, upper and middle side slopes in the higher positions. Typically, the upper part of the surface layer is a root mat about 2 inches (5 cm) thick. The lower part of the surface layer, to a depth of 7 inches (18 cm), is dark yellowish brown clay that has mottles in shades of brown. The upper part of the subsoil, to a depth of 30 inches (76 cm), is yellowish brown clay that has mottles in shades of red, yellow, gray, and brown. The next part of the subsoil, to a depth of 51 inches

(130 cm), is yellowish red to strong brown silty clay to silty clay loam having mottles in shades of brown and gray. The lower part of the subsoil, to a depth of 62 inches (157 cm), is silty clay loam mottled in shades of red and brown.

Important properties of the Yunque soil—

Permeability: Moderate
Available water capacity: High
Content of organic matter: Medium
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 30 to 48 inches (76 to 122 cm) from December to March, perched; at a depth of 24 to 30 inches (61 to 76 cm) from April to November, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

The Moteado soil is generally in the concave, lower positions and drainageways. Typically, the upper part of the surface layer is a root mat about 1 inch (3 cm) thick. The lower part of the surface layer is grayish brown to dark grayish brown clay about 13 inches (33 cm) thick. The upper part of the subsoil, to a depth of 22 inches (56 cm), is dark grayish brown clay that has mottles in shades of brown and gray. The next part of the subsoil, to a depth of 41 inches (104 cm), is yellowish brown to light olive brown clay that has mottles in shades of brown, gray, and, below a depth of 27 inches (69 cm), red. The lower part of the subsoil, to a depth of 54 inches (137 cm), is olive gray clay that has mottles in shades of brown. The underlying material, below a depth of 54 inches (137 cm), is unweathered, volcanic sandstone bedrock.

Important properties of the Moteado soil—

Permeability: Slow
Available water capacity: High
Content of organic matter: High
Natural fertility: Medium
Depth to bedrock: 40 to 60 inches (102 to 152 cm)
Root zone: 40 to 60 inches (102 to 152 cm)
Seasonal high water table: At the surface to a depth of 12 inches (30 cm) from December through March, perched; at the surface to a depth of 6 inches (15 cm) from April through November, perched
Shrink-swell potential: High
Flooding: None
Hydric: Yes

Included in mapping are small areas of Los Guineos and Palm soils. The very deep, well drained Los Guineos soils are on the higher and more stable ridgetops and shoulders. The very deep, poorly drained Palm soils are in landscape positions similar to those of the Yunque and Moteado soils and have more coarse fragments in the subsoil. Also included are small areas of narrow, rocky drainageways and extremely stony soils. The inclusions make up about 30 percent of the map unit and are generally less than 10 acres (4 hectare) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is not suited to commercial timber production, recreational development, or the establishment of local roads. The slope, wetness in the Moteado soil, restricted permeability, the shrink-swell potential, the restricted use of equipment, and erosion are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are the slope, clayey surfaces, and wetness in the Moteado soil. Because of the high rainfall, trails must be armored as protection against erosion and eventual washout. Locating paths and trails on ridges and contours, applying gravel to the pathways, and selecting the less sloping parts of the map unit help to overcome the slope, the clayey surfaces, and the wetness.

213—Yunque cobbly clay, 40 to 80 percent slopes, extremely stony

This very deep, moderately well drained soil is at the middle and upper elevations (1,970 to 2,953 feet, or 600 to 900 m, Palo Colorado zone) in mountain canyons and on side slopes. It is characterized by continuous and sustained slopes topped by narrow ridgetops or benches that are too small to be separated at the scale selected for mapping (fig. 12). Large amounts of surface cobbles and stones and frequent rock outcrops are distinctive features of this map unit. Slopes are convex and complex. Individual areas are irregular in shape and range from 10 to more than 500 acres (4 to 202 hectares) in size.

The Yunque soil is isothermic. Rainfall is high: 160 inches (406 cm).

Typically, the upper part of the surface layer is composed of a root mat about 2 inches (5 cm) thick. The lower part of the surface layer, to a depth of 7 inches (18 cm), is dark yellowish brown cobbly clay that has mottles in shades of brown. The upper part of the subsoil, to a depth of 30 inches (76 cm), is yellowish brown clay that has mottles in shades of red,

Figure 12.—An area of Yunque cobbly clay, 40 to 80 percent slopes, extremely stony. Rock outcrops are a minor but prominent inclusion in this map unit.

yellow, gray, and brown. The next part of the subsoil, to a depth of 51 inches (130 cm), is yellowish red to strong brown silty clay to silty clay loam having mottles in shades of brown and gray. The lower part of the subsoil, to a depth of 62 inches (157 cm), is silty clay loam mottled in shades of red and brown.

Important properties of the Yunque soil—

Permeability: Moderate
Available water capacity: High
Content of organic matter: High
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 30 to 48 inches (76 to 122 cm) from December to March, perched; at a depth of 24 to 30 inches (61 to 76 cm) from April to November, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

Included in mapping are small areas of Los Guineos, Moteado, and Palm soils. The well drained Los Guineos soils are in the higher positions on narrow ridgetops and benches. The poorly drained Moteado soils are in narrow concave areas on benches and intermittent drainageways and are deep to bedrock. The poorly drained Palm soils are in narrow concave areas and have more coarse fragments in the subsoil than the Yunque soil. Also included are small areas of narrow, rocky drainageways and rock outcrops. The inclusions make

up about 25 percent of the map unit and are generally less than 10 acres (4 hectares) in size.

Most areas of this map unit are used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is not suited to commercial timber production, recreational development, or the establishment of local roads. The slope, erosion, a high content of clay in the subsoil, restricted permeability, the moderate shrink-swell potential, cobbles and stones, slumping, and landslides are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are the slope and a high content of clay in the subsoil. Locating paths and trails on ridges and contours helps to overcome the slope. Applying gravel to the pathways helps to overcome the high content of clay in the subsoil.

214—Yunque-Los Guineos-Moteado complex, 5 to 30 percent slopes

This map unit consists of the very deep, moderately well drained Yunque soil; the very deep, well drained Los Guineos soil; and the deep, poorly drained Moteado soil. The soils are on summits, ridgetops, and mountain side slopes at the upper and middle elevations (1,970 to 2,953 feet, or 600 to 900 m, Palo Colorado zone). This map unit occupies the most stable and least sloping positions of the landscape. This map unit is characterized by high variability in microrelief. Generally, the slope is convex in areas of the Yunque and Los Guineos soils and concave in areas of the Moteado soil. Individual areas are generally long and narrow in shape and range from 10 to 200 acres (4 to 81 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Yunque soil makes up about 50 percent of the map unit, the Los Guineos soil makes up about 25 percent, and the Moteado soil makes up about 15 percent.

The soils in this map unit are isothermic. Rainfall is high: 120 to 165 inches (305 to 419 cm).

The Yunque soil is on ridgetops and side slopes. Typically, the upper part of the surface layer is a root mat about 2 inches (5 cm) thick. The lower part of the surface layer, to a depth of 7 inches (18 cm), is dark yellowish brown clay that has mottles in shades of brown. The upper part of the subsoil, to a depth of 30 inches (76 cm), is yellowish brown clay that has mottles in shades of red, yellow, gray, and brown. The next part of the subsoil, to a depth of 51 inches (130 cm), is yellowish red to strong brown silty clay to silty clay loam having mottles in shades of brown and gray. The lower part of the subsoil, to a depth of 62 inches (157 cm), is silty clay loam mottled in shades of red and brown.

Important properties of the Yunque soil—

Permeability: Moderate
Available water capacity: High
Content of organic matter: High
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 30 to 48 inches (76 to 122 cm) from December to March, perched; at a depth of 24 to 30 inches (61 to 76 cm) from April to November, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

The Los Guineos soil is in the convex, more rounded positions on ridgetops and summits. Typically, the surface layer is dark yellowish brown clay about 1 inch (3 cm) thick. The upper part of the subsoil, to a depth of 18 inches (46 cm), is yellowish brown to brownish yellow clay that has red mottles below a depth of 9 inches (23 cm). The next part of the subsoil, to a depth of 43 inches (109 cm), is red clay that has mottles in shades of brown. The lower part of the subsoil, to a depth of 93 inches (236 cm), is strong brown to yellowish red clay that has mottles in shades of brown and red.

Important properties of the Los Guineos soil—

Permeability: Moderate
Available water capacity: High
Content of organic matter: High
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Depth to seasonal high water table: More than 6.0 feet (1.8 m)
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

The Moteado soil is in concave positions and on ridgetops. Typically, the upper part of the surface layer is a root mat about 1 inch (3 cm) thick. The lower part of the surface layer, to a depth of 13 inches (33 cm), is grayish brown to dark grayish brown clay that has mottles in shades of brown, and, below a depth of 6

inches (15 cm), gray. The upper part of the subsoil, to a depth of 22 inches (56 cm), is dark grayish brown clay that has mottles in shades of brown and gray. The next part of the subsoil, to a depth of 41 inches (104 cm), is yellowish brown and light olive brown clay that has mottles in shades of brown, gray, and red. The lower part of the subsoil, to a depth of 54 inches (137 cm), is olive gray clay that has mottles in shades of brown. The underlying material, below a depth of 54 inches (137 cm), is unweathered, volcanic sandstone bedrock.

Important properties of the Moteado soil—

Permeability: Slow
Available water capacity: High
Content of organic matter: High
Natural fertility: Medium
Depth to bedrock: 40 to 60 inches (102 to 152 cm)
Root zone: 40 to 60 inches (102 to 152 cm)
Seasonal high water table: At the surface to a depth of 12 inches (30 cm) from December through March, perched; at the surface to a depth of 6 inches (15 cm) from April through November, perched
Shrink-swell potential: High
Flooding: None
Hydric: Yes

Included in mapping are small areas of the poorly drained Palm soils in the higher positions. The Palm soils are moderately deep and clayey-skeletal. Also included are small areas of narrow, rocky drainageways and rock outcrops. The inclusions make up about 10 percent of the map unit and are generally less than 10 acres (4 hectares) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is suited to timber management. The major management concerns are the slope, the hazard of erosion, the restricted use of equipment, the hazard of windthrow, seedling mortality, and plant competition. Locating roads and skid trails on the contour and, in the less sloping areas, establishing turnouts and mulching help to reduce the hazard of erosion. Restricting timber operations to the drier periods of the year and using vehicles that have wide tires or using crawler-type equipment help to overcome the equipment limitations. Proper thinning techniques help to reduce the hazard of windthrow. The removal of undesirable species by hand is the most acceptable method of limiting plant competition. Artificial regeneration (plantings) is not recommended. This map unit should be regenerated from coppice rootstock or seed.

The map unit is poorly suited to recreational development. The major management concerns are the slope, a high content of clay in the subsoil, the shrink-swell potential, restricted permeability, and wetness and the depth to bedrock in the Moteado soil. Cutting and filling with suitable fill material from an offsite location and locating facilities in the less sloping areas help to minimize the slope limitation. Special design, suitable fill material from an offsite location, the selection of areas that do not include the Moteado soil, and the use of an alternate sewage disposal system help to overcome the clay in the subsoil, the restricted permeability, the shrink-swell potential, and the wetness.

This map unit is suited to the establishment of paths and trails. The major management concerns are clayey surfaces, the slope, and the wetness in the Moteado soil. Applying gravel to the pathways helps to overcome the clayey surfaces. Locating paths and trails on the ridges and selecting areas that do not include the Moteado soil help to overcome the slope and the wetness. Because of the high rainfall, trails must be armored as protection against erosion and eventual washout.

This map unit is poorly suited to the construction of local roads. The major management concerns are low bearing strength, the high shrink-swell potential, the slope, and wetness and landslides in areas of the Moteado soil. These limitations can be partially overcome by surfacing the roads, using suitable subgrade material, and constructing lined ditches. Also, selecting the drier parts of the map unit helps to overcome the wetness. Because of the slope, culvert water should be drained away from the roadbed such that the water does not flow back to the roadbed farther downslope. Roads built in areas of this map unit entail steep grades, switchbacks, and cutbanks over 6 feet (1.8 m). The cutbanks are susceptible to slumping and landslides. The design and implementation of cuts that have proper slope ratios, the use of rip-rap to support the lower parts of the slope, and the use of benching help to minimize the slumping and landslides. If possible, roads should be constructed on the ridgetops or in the less sloping areas. Unshaped cutbanks should be less than 6 feet (1.8 m) in length because of the hazard of slumping.

215—Palm-Yunque complex, 35 to 85 percent slopes, extremely stony

This map unit consists of the very deep, poorly drained Palm soil and the very deep, moderately well drained Yunque soil. The soils are on mountain side

slopes at the upper elevations (2,460 to 2,952 feet, or 750 to 900 m, Palo Colorado zone). Generally, the slope is concave in areas of the Palm soil and convex in areas of the Yunque soil. Individual areas are irregular in shape and range from 20 to more than 300 acres (8 to 121 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Palm soil makes up about 40 percent of the map unit, and the Yunque soil makes up about 30 percent.

The soils in this map unit are isothermic. Rainfall is very high: 160 inches (406 cm).

A combination of very steep slopes, high rainfall, and overland flow have left a continuous mantel of cobbles and stones on the surface. Vegetation types are dominated by Sierra Palm. Sierra Palm is a site indicator of unstable, rocky, wet landscapes. Saturation is a function of rainfall as opposed to ponding from upslope runoff in depressions and level areas.

The Palm soil is on concave side slopes and benches. Typically, the upper part of the surface layer is a root mat about 3 inches (8 cm) thick. The next part of the surface layer, to a depth of about 10 inches (25 cm), is dark reddish brown mucky clay. The lower part of the surface layer, to a depth of 19 inches (48 cm), is black clay. The upper part of the subsoil, to a depth of 31 inches (79 cm), is olive gray very cobbly clay that has mottles in shades of brown. The lower part of the subsoil, to a depth of 63 inches (160 cm) or more, is olive very cobbly clay that has mottles in shades of red and gray.

Important properties of the Palm soil—

Permeability: Moderately slow
Available water capacity: Medium
Content of organic matter: High
Natural fertility: High
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At the surface to a depth of 12 inches (30 cm) from December through March, perched; at the surface to a depth of 6 inches (15 cm) from April through November, perched
Shrink-swell potential: High
Flooding: None
Hydric: Yes

The Yunque soils generally are on convex ridgetops. Typically, the upper part of the surface layer is a root mat about 2 inches (5 cm) thick. The lower part of the surface layer, to a depth of 7 inches (13 cm), is dark yellowish brown clay that has mottles in shades of brown. The upper part of the subsoil, to a depth of 30 inches (76 cm), is yellowish brown clay that has mottles in shades of red, yellow, gray, and brown. The next part of the subsoil, to a depth of 51 inches (130 cm), is yellowish red to strong brown silty clay to silty clay loam having mottles in shades of brown and gray. The lower part of the subsoil, to a depth of 62 inches (157 cm), is silty clay loam mottled in shades of red and brown.

Important properties of the Yunque soil—

Permeability: Moderate
Available water capacity: High
Content of organic matter: High
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 30 to 48 inches (76 to 122 cm) from December to March, perched; at a depth of 24 to 30 inches (61 to 76 cm) from April to November, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

Included in mapping are small areas of Los Guineos and Moteado soils. The well drained Los Guineos soils are on the higher, isolated, convex ridgetops. The poorly drained Moteado soils are deep to bedrock and are in the slightly lower concave areas on narrow benches and in drainageways. Also included are small areas of narrow, rocky drainageways and rock outcrops. The inclusions make up about 30 percent of the map unit and are generally less than 10 acres (4 hectares) in size.

Most areas of this map unit are used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection (fig. 13).

This map unit is not suited to commercial timber production, recreational development, or local roads. The slope, the shrink-swell potential, wetness and large stones in the Palm soil, landslides, restricted permeability, and a high content of clay in the subsoil are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are the slope, cobbles and stones, and clayey surfaces and the wetness in the Palm soil. Locating paths and trails on ridges and selecting areas that do not include the Palm soil help to overcome the wetness and the slope. Trails constructed without surfacing are difficult to utilize because of the rough edges of the coarse fragments. Removing the large cobbles and stones and applying gravel to the pathways help to

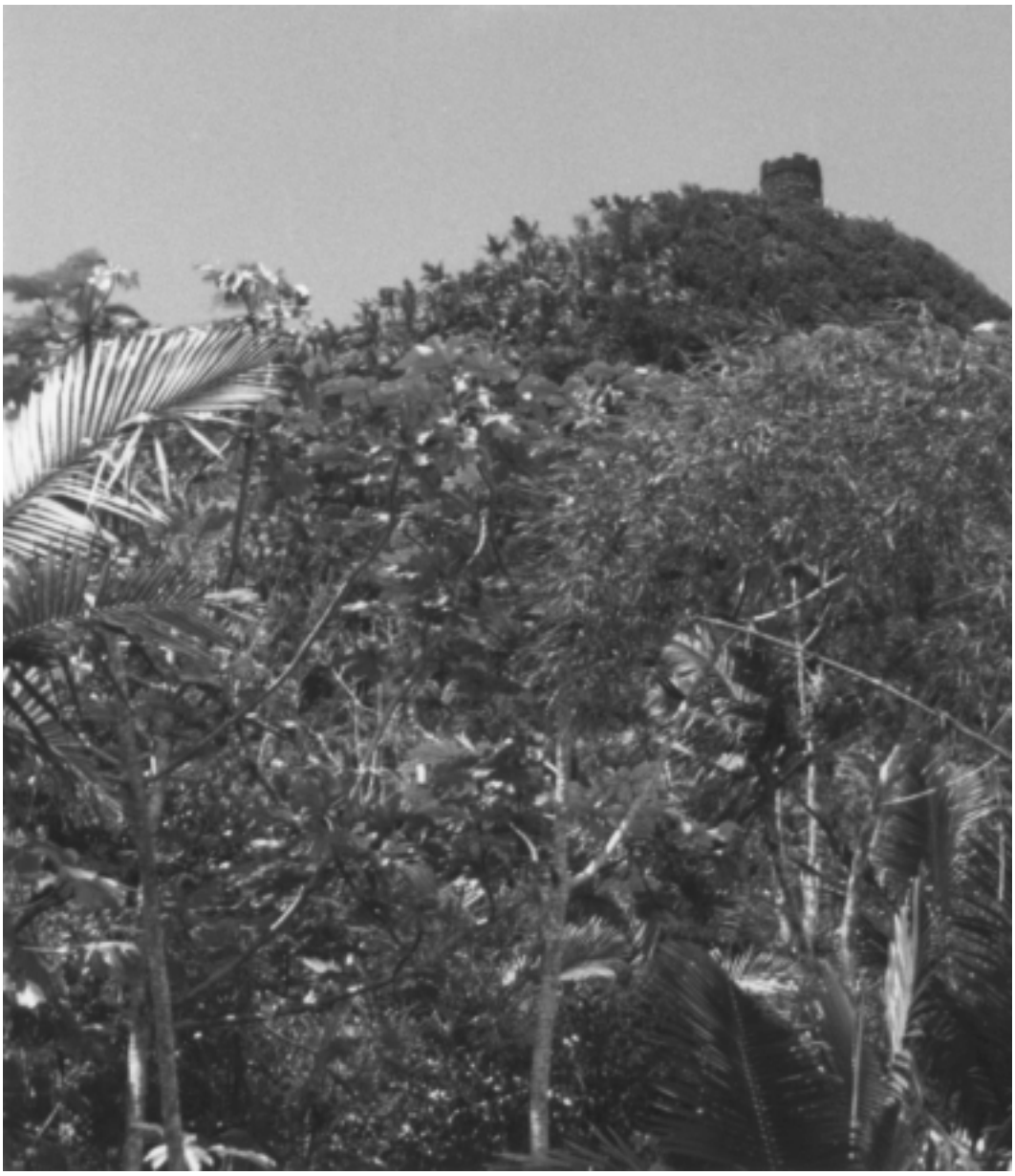

Figure 13.—A view looking up towards the Mt. Britton observation tower. The side slopes are dominated by Palm-Yunque complex, 35 to 85 percent slopes, extremely stony. The crest is dominated by Dwarf muck, 10 to 65 percent slopes, windswept.

overcome the coarse fragments and the clayey surfaces. Installing culverts and armoring the trails reduce the hazard of washout.

221—Picacho-Utuado complex, 35 to 80 percent slopes

This map unit consists of the very deep, somewhat poorly drained Picacho and Utuado soils. The soils are on mountain side slopes at the middle and upper elevations (1,970 to 2,790 feet, or 600 to 850 m, Palo Colorado zone). This unit is characterized by a toposequence that reflects profile development as a function of position on the slope. Slopes generally are convex and concave and are complex. Individual areas are irregular in shape and more than 1,000 acres (400 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Picacho soil makes up

about 60 percent of the map unit, and the Utuado soil makes up about 35 percent.

The soils in this map unit are isothermic. Rainfall is high: 120 to 160 inches (305 to 406 cm).

The Picacho soil is generally in the higher positions on upper and middle side slopes of mountains. Typically, the upper part of the surface layer is a root mat up to 3 inches (8 cm) thick. The lower part of the surface layer, to a depth of about 4 inches (10 cm), is reddish brown sandy loam that has mottles in shades of brown. The upper part of the subsoil, to a depth of 10 inches (25 cm), is brown sandy clay loam that has mottles in shades of brown and gray. The next part of the subsoil, to a depth of 15 inches (38 cm), is reddish yellow sandy clay loam that has mottles in shades of brown. The lower part of the subsoil, to a depth of 27 inches (69 cm), is yellowish brown sandy clay loam that has mottles in shades of brown. The substratum, to a depth of 63 inches (160 cm) or more, is cobbly sandy loam mottled in shades of red, brown, and yellow.

Important properties of the Picacho soil—

Permeability: Moderate
Available water capacity: High
Content of organic matter: Low
Natural fertility: Low
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 12 to 18 inches (30 to 46 cm) from January through December, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

The Utuado soil is generally in the lower positions on the landscape. Typically, the upper part of the surface layer is a root mat about 1 inch (3 cm) thick. The lower part of the surface layer, to a depth of about 2 inches (5 cm), is dark brown gravelly loam. The upper part of the subsoil, to a depth of 7 inches (18 cm), is dark brown loam that has mottles in shades of brown and gray. The lower part of the subsoil, to a depth of 13 inches (33 cm), is dark yellowish brown loam that has mottles in shades of gray. The upper part of the substratum, to a depth of 28 inches (71 cm), is yellowish brown sandy loam. The lower part of the substratum, to a depth of 61 inches (155 cm) or more, is saprolite that is mottled in white, black, and brown and that has a texture of loamy sand.

Important properties of the Utuado soil—

Permeability: Moderately rapid
Available water capacity: High
Content of organic matter: Medium
Natural fertility: Low
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 12 to 24 inches (30 to 61 cm) from January through December, perched
Shrink-swell potential: Low
Flooding: None
Hydric: No

Included in mapping are small areas of Ciales and Icacos soils. The poorly drained Ciales soils are in concave areas on the narrow, higher, more stable ridgetops. Icacos soils are in the adjacent narrow drainageways. Also included are small areas of very bouldery drainageways. The inclusions make up about 5 percent of the map unit and are generally less than 10 acres (4 hectares) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is not suited to commercial timber production, recreational development, or the construction of local roads. The slope, wetness, and a high content of clay in the subsoil are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are the slope and wetness. Locating trails on ridges and on the contour, selecting areas that do not include the Utuado soils, applying gravel to the pathways, and armoring the trails help to overcome these limitations.

223—Picacho-Ciales complex, 5 to 30 percent slopes

This map unit consists of the very deep, somewhat poorly drained Picacho soil and the very deep, poorly drained Ciales soil. The soils are on ridgetops, tablelands, and mountain side slopes at the middle elevations (1,970 to 2,625 feet, or 600 to 800 m, Palo Colorado zone). Generally, the slope is concave in areas of the Ciales soil and convex in areas of the Picacho soil. Individual areas of this map unit are irregular in shape and range from 10 to more than 100 acres (4 to 40 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Picacho soil makes up about 50 percent of the map unit, and the Ciales soil makes up about 30 percent.

The soils in this map unit are isothermic. Rainfall is high: 150 to 160 inches (381 to 406 cm).

This map unit is characterized by open stands of Palo Colorado with little understory vegetation. It has a surface layer overlain by organic material with a low bearing strength that is generally saturated.

The Picacho soil is on the higher ridges and side slopes. Typically, the upper part of the surface layer is a root mat about 3 inches (8 cm) thick. The lower part of the surface layer, to a depth of about 4 inches (10 cm), is reddish brown sandy loam that has mottles in shades of brown. The upper part of the subsoil, to a depth of 10 inches (25 cm), is brown sandy clay loam that has mottles in shades of brown and gray. The next part of the subsoil, to a depth of 15 inches (38 cm), is reddish yellow sandy clay loam that has mottles in shades of brown. The lower part of the subsoil, to a depth of 27 inches (69 cm), is yellowish brown sandy clay loam that has mottles in shades of brown. The substratum, to a depth of 63 inches (160 cm) or more, is cobbly sandy loam mottled in shades of red, brown, and yellow.

Important properties of the Picacho soil—

Permeability: Moderate
Available water capacity: High
Content of organic matter: Low
Natural fertility: Low
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 12 to 18 inches (30 to 46 cm) from January through December, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

The Ciales soil generally is in the concave areas on lower ridges and in side slope positions. Typically, the surface layer is dark reddish brown mucky clay loam about 9 inches (23 cm) thick. The upper part of the subsoil, to a depth of 25 inches (64 cm), is dark gray to olive gray sandy clay loam that has mottles in shades of black and brown. The next part of the subsoil, to a depth of 39 inches (99 cm), is strong brown to yellowish brown sandy loam that has mottles in shades of brown. The lower part of the subsoil, to a depth of 56 inches (142 cm), is yellowish brown and dark brown loam. The substratum, to a depth of 73 inches (185 cm) or more, is stratified dark yellowish brown, strong brown, yellowish brown, and dark red sandy loam.

Important properties of the Ciales soil—

Permeability: Slow
Available water capacity: High
Content of organic matter: High
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 6 to 12 inches (15 to 30 cm) from December through March, perched; at the surface to a depth of 6 inches (15 cm) from April through November, perched
Shrink-swell potential: Low
Flooding: None
Hydric: Yes

Included in mapping are small areas of Icacos and Utuado soils. Icacos soils are on the adjacent lower flood plains and terraces. The somewhat poorly drained Utuado soils are in landscape positions similar to those of the Picacho and Ciales soils but have less clay in the subsoil. Also included are small areas of very bouldery drainageways. The inclusions make up about 20 percent of the map unit and are generally less than 10 acres (4 hectares) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is not suited to commercial timber production. The restricted use of equipment due to wetness, the slope, erosion, plant competition, seedling mortality, and windthrow are severe limitations.

This map unit is not suited to recreational development or to low-standard access roads. The slope, restricted permeability, the shrink-swell potential, and wetness are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are wetness, the slope, and the mucky surface of the Ciales soil. Locating pathways along the contour and on ridges helps to overcome the slope. Applying gravel to the pathways and selecting areas that do not include the Ciales soil help to overcome the wetness and the mucky surfaces.

224—Picacho-Utuado complex, 5 to 35 percent slopes

This map unit consists of the very deep, somewhat poorly drained Picacho and Utuado soils. The soils are on hills and footslopes in mountain river valleys at the middle and upper elevations (1,970 to 2,790 feet, or 600 to 850 m, Palo Colorado zone). Slopes are generally convex and complex in areas of the Picacho soil and convex, concave, and complex in areas of the Utuado soil. Individual areas of this map unit are irregular in shape and range from 10 to more than 100 acres (4 to 40 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Picacho soil makes up about 50 percent of the map unit, and the Utuado soil makes up about 35 percent.

The soils in this map unit are isothermic. Rainfall is high: 120 to 160 inches (305 to 406 cm).

This map unit is characterized by dissected low hills and drainageways between steep side slopes and the adjacent alluvial lands. This map unit receives water from the adjacent upper areas and from frequent rainfall.

The Picacho soil is generally on hilltops and upper side slopes. Typically, the upper part of the surface layer is a root mat about 3 inches (8 cm) thick. The lower part of the surface layer, to a depth of 4 inches (10 cm), is reddish brown sandy loam that has mottles in shades of brown. The upper part of the subsoil, to a depth of 10 inches (25 cm), is brown sandy clay loam that has mottles in shades of brown and gray. The next part of the subsoil, to a depth of 15 inches (38 cm), is reddish yellow sandy clay loam that has mottles in shades of brown. The lower part of the subsoil, to a depth of 27 inches (69 cm), is yellowish brown sandy clay loam that has mottles in shades of gray. The substratum, to a depth of 63 inches (160 cm) or more, is cobbly sandy loam mottled in shades of red, brown, and yellow.

Important properties of the Picacho soil—

Permeability: Moderate
Available water capacity: High
Content of organic matter: Low
Natural fertility: Low
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 12 to 18 inches (30 to 46 cm) from January through December, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

The Utuado soil is generally on convex or concave lower side slopes and in drainageways. Typically, the upper part of the surface layer is a root mat about 1 inch (3 cm) thick. The lower part of the surface layer, to a depth of about 2 inches (5 cm), is dark brown gravelly loam. The upper part of the subsoil, to a depth of 7 inches (18 cm), is dark brown loam that has mottles in shades of brown and gray. The lower part of the subsoil, to a depth of 13 inches (33 cm), is dark yellowish brown loam that has mottles in shades of gray. The upper part of the substratum, to a depth of 28 inches (71 cm), is yellowish brown sandy loam. The lower part of the substratum, to a depth of 61 inches (155 cm) or more, is saprolite that is mottled in white, black, and brown and that has a texture of loamy sand.

Important properties of the Utuado soil—

Permeability: Moderately rapid
Available water capacity: High
Content of organic matter: Medium
Natural fertility: Low
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 12 to 24 inches (30 to 61 cm) from January through December, perched
Shrink-swell potential: Low
Flooding: None
Hydric: No

Included in mapping are small areas of Ciales and Icacos soils. The poorly drained Ciales soils are in the lower positions and have mucky surface layers. Icacos soils are on the adjacent lower flood plains. Also included are small areas of narrow, rocky drainageways and very stony soils. The inclusions make up about 15 percent of the map unit and are generally less than 10 acres (4 hectares) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is poorly suited to commercial timber production. The major management concerns are the hazard of erosion, the slope, the restricted use of equipment, seedling mortality, and plant competition. Equipment use during wet periods causes excessive disturbance of the soil, rutting, and compaction of the site and thus makes the soil susceptible to high rates of erosion. Restricting timber operations to the dry season, using vehicles that have wide tires, using crawler-type equipment, and using cable-yarding systems help to overcome the equipment limitations. Locating logging roads and skid trails on the contour, establishing turnouts, and mulching reduce the hazard of erosion. The removal of undesirable species by hand is the most acceptable method of limiting plant competition. Artificial regeneration (planting) is not recommended. This map unit should be regenerated from coppice rootstock or seed.

This map unit is poorly suited to recreational development. The major management concerns are the slope and wetness. Locating facilities in the less sloping areas and cutting and filling help to overcome the slope. The use of fill material from an offsite location and alternate sewage disposal systems help to overcome the wetness.

This map unit is suited to the establishment of paths and trails. The major management concerns are wetness and the slope. Applying gravel to the pathways, constructing proper ditches, armoring the trails, and establishing turnouts help to overcome the wetness. Locating pathways in the less sloping areas, along the contour, and on ridges help to overcome the slope. This map unit is well suited to light-use trails and to armored high-use trails.

This map unit is poorly suited to the construction of local roads. The major management concerns are the slope and wetness. These limitations can be partially overcome by surfacing roads, constructing lined ditches, and installing culverts. Because of the slope, culvert water should be drained away from the roadbed such that the water does not flow back to the roadbed farther downslope. If mixed with gravel, the soils in this map unit are well suited to use as subgrade in road construction. If possible, roads should be constructed in the less sloping areas. Unshaped cutbanks should be less than 6 feet (1.8 m) in length because of the hazard of slumping.

225—Icacos loam, occasionally flooded

This very deep, somewhat poorly drained soil is on flood plains and on low terraces along perennial river valleys at the middle elevations (1,970 to 2,460 feet, or 600 to 750 m, Palo Colorado zone). Slopes are generally smooth and concave. Individual areas are generally long and narrow in shape and range from 50 to 200 acres (20 to 81 hectares) in size.

The Icacos soil is isothermic. Rainfall is high: 150 inches (381 cm). The unit is flooded an average of once every 5 years.

Typically, the surface layer is brown loam about 4 inches (10 cm) thick. The subsoil, to a depth of 14 inches (36 cm), is yellowish brown silty clay loam that has mottles in shades of brown and gray. The upper part of the substratum, to a depth of 23 inches (58 cm), is gray silt loam that has mottles in shades of brown. The next part of the substratum, to a depth of 37 inches (94 cm), is greenish gray silty clay loam that has red mottles. The lower part of the substratum, to a depth of 60 inches (152 cm) or more, is olive brown silt loam that has mottles in shades of red and brown.

Important properties of the Icacos soil—

Permeability: Moderate
Available water capacity: High
Content of organic matter: High
Natural fertility: High
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 6 to 12 inches (15 to 30 cm) from April through December, apparent
Shrink-swell potential: Low
Flooding: Occasional; brief; January through December
Hydric: No

Included in mapping are small areas of Picacho and Utuado soils on the adjacent higher side slopes. Utuado soils have less clay in the subsoil than the Icacos soil. Also included are small areas of sandy riverbeds. The inclusions make up about 10 percent of the map unit and are generally less than 5 acres (2 hectares) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is poorly suited to timber production. The major management concerns are the restricted use of equipment, seedling mortality, the hazard of windthrow, and plant competition. Restricting timber operations to the drier periods, using vehicles that have wide tires, and using crawler-type equipment help to overcome the equipment limitations. Proper thinning techniques help to reduce the hazard of windthrow. The most acceptable method of minimizing the plant competition is removing the undesirable species by hand. The use of native or naturalized species from natural regeneration of rootstock or seed is recommended for reforestation.

This map unit is not suited to recreational development or to local roads. Wetness and the flooding are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. Wetness is a management concern. Applying gravel to the pathways helps to overcome the wetness. The occasional flooding is management concern. The flooding is very difficult to overcome on a cost-effective basis.

231—Guayabota-Yunque complex, 30 to 60 percent slopes

This map unit consists of the shallow, poorly drained Guayabota soil and the very deep, moderately well drained Yunque soil. The soils are on mountain side slopes at the middle elevations (1,970 to 2,460 feet, or 600 to 750 m, Palo Colorado zone). Generally, the slope is concave in areas of the Guayabota soil and convex in areas of the Yunque soil. Individual areas are generally

irregular in shape and range from 200 to more than 300 acres (81 to 121 hectares) in size.

The soils occur as areas so intricately intermingled that they could not be mapped separately at the scale selected for mapping. The Guayabota soil makes up about 70 percent of the map unit, and the Yunque soil makes up about 25 percent.

The soils in this map unit are isothermic. Rainfall is high: 160 to 165 inches (406 to 419 cm).

The soils formed in an association of two distinct geologic types: metamorphosed volcanic siltstone and breccia. These geologic types are intermingled in such a manner that the relative proportion of the soils differs significantly from one part of the unit to another. Generally, the Yunque soil has long, sustained slopes and is on broad ridgetops and the Guayabota soil has short slopes and is on rounded hilltops. The solum is deeper on the side slopes than on the ridgetops. Although this map unit is not widely distributed throughout the survey area, it is important due to its prominence in the El Yunque Recreation Area.

The Guayabota soil generally has 10 to 50 percent coarse fragments on the surface, and the Yunque soil generally has 10 to 40 percent.

The Guayabota soil is on ridges and upper side slopes. It formed over the metamorphosed volcanic siltstone. Typically, the surface layer is very dark gray silty clay loam about 5 inches (13 cm) thick. The upper part of the subsoil, to a depth of about 11 inches (28 cm), is dark olive silty clay that has mottles in shades of brown and gray. The lower part of the subsoil, to a depth of 14 inches (36 cm), is dark olive gray silty clay that has mottles in shades of brown, red, and gray. The substratum, to a depth of 18 inches (46 cm), is silty clay loam mottled in shades of gray, yellow, and red. The underlying material, below a depth of 18 inches (46 cm), is hard siltstone bedrock.

Important properties of the Guayabota soil—

Permeability: Slow
Available water capacity: High
Content of organic matter: Medium
Natural fertility: Low
Depth to bedrock: 10 to 20 inches (25 to 51 cm)
Root zone: 10 to 20 inches (25 to 51 cm)
Seasonal high water table: At a depth of 6 to 18 inches (15 to 46 cm) from December through March, perched; at the surface to a depth of 6 inches (15 cm) from April through November, perched
Shrink-swell potential: High
Flooding: None
Hydric: Yes

The Yunque soil is on ridges and side slopes. It formed over the breccia. Typically, the upper part of the surface layer is a root mat about 2 inches (5 cm) thick. The lower part of the surface layer, to a depth of 7 inches (18 cm), is dark yellowish brown clay that has mottles in shades of brown. The upper part of the subsoil, to a depth of 30 inches (76 cm), is yellowish brown clay that has mottles in shades of red, yellow, gray, and brown. The next part of the subsoil, to a depth of 51 inches (130 cm), is yellowish red to strong brown silty clay to silty clay loam having mottles in shades of brown and gray. The lower part of the subsoil, to a depth of 62 inches (157 cm), is silty clay loam mottled in shades of red and brown.

Important properties of the Yunque soil—

Permeability: Moderate
Available water capacity: High
Content of organic matter: High
Natural fertility: Medium
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At a depth of 30 to 48 inches (76 to 122 cm) from December through March, perched; at a depth of 24 to 30 inches (61 to 76 cm) from April through November, perched
Shrink-swell potential: Moderate
Flooding: None
Hydric: No

Included in mapping are small areas of Moteado, Palm, Picacho, and Utuado soils. The deep, poorly drained Moteado soils are in the lower concave positions. The poorly drained Palm soils are very deep, have more coarse fragments in the subsoil than the Guayabota and Yunque soils, and are in the higher, unstable, steep, rocky areas. The somewhat poorly drained Picacho and Utuado soils are very deep. The Picacho soils have less clay in the subsoil than the Guayabota and Yunque soils. The inclusions make up about 5 percent of the map unit and are generally less than 5 acres (2 hectares) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching, and for research, wildlife habitat, and watershed protection.

This map unit is not suited to commercial timber production, recreational development, or local roads. The slope, erosion, the restricted use of equipment, plant competition, seedling mortality, wetness, a high content of clay in the subsoil, the shrink-swell potential, and the depth to bedrock and windthrow in areas of the Guayabota soil are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are wetness and the slope and the clayey surface of the Yunque soil. Locating trails along the ridgetops, applying gravel to the pathways, and selecting areas

that do not include the Guayabota soil help to minimize these limitations. Because of the high rainfall, trails must be armored as protection against erosion and eventual washout.

311—Dwarf muck, 10 to 65 percent slopes, windswept

This map unit consists of very deep poorly drained soils on mountain summits at the upper elevations (>2,625 feet, or 800 m). Slopes are generally convex and concave and are complex. Individual areas are irregular in shape and range from 100 to 200 acres (40 to 81 hectares) in size.

High rainfall (180 inches, or 457 cm) and cool soil temperatures (52 to 58 °F, or 11 to 14 °C) dominate biological and chemical processes. Surface accumulation of organic matter is high. Rainfall exceeds evapotranspiration rates in all months, causing soil moisture tension to rarely exceed 1 atmosphere. These conditions result in very low productivity.

Typically, the upper part of the surface layer is very dark grayish brown muck about 4 inches (10 cm) thick. The lower part of the surface layer, to a depth of 9 inches (23 cm), is dark brown mucky sandy loam that has mottles in shades of brown. The upper part of the subsoil, to a depth of 26 inches (66 cm), is dark grayish brown to olive gray silty clay loam to silty clay having mottles in shades of brown and olive. The next part of the subsoil, to a depth of 35 inches (89 cm), is olive silty clay that has mottles in shades of olive, brown, and gray. The lower part of the subsoil, to a depth of 43 inches (109 cm), is olive brown clay loam that has mottles in shades of brown and gray. The upper part of the substratum, to a depth of 52 inches (132 cm), is olive silt loam that has mottles in shades of brown and gray. The lower part of the substratum, to a depth of 60 inches (152 cm) or more, is strong brown silty clay loam that has mottles in shades of brown.

Important properties of the Dwarf soil—

Permeability: Moderately slow
Available water capacity: High
Content of organic matter: Very high
Natural fertility: High
Depth to bedrock: More than 60 inches (152 cm)
Root zone: More than 60 inches (152 cm)
Seasonal high water table: At the surface to a depth of 6 inches (15 cm) from April through November, perched; at a depth of 6 to 12 inches (15 to 30 cm) from December through March, perched
Shrink-swell potential: High
Flooding: None
Hydric: Yes

Included in mapping are areas of Palm soils in the lower drainageways and on very steep side slopes. Palm soils have more coarse fragments in the subsoil than the Dwarf soil and have less organic matter in the surface layer. Also included are areas that have bedrock at a depth of less than 40 inches and areas that have rock outcrops on ledges. The inclusions make up about 10 percent of the map unit and are generally less than 5 acres (2 hectares) in size.

This map unit is used for dispersed recreational activities, such as hiking and bird watching; for research, wildlife habitat, and watershed protection; and as a site for communication towers.

This map unit is not suited to commercial timber production, recreational development, or local roads. The slope, the restricted use of equipment, seedling mortality, plant competition, wetness, erosion, a high content of clay in the subsoil, the shrink-swell potential, and the low bearing strength of the organic surface layer are severe limitations.

This map unit is poorly suited to the establishment of paths and trails. The major management concerns are the slope, wetness, and the mucky texture of the surface layer. Locating pathways on ridges and along the contour helps to overcome the slope. The organic layers have a very low bearing strength and are subject to subsidence. Removing the organic matter on pathways and applying gravel help to minimize the limitations associated with the organic material and the wetness. Because of erosion and puddling, trails should be paved or have a thick layer of gravel added. Organic material removed from this map unit should not be used as fill because it decomposes and thus weakens the base.

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help to prevent soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavioral characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for recreation and forestland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreational facilities; and as wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties (fig. 14).

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, and trails.

Interpretive Ratings

The interpretive tables in this survey rate the soils in the survey area for various uses. Many of the tables identify the limitations that affect specified uses and indicate the severity of those limitations. The ratings in these tables are both verbal and numerical.

Rating Class Terms

Rating classes are expressed in the tables in terms that indicate the extent to which the soils are limited by all of the soil features that affect a specified use or in terms that indicate the suitability of the soils for the use. Thus, the tables may show limitation classes or suitability classes. Terms for the limitation classes are *not limited, somewhat limited,* and *very limited*. The suitability ratings are expressed as *well suited, moderately suited, poorly suited,* and *unsuited* or as *good, fair,* and *poor*.

Numerical Ratings

Numerical ratings in the tables indicate the relative severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.00 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use and the point at which the soil feature is not a limitation. The limitations appear in order from the most limiting to the least limiting. Thus, if more than one limitation is identified, the most severe limitation is listed first and the least severe one is listed last.

Hydric Soils

Wade Hurt, Natural Resources Conservation Service, Soils Division, helped prepare this section.

In this section, hydric soils are defined and described. The hydric soils in the survey area are listed.

The three essential characteristics of wetlands are hydrophytic vegetation, hydric soils, and wetland hydrology (Cowardin and others, 1979; U.S. Army Corps of Engineers, 1987; National Research Council, 1995; Tiner and Burke, 1995). Criteria for each of the characteristics must be met for areas to be identified as wetlands. Undrained hydric soils that have natural vegetation should support a dominant population of ecological wetland plant species. Hydric soils that have been

Figure 14.—The Palo Colorado Picnic Area, which is located in an area of Yunque-Moteado complex, 20 to 65 percent slopes. These facilities provide shelter for picnics and other recreational activities.

converted to other uses should be capable of being restored to wetlands.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). These soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytes if hydrologically unaltered.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or a nonhydric soil, however, more specific information, such as information about depth and duration of saturation, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 1995). These criteria are used to identify a phase of a soil series that normally is associated with wetlands. The criteria use selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999), "Keys to Soil Taxonomy" (Soil Survey Staff, 1998), and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993) to identify a particular soil as having a probability of being hydric.

If soils are wet enough for a long enough period to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators that can be used to make onsite

determinations of hydric soils are listed as those appropriate for the Caribbean National Forest, Puerto Rico, in "Field Indicators of Hydric Soils in the United States" (Hurt, Whited, and Pringle, 1998).

Hydric soils are identified by examining and describing the soil to a depth of about 20 inches. This depth may be greater if determination of an appropriate indicator so requires. It is always recommended that soils be excavated and described to the depth necessary for an understanding of the redoximorphic processes. Then, using the completed soil description, soil scientists can compare the soil features required by each indicator and specify which indicator, if any, has been matched with the conditions observed in the soil. The soil can be classified as a hydric soil if one (or more) of the approved indicators is present. Conversely, the soil is assumed to be nonhydric if none of the approved indicators are present.

This soil survey can be used to locate probable areas of hydric soils.

Field Indicators have been developed for onsite identification of hydric soils. These indicators have been established by combining the best professional judgement of practicing wetland soil scientists with data generated by participating research soil scientists. Often it is assumed that soils with a field indicator are hydric and soils without a field indicator are nonhydric. This assumption may or may not be correct. All soils with an indicator may not, in fact, be hydric. Conversely soils without an indicator may, in fact, be hydric. Presently, there is no approved methodology for proving the hydric status of a soil using site-specific data; therefore, it is necessary to have a technical standard based on soil properties that reflect the hydric soil definition.

The NTCHS has developed specific requirements for measurement of saturation, reduction/oxidation potential, reduced iron (Fe^{++}), in-situ pH, and onsite precipitation. The technical standard for hydric soils establishes threshold value requirements and instrumentation methodology for data collection. Guidelines have been developed by the NTCHS for the interpretation of each data set. To be useful for improving the field indicators or proving the hydric status of a specific site, the data must be collected during "normal" precipitation months.

The following map units, or parts of map units which are complexes, meet the definition of hydric soils and have at least one of the hydric soil indicators. This list can help in planning land uses and updates the hydric soils previously noted in the Caribbean National Forest (USDA–SCS, 1993). Due to scale limitations, however, onsite investigation is recommended to determine the presence of hydric soils on a specific site (National Research Council, 1995; Hurt, Whited, and Pringle, 1998). Table 4 lists additional information.

135 Prieto very cobbly clay loam, 25 to 50 percent slopes
212 Yunque-Moteado complex, 20 to 65 percent slopes (Moteado part)
214 Yunque-Los Guineos-Moteado complex, 5 to 30 percent slopes (Moteado part)
215 Palm-Yunque complex, 35 to 85 percent slopes, extremely stony (Palm part)
223 Picacho-Ciales complex, 5 to 30 percent slopes (Ciales part)
231 Guayabota-Yunque complex, 30 to 60 percent slopes (Guayabota part)
311 Dwarf muck, 10 to 65 percent slopes, windswept

Map units that are made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the better drained or convex portions of the landform. Map units made up of nonhydric soils may have inclusions of hydric soils in the poorer drained or concave portions of the landform.

The following map units, in general, do not meet the definition of hydric soils and therefore do not have one of the hydric soil indicators. A portion of these map units, however, may include hydric soils. Onsite investigation is recommended to determine if hydric soils occur on a specific site.

141 Luquillo stony clay loam, occasionally flooded
142 Coloso silty clay loam, occasionally flooded
221 Picacho-Utuado complex, 35 to 80 percent slopes
224 Picacho-Utuado complex, 5 to 35 percent slopes
225 Icacos loam, occasionally flooded

Recreation

The Caribbean National Forest provides numerous opportunities for recreation. The Forest receives abundant rainfall, and numerous areas are used for swimming (fig. 15). Hiking trails throughout the Forest provide access for recreation and research.

The soils of the survey area are rated in tables 5a and 5b according to limitations that affect their suitability for recreation. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the recreational uses. *Not limited* indicates that the soil has features that are very favorable for

Figure 15.—One of the many streams that are available for swimming in the survey area.

the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the tables indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The ratings in the tables are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation also are important. Soils that are subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

The information in tables 5a and 5b can be supplemented by other information in this survey, for example, interpretations for building site development, construction materials, sanitary facilities, and water management.

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The ratings are based on the soil properties that affect the ease of developing camp areas and the performance of the areas after development. Slope, stoniness, and depth to bedrock or a cemented pan are the main concerns affecting the development of camp areas. The soil properties that affect the performance of the areas after development are those that influence trafficability and promote the growth of vegetation, especially in heavily used areas. For good trafficability, the surface of camp areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, permeability, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, permeability, and toxic substances in the soil.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The ratings are based on the soil properties that affect the ease of developing picnic

areas and that influence trafficability and the growth of vegetation after development. Slope and stoniness are the main concerns affecting the development of picnic areas. For good trafficability, the surface of picnic areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, permeability, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, permeability, and toxic substances in the soil.

Playgrounds require soils that are nearly level, are free of stones, and can withstand intensive foot traffic. The ratings are based on the soil properties that affect the ease of developing playgrounds and that influence trafficability and the growth of vegetation after development. Slope and stoniness are the main concerns affecting the development of playgrounds. For good trafficability, the surface of the playgrounds should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, permeability, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, permeability, and toxic substances in the soil.

Paths and trails for hiking and horseback riding should require little or no slope modification through cutting and filling (fig. 16). The ratings are based on the soil properties that affect trafficability and

Figure 16.—A view looking south from a waterfall on the Río Icacos. Hiking trails and paths provide spectacular views throughout the survey area.

erodibility. These properties are stoniness, depth to a water table, ponding, flooding, slope, and texture of the surface layer.

Wildlife Habitat

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 6, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

The elements of wildlife habitat are described in the following paragraphs.

Grasses and legumes are domestic perennial grasses and herbaceous legumes. Soil properties and features that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flooding, and slope. Soil temperature and soil moisture also are considerations.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flooding. Soil temperature and soil moisture also are considerations.

Shrubs are bushy woody plants that produce fruit, buds, twigs, bark, and foliage. Soil properties and features that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and soil moisture.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness.

Shallow water areas have an average depth of less than 5 feet. Some are naturally wet areas. Others are created by dams, levees, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife consists of pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants.

Habitat for woodland wildlife consists of areas of large canopy plants and associated grasses, legumes, and wild herbaceous plants.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. Ratings are given for building site development, sanitary facilities, construction materials, and water management. The ratings are based on observed performance of the soils and on the data in the tables described under the heading “Soil Properties.”

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of

the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about particle-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 to 7 feet of the surface, soil wetness, depth to a water table, ponding, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kinds of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to evaluate the potential of areas for residential, commercial, industrial, and recreational uses; make preliminary estimates of construction conditions; evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; plan detailed onsite investigations of soils and geology; locate potential sources of gravel, sand, earthfill, and topsoil; plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey, can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary. Additional information is contained in the USDA Natural Resources Conservation Services National Engineering Handbook (USDA–NRCS, n.d.).

Building Site Development

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. Tables 7a and 7b show the degree and kind of soil limitations that affect dwellings with and without basements, small commercial buildings, local roads, and shallow excavations.

The ratings in the tables are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the tables indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Dwellings are single-family houses of three stories or less. For dwellings without basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet. For dwellings with basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of about 7 feet. The ratings for dwellings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility. Compressibility is inferred from the Unified classification. The properties that affect the ease and amount of excavation include depth to a water table, ponding, flooding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a

cemented pan, and the amount and size of rock fragments.

Small commercial buildings are structures that are less than three stories high and do not have basements. The foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet. The ratings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility (which is inferred from the Unified classification). The properties that affect the ease and amount of excavation include flooding, depth to a water table, ponding, slope, depth to bedrock, hardness of bedrock, and the amount and size of rock fragments.

Local roads have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or soil material stabilized by lime or cement; and a surface of flexible material (asphalt), rigid material (concrete), or gravel with a binder. The ratings are based on the soil properties that affect the ease of excavation and grading and the traffic-supporting capacity. The properties that affect the ease of excavation and grading are depth to bedrock, hardness of bedrock, depth to a water table, ponding, flooding, the amount of large stones, and slope. The properties that affect the traffic-supporting capacity are soil strength (as inferred from the AASHTO group index number), subsidence, linear extensibility (shrink-swell potential), depth to a water table, and ponding.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing. Depth to bedrock, hardness of bedrock, the amount of large stones, and dense layers influence the ease of digging, filling, and compacting. Depth to the seasonal high water table, flooding, and ponding may restrict the period when excavations can be made. Slope influences the ease of using machinery. Soil texture, depth to the water table, and linear extensibility (shrink-swell potential) influence the resistance to sloughing.

Sanitary Facilities

Table 8 shows the degree and kind of soil limitations that affect septic tank absorption fields and sewage lagoons. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the tables indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 60 inches is evaluated. The ratings are based on the soil properties that affect absorption of the effluent, construction and maintenance of the system, and public health. Permeability, depth to a water table, ponding, depth to bedrock, and flooding affect absorption of the effluent. Stones and boulders and bedrock interfere with installation. Subsidence interferes with installation and maintenance. Excessive slope may cause lateral seepage and surfacing of the effluent in downslope areas.

Some soils are underlain by loose sand and gravel or fractured bedrock at a depth of less than 4 feet below the distribution lines. In these soils the absorption field may not adequately filter the effluent, particularly when the system is new. As a result, the ground water may become contaminated.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water. Considered in the ratings are slope, permeability, depth to a water table, ponding, depth to bedrock, flooding, large stones, and content of organic matter.

Soil permeability is a critical property affecting the suitability for sewage lagoons. Most porous soils eventually become sealed when they are used as sites for sewage lagoons. Until sealing occurs, however, the hazard of pollution is severe. Soils that have a permeability rate of more than 2 inches per hour are too porous for the proper functioning of sewage lagoons. In these soils, seepage of the effluent can result in contamination of the ground water. Ground-water contamination is also a hazard if fractured bedrock is within a depth of 40 inches, if the water table is high enough to raise the level of sewage in the lagoon, or if floodwater overtops the lagoon.

A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope and bedrock can cause construction problems, and large stones can hinder compaction of the lagoon floor. If the lagoon is to be uniformly deep throughout, the slope must be gentle enough and the soil material must be thick enough over bedrock to make land smoothing practical.

Construction Materials

Tables 9a and 9b give information about the soils as potential sources of gravel, sand, topsoil, reclamation material, and roadfill. Normal compaction, minor processing, and other standard construction practices are assumed.

Sand and *gravel* are natural aggregates suitable for commercial use with a minimum of processing. They are used in many kinds of construction. Specifications for each use vary widely. In table 9a, only the likelihood of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material. The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the Unified classification of the soil), the thickness of suitable material, and the content of rock fragments. If the bottom layer of the soil contains sand or gravel, the soil is considered a likely source regardless of thickness. The assumption is that the sand or gravel layer below the depth of observation exceeds the minimum thickness.

The soils are rated *good, fair,* or *poor* as potential sources of sand and gravel. A rating of *good* or *fair* means that the source material is likely to be in or below the soil. The bottom layer and the thickest layer of the soils are assigned numerical ratings. These ratings indicate the likelihood that the layer is a source of sand or gravel. The number 0.00 indicates that the layer is a poor source. The number 1.00 indicates that the layer is a good source. A number between 0.00 and 1.00 indicates the degree to which the layer is a likely source.

The soils are rated *good, fair,* or *poor* as potential sources of topsoil, reclamation material, and roadfill. The features that limit the soils as sources of these materials are specified in the tables. The numerical ratings given after the specified features indicate the degree to which the features limit the soils as sources of topsoil, reclamation material, or roadfill. The lower the number, the greater the limitation.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area. The ratings are based on the soil properties that affect plant growth; the ease of excavating, loading, and spreading the material; and reclamation of the borrow area. Toxic substances, soil reaction, and the properties that are inferred from soil texture, such as available water capacity and fertility, affect plant growth. The ease of excavating, loading, and spreading is affected by rock fragments, slope, depth to a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, depth to a water table, rock fragments, depth to bedrock or a cemented pan, and toxic material.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Reclamation material is used in areas that have been drastically disturbed by surface mining or similar activities. When these areas are reclaimed, layers of soil material or unconsolidated geological material, or both, are replaced in a vertical sequence. The reconstructed soil favors plant growth. The ratings in the table do not apply to quarries and other mined areas that require an offsite source of reconstruction material. The ratings are based on the soil properties that affect erosion and stability of the surface and the productive potential of the reconstructed soil. These properties include the content of sodium, salts, and calcium carbonate; reaction; available water capacity; erodibility; texture; content of rock fragments; and content of organic matter and other features that affect fertility.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments.

The ratings are for the whole soil, from the surface to a depth of about 5 feet. It is assumed that soil layers will be mixed when the soil material is excavated and spread.

The ratings are based on the amount of suitable material and on soil properties that affect the ease of excavation and the performance of the material after it is in place. The thickness of the suitable material is a major consideration. The ease of excavation is affected by large stones, depth to a water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the AASHTO classification of the soil) and linear extensibility (shrink-swell potential).

Water Management

Table 10 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas and embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect drainage.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock or other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; and subsidence of organic layers. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, and sulfur. Availability of drainage outlets is not considered in the ratings.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey.

Soil properties are ascertained by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine particle-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help to characterize key soils.

The estimates of soil properties are shown in tables. They include engineering index properties, physical and chemical properties, and pertinent soil and water features.

Engineering Index Properties

Table 11 gives the engineering classifications and the range of index properties for the layers of each soil in the survey area.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. “Loam,” for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, “gravelly.” Textural terms are defined in the Glossary.

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2001) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2000).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

The estimates of particle-size distribution, liquid limit, and plasticity index are generally rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is generally omitted in the table.

Physical and Chemical Analyses of Selected Soils

The results of physical analyses of several typical pedons in the survey area are given in table 12 and the results of chemical analyses in table 13. The data are for soils sampled at carefully selected sites. Unless otherwise indicated, the pedons are typical of the series. They are described in the section "Soil Series and Their Morphology." Soil samples were analyzed by the National Soil Survey Laboratory, Lincoln, Nebraska.

Most determinations, except those for grain-size analysis and bulk density, were made on soil material smaller than 2 millimeters in diameter. Measurements reported as percent or quantity of unit weight were calculated on an ovendry basis. The methods used in obtaining the data are indicated in the list that follows. The codes in parentheses refer to published methods (USDA, 1996).

Sand—(0.05-2.0 mm fraction) weight percentages of material less than 2 mm (3A1).
Silt—(0.002-0.05 mm fraction) pipette extraction, weight percentages of all material less than 2 mm (3A1).
Clay—(fraction less than 0.002 mm) pipette extraction, weight percentages of material less than 2 mm (3A1).
Organic carbon—wet combustion. Walkley-Black modified acid-dichromate, ferric sulfate titration (6A1c).
Extractable cations—ammonium acetate pH 7.0, ICP; calcium (6N2i), magnesium (6O2h), sodium (6P2f), potassium (6Q2f).
Extractable acidity—barium chloride-triethanolamine IV (6H5a).
Cation-exchange capacity—ammonium acetate, pH 7.0, steam distillation (5A8b).
Cation-exchange capacity—sum of cations (5A3a).
Effective cation-exchange capacity—sum of extractable cations plus aluminum (5A3b).
Base saturation—ammonium acetate, pH 7.0 (5C1).
Reaction (pH)—potassium chloride (8C1g).
Reaction (pH)—calcium chloride (8C1f).
Aluminum—potassium chloride extraction (6G9a).

Soil Features

Table 14 gives estimates of various soil features. The estimates are used in land use planning that involves engineering considerations.

A *restrictive layer* is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, and dense layers. The table indicates the hardness of the restrictive layer, which significantly affects the ease of excavation. *Depth to top* is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel or concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel or concrete in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low, moderate,* or *high,* is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion also is expressed as *low, moderate,* or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Water Features

Table 15 gives estimates of various water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when

the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

The *months* in the table indicate the portion of the year in which the feature is most likely to be a concern.

Water table refers to a saturated zone in the soil. Table 15 indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Physical Properties

Table 16 shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In table 16, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and

physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at $^1/_3$- or $^1/_{10}$-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity refers to the ability of a soil to transmit water. The term "permeability," as used in soil surveys, indicates saturated hydraulic conductivity (K_{sat}). The estimates in the table indicate the rate of water movement, in micrometers per second (um/sec), when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at $^1/_3$- or $^1/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. Volume change is influenced by the amount and type of clay minerals in the soil.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3 percent, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In table 16, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter in a soil can be maintained by returning crop residue to the soil. Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for plants and soil organisms.

Erosion factors are shown in table 16 as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and permeability. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Chemical Properties

Table 17 shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field

observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable bases that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Soil reaction is a measure of acidity or alkalinity. The pH of each soil horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (Soil Survey Staff, 1998 and 1999). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 18 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Twelve soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Oxisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Udox (*Ud*, meaning humid, plus *ox*, from Oxisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; type of saturation; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Hapludox (*Hapl*, meaning other, plus *udox*, the suborder of the Oxisols that has a udic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic subgroup is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other taxonomic class. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Aquic* identifies the subgroup that has gray mottles within a depth of 50 inches (125 cm) and has aquic conditions for some time in normal years. An example is Aquic Hapludox.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineralogy class, cation-exchange activity class, soil temperature regime, soil depth, and reaction class. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is very-fine, kaolinitic, isohyperthermic Aquic Hapludox.

SERIES. The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The soils of the Cristal series are very-fine, kaolinitic, isohyperthermic Aquic Hapludox.

Soil Series and Their Morphology

In this section, each soil series recognized in the Caribbean National Forest is described. The field data that were collected for each soil include a minimum of three complete descriptions for series of minor extent and ten or more for the major series. Characteristics of the soil and the material in which it formed are identified for each series. The detailed description of each soil horizon follows standards in the Soil Survey Manual (Soil Survey Division Staff, 1993). Many of the technical terms used in the descriptions are defined in Soil Taxonomy (Soil Survey Staff, 1998 and 1999). Unless otherwise stated, colors in the description are for moist soil. Following the pedon description is the range of the important characteristics of the soils in the series for this survey area.

A pedon is a small three-dimensional area of soil. A typical pedon for each series in the survey area is described. Lab data for many of the typical pedons are in tables 12 and 13. The typical pedons represent the

central theme or idea of a particular soil series as it occurs in the survey area. The typical pedon is compared and contrasted with similar soils and with nearby soils of other series. Characteristics which set it apart from other recognized series in the survey area are given.

Caguabo Series

The Caguabo series consists of shallow, well drained soils on ridgetops, ledges, and side slopes of strongly dissected uplands. These soils formed in material that weathered from andesitic to basaltic, marine-deposited, calcareous mudstone of the Hato Puerco Formation. Near the type location, the mean annual precipitation is about 80 inches (203 cm) and the mean annual temperature is 76 degrees F (24 °C). Slopes range from 8 to 70 percent. These soils are loamy, mixed, active, isohyperthermic, shallow Typic Eutrudepts.

Caguabo soils are commonly associated with Prieto and Sonadora soils. The poorly drained Prieto soils are in the higher positions, are moderately deep, and have more clay in the subsoil than the Caguabo soils. Sonadora soils are generally in the lower positions, are moderately deep, and have a clayey, smectitic cambic horizon.

Typical pedon of Caguabo gravelly clay loam, 8 to 15 percent slopes; about 3,500 feet (1,067 m) southeast of the garage at El Verde, along trail number 21 to the ridgetop, then west about 100 feet (30 m) along the ridgetop; El Yunque topographic quadrangle; lat. 18 degrees 20 minutes 11 seconds N. and long. 65 degrees 49 minutes 41 seconds W.; PRD 1940; Río de Grande Municipio, Caribbean National Forest:

A—0 to 3 inches (0 to 8 cm); dark grayish brown (10YR 4/2) gravelly clay loam; moderate very fine and fine granular structure; friable, slightly sticky and slightly plastic; common very fine, fine, medium, and coarse roots; about 15 percent, by volume, pebbles; slightly acid; abrupt smooth boundary.

Bw—3 to 7 inches (8 to 18 cm); brown (10YR 4/3) very gravelly clay loam; moderate fine subangular blocky structure; common very fine, fine, and medium roots; about 25 percent, by volume, pebbles; about 10 percent, by volume, pale yellow (2.5Y 8/2) and brown (10YR 5/3) highly weathered mudstone paragravel; slightly acid; clear wavy boundary.

C—7 to 11 inches (18 to 28 cm); brown (10YR 4/3) very gravelly clay loam; massive; few fine and common medium roots; about 35 percent, by volume, pebbles; about 40 percent, by volume, pale yellow (2.5Y 8/2) and brown (10YR 5/3) mudstone paragravel; slightly acid; clear wavy boundary.

Cr—11 to 16 inches (28 to 41 cm); 25 percent light olive gray (5Y 6/2), 25 percent olive brown (2.5Y 4/4), 25 percent dark grayish brown (2.5Y 4/2), and 25 percent brown (10YR 5/3) mudstone conglomerate that crushes to very gravelly sandy clay loam; massive; few fine and medium roots in fractures; about 60 percent, by volume, lithic pebbles and about 40 percent, by volume, mudstone paragravel; slightly acid; clear wavy boundary.

R—16 inches (41 cm); mudstone; massive; hard; few fractures.

The thickness of the solum ranges from 6 to 18 inches (15 to 46 cm). Depth to bedrock ranges from 10 to 20 inches (25 to 50 cm). Reaction is slightly acid throughout the profile.

The A horizon has hue of 7.5YR to 2.5Y, value of 3 to 5, and chroma of 2 to 6. It is loam, clay loam, or the gravelly analogs of those textures.

The Bw horizon has hue of 7.5YR to 2.5Y, value of 4 to 6, and chroma of 3 to 6. It is the gravelly to extremely gravelly analogs of silty clay loam, clay loam, or clay.

The content of mudstone pararock fragments ranges from 10 to 20 percent, by volume. The content of pebbles ranges from 25 to 50 percent, by volume.

The C horizon, where present, has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 3 to 6; or it has no dominant matrix color and is multicolored in shades of brown and yellow. It is the gravelly or very gravelly analogs of sandy clay loam or clay loam. The content of mudstone pararock fragments ranges from 20 to 80 percent, by volume. The content of pebbles ranges from 15 to 50 percent, by volume.

The Cr horizon, where present, is mudstone conglomerate that is multicolored in shades of olive, gray, brown, and yellow.

The R layer is extremely hard, massive mudstone that has a few fractures.

Ciales Series

The Ciales series consists of very deep, poorly drained soils in concave positions on lower side slopes and footslopes of dissected mountains. These soils formed in residuum from igneous rocks. Near the type location, the mean annual precipitation is about 150 inches (381 cm) and the mean annual temperature is about 71 degrees F (22 °C). Slopes range from 5 to 45 percent. These

soils are fine-loamy, isotic, acid, isothermic Histic Humaquepts.

Ciales soils are commonly associated with Picacho, Utuado, and Yunque soils. The associated soils are in the higher positions. The somewhat poorly drained Picacho soils do not have a histic epipedon. Utuado soils have a coarse-loamy control section. The moderately well drained Yunque soils have a clayey subsoil and are Oxisols.

Typical pedon of Ciales mucky clay loam, in an area of Picacho-Ciales complex, 5 to 30 percent slopes; about 2,000 feet (610 m) southwest of the junction of Puerto Rico Highways 191 and 990 at kilometer marker 130, on Trade Winds Trail; lat. 18 degrees 17 minutes 38 seconds N. and long. 65 degrees 47 minutes 41 seconds W.; PRD 1940; El Yunque topographic quadrangle; Naguabo Municipio, Caribbean National Forest:

A—0 to 9 inches (0 to 23 cm); dark reddish brown (5YR 3/3) mucky clay loam; moderate fine subangular blocky structure parting to moderate fine granular; friable, slightly sticky and slightly plastic; many fine and medium roots; common large worm tunnels filled with black (7.5YR 2.5/1) material and girdled with yellowish red (5YR 5/8) material; very strongly acid; abrupt smooth boundary.

Bg1—9 to 16 inches (23 to 41 cm); dark gray (10YR 4/1) sandy clay loam; moderate medium subangular blocky structure parting to moderate fine subangular blocky; friable, slightly sticky and slightly plastic; common fine and medium roots; common fine interstitial and tubular pores; common large worm tunnels filled with black (7.5YR 2.5/1) material; few fine flakes of mica; common medium distinct light yellowish brown (10YR 6/4) and common medium distinct yellowish brown (10YR 5/8) masses of iron accumulation; very strongly acid; clear smooth boundary.

Bg2—16 to 25 inches (41 to 64 cm); olive gray (5Y 5/2) sandy clay loam; moderate medium subangular blocky structure parting to moderate fine subangular blocky; friable, slightly sticky and slightly plastic; common fine roots; common fine tubular pores; few large worm tunnels filled with black (7.5YR 2.5/1) material; few fine quartz grains; few fine flakes of mica; common fine rounded soft masses of iron-manganese; common medium distinct light yellowish brown (2.5Y 6/4) and strong brown (7.5YR 5/6) masses of iron accumulation and common medium faint gray (N 5/0) iron depletions; very strongly acid; abrupt smooth boundary.

Bw1—25 to 36 inches (64 to 91 cm); strong brown (7.5YR 5/6) sandy loam; weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; few fine interstitial and tubular pores; common fine flakes of mica; very strongly acid; clear wavy boundary.

Bw2—36 to 39 inches (91 to 99 cm); yellowish brown (10YR 5/6) sandy loam; weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; few fine interstitial and tubular pores; common fine flakes of mica; common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation; very strongly acid; clear smooth boundary.

BC—39 to 56 inches (99 to 142 cm); 34 percent yellowish brown (10YR 5/6), 33 percent dark brown (7.5YR 4/4), and 33 percent dark brown (7.5YR 3/2) loam; weak coarse subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; common fine tubular pores; many fine grains of quartz; very strongly acid; clear smooth boundary.

C—56 to 73 inches (142 to 191 cm); stratified dark yellowish brown (10YR 4/6), strong brown (7.5YR 5/8), yellowish brown (10YR 5/8), and dark red (7.5R 3/6) sandy loam; massive; very friable; few fine roots; common fine tubular pores; common fine flakes and grains of quartz; very strongly acid.

The thickness of the solum ranges from 36 to more than 60 inches (91 to 152 cm). Reaction ranges from extremely acid to strongly acid throughout the profile. The content of rock fragments ranges from 0 to 15 percent, by volume.

The upper part of the A horizon has hue of 5YR to 10YR and value and chroma of 3 or less. It is mucky loam or mucky clay loam. The lower part of the A horizon, where present, has hue of 5YR to 2.5Y, value of 5 or less, and chroma of 1 to 3. It is loam, sandy clay loam, or clay loam.

The Bg horizon has hue of 10YR to 5Y, value of 4 to 7, and chroma of 1 or 2; or it is neutral in hue and has value of 4 to 7. It is loam, sandy clay loam, clay loam, silty clay, or clay.

The Bw horizon has hue of 7.5YR or 10YR, value of 4 to 6, and chroma of 3 to 8. It has few to many redoximorphic features in shades of yellow, brown, red, and gray. It is sandy loam, loam, or sandy clay loam.

The BC horizon, where present, has hue of 7.5YR or 10YR, value of 4 to 7, and chroma of 3 to 8; or it has no dominant matrix color and is multicolored in shades of brown, yellow, and red. It is sandy loam, loam, or sandy clay loam.

The C horizon has hue of 5YR or 7.5YR, value of 4

to 6, and chroma of 4 to 8; or it has no dominant color and is multicolored in shades of brown, yellow, and red. It is sandy, loam, silt loam, sandy clay loam, or silty clay loam.

Coloso Series

The Coloso series consists of very deep, somewhat poorly drained, slowly permeable soils on flood plains and terraces. These soils formed in stratified loamy and clayey alluvial sediments. Near the type location, the mean annual precipitation is about 80 inches (203 cm) and the mean annual air temperature is about 78 degrees F (26 °C). Slopes range from 0 to 8 percent. These soils are very-fine, kaolinitic, acid, isohyperthermic Vertic Endoaquepts.

Coloso soils are commonly associated with Cristal, Luquillo, and Zarzal soils. Cristal and Zarzal soils are on uplands in the higher positions. The Cristal soils and the well drained Zarzal soils have more clay in the control section than the Coloso soils. The well drained Luquillo soils have mixed mineralogy and are in positions that are similar to those of the Coloso soils or higher.

Typical pedon of Coloso silty clay loam, occasionally flooded; on the west side of the Río Espíritu Santo at kilometer marker 21.9 on Puerto Rico Road 186, on the terrace about 30 feet (9 m) north of the west side of the low water ford behind the Girl Scout camp; El Yunque topographic quadrangle; lat. 18 degrees 20 minutes 21 seconds N. and long. 65 degrees 49 minutes 18 seconds W.; PRD 1940; Caribbean National Forest:

A—0 to 4 inches (0 to 10 cm); dark yellowish brown (10YR 4/4) silty clay loam; weak thick platy structure; friable; common very fine and fine roots; slightly acid; abrupt smooth boundary.

Bw—4 to 7 inches (10 to 18 cm); dark yellowish brown (10YR 4/4) clay; weak fine subangular blocky structure; firm, slightly sticky and plastic; few fine and medium roots; common faint pressure faces on surfaces of peds; common medium distinct yellowish red (5YR 5/6) masses of iron accumulation; slightly acid; clear smooth boundary.

C1—7 to 35 inches (18 to 89 cm); light yellowish brown (10YR 6/4) clay; massive; firm, slightly sticky and plastic; few medium roots; common medium distinct black (10YR 2/1) masses of iron and manganese oxide; common medium distinct yellowish red (5YR 5/6) masses of iron accumulation and light olive gray (5Y 6/2) iron depletions; moderately acid; gradual smooth boundary.

C2—35 to 60 inches (89 to 152 cm); light yellowish brown (10YR 6/4) clay; massive; firm, slightly sticky and plastic; about 10 percent, by volume, saprolite fragments; common medium distinct black (10YR 2/1) masses of iron and manganese oxide; common medium distinct light olive gray (5Y 6/2) iron depletions; moderately acid.z

The thickness of the solum ranges from 7 to 22 inches (18 to 56 cm). Reaction is moderately acid or slightly acid throughout the profile. The content of rock fragments ranges from 0 to 10 percent, by volume, throughout.

The A horizon has hue of 10YR, value of 3 or 4, and chroma of 2 to 4. It is silty clay loam or silty clay.

The Bw horizon has hue of 10YR, value of 4 or 5, and chroma of 3 to 6. It has few to many redoximorphic features in shades of red, yellow, brown, and gray. It is silty clay loam, silty clay, or clay.

The C horizon has hue of 10YR, value of 5 or 6, and chroma of 3 or 4. It has few or common redoximorphic features in shades of yellow, red, olive, and gray. It is silty clay or clay.

Cristal Series

The Cristal series consists of very deep, somewhat poorly drained soils in concave positions in mountain coves and on lower side slopes of volcanic hills and mountains. These soils formed in a mixture of alluvium and colluvium. Near the type location, the mean annual rainfall is about 90 inches (229 cm) and the mean annual temperature is about 75 degrees F (24 °C). Slopes range from 5 to 60 percent. These soils are very-fine, kaolinitic, isohyperthermic Aquic Hapludox.

Cristal soils are commonly associated with Coloso, Humatas, Luquillo, and Zarzal soils. The somewhat poorly drained Coloso soils and the well drained Luquillo soils are in lower positions than the Cristal soils and are on adjacent flood plains. The well drained Humatas soils are also in lower positions than the Cristal soils and have less clay in the control section. The well drained Luquillo soils also have less clay in the control section. The well drained Zarzal soils are in the higher positions and are Oxisols.

Typical pedon of Cristal clay loam, in an area of Cristal-Zarzal complex, 5 to 40 percent slopes; about 1,000 feet (305 m) south of the junction of Puerto Rico Road 988 and the Virgilio (number 5) Trail, past the grove of royal palm, then downslope to the north about 20 feet (6 m); Fajardo topographic quadrangle; lat. 18 degrees 19 minutes 41 seconds N. and long. 65 degrees 42 minutes 30 seconds W.; PRD 1940; Caribbean National Forest:

A—0 to 2 inches (0 to 5 cm); brown (10YR 4/3) clay loam; moderate fine granular structure; friable; many fine, medium, and coarse roots; about 10 percent, by volume, cobbles; very strongly acid; clear smooth boundary.

Bw1—2 to 15 inches (5 to 38 cm); pale brown (10YR 6/3) clay; weak medium subangular blocky structure; firm; few fine, medium, and coarse roots; common medium distinct very dark brown (10YR 2/2) masses of iron and manganese and yellowish red (5YR 5/6) masses of iron accumulation; common medium faint light brownish gray (10YR 6/2) iron depletions; very strongly acid; clear smooth boundary.

Bw2—15 to 26 inches (38 to 66 cm); yellowish brown (10YR 5/6) gravelly clay; weak medium subangular blocky structure; firm; few fine roots; about 15 percent, by volume, pebbles; common medium distinct very dark brown (10YR 2/2) masses of iron and manganese and yellowish red (5YR 5/6) masses of iron accumulation; common medium distinct light gray (10YR 7/2) iron depletions; very strongly acid; gradual smooth boundary.

Bw3—26 to 39 inches (66 to 99 cm); strong brown (7.5YR 5/6) clay; weak fine subangular blocky structure; firm; common medium distinct yellow (10YR 7/6) and red (2.5YR 5/6) masses of iron accumulation and very dark brown (10YR 2/2) masses of iron and manganese; very strongly acid; gradual smooth boundary.

C—39 to 60 inches (99 to 152 cm); yellowish red (5YR 5/8) clay loam; massive; friable; many medium distinct yellow (10YR 7/6) masses of iron accumulation and very dark brown (10YR 2/2) masses of iron and manganese; very strongly acid.

The thickness of the solum ranges from 30 to 50 inches (76 to 127 cm). Reaction ranges from extremely acid to strongly acid throughout the profile. The content of rock fragments ranges from 0 to 30 percent, by volume, throughout.

The A horizon has hue of 10YR, value of 2 to 5, and chroma of 4 to 8. It is loam, silty clay loam, clay loam, or the gravelly, cobbly, or stony analogs of those textures.

The Bw horizon has hue of 7.5YR to 5Y, value of 4 to 6, and chroma of 3 to 8. It has few to many redoximorphic features in shades of yellow, brown, red, and gray. It is silty clay loam, silty clay, clay loam, clay, or the gravelly analogs of those textures.

The C horizon has hue of 5YR to 5GY, value of 4 to 6, and chroma of 1 to 8; or it has no dominant color and is multicolored in shades of gray, brown, yellow, and red. It is silty clay loam, clay loam, or the gravelly analogs of those textures.

Dwarf Series

The Dwarf series consists of very deep, poorly drained, moderately slowly permeable soils on summits, ridges, and side slopes of mountains. These soils formed in residuum from volcanic sandstone. Near the type location, the mean annual precipitation is about 180 inches (457 cm) and the mean annual temperature is about 55 degrees F (13 °C). Slopes range from 5 to 80 percent. These soils are very-fine, mixed, isomesic Humic Haplaquox.

Dwarf soils are commonly associated with Moteado and Palm soils. Both of the associated soils are in lower positions than the Dwarf soils. The Moteado soils are deep to bedrock and are not Oxisols. The Palm soils are clayey-skeletal.

Typical pedon of Dwarf muck, 10 to 65 percent slopes, windswept; about 0.9 mile (1.45 km) north of Forest Road 10 (El Yunque Peak Road) from its junction with Puerto Rico Road 191, about 20 feet (6 m) from the east side of Forest Road 10, and about 20 feet (6 m) northeast from the pullout of the first electronic-site building and Forest Road 10; El Yunque topographic quadrangle sheet; lat. 18 degrees 17 minutes 37 seconds N. and long. 65 degrees 47 minutes 44 seconds W.; PRD 1940; Río Grande Municipio, Caribbean National Forest:

Oa—0 to 4 inches (0 to 10 cm); very dark grayish brown (10YR 3/2) muck; massive; very friable; many medium roots; common fine interstitial and tubular pores; very strongly acid; clear smooth boundary.

A—4 to 9 inches (10 to 23 cm); dark brown (10YR 3/3) mucky sandy loam; weak fine subangular blocky structure; very friable, slightly sticky and slightly plastic; many fine and medium roots; common fine and medium interstitial and tubular pores; few faint dark brown (7.5YR 3/2 and 4/4) masses of iron accumulation along root channels; few medium distinct grayish brown (2.5Y 5/2) iron depletions; very strongly acid; abrupt smooth boundary.

Bg1—9 to 16 inches (23 to 41 cm); dark grayish brown (2.5Y 4/2) silty clay loam; weak medium subangular blocky structure parting to weak fine subangular blocky; very friable, slightly sticky and slightly plastic; common fine and medium roots; common fine and medium vesicular and tubular pores; many dark brown (7.5YR 3/4) and strong brown (7.5YR 4/6) masses of iron accumulation along root channels; common very dark grayish

brown (10YR 3/2) wormcasts; very strongly acid; clear smooth boundary.

Bg2—16 to 26 inches (41 to 66 cm); olive gray (5Y 4/2) silty clay; weak medium subangular blocky structure parting to weak fine subangular blocky; friable, slightly sticky and slightly plastic; common fine and medium roots; common fine and medium vesicular and tubular pores; few distinct coats of organic material in root channels and pores; common large very dark grayish brown (10YR 3/2) wormcasts; common coarse distinct olive (5Y 4/4) masses of iron accumulation; very strongly acid; clear smooth boundary.

Bw—26 to 35 inches (66 to 89 cm); olive (5Y 4/4) silty clay; weak coarse angular blocky structure; friable, sticky and plastic; few fine roots; few fine and medium vesicular and tubular pores; few distinct pressure faces on horizontal faces of peds; few coarse and common medium irregular concretions of iron and manganese oxide; many large very dark grayish brown (2.5Y 3/2) wormcasts; few old roots; common fine distinct olive (5Y 5/6) and light olive brown (2.5Y 5/6) masses of iron accumulation; few coarse distinct greenish gray (5GY 5/1) iron depletions; very strongly acid; clear smooth boundary.

2BC—35 to 43 inches (89 to 109 cm); olive brown (2.5Y 4/4) clay loam; weak coarse angular blocky structure; firm, sticky and plastic; few fine and medium vesicular and tubular pores; few distinct pressure faces on horizontal faces of peds; common large wormcasts; few distinct very dark grayish brown (2.5Y 3/2) stains and organic coatings on faces of peds; many medium prominent dark yellowish brown (10YR 4/4) masses of iron accumulation and common coarse prominent greenish gray (5GY 5/1) areas of iron depletions; very strongly acid; clear smooth boundary.

2C1—43 to 52 inches (109 to 132 cm); olive (5Y 5/6) silt loam; massive; friable, slightly sticky and plastic; few fine and medium vesicular and tubular pores; few large very dark grayish brown (2.5Y 3/2) and light olive brown (2.5Y 5/4) wormcasts; few coarse prominent strong brown (7.5YR 4/6) and few medium prominent yellowish brown (10YR 5/8) masses of iron accumulation; few fine distinct greenish gray (5GY 5/1) iron depletions; very strongly acid; clear smooth boundary.

2C2—52 to 60 inches (132 to 152 cm); strong brown (7.5YR 5/6) silty clay loam; massive; friable, slightly sticky and plastic; few fine and medium vesicular and tubular pores; few large dark olive gray (5Y 3/2) wormcasts; few medium irregular concretions of iron and manganese oxides; many coarse prominent strong brown (7.5YR 5/8) and yellowish brown (10YR 5/8) masses of iron accumulation; few medium prominent very pale brown (10YR 8/3) iron depletions; very strongly acid.

The thickness of the solum ranges from 30 to 50 inches (76 to 127 cm). Reaction ranges from extremely acid to strongly acid throughout the profile. The content of rock fragments ranges from 0 to 10 percent, by volume, throughout.

The Oa horizon has hue of 10YR, value of 2 or 3, and chroma of 2 or less; or it is neutral in hue and has value of 2 or 3. Rubbed fiber content is less than 25 percent.

The A horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 3 or less; or it is neutral in hue and has value of 2 or 3. It is mucky sandy loam, loam, or mucky silt loam.

The Bg horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 or 2. It is silt loam, silty clay loam, or silty clay.

The Bw horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 3 or 4. It has common or many redoximorphic features in shades of yellow, brown, olive, and gray. It is silty clay or clay.

The BC or 2BC horizon, where present, is similar in color to the Bw horizon. Texture ranges from sandy loam to clay.

The C or 2C horizon has hue of 7.5YR to 5GY, value of 4 to 6, and chroma of 1 to 8; or it has no dominant color and is multicolored in shades of brown, yellow, olive, and gray. It is sandy loam, loam, silt loam, silty clay loam, or clay loam.

Guayabota Series

The Guayabota series consists of shallow, poorly drained soils on ridgetops and side slopes of deeply dissected mountains of volcanic origin. These soils formed in material weathered from andesitic to basaltic, marine-deposited, metamorphosed volcanic siltstone of the Tabonuco Formation. Near the type location, the mean annual rainfall is about 165 inches (419 cm) and the mean annual temperature is about 72 degrees F (22 °C). Slopes range from 5 to 80 percent. These soils are clayey, mixed, subactive, acid, isothermic, shallow Typic Humaquepts.

Guayabota soils are commonly associated with Moteado, Palm, Picacho, Utuado, and Yunque soils. Moteado soils are in positions similar to those of the Guayabota soils, are deep to bedrock, and are Oxisols. Palm soils are in the higher positions, are

very deep, and have a clayey-skeletal control section. The somewhat poorly drained Picacho and Utuado soils are very deep and are in the lower positions. The Picacho soils have a fine-loamy control section, and the Utuado soils have a coarse-loamy control section. The moderately well drained Yunque soils are very deep and are in positions that are similar to those of the Guayabota soils or higher.

Typical pedon of Guayabota silty clay loam, in an area of Guayabota-Yunque complex, 30 to 60 percent slopes; about 300 feet (91 m) northwest from kilometer marker 11.8 on Highway 191 to Glorieta Bohique, then about 150 (46 m) feet south; El Yunque topographic quadrangle; lat. 18 degrees 18 minutes 22 seconds N. and long 65 degrees 47 minutes 5 seconds W.; PRD 1940; Caribbean National Forest:

A—0 to 5 inches (0 to 13 cm); very dark gray (5Y 3/1) silty clay loam; weak fine subangular blocky structure; slightly sticky and slightly plastic; many fine and medium roots; few fine and medium interstitial pores; few fine reddish brown (5YR 4/4) masses of iron accumulation along pores; very strongly acid; clear smooth boundary.

Bg1—5 to 11 inches (13 to 28 cm); dark olive gray (5Y 3/2) silty clay; weak coarse subangular blocky structure parting to weak medium subangular blocky; firm, slightly sticky and slightly plastic; common fine and medium roots; few fine vesicular and tubular pores; many fine dark reddish brown (5YR 3/4) and few medium distinct yellowish brown (10YR 5/8) masses of iron accumulation; common medium distinct dark bluish gray (5B 4/1) iron depletions; very strongly acid; gradual smooth boundary.

Bg2—11 to 14 inches (28 to 36 cm); dark olive gray (5Y 3/2) silty clay; weak medium subangular blocky structure; firm, slightly sticky and plastic; about 5 percent, by volume, weathered siltstone fragments; common coarse distinct yellowish brown (10YR 5/8) and few medium distinct yellowish red (5YR 5/8) masses of iron accumulation; few fine distinct dark gray (10YR 4/1) iron depletions; extremely acid; abrupt smooth boundary.

Cg—14 to 18 inches (36 to 46 cm); 34 percent dark bluish gray (5B 4/1), 33 percent dark greenish gray (5G 4/1), and 33 percent yellowish red (5YR 4/8) silty clay loam; massive; friable, slightly sticky and slightly plastic; few fine and medium roots; few fine pores; about 50 percent, by volume, saprolite fragments; the areas of yellowish red are iron accumulation and the areas of dark bluish gray and greenish gray are iron depletions; extremely acid; abrupt smooth boundary.

R—18 inches (46 cm); dark bluish gray (5B 4/1) and greenish gray (5G 4/1) hard siltstone bedrock.

Depth to the hard siltstone bedrock ranges from 10 to 20 inches (25 to 50 cm). Reaction ranges from extremely acid to strongly acid throughout the profile.

The Oi horizon, where present, is composed of fine, medium, and coarse roots that form a mat up to 5 inches (13 cm) thick.

The A horizon has hue of 2.5Y to 5B, value of 2 to 4, and chroma of 3 or less; or it is neutral in hue and has value of 2 to 4. The quantity of redoximorphic features in shades of brown ranges from none to common. The A horizon is silty clay loam or silty clay.

The Bg horizon has hue of 2.5Y to 5B, value of 3 to 5, and chroma of 2 or less; or it is neutral in hue and has value of 3 to 5. It has few to many redoximorphic features in shades of brown, yellow, red, and gray. It is silty clay loam, clay loam, or silty clay.

The Cg horizon, where present, has colors similar to those of the Bg horizon. The Cg horizon is silty clay loam or silty clay. The content of saprolite fragments ranges from 40 to 70 percent, by volume.

The Cr horizon, where present, is fractured siltstone that has a texture of silt loam when crushed. It has colors similar to those of the Bg horizon.

The R layer is hard siltstone bedrock.

Humatas Series

The Humatas series consists of very deep, well drained soils on side slopes and ridges of strongly dissected uplands. These soils formed in clayey and loamy material that weathered from igneous rocks. Near the type location, the mean annual precipitation is about 80 inches (203 cm) and the mean annual temperature is about 75 degrees F (24 °C). Slopes range from 5 to 60 percent. These soils are very-fine, parasesquic, isohyperthermic Typic Haplohumults.

Humatas soils are commonly associated with Cristal and Zarzal soils. The somewhat poorly drained Cristal soils are in higher positions than the Humatas soils and have more clay in the control section. Zarzal soils are in the lower positions, have more clay in the control section, have kaolinitic mineralogy, and are Oxisols.

Typical pedon of Humatas silty clay, in an area of Humatas-Zarzal complex, 5 to 30 percent slopes; about 0.5 mile (0.80 km) west of Sabana, on the east side of Puerto Rico Road 988, in the curve that turns north, about 40 feet (12 m) from the road, in the middle of planted mahogany; Fajardo topographic quadrangle; lat. 18 degrees 19 minutes 37 seconds N. and long. 65 degrees 44 minutes 11 seconds W.; PRD 1940; Caribbean National Forest:

A—0 to 4 inches (0 to 10 cm); dark brown (10YR 4/3) silty clay; moderate fine and medium subangular blocky structure; friable, slightly sticky and slightly plastic; common very fine, fine, medium, and coarse roots; very strongly acid; clear wavy boundary.

Bt1—4 to 12 inches (10 to 30 cm); yellowish brown (10YR 5/6) silty clay; weak medium and coarse subangular blocky structure; friable, slightly sticky and plastic; few fine roots; common faint clay pressure faces on peds; very strongly acid; clear smooth boundary.

Bt2—12 to 19 inches (30 to 48 cm); yellowish brown (10YR 5/6) clay; weak medium and coarse prismatic structure parting to weak medium and coarse subangular blocky; firm, slightly sticky and plastic; few fine and common medium roots; common faint pressure faces on peds; common medium distinct red (2.5YR 5/6) masses of iron accumulation; very strongly acid; clear wavy boundary.

BC—19 to 38 inches (48 to 97 cm); 50 percent red (2.5YR 4/6) and 50 percent brownish yellow (10YR 6/6) clay; weak medium subangular blocky structure; firm, slightly sticky and slightly plastic; few very fine and fine roots; very strongly acid; gradual wavy boundary.

C—38 to 60 inches (97 to 152 cm); red (2.5YR 4/6) clay; massive; firm, nonsticky and slightly plastic; common medium distinct brownish yellow (10YR 6/6) masses of iron accumulation; very strongly acid.

The thickness of the solum ranges from 22 to 51 inches (56 to 130 cm). Reaction is very strongly acid or strongly acid throughout the profile. The content of rock fragments ranges from 0 to 20 percent, by volume, throughout; except in the A horizon, which ranges from 0 to 40 percent.

The A horizon has hue of 5YR to 10YR, value of 3 to 5, and chroma of 3 to 6. It is silty clay loam, silty clay, clay, or the gravelly or cobbly analogs of those textures.

The Bt horizon has hue of 10YR or 2.5YR, value of 4 to 6, and chroma of 4 to 8. It is silty clay, clay, or the gravelly analogs of those textures.

The BC horizon has hue of 10R to 5YR, value of 4 to 6, and chroma of 4 to 8; or it has no dominant matrix color and is multicolored in shades of red, yellow, brown, and gray. It is silty clay loam, silty clay, clay, or the gravelly analogs of those textures.

The C horizon has hue of 10R to 5YR, value of 4 to 6, and chroma of 4 to 8. It is silty clay loam, clay loam, clay, or the gravelly analogs of those textures.

Icacos Series

The Icacos series consists of very deep, somewhat poorly drained soils on flood plains along rivers. These soils formed in alluvium that weathered from granodiorite in the plutonic uplands of Rio Blanco stock. Near the type location, the mean annual precipitation is about 150 inches (381 cm) and the mean annual temperature is about 65 degrees F (18 °C). Slopes range from 0 to 15 percent. These soils are fine-loamy, mixed, semiactive, acid, isothermic Aeric Endoaquepts.

Icacos soils are commonly associated with Picacho and Utuado soils. The associated soils are on uplands in higher positions than the Icacos soils. Picacho soils have kaolinitic mineralogy, and Utuado soils have a coarse-loamy control section.

Typical pedon of Icacos loam, occasionally flooded; about 75 feet (23 m) east of kilometer marker 16.5 on Puerto Rico Road 191, on the west side of the Icacos flood plain; El Yunque topographic quadrangle; lat. 18 degrees 16 minutes 16 seconds N. and long. 65 degrees 47 minutes 57 seconds W.; PRD 1940; Caribbean National Forest:

A—0 to 4 inches (0 to 10 cm); brown (10YR 4/3) loam; moderate fine granular structure; friable; many very fine, fine, medium, and coarse roots; very strongly acid; clear smooth boundary.

Bw—4 to 14 inches (10 to 36 cm); yellowish brown (10YR 5/4) silty clay loam; weak fine subangular blocky structure; friable; few fine roots; common medium distinct strong brown (7.5YR 5/6) masses of iron accumulation; common medium distinct gray (10YR 5/1) areas of iron depletions; very strongly acid; clear smooth boundary.

Cg1—14 to 23 inches (36 to 58 cm); gray (10YR 5/1) silt loam; massive; few fine roots; common fine flakes of mica; common medium distinct strong brown (7.5YR 5/6) masses of iron accumulation; very strongly acid; gradual smooth boundary.

Cg2—23 to 37 inches (58 to 94 cm); greenish gray (5GY 5/1) silty clay loam; massive; few very fine roots; common fine flakes of mica; common medium distinct red (2.5YR 4/6) masses of iron accumulation; very strongly acid; common fine flakes of mica; abrupt smooth boundary.

Cg3—37 to 60 inches (94 to 152 cm); olive gray (5Y 4/2) silt loam; massive; common fine flakes of mica; common medium distinct yellowish red (5YR 5/6) and dark brown (10YR 3/3) masses of iron accumulation; very strongly acid.

The thickness of the solum ranges from 10 to 40 inches (25 to 102 cm). Reaction ranges from

extremely acid to strongly acid throughout the profile. The content of rock fragments ranges from 0 to 10 percent, by volume, throughout.

The A horizon has hue of 10YR or 2.5Y, value of 2 to 5, and chroma of 2 to 4; or it is neutral in hue and has value of 2 to 5. It is silt loam, loam, or clay loam.

The Bw horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 3 or 4. It has few or common redoximorphic features in shades of brown and gray. It is silt loam, silty clay loam, or clay loam.

The Cg horizon has hue of 7.5YR to 5GY, value of 4 to 6, and chroma of 1 or 2; or it has no dominant matrix color and is multicolored in shades of gray, yellow, and brown. In areas that have a dominant matrix color, the Cg horizon has common or many redoximorphic accumulations in shades of yellow, brown, and gray. The Cg horizon is sandy loam, silt loam, loam, silty clay loam, clay loam, or clay.

Los Guineos Series

The Los Guineos series consists of very deep, well drained soils on side slopes of mountains. These soils formed in residuum that weathered from sandstone material. Near the type location, the mean annual precipitation is about 120 inches (305 cm) and the mean annual temperature is about 68 degrees F (20 °C). Slopes range from 5 to 60 percent. These soils are very-fine, kaolinitic, isothermic Humic Hapludox.

Los Guineos soils are commonly associated with Moteado, Picacho, Utuado, Yunque, and Zarzal soils. The poorly drained Moteado soils are deep to bedrock and are in positions that are similar to those of the Los Guineos soils or slightly lower. The somewhat poorly drained Picacho soils are in lower positions than the Los Guineos soils, have less clay in the control section, and have kaolinitic mineralogy. The somewhat poorly drained Utuado soils are in lower positions than the Los Guineos soils and have less clay in the control section. The moderately well drained Yunque soils are in higher positions than the Los Guineos soils, have kaolinitic mineralogy, and have less clay in the control section. Zarzal soils are in the lower positions, are isohyperthermic, and have a kaolinitic control section.

Typical pedon of Los Guineos clay, in an area of Yunque-Los Guineos-Moteado complex, 5 to 30 percent slopes; about 150 feet (46 m) southwest of a bridge on Puerto Rico Road 911; El Yunque topographic quadrangle; lat. 18 degrees 18 minutes 47 seconds N. and long. 65 degrees 49 minutes 27 seconds W.; PRD 1940; Caribbean National Forest:

A—0 to 1 inch (0 to 3 cm); dark yellowish brown (10YR 4/4) clay; moderate medium granular structure parting to moderate fine granular; firm, sticky and plastic; common very fine and many fine roots; few fine discontinuous tubular pores; many faint organic coats on vertical and horizontal faces of peds; extremely acid; clear smooth boundary.

Bt1—1 to 3 inches (3 to 8 cm); yellowish brown (10YR 5/4) clay; moderate fine subangular blocky structure; firm, very sticky and very plastic; very few coarse and common fine and medium roots; common very fine discontinuous tubular pores; few faint clay films on vertical and horizontal faces of peds; few wormcasts; extremely acid; clear smooth boundary.

Bt2—3 to 9 inches (8 to 23 cm); yellowish brown (10YR 5/6) clay; moderate medium subangular blocky structure parting to moderate coarse subangular blocky; firm, very sticky and very plastic; common fine and medium roots; common fine and medium discontinuous tubular pores; many distinct clay films on vertical and horizontal faces of peds; few wormcasts; extremely acid; clear smooth boundary.

Bt3—9 to 18 inches (23 to 46 cm); brownish yellow (10YR 6/6) clay; moderate coarse subangular blocky structure; firm, very sticky and very plastic; common fine and medium roots; few fine discontinuous tubular pores; many distinct clay films on vertical and horizontal faces of peds; few wormcasts; common fine distinct red (2.5YR 4/6) masses of iron accumulation; extremely acid; clear wavy boundary.

Bt4—18 to 31 inches (46 to 79 cm); red (2.5YR 4/6) clay; moderate coarse subangular blocky structure parting to moderate medium subangular blocky; firm, very sticky and very plastic; few fine roots; few medium discontinuous tubular pores; many distinct clay films on vertical and horizontal faces of peds; few wormcasts; many coarse distinct yellowish brown (10YR 5/6) masses of iron accumulation; very strongly acid; gradual smooth boundary.

Bw1—31 to 43 inches (79 to 109 cm); red (2.5YR 4/6) clay; weak coarse subangular blocky structure; firm, very sticky and very plastic; few fine roots; few medium discontinuous tubular pores; common distinct pressure faces on peds; common medium distinct yellowish brown (10YR 5/6) masses of iron accumulation; very strongly acid; gradual smooth boundary.

Bw2—43 to 61 inches (109 to 155 cm); strong brown (7.5YR 5/6) clay; weak very coarse subangular blocky structure; firm, sticky and plastic; few fine roots; few medium discontinuous tubular pores;

common faint pressure faces on peds; many medium distinct yellowish red (5YR 4/6) and few medium distinct yellowish brown (10YR 5/6) masses of iron accumulation; very strongly acid; clear smooth boundary.

Bw3—61 to 74 inches (155 to 188 cm); strong brown (7.5YR 5/6) clay; weak very coarse subangular blocky structure; firm, sticky and plastic; few medium discontinuous tubular pores; common distinct coatings in root channels and pores; about 10 percent, by volume, saprolite fragments; many medium distinct yellowish red (5YR 4/6) masses of iron accumulation; very strongly acid; gradual smooth boundary.

Bw4—74 to 93 inches (188 to 236 cm); yellowish red (5YR 4/6) clay; weak very coarse subangular blocky structure; firm, sticky and plastic; few medium discontinuous tubular pores; about 10 percent, by volume, saprolite fragments; very strongly acid.

The thickness of the solum and the depth to bedrock are more than 80 inches (205 cm). The content of rock fragments ranges from 0 to 10 percent, by volume, throughout the profile. Reaction ranges from extremely acid to strongly acid throughout. The lower depth of the Oxic horizon is about 50 inches (127 cm). Cobbles and stones cover 0 to 15 percent of the surface.

The A horizon has hue of 7.5YR or 10YR and value and chroma of 3 or 4. It is clay loam or clay.

The Bt horizon has hue of 2.5YR to 10YR, value of 4 to 6, and chroma of 4 to 8. It is clay loam or clay.

The Bo horizon, where present, has hue of 2.5YR to 10YR, value of 4 or 5, and chroma of 6 to 8. It is clay.

The Bw horizon has hue of 2.5YR to 7.5YR, value of 4 to 6, and chroma of 6 to 8. It is clay (calculated at either 2.5 or 3 times the 15-bar water). Because of poor dispersion, the measured content of clay ranges from 15 to 45 percent. The content of saprolite fragments ranges from 0 to 20 percent, by volume, in the lower part.

Luquillo Series

The Luquillo series consists of very deep, well drained soils on terraces and flood plains along large streams and rivers. These soils formed in unconsolidated Quaternary-terrace- and bouldery-alluvial deposits that weathered from material of sandstone origin. Near the type location, the mean annual precipitation is about 80 inches (203 cm) and the mean annual temperature is about 76 degrees F (24 °C). Slopes range from 0 to 5 percent. These soils are fine, mixed, semiactive, isohyperthermic Typic Eutrudepts.

Luquillo soils are commonly associated with Coloso, Cristal, and Zarzal soils. The somewhat poorly drained Coloso soils have kaolinitic mineralogy and are in positions that are similar to those of the Luquillo soils or slightly lower. Cristal and Zarzal soils are not subject to flooding and are on side slopes in higher positions than the Luquillo soils. The somewhat poorly drained Cristal soils have more clay in the control section than the Luquillo soils. The well drained Zarzal soils have more clay in the control section than the Luquillo soils, have kaolinitic mineralogy, and are Oxisols.

Typical pedon of Luquillo stony clay loam, occasionally flooded; at the junction of the Quebrada Jimenez and the Forest boundary on the north cutback just before the river leaves the Forest; El Yunque topographic quadrangle; lat. 18 degrees 21 minutes 03 seconds N. and long. 65 degrees 48 minutes 09 seconds W.; PRD 1940; Caribbean National Forest:

A—0 to 5 inches (0 to 13 cm); dark yellowish brown (10YR 4/6) stony clay loam; moderate fine granular structure; friable; many very fine, fine, and medium roots; about 25 percent, by volume, pebbles and cobbles; very strongly acid; abrupt smooth boundary.

Bw1—5 to 17 inches (13 to 43 cm); yellowish brown (10YR 5/8) clay; moderate medium subangular blocky structure; firm; few fine and medium roots; strongly acid; common distinct black (10YR 2/1) concretions; clear smooth boundary.

Bw2—17 to 35 inches (43 to 89 cm); strong brown (7.5YR 5/8) clay; moderate medium subangular blocky structure; firm; few fine and medium roots; common distinct black (10YR 2/1) concretions; strongly acid; clear smooth boundary.

2C—35 to 60 inches (89 to 152 cm); brownish yellow (10YR 6/6) very stony clay; massive; firm; few medium roots; about 60 percent, by volume, stones; common medium distinct yellowish red (5YR 5/6) masses of iron accumulation; extremely acid.

The thickness of the solum ranges from 20 to 50 inches (51 to 127 cm). Reaction ranges from extremely acid to strongly acid throughout the profile. The content of rock fragments, by volume, ranges from 10 to 60 percent in the A horizon, from 0 to 30 percent in the Bw horizon, and from 10 to 65 percent in the C horizon. It averages less than 35 percent in the control section. Pebbles, cobbles, stones, and

boulders cover less than 1 percent to more than 50 percent of the surface.

The A horizon has hue of 10YR, value of 4 or 5, and chroma of 3 to 6. It is loam, silt loam, clay loam, clay, or the cobbly, stony, or bouldery analogs of those textures.

The Bw horizon has hue of 7.5YR to 2.5Y, value of 4 to 6, and chroma of 4 to 8. The quantity of soft masses of black concretions ranges from none to common. The Bw horizon is silty clay loam, clay loam, silty clay, sandy clay, clay, or the pebbly or cobbly analogs of those textures.

The C or 2C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 3 to 8. The quantity of masses of iron accumulation ranges from none to common. Texture ranges from loam to clay and the cobbly and stony analogs of those textures.

Moteado Series

The Moteado series consists of deep, poorly drained soils in narrow concave areas on ridgetops and side slopes in uplands. These soils formed in residuum that weathered from andesitic to basaltic, marine-deposited, volcanic and volcaniclastic sandstone and mudstone of the Hato Puerco, Fajardo, and Tabonuco Formations. Near the type location, the mean annual precipitation is about 165 inches (419 cm) and the mean annual temperature is about 65 degrees F (18 °C). Slopes range from 15 to 75 percent. These soils are very-fine, kaolinitic, isothermic Humic Haplaquox.

Moteado soils are commonly associated with Dwarf, Guayabota, Los Guineos, Palm, and Yunque soils. Dwarf soils are very deep, are in the higher positions, are isomesic, and have a histic epipedon. Guayabota soils are shallow to bedrock and are in positions similar to those of the Moteado soils. The well drained Los Guineos soils are very deep to bedrock and are in positions that are similar to those of the Moteado soils or slightly higher. Palm soils are in positions similar to those of the Moteado soils, are very deep, and have a clayey-skeletal control section. The moderately well drained Yunque soils are in the higher positions and are very deep.

Typical pedon of the Moteado clay, in an area of Yunque-Moteado complex, 20 to 65 percent slopes; about 3,000 feet (914 m) east-southeast of the end of Puerto Rico Road 911 on West Fork Trail past the creeks and past where the trail turns south and levels out on the contour, then downslope; El Yunque topographic quadrangle; lat. 18 degrees 18 minutes 46 seconds N. and long. 65 degrees 48 minutes 54 seconds W.; PRD 1940; Caribbean National Forest:

Oi—0 to 1 inch (0 to 3 cm); undecomposed accumulations consisting of a root mat; many fine and medium roots with up to 3 inches of aerial roots; abrupt smooth boundary.

A1—1 to 6 inches (3 to 15 cm); grayish brown (10YR 5/2) clay; moderate fine subangular blocky structure parting to weak fine granular; firm, sticky and plastic; many fine and medium roots; common fine interstitial and tubular pores; common large grayish brown (10YR 5/2) wormcasts; few fine distinct dark yellowish brown (10YR 4/4) masses of iron accumulation; very strongly acid; clear smooth boundary.

A2—6 to 13 inches (15 to 33 cm); dark grayish brown (2.5Y 4/2) clay; moderate medium subangular blocky structure parting to moderate fine subangular blocky; firm, sticky and plastic; common fine and medium roots; common medium interstitial and tubular pores; common large dark yellowish brown (10YR 4/4) wormcasts; common medium distinct yellowish brown (10YR 5/6) masses of iron accumulation along root channels and common medium distinct dark yellowish brown (10YR 4/6) masses of iron accumulation; common coarse distinct greenish gray (5G 6/1) iron depletions; very strongly acid; clear smooth boundary.

Btg—13 to 22 inches (33 to 56 cm); dark grayish brown (2.5Y 4/2) clay; moderate medium prismatic structure parting to moderate medium subangular blocky; firm, very sticky and very plastic; few fine roots; common fine and medium interstitial and tubular pores; common medium distinct reddish brown (5YR 4/4) masses of iron accumulation on vertical and horizontal faces of peds; common large olive (5Y 4/4) and dark reddish brown (5YR 2.5/2) wormcasts; many medium distinct light olive brown (2.5Y 5/6) and common coarse prominent yellowish brown (10YR 5/6) masses of iron accumulation; common medium distinct gray (5Y 5/1) iron depletions; very strongly acid; clear smooth boundary.

Bt1—22 to 27 inches (56 to 69 cm); yellowish brown (10YR 5/8) clay; weak medium prismatic structure parting to weak medium subangular blocky; firm, sticky and very plastic; few fine and medium interstitial and tubular pores; many medium distinct reddish brown (5YR 4/4) masses of iron accumulation on vertical faces of peds; common large strong brown (7.5YR 4/6) and gray (5Y 5/1) wormcasts; about 1/3-inch (1 cm) thin

discontinuous brittle layer; common fine prominent dark yellowish brown (10YR 4/4) masses of iron accumulation; few coarse distinct greenish gray (5G 6/1) areas of iron depletions; very strongly acid; clear smooth boundary.

Bt2—27 to 41 inches (69 to 104 cm); light olive brown (2.5Y 5/6) clay; weak medium subangular blocky structure; firm, sticky and very plastic; few fine and medium interstitial and tubular pores; many medium distinct reddish brown (5YR 4/4) masses of iron accumulation on vertical faces of peds; few large strong brown (7.5YR 4/6) and gray (5Y 5/1) wormcasts; few fine irregular soft masses of iron and manganese oxide; common medium distinct yellowish brown (10YR 5/6) and common coarse prominent yellowish red (5YR 5/6) masses of iron accumulation; very strongly acid; clear smooth boundary.

Bt´g—41 to 54 inches (104 to 137 cm); olive gray (5Y 4/2) clay; weak medium subangular blocky structure; few fine and medium interstitial and tubular pores; common medium distinct reddish brown (5YR 4/4) coatings on vertical faces of peds and along old root channels; few large strong brown (7.5YR 4/6) and gray (5Y 5/1) wormcasts; few fine masses of iron and manganese oxide concretions; common medium prominent strong brown (7.5YR 5/6) masses of iron accumulation; very strongly acid; abrupt smooth boundary.

R—54 inches (137 cm); unweathered, volcanic sandstone bedrock.

The thickness of the solum and the depth to volcanic sandstone bedrock range from 40 to 60 inches (102 to 152 cm). The content of rock fragments ranges from 0 to 30 percent, by volume, throughout the profile. Cobbles and stones cover 0 to 15 percent of the surface area. Reaction ranges from extremely acid to strongly acid throughout the profile.

The Oi horizon, where present, is composed roots forming a mat.

The A horizon has hue of 10YR or 2.5Y, value of 3 to 6, and chroma of 1 to 4. The quantity of redoximorphic features in shades of brown and gray ranges from none to common. The A horizon is silty clay loam, clay loam, clay, or the cobbly or stony analogs of those textures.

The Bt horizon has hue of 7.5YR to 5Y, value of 4 to 8, and chroma of 3 to 8. It has few to many redoximorphic features in shades of brown, yellow, red, and gray. It is clay loam, clay, or the gravelly or very gravelly analogs of those textures.

The Btg and Bt´g horizons have hue of 10YR to 5Y, value of 4 to 7, and chroma of 2 or less; or they are neutral in hue and have value of 4 to 7. They have few to many redoximorphic features in shades of brown and gray. They are clay loam, clay, or the gravelly or very gravelly analogs of those textures.

The R horizon is unweathered, volcanic sandstone bedrock.

Palm Series

The Palm series consists of very deep, poorly drained soils in concave positions on benches along mountainsides. These soils formed in residuum and colluvium that weathered from andesitic to basaltic, marine-deposited, volcanic and volcaniclastic sandstone of the Hato Puerco and Fajardo Formations. Near the type location, the mean annual precipitation is about 160 inches (406 cm) and the mean annual temperature is about 68 degrees F (20 °C). Slopes range from 35 to 85 percent. These soils are clayey-skeletal, isotic, acid, isothermic Aquandic Humaquepts.

Palm soils are commonly associated with Dwarf, Guayabota, Moteado, Prieto, Yunque, and Zarzal soils. All of these associated soils are non-skeletal. Dwarf soils are in the higher positions, are isomesic, and have a histic epipedon. Guayabota soils are in the lower positions, are shallow to bedrock, and have fewer fragments in the control section. Moteado soils are in positions similar to those of the Palm soils or lower, are deep to bedrock, and have more clay in the control section. Prieto soils are in the lower positions, are isohyperthermic, are moderately deep to bedrock, have mixed mineralogy, and have a clayey subsoil. The moderately well drained Yunque soils are in higher positions than those of the Palm soils, have more clay in the control section, and are Oxisols. The well drained Zarzal soils are in lower positions than those of the Palm soils, are isohyperthermic, and have more clay in the control section.

Typical pedon of Palm mucky clay, in an area of Palm-Yunque complex, 35 to 85 percent slopes, extremely stony; about 30 feet (9 m) west of Forest Route 10, about 4,300 feet (1,310 m) from its junction with Puerto Rico Road 191, or 30 feet (9 m) west of Forest Route 10 and its junction with the 940 meter contour line; El Yunque topographic quadrangle; lat. 18 degrees 18 minutes 21 seconds N. and long. 65 degrees 47 minutes 45 seconds W.; PRD 1940; Caribbean National Forest:

Oi—0 to 3 inches (0 to 8 cm); many fine, medium, and coarse roots forming a root mat; abrupt smooth boundary.

A—3 to 10 inches (8 to 25 cm); dark reddish brown (5YR 3/2) mucky clay; weak medium subangular

blocky structure parting to weak fine subangular blocky and moderate fine granular; friable, nonsticky and slightly plastic; many very fine and fine roots; few very fine and fine interstitial and tubular pores; few fine distinct dark reddish brown (2.5YR 3/4) masses of iron accumulation; strongly acid; clear smooth boundary.

BA—10 to 19 inches (25 to 48 cm); black (N 2/0) clay; weak medium subangular blocky structure parting to weak fine subangular blocky; firm, slightly sticky and plastic; common very fine, fine, and medium roots; common very fine and fine interstitial and tubular pores; few distinct brown (7.5YR 4/4) masses of iron accumulation on vertical and horizontal faces of peds; common large dark yellowish brown (10YR 4/4) and black (10YR 2/1) wormcasts; common distinct dark reddish brown (5YR 3/3) masses of iron accumulation along root channels; very strongly acid; clear smooth boundary.

Bg—19 to 31 inches (48 to 79 cm); olive gray (5Y 5/2) very cobbly clay; weak coarse angular blocky structure; firm, sticky and plastic; few very fine, fine, and medium roots; few fine interstitial and tubular pores; many distinct dark brown (7.5YR 4/4) masses of iron accumulation on pressure faces and horizontal faces of peds; about 10 percent pebbles, 20 percent cobbles, and 30 percent stones; common coarse distinct very dark grayish brown (10YR 3/2) iron depletions; strongly acid; gradual wavy boundary.

Bw—31 to 63 inches (79 to 160 cm); olive (5Y 5/3) very cobbly clay; weak fine subangular blocky structure; firm, sticky and plastic; few fine interstitial and tubular pores; about 10 percent pebbles, 20 percent cobbles, and 30 percent stones; common coarse distinct yellowish red (5YR 4/6) masses of iron accumulation; few medium distinct greenish gray (5G 6/1) iron depletions; strongly acid.

The thickness of the solum and the depth to bedrock are more than 60 inches (152 cm). Reaction ranges from extremely acid to strongly acid throughout the profile. The content of rock fragments, by volume, ranges from 0 to 10 percent in the A and AB horizons and from 35 to 70 percent in the Bg and Bw horizons. Textures as determined in the field range from clay loam to silty clay loam throughout; however, textures as determined in the lab calculated at 2.5 times 15-bar water are clay throughout.

The Oi horizon, where present, is composed of roots forming a mat.

The A horizon has hue of 5YR to 10YR, value of 2 to 4, and chroma of 2 or less; or it is neutral in hue and has value of 2 to 4. It is mucky silty clay, mucky clay, or clay.

The BA horizon, where present, has hue of 7.5YR to 5Y, value of 2 or 3, and chroma of 3 or less; or it is neutral in hue and has value of 2 or 3. The quantity of redoximorphic features in shades of brown and gray ranges from none to common. The BA horizon is silty clay loam, silty clay, clay loam, or clay.

The Bg horizon has hue of 10YR to 5GY, value of 3 to 6, and chroma 2 or less; or it is neutral in hue and has value of 3 to 6. It has few or common redoximorphic features in shades of brown and gray. It is the gravelly, cobbly, or stony analogs of silty clay or clay.

The Bw horizon has hue of 10YR to 5Y and value and chroma of 3 to 6. It has few to many redoximorphic features in shades of yellow, red, brown, and gray. It is the gravelly, cobbly, or stony to extremely gravelly, cobbly, or stony analogs of silty clay or clay.

Picacho Series

The Picacho series consists of very deep, somewhat poorly drained soils on strongly dissected plutonic uplands. These soils formed in residuum and colluvium that weathered from granodiorite of Rio Blanco stock (fig. 17). Near the type location, the mean annual precipitation is about 160 inches (406 cm) and the mean annual temperature is about 72 degrees F (22 °C). Slopes range from 10 to 80 percent. These soils are fine-loamy, kaolinitic, isothermic Aquic Dystrudepts.

Picacho soils are commonly associated with Ciales, Guayabota, Icacos, Los Guineos, Utuado, and Yunque soils. The poorly drained Ciales soils are in the lower positions and have a histic epipedon. The poorly drained Guayabota soils are in the higher positions, are shallow to bedrock, and have a clayey, mixed, control section. Icacos soils are in lower positions than the Picacho soils, are in adjacent positions on flood plains along rivers, and have mixed mineralogy. The well drained Los Guineos soils have more clay in the control section than the Picacho soils, have mixed mineralogy, and are Oxisols. Utuado soils are in the lower positions, have mixed mineralogy, and have a coarse-loamy control section. The moderately well drained Yunque soils are in higher positions than the Picacho soils and have more clay in the control section.

Typical pedon of Picacho sandy loam, in a area of Picacho-Utuado complex, 35 to 80 percent slopes; near kilometer 13.9 on Puerto Rico Road 191; El Yunque topographic quadrangle; lat. 18 degrees 17

minutes 44 seconds N. and long. 65 degrees 47 minutes 38 seconds W.; PRD 1940; Caribbean National Forest:

Oi—0 to 3 inches (0 to 8 cm); many fine, medium, and coarse aerial roots forming a root mat; abrupt smooth boundary.

A—3 to 4 inch (8 to 10 cm); reddish brown (5YR 4/3) sandy loam; moderate fine subangular blocky structure; very friable, slightly sticky and nonplastic; many fine and medium roots; few fine pores; common fine grains of quartz; few faint dark yellowish brown (10YR 4/4) masses of iron accumulation along root channels; many fine distinct dark yellowish brown (10YR 4/3) and common coarse distinct dark brown (7.5 YR 4/4) masses of iron accumulation; very strongly acid; clear smooth boundary.

Bw1—4 to 10 inches (10 to 25 cm); brown (7.5YR 4/3) sandy clay loam (fig. 18); moderate medium subangular blocky structure; friable, slightly sticky and slightly plastic; common very fine, fine, and medium roots; common fine interstitial and tubular pores; few faint dark yellowish brown (10YR 4/4) masses of iron accumulation along root channels; few large dark grayish brown (10YR 3/2) wormcasts; few fine quartz grains; common medium distinct yellowish brown (10YR 5/6) masses of iron accumulation; many medium distinct gray (10YR 5/1) iron depletions; very strongly acid; clear smooth boundary.

Bw2—10 to 15 inches (25 to 38 cm); reddish yellow (7.5YR 6/6) sandy clay loam; weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; common very fine roots; common fine interstitial and tubular pores; few large dark brown (7.5YR 4/2) wormcasts; about 3 percent, by volume, pebbles; few faint pressure faces on ped surfaces; common fine grains of quartz; common fine distinct yellowish brown (10YR 5/6) masses of iron accumulation; common medium distinct grayish brown (10YR 5/2) iron depletions; very strongly acid; clear smooth boundary.

Bw3—15 to 27 inches (38 to 69 cm); yellowish brown (10YR 5/6) sandy clay loam; weak fine and medium subangular blocky structure; friable, slightly sticky and slightly plastic; few very fine roots; common very fine and fine interstitial and tubular pores; few faint pressure faces on ped surfaces; many very fine flakes of mica; few fine distinct grayish brown (10 YR 5/2) iron depletions; very strongly acid; clear smooth boundary.

C—27 to 63 inches (69 to 160 cm); 45 percent yellowish red (5YR 5/6), 35 percent brown (7.5YR 5/4), and 20 percent dark brown (10 YR 4/3) cobbly sandy loam (fig. 19); massive; friable, nonsticky and plastic; few very fine roots; common distinct pockets of brownish yellow (10YR 6/6) loam; about 5 percent, by volume, pebbles and about 10 percent, by volume, cobbles; many distinct flakes of mica; strongly acid.

The thickness of the solum ranges from 24 to 47 inches (61 to 119 cm). Reaction ranges from extremely acid to strongly acid throughout the profile. The content of pebbles and cobbles ranges, by volume, from 0 to 10 percent in the A and Bw horizons and from 0 to 15 percent in the C horizon.

The Oi horizon, where present, is composed of roots forming a mat.

The A horizon has hue of 5YR to 10YR, value of 3 or 4, and chroma of 2 to 4. It is sandy loam, loam, sand clay loam, or silty clay loam.

The Bw horizon has hue of 5YR to 10YR, value of 4 to 6, and chroma of 3 to 8. It has few to many redoximorphic features in shades of gray, yellow, and brown. The upper part of the Bw horizon has common or many redox depletions; the quantity decreases with depth. The Bw horizon is sandy clay loam, loam, or clay loam.

The C horizon has hue of 2.5YR to 7.5YR, value of 4 to 6, and chroma of 4 to 8; or it has no dominant color and is multicolored in shades of red, brown, and yellow. It is sandy loam, loam, sandy clay loam, clay loam, or the gravelly or cobbly analogs of those textures.

Prieto Series

The Prieto series consists of moderately deep, poorly drained soils in concave areas of mountain coves, side slopes, and drainageways. These soils formed in residuum and colluvium that weathered from andesitic to basaltic, marine-deposited, metamorphosed volcanic mudstone of the Fajardo Formation. Near the type location, the mean annual precipitation is about 130 inches (330 cm) and the mean annual temperature is about 73 degrees F (23 °C). Slopes range from 25 to 50 percent. These soils are very-fine, mixed, semiactive, nonacid, isohyperthermic Vertic Epiaquepts.

Prieto soils are associated with Caguabo, Palm, Sonadora, and Zarzal soils. The well drained Caguabo soils are in the lower positions, are shallow to bedrock, and have a loamy control section. Palm soils are very deep, are in the higher positions, are isothermic, have kaolinitic mineralogy, and are clayey-skeletal. The well drained Sonadora soils are in the lower positions and have smectitic mineralogy. The

Figure 17.—The upper part of the profile in an area of the Picacho series, which is an Inceptisol that developed in sandy residuum from quartzdiorite. Note the segregation of iron in this water-saturated soil.

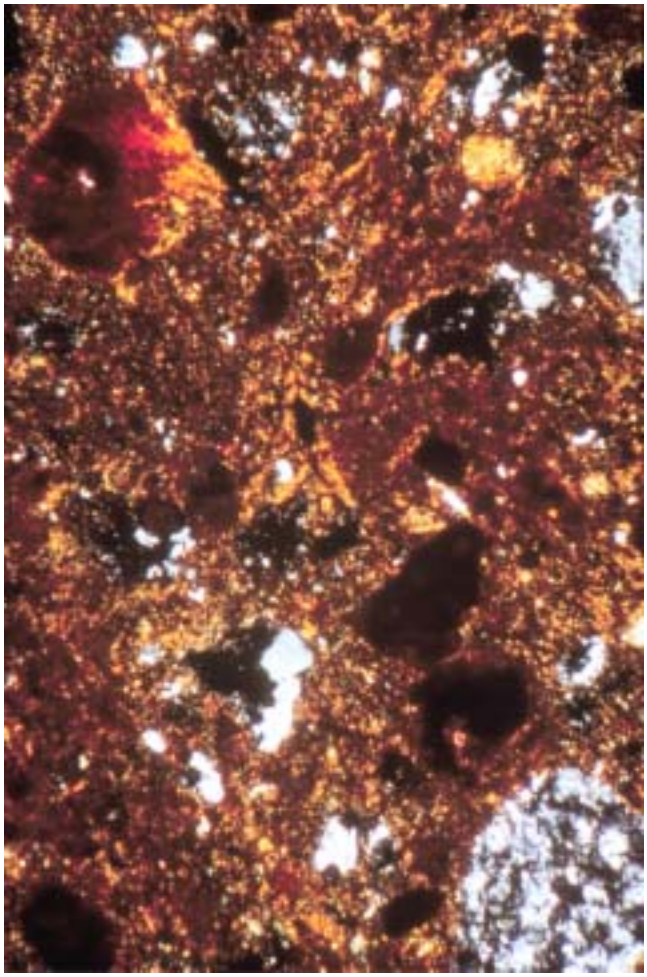

Figure 18.—Thin-section micrograph of a Picacho soil at a depth of 10 inches (25 cm). The micrograph shows an intense weathering of feldspars and micas and an absence of clay skins, which precludes the presence of an argillic horizon. Magnification x 60.

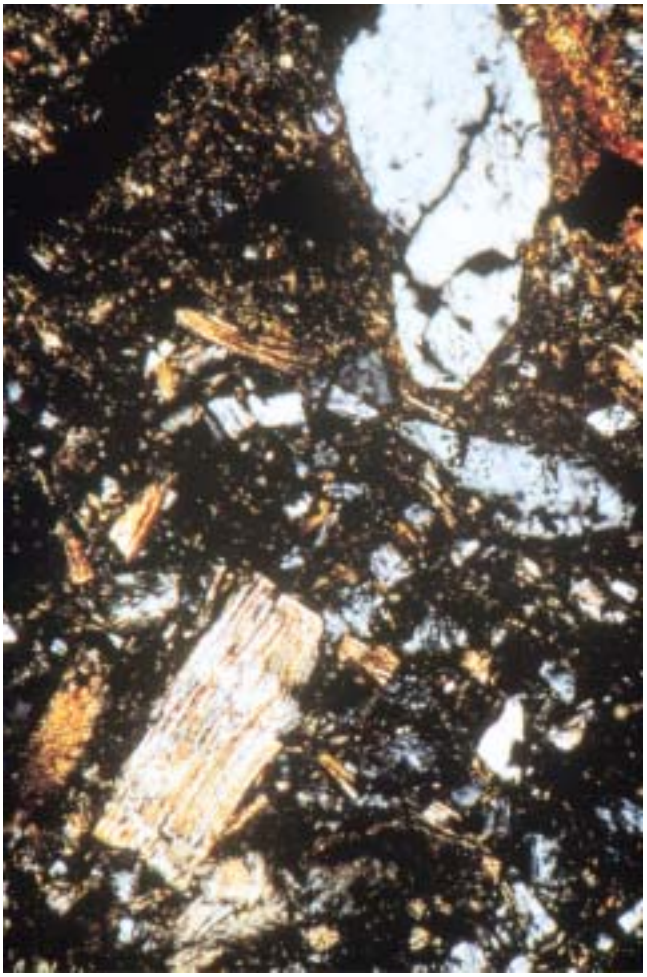

Figure 19.—Thin-section micrograph of a Picacho soil at a depth of 47.25 inches (120 cm). The micrograph shows a quartz grain (upper right) and kaolinite booklets (lower left). Magnification x 60.

Figure 20.—Pieces of volcanic siltstone, which is a prominent type of rock in the survey area.

Figure 21.—Volcanic sandstone that has concentric weathering features in a stratification plane. Such rocks occur extensively in the survey area.

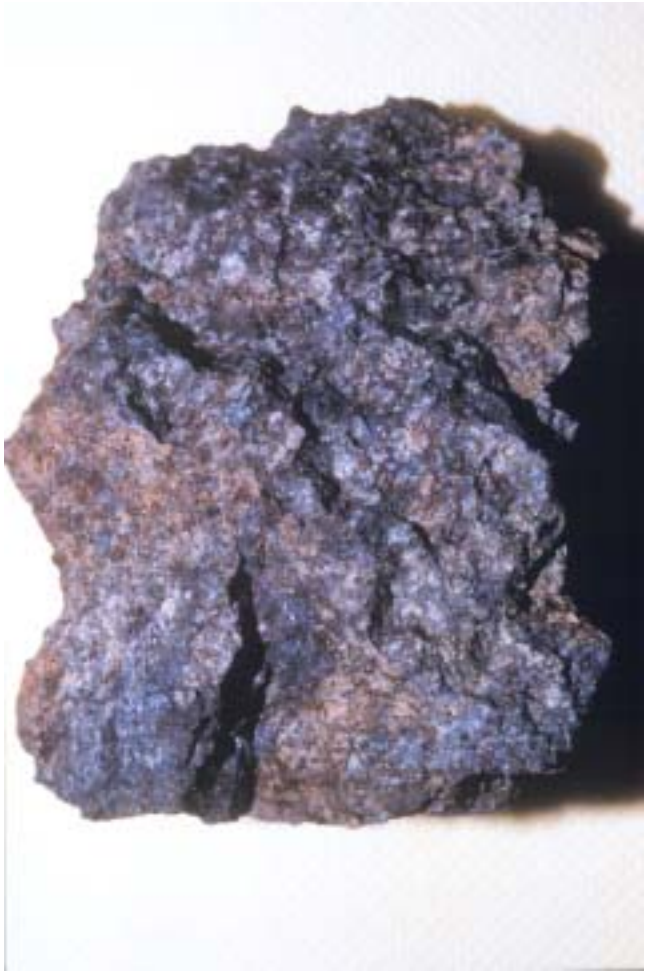

Figure 22.—A piece of volcanic breccia. This rock is an example of the volcaniclastic rocks that predominate in the survey area.

Figure 23.—Quartz diorite, a plutonic rock that produces a sandy regolith. It occurs in the south-central part of the survey area.

Figure 24.—Saprolite derived from volcanic sandstone. Saprolite is the result of intense chemical weathering occurring without the destruction of the original rock fabric. This soft, friable material is the parent material for most of the soils of the survey area.

well drained Zarzal soils are very deep, are in positions that are similar to those of the Prieto soils or slightly higher, have more clay in the subsoil, have kaolinitic mineralogy, and are Oxisols.

Typical pedon of Prieto very cobbly clay loam, 25 to 50 percent slopes; about 150 feet (46 m) north from the southernmost point of the Forest boundary, or from Puerto Rico Road 969, on the road on the ridge up to the power line, then along the fence line to the corner just inside the Forest property; Humacao topographic quadrangle; lat. 18 degrees 14 minutes 45 seconds N. and long. 65 degrees 46 minutes 09 seconds W.; PRD 1940; Caribbean National Forest:

A—0 to 4 inches (0 to 10 cm); gray (10YR 5/1) very cobbly clay loam; moderate fine granular structure; friable; common fine and medium roots; about 35 percent, by volume, cobbles; moderately acid; clear smooth boundary.

Bg1—4 to 13 inches (10 to 33 cm); dark gray (10YR 4/1) cobbly clay; weak coarse subangular blocky structure; firm; common fine and medium roots; about 15 percent, by volume, cobbles; common medium distinct olive brown (2.5Y 4/4) and brown (10YR 5/3) masses of iron accumulation; moderately acid; clear smooth boundary.

Bg2—13 to 25 inches (33 to 64 cm); greenish gray (5G 6/1) cobbly clay; weak coarse subangular blocky structure; firm; few fine and medium roots; common large wormcasts filled with very dark brown (10YR 2/2) organic material; common medium distinct brownish yellow (10YR 6/6) and dark brown (10YR 3/3) masses of iron accumulation; moderately acid; clear smooth boundary.

BCg—25 to 35 inches (64 to 89 cm); light gray (2.5Y 7/2) cobbly silty clay; massive; friable; few quartz crystals; about 15 percent, by volume, cobbles; common medium distinct yellowish brown (10YR 5/6) masses of iron accumulation; common medium distinct dark gray (10YR 4/1) iron depletions; moderately acid; abrupt smooth boundary.

R—35 inches (89 cm); metamorphosed volcanic mudstone; massive; hard.

The thickness of the solum ranges from 20 to 40 inches (51 to 102 cm). Reaction is moderately acid or slightly acid throughout the profile. The content of rock fragments, pebbles, and cobbles ranges from 10 to 40 percent, by volume, throughout the profile but averages less than 35 percent, by volume, in the particle-size control section.

The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 3 or less; or it is neutral in hue and has value of 2 or 3. It is clay loam, clay, or the gravelly to very gravelly or cobbly to very cobbly analogs of those textures.

The Bg horizon has hue of 10YR to 5GY, value of 4 to 6, and chroma of 2 or less. It is clay loam, clay, or the cobbly or very cobbly analogs of those textures.

The BCg horizon has hue of 10YR to 5Y, value of 6 to 8, and chroma of 1 or 2. It is silty clay, clay loam, clay, or the gravelly or cobbly analogs of those textures.

The R layer is hard volcanic mudstone.

Sonadora Series

The Sonadora series consists of moderately deep, well drained soils on side slopes of lower hills and on footslopes of strongly dissected uplands. These soils formed in residuum and colluvium that weathered from calcareous mudstone of the Hato Puerco Formation. Near the type location, the mean annual precipitation is about 80 inches (203 cm) and the mean annual temperature is about 76 degrees F (24 °C). Slopes range from 25 to 70 percent. These soils are fine, smectitic, isohyperthermic Vertic Eutrudepts.

Sonadora soils are commonly associated with Caguabo and Prieto soils. Caguabo soils are in the higher positions, are shallow to bedrock, and have a loamy-skeletal control section. The poorly drained Prieto soils are in the higher positions and have mixed mineralogy.

Typical pedon of Sonadora clay loam, in an area of Sonadora-Caguabo complex, 40 to 70 percent slopes; about 3,000 feet (914 m) southeast of the garage at the El Verde Work Center, along Trail Number 21 to the second switchback, and about 15 feet (5 m) west; El Yunque topographic quadrangle; lat. 18 degrees 20 minutes 11 seconds N. and long. 65 degrees 49 minutes 16 seconds W.; PRD 1940; Caribbean National Forest:

A—0 to 1 inch (0 to 3 cm); dark reddish brown (5YR 3/2) clay loam; moderate fine subangular blocky structure; friable, slightly sticky and plastic; many very fine, fine, and medium roots; strongly acid; abrupt smooth boundary.

Bw1—1 to 4 inches (3 to 10 cm); dark brown (10YR 3/3) clay; moderate fine and medium subangular blocky structure; about 0.2-inch (0.5 cm) cracks between peds; common very fine and fine roots; firm, sticky and very plastic; very strongly acid; clear smooth boundary.

Bw2—4 to 10 inches (10 to 25 cm); dark yellowish brown (10YR 4/6) clay; strong medium and coarse subangular blocky structure; few very fine, fine, and coarse roots along pressure faces; firm, sticky

and very plastic; about 0.3-inch (0.75 cm) cracks between peds; few faint pressure faces on surfaces of peds; very strongly acid; clear wavy boundary.

Bw3—10 to 16 inches (25 to 41 cm); dark yellowish brown (10YR 4/6) clay; strong coarse prismatic structure parting to strong medium subangular blocky; few fine, medium, and coarse roots along pressure faces; firm, sticky and very plastic; about 0.3-inch (0.75 cm) cracks between peds; common distinct pressure faces on surfaces of peds; few faint slickensides that have faintly polished and grooved surfaces; very strongly acid; clear smooth boundary.

BC—16 to 21 inches (41 to 53 cm); grayish brown (2.5Y 5/2) clay; moderate coarse subangular blocky structure; firm, sticky and plastic; few fine, medium, and coarse roots; about 10 percent, by volume, fragments of mudstone; strongly acid; clear smooth boundary.

C—21 to 36 inches (53 to 91 cm); 35 percent grayish brown (10YR 5/2), 35 percent yellowish brown (10YR 5/6), and 30 percent very dark grayish brown (10YR 3/2) clay loam; massive; friable, sticky and slightly plastic; few very fine roots; strongly acid; clear smooth boundary.

R—36 inches (91 cm); dark gray (10YR 4/1) mudstone; extremely hard.

The thickness of the solum ranges from 10 to 25 inches (25 to 64 cm). The content of pebbles and cobbles ranges from 0 to 20 percent, by volume, throughout. Depth to mudstone bedrock ranges from 20 to 40 inches (51 to 102 cm). Reaction ranges from very strongly acid to neutral in the A and Bw horizons and from strongly acid to neutral in the BC and C horizons.

The A horizon has hue of 5YR to 10YR and value and chroma of 2 or 3. It is loam, silty clay loam, clay loam, or the gravelly or cobbly analogs of those textures.

The Bw horizon has hue of 10YR or 2.5Y, value of 3 to 6, and chroma of 2 to 6. It is clay loam, clay, or the gravelly or cobbly analogs of those textures.

The BC horizon, where present, has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 6. It is clay loam, clay, or the gravelly or cobbly analogs of those textures.

The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 6; or it has no dominant color and is multicolored in shades of brown, yellow, and gray. It is loam, clay loam, or the gravelly or cobbly analogs of those textures.

The Cr horizon, where present, has the same range in colors as the C horizon. It is weathered mudstone.

The R layer is mudstone bedrock.

Utuado Series

The Utuado series consists of very deep, somewhat poorly drained soils on the middle and lower side slopes of strongly dissected uplands. These soils formed in the plutonic uplands in residuum weathering from granodiorite of Río Blanco stock. Near the type location, the mean annual precipitation is about 120 inches (305 cm) and the mean annual temperature is about 69 degrees F (21 °C). Slopes range from 25 to 80 percent. These soils are coarse-loamy, mixed, active, isothermic Aquic Humic Dystrudepts.

Utuado soils are commonly associated with Ciales, Guayabota, Icacos, Los Guineos, Picacho, and Yunque soils. The poorly drained Ciales soils are in the lower positions and have a fine-loamy control section. The poorly drained Guayabota soils are shallow to bedrock, are in the higher positions, and have a clayey control section. Icacos soils are in lower positions than those of the Utuado soils, are on adjacent flood plains, and have a fine-loamy control section. The well drained Los Guineos soils are in higher positions than those of the Utuado soils and have more clay in the control section. Picacho soils are in the higher positions, have kaolinitic mineralogy, and have a fine-loamy control section. The moderately well drained Yunque soils are in higher positions than those of the Utuado soils, have a kaolinitic control section, and have more clay in the control section.

Typical pedon of the Utuado gravelly loam, in an area of Picacho-Utuado complex, 35 to 80 percent slopes; about 75 feet (23 m) west of kilometer marker 14 on Puerto Rico Road 191; El Yunque topographic quadrangle; lat. 18 degrees 17 minutes 38 seconds N. and long. 65 degrees 47 minutes 32 seconds W.; PRD 1940; Caribbean National Forest:

Oi—0 to 1 inch (0 to 3 cm); many fine, medium, and coarse roots forming a mat; abrupt smooth boundary.

A—1 to 2 inch (3 to 5 cm); dark brown (10YR 3/3) gravelly loam; moderate very fine and fine subangular blocky structure; common fine, medium, and coarse roots; many fine interstitial pores; about 20 percent, by volume, pebbles; strongly acid; abrupt smooth boundary.

Bw1—2 to 7 inches (5 to 18 cm); dark brown (10YR 3/3) loam; weak fine and medium subangular blocky structure; very friable; few medium roots; about 10 percent, by volume, stones; common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation; common medium distinct gray (10YR 5/1) iron depletions; strongly acid; clear smooth boundary.

Bw2—7 to 13 inches (18 to 33 cm); dark yellowish brown (10YR 4/4) loam; moderate medium subangular blocky structure; few very fine and fine roots; few fine tubular pores; about 10 percent, by volume, stones; common medium distinct gray (10YR 5/1) iron depletions; strongly acid; abrupt smooth boundary.

C1—13 to 28 inches (33 to 71 cm); yellowish brown (10YR 5/6) sandy loam; weak fine and medium subangular structure; common very fine, fine, and medium roots; few fine tubular pores; strongly acid; gradual smooth boundary.

C2—28 to 61 inches (71 to 155 cm); variegated very pale brown (10YR 8/2), black (10YR 2/1), and brown (10YR 5/3) saprolite having a texture of loamy sand; about 40 percent, by volume, stones; strongly acid.

The thickness of the solum ranges from 18 to 31 inches (46 to 79 cm). Reaction ranges from extremely acid to strongly acid throughout the profile. The content of pebbles, cobbles, and stones ranges from 0 to 20 percent, by volume, throughout.

The Oi, where present, is composed of roots forming a mat.

The A horizon has hue of 7.5YR to 2.5Y, value of 2 to 5, and chroma of 1 to 4. It is sandy loam, loam, or the gravelly, cobbly, or stony analogs of those textures.

The Bw horizon has hue of 7.5YR or 10YR, value of 3 to 6, and chroma of 3 to 8. It has few to many redoximorphic features in shades of yellow, brown, and gray; the quantity decreases with depth and may be none in the lower part of the Bw horizon in some pedons. The Bw horizon is sandy loam, loam, or the gravelly, cobbly, or stony analogs of those textures.

The upper part of the C horizon has hue of 7.5YR to 2.5YR, value of 4 to 6, and chroma of 4 to 8. It is loamy sand, sandy loam, or the gravelly, cobbly, or stony analogs of those textures. The lower part of the C horizon is saprolite in shades of brown, yellow, and black. It can be dug with a spade.

Yunque Series

The Yunque series consists of very deep, moderately well drained soils on side slopes and convex ridgetops of strongly dissected uplands. These soils formed in a mixture of colluvium and residuum that weathered from andesitic to basaltic, marine-deposited, volcanic and volcaniclastic sandstone and mudstone of the Hato Puerco and Tabonuco Formations. Near the type location, the mean annual precipitation is about 160 inches (406 cm) and the mean annual temperature is about 69 degrees F (21 °C). Slopes range from 10 to 90 percent. These soils are very-fine, kaolinitic, isothermic Humic Hapludox.

Yunque soils are commonly associated with Ciales, Guayabota, Los Guineos, Moteado, Palm, Picacho, and Utuado soils. The associated soils are in lower positions than those of the Yunque soils. The poorly drained Ciales soils have a fine-loamy control section and do not have Oxic horizons. The poorly drained Guayabota soils are shallow to bedrock and have less clay in the control section than the Yunque soils. The well drained Los Guineos soils have mixed mineralogy. The poorly drained Moteado soils are deep to bedrock and have mixed mineralogy. The poorly drained Palm soils have a clayey-skeletal control section. The somewhat poorly drained Picacho soils have a fine-loamy control section. The somewhat poorly drained Utuado soils have mixed mineralogy and have a coarse-loamy control section.

Typical pedon of the Yunque clay, in an area of Yunque-Moteado complex, 20 to 65 percent slopes; about 1.6 miles (2.6 km) northwest of Mt. Britton and about 3,000 feet (914 m) east-southeast of the end of Puerto Rico Road 911 at the Estacion Fluviometrica, down the west fork trail past the creeks and past where the trail turns south and levels out on the contour, then upslope; El Yunque topographic quadrangle; lat. 18 degrees 18 minutes 44 seconds N. and long. 65 degrees 48 minutes 54 seconds W.; PRD 1940; Caribbean National Forest:

Oi—0 to 2 inches (0 to 5 cm); many fine and medium roots forming a root mat; abrupt smooth boundary.

A—2 to 7 inches (5 to 18 cm); dark yellowish brown (10YR 4/6) clay; weak fine subangular blocky structure; firm, sticky and plastic; many fine and medium roots; common large very dark brown (10YR 2/2) wormcasts; extremely acid; clear smooth boundary.

Bto1—7 to 17 inches (18 to 43 cm); yellowish brown (10YR 5/8) clay; weak coarse subangular blocky structure parting to weak medium subangular blocky; firm, sticky and very plastic; common fine and medium roots; common fine interstitial and tubular pores; few faint clay films on vertical and horizontal faces of peds; common large very dark brown (10YR 2/2) wormcasts; common distinct red (2.5YR 4/6) masses of iron accumulation along root channels; few fine distinct strong brown (7.5YR 5/6) and few medium distinct light yellowish brown (10YR 6/4) masses of iron accumulation; extremely acid; clear smooth boundary.

Bto2—17 to 30 inches (43 to 76 cm); yellowish brown (10YR 5/8) clay; weak medium prismatic structure parting to weak medium subangular blocky; firm,

sticky and very plastic; few fine and medium interstitial and tubular pores; common distinct clay films on vertical and horizontal faces of peds; common large very dark brown (10YR 2/2) wormcasts; common coarse prominent strong brown (7.5YR 5/6) and few fine distinct yellow (10YR 7/6) masses of iron accumulation; few fine distinct light gray (10YR 7/1) iron depletions; extremely acid; abrupt smooth boundary.

Bw1—30 to 33 inches (76 to 84 cm); yellowish red (5YR 5/8) silty clay; weak medium platy structure; friable, sticky and plastic; weakly cemented; many coarse prominent strong brown (7.5YR 5/8) masses of iron accumulation; few fine distinct light gray (10YR 7/1) iron depletions; extremely acid; abrupt smooth boundary.

Bw2—33 to 51 inches (84 to 130 cm); strong brown (7.5YR 5/8) silty clay loam; massive; friable, sticky and plastic; common coarse prominent yellowish red (5YR 5/8) masses of iron accumulation; few fine distinct light gray (10YR 7/1) iron depletions; extremely acid; gradual wavy boundary.

Bw3—51 to 62 inches (130 to 157 cm); 50 percent yellowish red (5YR 5/8), 35 percent strong brown (7.5YR 5/8), and 15 percent very pale brown (10YR 8/2) silty clay loam; massive; friable, sticky and plastic; the yellowish red and strong brown areas are iron accumulations and the white areas are iron depletions; extremely acid.

The thickness of the solum is more than 60 inches (152 cm). The combined thickness of the Bt horizons ranges from 18 to 35 inches. Reaction ranges from extremely acid to strongly acid throughout the profile. The content of rock fragments ranges from 0 to 40 percent, by volume, throughout. Cobbles, stones, and boulders cover 0 to 60 percent of the surface. The cumulative volume in the control section does not exceed 35 percent.

The Oi horizon, where present, is composed of roots forming a mat.

The A horizon has hue of 7.5YR or 10YR, value of 2 to 5, and chroma of 1 to 6. It is silty clay loam, silty clay, or clay.

The Bto horizon has hue of 7.5YR to 2.5Y, value of 4 or 5, and chroma of 4 to 8. It has few to many redoximorphic features in shades of yellow, brown, red, and gray. It is clay, gravelly clay, or very gravelly clay.

The Bo horizon, where present, has colors and textures similar to those of the Bt horizon.

The Bw horizon has hue of 2.5YR to 7.5YR, value of 4 to 6, and chroma of 4 to 8. It has few to many redoximorphic features in shades of yellow, brown, red, and gray. In some pedons, the lower part of the horizon does not have a dominant matrix color and is multicolored in shades of yellow, red, brown, and gray. The Bw horizon is silty clay loam, silty clay, clay loam, clay, or the gravelly or very gravelly analogs of those textures.

The BC horizon, where present, has hue of 2.5YR to 7.5YR, value of 4 to 6, and chroma of 6 to 8; or it has no dominant matrix color and it is multicolored in shades of yellow, red, brown, and gray. It has few to many redoximorphic features in shades of yellow, brown, red, and gray. It is silty clay loam, silty clay, clay loam, clay, or the gravelly or very gravelly analogs of those textures.

The C horizon, where present, has colors and textures similar to those of the BC horizon.

Zarzal Series

The Zarzal series consists of very deep, well drained soils on mountain side slopes and footslopes. These soils formed in a mixture of colluvium and residuum that weathered from andesitic to basaltic, marine-deposited, volcanic and volcaniclastic sandstone and mudstone of the Hato Puerco and Tabonuco Formations. Near the type location, the mean annual precipitation is about 80 inches (203 cm) and the mean annual temperature is about 77 degrees F (25 °C). Slopes range from 15 to 90 percent. These soils are very-fine, kaolinitic, isohyperthermic Inceptic Hapludox.

Zarzal soils are commonly associated with Coloso, Cristal, Humatas, Los Guineos, Luquillo, Palm, and Prieto soils. The somewhat poorly drained Coloso soils are on flood plains, are in lower positions than the Zarzal soils, and have less clay in the control section. The somewhat poorly drained Cristal soils are also in the lower positions and are not Oxisols. Humatas soils are in higher positions than those of the Zarzal soils, have less clay in the control section, and have mixed mineralogy. Los Guineos soil are also in the higher positions, are isothermic, and have mixed mineralogy. The Luquillo soils have mixed mineralogy, are on flood plains, are in lower positions than the Zarzal soils, and have less clay in the control section. The poorly drained Palm soils are in the higher positions, are isothermic, and have a clayey-skeletal control section. The poorly drained Prieto soils are in positions similar to those of the Zarzal soils or slightly lower, are moderately deep to bedrock, and have mixed mineralogy.

Typical pedon of the Zarzal clay, in an area of Zarzal-Cristal complex, 20 to 60 percent slopes; about 600 feet (183 m) north of kilometer marker 7.0 on Puerto Rico Road 966; El Yunque topographic

quadrangle; lat. 18 degrees 19 minutes 44 seconds N. and long. 65 degrees 49 minutes 19 seconds W.; PRD 1940; Caribbean National Forest:

A—0 to 1 inch (0 to 2 cm); dark reddish brown (5YR 2/2) clay; moderate fine granular structure; firm, nonsticky; many fine and medium roots; common fine discontinuous interstitial pores; slightly acid; abrupt smooth boundary.

Bo—1 to 7 inches (2 to 17 cm); yellowish brown (10YR 5/6) clay; moderate fine subangular blocky structure; firm, slightly sticky and slightly plastic; few fine and medium roots; common very fine discontinuous tubular pores; common distinct organic coats on faces of peds; few fine rounded concretions of iron and manganese oxide; few large dark reddish brown (5YR 2/2) wormcasts; strongly acid; clear smooth boundary.

Bto1—7 to 15 inches (17 to 38 cm); yellowish brown (10YR 5/8) clay; moderate fine subangular blocky structure; firm, slightly sticky and slightly plastic; few fine and medium roots; common distinct clay films on faces of peds; common fine rounded concretions of iron and manganese oxide; many large dark reddish brown (5YR 2/2) wormcasts; strongly acid; clear smooth boundary.

Bto2—15 to 26 inches (38 to 65 cm); yellowish brown (10YR 5/8) clay; moderate medium subangular blocky structure; slightly sticky and slightly plastic; few fine and medium roots; few very fine discontinuous tubular pores; common distinct clay films on faces of peds; common fine rounded concretions of iron and manganese oxide; common large root channels filled with dark material; strongly acid; gradual smooth boundary.

Bto3—26 to 35 inches (65 to 89 cm); yellowish brown (10YR 5/4) clay; moderate medium subangular blocky structure; firm, slightly sticky and slightly plastic; few fine roots; few fine discontinuous tubular pores; common distinct clay films on faces of peds; few fine rounded concretions of iron and manganese oxide; few medium prominent red (2.5YR 4/8) masses of iron accumulation; strongly acid; gradual smooth boundary.

Bw1—35 to 46 inches (89 to 118 cm); strong brown (7.5YR 5/8) clay; weak coarse subangular blocky structure; firm, slightly sticky and slightly plastic; few fine roots; few fine discontinuous tubular pores; few fine rounded concretions of iron and manganese oxide; about 10 percent, by volume, igneous pebbles; common fine prominent red (2.5YR 4/8) masses of iron accumulation; very strongly acid; gradual smooth boundary.

Bw2—46 to 56 inches (118 to 143 cm); strong brown (7.5YR 5/8) clay; weak coarse subangular blocky structure parting to weak medium subangular; firm, slightly sticky and slightly plastic; few fine discontinuous tubular pores; few fine rounded concretions of iron and manganese oxide; about 15 percent, by volume, saprolite fragments; strongly acid; clear wavy boundary.

Bw3—56 to 69 inches (143 to 175 cm); strong brown (7.5YR 5/8) clay; weak very coarse subangular blocky structure; firm, slightly sticky and slightly plastic; few fine discontinuous tubular pores; few fine rounded iron-manganese concretions; about 40 percent, by volume, saprolite fragments; common distinct light gray (10YR 7/1) iron depletions; strongly acid; clear wavy boundary.

Bw4—69 to 75 inches (175 to 190 cm); strong brown (7.5YR 5/8) clay; weak very coarse subangular blocky structure; firm, slightly sticky and slightly plastic; strongly acid; gradual smooth boundary.

Bw5—75 to 82 inches (190 to 209 cm); strong brown (7.5YR 5/8) clay; weak very coarse subangular blocky structure; firm, slightly sticky and slightly plastic; few fine prominent red (2.5YR 4/8) and few fine faint yellowish brown (10YR 5/8) masses of iron accumulation; strongly acid; gradual smooth boundary.

Cr—82 to 91 inches (209 to 230 cm); strong brown (7.5YR 5/8) weathered sandstone conglomerate; massive; about 40 percent, by volume, igneous pebbles.

The thickness of the solum and the depth to bedrock are more than 80 inches (203 cm). Reaction is moderately acid or slightly acid in the A horizon and very strongly acid or strongly acid in the Bo, Bto, and Bw horizons.

The Oi horizon, where present, is composed of roots forming a mat.

The A horizon, where present, has hue of 5YR to 10YR, value of 2 to 5, and chroma of 1 to 4. It is clay loam or clay.

The B horizon has hue of 5YR to 10YR, value of 4 to 6, and chroma of 4 to 8. It is clay.

The C horizon, where present, has hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 6 to 8. It is clay loam, clay, or the cobbly or stony analogs of those textures.

The Cr horizon is weathered conglomerate sandstone. The content of igneous pebbles ranges from 10 to 50 percent, by volume.

Formation of the Soils

Factors of Soil Formation

This section describes the factors of soil formation as they relate to the soils of the Caribbean National Forest and explains the major processes in the development of soil horizons (Birkeland, 1974 and 1984; Jenny, 1941; Thornbury, 1969).

Climate

Temperature and precipitation influence the rates of chemical and physical processes in the soil. The survey area has a warm, maritime tropical climate that is influenced by trade winds interacting with the Luquillo Mountains.

Rainfall

The amount of annual rainfall increases substantially as elevation increases in the survey area. The average rainfall ranges from about 97 inches (246 cm) at the lower elevations to more than 200 inches (381 cm) at the highest elevations of the cloud (dwarf) forest. There is no sharply defined wet or dry season in the survey area. The peak rainfall is usually in May, and the driest period is in March (Robinson, 1997).

Temperature

The temperature in the survey area decreases as elevation and rainfall increase. Three soil temperature regimes occur in the survey area: isohyperthermic, isothermic, and isomesic. The Caguabo, Coloso, Cristal, Humatas, Luquillo, Prieto, Sonadora, and Zarzal soils are in the isohyperthermic regime. The Ciales, Guayabota, Icacos, Los Guineos, Moteado, Palm, Picacho, Utuado, and Yunque soils are in the isothermic regime. The Dwarf soils are in the isomesic regime.

The highest temperatures in the survey area occur in August or September, and the lowest temperatures occur in January or February. The leaching of nutrients becomes more efficient as elevation increases. This increased efficiency is evidenced by decreasing faunal biota in the soils and overstory at the higher elevations. Organic matter tends to accumulate at the higher elevations due to the higher rainfall and cooler temperatures (Stevenson, 1982).

Plant and Animal Life

Plants, animals, bacteria, fungi, and humans affect the formation of soils. The impact of plant and animal life on soil formation is especially significant in wet tropical climates because activity occurs year-round. The type of vegetation affects the content of organic matter and the amount of nutrients released to the soil. Animals, particularly burrowing animals and insects, keep the soil open and porous. Bacteria and fungi decompose plant material into organic matter and promote the incorporation of the organic matter into the soil. Research into overstory fungi and epiphytes indicates a significant amount of decomposition occurs before organic debris reaches the forest floor. Human activities that alter the soils in the survey area include clearing, construction, and recreational activities. Nutrient recycling in organic matter is crucially important in tropical climates. Slash and burn agriculture is practiced in the tropics because nutrients are released into the relatively infertile soil when vegetation is burned.

Parent Material

Parent material is the weathered mass from which soil forms. Parent material generally determines the chemical and mineral composition of the soil. The soils in the Caribbean National Forest formed in materials of volcanic origin extruded in the sea and then subjected to weathering and erosion.

Topography

Topography, or relief, modifies the effects of the other soil-forming factors. In many places that have similar parent material, differences in topography result in differences in the kind of soil that forms. For example, soils in convex areas typically are

drier than soils in flat areas because water moves away from the convex areas. In contrast, soils in concave areas can display wetness indicators resulting from the concentration of surface and subsurface water. Cristal and Zarzal soils formed in similar parent material and are adjacent to each other. Because of topography, however, Zarzal soils are better drained than the Cristal soils. Soils in the survey area that are subject to flooding include the Coloso, Icacos, and Luquillo soils. They receive new sediments during each period of flooding, show little profile development, and are considered young soils (Coleman, 1981).

Time

Time is needed for the development of a soil profile; consequently, younger soils have less developed horizons than older soils. Many of the soils throughout the survey area are shallow but have well-developed horizons.

Major Soil Horizons

The results of the soil-forming factors can be distinguished by the different layers, or soil horizons, in a soil profile. The soil profile extends from the surface down to materials that are only slightly altered by soil-forming processes. Most soils in the survey area contain horizons, generally identified as A, B, and C horizons. These major horizons are subdivided by the use of numbers and letters to indicate changes within a horizon. The Bt horizon, for example, is a B horizon that has an accumulation of clay.

The A horizon, or surface layer, is characterized by an accumulation of organic matter.

The B horizon underlies the A horizon and is commonly called the subsoil. It is the horizon of maximum accumulation, or illuviation, of clay, iron, aluminum, or other compounds leached from the surface and subsurface layers. In the survey area, the B horizon forms through the alteration of materials in place and illuviation. Most of the weathering products in the survey area are completely leached out of the system unless they are taken up by plants. Iron and aluminum stay as oxides and weather toward Oxisols. Some of the soils in the survey area, such as the Los Guineos and Yunque soils, feel coarser to the touch than would be expected from the laboratory data. This is likely due to iron oxides causing a high aggregation of particles. Some of the clayey soils in the survey area have the moisture-release characteristics of sandy soils. The B horizon commonly has blocky or prismatic structure. Generally, the B horizon is firmer and lighter in color than the A horizon. The B horizon may be darker in color than the C horizon.

The C horizon consists of materials that have been altered little by the soil-forming processes. Some C horizons are composed of saprolite, which is the parent material that has been altered chemically but retains the spatial characteristics of the parent rock material (Jenny, 1980).

Processes of Horizon Differentiation

In the Caribbean National Forest, several processes are involved in the formation of soil horizons. Among these are the accumulation of organic matter, the leaching of soluble salts, the reduction and transfer of iron, the formation of soil structure, and the formation and translocation of clay minerals. These processes continually take place, generally at the same time, throughout the profile. Processes such as these have been going on for thousands of years. The accumulation and incorporation of organic matter takes place with the decomposition of plant residue. These additions of residue darken the surface layer and help to form the A horizon. If organic matter has been lost, a long period of time generally is needed to replace it.

Most soils have strong to moderate, fine to medium, granular structure in the surface layer. The structure of the subsoil is weak to strong and prismatic or blocky.

Well drained and moderately well drained soils in the survey area have a dark reddish brown to light olive brown subsoil. These colors have been caused mainly by thin coatings of iron oxides on sand and silt grains, except where the colors were inherited from the parent material.

The reduction of iron, called gleying, is associated mainly with the wetter, more poorly drained soils. Because rainfall increases with elevation in the survey area, the poorly drained soils, such as Ciales, Dwarf, and Moteodo soils, are predominantly gray in the upper horizons and the lower horizons are less reduced. Moderately well drained to somewhat poorly drained soils have yellowish brown and strong brown redoximorphic concentrations because of the segregation of iron and manganese. In poorly drained soils, such as Ciales, Dwarf, and Moteado soils, and in somewhat poorly drained soils, such as Coloso, Cristal, and Icacos soils, the grayish subsoil is the result of the reduction of iron in solution (Buol, Hole, and McCracken, 1980; Jenny, 1980; Simonson, 1959).

Geology

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The geology of the Caribbean National Forest (CNF) is characterized by the dominance of volcanic rocks of Cretaceous age into which plutonic rocks intruded during the Lower Tertiary. Although the geologic history of the area is short, it exhibits considerable complexity. Most of the CNF is located in the southeastern part of the El Yunque quadrangle. A smaller part extends into the western part of the Fajardo quadrangle. The U.S. Geological Survey has mapped both quadrangles and has published maps at a scale of 1:20,000 with explanatory texts (Briggs and Cortés, 1980; Seiders, 1971). A more recent paper by Jolly et al. (1998) describes the volcanism and tectonics of the region. Much of the following account has been gleaned from these publications.

Tectonics and Structure

The island of Puerto Rico is located on a microplate in the tension zone between the North American plate and the Caribbean plate. The latter originated about 88 million years ago in the Pacific basin as a plateau of oceanic crust of Jurassic and Cretaceous age known as the Caribbean Cretaceous Basalt Province. The Caribbean plate subsequently moved eastward into a widening gap between North and South America. By about 75 million years ago, the gap had become the Atlantic Ocean. The younger and more buoyant Caribbean plate overrode the older North American and South American plates but subducted into the Muertos trough and under a sliver of oceanic crust that forms the Puerto Rico-Virgin Islands block. This block collided with the Bahama banks to the north during mid-Santonian time (about 85 million ago) and then rotated counterclockwise to its present east-west orientation (Jolly and others, 1998).

Although various tectonic models of the formation of the Caribbean are currently under consideration, a consensus has yet to emerge. As a result, the geography and polarity of the subduction zone that produced the Greater Antilles arc is indeterminate at this time.

The island arc volcanic strata in Puerto Rico range in age from Lower Cretaceous (Aptian) to mid-Tertiary (Eocene), about 120 to 45 million years, and represent one of the longest oceanic arc sequences preserved in the world. Cessation of subduction-related magmatism during the Eocene was probably caused by the collision of the Greater Antilles arc with the North American plate. Subsequent movement along the northern boundary of the Caribbean plate changed to a left-lateral strike-slip motion (Jolly and others, 1998).

The volcanic strata of Puerto Rico are subdivided into three provinces: the western volcanic province, the central volcanic province, and the northeastern volcanic province. The survey area is located in the northeastern volcanic province. This province is separated from the central province by the Cerro Mula Fault, which is a northwest-southeast oriented strike-slip fault of mid-Santonian age and has at least a 50-kilometer lateral displacement (Jolly and others, 1998). A few, mostly northwest trending, faults of moderate displacement have also been mapped in the survey area.

Two broad, northeast-trending folds are major geologic structures of importance to the survey area. They are the axis of the Rio Canovanas syncline to the northwest and the axis of the Luquillo anticline to the southeast. The area between these two fold axes is, therefore, largely underlain by northwest-dipping beds.

The plutonic Río Blanco stock and other small intrusive bodies are younger than the folds and faults. The rectilinear outline of Río Blanco stock suggests that its emplacement was influenced by northwest-trending fractures (Seiders, 1971).

During the Paleocene and Eocene epochs of the lower Tertiary (about 65 to 45 million years ago), compressive orogenic forces severely faulted and folded the volcanic strata and lifted them above sea level, thus creating the island of Puerto Rico. A succession of minor uplifts that occurred sporadically through the end of the Tertiary brought the island to its present altitude. Periods of quiescence between uplifts allowed widespread degradation of the mountainous island, resulting in a series of erosion surfaces of which the St. John Peneplain is the most prominent (Beinroth, 1969).

Stratigraphy

The oldest rocks in the survey area are the Unnamed Volcaniclastics of Lower Cretaceous age. By correlation with beds in the adjacent Fajardo area, where a specimen of the ammonite Manuaniceras has been recovered, the rocks are presumed to be of Albian age (about 120 to 105 million years). These strata are overlain by the Tabonuco Formation, which yielded both ammonites and planktonic Foraminifera of Albian age. The youngest stratified rocks are those of the Hato Puerco Formation, which originated in the Upper Cretaceous. This formation contains

Foraminifera and rudists, which dates their age as Cenomanian (about 97 to 92 million years).

The plutonic rocks of the Río Blanco stock are younger than the stratified volcanics. They were likely emplaced during the Upper Cretaceous (Maastrichtian, about 65 to 73 million years ago) and lower Tertiary (Paleocene, about 65 to 55 million years ago), concurrent with tectonic and orogenic processes.

Rocks

Stratified Rocks

The volcanic rocks of the survey area are predominantly of primary and reworked volcanic origin. Figures 20, 21, and 22 illustrate common rocks of volcanic origin in the survey area. The moderately good sorting and graded bedding in the volcaniclastic rocks together with the exclusively planktonic character of the interbedded mudstones indicate an environment of deposition in at least moderately deep water.

The Unnamed Volcanic Rocks are marine-deposited, andesitic, thick-bedded, grayish-green volcanic sandstone and fine volcanic breccia. They are of moderate extent in the southeastern part of the survey area.

The Tabonuco Formation is composed of marine-deposited, andesitic to basaltic volcanic sandstone (about 60 percent), mudstone (about 30 percent), and volcanic breccia and conglomerate (about 10 percent). The volcanic sandstone is thick-bedded, moderately sorted, calcareous, and gray. The breccia-conglomerate member of the Tabonuco Formation consists of fine to coarse, poorly sorted breccia-conglomerate and pebbly mudstone and sandstone. This formation is moderately extensive in the northeastern part of the survey area.

The rocks of the Hato Puerco Formation also are predominantly marine-deposited, grayish-greenish andesitic to basaltic volcanic sandstone and breccia with minor amounts of volcanic mudstone. Grains and, rarely, boulders of shallow-water limestone occur sparsely in the volcanic rocks. This is the most extensive formation in the survey area.

No mineralogical analysis is available for the volcaniclastic rocks in the survey area. However, very similar rocks from the nearby Barranquitas area, which presumably came from the same magmatic reservoir, have the following composition: 53 percent plagioclase, 11 percent orthoclase, 27 percent pyroxene, 1 percent olivine, 6 percent magnetite, 1 percent ilmenitite, and 1 percent apatite (Briggs and Gelabert, 1962).

Intrusive Rocks

The quartz diorite of the survey area is a light-gray, medium- to coarse-grained rock that forms the bulk of the Río Blanco stock (fig. 23). According to Seiders (1971), the typical mineral composition of this rock is about one quarter quartz and three quarters silicates (26 percent quartz, 5 percent orthoclase, 59 percent plagioclase, 6 percent hornblende, and 4 percent biotite).

Medium-gray, medium-grained hornblende diorite occurs as a local border phase and apophyses of the Río Blanco stock. It is the plutonic equivalent of the andesitic to basaltic volcaniclastics and therefore has a similar mineralogical composition.

Contact Metamorphism

An aureole of contact metamorphism with diffuse outer limits surrounds the Río Blanco stock. Contact metamorphosed volcaniclastic rocks typically show greater hardness and darker colors than their unmetamorphosed equivalents. Chief mineralogical changes are the development of actinolite, blue-green hornblende, and, occasionally, biotite in place of clinopyroxene and chlorite; epidote is locally abundant. Parenthetically, it may be noted that the metamorphosed rocks are the source for the placer gold that many years ago was washed from alluvium along the lower parts of the Río Espiritu Santo and the Río Blanco.

Weathering Products

Volcaniclastic Rocks

The volcaniclastic rocks in the survey area vary in appearance, but because they are derived from the same pool of magma they have essentially the same mineralogical composition. They are intermediate to basaltic and therefore contain only small or very small amounts of quartz. These rocks are predominantly composed of basic feldspars and smaller amounts of ferromagnesian minerals. The volcaniclastic rocks weather to form residuum that, under conditions of free drainage, consists mainly of clay minerals of the 1:1 lattice type, such as kaolinite; oxides of iron and aluminum; and small amounts of quartz.

Intrusive Rocks

The substantial amount of quartz in the quartz diorite accumulates residually during the weathering process because quartz resists decomposition. The primary silicates decompose to produce clay minerals

and sesquioxides. This results in a sandy to loamy regolith.

Intense, continuous weathering in the warm, humid tropical climate that has prevailed in the survey area since the emergence of the island above seal level has transformed the rocks into saprolite (fig. 24). This saprolite is the parent material of the soils. Because the lithology of the country rock determines the quartz and clay content of the saprolite, the soils in the area of volcaniclastic rocks are clayey and the soils in the outcrop area of quartz diorite are sandy or loamy. Because of its medium to coarse texture, quartz diorite weathers more rapidly than the volcanic rocks. Other conditions being equal, the regolith in the area of quartz diorite is thicker than that in the volcanic areas.

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Glossary

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Albian. The uppermost stage of the Lower Cretaceous period, after the Aptian stage and before the Cennomanian; about 113 to 97 million years ago.

Alluvial cone. The material washed down the sides of mountains and hills by ephemeral streams and deposited at the mouth of gorges in the form of a moderately steep, conical mass descending equally in all directions from the point of issue.

Alluvial fan. The fanlike deposit of a stream where it issues from a gorge upon a plain or of a tributary stream near or at its junction with its main stream.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Alpha,alpha-dipyridyl. A dye that when dissolved in 1N ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction indicates a type of redoximorphic feature.

Andesite. A dark-colored, fine-grained extrusive rock that is typically composed primarily of plagioclase and one or more mafic minerals, such as hornblende and pyroxene.

Apophysis. A branch or offshoot of a larger intrusive body.

Aptian. A stage of the Lower Cretaceous period, above the Barremian stage and below the Albian; about 120 to 113 million years ago.

Aquic. A mostly reducing soil moisture regime that is nearly free of dissolved oxygen due to saturation by water and that occurs during periods when the soil temperature at a depth of 20 inches (50 cm) is above 41 degrees F (5 °C).

Aquic conditions. Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon. A subsoil horizon characterized by an accumulation of illuvial clay.

Armored trail. A trail to which material, such as gravel, asphalt, boards, soil cement, and sawdust, has been applied to protect the surface from erosion and the wearing caused by foot traffic.

Aspect. The direction in which a slope faces.

Association, soil. A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Backslope. The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Basal area. The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope. A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of

a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedding planes. Fine strata, less than 5 millimeters thick, in unconsolidated alluvial, eolian, lacustrine, or marine sediment.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography. A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bisequum. Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Bottom land. The normal flood plain of a stream, subject to flooding.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks. The steep and very steep broken land at the border of an upland summit that is dissected by ravines.

Breast height. An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Breccia. A coarse-grained clastic rock composed of angular, broken rock fragments.

Brush management. Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Cable yarding. A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

California bearing ratio (CBR). The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

Canopy. The leafy crown of trees or shrubs. (See Crown.)

Canyon. A long, deep, narrow, very steep sided valley with high, precipitous walls in an area of high local relief.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena. A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Cenomanian. The lowermost stage of the Upper Cretaceous period, above the Albian stage and below the Turonian; about 97 to 92 million years ago.

Channery soil material. Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment. Control of unwanted vegetation through the use of chemicals.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions. Low-chroma zones having a low content of iron, manganese, and clay because of the chemical reduction of iron and manganese and the removal of iron, manganese, and clay. A type of redoximorphic depletion.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

Climax plant community. The stabilized plant

community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse fragments. Mineral or rock particles 0.10 to 10.0 inches (2 mm to 25 cm) in diameter.

Coarse textured soil. Sand or loamy sand.

Cobble (or cobblestone). A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material. Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility). See Linear extensibility.

Colluvium. Soil material or rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions. Cemented bodies with crude internal symmetry organized around a point, a line, or a plane. They typically take the form of concentric layers visible to the naked eye. Calcium carbonate, iron oxide, and manganese oxide are common compounds making up concretions. If formed in place, concretions of iron oxide or manganese oxide are generally considered a type of redoximorphic concentration.

Conglomerate. A sedimentary rock made of rounded rock fragments, such as pebbles, cobbles, and boulders, in a finer-grained matrix. For material to be conglomerate, some of the constituent pebbles must be at least $^{1}/_{13}$ of an inch (2 mm) in diameter.

Consistence, soil. Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the “Soil Survey Manual.”

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coppice. A method of reforestation in which all but one sprout is cut from a stump. Some trees sprout from the stump when cut. Generally, multiple sprouts grow and develop into more of a bush than a tree. If all but one sprout is pruned, the sprout forms a new tree on the old stump.

Corrosion. Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cretaceous. The final period of the Mesozoic era, after the Jurassic period and before the Tertiary period of the Cenozoic era; about 135 to 65 million years ago.

Crown. The upper part of a tree or shrub, including the living branches and their foliage.

Cuesta. A hill or ridge that has a gentle slope on one side and a steep slope on the other; specifically, an asymmetric, homoclinal ridge capped by resistant rock layers of slight or moderate dip.

Culmination of the mean annual increment (CMAI). The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Depth, soil. The thickness of the soil over hard bedrock. Very deep soils are more than 60 inches (152 cm) deep over bedrock; deep soils, 40 to 60 inches (100 to 152 cm); moderately deep, 20 to 40 inches (50 to 100 cm); and shallow, 10 to 20 inches (20 to 50 cm).

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Diorite. A plutonic rock intermediate between acidic and basic and typically composed of plagioclase, hornblende, and pyroxene with little or no quartz.

Dip slope. A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Drainage. Refers to the frequency and duration of periods of saturation or partial saturation during

soil formation. The classes of drainage recognized in the survey area are:

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the year, and wetness does not inhibit growth of roots for significant periods. Well drained soils are commonly medium-textured. They are mainly free of redoximorphic features.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time but periodically they are wet long enough that most mesophytic plants are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods of time. Wetness markedly restricts the growth of mesophytic plants. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage or upslope runoff, nearly continuous rainfall, or a combination of these factors.

Poorly drained.—Water is removed so slowly that the soil is saturated and remains wet for long periods. Free water is commonly at or near the surface long enough that most mesophytic plants cannot be grown. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or near the surface at all times. Very poorly drained soils are commonly level, concave positions, or in depressional areas. Where rainfall is high, they can have moderate or high slope gradients.

Drainage, surface. Runoff, or surface flow of water, from an area.

Draw. A small stream valley that generally is more open and has broader bottom land than a ravine or gulch.

Duff. A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Ecological site. An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Endosaturation. A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

Eocene. An epoch of the early Tertiary period; about 55 to 45 million years ago.

Ephemeral stream. A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Episaturation. A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion pavement. A layer of gravel or stones that remains on the surface after fine particles are removed by sheet or rill erosion.

Escarpment. A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Synonym: scarp.

Extrusive rock. Igneous rock derived from deep-seated molten matter (magma) emplaced on the earth's surface.

Feldspar. A group of abundant rock-forming minerals, including plagioclase—Ca, $Na(AlSi_3O_8)$—and orthoclase—$K(AlSi_3O_8)$.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat). The least decomposed of

all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope. A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil. Sandy clay, silty clay, or clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flaggy soil material. Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone. A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flooding. Accumulation of large amounts of runoff on the landscape as a result of rainfall in excess of the soil's ability to drain water from the landscape before extensive inundation and ponding occurs. Frequency is expressed as none, rare, occasional, and frequent. *None* means that there is no reasonable possibility of flooding; *rare* that flooding occurs on the average 1 to 5 times in 100 years; *occasional* that flooding occurs 5 to 50 times in 100 years; and *frequent* that flooding occurs 50 or more times in 100 years.

Flood plain. The land bordering a stream, built up of sediment from stream overflow and subject to inundation when the stream is at flood stage.

Fluvial. Of or pertaining to rivers; produced by river action, as a fluvial plain.

Foothill. A steeply sloping upland that has relief of as much as 1,000 feet (300 meters) and fringes a mountain range or high-plateau escarpment.

Footslope. The position that forms the inner, gently inclined surface at the base of a hillslope. In profile, footslopes are commonly concave. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Foraminfera. An order of marine protozoans composed of calcite.

Forb. Any herbaceous plant not a grass or a sedge.

Forest cover. All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type. A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

GIS. Geographic Information System. A form of computer-based land and resource data manipulation.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Gravel. Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Ground water. Water filling all the unblocked pores of the material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock. Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hard to reclaim (in tables). Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Head slope. A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

Hill. A natural elevation of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a

well defined outline; hillsides generally have slopes of more than 15 percent. The distinction between a hill and a mountain is arbitrary and is dependent on local usage.

Histic. A thin, organic soil horizon that is saturated with water at some period of the year unless artificially drained and that is at or near the surface of a mineral soil. A histic epipedon has a maximum thickness depending on the kind of materials in the horizon; the lower limit of organic carbon is the upper limit for the mollic epipedon.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the "Soil Survey Manual." The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties are depth to a seasonal high water table, the infiltration rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock. Rock formed by solidification from a molten or partially molten state. Major varieties include plutonic and volcanic rock. Examples are andesite, basalt, and granite.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Interfluve. An elevated area between two drainageways that sheds water to those drainageways.

Intermittent stream. A stream, or reach of a stream, that flows for prolonged periods only when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Iron depletions. Low-chroma zones having a low content of iron and manganese oxide because of chemical reduction and removal, but having a clay content similar to that of the adjacent matrix. A type of redoximorphic depletion.

Isohyperthermic. A soil temperature regime that has mean annual soil temperatures of 22 degrees C or more and has less than 5 degrees C difference between mean summer and mean

winter soil temperatures at a depth of 50 centimeters.

Isomesic. A soil temperature regime that has mean annual soil temperatures of 8 degrees C or more but less than 15 degrees C and has less than 5 degrees C difference between mean summer and mean winter soil temperatures at a depth of 50 centimeters.

Isothermic. A soil temperature regime that has mean annual soil temperatures of 15 degrees C or more but less than 22 degrees C and has less than 5 degrees C difference between mean summer and mean winter soil temperatures at a depth of 50 centimeters.

Jurassic. The second period of the Mesozoic era, after the Triassic period and before the Cretaceous; about 190 to 135 million years ago.

Knoll. A small, low, rounded hill rising above adjacent landforms.

K_{sat}. Saturated hydraulic conductivity. (See Permeability.)

Landform. A particular member of a landscape.

Landscape. All the natural features, such as hills, valleys, and slopes, that distinguish one part of the earth's surface from another.

Landslide. The rapid downhill movement of a mass of soil and loose rock, generally when wet or saturated. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones (in tables). Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

Linear extensibility. Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $^1/_3$- or $^1/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Lined ditch. A ditch that is lined with gravel, rip-rap, or concrete to protect from overflow and scouring.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Low strength. The soil is not strong enough to support loads.

Maastrichtian. The uppermost stage of the Cretaceous period, above the Campanian stage and below the Danian stage of the Tertiary period; about 73 to 65 million years ago.

Masses. Concentrations of substances in the soil matrix that do not have a clearly defined boundary with the surrounding soil material and cannot be removed as a discrete unit. Common compounds making up masses are calcium carbonate, gypsum or other soluble salts, iron oxide, and manganese oxide. Masses consisting of iron oxide or manganese oxide generally are considered a type of redoximorphic concentration.

Mechanical treatment. Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Metamorphic rock. Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement. Nearly all such rocks are crystalline.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderate. As applied to management concerns caused by soil properties, this term indicates that the limitation(s) can be overcome or alleviated by planning, design, or special maintenance.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon. A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size

measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain. A natural elevation of the land surface, rising more than 1,000 feet above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range.

Muck. Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mudstone. Sedimentary rock formed by induration of silt and clay in approximately equal amounts.

Munsell notation. A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules. Cemented bodies lacking visible internal structure. Calcium carbonate, iron oxide, and manganese oxide are common compounds making up nodules. If formed in place, nodules of iron oxide or manganese oxide are considered types of redoximorphic concentrations.

Nose slope. A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent.

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low	less than 0.5 percent
Low	0.5 to 1.0 percent
Moderately low	1.0 to 2.0 percent
Moderate	2.0 to 4.0 percent
High	4.0 to 8.0 percent
Very high	more than 8.0 percent

Paleocene. An epoch of the early Tertiary period; about 65 to 55 million years ago.

Pan. A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affects the specified use.

Permeability. The quality of the soil that enables water or air to move downward through the profile. The rate at which a saturated soil transmits water is accepted as a measure of this quality. In soil physics, the rate is referred to as "saturated hydraulic conductivity," which is defined in the "Soil Survey Manual." In line with conventional usage in the engineering profession and with traditional usage in published soil surveys, this rate of flow continues to be expressed as "permeability." Terms describing permeability, measured in inches per hour, are as follows:

Impermeable	less than 0.0015 inch
Very slow	0.0015 to 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially

drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Potential native plant community. See Climax plant community.

Potential rooting depth (effective rooting depth). Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Quartz diorite. A plutonic rock having the composition of diorite but with an appreciable amount of quartz.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid	less than 3.5
Extremely acid	3.5 to 4.4
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Moderately acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Slightly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Redoximorphic concentrations. Nodules, concretions, soft masses, pore linings, and other features resulting from the accumulation of iron or manganese oxide. An indication of chemical reduction and oxidation resulting from saturation.

Redoximorphic depletions. Low-chroma zones from which iron and manganese oxide or a combination of iron and manganese oxide and clay has been removed. These zones are indications of the chemical reduction of iron resulting from saturation.

Redoximorphic features. Redoximorphic concentrations, redoximorphic depletions, reduced matrices, a positive reaction to alpha,alpha-dipyridyl, and other features indicating the chemical reduction and oxidation of iron and manganese compounds resulting from saturation.

Reduced matrix. A soil matrix that has low chroma in situ because of chemically reduced iron (Fe II). The chemical reduction results from nearly continuous wetness. The matrix undergoes a change in hue or chroma within 30 minutes after exposure to air as the iron is oxidized (Fe III). A type of redoximorphic feature.

Regolith. The fragmental and unconsolidated rock material that overlies unweathered bedrock.

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rill. A steep-sided channel resulting from accelerated erosion. A rill generally is a few inches deep and not wide enough to be an obstacle to farm machinery.

Road cut. A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments. Unattached pieces of rock 2 millimeters in diameter or larger that have rupture resistance of strongly cemented or higher. The roundness of the fragments may be indicated as angular (strongly developed faces with sharp edges), irregular (prominent flat faces with incipient rounding of corners), subrounded (detectable flat faces with well-rounded corners), and rounded (flat faces absent or nearly absent with all corners).

Shape and size	Noun	Adjective
Spherical, cubelike, or equiaxial (diameter):		
2 to 75 mm	Pebbles	Gravelly
2 to 5 mm	Fine	Fine
5 to 20 mm	Medium	Medium
20 to 75 mm	Coarse	Coarse
75 to 250 mm	Cobbles	Cobbly
250 to 600 mm	Stones	Stony
>600 mm	Boulders	Bouldery
Flat (length):		
2 to 150 mm	Channers	Channery
150 to 380 mm	Flagstones	Flaggy
380 to 600 mm	Stones	Stony
>600 mm	Boulders	Bouldery

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone. Sedimentary rock containing dominantly sand-sized particles.

Santonian. A stage of the Upper Cretaceous period, above the Coniacian stage and below the Campanian; about 87 to 83 million years ago.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saprolite. Soft, friable, isovolumetrically weathered bedrock that retains the fabric and structure of the parent rock exhibiting extensive inter-crystal and intra-crystal weathering. In pedology, saprolite was formerly applied to any unconsolidated residual material underlying the soil and grading to hard bedrock below.

Saturation. Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Second bottom. The first terrace above the normal flood plain (or first bottom) of a river.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Sequum. A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Severe. As applied to management concerns caused by soil properties, this term indicates that the soil properties are not favorable and that limitation(s) can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or a combination of the above.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shoulder. The position that forms the uppermost inclined surface near the top of a hillslope. It is a transition from backslope to summit. The surface is dominantly convex in profile and erosional in origin.

Shrink-swell (in tables). The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Side slope. A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silicate. The most abundant group of minerals whose crystal structure contains SiO_4 tetrahedra, including feldspars, hornblende, pyroxene, olivine, biotite, and kaolinite.

Silica-sesquioxide ratio. The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees

in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Skeletal. Soil material having more than 35 percent fragments, by volume.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slight. As applied to management concerns caused by soil properties, this term indicates that no significant limitations are present.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance. In this survey, classes for simple slopes are as follows:

Nearly level	0 to 2 percent
Gently sloping	2 to 5 percent
Strongly sloping	5 to 12 percent
Moderately steep	12 to 20 percent
Steep	20 to 40 percent
Very steep	40 to 60 percent
Strongly steep	60 to 90 percent

Classes for complex slopes are as follows:

Nearly level	0 to 2 percent
Undulating	2 to 5 percent
Rolling	5 to 12 percent
Hilly	12 to 20 percent
Steep	20 to 40 percent
Very steep	40 to 60 percent
Strongly steep	60 to 90 percent

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

Soft bedrock. Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Stone line. A concentration of coarse fragments in a soil. Generally, it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stratigraphy. The science of rock strata concerned with all characteristics and attributes of rock as strata and their interpretation in terms of origin and geologic history.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Subduction. The process of one lithospheric plate descending beneath another.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summit. The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth

from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus. Fragments of rock and other soil material accumulated by gravity at the foot of cliffs or steep slopes.

Tectonics. A branch of geology dealing with the broad architecture of the outer earth, including the major structural or deformational features and their relations, origin, and historical evolution.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Tertiary. The first period of the Cenozoic era, after the Cretaceous period of the Mesozoic era and before the Quaternary era; about 65 to 2 million years ago.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material that is too thin for the specified use.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope. The position that forms the gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Toposequence. A sequence of related soils that differ from each other primarily because of the effects of topography (landscape position or slope) on soil formation.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Transect. A method of data collection based on even-spaced points of observation along a straight line that dissects transversely across a map unit delineation.

Tuff. A compacted deposit that is 50 percent or more volcanic ash and dust.

Upland. Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Volcaniclastic. A rock containing fragmental volcanic material.

Water bars. Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Water table. The upper surface of ground water or that level below which the soil is saturated with water.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow. The uprooting and tipping over of trees by the wind.

Wolf tree. A generally predominant or dominant tree that has a broad, spreading crown and that occupies more growing space than its more desirable neighbors.

Tables

Table 1.--Mean Annual Rainfall at Stations Within and Adjacent to the Survey Area

Station	Elevation		Location Lat./Long.	Years of Record	Mean Annual Rainfall	
	Ft	M			In	cm
Río Blanco 1	100	30.5	18°15' N./65°47' W.	12	97	246
Río Blanco 2	131	39.9	18°15' N./65°47' W.	16	104	264
Paraiso	331	100.9	18°16' N./65°43' W.	43	92	234
Río Grande El Verde	351	107.0	18°21' N./65°49' W.	20	104	264
Río Blanco 3	499	152.1	18°15' N./65°47' W.	18	106	269
El Verde	1,640	499.9		7	154	391
Río Blanco 4	1,800	548.6	18°18' N./65°47' W.	27	152	386
La Mina	2,350	716.3		8	185	470
Pico del Este	3,448	1,1051.0	18°16' N./65°45' W.	9	142	361

Table 2.--Soil Temperatures at Selected Sites

(Temperatures in degrees Fahrenheit and Celsius at a depth of 20 inches (50 cm). Data were recorded during a 20-month period at eight elevations. See the text for a description of "Average, one year.")

Date	Soil temperature															
	425 feet (130 m)		755 feet (230 m)		1,080 feet (330 m)		1,380 feet (420 m)		1,720 feet (525 m)		2,395 feet (730 m)		2,710 feet (825 m)		3,215 feet (980 m)	
	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
04/16/85	74	23	72	22	70	21	69	21	65	18	64	18	60	16	56	13
05/05/85	75	24	73	22	72	22	70	21	66	19	65	18	61	16	58	14
06/14/85	78	26	75	24	74	23	73	22	69	21	67	19	62	17	60	16
07/18/85	79	26	75	24	*	*	73	22	69	21	68	20	63	17	61	16
08/29/85	79	26	78	26			73	22	70	21	69	21	64	18	62	17
09/16/85	79	26	79	26			73	22	70	21	69	21	64	18	62	17
10/23/85	77	25	75	24			73	22	69	21	68	20	63	17	60	16
11/26/85	76	24	74	23			71	22	67	19	66	19	62	17	58	14
12/19/85	76	24	73	22			70	21	67	19	66	19	62	17	58	14
01/16/86	75	24	72	22			70	21	66	19	65	18	61	16	57	14
02/14/86	73	22	71	22			69	21	65	18	64	18	60	16	56	13
03/20/86	74	23	72	22			69	21	65	18	65	18	60	16	57	14
04/17/86	76	24	73	22			71	22	66	19	63	17	61	16	59	15
05/15/86	74	23	73	23			71	22	67	19	66	19	62	17	58	14
06/18/86	77	25	75	22			72	22	69	21	67	19	63	17	60	16
07/17/86	78	26	76	24			73	22	68	20	69	21	64	18	61	16
08/26/86	78	26	76	24			74	23	70	21	68	20	66	19	62	17
09/15/86	79	26	77	25			74	23	69	21	66	19	61	16	---	---
10/27/86	78	26	76	24			74	23	68	20	68	20	64	18	61	16
11/27/86	78	26	74	23			71	22	68	20	67	19	63	17	61	16
Average	76.7	24.8	74.5	23.6			71.7	22.0	67.7	19.8	66.7	19.3	62.6	19.7	59.4	15.2
Average, one year	76.25	24.6	74.08	23.4			71.08	21.7	67.33	19.6	66.33	19.1	61.83	16.6	58.75	14.9

* Station vandalized

Table 3.--Acreage and Proportionate Extent of the Soils

Map symbol	Soil name	Acres	Percent
112	Zarzal-Cristal complex, 20 to 60 percent slopes	5,685	20.4
113	Cristal-Zarzal complex, 5 to 40 percent slopes	1,784	6.4
114	Zarzal very cobbly clay, 40 to 80 percent slopes	1,919	6.9
115	Humatas-Zarzal complex, 5 to 30 percent slopes	940	3.4
121	Sonadora-Caguabo complex, 25 to 40 percent slopes	180	0.6
131	Sonadora-Caguabo complex, 40 to 70 percent slopes	995	3.6
132	Caguabo gravelly clay loam, 8 to 15 percent slopes	84	0.3
135	Prieto very cobbly clay loam, 25 to 50 percent slopes	222	0.8
141	Luquillo stony clay loam, occasionally flooded	99	0.4
142	Coloso silty clay loam, occasionally flooded	30	0.1
212	Yunque-Moteado complex, 20 to 65 percent slopes	5,878	21.1
213	Yunque cobbly clay, 40 to 80 percent slopes, extremely stony	2,227	8.0
214	Yunque-Los Guineos-Moteado complex, 5 to 30 percent slopes	850	3.1
215	Palm-Yunque complex, 35 to 85 percent slopes, extremely stony	1,194	4.3
221	Picacho-Utuado complex, 35 to 80 percent slopes	3,950	14.2
223	Picacho-Ciales complex, 5 to 30 percent slopes	336	1.2
224	Picacho-Utuado complex, 5 to 35 percent slopes	552	2.0
225	Icacos loam, occasionally flooded	239	0.9
231	Guayabota-Yunque complex, 30 to 60 percent slopes	205	0.7
311	Dwarf muck, 10 to 65 percent slopes, windswept	477	1.7
	Total	27,846	100.0

Table 4.--Hydric Soils List

Map symbol and map unit name	Component	Hydric	Local landform	Hydric soils criteria: Hydric criteria code	Meets saturation criteria	Meets flooding criteria	Meets ponding criteria	Acres
112:								
Zarzal-Cristal complex, 20 to 60 percent slopes	Zarzal	No	Mountain slope	---	---	---	---	2,842
	Cristal	No	Mountain slope	---	---	---	---	1,421
	Unnamed	No	Mountain slope	---	---	---	---	568
	Humatas	No	Mountain slope	---	---	---	---	455
	Luquillo	No	Flood plain	---	---	---	---	398
113:								
Cristal-Zarzal complex, 5 to 40 percent slopes	Cristal	No	Mountain slope	---	---	---	---	981
	Zarzal	No	Mountain slope	---	---	---	---	714
	Humatas	No	Mountain slope	---	---	---	---	36
	Unnamed	Yes	Drainageway	2B3	Yes	No	No	36
	Luquillo	No	Flood plain	---	---	---	---	18
114:								
Zarzal very cobbly clay, 40 to 80 percent slopes	Zarzal	No	Mountain slope	---	---	---	---	1,439
	Unnamed	No	Mountain slope	---	---	---	---	249
	Humatas	No	Mountain slope	---	---	---	---	77
	Cristal	No	Mountain slope	---	---	---	---	58
	Los Guineos	No	Mountain slope	---	---	---	---	58
	Luquillo	No	Flood plain	---	---	---	---	38
115:								
Humatas-Zarzal complex, 5 to 30 percent slopes	Humatas	No	Mountain slope	---	---	---	---	489
	Zarzal	No	Mountain slope	---	---	---	---	423
	Cristal	No	Mountain slope	---	---	---	---	19
	Unnamed	Yes	Drainageway	2B3	Yes	No	No	9
121:								
Sonadora-Caguabo complex, 25 to 40 percent slopes	Sonadora	No	Mountain slope	---	---	---	---	108
	Caguabo	No	Mountain slope	---	---	---	---	45
	Unnamed	Yes	Mountain slope	2B3	Yes	No	No	18
	Zarzal	No	Mountain slope	---	---	---	---	9
131:								
Sonadora-Caguabo complex, 40 to 70 percent slopes	Sonadora	No	Mountain slope	---	---	---	---	696
	Caguabo	No	Mountain slope	---	---	---	---	149
	Unnamed	Yes	Mountain slope	2B3	Yes	No	No	100
	Zarzal	No	Mountain slope	---	---	---	---	50
132:								
Caguabo gravelly clay loam, 8 to 15 percent slopes	Caguabo	No	Mountain slope	---	---	---	---	76
	Sonadora	No	Mountain slope	---	---	---	---	4
135:								
Prieto very cobbly clay loam, 25 to 50 percent slopes	Prieto	Yes	Mountain slope	2B3	Yes	No	No	200
	Unnamed	Yes	Mountain slope	2B3	Yes	No	No	13
	Zarzal	No	Mountain slope	---	---	---	---	9
141:								
Luquillo stony clay loam, occasionally flooded	Luquillo	No	Flood plain	---	---	---	---	84
	Unnamed	Yes	Flood plain	2B3	Yes	No	No	8
	Zarzal	No	Mountain slope	---	---	---	---	3
	Coloso	No	Flood plain	---	---	---	---	2
	Cristal	No	Mountain slope	---	---	---	---	2

Table 4.--Hydric Soils List--Continued

Map symbol and map unit name	Component	Hydric	Local landform	Hydric soils criteria: Hydric criteria code	Hydric soils criteria: Meets saturation criteria	Hydric soils criteria: Meets flooding criteria	Hydric soils criteria: Meets ponding criteria	Acres
142:								
Coloso silty clay loam, occasionally flooded	Coloso	No	Flood plain	---	---	---	---	22
	Unnamed	Yes	Flood plain	2B3	Yes	No	No	4
	Luquillo	No	Flood plain	---	---	---	---	3
	Cristal	No	Mountain slope	---	---	---	---	1
	Zarzal	No	Mountain slope	---	---	---	---	1
212:								
Yunque-Moteado complex, 20 to 65 percent slopes	Yunque	No	Mountain slope	---	---	---	---	2,645
	Moteado	Yes	Mountain slope	2B3	Yes	No	No	1,470
	Unnamed	No	Mountain slope	---	---	---	---	705
	Palm	Yes	Mountain slope	2B3	Yes	No	No	647
	Los Guineos	No	Mountain slope	---	---	---	---	411
213:								
Yunque cobbly clay, 40 to 80 percent slopes, extremely stony	Yunque	No	Mountain slope	---	---	---	---	1,670
	Palm	Yes	Mountain slope	2B3	Yes	No	No	178
	Rock outcrop	No	Mountain slope	---	---	---	---	178
	Moteado	Yes	Mountain slope	2B3	Yes	No	No	111
	Los Guineos	No	Mountain slope	---	---	---	---	45
	Unnamed	Yes	Mountain slope	2B3	Yes	No	No	45
214:								
Yunque-Los Guineos-Moteado complex, 5 to 30 percent slopes	Yunque	No	Mountain slope	---	---	---	---	425
	Los Guineos	No	Mountain slope	---	---	---	---	212
	Moteado	Yes	Mountain slope	2B3	Yes	No	No	128
	Palm	Yes	Mountain slope	2B3	Yes	No	No	42
	Unnamed	Yes	Mountain slope	2B3	Yes	No	No	26
	Rock outcrop	No	Mountain slope	---	---	---	---	17
215:								
Palm-Yunque complex, 35 to 85 percent slopes, extremely stony	Palm	Yes	Mountain slope	2B3	Yes	No	No	597
	Yunque	No	Mountain slope	---	---	---	---	358
	Los Guineos	No	Mountain slope	---	---	---	---	60
	Moteado	Yes	Mountain slope	2B3	Yes	No	No	60
	Rock outcrop	No	Mountain slope	---	---	---	---	60
	Unnamed	Yes	Mountain slope	2B3	Yes	No	No	60
221:								
Picacho-Utuado complex, 35 to 80 percent slopes	Picacho	No	Mountain slope	---	---	---	---	2,370
	Utuado	No	Mountain slope	---	---	---	---	1,382
	Ciales	Yes	Mountain slope	2B3	Yes	No	No	79
	Icacos	No	Flood plain	---	---	---	---	79
	Unnamed	Yes	Mountain slope	2B3	Yes	No	No	40
223:								
Picacho-Ciales complex, 5 to 30 percent slopes	Picacho	No	Mountain slope	---	---	---	---	168
	Ciales	Yes	Mountain slope	2B3	Yes	No	No	101
	Unnamed	No	Mountain slope	---	---	---	---	34
	Icacos	No	Flood plain	---	---	---	---	17
	Utuado	No	Mountain slope	---	---	---	---	17
224:								
Picacho-Utuado complex, 5 to 35 percent slopes	Picacho	No	Mountain slope	---	---	---	---	276
	Utuado	No	Mountain slope	---	---	---	---	193
	Ciales	Yes	Mountain slope	2B3	Yes	No	No	28
	Icacos	No	Flood plain	---	---	---	---	28
	Unnamed	Yes	Mountain slope	2B3	Yes	No	No	28

Table 4.--Hydric Soils List--Continued

Map symbol and map unit name	Component	Hydric	Local landform	Hydric soils criteria: Hydric criteria code	Meets saturation criteria	Meets flooding criteria	Meets ponding criteria	Acres
225:								
Icacos loam, occasionally flooded	Icacos	No	Flood plain	---	---	---	---	215
	Utuado	No	Mountain slope	---	---	---	---	12
	Picacho	No	Mountain slope	---	---	---	---	7
	Unnamed	Yes	Flood plain	2B3	Yes	No	No	5
231:								
Guayabota-Yunque complex, 30 to 60 percent slopes	Guayabota	Yes	Mountain slope	2B3	Yes	No	No	144
	Yunque	No	Mountain slope	---	---	---	---	51
	Moteado	Yes	Mountain slope	2B3	Yes	No	No	4
	Palm	Yes	Mountain slope	2B3	Yes	No	No	2
	Picacho	No	Mountain slope	---	---	---	---	2
	Utuado	No	Mountain slope	---	---	---	---	2
311:								
Dwarf muck, 10 to 65 percent slopes, windswept	Dwarf	Yes	Mountain slope	2B3	Yes	No	No	429
	Rock outcrop	No	Mountain slope	---	---	---	---	33
	Palm	Yes	Mountain slope	2B3	Yes	No	No	14

Table 5a.--Recreation

(The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table.)

Map symbol and soil name	Pct. of map unit	Camp areas: Rating class and limiting features	Value	Picnic areas: Rating class and limiting features	Value	Playgrounds: Rating class and limiting features	Value
112:							
Zarzal	50	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Too clayey	0.50	Too clayey	0.50	Too clayey	0.50
		Restricted permeability	0.26	Restricted permeability	0.26	Restricted permeability	0.26
						Content of large stones	0.20
Cristal	25	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	0.94	Depth to saturated zone	1.00
		Too clayey	0.50	Too clayey	0.50	Too clayey	0.50
		Restricted permeability	0.26	Restricted permeability	0.26	Restricted permeability	0.26
						Content of large stones	0.20
113:							
Cristal	55	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	0.94	Depth to saturated zone	1.00
		Too clayey	0.50	Too clayey	0.50	Too clayey	0.50
		Restricted permeability	0.26	Restricted permeability	0.26	Restricted permeability	0.26
						Content of large stones	0.01
Zarzal	40	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Too clayey	0.50	Too clayey	0.50	Too clayey	0.50
		Restricted permeability	0.26	Restricted permeability	0.26	Restricted permeability	0.26
						Content of large stones	0.11
114:							
Zarzal	75	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Too clayey	0.50	Too clayey	0.50	Too clayey	0.50
		Restricted permeability	0.26	Restricted permeability	0.26	Restricted permeability	0.26
						Content of large stones	0.20
115:							
Humatas	52	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Too clayey	0.50	Too clayey	0.50	Too clayey	0.50
Zarzal	45	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Too clayey	0.50	Too clayey	0.50	Too clayey	0.50
		Restricted permeability	0.26	Restricted permeability	0.26	Restricted permeability	0.26

Table 5a.--Recreation--Continued

Map symbol and soil name	Pct. of map unit	Camp areas: Rating class and limiting features	Value	Picnic areas: Rating class and limiting features	Value	Playgrounds: Rating class and limiting features	Value
121:							
Sonadora	60	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Restricted permeability	0.96	Restricted permeability	0.96	Restricted permeability	0.96
						Depth to bedrock	0.42
						Content of large stones	0.20
Caguabo	25	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to bedrock	1.00	Depth to bedrock	1.00	Depth to bedrock	1.00
		Restricted permeability	0.96	Restricted permeability	0.96	Restricted permeability	0.96
						Content of large stones	0.11
						Gravel content	0.01
131:							
Sonadora	70	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Restricted permeability	0.96	Restricted permeability	0.96	Restricted permeability	0.96
						Content of large stones	0.84
						Depth to bedrock	0.42
Caguabo	15	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to bedrock	1.00	Depth to bedrock	1.00	Depth to bedrock	1.00
		Restricted permeability	0.96	Restricted permeability	0.96	Gravel content	1.00
		Gravel content	0.05	Gravel content	0.05	Restricted permeability	0.96
						Content of large stones	0.84
132:							
Caguabo	90	Very limited		Very limited		Very limited	
		Depth to bedrock	1.00	Depth to bedrock	1.00	Gravel content	1.00
		Restricted permeability	0.96	Restricted permeability	0.96	Slope	1.00
		Slope	0.63	Slope	0.63	Depth to bedrock	1.00
		Gravel content	0.50	Gravel content	0.50	Restricted permeability	0.96
135:							
Prieto	90	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00	Depth to saturated zone	1.00
		Slope	1.00	Depth to saturated zone	1.00	Slope	1.00
		Restricted permeability	0.26	Restricted permeability	0.26	Content of large stones	0.95
		Content of large stones	0.01	Content of large stones	0.01	Depth to bedrock	0.42
						Restricted permeability	0.26
141:							
Luquillo	85	Very limited		Very limited		Very limited	
		Flooding	1.00	Too clayey	1.00	Too clayey	1.00
		Too clayey	1.00			Flooding	0.60
						Content of large stones	0.54
						Gravel content	0.01

Table 5a.--Recreation--Continued

Map symbol and soil name	Pct. of map unit	Camp areas: Rating class and limiting features	Value	Picnic areas: Rating class and limiting features	Value	Playgrounds: Rating class and limiting features	Value
142:							
Coloso	75	Very limited		Somewhat limited		Somewhat limited	
		Flooding	1.00	Restricted permeability	0.60	Restricted permeability	0.60
		Restricted permeability	0.60			Flooding	0.60
212:							
Yunque	45	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	0.08	Depth to saturated zone	0.03	Depth to saturated zone	0.08
Moteado	25	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00	Depth to saturated zone	1.00
		Slope	1.00	Depth to saturated zone	1.00	Slope	1.00
		Restricted permeability	0.96	Restricted permeability	0.96	Restricted permeability	0.96
213:							
Yunque	75	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	0.08	Depth to saturated zone	0.03	Depth to saturated zone	0.08
214:							
Yunque	50	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	0.08	Depth to saturated zone	0.03	Depth to saturated zone	0.08
Los Guineos	25	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Too clayey	0.50	Too clayey	0.50	Too clayey	0.50
Moteado	15	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Slope	1.00	Slope	1.00	Slope	1.00
		Restricted permeability	0.96	Restricted permeability	0.96	Restricted permeability	0.96
215:							
Palm	50	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00	Depth to saturated zone	1.00
		Slope	1.00	Depth to saturated zone	1.00	Slope	1.00
		Restricted permeability	0.26	Restricted permeability	0.26	Restricted permeability	0.26
Yunque	30	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	0.08	Depth to saturated zone	0.03	Depth to saturated zone	0.08
221:							
Picacho	60	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	0.94	Depth to saturated zone	1.00
		Restricted permeability	0.26	Restricted permeability	0.26	Restricted permeability	0.26

Table 5a.--Recreation--Continued

Map symbol and soil name	Pct. of map unit	Camp areas: Rating class and limiting features	Value	Picnic areas: Rating class and limiting features	Value	Playgrounds: Rating class and limiting features	Value
221:							
Utuado	35	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	0.75	Depth to saturated zone	1.00
223:							
Picacho	50	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00	Depth to saturated zone	1.00
		Slope	1.00	Depth to saturated zone	0.94	Slope	1.00
		Restricted permeability	0.26	Restricted permeability	0.26	Restricted permeability	0.26
Ciales	30	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Slope	1.00	Slope	1.00	Slope	1.00
		Restricted permeability	0.96	Restricted permeability	0.96	Restricted permeability	0.96
224:							
Picacho	50	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00	Depth to saturated zone	1.00
		Slope	1.00	Depth to saturated zone	0.94	Slope	1.00
Utuado	35	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	0.75	Depth to saturated zone	1.00
225:							
Icacos	90	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Flooding	1.00			Flooding	0.60
						Slope	0.01
231:							
Guayabota	70	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00	Depth to saturated zone	1.00
		Slope	1.00	Depth to saturated zone	1.00	Slope	1.00
		Restricted permeability	1.00	Restricted permeability	1.00	Restricted permeability	1.00
		Depth to bedrock	1.00	Depth to bedrock	1.00	Depth to bedrock	1.00
Yunque	25	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	0.08	Depth to saturated zone	0.03	Depth to saturated zone	0.08
311:							
Dwarf	90	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Content of organic matter	1.00	Content of organic matter	1.00	Slope	1.00
		Slope	1.00	Slope	1.00	Content of organic matter	1.00
		Restricted permeability	0.26	Restricted permeability	0.26	Restricted permeability	0.26

Table 5b.--Recreation

(The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value column range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table.)

Map symbol and soil name	Pct. of map unit	Paths and trails: Rating class and limiting features	Value
112:			
Zarzal	50	Very limited	
		Slope	1.00
		Too clayey	0.50
Cristal	25	Very limited	
		Slope	1.00
		Depth to saturated zone	0.86
		Too clayey	0.50
113:			
Cristal	55	Very limited	
		Slope	1.00
		Depth to saturated zone	0.86
		Too clayey	0.50
Zarzal	40	Very limited	
		Slope	1.00
		Too clayey	0.50
114:			
Zarzal	75	Very limited	
		Slope	1.00
		Too clayey	0.50
115:			
Humatas	52	Somewhat limited	
		Too clayey	0.50
		Slope	0.18
Zarzal	45	Somewhat limited	
		Too clayey	0.50
		Slope	0.18
121:			
Sonadora	60	Very limited	
		Slope	1.00
Caguabo	25	Very limited	
		Slope	1.00
131:			
Sonadora	70	Very limited	
		Slope	1.00
Caguabo	15	Very limited	
		Slope	1.00
132:			
Caguabo	90	Not limited	

Table 5b.--Recreation--Continued

Map symbol and soil name	Pct. of map unit	Paths and trails: Rating class and limiting features	Value
135:			
Prieto	90	Very limited	
		Depth to saturated zone	1.00
		Slope	1.00
		Content of large stones	0.01
141:			
Luquillo	85	Very limited	
		Too clayey	1.00
142:			
Coloso	75	Not limited	
212:			
Yunque	45	Very limited	
		Water erosion	1.00
		Slope	1.00
Moteado	25	Very limited	
		Depth to saturated zone	1.00
		Water erosion	1.00
		Slope	1.00
213:			
Yunque	75	Very limited	
		Slope	1.00
		Water erosion	1.00
214:			
Yunque	50	Very limited	
		Water erosion	1.00
		Slope	0.18
Los Guineos	25	Somewhat limited	
		Too clayey	0.50
		Slope	0.18
Moteado	15	Very limited	
		Depth to saturated zone	1.00
		Water erosion	1.00
		Slope	0.18
215:			
Palm	50	Very limited	
		Depth to saturated zone	1.00
		Slope	1.00
		Water erosion	1.00
Yunque	30	Very limited	
		Slope	1.00
		Water erosion	1.00
221:			
Picacho	60	Very limited	
		Slope	1.00
		Water erosion	1.00
		Depth to saturated zone	0.86

Table 5b.--Recreation--Continued

Map symbol and soil name	Pct. of map unit	Paths and trails: Rating class and limiting features	Value
221:			
Utuado	35	Very limited	
		Slope	1.00
		Water erosion	1.00
		Depth to saturated zone	0.44
223:			
Picacho	50	Very limited	
		Water erosion	1.00
		Depth to saturated zone	0.86
		Slope	0.18
Ciales	30	Very limited	
		Depth to saturated zone	1.00
		Slope	0.18
224:			
Picacho	50	Very limited	
		Water erosion	1.00
		Slope	0.92
		Depth to saturated zone	0.86
Utuado	35	Very limited	
		Water erosion	1.00
		Slope	0.92
		Depth to saturated zone	0.44
225:			
Icacos	90	Very limited	
		Depth to saturated zone	1.00
231:			
Guayabota	70	Very limited	
		Depth to saturated zone	1.00
		Slope	1.00
Yunque	25	Very limited	
		Slope	1.00
		Water erosion	1.00
311:			
Dwarf	90	Very limited	
		Depth to saturated zone	1.00
		Content of organic matter	1.00
		Slope	1.00

Table 6.--Wildlife Habitat

(See text for definitions of terms used in this table. Absence of an entry indicates that no rating is applicable.)

Map symbol and soil name	Potential for habitat elements					Potential as habitat for--		
	Grasses and legumes	Wild herbaceous plants	Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
112:								
Zarzal	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
Cristal	Very poor	Fair	Good	Fair	Very poor	Very poor	Good	Fair
113:								
Cristal	Very poor	Fair	Good	Fair	Very poor	Very poor	Good	Fair
Zarzal	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
114:								
Zarzal	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
115:								
Humatas	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
Zarzal	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
121:								
Sonadora	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
Caguabo	Very poor	Fair	Fair	Very poor	Very poor	Very poor	Good	Very poor
131:								
Sonadora	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
Caguabo	Very poor	Good	Fair	Very poor	Very poor	Very poor	Good	Very poor
132:								
Caguabo	Very poor	Good	Fair	Very poor	Very poor	Very poor	Good	Very poor
135:								
Prieto	Very poor	Fair	Fair	Good	Very poor	Very poor	Good	Good
141:								
Luquillo	Good	Good	Good	Poor	Poor	Good	Good	Very poor
142:								
Coloso	Fair	Fair	Good	Fair	Fair	Good	Good	Fair

Table 6.--Wildlife Habitat--Continued

Map symbol and soil name	Potential for habitat elements: Grasses and legumes	Wild herbaceous plants	Shrubs	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
212:								
Yunque	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
Moteado	Very poor	Fair	Good	Good	Very poor	Very poor	Good	Good
213:								
Yunque	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
214:								
Yunque	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
Los Guineos	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
Moteado	Very poor	Fair	Good	Good	Very poor	Very poor	Good	Good
215:								
Palm	Very poor	Fair	Fair	Good	Very poor	Very poor	Good	Good
Yunque	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
221:								
Picacho	Very poor	Fair	Good	Fair	Very poor	Very poor	Good	Fair
Utuado	Very poor	Fair	Good	Fair	Very poor	Very poor	Good	Fair
223:								
Picacho	Very poor	Fair	Good	Fair	Very poor	Very poor	Good	Fair
Ciales	Very poor	Fair	Fair	Good	Poor	Very poor	Good	Good
224:								
Picacho	Very poor	Fair	Good	Fair	Very poor	Very poor	Good	Fair
Utuado	Very poor	Fair	Good	Fair	Very poor	Very poor	Good	Fair
225:								
Icacos	Fair	Fair	Good	Fair	Fair	Fair	Good	Fair
231:								
Guayabota	Very poor	Poor	Fair	Good	Very poor	Very poor	Good	Good
Yunque	Very poor	Good	Good	Very poor	Very poor	Very poor	Good	Very poor
311:								
Dwarf	Very poor	Fair	Good	Good	Very poor	Very poor	Good	Good

Table 7a.--Building Site Development

(The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table.)

Map symbol and soil name	Pct. of map unit	Dwellings without basements: Rating class and limiting features	Value	Dwellings with basements: Rating class and limiting features	Value	Small commercial buildings: Rating class and limiting features	Value
112:							
Zarzal	50	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
Cristal	25	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Shrink-swell	0.50			Shrink-swell	0.50
113:							
Cristal	55	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Slope	1.00	Depth to saturated zone	1.00
		Shrink-swell	0.50			Shrink-swell	0.50
Zarzal	40	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
114:							
Zarzal	75	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
115:							
Humatas	52	Very limited		Very limited		Very limited	
		Shrink-swell	1.00	Shrink-swell	1.00	Shrink-swell	1.00
		Slope	1.00	Slope	1.00	Slope	1.00
Zarzal	45	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
121:							
Sonadora	60	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	1.00	Shrink-swell	1.00	Shrink-swell	1.00
				Depth to soft bedrock	0.42		
Caguabo	25	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
131:							
Sonadora	70	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	1.00	Shrink-swell	1.00	Shrink-swell	1.00
				Depth to soft bedrock	0.42		

Table 7a.--Building Site Development--Continued

Map symbol and soil name	Pct. of map unit	Dwellings without basements: Rating class and limiting features	Value	Dwellings with basements: Rating class and limiting features	Value	Small commercial buildings: Rating class and limiting features	Value
131:							
Caguabo	15	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
132:							
Caguabo	90	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Slope	0.63	Slope	0.63	Slope	1.00
135:							
Prieto	90	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
				Depth to soft bedrock	0.42		
141:							
Luquillo	85	Very limited		Very limited		Very limited	
		Flooding	1.00	Flooding	1.00	Flooding	1.00
142:							
Coloso	75	Very limited		Very limited		Very limited	
		Flooding	1.00	Flooding	1.00	Flooding	1.00
		Shrink-swell	0.50	Depth to saturated zone	0.95	Shrink-swell	0.50
				Shrink-swell	0.50		
212:							
Yunque	45	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Depth to saturated zone	1.00	Shrink-swell	0.50
		Depth to saturated zone	0.08	Shrink-swell	0.50	Depth to saturated zone	0.08
Moteado	25	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Shrink-swell	1.00	Shrink-swell	1.00	Shrink-swell	1.00
				Depth to hard bedrock	0.42		
213:							
Yunque	75	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Depth to saturated zone	1.00	Shrink-swell	0.50
		Depth to saturated zone	0.08	Shrink-swell	0.50	Depth to saturated zone	0.08
214:							
Yunque	50	Very limited		Very limited		Very limited	
		Slope	1.00	Depth to saturated zone	1.00	Slope	1.00
		Shrink-swell	0.50	Slope	1.00	Shrink-swell	0.50
		Depth to saturated zone	0.08	Shrink-swell	0.50	Depth to saturated zone	0.08

Table 7a.--Building Site Development--Continued

Map symbol and soil name	Pct. of map unit	Dwellings without basements: Rating class and limiting features	Value	Dwellings with basements: Rating class and limiting features	Value	Small commercial buildings: Rating class and limiting features	Value
214:							
Los Guineos	25	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
Moteado	15	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Shrink-swell	1.00	Shrink-swell	1.00	Shrink-swell	1.00
		Slope	1.00	Slope	1.00	Slope	1.00
				Depth to hard bedrock	0.42		
215:							
Palm	50	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Content of large stones	0.90	Content of large stones	0.90	Content of large stones	0.90
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
Yunque	30	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Depth to saturated zone	1.00	Shrink-swell	0.50
		Depth to saturated zone	0.08	Shrink-swell	0.50	Depth to saturated zone	0.08
221:							
Picacho	60	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Shrink-swell	0.50			Shrink-swell	0.50
Utuado	35	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
223:							
Picacho	50	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
Ciales	30	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Slope	1.00	Slope	1.00	Slope	1.00
224:							
Picacho	50	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Slope	1.00	Slope	1.00	Slope	1.00
Utuado	35	Very limited		Very limited		Very limited	
		Slope	1.00	Depth to saturated zone	1.00	Slope	1.00
		Depth to saturated zone	1.00	Slope	1.00	Depth to saturated zone	1.00

Table 7a.--Building Site Development--Continued

Map symbol and soil name	Pct. of map unit	Dwellings without basements: Rating class and limiting features	Value	Dwellings with basements: Rating class and limiting features	Value	Small commercial buildings: Rating class and limiting features	Value
225:							
Icacos	90	Very limited		Very limited		Very limited	
		Flooding	1.00	Flooding	1.00	Flooding	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
231:							
Guayabota	70	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Shrink-swell	1.00	Shrink-swell	1.00	Shrink-swell	1.00
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
Yunque	25	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Depth to saturated zone	1.00	Shrink-swell	0.50
		Depth to saturated zone	0.08	Shrink-swell	0.50	Depth to saturated zone	0.08
311:							
Dwarf	90	Very limited		Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00	Slope	1.00
		Shrink-swell	1.00	Slope	1.00	Depth to saturated zone	1.00
		Slope	1.00			Shrink-swell	1.00

Table 7b.--Building Site Development

(The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table.)

Map symbol and soil name	Pct. of map unit	Local roads: Rating class and limiting features	Value	Shallow excavations: Rating class and limiting features	Value
112:					
Zarzal	50	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Too clayey	0.97
				Cutbanks cave	0.10
Cristal	25	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Depth to saturated zone	0.94	Depth to saturated zone	1.00
		Shrink-swell	0.50	Too clayey	0.28
				Cutbanks cave	0.10
113:					
Cristal	55	Very limited		Very limited	
		Slope	1.00	Depth to saturated zone	1.00
		Depth to saturated zone	0.94	Slope	1.00
		Shrink-swell	0.50	Too clayey	0.28
				Cutbanks cave	0.10
Zarzal	40	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Too clayey	0.97
				Cutbanks cave	0.10
114:					
Zarzal	75	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Too clayey	0.97
				Cutbanks cave	0.10
115:					
Humatas	52	Very limited		Very limited	
		Shrink-swell	1.00	Too clayey	1.00
		Slope	1.00	Slope	1.00
				Cutbanks cave	0.10
Zarzal	45	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Too clayey	0.97
				Cutbanks cave	0.10
121:					
Sonadora	60	Very limited		Very limited	
		Shrink-swell	1.00	Slope	1.00
		Slope	1.00	Depth to soft bedrock	0.42
				Too clayey	0.28
				Cutbanks cave	0.10

Table 7b.--Building Site Development--Continued

Map symbol and soil name	Pct. of map unit	Local roads: Rating class and limiting features	Value	Shallow excavations: Rating class and limiting features	Value
121:					
Caguabo	25	Very limited		Very limited	
		Slope	1.00	Depth to hard bedrock	1.00
		Depth to hard bedrock	1.00	Slope	1.00
				Cutbanks cave	0.10
131:					
Sonadora	70	Very limited		Very limited	
		Shrink-swell	1.00	Slope	1.00
		Slope	1.00	Depth to soft bedrock	0.42
				Too clayey	0.28
				Cutbanks cave	0.10
Caguabo	15	Very limited		Very limited	
		Slope	1.00	Depth to hard bedrock	1.00
		Depth to hard bedrock	1.00	Slope	1.00
				Cutbanks cave	0.10
132:					
Caguabo	90	Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Slope	0.63	Slope	0.63
				Cutbanks cave	0.10
135:					
Prieto	90	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	1.00
		Shrink-swell	0.50	Depth to soft bedrock	0.42
				Cutbanks cave	0.10
				Too clayey	0.03
141:					
Luquillo	85	Very limited		Very limited	
		Flooding	1.00	Cutbanks cave	1.00
				Flooding	0.60
142:					
Coloso	75	Very limited		Somewhat limited	
		Flooding	1.00	Depth to saturated zone	0.95
		Shrink-swell	0.50	Flooding	0.60
				Too clayey	0.12
				Cutbanks cave	0.10
212:					
Yunque	45	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Depth to saturated zone	1.00
		Depth to saturated zone	0.03	Too clayey	0.72
				Cutbanks cave	0.10

Table 7b.--Building Site Development--Continued

Map symbol and soil name	Pct. of map unit	Local roads: Rating class and limiting features	Value	Shallow excavations: Rating class and limiting features	Value
212:					
Moteado	25	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	1.00
		Shrink-swell	1.00	Too clayey	0.97
				Depth to hard bedrock	0.42
				Cutbanks cave	0.10
213:					
Yunque	75	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Depth to saturated zone	1.00
		Depth to saturated zone	0.03	Too clayey	0.72
				Cutbanks cave	0.10
214:					
Yunque	50	Very limited		Very limited	
		Slope	1.00	Depth to saturated zone	1.00
		Shrink-swell	0.50	Slope	1.00
		Depth to saturated zone	0.03	Too clayey	0.72
				Cutbanks cave	0.10
Los Guineos	25	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Too clayey	0.72
				Cutbanks cave	0.10
Moteado	15	Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Shrink-swell	1.00	Slope	1.00
		Slope	1.00	Too clayey	0.97
				Depth to hard bedrock	0.42
				Cutbanks cave	0.10
215:					
Palm	50	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	1.00
		Content of large stones	0.90	Content of large stones	0.90
		Shrink-swell	0.50	Too clayey	0.12
				Cutbanks cave	0.10
Yunque	30	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Depth to saturated zone	1.00
		Depth to saturated zone	0.03	Too clayey	0.72
				Cutbanks cave	0.10
221:					
Picacho	60	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Depth to saturated zone	0.94	Depth to saturated zone	1.00
		Shrink-swell	0.50	Too clayey	1.00
				Cutbanks cave	0.10

Table 7b.--Building Site Development--Continued

Map symbol and soil name	Pct. of map unit	Local roads: Rating class and limiting features	Value	Shallow excavations: Rating class and limiting features	Value
221:					
Utuado	35	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Depth to saturated zone	0.75	Depth to saturated zone	1.00
				Cutbanks cave	0.10
223:					
Picacho	50	Very limited		Very limited	
		Slope	1.00	Depth to saturated zone	1.00
		Depth to saturated zone	0.94	Slope	1.00
		Shrink-swell	0.50	Cutbanks cave	0.10
Ciales	30	Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Slope	1.00	Slope	1.00
				Too clayey	0.12
				Cutbanks cave	0.10
224:					
Picacho	50	Very limited		Very limited	
		Slope	1.00	Depth to saturated zone	1.00
		Depth to saturated zone	0.94	Slope	1.00
				Cutbanks cave	0.10
Utuado	35	Very limited		Very limited	
		Slope	1.00	Depth to saturated zone	1.00
		Depth to saturated zone	0.75	Slope	1.00
				Cutbanks cave	0.10
225:					
Icacos	90	Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Flooding	1.00	Flooding	0.60
				Cutbanks cave	0.10
231:					
Guayabota	70	Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to hard bedrock	1.00
		Slope	1.00	Slope	1.00
		Shrink-swell	1.00	Depth to saturated zone	1.00
		Depth to hard bedrock	1.00	Too clayey	0.50
				Cutbanks cave	0.10
Yunque	25	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Shrink-swell	0.50	Depth to saturated zone	1.00
		Depth to saturated zone	0.03	Too clayey	0.72
				Cutbanks cave	0.10

Table 7b.--Building Site Development--Continued

Map symbol and soil name	Pct. of map unit	Local roads: Rating class and limiting features	Value	Shallow excavations: Rating class and limiting features	Value
311:					
Dwarf	90	Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Shrink-swell	1.00	Slope	1.00
		Slope	1.00	Too clayey	0.28
				Cutbanks cave	0.10

Table 8.--Sanitary Facilities

(The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table.)

Map symbol and soil name	Pct. of map unit	Septic tank absorption fields: Rating class and limiting features	Value	Sewage lagoons: Rating class and limiting features	Value
112:					
Zarzal	50	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Restricted permeability	1.00		
Cristal	25	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	0.08
		Restricted permeability	1.00		
113:					
Cristal	55	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Restricted permeability	1.00	Depth to saturated zone	0.08
		Slope	1.00		
Zarzal	40	Very limited		Very limited	
		Restricted permeability	1.00	Slope	1.00
		Slope	1.00		
114:					
Zarzal	75	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Restricted permeability	1.00		
115:					
Humatas	52	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Restricted permeability	0.50	Seepage	0.50
Zarzal	45	Very limited		Very limited	
		Restricted permeability	1.00	Slope	1.00
		Slope	1.00		
121:					
Sonadora	60	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Depth to bedrock	1.00	Depth to soft bedrock	1.00
				Seepage	0.50
Caguabo	25	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slope	1.00	Slope	1.00

Table 8.--Sanitary Facilities--Continued

Map symbol and soil name	Pct. of map unit	Septic tank absorption fields: Rating class and limiting features	Value	Sewage lagoons: Rating class and limiting features	Value
131:					
Sonadora	70	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Depth to bedrock	1.00	Depth to soft bedrock	1.00
				Seepage	0.50
Caguabo	15	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slope	1.00	Slope	1.00
132:					
Caguabo	90	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slope	0.63	Slope	1.00
135:					
Prieto	90	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Depth to soft bedrock	1.00
		Restricted permeability	1.00		
		Depth to bedrock	1.00		
141:					
Luquillo	85	Very limited		Very limited	
		Flooding	1.00	Flooding	1.00
				Seepage	1.00
142:					
Coloso	75	Very limited		Very limited	
		Flooding	1.00	Flooding	1.00
		Restricted permeability	1.00	Depth to saturated zone	1.00
		Depth to saturated zone	1.00		
212:					
Yunque	45	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	1.00
		Restricted permeability	0.50	Seepage	0.50
Moteado	25	Very limited		Very limited	
		Restricted permeability	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to hard bedrock	0.42
		Slope	1.00		
		Depth to bedrock	0.78		
213:					
Yunque	75	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	1.00
		Restricted permeability	0.50	Seepage	0.50

Table 8.--Sanitary Facilities--Continued

Map symbol and soil name	Pct. of map unit	Septic tank absorption fields: Rating class and limiting features	Value	Sewage lagoons: Rating class and limiting features	Value
214:					
Yunque	50	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	1.00
		Restricted permeability	0.50	Seepage	0.50
Los Guineos	25	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Restricted permeability	0.50	Seepage	0.50
Moteado	15	Very limited		Very limited	
		Restricted permeability	1.00	Slope	1.00
		Depth to saturated zone	1.00	Depth to hard bedrock	0.42
		Slope	1.00		
		Depth to bedrock	0.78		
215:					
Palm	50	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Content of organic matter	1.00
		Restricted permeability	1.00		
		Content of large stones	0.90		
Yunque	30	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	1.00
		Restricted permeability	0.50	Seepage	0.50
221:					
Picacho	60	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Seepage	0.50
		Restricted permeability	1.00		
Utuado	35	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Seepage	1.00
		Filtering capacity	1.00	Depth to saturated zone	0.01
223:					
Picacho	50	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Restricted permeability	1.00		
		Slope	1.00		

Table 8.--Sanitary Facilities--Continued

Map symbol and soil name	Pct. of map unit	Septic tank absorption fields: Rating class and limiting features	Value	Sewage lagoons: Rating class and limiting features	Value
223:					
Ciales	30	Very limited		Very limited	
		Restricted permeability	1.00	Slope	1.00
		Depth to saturated zone	1.00	Seepage	0.50
		Slope	1.00		
224:					
Picacho	50	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Seepage	0.50
		Restricted permeability	0.50		
Utuado	35	Very limited		Very limited	
		Depth to saturated zone	1.00	Seepage	1.00
		Filtering capacity	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	0.01
225:					
Icacos	90	Very limited		Very limited	
		Flooding	1.00	Flooding	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Restricted permeability	0.50	Seepage	0.50
				Slope	0.01
231:					
Guayabota	70	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Seepage	0.50
Yunque	25	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Slope	1.00	Depth to saturated zone	1.00
		Restricted permeability	0.50	Seepage	0.50
311:					
Dwarf	90	Very limited		Very limited	
		Depth to saturated zone	1.00	Slope	1.00
		Restricted permeability	1.00	Content of organic matter	1.00
		Slope	1.00		

Table 9a.--Construction Materials

(The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The ratings given for the thickest layer are for the thickest layer above and excluding the bottom layer. The numbers in the value columns range from 0.00 to 0.99. The greater the value, the greater the likelihood that the bottom layer or thickest layer of the soil is a source of sand or gravel. See text for further explanation of ratings in this table.)

Map symbol and soil name	Pct. of map unit	Potential source of gravel		Potential source of sand	
		Rating class	Value	Rating class	Value
112:					
Zarzal	50	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Cristal	25	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
113:					
Cristal	55	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Zarzal	40	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
114:					
Zarzal	75	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
115:					
Humatas	52	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Zarzal	45	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
121:					
Sonadora	60	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Caguabo	25	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
131:					
Sonadora	70	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Caguabo	15	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
132:					
Caguabo	90	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00

Table 9a.--Construction Materials--Continued

Map symbol and soil name	Pct. of map unit	Potential source of gravel: Rating class	Value	Potential source of sand: Rating class	Value
135:					
Prieto	90	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
141:					
Luquillo	85	Fair		Poor	
		Bottom layer	0.06	Bottom layer	0.00
		Thickest layer	0.06	Thickest layer	0.00
142:					
Coloso	75	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
212:					
Yunque	45	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Moteado	25	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
213:					
Yunque	75	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
214:					
Yunque	50	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Los Guineos	25	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Moteado	15	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
215:					
Palm	50	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Yunque	30	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
221:					
Picacho	60	Poor		Fair	
		Bottom layer	0.00	Thickest layer	0.00
		Thickest layer	0.00	Bottom layer	0.08
Utuado	35	Poor		Fair	
		Bottom layer	0.00	Thickest layer	0.00
		Thickest layer	0.00	Bottom layer	0.08

Table 9a.--Construction Materials--Continued

Map symbol and soil name	Pct. of map unit	Potential source of gravel: Rating class	Value	Potential source of sand: Rating class	Value
223:					
Picacho	50	Poor		Fair	
		Bottom layer	0.00	Thickest layer	0.00
		Thickest layer	0.00	Bottom layer	0.08
Ciales	30	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
224:					
Picacho	50	Poor		Fair	
		Bottom layer	0.00	Thickest layer	0.00
		Thickest layer	0.00	Bottom layer	0.08
Utuado	35	Poor		Fair	
		Bottom layer	0.00	Thickest layer	0.00
		Thickest layer	0.00	Bottom layer	0.08
225:					
Icacos	90	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
231:					
Guayabota	70	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
Yunque	25	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
311:					
Dwarf	90	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00

Table 9b.--Construction Materials

(The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value columns range from 0.00 to 0.99. The smaller the value, the greater the limitation. See text for further explanation of ratings in this table.)

Map symbol and soil name	Pct. of map unit	Potential source of reclamation material: Rating class and limiting features	Value	Potential source of roadfill: Rating class and limiting features	Value	Potential source of topsoil: Rating class and limiting features	Value
112:							
Zarzal	50	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Slope	0.00
		Too acid	0.32			Too Clayey	0.00
						Too acid	0.88
Cristal	25	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Slope	0.00
		Too acid	0.08	Depth to saturated zone	0.04	Too Clayey	0.00
		Low content of organic matter	0.12	Shrink-swell	0.99	Depth to saturated zone	0.04
						Too acid	0.50
113:							
Cristal	55	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Too Clayey	0.00
		Too acid	0.08	Depth to saturated zone	0.04	Slope	0.00
		Low content of organic matter	0.12	Shrink-swell	0.99	Depth to saturated zone	0.04
						Too acid	0.50
Zarzal	40	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Too Clayey	0.00
		Too acid	0.32			Slope	0.00
						Too acid	0.88
114:							
Zarzal	75	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Slope	0.00
		Too acid	0.32			Too Clayey	0.00
						Too acid	0.88
115:							
Humatas	52	Poor		Fair		Poor	
		Too clayey	0.00	Shrink-swell	0.79	Too Clayey	0.00
		Too acid	0.32	Slope	0.82	Slope	0.00
						Too acid	0.88
Zarzal	45	Poor		Fair		Poor	
		Too clayey	0.00	Slope	0.82	Too Clayey	0.00
		Too acid	0.32			Slope	0.00
						Too acid	0.88
121:							
Sonadora	60	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Slope	0.00
		Droughty	0.24	Depth to bedrock	0.00	Too Clayey	0.00
		Depth to bedrock	0.58	Shrink-swell	0.00	Depth to bedrock	0.58
		Too acid	0.95			Rock fragments	0.88
Caguabo	25	Poor		Poor		Poor	
		Droughty	0.00	Depth to bedrock	0.00	Slope	0.00
		Depth to bedrock	0.00	Slope	0.00	Rock fragments	0.00
		Low content of organic matter	0.88			Depth to bedrock	0.00
		Too clayey	0.98			Too Clayey	0.70
		Too acid	0.99				

Table 9b.--Construction Materials--Continued

Map symbol and soil name	Pct. of map unit	Potential source of reclamation material: Rating class and limiting features	Value	Potential source of roadfill: Rating class and limiting features	Value	Potential source of topsoil: Rating class and limiting features	Value
131:							
Sonadora	70	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Slope	0.00
		Droughty	0.25	Depth to bedrock	0.00	Too Clayey	0.00
		Depth to bedrock	0.58	Shrink-swell	0.00	Depth to bedrock	0.58
		Too acid	0.95			Rock fragments	0.88
Caguabo	15	Poor		Poor		Poor	
		Droughty	0.00	Depth to bedrock	0.00	Slope	0.00
		Depth to bedrock	0.00	Slope	0.00	Rock fragments	0.00
		Low content of organic matter	0.88			Depth to bedrock	0.00
		Too clayey	0.98			Too Clayey	0.70
		Too acid	0.99				
132:							
Caguabo	90	Poor		Poor		Poor	
		Droughty	0.00	Depth to bedrock	0.00	Rock fragments	0.00
		Depth to bedrock	0.00			Depth to bedrock	0.00
		Low content of organic matter	0.88			Slope	0.37
		Too clayey	0.98			Too Clayey	0.70
		Too acid	0.99				
135:							
Prieto	90	Poor		Poor		Poor	
		Too clayey	0.00	Depth to saturated zone	0.00	Slope	0.00
		Depth to bedrock	0.58	Slope	0.00	Depth to saturated zone	0.00
		Droughty	0.83	Depth to bedrock	0.00	Too Clayey	0.00
		Too acid	0.95	Shrink-swell	0.87	Rock fragments	0.41
				No cobble limitation	0.99	Depth to bedrock	0.58
141:							
Luquillo	85	Poor		Fair		Poor	
		Too clayey	0.00	Stone content	0.08	Hard to reclaim	0.00
		Too acid	0.08			Rock fragments	0.00
		Stone content	0.08			Too Clayey	0.00
						Too acid	0.50
142:							
Coloso	75	Poor		Fair		Poor	
		Too clayey	0.00	Shrink-swell	0.87	Too Clayey	0.00
		Too acid	0.95				
212:							
Yunque	45	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Slope	0.00
		Too acid	0.20	Depth to saturated zone	0.76	Too Clayey	0.00
		Low content of organic matter	0.50	Shrink-swell	0.87	Depth to saturated zone	0.76
						Too acid	0.76
Moteado	25	Poor		Poor		Poor	
		Too clayey	0.00	Depth to saturated zone	0.00	Slope	0.00
		Too acid	0.08	Slope	0.00	Too Clayey	0.00
				Shrink-swell	0.26	Depth to saturated zone	0.00
				Depth to bedrock	0.58	Too acid	0.50

Table 9b.--Construction Materials--Continued

Map symbol and soil name	Pct. of map unit	Potential source of reclamation material: Rating class and limiting features	Value	Potential source of roadfill: Rating class and limiting features	Value	Potential source of topsoil: Rating class and limiting features	Value
213:							
Yunque	75	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Slope	0.00
		Too acid	0.20	Depth to saturated zone	0.76	Too Clayey	0.00
		Low content of organic matter	0.50	Shrink-swell	0.87	Depth to saturated zone	0.76
						Too acid	0.76
214:							
Yunque	50	Poor		Fair		Poor	
		Too clayey	0.00	Depth to saturated zone	0.76	Too Clayey	0.00
		Too acid	0.20	Slope	0.82	Slope	0.00
		Low content of organic matter	0.50	Shrink-swell	0.87	Depth to saturated zone	0.76
						Too acid	0.76
Los Guineos	25	Poor		Fair		Poor	
		Too clayey	0.00	Slope	0.82	Too Clayey	0.00
		Too acid	0.03	Shrink-swell	0.87	Slope	0.00
						Too acid	0.32
Moteado	15	Poor		Poor		Poor	
		Too clayey	0.00	Depth to saturated zone	0.00	Too Clayey	0.00
		Too acid	0.08	Shrink-swell	0.26	Depth to saturated zone	0.00
				Depth to bedrock	0.58	Slope	0.00
				Slope	0.82	Too acid	0.50
215:							
Palm	50	Poor		Poor		Poor	
		Stone content	0.00	Depth to saturated zone	0.00	Slope	0.00
		Too clayey	0.00	Slope	0.00	Depth to saturated zone	0.00
		Too acid	0.08	Stone content	0.00	Rock fragments	0.00
				Shrink-swell	0.76	Hard to reclaim	0.00
				Cobble content	0.95	Too Clayey	0.00
						Too acid	0.50
Yunque	30	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Slope	0.00
		Too acid	0.20	Depth to saturated zone	0.76	Too Clayey	0.00
		Low content of organic matter	0.50	Shrink-swell	0.87	Depth to saturated zone	0.76
						Too acid	0.76
221:							
Picacho	60	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Slope	0.00
		Too acid	0.08	Depth to saturated zone	0.04	Too Clayey	0.00
						Depth to saturated zone	0.04
						Too acid	0.50
						Hard to reclaim	0.68
Utuado	35	Fair		Poor		Poor	
		Low content of organic matter	0.12	Slope	0.00	Slope	0.00
		Too acid	0.20	Depth to saturated zone	0.14	Depth to saturated zone	0.14
						Hard to reclaim	0.35
						Too acid	0.76

Table 9b.--Construction Materials--Continued

Map symbol and soil name	Pct. of map unit	Potential source of reclamation material: Rating class and limiting features	Value	Potential source of roadfill: Rating class and limiting features	Value	Potential source of topsoil: Rating class and limiting features	Value
223:							
Picacho	50	Fair		Fair		Poor	
		Too acid	0.08	Depth to saturated zone	0.04	Slope	0.00
		Low content of organic matter	0.88	Slope	0.82	Depth to saturated zone	0.04
				Shrink-swell	0.87	Too acid	0.50
						Hard to reclaim	0.68
Ciales	30	Poor		Poor		Poor	
		Too clayey	0.00	Depth to saturated zone	0.00	Too Clayey	0.00
		Too acid	0.08	Slope	0.82	Depth to saturated zone	0.00
		Low content of organic matter	0.50			Slope	0.00
						Too acid	0.50
224:							
Picacho	50	Fair		Fair		Poor	
		Too acid	0.08	Depth to saturated zone	0.04	Slope	0.00
		Too clayey	0.76	Slope	0.08	Depth to saturated zone	0.04
		Low content of organic matter	0.88			Too acid	0.50
						Too Clayey	0.66
						Hard to reclaim	0.68
Utuado	35	Fair		Fair		Poor	
		Low content of organic matter	0.12	Slope	0.08	Slope	0.00
		Too acid	0.20	Depth to saturated zone	0.14	Depth to saturated zone	0.14
						Hard to reclaim	0.35
						Too acid	0.76
225:							
Icacos	90	Fair		Poor		Poor	
		Too acid	0.08	Depth to saturated zone	0.00	Depth to saturated zone	0.00
						Too acid	0.50
231:							
Guayabota	70	Poor		Poor		Poor	
		Too clayey	0.00	Depth to bedrock	0.00	Slope	0.00
		Droughty	0.00	Depth to saturated zone	0.00	Too Clayey	0.00
		Depth to bedrock	0.00	Slope	0.00	Depth to saturated zone	0.00
		Too acid	0.08	Shrink-swell	0.21	Depth to bedrock	0.00
						Too acid	0.76
Yunque	25	Poor		Poor		Poor	
		Too clayey	0.00	Slope	0.00	Slope	0.00
		Too acid	0.20	Depth to saturated zone	0.76	Too Clayey	0.00
		Low content of organic matter	0.50	Shrink-swell	0.87	Depth to saturated zone	0.76
						Too acid	0.76
311:							
Dwarf	90	Fair		Poor		Poor	
		Too clayey	0.02	Depth to saturated zone	0.00	Depth to saturated zone	0.00
		Too acid	0.08	Slope	0.00	Slope	0.00
				Shrink-swell	0.87	Too Clayey	0.02
						Too acid	0.50

Table 10.--Water Management

(The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. See text for definitions of terms used in this table. Absence of an entry indicates that no rating is applicable.)

Map symbol and soil name	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting drainage
112:			
Zarzal	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
Cristal	Severe: slope	Moderate: wetness	Limitation: slope
113:			
Cristal	Severe: slope	Moderate: wetness	Limitation: slope
Zarzal	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
114:			
Zarzal	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
115:			
Humatas	Severe: slope	Moderate: piping	Limitation: slope deep to water
Zarzal	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
121:			
Sonadora	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
Caguabo	Severe: slope depth to rock	Severe: thin layer	Limitation: slope deep to water
131:			
Sonadora	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
Caguabo	Severe: slope depth to rock	Severe: thin layer	Limitation: slope deep to water
132:			
Caguabo	Severe: slope depth to rock	Severe: thin layer	Limitation: deep to water
135:			
Prieto	Severe: slope	Severe: hard to pack wetness	Limitation: large stones slope depth to rock

Table 10.--Water Management--Continued

Map symbol and soil name	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting drainage
141:			
Luquillo	Severe: flooding seepage	Slight	Limitation: flooding percs slowly deep to water
142:			
Coloso	Moderate: flooding	Moderate: hard to pack wetness	Limitation: flooding percs slowly
212:			
Yunque	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
Moteado	Severe: slope	Severe: hard to pack wetness	Limitation: percs slowly slope
213:			
Yunque	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
214:			
Yunque	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
Los Guineos	Severe: slope	Severe: hard to pack	Limitation: percs slowly slope deep to water
Moteado	Severe: slope	Severe: hard to pack wetness	Limitation: percs slowly slope
215:			
Palm	Severe: slope	Severe: hard to pack wetness	Limitation: large stones slope
Yunque	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
221:			
Picacho	Severe: slope	Severe: wetness	Limitation: slope deep to water
Utuado	Severe: seepage slope	Slight	Limitation: slope deep to water
223:			
Picacho	Severe: slope	Severe: wetness	Limitation: slope deep to water
Ciales	Severe: slope	Severe: wetness	Limitation: slope

Table 10.--Water Management--Continued

Map symbol and soil name	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting drainage
224:			
Picacho	Severe: slope	Severe: wetness	Limitation: slope deep to water
Utuado	Severe: seepage slope	Slight	Limitation: slope deep to water
225:			
Icacos	Moderate: flooding	Severe: wetness	Limitation: flooding
231:			
Guayabota	Severe: slope depth to rock	Severe: thin layer wetness	Limitation: percs slowly slope depth to rock
Yunque	Severe: slope	Severe: hard to pack	Limitation: slope deep to water
311:			
Dwarf	Severe: slope	Severe: hard to pack wetness	Limitation: percs slowly slope

Table 11.--Engineering Index Properties

(Absence of an entry indicates that the data were not estimated.)

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 inches	Fragments: 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
112:												
Zarzal----------	0-1	Clay	MH	A-7-5	0-10	5-10	90-100	90-100	85-100	75-95	50-65	20-27
	1-7	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	75-95	55-65	20-25
	7-35	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	75-95	55-65	20-25
	35-46	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	70-90	50-65	17-24
	46-82	Clay, clay loam, silty clay loam	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	70-90	55-60	16-20
	82-91	Weathered bedrock			---	---	---	---	---	---	---	---
Cristal---------	0-2	Clay loam	MH	A-7-5	0-10	5-10	90-100	90-100	85-100	75-95	50-65	18-25
	2-15	Clay loam, clay, gravelly clay	MH	A-7-5	0-1	0-5	90-100	90-100	85-100	70-95	55-70	18-25
	15-26	Clay loam, clay, gravelly clay	MH	A-7-5	0-1	0-5	90-100	90-100	85-100	70-95	55-70	18-25
	26-39	Clay loam, clay, gravelly clay	MH	A-7-5	0-1	0-5	90-100	90-100	85-100	70-95	50-65	16-23
	39-60	Clay loam, silty clay loam	CL, ML	A-6, A-7-6	0-1	0-1	85-100	80-95	75-95	65-90	36-48	14-20
113:												
Cristal---------	0-2	Clay loam	MH, ML	A-7-5, A-7-6	0-5	0-5	90-100	90-100	85-100	70-90	45-55	16-22
	2-15	Clay loam, clay, gravelly clay	MH	A-7-5	0-1	0-5	90-100	90-100	85-100	70-95	55-70	18-25
	15-26	Clay loam, clay, gravelly clay	MH	A-7-5	0-1	0-5	90-100	90-100	85-100	70-95	55-70	18-25
	26-39	Clay loam, clay, gravelly clay	MH	A-7-5	0-1	0-5	90-100	90-100	85-100	70-95	50-65	16-23
	39-60	Clay loam, silty clay loam	CL, ML	A-6, A-7-6	0-1	0-1	85-100	80-95	75-95	65-90	36-48	14-20

Table 11.--Engineering Index Properties--Continued

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 inches	Fragments: 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
113:												
Zarzal----------	0-1	Clay	MH	A-7-5	5-10	0-5	90-100	90-100	85-100	75-95	50-65	20-27
	1-7	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	75-95	55-65	20-25
	7-35	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	75-95	55-65	20-25
	35-46	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	70-90	50-65	17-24
	46-82	Clay, clay loam, silty clay loam	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	70-90	55-60	16-20
	82-91	Weathered bedrock			---	---	---	---	---	---	---	---
114:												
Zarzal----------	0-1	Very cobbly clay	MH	A-7-5	0-10	5-10	90-100	90-100	85-100	75-95	50-65	20-27
	1-7	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	75-95	55-65	20-25
	7-35	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	75-95	55-65	20-25
	35-46	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	70-90	50-65	17-24
	46-82	Clay, clay loam, silty clay loam	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	70-90	55-60	16-20
	82-91	Weathered bedrock			---	---	---	---	---	---	---	---
115:												
Humatas---------	0-4	Silty clay	ML	A-7-5, A-7-6	0	0	100	100	90-100	85-95	52-65	23-30
	4-38	Clay, silty clay	MH, ML	A-7-5	0	0	100	100	90-100	85-95	61-72	28-36
	38-60	Silty clay loam, silty clay, clay	CL	A-6, A-7-6	0	0	100	100	95-100	85-95	36-47	14-20
Zarzal----------	0-1	Clay	MH	A-7-5	0-1	0-5	90-100	90-100	85-100	75-95	50-65	20-27
	1-7	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	75-95	55-65	20-25
	7-35	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	75-95	55-65	20-25
	35-46	Clay	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	70-90	50-65	17-24
	46-82	Clay, clay loam, silty clay loam	MH	A-7-5	0-1	0-1	90-100	90-100	85-100	70-90	55-60	16-20
	82-91	Weathered bedrock			---	---	---	---	---	---	---	---

Table 11.--Engineering Index Properties--Continued

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 inches	Fragments: 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
121:												
Sonadora--------	0-1	Clay loam	CH, CL	A-7-6	1-5	0-20	100	100	90-100	75-95	46-56	25-33
	1-21	Clay, silty clay, cobbly clay	CH	A-7-6	0	0-20	100	100	90-100	75-95	56-72	33-46
	21-36	Loam, clay loam	CL, ML	A-7-6	0	0-20	100	100	90-100	75-95	46-56	25-33
	36-60	Weathered bedrock			---	---	---	---	---	---	---	---
Caguabo---------	0-3	Gravelly clay loam	CL	A-6, A-7-6	1-5	5-10	80-100	75-100	75-100	50-80	35-43	15-21
	3-11	Gravelly clay loam, very gravelly clay loam	GC	A-2-6, A-2-7	0	0	35-50	30-45	25-45	20-35	35-43	15-21
	11-16	Weathered bedrock			---	---	---	---	---	---	---	---
	16-60	Unweathered bedrock			---	---	---	---	---	---	---	---
131:												
Sonadora--------	0-1	Clay loam	CH, CL	A-7-6	5-20	0-20	100	100	95-100	85-95	46-56	25-33
	1-21	Clay, silty clay, cobbly clay	CH	A-7-6	0	0-20	100	100	90-100	75-95	56-72	33-46
	21-36	Loam, clay loam	CL, ML	A-7-6	0	0-20	100	100	90-100	75-95	46-56	25-33
	36-60	Unweathered bedrock			---	---	---	---	---	---	---	---
Caguabo---------	0-3	Gravelly clay loam	CL, GC, SC	A-6, A-7-6	5-20	5-15	55-80	50-75	45-75	35-60	35-43	15-21
	3-11	Gravelly clay loam, very gravelly clay loam	GC	A-2-6, A-2-7	0	0	35-50	30-45	25-45	20-35	35-43	15-21
	11-16	Weathered bedrock			---	---	---	---	---	---	---	---
	16-60	Unweathered bedrock			---	---	---	---	---	---	---	---

Table 11.--Engineering Index Properties--Continued

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 inches	Fragments: 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
132:												
Caguabo---------	0-3	Gravelly clay loam	CL	A-6, A-7-6	0	0	55-80	50-75	45-75	35-60	35-43	15-21
	3-11	Gravelly clay loam, very gravelly clay loam	GC, SC	A-2-6, A-2-7	0	0	35-50	30-45	25-45	20-35	35-43	15-21
	11-16	Weathered bedrock			---	---	---	---	---	---	---	---
	16-60	Unweathered bedrock			---	---	---	---	---	---	---	---
135:												
Prieto----------	0-4	Very cobbly clay loam	MH, ML	A-7-6	0-1	10-40	90-100	85-95	80-90	75-90	45-55	18-25
	4-13	Cobbly clay loam, cobbly clay, clay	MH	A-7-5	0-1	1-30	90-100	85-100	80-95	75-95	55-70	18-25
	13-25	Cobbly clay loam, cobbly clay, clay	MH	A-7-5	0-1	1-30	90-100	85-100	80-95	75-95	55-70	18-25
	25-35	Cobbly clay loam, cobbly clay, cobbly silty clay	MH, ML	A-7-5	0-1	5-30	90-100	85-95	80-90	75-90	50-65	15-22
	35-60	Unweathered bedrock			---	---	---	---	---	---	---	---
141:												
Luquillo--------	0-5	Stony clay loam	CH, CL	A-7, A-6	5-20	0-10	90-95	85-90	75-90	65-85	48-66	25-39
	5-35	Clay, gravelly clay loam, gravelly clay, stony clay loam	GC	A-2-6, A-2-7, A-6	5-20	0-10	45-50	35-50	30-50	25-40	37-43	16-21
	35-60	Very stony clay, gravelly clay loam, very gravelly clay loam, very stony clay loam	GC	A-2-6, A-2-7, A-6	5-20	0-10	45-50	35-50	30-50	25-40	37-43	16-21

Table 11.--Engineering Index Properties--Continued

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 inches	Fragments: 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
142:												
Coloso----------	0-4	Silty clay loam	CL	A-6, A-7	0	0	100	100	95-100	85-95	39-48	18-25
	4-60	Silty clay loam, silty clay, clay	CH, CL	A-7-6	0	0	100	100	95-100	75-95	43-61	21-35
212:												
Yunque----------	0-2				---	---	---	---	---	---	---	---
	2-7	Clay	MH	A-7	0-10	5-10	100	100	90-100	75-98	56-68	18-24
	7-30	Silty clay, clay, clay loam	MH	A-7	0	0-5	95-100	95-100	90-100	75-98	55-75	18-25
	30-62	Silty clay, clay, clay loam	MH, ML	A-7, A-7-6	0	0-5	95-100	95-100	90-100	75-98	55-75	15-20
Moteado---------	0-1				---	---	---	---	---	---	---	---
	1-6	Clay	MH	A-7-5	0-10	5-10	95-100	85-95	65-85	60-75	50-60	17-25
	6-22	Clay, cobbly clay	MH	A-7-5	0-1	0-5	95-100	85-100	75-95	65-85	55-70	17-25
	22-41	Clay, cobbly clay	MH	A-7-5	0	0-1	95-100	90-100	85-100	85-100	55-70	17-25
	41-54	Clay, cobbly clay	MH, ML	A-7-5	0	0-1	95-100	95-100	90-100	85-100	55-70	17-25
	54-60	Unweathered bedrock			---	---	---	---	---	---	---	---
213:												
Yunque----------	0-2				---	---	---	---	---	---	---	---
	2-7	Cobbly clay	MH	A-7	0-10	5-10	100	100	90-100	75-98	56-68	18-24
	7-30	Silty clay, clay, clay loam	MH	A-7	0	0-5	95-100	95-100	90-100	75-98	55-75	18-25
	30-62	Silty clay, clay, clay loam	MH, ML	A-7, A-7-6	0	0-5	95-100	95-100	90-100	75-98	55-75	15-20
214:												
Yunque----------	0-2				---	---	---	---	---	---	---	---
	2-7	Clay	MH	A-7	0	0	100	100	90-100	75-98	56-68	18-24
	7-30	Silty clay, clay, clay loam	MH	A-7	0	0-5	95-100	95-100	90-100	75-98	55-75	18-25
	30-62	Silty clay, clay, clay loam	MH, ML	A-7, A-7-6	0	0-5	95-100	95-100	90-100	75-98	55-75	15-20

Table 11.--Engineering Index Properties--Continued

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 inches	Fragments: 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plas-ticity index
	In				Pct	Pct					Pct	
214:												
Los Guineos-----	0-1	Clay	CH, CL, MH, ML	A-7-5, A-7-6	0	0	100	100	90-100	75-95	47-61	20-28
	1-31	Clay	CH, CL, MH, ML	A-7-5, A-7-6	0	0	100	100	90-100	75-95	47-61	20-28
	31-93	Clay	CH, CL, MH, ML	A-7-5, A-7-6	0	0	100	100	90-100	75-95	47-61	20-28
Moteado---------	0-1				---	---	---	---	---	---	---	---
	1-6	Clay	MH	A-7-5	0-1	0-20	90-100	85-95	65-85	60-75	50-60	17-25
	6-22	Clay, cobbly clay	MH	A-7-5	0-1	0-5	95-100	85-100	75-95	65-85	55-70	17-25
	22-41	Clay, cobbly clay	MH	A-7-5	0	0-1	95-100	90-100	85-100	85-100	55-70	17-25
	41-54	Clay, cobbly clay	MH	A-7-5	0	0-1	95-100	95-100	90-100	85-100	55-70	17-25
	54-60	Unweathered bedrock			---	---	---	---	---	---	---	---
215:												
Palm----------	0-3				---	---	---	---	---	---	---	---
	3-10	Mucky clay	MH, ML, OH, OL	A-7-6	20-40	0-10	90-100	90-100	90-100	75-95	45-55	18-25
	10-19	Clay, silty clay, clay loam	MH, ML	A-7-6	0-1	0-15	90-100	90-100	85-100	70-95	45-55	18-25
	19-31	Very cobbly clay, very cobbly clay loam	GM, MH	A-7-5	30-50	20-40	55-70	55-70	50-65	45-60	55-70	18-25
	31-63	Very cobbly clay, very cobbly clay loam	GM, MH	A-7-5	30-50	20-40	50-70	50-70	45-65	45-60	55-70	18-25
Yunque----------	0-2				---	---	---	---	---	---	---	---
	2-7	Clay	MH	A-7	20-40	5-10	100	100	90-100	75-98	56-68	18-24
	7-30	Silty clay, clay, clay loam	MH	A-7	0	0-5	95-100	95-100	90-100	75-98	55-75	18-25
	30-62	Silty clay, clay, clay loam	MH, ML	A-7, A-7-6	0	0-5	95-100	95-100	90-100	75-98	55-75	15-20

Table 11.--Engineering Index Properties--Continued

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 inches	Fragments: 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
221:												
Picacho---------	0-3				---	---	---	---	---	---	---	---
	3-4	Sandy loam	SC-SM	A-2, A-4	0	0-10	100	100	90-100	30-40	21-28	5-10
	4-27	Loam, sandy clay loam, clay loam	SC-SM, CL-ML	A-6, A-4	0	0-10	100	100	90-100	60-75	21-35	12-18
	27-63	Cobbly sandy loam, sandy loam	SC-SM, SC	A-4, A-2	0-10	5-20	100	100	80-95	30-40	21-28	4-9
Utuado----------	0-1				---	---	---	---	---	---	---	---
	1-2	Gravelly loam	CL	A-6, A-7-6	0	0	100	100	90-100	70-80	37-43	16-21
	2-13	Clay loam, loam	CL	A-6, A-7-6	0	0	100	100	90-100	70-80	37-43	16-21
	13-28	Loam	CL, CL-ML	A-4, A-6	0	0	100	100	85-95	60-75	21-36	4-16
	28-61	Sandy loam	SC, SC-SM	A-2, A-4	0	0	100	100	60-70	30-40	21-28	4-9
223:												
Picacho---------	0-3				---	---	---	---	---	---	---	---
	3-4	Sandy loam	SC-SM	A-4, A-2	0	0-10	100	100	90-100	30-40	21-28	5-10
	4-27	Sandy clay loam, clay loam, loam	SC-SM, CL-ML	A-6, A-4	0	0-10	100	100	90-100	60-75	21-35	12-18
	27-63	Sandy loam, cobbly sandy loam	SC-SM, SC	A-4, A-2	0-10	5-20	100	100	90-100	30-40	21-28	4-9
Ciales----------	0-9	Mucky clay loam	ML	A-4, A-5, A-7-5, A-7-6	0	0	100	100	95-100	70-85	34-50	5-17
	9-25	Clay, silty clay	CH, CL, MH, ML	A-7-6	0	0	100	100	90-100	75-95	43-52	18-23
	25-39	Silty clay loam	CL	A-6, A-7-6	0	0	100	100	95-100	85-95	36-41	14-17
	39-73	Silty clay loam	CL	A-6	0	0	100	100	95-100	85-95	30-38	11-15
224:												
Picacho---------	0-3				---	---	---	---	---	---	---	---
	3-4	Sandy loam	SC-SM	A-4, A-2	0	0-10	100	100	90-100	30-40	12-28	5-10
	4-27	Loam, clay loam, sandy clay loam	SC-SM, CL-ML	A-6, A-4	0	0-10	100	100	90-100	60-75	21-35	12-18
	27-63	Cobbly sandy loam, sandy loam	SC-SM, SC	A-4, A-2	0-10	5-20	100	100	80-95	30-40	12-28	4-9

Table 11.--Engineering Index Properties--Continued

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 inches	Fragments: 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
224:												
Utuado----------	0-1				---	---	---	---	---	---	---	---
	1-2	Gravelly loam	CL	A-6, A-7-6	0-5	10-30	100	100	90-100	70-80	37-43	16-21
	2-13	Clay loam, loam	CL	A-6, A-7-6	0	0	100	100	90-100	70-80	37-43	16-21
	13-28	Loam	CL, CL-ML	A-4, A-6	0	0	100	100	85-95	60-75	21-36	4-16
	28-61	Sandy loam	SC, SC-SM	A-2, A-4	0	0	100	100	60-70	30-40	21-28	4-9
225:												
Icacos----------	0-4	Loam	CL	A-6, A-7-6	0	0-5	100	100	85-100	60-80	35-45	16-21
	4-14	Silt loam, silty clay loam, clay loam	CL	A-6, A-7-6	0	0-5	100	100	85-100	60-85	35-47	16-23
	14-60	Silt loam, silty clay loam, clay loam	CL	A-6, A-7-6	0	0-5	100	100	85-100	60-85	35-47	16-23
231:												
Guayabota-------	0-5	Silty clay loam	CL	A-6, A-7	0	0	100	100	95-100	85-95	35-48	15-25
	5-14	Silty clay	CH, CL	A-7	0	0	100	100	95-100	90-95	48-66	25-39
	14-18	Silty clay loam	CL	A-6, A-7	0	0	100	100	95-100	85-95	35-48	15-25
	18-60	Unweathered bedrock			---	---	---	---	---	---	---	---
Yunque----------	0-2				---	---	---	---	---	---	---	---
	2-7	Clay	MH	A-7	0	0-10	100	100	90-100	75-98	56-68	18-24
	7-30	Silty clay, clay loam, clay loam	MH	A-7	0	0-5	95-100	95-100	90-100	75-98	55-75	18-25
	30-62	Silty clay, clay loam, clay loam	MH, ML	A-7, A-7-6	0	0-5	95-100	95-100	90-100	75-98	55-75	15-20

Table 11.--Engineering Index Properties--Continued

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 inches	Fragments: 3-10 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
311:												
Dwarf----------	0-4	Muck	PT	A-8	---	---	---	---	---	---	---	---
	4-9	Mucky sandy loam, mucky silt loam, loam	SC, SC-SM	A-2-6, A-4, A-6	0	0	90-100	90-100	50-75	30-50	21-36	5-16
	9-26	Silt loam, silty clay loam, silty clay	MH, ML	A-7-5	0	0	90-100	90-100	90-100	85-97	45-65	15-24
	26-35	Silty clay loam, silty clay, clay	MH	A-7-5	0	0	90-100	90-100	90-100	85-97	55-70	16-25
	35-43	Sandy loam, clay loam, clay	CH, CL, MH, ML	A-4, A-6, A-7-5	0	0	90-100	90-100	65-90	45-85	25-55	8-24
	43-60	Sandy loam, silt loam, silty clay loam	CL, ML, SC, SM	A-4, A-6, A-7-6	0	0	90-100	90-100	60-99	35-98	25-50	8-20

Table 12.--Physical Analyses of Selected Soils

Soil name and sample number	Depth		Horizon	Particle-size distribution (Percent less than 2.0 mm)		
				Sand (2.0-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)
	In	cm				
Dwarf:						
S87PR-003-003	0-4	0-10	Oa	---	---	---
	4-9	10-23	A	70.4	23.0	6.6
	9-16	23-41	Bg1	8.0	58.8	33.2
	16-26	41-66	Bg2	4.9	52.1	43.0
	26-35	66-89	Bw	7.7	46.8	45.5
	35-43	89-109	2BC	26.2	44.5	29.3
	43-52	109-132	2C1	2.5	71.0	26.5
	52-60	132-152	2C2	5.7	66.8	27.5
Los Guineos:						
S86PR-119-010	0-1	0-3	A	4.3	16.2	79.5
	1-3	3-8	Bt1	2.9	13.2	83.9
	3-9	8-23	Bt2	3.3	13.7	83.0
	9-18	23-45	Bt3	3.4	16.7	79.9
	18-31	45-80	Bt4	8.7	35.0	56.3
	31-43	80-110	Bw1	16.4	40.6	43.0
	43-61	110-155	Bw2	13.1	50.9	36.0
	61-74	155-187	Bw3	28.0	50.4	21.6
	74-93	187-237	Bw4	30.3	52.0	17.7
Palm:						
S87PR-119-004	0-3	0-8	Oi	---	---	---
	3-10	8-25	A	17.2	50.4	32.4
	10-19	25-48	BA	26.2	40.9	32.9
	19-31	48-79	Bg	21.6	42.5	35.9
	31-63	79-160	Bw	19.4	43.1	37.5
Picacho:						
S87PR-003-005	0-3	0-8	Oi	---	---	---
	3-4	8-10	A	67.0	14.4	18.6
	4-10	10-25	Bw1	65.7	14.1	20.2
	10-15	25-38	Bw2	64.3	15.2	20.5
	15-27	38-69	Bw3	61.5	15.9	22.6
	27-63	69-160	C	61.7	23.7	14.6
Utuado:						
S85PR-103-001	0-1	0-3	Oi	---	---	---
	1-2	3-5	A	62.1	21.0	16.9
	2-7	5-18	Bw1	62.7	20.2	17.1
	7-13	18-33	Bw2	65.1	19.7	15.2
	13-28	33-71	C1	73.2	24.0	2.8
	28-61	71-155	C2	78.6	19.2	2.2
Yunque:						
S87PR-003-002	0-2	0-5	Oi	---	---	---
	2-7	5-18	A	3.1	21.5	75.4
	7-17	18-43	Bt1	2.8	21.7	75.5
	17-30	43-76	Bt2	3.1	34.1	62.8
	30-33	76-84	Bw1	7.9	47.8	44.3
	33-51	84-130	Bw2	12.9	50.0	37.1
	51-62	130-157	Bw3	15.2	51.3	33.5

Table 12.--Physical Analyses of Selected Soils--Continued

Soil name and sample number	Depth		Horizon	Particle-size distribution (Percent less than 2.0 mm)		
				Sand (2.0-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)
	In	cm				
Zarzal:						
S86PR-119-012	0-1	0-2	A	20.2	29.7	50.1
	1-7	2-17	Bo	11.4	24.3	64.3
	7-15	17-38	Bto1	10.6	24.2	65.2
	15-26	38-65	Bto2	12.6	22.6	64.8
	26-35	65-89	Bto3	17.0	24.1	58.9
	35-46	89-118	Bw1	26.3	29.7	44.0
	46-56	118-143	Bw2	26.8	36.3	36.9
	56-69	143-175	Bw3	18.4	49.0	32.6
	69-75	175-190	Bw4	27.0	41.8	31.2
	75-82	190-209	Bw5	29.2	43.9	26.9
	82-90	209-230	Cr	31.8	38.7	29.5

Table 13.--Chemical Analyses of Selected Soils

(Dashes indicate that data were not determined. TR means trace, and CEC means cation-exchange capacity.)

Soil name and sample number	Depth		Horizon	Extractable bases					Acidity	Extractable Aluminium	CEC			Base sum	pH (H_2O)	pH (KCl)	Organic carbon
				Ca	Mg	K	Na	Sum			Sum cations	NH_4OAc	Bases +Al				
	In	cm		Milliequivalents/100 grams of soil										Pct			Pct
Dwarf:	0-4	0-10	Oa	0.6	1.7	0.2	0.3	2.8	71.6	7.1	74.4	54.2	9.9	4	4.6	3.9	22.20
S87PR-003-003	4-9	10-23	A	---	0.2	TR	---	0.2	49.4	7.9	49.6	43.5	8.1	TR	4.5	3.7	11.70
	9-16	23-40	Bg1	---	0.1	---	---	0.1	34.2	6.3	34.3	29.8	6.4	TR	4.7	3.9	9.42
	16-26	40-66	Bg2	---	0.1	---	---	0.1	29.7	5.5	29.8	21.0	5.6	TR	4.9	4.0	7.17
	26-35	66-89	Bw	---	TR	---	---	TR	25.2	4.5	25.2	13.7	0.2	TR	5.0	4.1	4.25
	35-43	89-110	2BC	---	0.2	---	TR	0.2	16.6	3.0	16.8	9.7	3.2	2	5.0	4.0	1.23
	43-52	110-133	2C1	---	0.2	---	---	0.2	11.8	4.8	12.0	8.3	5.0	2	4.8	3.9	0.97
	52-60	133-152	2C2	---	0.1	---	---	0.1	11.0	5.0	11.1	8.0	5.1	1	4.7	3.9	0.57
Los Guineos:	0-1	0-3	A	3.6	3.9	0.4	0.2	8.1	43.1	4.6	51.2	41.2	12.7	16	4.3	3.5	12.40
S86PR-119-010	1-3	3-8	Bt1	1.0	1.6	0.2	---	2.8	32.6	4.0	35.4	26.4	6.8	8	4.4	3.7	7.65
	3-9	8-23	Bt2	0.2	0.6	0.1	---	0.9	21.1	4.0	22.0	14.5	4.9	4	4.3	3.8	3.91
	9-18	23-46	Bt3	0.1	0.3	0.1	---	0.5	17.3	3.5	17.8	10.7	4.0	3	4.4	3.8	2.64
	18-31	46-70	Bt4	0.1	0.1	---	---	0.2	15.6	2.8	15.8	8.3	3.0	1	4.5	3.9	1.01
	31-43	70-109	Bw1	---	0.1	---	---	0.1	15.0	2.3	15.1	8.2	2.4	1	4.7	4.0	0.58
	43-61	109-155	Bw2	---	0.1	---	---	0.1	13.9	3.5	14.0	8.1	3.6	1	4.7	3.9	0.46
	61-74	155-188	Bw3	---	0.1	---	---	0.1	11.5	3.8	11.6	6.9	3.9	1	4.7	4.0	0.33
	74-93	188-236	Bw4	---	0.1	---	0.2	---	13.7	3.2	---	5.7	3.2	---	4.8	---	0.17
Palm:	0-3	0-8	Oi	---	---	---	---	---	---	---	---	---	---	---	---	---	---
S87PR-119-004	3-10	8-25	A	19.3	2.4	---	---	21.7	39.5	0.5	61.2	40.5	22.2	35	5.3	4.6	13.30
	10-19	25-48	BA	10.3	1.9	0.2	0.1	12.5	42.8	2.7	55.3	45.6	15.2	23	4.8	4.0	10.40
	19-31	48-79	Bg	2.0	0.7	0.2	---	2.9	19.3	1.0	22.2	16.9	3.9	13	5.1	4.2	2.07
	31-63	79-160	Bw	1.5	0.5	0.1	TR	2.1	18.3	0.6	20.4	15.8	2.7	10	5.3	4.4	1.48
Picacho:	0-3	0-8	Oi	---	---	---	---	---	---	---	---	---	---	---	---	---	---
S87PR-003-005	3-4	8-10	A	2.0	1.0	0.2	---	3.2	18.8	1.3	22.0	14.5	4.5	15	4.8	3.9	5.32
	4-10	10-25	Bw1	1.3	0.9	TR	---	2.2	16.0	1.5	18.2	11.8	3.7	12	4.9	3.9	4.31
	10-15	25-38	Bw2	0.1	0.2	---	---	0.3	8.1	1.5	8.4	5.4	1.8	4	4.9	4.0	1.44
	15-27	38-69	Bw3	---	0.1	---	---	0.1	8.7	1.6	8.8	6.1	1.7	1	5.0	4.0	1.00
	27-63	69-160	C	TR	1.3	TR	---	0.3	9.6	2.6	9.9	8.7	2.9	3	5.1	3.9	0.20
Utuado:	0-1	0-3	Oi	---	---	---	---	---	---	---	---	---	---	---	---	---	---
S85PR-103-001	1-2	3-5	A	4.4	1.7	0.3	0.2	6.6	16.1	0.4	22.7	15.4	7.0	29	5.4	---	5.69
	2-7	5-18	Bw1	2.3	0.8	0.1	0.1	3.3	13.0	0.9	16.3	10.5	4.2	20	5.2	---	3.20
	7-13	18-33	Bw2	0.9	0.5	TR	0.1	1.5	8.6	0.9	10.1	7.3	2.4	15	5.2	---	1.50
	13-28	33-71	C1	0.6	0.4	TR	0.1	1.1	5.4	2.0	6.5	8.3	3.1	17	5.1	---	0.17
	28-61	71-155	C2	0.6	0.7	---	0.1	1.4	7.4	3.9	6.8	9.4	5.3	16	5.2	---	0.14

Table 13.--Chemical Analyses of Selected Soils--Continued

Soil name and sample number	Depth		Horizon	Extractable bases					Acidity	Extractable Aluminium	CEC			Base sum	pH (H_2O)	pH (KCl)	Organic carbon
				Ca	Mg	K	Na	Sum			Sum cations	NH_4OAc	Bases +Al				
	In	cm		Milliequivalents/100 grams of soil										Pct			Pct
Yunque:	0-2	0-5	Oi	---	---	---	---	---	---	---	---	---	---	---	---	---	---
S87PR-003-002	2-7	5-18	A	0.2	0.4	0.1	0.2	0.9	24.7	4.3	25.6	16.1	5.2	4	4.5	3.9	4.55
	7-17	18-43	Bt1	0.1	0.2	TR	0.1	0.4	19.3	3.8	19.7	11.2	4.2	2	4.5	4.0	3.11
	17-30	43-76	Bt2	0.1	0.1	---	0.2	0.4	15.1	2.6	15.1	8.9	3.0	3	4.7	4.0	1.55
	30-33	76-84	Bw1	0.1	TR	---	0.1	0.2	9.2	25.0	9.2	6.6	25.2	2	5.0	4.0	0.37
	33-51	84-130	Bw2	0.1	TR	---	0.2	0.3	6.3	29.0	6.3	8.0	29.3	5	4.9	3.9	0.19
	51-62	130-157	Bw3	---	0.1	---	0.1	0.2	9.7	3.3	9.9	7.4	3.5	2	5.0	3.9	0.15
Zarzal:	0-1	0-2	A	52.7	11.2	1.1	TR	65.0	22.3	---	87.3	63.8	---	74	6.3	5.9	16.20
S86PR-119-012	1-7	2-17	Bo	3.4	2.5	0.4	---	6.3	18.1	1.0	24.4	18.8	7.3	26	4.9	4.1	2.46
	7-15	17-38	Bto1	2.2	2.1	0.1	0.1	4.5	17.2	1.6	21.7	15.3	6.1	21	5.0	4.0	1.94
	15-26	38-65	Bto2	1.1	1.5	TR	TR	2.6	16.2	2.1	18.8	12.8	4.7	14	5.1	4.0	1.03
	26-35	65-89	Bto3	0.8	1.6	TR	0.1	2.5	16.1	2.5	18.6	13.0	5.0	13	5.1	4.0	0.66
	35-46	89-118	Bw1	0.6	1.8	TR	0.1	2.5	16.4	4.0	18.9	13.4	6.5	13	5.2	3.9	0.30
	46-56	118-143	Bw2	0.8	1.9	TR	0.1	2.8	16.0	5.0	18.8	13.6	7.8	15	5.2	3.9	0.29
	56-69	143-175	Bw3	0.4	1.2	TR	0.2	1.8	12.4	3.6	14.2	9.6	5.4	13	5.2	3.9	0.26
	69-75	175-192	Bw4	0.8	2.5	TR	0.2	3.5	17.3	6.6	20.8	15.4	10.1	17	5.0	3.8	0.23
	75-82	192-209	Bw5	0.6	2.4	TR	0.2	3.2	18.0	7.7	21.2	16.5	10.9	15	5.1	3.8	0.17
	82-90	209-230	Cr	0.4	1.9	0.1	0.2	2.6	15.0	6.2	17.6	14.4	8.8	15	5.0	3.8	0.14

Table 14.--Soil Features

(See text for definitions of terms used in this table. Absence of an entry indicates that the feature is not a concern or that data were not estimated.)

Map symbol and soil name	Restrictive layer			Risk of corrosion	
	Kind	Depth to top	Hardness	Uncoated steel	Concrete
		In			
112:					
Zarzal	---	---	---	High	High
Cristal	---	---	---	High	High
113:					
Cristal	---	---	---	High	High
Zarzal	---	---	---	High	High
114:					
Zarzal	---	---	---	High	High
115:					
Humatas	---	---	---	High	High
Zarzal	---	---	---	High	High
121:					
Sonadora	Bedrock (paralithic)	20-40	Strongly cemented	High	Low
Caguabo	Bedrock (lithic)	10-20	Indurated	Moderate	Low
131:					
Sonadora	Bedrock (paralithic)	20-40	Strongly cemented	High	Low
Caguabo	Bedrock (lithic)	10-20	Indurated	Moderate	Low
132:					
Caguabo	Bedrock (lithic)	10-20	Indurated	Moderate	Low
135:					
Prieto	Bedrock (paralithic)	20-40	Strongly cemented	High	Moderate
141:					
Luquillo	---	---	---	High	Moderate
142:					
Coloso	---	---	---	High	Moderate
212:					
Yunque	---	---	---	High	High
Moteado	Bedrock (lithic)	40-60	Indurated	High	High
213:					
Yunque	---	---	---	High	High
214:					
Yunque	---	---	---	High	High
Los Guineos	---	---	---	High	High
Moteado	Bedrock (lithic)	40-60	Indurated	High	High
215:					
Palm	---	---	---	High	High
Yunque	---	---	---	High	High

Table 14.--Soil Features--Continued

Map symbol and soil name	Restrictive layer			Risk of corrosion	
	Kind	Depth to top	Hardness	Uncoated steel	Concrete
		In			
221:					
Picacho	---	---	---	High	High
Utuado	---	---	---	Moderate	High
223:					
Picacho	---	---	---	High	High
Ciales	---	---	---	High	High
224:					
Picacho	---	---	---	High	High
Utuado	---	---	---	Moderate	High
225:					
Icacos	---	---	---	High	High
231:					
Guayabota	Bedrock (lithic)	10-20	Indurated	High	High
Yunque	---	---	---	High	High
311:					
Dwarf	---	---	---	High	High

Table 15.--Water Features

(See text for definitions of terms used in this table. Estimates of the frequency of flooding apply to the whole year rather than to individual months. Absence of an entry indicates that the feature is not a concern or that data were not estimated.)

Map symbol and soil name	Hydrologic group	Month	Water table: Upper limit	Water table: Lower limit	Flooding: Duration	Flooding: Frequency
			Ft	Ft		
112:						
Zarzal	B	Jan-Dec	---	---	---	None
Cristal	C	January	1.5-2.0	2.0-3.0	---	None
		February	1.5-2.0	2.0-3.0	---	None
		March	1.5-2.0	2.0-3.0	---	None
		April	1.0-1.5	1.5-2.0	---	None
		May	1.0-1.5	1.5-2.0	---	None
		June	1.0-1.5	1.5-2.0	---	None
		July	1.0-1.5	1.5-2.0	---	None
		August	1.0-1.5	1.5-2.0	---	None
		September	1.0-1.5	1.5-2.0	---	None
		October	1.0-1.5	1.5-2.0	---	None
		November	1.0-1.5	1.5-2.0	---	None
		December	1.5-2.0	2.0-3.0	---	None
113:						
Cristal	C	January	1.5-2.0	2.0-3.0	---	None
		February	1.5-2.0	2.0-3.0	---	None
		March	1.5-2.0	2.0-3.0	---	None
		April	1.0-1.5	1.5-2.0	---	None
		May	1.0-1.5	1.5-2.0	---	None
		June	1.0-1.5	1.5-2.0	---	None
		July	1.0-1.5	1.5-2.0	---	None
		August	1.0-1.5	1.5-2.0	---	None
		September	1.0-1.5	1.5-2.0	---	None
		October	1.0-1.5	1.5-2.0	---	None
		November	1.0-1.5	1.5-2.0	---	None
		December	1.5-2.0	2.0-3.0	---	None
Zarzal	B	Jan-Dec	---	---	---	None
114:						
Zarzal	B	Jan-Dec	---	---	---	None
115:						
Humatas	C	Jan-Dec	---	---	---	None
Zarzal	B	Jan-Dec	---	---	---	None
121:						
Sonadora	D	Jan-Dec	---	---	---	None
Caguabo	D	Jan-Dec	---	---	---	None
131:						
Sonadora	D	Jan-Dec	---	---	---	None
Caguabo	D	Jan-Dec	---	---	---	None
132:						
Caguabo	D	Jan-Dec	---	---	---	None

Table 15.--Water Features--Continued

Map symbol and soil name	Hydrologic group	Month	Water table: Upper limit	Water table: Lower limit	Flooding: Duration	Flooding: Frequency
			Ft	Ft		
135:						
Prieto	D	January	0.0-1.0	1.7-3.3	---	None
		February	0.0-1.0	1.7-3.3	---	None
		March	0.0-1.0	1.7-3.3	---	None
		April	0.0-0.5	1.7-3.3	---	None
		May	0.0-0.5	1.7-3.3	---	None
		June	0.0-0.5	1.7-3.3	---	None
		July	0.0-0.5	1.7-3.3	---	None
		August	0.0-0.5	1.7-3.3	---	None
		September	0.0-0.5	1.7-3.3	---	None
		October	0.0-0.5	1.7-3.3	---	None
		November	0.0-0.5	1.7-3.3	---	None
		December	0.0-1.0	1.7-3.3	---	None
141:						
Luquillo	B	June	---	---	Brief	Occasional
		July	---	---	Brief	Occasional
		August	---	---	Brief	Occasional
		September	---	---	Brief	Occasional
142:						
Coloso	D	July	2.0-4.0	>6.0	Brief	Occasional
		August	2.0-4.0	>6.0	Brief	Occasional
		September	2.0-4.0	>6.0	Brief	Occasional
212:						
Yunque	C	January	2.5-4.0	3.0-5.0	---	None
		February	2.5-4.0	3.0-5.0	---	None
		March	2.5-4.0	3.0-5.0	---	None
		April	2.0-2.5	3.0-5.0	---	None
		May	2.0-2.5	3.0-5.0	---	None
		June	2.0-2.5	3.0-5.0	---	None
		July	2.0-2.5	3.0-5.0	---	None
		August	2.0-2.5	3.0-5.0	---	None
		September	2.0-2.5	3.0-5.0	---	None
		October	2.0-2.5	3.0-5.0	---	None
		November	2.0-2.5	3.0-5.0	---	None
		December	2.5-4.0	3.0-5.0	---	None
Moteado	D	January	0.0-1.0	3.3-5.0	---	None
		February	0.0-1.0	3.3-5.0	---	None
		March	0.0-1.0	3.3-5.0	---	None
		April	0.0-1.0	3.3-5.0	---	None
		May	0.0-0.5	3.3-5.0	---	None
		June	0.0-0.5	3.3-5.0	---	None
		July	0.0-1.0	3.3-5.0	---	None
		August	0.0-0.5	3.3-5.0	---	None
		September	0.0-0.5	1.5-4.0	---	None
		October	0.0-1.0	3.3-5.0	---	None
		November	0.0-0.5	3.3-5.0	---	None
		December	0.0-1.0	3.3-5.0	---	None

Table 15.--Water Features--Continued

Map symbol and soil name	Hydrologic group	Month	Water table: Upper limit	Water table: Lower limit	Flooding: Duration	Flooding: Frequency
			Ft	Ft		
213:						
Yunque	C	January	2.5-4.0	3.0-5.0	---	None
		February	2.5-4.0	3.0-5.0	---	None
		March	2.5-4.0	3.0-5.0	---	None
		April	2.0-2.5	3.0-5.0	---	None
		May	2.0-2.5	3.0-5.0	---	None
		June	2.0-2.5	3.0-5.0	---	None
		July	2.0-2.5	3.0-5.0	---	None
		August	2.0-2.5	3.0-5.0	---	None
		September	2.0-2.5	3.0-5.0	---	None
		October	2.0-2.5	3.0-5.0	---	None
		November	2.0-2.5	3.0-5.0	---	None
		December	2.5-4.0	3.0-5.0	---	None
214:						
Yunque	C	January	2.5-4.0	3.0-5.0	---	None
		February	2.5-4.0	3.0-5.0	---	None
		March	2.5-4.0	3.0-5.0	---	None
		April	2.0-2.5	3.0-5.0	---	None
		May	2.0-2.5	3.0-5.0	---	None
		June	2.0-2.5	3.0-5.0	---	None
		July	2.0-2.5	3.0-5.0	---	None
		August	2.0-2.5	3.0-5.0	---	None
		September	2.0-2.5	3.0-5.0	---	None
		October	2.0-2.5	3.0-5.0	---	None
		November	2.0-2.5	3.0-5.0	---	None
		December	2.5-4.0	3.0-5.0	---	None
Los Guineos	C	Jan-Dec	---	---	---	None
Moteado	D	January	0.0-1.0	3.3-5.0	---	None
		February	0.0-1.0	3.3-5.0	---	None
		March	0.0-1.0	3.3-5.0	---	None
		April	0.0-0.5	3.3-5.0	---	None
		May	0.0-0.5	3.3-5.0	---	None
		June	0.0-0.5	3.3-5.0	---	None
		July	0.0-0.5	3.3-5.0	---	None
		August	0.0-0.5	3.3-5.0	---	None
		September	0.0-0.5	3.3-5.0	---	None
		October	0.0-0.5	3.3-5.0	---	None
		November	0.0-0.5	3.3-5.0	---	None
		December	0.0-1.0	3.3-5.0	---	None
215:						
Palm	D	January	0.0-1.0	1.0-6.0	---	None
		February	0.0-1.0	1.0-6.0	---	None
		March	0.0-1.0	1.0-6.0	---	None
		April	0.0-0.5	1.0-6.0	---	None
		May	0.0-0.5	1.0-6.0	---	None
		June	0.0-0.5	1.0-6.0	---	None
		July	0.0-0.5	1.0-6.0	---	None
		August	0.0-0.5	1.0-6.0	---	None
		September	0.0-0.5	1.0-6.0	---	None
		October	0.0-0.5	1.0-6.0	---	None
		November	0.0-0.5	1.0-6.0	---	None
		December	0.0-1.0	1.0-6.0	---	None

Table 15.--Water Features--Continued

Map symbol and soil name	Hydro-logic group	Month	Water table: Upper limit	Water table: Lower limit	Flooding: Duration	Flooding: Frequency
			Ft	Ft		
215:						
Yunque	C	January	2.5-4.0	3.0-5.0	---	None
		February	2.5-4.0	3.0-5.0	---	None
		March	2.5-4.0	3.0-5.0	---	None
		April	2.0-2.5	3.0-5.0	---	None
		May	2.0-2.5	3.0-5.0	---	None
		June	2.0-2.5	3.0-5.0	---	None
		July	2.0-2.5	3.0-5.0	---	None
		August	2.0-2.5	3.0-5.0	---	None
		September	2.0-2.5	3.0-5.0	---	None
		October	2.0-2.5	3.0-5.0	---	None
		November	2.0-2.5	3.0-5.0	---	None
		December	2.5-4.0	3.0-5.0	---	None
221:						
Picacho	C	January	1.0-1.5	2.0-5.0	---	None
		February	1.0-1.5	2.0-5.0	---	None
		March	1.0-1.5	2.0-5.0	---	None
		April	1.0-1.5	2.0-5.0	---	None
		May	1.0-1.5	2.0-5.0	---	None
		June	1.0-1.5	2.0-5.0	---	None
		July	1.0-1.5	2.0-5.0	---	None
		August	1.0-1.5	2.0-5.0	---	None
		September	1.0-1.5	2.0-5.0	---	None
		October	1.0-1.5	2.0-5.0	---	None
		November	1.0-1.5	2.0-5.0	---	None
		December	1.0-1.5	2.0-5.0	---	None
Utuado	B	January	1.0-2.0	1.5-2.5	---	None
		February	1.0-2.0	1.5-2.5	---	None
		March	1.0-2.0	1.5-2.5	---	None
		April	1.0-2.0	1.5-2.5	---	None
		May	1.0-2.0	1.5-2.5	---	None
		June	1.0-2.0	1.5-2.5	---	None
		July	1.0-2.0	1.5-2.5	---	None
		August	1.0-2.0	1.5-2.5	---	None
		September	1.0-2.0	1.5-2.5	---	None
		October	1.0-2.0	1.5-2.5	---	None
		November	1.0-2.0	1.5-2.5	---	None
		December	1.0-2.0	1.5-2.5	---	None
223:						
Picacho	C	January	1.0-1.5	2.0-5.0	---	None
		February	1.0-1.5	2.0-5.0	---	None
		March	1.0-1.5	2.0-5.0	---	None
		April	1.0-1.5	2.0-5.0	---	None
		May	1.0-1.5	2.0-5.0	---	None
		June	1.0-1.5	2.0-5.0	---	None
		July	1.0-1.5	2.0-5.0	---	None
		August	1.0-1.5	2.0-5.0	---	None
		September	1.0-1.5	2.0-5.0	---	None
		October	1.0-1.5	2.0-5.0	---	None
		November	1.0-1.5	2.0-5.0	---	None
		December	1.0-1.5	2.0-5.0	---	None

Table 15.--Water Features--Continued

Map symbol and soil name	Hydrologic group	Month	Water table: Upper limit	Water table: Lower limit	Flooding: Duration	Flooding: Frequency
			Ft	Ft		
223:						
Ciales	D	January	0.5-1.0	1.5-2.5	---	None
		February	0.5-1.0	1.5-2.5	---	None
		March	0.5-1.0	1.5-2.5	---	None
		April	0.0-0.5	1.5-2.5	---	None
		May	0.0-0.5	1.5-2.5	---	None
		June	0.0-0.5	1.5-2.5	---	None
		July	0.0-0.5	1.5-2.5	---	None
		August	0.0-0.5	1.5-2.5	---	None
		September	0.0-0.5	1.5-2.5	---	None
		October	0.0-0.5	1.5-3.0	---	None
		November	0.0-0.5	1.5-2.5	---	None
		December	0.5-1.0	1.5-2.5	---	None
224:						
Picacho	C	January	1.0-1.5	2.0-5.0	---	None
		February	1.0-1.5	2.0-5.0	---	None
		March	1.0-1.5	2.0-5.0	---	None
		April	1.0-1.5	2.0-5.0	---	None
		May	1.0-1.5	2.0-5.0	---	None
		June	1.0-1.5	2.0-5.0	---	None
		July	1.0-1.5	2.0-5.0	---	None
		August	1.0-1.5	2.0-5.0	---	None
		September	1.0-1.5	2.0-5.0	---	None
		October	1.0-1.5	2.0-5.0	---	None
		November	1.0-1.5	2.0-5.0	---	None
		December	1.0-1.5	2.0-5.0	---	None
Utuado	B	January	1.0-2.0	1.5-2.5	---	None
		February	1.0-2.0	1.5-2.5	---	None
		March	1.0-2.0	1.5-2.5	---	None
		April	1.0-2.0	1.5-2.5	---	None
		May	1.0-2.0	1.5-2.5	---	None
		June	1.0-2.0	1.5-2.5	---	None
		July	1.0-2.0	1.5-2.5	---	None
		August	1.0-2.0	1.5-2.5	---	None
		September	1.0-2.0	1.5-2.5	---	None
		October	1.0-2.0	1.5-2.5	---	None
		November	1.0-2.0	1.5-2.5	---	None
		December	1.0-2.0	1.5-2.5	---	None
225:						
Icacos	D	January	---	---	Brief	Occasional
		February	---	---	Brief	Occasional
		March	---	---	Brief	Occasional
		April	0.5-1.0	>6.0	Brief	Occasional
		May	0.5-1.0	>6.0	Brief	Occasional
		June	0.5-1.0	>6.0	Brief	Occasional
		July	0.5-1.0	>6.0	Brief	Occasional
		August	0.5-1.0	>6.0	Brief	Occasional
		September	0.5-1.0	>6.0	Brief	Occasional
		October	0.5-1.0	>6.0	Brief	Occasional
		November	0.5-1.0	>6.0	Brief	Occasional
		December	0.5-1.0	>6.0	Brief	Occasional

Table 15.--Water Features--Continued

Map symbol and soil name	Hydrologic group	Month	Water table: Upper limit	Water table: Lower limit	Flooding: Duration	Flooding: Frequency
			Ft	Ft		
231:						
Guayabota	D	January	0.5-1.5	0.8-1.7	---	None
		February	0.5-1.5	0.8-1.7	---	None
		March	0.5-1.5	0.8-1.7	---	None
		April	0.0-0.5	0.8-1.7	---	None
		May	0.0-0.5	0.8-1.7	---	None
		June	0.0-0.5	0.8-1.7	---	None
		July	0.0-0.5	0.8-1.7	---	None
		August	0.0-0.5	0.8-1.7	---	None
		September	0.0-0.5	0.8-1.7	---	None
		October	0.0-0.5	0.8-1.7	---	None
		November	0.0-0.5	0.8-1.7	---	None
		December	0.5-1.5	0.8-1.7	---	None
Yunque	C	January	2.5-4.0	3.0-5.0	---	None
		February	2.5-4.0	3.0-5.0	---	None
		March	2.5-4.0	3.0-5.0	---	None
		April	2.0-2.5	3.0-5.0	---	None
		May	2.0-2.5	3.0-5.0	---	None
		June	2.0-2.5	3.0-5.0	---	None
		July	2.0-2.5	3.0-5.0	---	None
		August	2.0-2.5	3.0-5.0	---	None
		September	2.0-2.5	3.0-5.0	---	None
		October	2.0-2.5	3.0-5.0	---	None
		November	2.0-2.5	3.0-5.0	---	None
		December	2.5-4.0	3.0-5.0	---	None
311:						
Dwarf	D	January	0.5-1.0	3.0-5.0	---	None
		February	0.5-1.0	3.0-5.0	---	None
		March	0.5-1.0	3.0-5.0	---	None
		April	0.0-0.5	3.0-5.0	---	None
		May	0.0-0.5	3.0-5.0	---	None
		June	0.0-0.5	3.0-5.0	---	None
		July	0.0-0.5	3.0-5.0	---	None
		August	0.0-0.5	3.0-5.0	---	None
		September	0.0-0.5	3.0-5.0	---	None
		October	0.0-0.5	3.0-5.0	---	None
		November	0.0-0.5	3.0-5.0	---	None
		December	0.5-1.0	3.0-5.0	---	None

Table 16.--Physical Properties of the Soils

(Entries under "Erosion factors--T" apply to the entire profile. Absence of an entry indicates that data were not estimated.)

Map symbol and soil name	Depth	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensi-bility	Organic matter	Erosion factors Kw	Kf	T
	In	Pct	g/cc	um/sec	In/in	Pct	Pct			
112:										
Zarzal---------	0-1	45-55	1.05-1.20	4.00-14.00	0.12-0.20	6.0-8.9	3.0-6.0	.02	.10	5
	1-7	50-65	1.05-1.20	1.40-4.00	0.13-0.21	3.0-5.9	2.0-5.0	.17	.20	
	7-35	50-65	1.00-1.15	1.40-4.00	0.13-0.20	3.0-5.9	1.0-4.0	.15	.20	
	35-46	50-60	1.05-1.20	1.40-4.00	0.13-0.17	0.0-2.9	0.5-1.0	.15	.20	
	46-82	25-45	1.00-1.20	1.40-4.00	0.18-0.25	0.0-2.9	0.0-0.5	.28	.32	
	82-91	---	---	---	---	---	---	---	---	
Cristal--------	0-2	30-55	1.00-1.20	4.00-14.00	0.11-0.22	3.0-5.9	2.0-5.0	.02	.10	5
	2-15	35-60	1.05-1.25	1.40-4.00	0.13-0.21	3.0-5.9	1.0-3.0	.17	.20	
	15-26	35-55	1.10-1.25	1.40-4.00	0.13-0.21	3.0-5.9	0.5-2.0	.15	.20	
	26-39	30-50	1.10-1.25	1.40-4.00	0.13-0.21	3.0-5.9	0.0-1.0	.15	.20	
	39-60	30-40	1.00-1.25	1.40-4.00	0.15-0.20	0.0-2.9	0.0-0.5	.28	.32	
113:										
Cristal--------	0-2	30-55	1.00-1.20	4.00-14.00	0.12-0.22	3.0-5.9	2.0-5.0	.05	.10	5
	2-15	35-60	1.05-1.25	1.40-4.00	0.13-0.21	3.0-5.9	1.0-3.0	.17	.20	
	15-26	35-55	1.10-1.25	1.40-4.00	0.13-0.21	3.0-5.9	0.5-2.0	.15	.20	
	26-39	30-50	1.10-1.25	1.40-4.00	0.13-0.21	3.0-5.9	0.0-1.0	.15	.20	
	39-60	30-40	1.00-1.25	1.40-4.00	0.15-0.20	0.0-2.9	0.0-0.5	.28	.32	
Zarzal---------	0-1	45-55	1.05-1.20	4.00-14.00	0.12-0.20	6.0-8.9	3.0-6.0	.05	.10	5
	1-7	50-65	1.05-1.20	1.40-4.00	0.13-0.21	3.0-5.9	2.0-5.0	.17	.20	
	7-35	50-65	1.00-1.15	1.40-4.00	0.13-0.20	3.0-5.9	1.0-4.0	.15	.20	
	35-46	50-60	1.05-1.20	1.40-4.00	0.13-0.17	0.0-2.9	0.5-1.0	.15	.20	
	46-82	25-45	1.00-1.20	1.40-4.00	0.18-0.25	0.0-2.9	0.0-0.5	.28	.32	
	82-91	---	---	---	---	---	---	---	---	
114:										
Zarzal---------	0-1	45-55	1.05-1.20	4.00-14.00	0.12-0.20	6.0-8.9	3.0-6.0	.02	.10	5
	1-7	50-65	1.05-1.20	1.40-4.00	0.13-0.21	3.0-5.9	2.0-5.0	.17	.20	
	7-35	50-65	1.00-1.15	1.40-4.00	0.13-0.20	3.0-5.9	1.0-4.0	.15	.20	
	35-46	50-60	1.05-1.20	1.40-4.00	0.13-0.17	0.0-2.9	0.5-1.0	.15	.20	
	46-82	25-45	1.00-1.20	1.40-4.00	0.18-0.25	0.0-2.9	0.0-0.5	.28	.32	
	82-91	---	---	---	---	---	---	---	---	
115:										
Humatas--------	0-4	45-65	1.00-1.25	4.00-14.00	0.12-0.18	3.0-5.9	2.0-8.0	.02	.02	5
	4-38	60-75	1.05-1.20	4.00-14.00	0.12-0.18	6.0-8.9	1.0-4.0	.02	.02	
	38-60	32-45	1.00-1.20	4.00-14.00	0.10-0.16	0.0-2.9	0.5-1.0	.02	.02	
Zarzal---------	0-1	45-60	1.00-1.10	4.00-14.00	0.16-0.22	6.0-8.9	3.0-6.0	.10	.10	5
	1-7	50-65	1.05-1.20	1.40-4.00	0.13-0.21	3.0-5.9	2.0-5.0	.17	.20	
	7-35	50-65	1.00-1.15	1.40-4.00	0.13-0.20	3.0-5.9	1.0-4.0	.15	.20	
	35-46	50-60	1.05-1.20	1.40-4.00	0.13-0.17	0.0-2.9	0.5-1.0	.15	.20	
	46-82	30-50	1.00-1.20	1.40-4.00	0.18-0.25	0.0-2.9	0.0-0.5	.28	.32	
	82-91	---	---	---	---	---	---	---	---	
121:										
Sonadora--------	0-1	30-40	1.35-1.45	4.00-14.00	0.10-0.13	6.0-8.9	2.0-6.0	.10	.10	3
	1-21	40-55	1.35-1.45	4.00-14.00	0.18-0.20	9.0-25.0	1.0-3.0	.24	.24	
	21-36	30-40	1.35-1.45	0.42-1.40	0.00-0.01	6.0-8.9	0.5-1.0	.10	.10	
	36-60	---	---	---	---	---	---	---	---	
Caguabo--------	0-3	27-35	1.25-1.35	4.00-14.00	0.15-0.20	3.0-5.9	1.0-3.0	.17	.24	1
	3-11	27-35	1.30-1.40	4.00-14.00	0.05-0.10	0.0-2.9	0.5-1.0	.17	.24	
	11-16	---	---	0.42-1.40	0.00-0.01	---	---	---	---	
	16-60	---	---	---	---	---	---	---	---	

Table 16.--Physical Properties of the Soils--Continued

Map symbol and soil name	Depth	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensi-bility	Organic matter	Erosion factors Kw	Kf	T
	In	Pct	g/cc	um/sec	In/in	Pct	Pct			
131:										
Sonadora--------	0-1	30-40	1.30-1.40	4.00-14.00	0.10-0.12	6.0-8.9	2.0-6.0	.05	.10	3
	1-21	40-55	1.35-1.45	4.00-14.00	0.18-0.20	9.0-25.0	1.0-3.0	.24	.24	
	21-36	30-40	1.35-1.45	0.42-1.40	0.00-0.01	6.0-8.9	0.5-1.0	.05	.10	
	36-60	---	---	---	---	---	---	---	---	
Caguabo---------	0-3	27-35	1.25-1.35	4.00-14.00	0.10-0.15	0.0-2.9	1.0-3.0	.15	.24	1
	3-11	27-35	1.30-1.40	4.00-14.00	0.05-0.10	0.0-2.9	0.5-1.0	.17	.24	
	11-16	---	---	0.42-1.40	0.00-0.01	---	---	---	---	
	16-60	---	---	---	---	---	---	---	---	
132:										
Caguabo---------	0-3	27-35	1.25-1.35	4.00-14.00	0.10-0.15	0.0-2.9	1.0-3.0	.17	.24	1
	3-11	27-35	1.30-1.40	4.00-14.00	0.05-0.10	0.0-2.9	0.5-1.0	.17	.24	
	11-16	---	---	0.42-1.40	0.00-0.01	---	---	---	---	
	16-60	---	---	---	---	---	---	---	---	
135:										
Prieto----------	0-4	35-45	1.00-1.20	4.00-14.00	0.10-0.16	3.0-5.9	3.0-6.0	.02	.15	3
	4-13	35-50	1.05-1.25	1.40-4.00	0.13-0.21	3.0-5.9	2.0-4.0	.10	.17	
	13-25	35-50	1.10-1.25	1.40-4.00	0.13-0.21	3.0-5.9	1.0-3.0	.10	.17	
	25-35	35-50	1.10-1.25	1.40-4.00	0.15-0.20	3.0-5.9	0.5-3.0	.15	.20	
	35-60	---	---	---	---	---	---	---	---	
141:										
Luquillo--------	0-5	30-60	1.20-1.35	4.00-14.00	0.15-0.20	6.0-8.9	1.0-3.0	.10	.10	5
	5-35	30-50	1.30-1.50	14.00-42.00	0.10-0.15	0.0-2.9	1.0-3.0	.10	.05	
	35-60	25-40	1.30-1.50	14.00-42.00	0.10-0.15	0.0-2.9	1.0-3.0	.10	.05	
142:										
Coloso----------	0-4	30-40	1.25-1.35	1.40-4.00	0.14-0.18	3.0-5.9	2.0-4.0	.24	.24	5
	4-60	35-55	1.25-1.30	0.42-4.00	0.12-0.18	3.0-5.9	1.0-3.0	.24	.24	
212:										
Yunque----------	0-2	---	---	---	---	---	---	---	---	5
	2-7	40-70	1.20-1.40	4.00-14.00	0.15-0.20	3.0-5.9	2.0-8.0	.05	.10	
	7-30	35-70	1.00-1.30	4.00-14.00	0.10-0.16	3.0-5.9	0.5-3.0	.10	.10	
	30-62	30-60	1.00-1.30	4.00-14.00	0.10-0.16	3.0-5.9	0.2-1.0	.10	.10	
Moteado---------	0-1	---	---	---	---	---	---	---	---	3
	1-6	35-55	0.80-1.20	4.00-14.00	0.10-0.15	6.0-8.9	6.0-10	.05	.15	
	6-22	45-60	0.90-1.20	0.42-1.40	0.12-0.20	6.0-8.9	5.0-8.0	.10	.15	
	22-41	50-65	0.90-1.20	0.42-1.40	0.10-0.19	6.0-8.9	0.5-2.0	.10	.15	
	41-54	50-65	1.00-1.25	0.42-1.40	0.10-0.15	3.0-5.9	0.5-1.0	.17	.20	
	54-60	---	---	---	---	---	---	---	---	
213:										
Yunque----------	0-2	---	---	---	---	---	---	---	---	5
	2-7	40-70	1.20-1.40	4.00-14.00	0.15-0.20	3.0-5.9	2.0-8.0	.05	.10	
	7-30	35-70	1.00-1.30	4.00-14.00	0.10-0.16	3.0-5.9	0.5-3.0	.10	.10	
	30-62	30-60	1.00-1.30	4.00-14.00	0.10-0.16	3.0-5.9	0.2-1.0	.10	.10	
214:										
Yunque----------	0-2	---	---	---	---	---	---	---	---	5
	2-7	40-70	1.20-1.40	4.00-14.00	0.15-0.20	3.0-5.9	2.0-8.0	.05	.10	
	7-30	35-70	1.00-1.30	4.00-14.00	0.10-0.16	3.0-5.9	0.5-3.0	.10	.10	
	30-62	30-70	1.00-1.30	4.00-14.00	0.10-0.16	3.0-5.9	0.2-1.0	.10	.10	
Los Guineos----	0-1	45-60	1.20-1.30	4.00-14.00	0.15-0.17	3.0-5.9	4.0-10	.10	.10	5
	1-31	45-60	1.20-1.35	4.00-14.00	0.15-0.17	3.0-5.9	1.0-4.0	.10	.10	
	31-93	45-60	1.20-1.35	4.00-14.00	0.15-0.17	3.0-5.9	1.0-4.0	.10	.10	

Table 16.--Physical Properties of the Soils--Continued

Map symbol and soil name	Depth	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensi-bility	Organic matter	Erosion factors Kw	Kf	T
	In	Pct	g/cc	um/sec	In/in	Pct	Pct			
214:										
Moteado--------	0-1	---	---	---	---	---	---	---	---	3
	1-6	35-55	0.80-1.20	4.00-14.00	0.10-0.15	6.0-8.9	6.0-10	.10	.15	
	6-22	45-60	0.90-1.20	0.42-1.40	0.12-0.20	6.0-8.9	5.0-8.0	.10	.15	
	22-41	50-65	0.90-1.20	0.42-1.40	0.10-0.19	6.0-8.9	0.5-2.0	.10	.15	
	41-54	50-65	1.00-1.25	0.42-1.40	0.10-0.15	3.0-5.9	0.5-1.0	.17	.20	
	54-60	---	---	---	---	---	---	---	---	
215:										
Palm----------	0-3	---	---	---	---	---	---	---	---	5
	3-10	40-50	0.60-0.75	1.40-4.00	0.18-0.25	6.0-8.9	20-30	.24	.32	
	10-19	30-50	0.60-0.80	1.40-4.00	0.20-0.25	6.0-8.9	14-19	.24	.28	
	19-31	30-50	0.80-1.20	1.40-4.00	0.08-0.12	3.0-5.9	2.0-5.0	.05	.24	
	31-63	30-50	0.80-1.20	1.40-4.00	0.08-0.16	3.0-5.9	1.0-3.0	.05	.24	
Yunque---------	0-2	---	---	---	---	---	---	---	---	5
	2-7	40-70	1.20-1.40	4.00-14.00	0.15-0.20	3.0-5.9	2.0-8.0	.05	.10	
	7-30	35-70	1.00-1.30	4.00-14.00	0.10-0.16	3.0-5.9	0.5-3.0	.10	.10	
	30-62	30-60	1.00-1.30	4.00-14.00	0.10-0.16	3.0-5.9	0.2-1.0	.10	.10	
221:										
Picacho--------	0-3	---	---	---	---	---	---	---	---	5
	3-4	18-27	1.20-1.35	4.00-14.00	0.15-0.20	3.0-5.9	1.0-3.0	.17	.17	
	4-27	40-80	1.25-1.30	1.40-4.00	0.20-0.25	3.0-5.9	1.0-3.0	.20	.20	
	27-63	18-27	1.20-1.30	4.00-14.00	0.15-0.20	0.0-2.9	0.5-2.0	.10	.10	
Utuado---------	0-1	---	---	---	---	---	---	---	---	5
	1-2	18-35	1.35-1.55	4.00-14.00	0.16-0.18	0.0-2.9	2.0-8.0	.17	.17	
	2-13	18-35	1.30-1.45	4.00-14.00	0.16-0.18	0.0-2.9	2.0-4.0	.17	.17	
	13-28	10-27	1.35-1.55	14.00-42.00	0.14-0.18	0.0-2.9	1.0-3.0	.20	.20	
	28-61	10-18	1.55-1.95	42.00-141.00	0.10-0.14	0.0-2.9	0.0-0.5	.10	.10	
223:										
Picacho--------	0-3	---	---	---	---	---	---	---	---	5
	3-4	13-27	1.20-1.35	4.00-14.00	0.15-0.20	3.0-5.9	1.0-3.0	.17	.17	
	4-27	18-40	1.25-1.30	1.40-4.00	0.20-0.25	3.0-5.9	1.0-2.0	.20	.20	
	27-63	13-27	1.25-1.30	1.40-4.00	0.15-0.20	3.0-5.9	0.5-1.0	.20	.20	
Ciales---------	0-9	27-35	1.10-1.15	4.00-14.00	0.16-0.20	0.0-2.9	10-30	.20	.20	5
	9-25	40-50	1.15-1.25	0.42-1.40	0.15-0.20	0.0-2.9	1.0-7.0	.24	.24	
	25-39	32-38	1.15-1.25	4.00-14.00	0.10-0.15	0.0-2.9	0.0-1.0	.24	.24	
	39-73	27-35	1.15-1.25	4.00-14.00	0.10-0.15	0.0-2.9	0.0-1.0	.24	.24	
224:										
Picacho--------	0-3	---	---	---	---	---	---	---	---	5
	3-4	13-27	1.20-1.35	4.00-14.00	0.15-0.20	3.0-5.9	1.0-3.0	.17	.17	
	4-27	27-40	1.30-1.40	4.00-14.00	0.15-0.20	0.0-2.9	0.5-2.0	.20	.20	
	27-63	18-27	1.20-1.30	4.00-14.00	0.15-0.20	0.0-2.9	0.5-1.0	.20	.20	
Utuado---------	0-1	---	---	---	---	---	---	---	---	5
	1-2	18-35	1.35-1.55	4.00-14.00	0.16-0.18	0.0-2.9	2.0-8.0	.17	.17	
	2-13	18-35	1.30-1.45	4.00-14.00	0.16-0.18	0.0-2.9	2.0-4.0	.17	.17	
	13-28	10-27	1.35-1.55	14.00-42.00	0.14-0.18	0.0-2.9	1.0-3.0	.20	.20	
	28-61	10-18	1.55-1.95	42.00-141.00	0.10-0.14	0.0-2.9	0.0-0.5	.10	.10	
225:										
Icacos---------	0-4	18-30	1.35-1.45	4.00-14.00	0.14-0.18	0.0-2.9	6.0-10	.15	.15	5
	4-14	20-30	1.35-1.45	4.00-14.00	0.14-0.18	0.0-2.9	4.0-6.0	.15	.15	
	14-60	20-40	1.35-1.45	4.00-14.00	0.12-0.17	0.0-2.9	3.0-5.0	.15	.15	

Table 16.--Physical Properties of the Soils--Continued

Map symbol and soil name	Depth	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensi-bility	Organic matter	Erosion factors Kw	Kf	T
	In	Pct	g/cc	um/sec	In/in	Pct	Pct			
231:										
Guayabota------	0-5	27-40	1.25-1.30	4.00-14.00	0.11-0.23	3.0-5.9	1.0-3.0	.24	.24	1
	5-14	40-60	1.30-1.35	0.01-0.42	0.12-0.19	6.0-8.9	1.0-3.0	.24	.24	
	14-18	27-40	1.30-1.45	4.00-14.00	0.10-0.13	3.0-5.9	0.5-1.0	.20	.20	
	18-60	---	---	---	---	---	---	---	---	
Yunque---------	0-2	---	---	---	---	---	---	---	---	5
	2-7	35-70	1.20-1.40	4.00-14.00	0.11-0.16	3.0-5.9	2.0-8.0	.05	.10	
	7-30	35-70	1.00-1.30	4.00-14.00	0.10-0.16	3.0-5.9	0.5-3.0	.10	.10	
	30-62	30-60	1.00-1.30	4.00-14.00	0.10-0.16	3.0-5.9	0.2-1.0	.10	.10	
311:										
Dwarf----------	0-4	0-0	0.30-0.45	4.00-14.00	0.22-0.25	0.0-2.9	35-43	.20	.20	5
	4-9	7-20	0.50-0.90	4.00-14.00	0.22-0.25	6.0-8.9	14-26	.20	.32	
	9-26	28-50	0.70-0.95	1.40-4.00	0.22-0.25	6.0-8.9	10-16	.17	.24	
	26-35	35-60	0.95-1.10	1.40-4.00	0.18-0.22	3.0-5.9	6.0-9.0	.24	.24	
	35-43	15-50	1.10-1.15	1.40-4.00	0.12-0.25	3.0-5.9	1.0-3.0	.24	.32	
	43-60	15-40	1.10-1.20	1.40-4.00	0.12-0.25	0.0-2.9	0.5-2.0	.17	.24	

Table 17.--Chemical Properties of the Soils

(Absence of an entry indicates that data were not estimated.)

Map symbol and soil name	Depth	Cation exchange capacity	Soil reaction
	In	meq/100 g	pH
112:			
Zarzal	0-1	12-15	5.6-6.5
	1-7	6.0-8.0	4.5-5.5
	7-35	5.0-7.0	4.5-5.5
	35-46	6.0-11	4.5-5.5
	46-82	7.0-9.0	4.5-5.5
	82-91	---	---
Cristal	0-2	12-15	3.5-5.5
	2-15	4.0-10	3.5-5.5
	15-26	4.0-10	3.5-5.5
	26-39	4.0-10	3.5-5.5
	39-60	3.0-8.0	3.5-5.5
113:			
Cristal	0-2	10-14	3.5-5.5
	2-15	4.0-10	3.5-5.5
	15-26	4.0-10	3.5-5.5
	26-39	4.0-10	3.5-5.5
	39-60	3.0-8.0	3.5-5.5
Zarzal	0-1	12-15	5.6-6.5
	1-7	6.0-8.0	4.5-5.5
	7-35	5.0-7.0	4.5-5.5
	35-46	6.0-11	4.5-5.5
	46-82	7.0-9.0	4.5-5.5
	82-91	---	---
114:			
Zarzal	0-1	12-15	5.6-6.5
	1-7	6.0-8.0	4.5-5.5
	7-35	5.0-7.0	4.5-5.5
	35-46	5.0-11	4.5-5.5
	46-82	7.0-9.0	4.5-5.5
	82-91	---	---
115:			
Humatas	0-4	9.0-17	4.5-5.5
	4-38	3.0-14	4.5-5.5
	38-60	3.0-17	4.5-5.5
Zarzal	0-1	12-15	5.6-6.5
	1-7	6.0-8.0	4.5-5.5
	7-35	5.0-7.0	4.5-5.5
	35-46	6.0-11	4.5-5.5
	46-82	7.0-9.0	4.5-5.5
	82-91	---	---
121:			
Sonadora	0-1	30-50	4.5-7.3
	1-21	30-50	4.5-7.3
	21-36	30-50	5.1-7.3
	36-60	---	---
Caguabo	0-3	25-40	6.1-6.5
	3-11	25-40	6.1-6.5
	11-16	---	---
	16-60	---	---

Table 17.--Chemical Properties of the Soils--
Continued

Map symbol and soil name	Depth	Cation exchange capacity	Soil reaction
	In	meq/100 g	pH
131:			
Sonadora	0-1	30-50	4.5-7.3
	1-21	30-50	4.5-7.3
	21-36	30-50	5.6-7.3
	36-60	---	---
Caguabo	0-3	25-40	6.1-6.5
	3-11	25-40	6.1-6.5
	11-16	---	---
	16-60	---	---
132:			
Caguabo	0-3	25-40	6.1-6.5
	3-11	25-40	6.1-6.5
	11-16	---	---
	16-60	---	---
135:			
Prieto	0-4	20-40	5.6-6.5
	4-13	15-20	5.6-6.5
	13-25	15-20	5.6-6.5
	25-35	15-18	5.6-6.5
	35-60	---	---
141:			
Luquillo	0-5	30-40	3.5-5.5
	5-35	30-40	3.5-5.5
	35-60	30-40	3.5-5.5
142:			
Coloso	0-4	20-30	5.6-6.5
	4-60	20-28	5.6-6.5
212:			
Yunque	0-2	---	---
	2-7	30-40	3.5-5.5
	7-30	22-30	3.5-5.5
	30-62	22-30	3.5-5.5
Moteado	0-1	---	---
	1-6	3.0-5.0	3.5-5.5
	6-22	3.0-5.0	3.5-5.5
	22-41	2.0-5.0	3.5-5.5
	41-54	2.0-5.0	3.5-5.5
	54-60	---	---
213:			
Yunque	0-2	---	---
	2-7	30-40	3.5-5.5
	7-30	22-30	3.5-5.5
	30-62	22-30	3.5-5.5
214:			
Yunque	0-2	---	---
	2-7	30-40	3.5-5.5
	7-30	22-30	3.5-5.5
	30-62	22-30	3.5-5.5
Los Guineos	0-1	12-23	3.5-5.0
	1-31	3.0-6.0	3.5-5.0
	31-93	3.0-6.0	3.5-5.0

Table 17.--Chemical Properties of the Soils--Continued

Map symbol and soil name	Depth	Cation exchange capacity	Soil reaction
	In	meq/100 g	pH
214:			
Moteado	0-1	---	---
	1-6	3.0-5.0	3.5-5.5
	6-22	3.0-5.0	3.5-5.5
	22-41	2.0-5.0	3.5-5.5
	41-54	2.0-5.0	3.5-5.5
	54-60	---	---
215:			
Palm	0-3	---	---
	3-10	18-26	3.5-5.5
	10-19	12-18	3.5-5.5
	19-31	3.0-6.0	3.5-5.5
	31-63	2.0-4.0	3.5-5.5
Yunque	0-2	---	---
	2-7	30-40	3.5-5.5
	7-30	22-30	3.5-5.5
	30-62	22-30	3.5-5.5
221:			
Picacho	0-3	---	---
	3-4	4.0-10	3.5-5.5
	4-27	2.0-6.0	3.5-5.5
	27-63	2.0-5.0	3.5-5.5
Utuado	0-1	---	---
	1-2	6.0-10	3.5-5.5
	2-13	3.0-6.0	3.5-5.5
	13-28	3.0-6.0	3.5-5.5
	28-61	1.0-4.0	3.5-5.5
223:			
Picacho	0-3	---	---
	3-4	4.0-10	3.5-5.5
	4-27	2.0-6.0	3.5-5.5
	27-63	2.0-6.0	3.5-5.5
Ciales	0-9	4.0-8.0	3.5-5.5
	9-25	2.0-4.0	3.5-5.5
	25-39	1.0-4.0	3.5-5.5
	39-73	1.0-4.0	3.5-5.5
224:			
Picacho	0-3	---	---
	3-4	4.0-10	3.5-5.5
	4-27	2.0-6.0	3.5-5.5
	27-63	1.0-5.0	3.5-5.5
Utuado	0-1	---	---
	1-2	6.0-10	3.5-5.5
	2-13	3.0-6.0	3.5-5.5
	13-28	3.0-6.0	3.5-5.5
	28-61	1.0-4.0	3.5-5.5
225:			
Icacos	0-4	6.0-10	3.5-5.5
	4-14	6.0-10	3.5-5.5
	14-60	6.0-10	3.5-5.5

Table 17.--Chemical Properties of the Soils--
Continued

Map symbol and soil name	Depth	Cation exchange capacity	Soil reaction
	In	meq/100 g	pH
231:			
Guayabota	0-5	15-20	3.5-5.5
	5-14	15-20	3.5-5.5
	14-18	10-15	3.5-5.5
	18-60	---	---
Yunque	0-2	---	---
	2-7	30-40	4.5-5.0
	7-30	22-30	4.5-5.0
	30-62	22-30	4.5-5.0
311:			
Dwarf	0-4	8.0-12	3.5-5.5
	4-9	7.0-10	3.5-5.5
	9-26	5.0-8.0	3.5-5.5
	26-35	4.0-7.0	3.5-5.5
	35-43	3.0-7.0	3.5-5.5
	43-60	3.0-6.0	3.5-5.5

Table 18.--Classification of the Soils

Soil name	Family or higher taxonomic class
Caguabo	Loamy, mixed, active, isohyperthermic, shallow Typic Eutrudepts
Ciales	Fine-loamy, isotic, acid, isothermic Histic Humaquepts
Coloso	Very-fine, kaolinitic, acid, isohyperthermic Vertic Endoaquepts
Cristal	Very-fine, kaolinitic, isohyperthermic Aquic Hapludox
Dwarf	Very-fine, mixed, isomesic Humic Haplaquox
Guayabota	Clayey, mixed, subactive, acid, isothermic, shallow Typic Humaquepts
Humatas	Very-fine, parasesquic, isohyperthermic Typic Haplohumults
Icacos	Fine-loamy, mixed, semiactive, acid, isothermic Aeric Endoaquepts
Los Guineos	Very-fine, kaolinitic, isothermic Humic Hapludox
Luquillo	Fine, mixed, semiactive, isohyperthermic Typic Eutrudepts
Moteado	Very-fine, kaolinitic, isothermic Humic Haplaquox
Palm	Clayey-skeletal, isotic, acid, isothermic Aquandic Humaquepts
Picacho	Fine-loamy, kaolinitic, isothermic Aquic Dystrudepts
Prieto	Very-fine, mixed, semiactive, nonacid, isohyperthermic Vertic Epiaquepts
Sonadora	Fine, smectitic, isohyperthermic Vertic Eutrudepts
Utuado	Coarse-loamy, mixed, active, isothermic Aquic Humic Dystrudepts
Yunque	Very-fine, kaolinitic, isothermic Humic Hapludox
Zarzal	Very-fine, kaolinitic, isohyperthermic Inceptic Hapludox

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