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## Final Report

# Provisional Ecological Site Descriptions for the U.S. Caribbean

USDA Forest Service International Institute of  
Tropical Forestry

NRCS Agreement number 67-F352-17-264



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## **Provisional Ecological Site Descriptions for the U.S. Caribbean**

Final report of activities conducted under the Interagency Agreement between USDA Natural Resources Conservation Service (NRCS) and USDA Forest Service International Institute of Tropical Forestry (IITF)

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Disclaimer: This is an internal report prepared for USDA-NRCS. All descriptions included here are preliminary and have not been subject to external revision.

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### **Abstract**

The identification and broad grouping of Ecological Sites (ES) across the landscape is based on multiple environmental indicators including soil-vegetation associations occurring within Major Land Resource Areas (MLRA) defined by The United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) across the United States (US) and its territories. In the U.S. Caribbean (Puerto Rico and U.S. Virgin Islands), Provisional Ecological Sites (PES) and generalized State-and-Transition Models (STM) were described for the first time using fifty-seven landscape units developed for Puerto Rico as the initial approach to start sorting the landscape into distinct ES. Multiple data sources were used to describe the vegetation within each of these sites including scientific papers, technical reports, expert knowledge, Forest Inventory Analysis (FIA) data, and maps of vegetation covers. Thirty-two PES were described for Puerto Rico, from which 15 also occur in the U.S. Virgin Islands. The PES described here represent a planning tool that can be useful to support land use management, and practices to mitigate the impacts from climate change and extreme weather events such as hurricanes and severe drought that annually affect these islands.

*Keywords: Caribbean, planning, Provisional Ecological Sites, Puerto Rico, soil, U.S. Virgin Islands, vegetation.*

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## Introduction

An Ecological Site (ES) is a conceptual division of the landscape based on soil, landform, geology, and climate characteristics that differs from other land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances (US Department of Agriculture 2017). The identification of distinctive ES in the landscape allows evaluating land suitability for different uses, the capability to respond to different management activities or disturbances, and on its ability to sustain productivity over the long-term.

An ES Description (ESD), involves the documentation of those concepts, their quantitative attributes, the ecological mechanisms, and the management interpretations (US Department of Agriculture 2017). Correlating ES with soil map units is an important component of soil mapping in the United States and a land management tool used by the United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) to identify needs, prioritize, and allocate funds from its incentive programs (e.g., EQIP) to promote the conservation of soil, water, and biodiversity.

The development of Provisional Ecological Sites (PES) is the initial step towards the description of formal ES. The identification and broad grouping of PES across the landscape is based on multiple environmental indicators including soil-vegetation associations occurring within Major Land Resource Areas (MLRA) defined across the United States (US) and its territories (US Department of Agriculture 2006).

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A key component of an ESD is the State and Transition Model (STM) that depicts and organizes information regarding the ecological dynamics or succession pathway of the site. In a STM, states are stable, long term ecological conditions that are produced on a site due to the interactions of the biotic, physical, and disturbance factors. States are composed of several plant community phases, which vary based on species composition and production. Ecological sites will also display multiple states, with the change from one state to another being non-reversible without significant management inputs. Transitions are the drivers and mechanisms of changes between states and the ESD will describe how these function. For example, a native shrubland state being converted to cropland and then converted to introduce pasture grasses is an example of three distinct states. Management actions, such as conservation practice implementation, grazing management, and other land use decisions are a significant part of the described state and transition model (US Department of Agriculture 2017).

Provisional Ecological Sites and generalized State and Transition Models (STM) were developed for the U.S. Caribbean Islands of Puerto Rico and the U.S Virgin Islands. The PES descriptions represent a big challenge for these islands with a long land-use history, regularly affected by natural disturbances (e.g., hurricanes), high abundance of exotic vegetation, and high rate of species naturalization (Rojas-Sandoval et al. 2017). But on the other hand, an opportunity to link vegetation, STM models, and conservation planning, in some of the better studied tropical forests across the world (Ewel and Withmore 1973),

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## Methodology

### *The U.S. Caribbean*

The U.S. Caribbean includes the Commonwealth of Puerto Rico (18°15'N, 66°30'W) and its largest satellite islands (Vieques, Culebra, and Mona) with a total extent of 8,938 km<sup>2</sup>, and the U.S. Virgin Islands (18°20'N, 64°50'W) composed of St. Thomas, St. John, and St Croix (Fig. 1) and an area of 350 km<sup>2</sup>.

The climate in Puerto Rico is mild tropical marine with little seasonal temperature variation (Daly et al. 2013), and higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north (Miller and Lugo 2009). Rainfall is distributed throughout the year, with peaks in May and October, while December to March is dryer (Daly et al. 2013). Puerto Rico's diverse forests have developed over alluvial, sedimentary, volcanic, limestone, and serpentine substrates. All forests in Puerto Rico and the USVI are classified by Holdridge as subtropical (i.e., subtropical moist forest, subtropical wet forest, subtropical rainforest, subtropical lower montane wet forest, subtropical lower montane rain, subtropical dry forest) (Ewel and Withmore 1973), supporting moist broadleaf evergreen and seasonal evergreen forests, as well as deciduous and semi-deciduous forests, cloud forests, forested wetlands, and rainforest (Helmer et al. 2008).

The forests of Puerto Rico include relatively large examples of most of the major Caribbean forest types and constitute a locally and globally valuable ecological resource (Brandeis et al. 2003). By 2014, forest area covered 55% of mainland Puerto Rico, 91% of Culebra, and 79% of Vieques (Mercano-Vega 2019).



Figure 1. Puerto Rico and largest satellite islands (Mona, Culebra, Vieques), and the U.S. Virgin Islands (St. Thomas, St. Johns, and St. Croix).

The climate in the USVI is mostly subtropical, with a hot and humid rainy season from May to November and a dry season more tempered by trade winds (Kennaway et al. 2008). Geological substrates include alluvial, sedimentary, volcanic, and limestone layers (Chakroff 2010), but not serpentine. The forests of the three islands are somewhat different but the two major forest types are subtropical moist and subtropical dry forests (Chakroff 2010), and most of the forest is secondary growth (Kennaway et al. 2008). The subtropical moist forests include evergreen forests found at higher elevations with substantial rainfall and clouds, and in riparian corridors and valleys at lower elevations with sufficient freshwater (Stein et al. 2014). Subtropical dry forests include lowland semi-deciduous and drought-deciduous forests that vary widely in structure and are heavily influenced by rainfall, slope and aspect, prevailing winds,

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and sea spray (Chakroff 2010). By 2014, forest area covered 50% of St Croix and St. Thomas, and 86% of St. John (Brandeis et al. 2013).

*The influence of past agriculture on the current vegetation of the U.S. Caribbean islands.*

Land-use change has been a major determinant of current vegetation composition and distribution in Puerto Rico (Grau et al. 2003, Helmer 2004) and in the USVI ((USVI Dept. of Agric. 2010). By the 1930s Puerto Rico was widely deforested for sugarcane plantations and pastures (Aide 1995, 1996, Thomlinson et al. 1996). Forest clearing and land cover change were very intense in the moist forest occurring at lower elevations and flatter topography (Helmer et al. 2008).

Ten years later (by the 1940s), the economy shifted from intense agriculture to industrial, promoting the abandonment of rural areas and an unprecedented recovery of secondary forests in these abandoned lands (Grau et al. 2003). Between 1940 and 1980, the percentage of Puerto Rico in farmland decreased from 85% to 37%, while forest cover grew from 6% to 42% (period 1930-1991) (Kennaway and Helmer 2007). This relatively fast land-cover change had major implications in the distribution and composition of the vegetation that we observe today in Puerto Rico's forests. For example, new forest communities include the introduced *Spathodea campanulata* emerging on abandoned sugarcane fields and former pasture (Chinea and Helmer 2003, Lugo et al. 2011, Rivera and Aide 1998). This species colonized abandoned lands and currently it is the most common tree in Puerto Rico (Lugo et al. 2011). Secondary forest recovery after rural land abandonment was faster in difficult to reach

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or “less productive” areas including at high elevations, steep slopes, in soils with low fertility, within or close to nature reserves or to large patches of forest remnants, in wetlands, far away from roads, and in areas with net population out-migration (Helmer et al. 2008). Older forest and old-growth remnants that we observe today have one (or more) of these attributes (Helmer et al. 2008).

The forests of the USVI also experienced a colonial period of deforestation for intensive agriculture, and a later period of deforestation from development pressure (Brandeis et al. 2006). By 1800 only about 5 percent or less of the forest cover remained, having been cleared primarily for sugar cane and cotton agriculture (USVI Dept. of Agric. 2010). Similar to Puerto Rico, forest structure, ecosystem function, and species composition of the USVI forests have been strongly influenced by forest clearing and the later establishment of exotic species (Kennaway et al. 2008). With the abandonment of agriculture from the 1800s to the early 20th century, forests gradually recovered (Brandeis and Oswalt 2007, Kennaway et al. 2008). At present, the alien flora in Puerto Rico and the USVI contributes to 32.3% of the total flora found on these islands, with a total of 1,032 species, represented by 117 families and 581 genera (Rojas-Sandoval et al. 2015).



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*Data sources and analysis*

Major Land Resource Areas

Major Land Resource Areas (MLRA) are geographically associated Land Resource Units (LRUs) that are important in statewide agricultural planning and have value in interstate, regional, and national planning (US Department of Agriculture 2006). Puerto Rico and the USVI are divided into four MLRA: 1) the Humid Mountains and Valleys of Puerto Rico (MLRA 270), 2) the Semiarid Mountains and Valleys of Puerto Rico and the USVI (MLRA 271), 3) the Humid Coastal Plains of Puerto Rico (MLRA 272), and 4) the Semiarid Coastal Plains of Puerto Rico and the USVI (MLRA 273) (Fig. 2). Humid MLRAs are not present in the USVI, however, the three islands have subtropical moist forests (Gould et al. 2013). The average annual precipitation ranges from 60 to 90 inches (1,525 to 2,285 millimeters) in the humid uplands, 45 to 60 inches (1,145 to 1,525 millimeters) in the humid coastal plains, 30 to 45 inches (760 to 1,145 millimeters) in the semiarid mountains and valleys, and 10 to 45 inches (255 to 1,145 millimeters) in the semiarid coastal plains (US Department of Agriculture 2017). The average annual temperature is 70 to 74 degrees F (21 to 23 degrees C) in the humid uplands, 77 degrees F (25 degrees C) in the humid coastal plains, and 79 degrees F (26 degrees C) in the semiarid mountains and valleys and in the semiarid coastal plains. A detailed description of each MLRA can be found in the Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin, United States Department of Agriculture Handbook (2006).

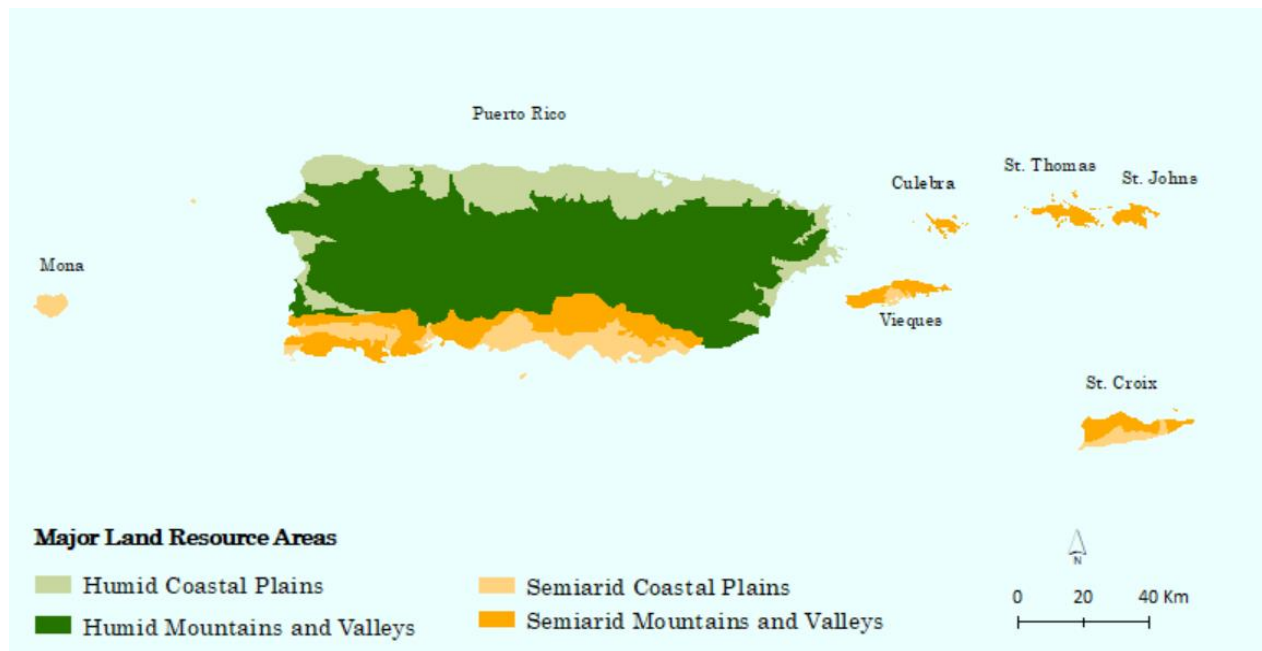


Figure 2. Major Land Resource Areas of Puerto Rico and the USVI (US Department of Agriculture 2006).

Table 1. Area and percentage occupied by the Major Land Resource Areas in Puerto Rico and the USVI.

MLRA Name	Puerto Rico		U.S Virgin Islands	
	km <sup>2</sup>	%	km <sup>2</sup>	%
MLRA 270-Humid Mountains and Valleys	5,533	62	---	---
MLRA 272-Humid Coastal Plains	1,696	19	---	---
MLRA 273-Semiarid Coastal Plains	671	7	84	24
MLRA 271-Semiarid Mountains and Valleys	1,051	12	265	76
<b>Total</b>	<b>8,951*</b>	<b>100</b>	<b>349</b>	<b>100</b>

\*The total area may vary due to coastline mismatch.

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## Landscape units and land cover maps

In the case of Puerto Rico, a Landscape Units map developed by the USDA Forest Service (Gould et al. 2008a, Fig. 3) was used to develop the initial ecological site key for the island. This map was developed from the combination of the six Holdridge Ecological Life Zones (ELZ) (Ewel and Withmore 1973), parental material or substrates (Bawiec 2001), topographic positions or landforms (Martinuzzi et al. 2007), and topography (Gould et al. 2008b), at a minimum mapping units of 15 meters. At the same time, the ELZ represent bioclimatic units, so each life zone lies within 1) a latitudinal region, 2) an altitudinal belt, and 3) a humidity province, and the variables to define each life zone include the mean annual precipitation, and the mean annual biotemperature (Ewel and Whitmore 1973). Forest types, dominant vegetation forms, and representative species are well-known and described for the ELZ in Puerto Rico and the USVI (Ewel and Whitmore 1973). In order to simplify the landscape units with 57 classification, landscape units occurring within the same forest type and similar landscape position were collapsed into a new class named “bottomland” for those occurring at lower elevations (i.e., plain and lower slope), and “upland” for those occurring at higher elevations (i.e., ridge, and upper slope) resulting in 34 landscape units. Landscape units were calculated for each MLRA as the PES are intended to function within the context defined by the MLRAs (Fig. 4). The ecological site name was defined according to the dominant MLRA (with the highest percentage) for each ecological site.

Because a map of landscape units is not available for the USVI, the USVI land cover map developed by the USDA Forest Service (Gould et al. 2013), was used as the base map to identify



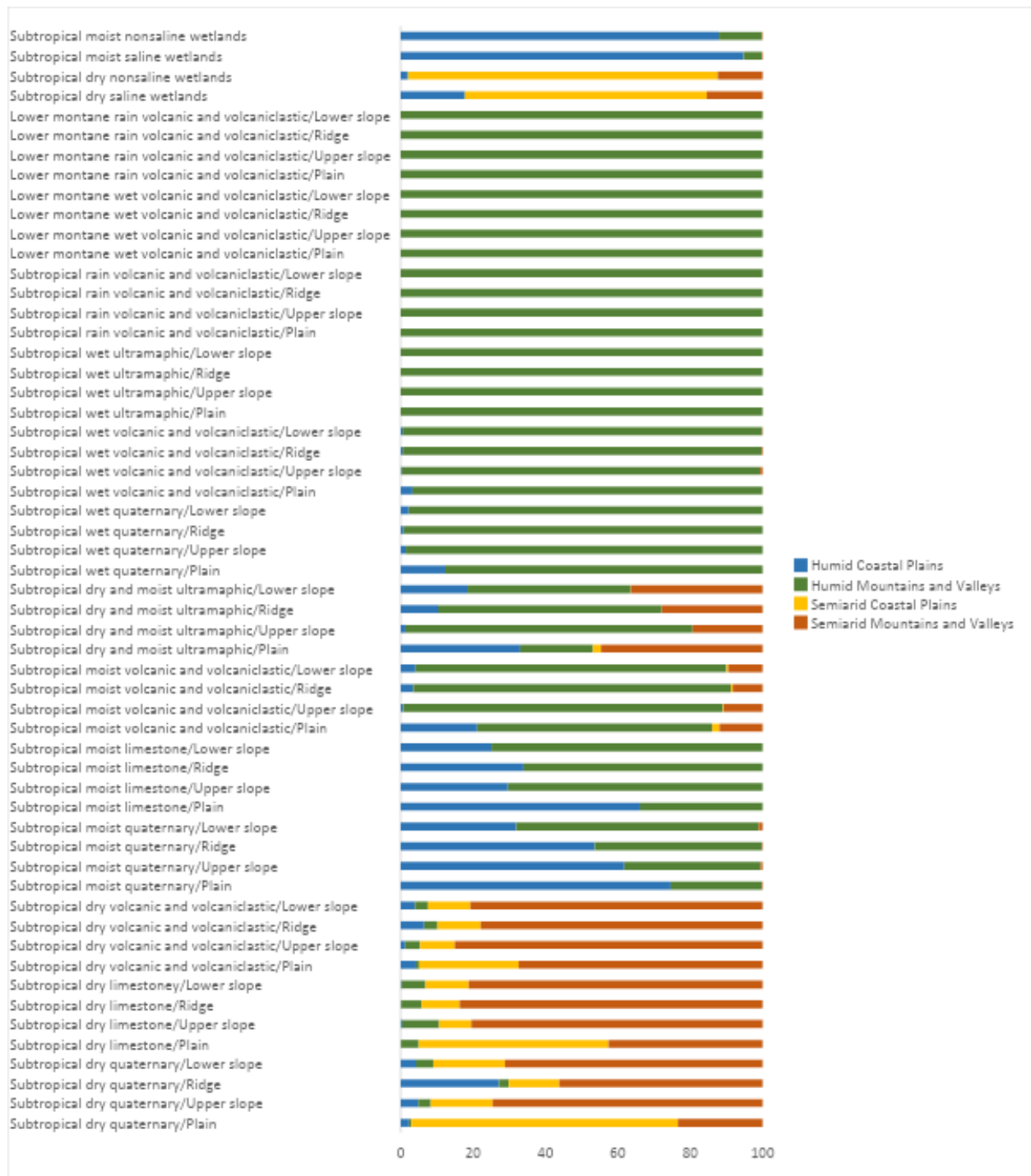


Figure 4. Puerto Rico landscape units within Major Land Resource Areas.

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## Climate data

Climate data was acquired from Daly et al. (2013) which applied Parameter-elevation Regressions on Independent Slopes Model (PRISM) to generate maps of mean monthly and annual precipitation and minimum and maximum temperature for the Caribbean islands of Puerto Rico, Vieques and Culebra over the 1963-1995, and at a minimum mapping unit of 450 meters. The regression-based (PRISM) uses spatial data sets, a knowledge base, and expert interaction to generate GIS-compatible grids of climate variables. Spatial temperature patterns were linked closely to elevation, topographic position, and coastal proximity.

Landscape units polygons were converted to points in order to extract a larger amount of data from each of the climate rasters. Mean annual precipitation, monthly low and high ranges of the precipitation and the temperature, and monthly minimum and maximum temperatures were calculated and plotted for each of the PES. All spatial analyses were conducted using ArcGIS 10.5.1.

## Physiography data

A map of simplified landforms developed for Puerto Rico and the U.S. Virgin Islands (Martinuzzi et al. 2007) was used to describe the presence and percentage of plains, side slope or mogote valley, steep slope or mogote side, and top mogote within each PES. A 10-meters Digital Elevation Model (DEM) (USGS 2013) was used to extract information on elevation, aspect, and slope. Landscape units polygons were converted to points in order to extract a larger amount of data from the elevation, slope, and aspect rasters.

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## Vegetation data

Different approaches were used to describe the vegetation occurring within the PES in Puerto Rico and the USVI. First, a literature review was conducted to extract information of typical vegetation forms and the most common species occurring within the different ELZ (e.g., subtropical moist forest), characteristics and composition of vegetation communities associated with particular environments (e.g., littoral vegetation), and general descriptions of the different ecosystems occurring in these islands (e.g., mangroves). Some key references used at this stage included “The Ecological Life Zones of Puerto Rico and the USVI” (Ewel and Whitmore 1973), “Guide to the Ecological Systems of Puerto Rico” (Miller and Lugo 2009), “Studies of the Vegetation of Puerto Rico” (Danserau and Buell 1966), “Puerto Rico State Forests” (Los Bosques Estatales de Puerto Rico) (Silander et al. 1979), “Guia de indicadores físicos y bióticos de la costa de Puerto Rico (Guide for biotic and physical indicators of Puerto Rico’s coastal zone) (DRNA 2012), “Wetlands of Puerto Rico” (Anegados de Puerto Rico (PRDNER, unknown year), “Puerto Rican karst, a vital resource” (Lugo et al. 2001), among others. More detailed references such as Brandeis et al. (2009) provided information of vegetation assemblages and dominant species in association with the six Holdridge Ecological Life Zones identified for Puerto Rico and the USVI. In the case of Puerto Rico, information available in the literature was complemented during working meetings with the Director of the Herbarium of the Puerto Rico Department of Natural and Environmental Resources (Mr. Jose Sustache). In addition, some scientific papers (e.g., Aide et al. 1995) also provided information of long-term studies and ecological succession that were used to develop STM for the most studied forest types (e.g., subtropical wet forest).

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The second approach included the use of spatial layers and overlay analysis to improve the information available in the literature. For example, the 34 landscape units were spatially related to the Puerto Rico land cover map of Puerto Rico (Gould et al. 2007) to extract information of the dominant vegetation classes (e.g., moist grasslands or pastures) within each landscape units/PES (e.g., subtropical moist limestone plain forest) (Fig. 5). The same analysis was conducted using the U.S. National Vegetation Classification (USNVC) Map (USNVC 2017) as this classification uses a nomenclature (e.g., Group G004 *Rhizophora* mangle Forest Group) that promotes a common language for the effective management and conservation of plant communities in the United States (USNVC 2017). In the case of Puerto Rico, PES were intersected to State Forests and the boundary of El Yunque National Forest, as inventories of the vegetation in these protected forests are available.



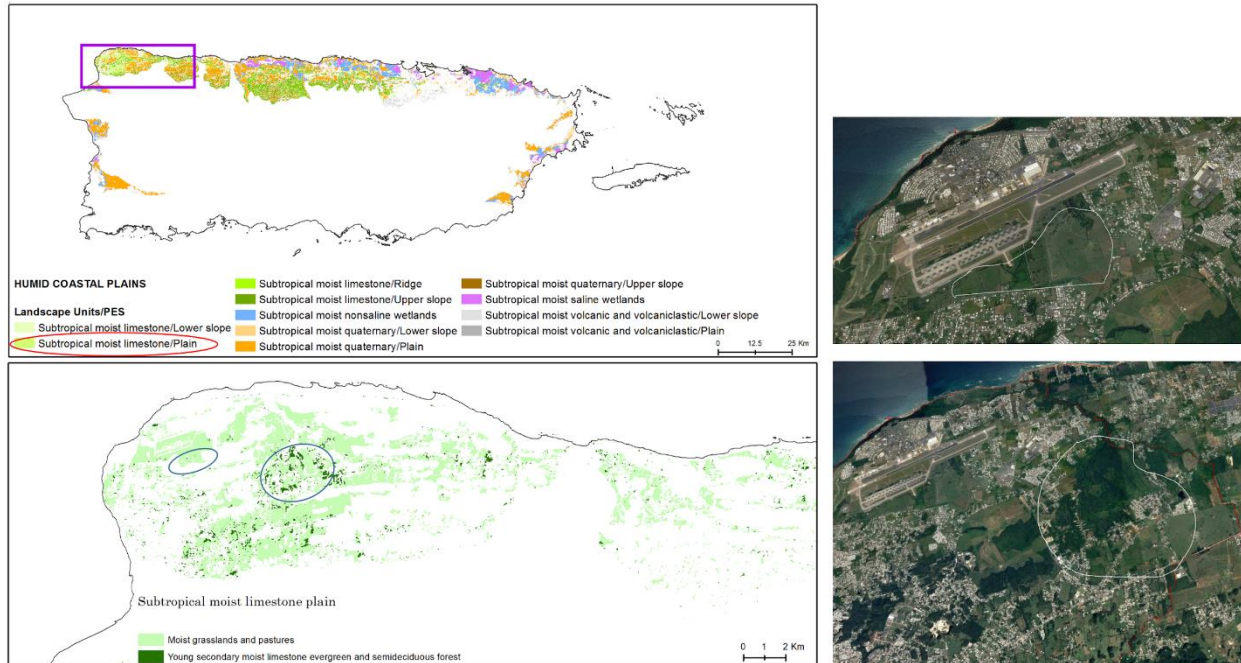


Figure 5. Example of an intersection analysis between a landscape unit (i.e., subtropical moist limestone plain) and the Puerto Rico land cover map. This example indicates that the subtropical moist limestone plain, occurring within the MLRA-272 (Humid Coastal Plains), is dominated by moist grasslands or pastures, and young secondary moist limestone evergreen and semi-deciduous forest.

Similarly, landscape units for Puerto Rico and land cover classes for the USVI were intersected to Forest Inventory and Analysis (FIA) inventory plots surveyed during the period 2011 to 2014 (Marcano-Vega 2019). Permanent FIA plots occur throughout the island of Puerto Rico, Vieques, Culebra, Mona and the USVI. Plots are distributed in the center of approximately 370 quadrilles with an area of 24 km<sup>2</sup> each. Plots to be considered for the long-term inventory must have at least 10% tree canopy coverage, trees height must be at least 30-cm, a minimum

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forested area of 0.4 ha around each plot center, and in the case of riparian forest a minimum length of 110.7 meters by 36.6 meters wide (Marcano-Vega 2019). The species list and in the case of Puerto Rico the importance value for each species were acquired for those plots occurring within the different ecological sites. The importance value for species occurring within FIA plots in the USVI was not available by the time of this report, but this information may be considered in the future as it allows to improve the descriptions of the PES.

### Soil-vegetation relationships

Soil components were assigned to the different ecological sites by NRCS soil scientists. Vegetation profiles available in the literature such as the example in Fig. 6, allowed aligning vegetation assemblages and representative flora to dominant soil components occurring across an elevational gradients.

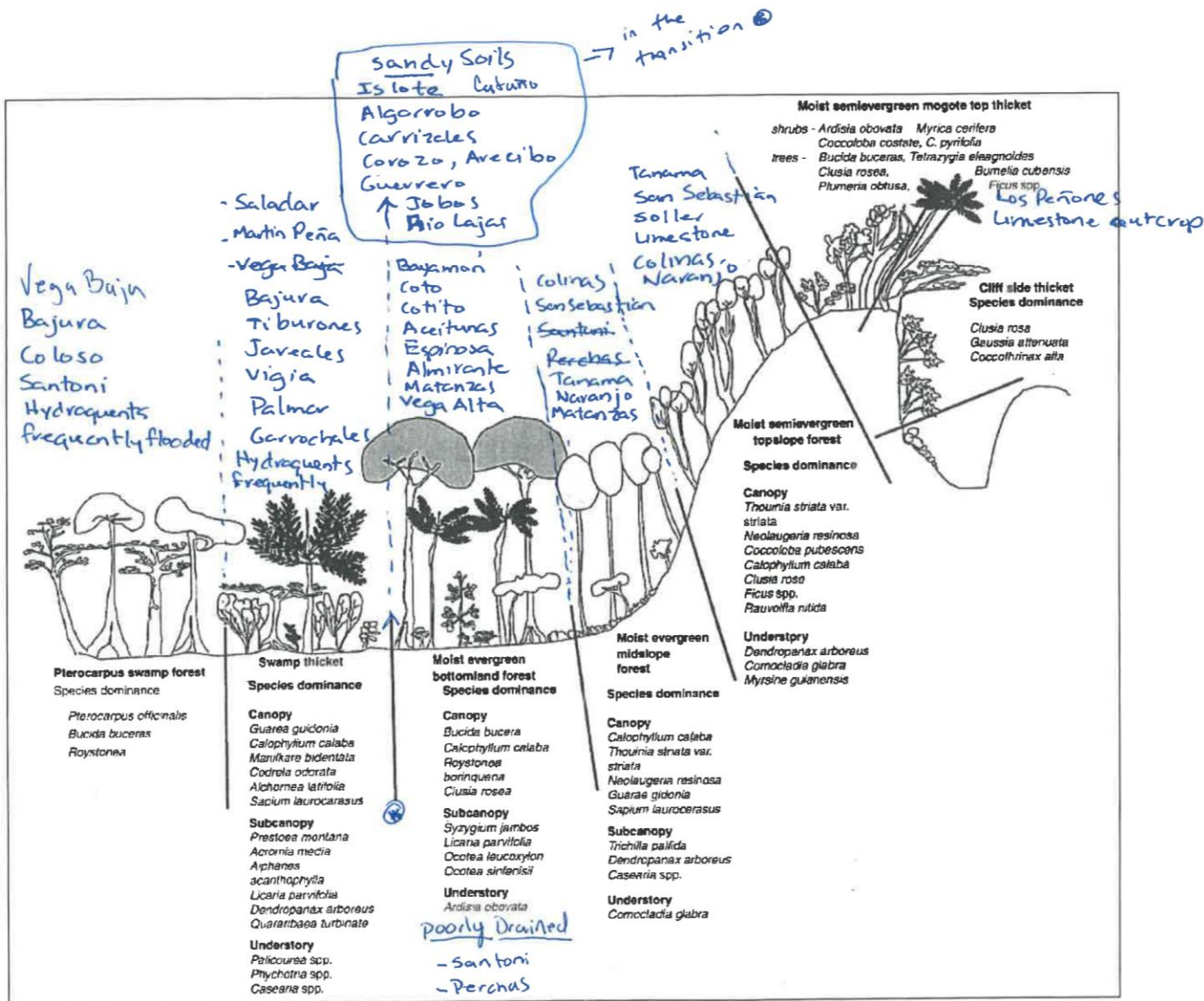


Figure 24—A profile view of a moist coastal and limestone forest.

Figure 6. A vegetation profile along and elevational gradient of a moist coastal and limestone forest (Miller and Lugo 2009), and its relationship to the soil catena.

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## Results

A total of 32 PES were identified for Puerto Rico, and 15 of these ecological sites may also occur in the USVI (Fig 7, Appendix 1). A generalized State and Transition Model was developed for the Holdridge Ecological Life Zones that can be adapted and used as a starting point of STM for the different PES described here.

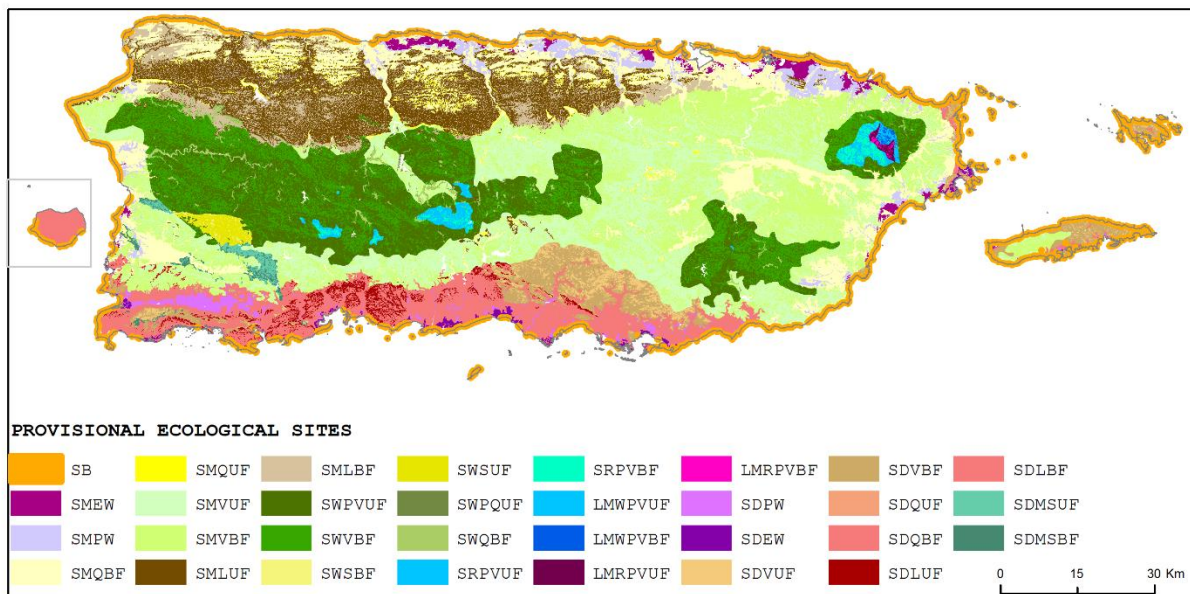


Figure 7. Distribution of the PES in Puerto Rico. SB= Sandy Beach Forest\*, SMEW= Subtropical Moist Estuarine Wetland, SMPW= Subtropical Moist Palustrine Wetland, SMQBF= Subtropical Moist Quaternary Bottomland Forest\*, SMQUF= Subtropical Moist Quaternary Upland Forest\*, SMVUF= Subtropical Moist Volcanic Upland Forest, SMVBF= Subtropical Moist Volcanic Bottomland Forest\*, SMLUF= Subtropical Moist Limestone Upland Forest\*, SMLBF= Subtropical Moist Limestone Bottomland Forest\*, SWPVUF= Subtropical Wet Palustrine Volcanic Upland Forest, SWVBF= Subtropical Wet Volcanic Bottomland Forest, SWSBF= Subtropical Wet Serpentine Bottomland Forest, SWSUF= Subtropical Wet Serpentine Upland Forest, SWPQUF= Subtropical Wet Palustrine Quaternary Upland Forest, SWQBF= Subtropical Wet Quaternary Bottomland Forest, SRPVUF= Subtropical Rain Palustrine Volcanic Upland Forest, SRPVBF= Subtropical Rain Palustrine Volcanic Bottomland Forest, LMWPVUF= Lower Montane Wet

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Palustrine Volcanic Upland Forest, LMWPVBF= Lower Montane Wet Palustrine Volcanic Bottomland Forest, LMRPVUF= Lower Montane Wet Palustrine Volcanic Upland Forest, LMWPVBF= Lower Montane Wet Palustrine Volcanic Bottomland Forest, SDPW= Subtropical Dry Palustrine Wetland\*, SDEW= Subtropical Dry Estuarine Wetland\*, SDVUF= Subtropical Dry Volcanic Upland Forest\*, SDVBF= Subtropical Dry Volcanic Bottomland Forest\*, SDQUF= Subtropical Dry Quaternary Upland Forest\*, SDQBF= Subtropical Dry Quaternary Bottomland Forest\*, SDLUF= Subtropical Dry Limestone Upland Forest\*, SDLBF= Subtropical Dry Limestone Bottomland Forest\*, SDMSUF= Subtropical Dry and Moist Serpentine Upland Forest, SDMSBF= Subtropical Dry and Moist Serpentine Bottomland Forest. Note: Sandy beaches (for moist and dry forest) were merged into a single layer in this map (SB).\*Provisional Ecological sites that may also occur in the USVI.

GENERALIZED STATE AND TRANSITION MODEL FOR ECOLOGICAL SUCCESSION IN PUERTO RICO AND USVI

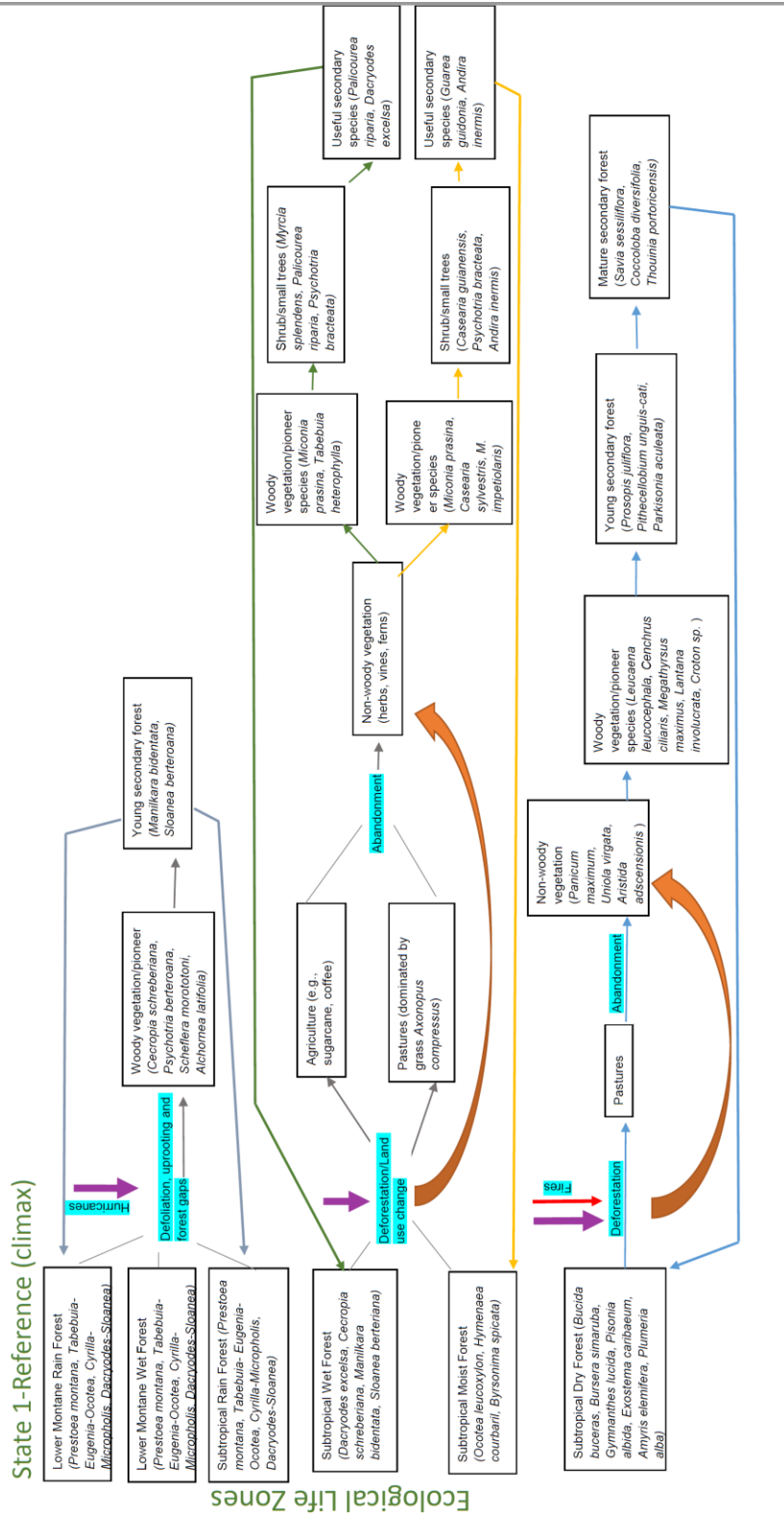


Figure 8. State and Transition Models for Ecological Life Zones in Puerto Rico and USVI. Dominant species in each state where described only for Puerto Rico.

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## Conclusion and Discussion

The Provisional Ecological Sites described for Puerto Rico and interpolated for the USVI allowed the identification of broad vegetation-soil associations in the U.S. Caribbean. The methodology used integrated vegetation data collected in field surveys during the 1960's available in technical reports and scientific publications, with more recent vegetation inventories (USDA-FIA). Furthermore, it aligned the occurrence of trees, shrubs, and herbs to specific environmental characteristics at island-wide scale (e.g., geology, slope). The description of the PES for the US Caribbean islands reveals that exotic and naturalized species contribute to a significant portion of the flora of the U.S Caribbean, and that several species occur in multiple PES indicating a wide distribution range and capacity of adaptation of some of the species. This finding supports previous studies that showed that none of the species assemblages identified for Puerto Rico were restricted to a single life zone or soil type (Brandeis et al. 2009). The vegetation-soil associations respond to multiple environmental factors but also to past land use, natural disturbances (e.g., hurricanes), and the colonization and establishment of exotic species that form novel ecosystems in these islands (Lugo 2013). Land accessibility, arability, and spatial contagion are equally important spatial factors that control patterns of species composition in today's Puerto Rico forests (Helmer et al. 2008). On the other hand, the PES described here are based on the best information available to describe the landscape in Puerto Rico and the USVI.

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The authors would like to acknowledge J. Sustache from the Department of Natural and Environmental Resources and H. Marcano-Vega from USDA Forest Service FIA for their invaluable contribution to describe the vegetation associated with each Provisional Ecological Site, and for providing key references that helped to fill the PES table key. Our special thanks to NRCS Project Manager Manuel Matos and the efforts of Matthew Duvall, Samuel Ríos, Abdiel Santana, and Debbie Anderson for the many discussions and working meetings that helped to set criteria and make decisions to move forward in the description of the Provisional Ecological Sites presented here. Thanks to E. Gonzalez and A. Lugo for providing important references and early discussion that helped to improve the description of the sites. Thanks to the team at the USDA Caribbean Climate Hub. This project were made possible thanks to the NRCS Agreement 67-F352-17-264 – Provisional Ecological Site Descriptions for Puerto Rico and the U.S. Virgin Islands. All research at the USDA Forest Service International Institute of Tropical Forestry is done in collaboration with the University of Puerto Rico.



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**APPENDIX 1: PROVISIONAL ECOLOGICAL  
SITE DESCRIPTIONS FOR PUERTO RICO  
AND USVI**

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SITE NAME: **LOWER MONTANE RAIN PALUSTRINE VOLCANIC BOTTOMLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (100%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Lower Montane Rain Palustrine Volcanic Bottomland Forest (LMRPVBF) combined the lower montane rain volcanic and volcanoclastic forests located in the plains and lower slopes of Puerto Rico, according to the USDA Forest Service Landscape Units Map of Puerto Rico (Gould et al. 2008). The LMRPVBF falls within the National Vegetation Classification Groups G448 Caribbean Wet Montane Forest, G451 Caribbean Montane Cloud Forest Group, and G452 Caribbean Montane Elfin Thicket Group (U.S. National Vegetation Classification 2019).

Dominant vegetation covers within this ecological site include mature primary Palo Colorado and secondary montane wet non-calcareous evergreen forest, mature primary Sierra Palm and secondary montane wet non-calcareous evergreen forest, mature primary Tabonuco and secondary montane wet non-calcareous evergreen forest, and young secondary montane wet non-calcareous evergreen forest, among others (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the Montane Forest

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subzone (zone V) which includes forests, savannas, scrub, grasslands, and approximately 11 vegetation communities (Danserau and Buell 1966).

### **Ecological Site Concept:**

The LMRPVBF has an extension of 3.4 km<sup>2</sup> (<0.5% of the island), and it occupies the lowest landscape positions of the lower montane rain forest, only occurring in a narrow band, immediately above the subtropical rainforest within El Yunque National Forest (Fig. 1). The lower montane rain forest ecological life zone, where this ecological site occurs, occupies the least extension in Puerto Rico, and it is not found in the USVI. This ecological site is a palustrine wetland (Miller and Lugo 2009), associated with the wettest conditions and volcanic geology in the central mountains of Puerto Rico. This site represents an environmental extreme and plants adapted to live here have developed physiological adaptations to tolerate extremely wet and windy conditions. This ecological site is characterized by high amounts of annual rainfall (annual mean higher than 4500 mm), abundant runoff (300 mm per month), low temperatures (annual mean 19 celsius degrees), constant wet soil, high relative humidity (annual mean higher than 95%), low light due to cloud formation, fog, acid soils, and oxygen stress that inhibits root respiration which influences the vegetation that grows in this site (Ewel and Whitmore 1973). Many trees, shrubs, and herbaceous species adapted to this ecological site are hydrophilic that can tolerate wet and anoxic soil conditions. Although the environmental conditions in this ecological site are quite different from those in the wet forest, the vegetation occurring here, in terms of species composition, is very similar to that found in the lower montane wet forest (Ewel and Whitmore 1973). In this ecological site as in the wet forests of Puerto Rico occurring at



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higher elevations, it is common to find azonal associations of Tabonuco forest (*Dacryodes-Sloanea*), Palo Colorado forest (*Cyrilla-Micropholis*), elfin woodland (*Tabebuia-Eugenia-Ocotea*) also called dwarf or cloud forest, and Sierra Palm forest (*Prestoea montana*). Even though these associations are similar among the wettest ecological sites at higher elevations all over the island, the species abundance and general physiognomy of the forest varies among them. For example, the dwarf cloud forest association dominates within this ecological site, as trees at the upper elevations of the rainforest are stunted or 'dwarfed' due to the exposure to continuous winds, very wet soils, and low transpiration rates that impedes nutrients flow from the soil to the leaves (Weaver 1973). What distinguishes the lower montane rain forest, described here, from the lower montane wet forest is the greater abundance of epiphytes, epiphyllae, palms, and tree ferns in the former (Ewel and Whitmore 1973).

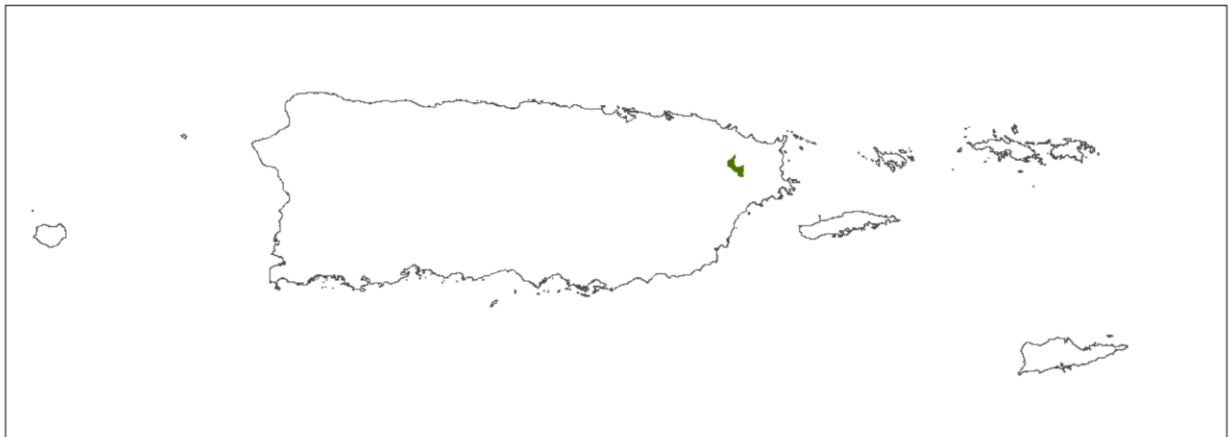


Figure 1. Distribution of the Lower Montane Rain Palustrine Volcanic Bottomland Forest.

**Dominant plant species:**

Dominant species in this ecological site include *Cecropia schreberiana*, *Prestoea acuminata*

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*Alchornea latifolia*, *Cordia borinquensis*, *Byrsonima wadsworthii*, *Croton poecilanthus*, *Henriettea squamulosum* (Marcano-Vega 2019). Secondary important species include *Eugenia stahlii*, *Micropholis garciniifolia*, *Schefflera morototonii*, and *Sloanea berteriana* (Marcano-Vega 2019). Two vegetation assemblages are common within this ecological site (Brandeis et al. 2009), listed below in decreasing order of importance. Dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### Species assemblages:

1. ***Prestoea montana***, ***Micropholis garciniifolia***, ***Sloanea berteriana***, *Micropholis chrysophylloides*, *Henriettea suamulosum*, *Byrsonima spicata*, *Dacryodes excelsa*, *Psychotria berteriana*, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.
  2. ***Cecropia schreberiana***, ***Citrus sinensis* (Ex)**, *Inga laurina*, *Cyathea arborea*, *Persea amaricana* (Ex).
- **Other trees:** *Prestoea montana*, *Cyathea arborea*, *Calyptanthus krugii*, *Ocotea spatulata*, *Micropholis guyanensis*, *Miconia pachyphylla*, *M. foveolata*, *Haenanthus salicifolius*, *Myrica horlidgeana*, *Ditta myricoides*, *Hedysmum arborescens*, *Daphnopsis philippiana*, *Magnolia portonicensis*, *Symplocos micrantha*, *Torralsia cuneifolia*.
  - **Shrubs:** *Gesneria portoricensis*

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- **Herbaceous, cactus, succulents:** *Werauhia sintenisii*, *Isachne angustifolia*, *Pilea sp.*, *Arthrostylidium sarmentosum*, *Adiantum sp.*, *Hilla parasitica*, *Guzmania sp.*, *Selaginella sp.*, *Gonocalyx portoricensis*, *Nephelea portoricensis*, *Cyathea pubescens*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slope (80%)

Steep slope (16%)

Top (4%)

### Physiographic features (characteristics ranges)

Elevation range: 418-1,007 m (mean= 713 m)

Slope: 9-102% (mean= 31%, or 17 degrees)

Aspect (mean): Southeast (133 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the LMRPVBF is about 4,023 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 26 °C, and the mean minimum temperature is 17°C. Monthly temperatures are similar throughout the year, with higher temperatures

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occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 4,023 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

**INFLUENCING WATER FEATURES**

**REPRESENTATIVE SOIL FEATURES**

Soil series components within this ecological site include Dwarf, El Duque, and Yunque.

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

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## ECOLOGICAL DYNAMICS OF THE SITE

### **State and Transition Models**

#### **COMMUNITY 1.1- State 1-Reference**

## ECOLOGICAL SITES INTERPRETATION

## SUPPORTING INFORMATION

### **Similar sites**

- Lower Montane Rain Palustrine Volcanic Upland Forest, Lower Montane Wet Palustrine Volcanic Bottomland Forest, Lower Montane Wet Palustrine Volcanic Upland Forest, Subtropical Rain Palustrine Volcanic Bottomland Forest, Subtropical Rain Palustrine Volcanic Upland Forest, Subtropical Wet Palustrine Quaternary Upland Forest.

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**SITE NAME: LOWER MONTANE RAIN PALUSTRINE VOLCANIC UPLAND FOREST  
(F270X...)**

MLRA 270-Humid Mountains and Valleys (100%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Lower Montane Rain Palustrine Volcanic Upland Forest (LMRPVUF) is the combination of the lower montane rain volcanic and volcanoclastic forests located in the upper slope and ridge according to the USDA Forest Service Landscape Units Map of Puerto Rico (Gould et al. 2008). The LMRPVUF falls within the National Vegetation Classification Groups G448 Caribbean Wet Montane Forest, G451 Caribbean Montane Cloud Forest Group, and G452 Caribbean Montane Elfin Thicket Group (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include mature primary Sierra Palm and secondary montane wet non-calcareous evergreen forest, mature primary Palo Colorado and secondary montane wet non-calcareous evergreen forest, mature primary elfin woodland and secondary montane wet non-calcareous evergreen cloud forest and mature primary Tabonuco and secondary montane wet non-calcareous evergreen forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the Montane Forest subzone (zone V)

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which includes forests, savannas, scrub, grasslands, and approximately 11 vegetation communities (Danserau and Buell 1966).

### **Ecological Site Concept:**

The LMRPVUF has an extension of 8.1 km<sup>2</sup> (<1% of the island), and it occupies the highest landscape positions of the lower montane rain forest, only occurring in a narrow band, immediately above the subtropical rainforest within El Yunque National Forest (Fig. 1). The lower montane rain forest ecological life zone, where this ecological site occurs, occupies the least extension in Puerto Rico, and it is not found in the USVI. This ecological site is a palustrine wetland (Miller and Lugo 2009), associated with the wettest conditions and volcanic geology in the central mountains of Puerto Rico. This site represents an environmental extreme and plants adapted to live here have developed physiological adaptations to tolerate extremely wet and windy conditions. This ecological site is characterized by high amounts of annual rainfall (annual mean higher than 4500 mm), abundant runoff (300 mm per month), low temperatures (annual mean 19 celsius degrees), constant wet soil, high relative humidity (annual mean higher than 95%), low light due to cloud formation, fog, acid soils, and oxygen stress that inhibits root respiration which influences the vegetation that grows in this site (Ewel and Whitmore 1973). Many trees, shrubs, and herbaceous species adapted to this ecological site are hydrophilic that can tolerate wet and anoxic soil conditions. Although the environmental conditions in this ecological site are quite different from those in the wet forest, the vegetation occurring here, in terms of species composition, is very similar to that found in the lower montane wet forest (Ewel and Whitmore 1973). In this ecological site as in the wet forests of Puerto Rico occurring at

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higher elevations, it is common to find azonal associations of Tabonuco forest (*Dacryodes-Sloanea*), Palo Colorado forest (*Cyrilla-Micropholis*), elfin woodland (*Tabebuia-Eugenia-Ocotea*) also called dwarf or cloud forest, and Sierra Palm forest (*Prestoea montana*). Even though these associations are similar among the wettest ecological sites at higher elevations all over the island, the species abundance and general physiognomy of the forest varies among them. For example, the dwarf cloud forest association dominates within this ecological site, as trees at the upper elevations of the rainforest are stunted or 'dwarfed' due to the exposure to continuous winds, very wet soils, and low transpiration rates that impedes nutrients flow from the soil to the leaves (Weaver 1973). What distinguishes the lower montane rain forest, described here, from the lower montane wet forest is the greater abundance of epiphytes, epiphyllae, palms, and tree ferns in the former (Ewel and Whitmore 1973).

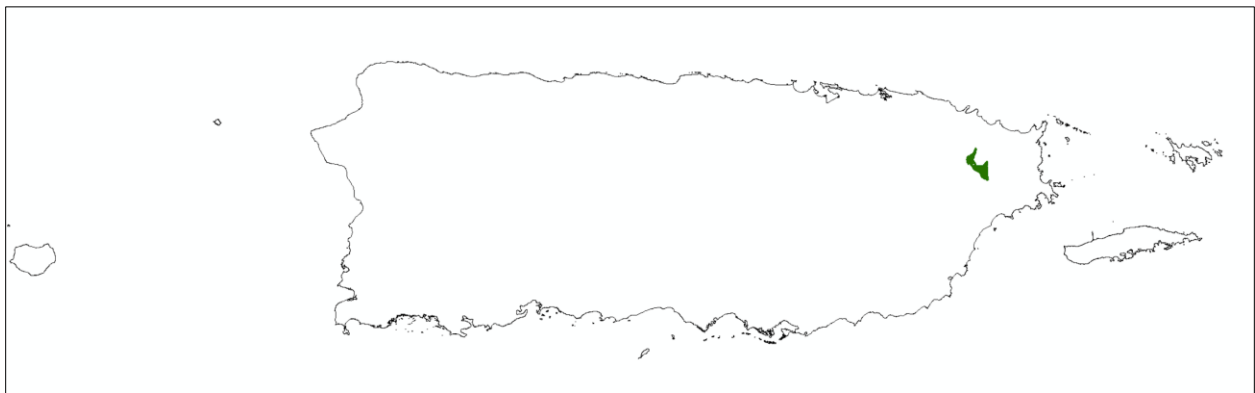


Figure 1. Distribution of the Lower Montane Rain Palustrine Volcanic Upland Forest.

**Dominant plant species:**

None of the FIA plots occurred within this ecological site. Two vegetation assemblages are common within this ecological site (Brandeis et al. 2009), listed below in decreasing order of



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importance. Dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

**Species assemblages:**

1. ***Prestoea montana***, ***Micropholis garciniifolia***, ***Sloanea berteriana***, *Micropholis chrysophylloides*, *Henriettea suamulosum*, *Byrsonima spicata*, *Dacryodes excelsa*, *Psychotria berteriana*, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.
  2. ***Cecropia schreberiana***, ***Citrus sinensis*** (Ex), *Inga laurina*, *Cyathea arborea*, *Persea amaricana* (Ex).
- **Other trees:** *Calyptanthes krugii*, *Ocotea spatulata*, *Micropholis guyanensis*, *Miconia pachyphylla*, *M. foveolata*, *Haenanthus salicifolius*, *Myrica horlidgeana*, *Dittha myricoides*, *Hediosmum arborescens*, *Daphnopsis philippiana*, *Magnolia portoricensis*, *Symplocos micrantha*, *Torrabasia cuneifolia*.
  - **Shrubs:** *Gesneria portoricensis*
  - **Herbaceous, cactus, succulents:** *Werauhia sintenisii*, *Isachne angustifolia*, *Pilea* sp., *Arthrostylidium sarmentosum*, *Adiantum* sp., *Hilla parasitica*, *Guzmania* sp., *Selaginella* sp., *Gonocalyx portoricensis*, *Nephelea portoricensis*, *Cyathea pubescens*.

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## PHYSIOGRAPHIC FEATURES

### **Landforms**

Steep slope (73%)

Top (19%)

Side slope (8%)

### **Physiographic features (characteristics ranges)**

Elevation range: 410-1,031 m (mean= 737 m)

Slope: 2-100% (mean= 40%, or 22 degrees)

Aspect (mean): South (162 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the LMRPVBF is about 4,044 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 26 °C, and the mean minimum temperature is 17°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

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Precipitation total: 4,044 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Soil series components within this ecological site include Dwarf, El Duque, and Yunque.

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

**State and Transition Models**

**COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

**Similar sites**

- Lower Montane Rain Palustrine Volcanic Upland Forest (LMRPVUF), Lower Montane

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Wet Palustrine Volcanic Bottomland Forest (LMWPVBF), Lower Montane Wet Palustrine Volcanic Upland Forest (LMRPVUF), Subtropical Rain Palustrine Volcanic Bottomland Forest (SRPVBF), Subtropical Rain Palustrine Volcanic Upland Forest (SRPVUF), Subtropical Wet Palustrine Quaternary Upland Forest (SWPQUF).

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SITE NAME: **LOWER MONTANE WET PALUSTRINE VOLCANIC BOTTOMLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (100%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Lower Montane Wet Palustrine Volcanic Bottomland Forest (LMWPVBF) was developed after collapsing the lower montane wet volcanic lower slope and the lower montane wet volcanic plain in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The LMWPVBF mostly falls within the National Vegetation Classification Group G448 Caribbean Wet Montane Forest (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include mature primary Tabonuco and secondary montane wet non-calcareous evergreen forest, and mature primary Sierra Palm and secondary montane wet non-calcareous evergreen forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the lower montane rainforest (zone IV) which includes forest, savanna, scrub, grassland, and about eleven vegetation communities.

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### **Ecological Site Concept:**

The LMWPVBF has an extension of 5 km<sup>2</sup> (less than 1% of the island), and it occupies the lowest landscape positions of the lower montane wet forest, only occurring in a small area within El Yunque National Forest (Fig. 1). This ecological site is very similar to the lower montane rain palustrine volcanic forest. Both are palustrine wetlands (Miller and Lugo 2009), associated with the wettest conditions and volcanic geology in the central mountains of Puerto Rico. These sites are environmental extremes and plants adapted to live there have developed physiological adaptations to tolerate extremely wet and windy conditions. Many trees, shrubs, and herbaceous species adapted to this ecological site are hydrophilic that can tolerate wet and anoxic soil conditions. The vegetation occurring here, in terms of species composition, is very similar to that found in the lower montane rain forest (Ewel and Whitmore 1973). In this ecological site as in the rain forests of Puerto Rico occurring at higher elevations, it is common to find azonal associations of Tabonuco forest (*Dacryodes-Sloanea*), Palo Colorado forest (*Cyrtilla-Micropholis*), elfin woodland (*Tabebuia-Eugenia-Ocotea*) also called dwarf or cloud forest, and Sierra Palm forest (*Prestoea montana*). Even though these associations are similar among the wettest ecological sites at higher elevations all-over the island, the species abundance and general physiognomy of the forest varies among them. For example, the dwarf cloud forest association dominates within this ecological site, as trees at the upper elevations of the rainforest are stunted or 'dwarfed' due to the exposure to continuous winds, very wet soils, and low transpiration rates that impedes nutrients flow from the soil to the leaves (Weaver 1973). What distinguishes the lower montane rain forest, described here, from the lower montane wet forest is the greater abundance of epiphytes, epiphyllae, palms, and tree ferns in the former (Ewel and Whitmore 1973).

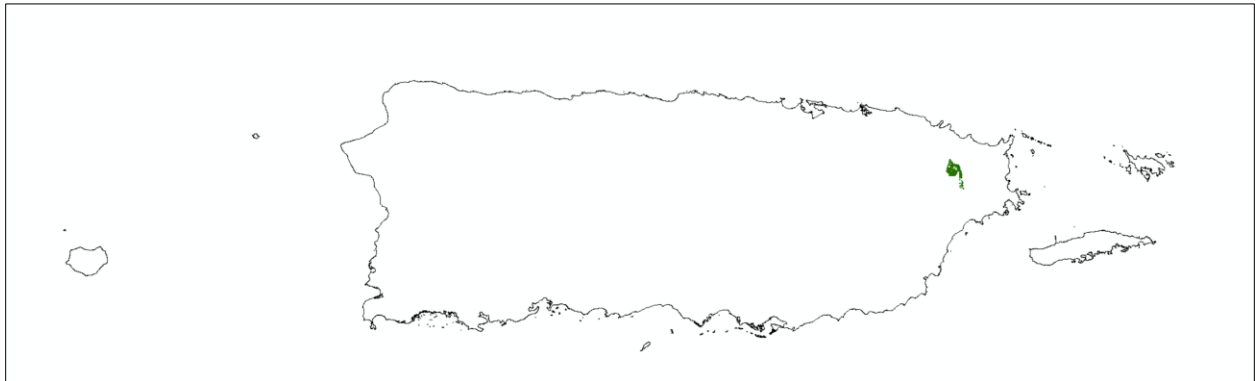


Figure 1. Distribution of the Lower Montane Wet Palustrine Volcanic Bottomland Forest in Puerto Rico.

### **Dominant plant species:**

Two vegetation assemblages are common within this ecological site (Brandeis et al. 2009), listed below in decreasing order of importance. Dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### **Species assemblages:**

1. ***Prestoea montana***, ***Micropholis garciniifolia***, ***Sloanea berteriana***, *Micropholis chrysophylloides*, *Henriettea suamulosum*, *Byrsonima spicata*, *Dacryodes excelsa*, *Psychotria berteriana*, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.

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2. *Cecropia schreberiana*, *Citrus sinensis* (Ex), *Inga laurina*, *Cyathea arborea*, *Persea amaricana* (Ex).

- **Other trees:** *Calyptranthes krugii*, *Ocotea spatulata*, *Micropholis guyanensis*, *Miconia pachyphylla*, *M. foveolata*, *Haenanthus salicifolius*, *Myrica horlidgeana*, *Ditella myricoides*, *Hedysmum arborescens*, *Daphnopsis philippiana*, *Magnolia portoricensis*, *Symplocos micrantha*, *Torrabasia cuneifolia*, *Cyrilla racemiflora*, *Ocotea spatulata*, *Micropholis chrysophylloides*, *Micropholis garciniaefolia*, *Eugenia borinquensis*, *Tabebuia rigida*, *Weinmannia pinnata*, *Calycogonium squamulosum*, *Prestoea montana*, *Cyathea arborea*, *Guettarda ovalifolia*, *Tabebuia haemantha*, *Dipholis cubensis*, *Guettarda pungens*, *Comocladia glabra*, *Clusia rosea*, *Clusia clusioides*.
- **Shrubs:** *Gesneria portoricensis*, *Acacia retusa*
- **Herbaceous, cactus, succulents:** *Werauhia sintenisii*, *Isachne angustifolia*, *Pilea* sp., *Arthrostylidium sarmentosum*, *Adiantum* sp., *Hilla parasitica*, *Guzmania* sp., *Selaginella* sp., *Gonocalyx portoricensis*, *Melinis minutiflora*, *Smilax coriacea*, *Chiococlea alba*, *Stigmaphyllon tomentosum*, *Cladonia* sp.

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slopes/mogote valley (77%)

Steep slopes/mogote side (18%)



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Tops (4%)

Plains (1%)

**Physiographic features (characteristics ranges)**

Elevation range: 133-308 m (mean= 465 m)

Slope: 2-106% (mean= 28%, or 15 degrees)

Aspect (mean): Southeast (153 degrees)

**CLIMATIC FEATURES**

Climate: The mean annual precipitation in the LMWPVBF is about 3,522 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 28 °C, and the mean minimum temperature is 18°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 3,522 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges):**

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**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Soil series components in this ecological site include Cristal, Prieto, Sonadora.

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

**State and Transition Models**

**COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

**Similar sites**

- Lower Montane Wet Palustrine Volcanic Upland Forest, Lower Montane Rain Palustrine Volcanic Upland Forest, Lower Montane Rain Palustrine Volcanic Bottomland Forest, Subtropical Rain Palustrine Volcanic Bottomland Forest, Subtropical Rain Palustrine Volcanic Upland Forest, Subtropical Wet Palustrine Quaternary Upland Forest.

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SITE NAME: **LOWER MONTANE WET PALUSTRINE VOLCANIC UPLAND FOREST**

**(F270X...)**

MLRA 270-Humid Mountains and Valleys (100%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Lower Montane Wet Palustrine Volcanic Upland Forest (LMWPVUF) was developed after collapsing the lower montane wet volcanic upper slope and the lower montane wet volcanic ridge in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The LMWPVUF mostly falls within the National Vegetation Classification Group G448 Caribbean Wet Montane Forest (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include mature primary Tabonuco and secondary montane wet non-calcareous evergreen forest, and mature primary Sierra Palm and secondary montane wet non-calcareous evergreen forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the lower montane rainforest (zone IV) which includes forest, savanna, scrub, grassland, and about eleven vegetation communities.

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### **Ecological Site Concept:**

The LMWPVUF has an extension of 9.4 km<sup>2</sup> (less than 1% of the island), only occurring in a small area within El Yunque National Forest (Fig. 1). This ecological site is very similar to the lower montane rain palustrine volcanic forest since both are palustrine wetlands (Miller and Lugo 2009), associated with the wettest conditions and volcanic geology in the central mountains of Puerto Rico. These sites are environmental extremes and plants adapted to live there have developed physiological adaptations to tolerate extremely wet and windy conditions. Many trees, shrubs, and herbaceous species adapted to this ecological site are hydrophilic that can tolerate wet and anoxic soil conditions. The vegetation occurring here, in terms of species composition, is very similar to that found in the lower montane rain forest (Ewel and Whitmore 1973). In this ecological site as in the rain forests of Puerto Rico occurring at higher elevations, it is common to find azonal associations of Tabonuco forest (*Dacryodes-Sloanea*), Palo Colorado forest (*Cyrilla-Micropholis*), elfin woodland (*Tabebuia-Eugenia-Ocotea*) also called dwarf or cloud forest, and Sierra Palm forest (*Prestoea montana*). Even though these associations are similar among the wettest ecological sites at higher elevations all-over the island, the species abundance and general physiognomy of the forest varies among them. For example, the dwarf cloud forest association dominates within this ecological site, as trees at the upper elevations of the rainforest are stunted or 'dwarfed' due to the exposure to continuous winds, very wet soils, and low transpiration rates that impedes nutrients flow from the soil to the leaves (Weaver 1973). What distinguishes the lower montane rain forest, described here, from the lower montane wet forest is the greater abundance of epiphytes, epiphyllae, palms, and tree ferns in the former (Ewel and Whitmore 1973).

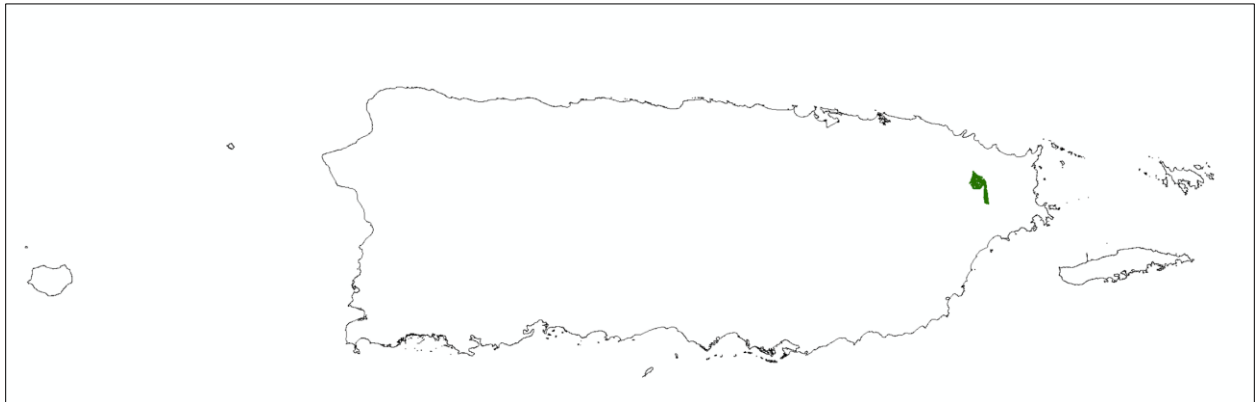


Figure 1. Distribution of the Lower Montane Wet Palustrine Volcanic Upland Forest in Puerto Rico.

### **Dominant plant species:**

Dominant species in FIA plots within this ecological site includes *Prestoea acuminata*, *Dacryodes excelsa*, *Cecropia schreberiana*, *Guarea glabra*, *Ocotea leucoxylon*, *Alchornea latifolia*, *Inga laurina*, *Ilex sideroxyloides* (Marcano-Vega 2019). Two vegetation assemblages are common within this ecological site (Brandeis et al. 2009), listed below in decreasing order of importance. Dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### **Species assemblages:**

1. ***Prestoea montana***, ***Micropholis garciniifolia***, ***Sloanea berteriana***, ***Micropholis chrysophylloides***, *Henriettea suamulosum*, *Byrsonima spicata*, *Dacryodes excelsa*,

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*Psychotria berteriana*, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*,  
*Myrcia citrifolia*.

2. ***Cecropia schreberiana*, *Citrus sinensis* (Ex), *Inga laurina*, *Cyathea arborea*, *Persea amaricana* (Ex).**

- **Other trees:** *Calyptanthes krugii*, *Ocotea spatulata*, *Micropholis guyanensis*, *Miconia pachyphylla*, *M. foveolata*, *Haenanthus salicifolius*, *Myrica horlidgeana*, *Ditta myricoides*, *Hediosmum arborescens*, *Daphnopsis philippiana*, *Magnolia portoricensis*, *Symplocos micrantha*, *Torrabasia cuneifolia*, *Cyrilla racemiflora*, *Ocotea spatulata*, *Microphilis chrysophylloides*, *Micropholis garciniaefolia*, *Eugenia borinquensis*, *Tabebuia rigida*, *Weinmannia pinnata*, *Calycogonium squamulosum*, *Prestoea montana*, *Cyathea arborea*, *Guettarda ovalifolia*, *Tabebuia haemantha*, *Dipholis cubensis*, *Guettarda pungens*, *Comocladia glabra*, *Clusia rosea*, *Clusia clusioides*.
- **Shrubs:** *Gesneria portoricensis*, *Acacia retusa*
- **Herbaceous, cactus, succulents:** *Werauhia sintenisii*, *Isachne angustifolia*, *Pilea sp.*, *Arthrostylidium sarmentosum*, *Adiantum sp.*, *Hilla parasitica*, *Guzmania sp.*, *Selaginella sp.*, *Gonocalyx portoricensis*, *Melinis minutiflora*, *Smilax coriacea*, *Chiococlea alba*, *Stigmaphyllon tomentosum*, *Cladonia sp.*

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## PHYSIOGRAPHIC FEATURES

### **Landforms**

Steep slopes/mogote side (75%)

Tops (14%)

Side slopes/mogote valley (11%)

### **Physiographic features (characteristics ranges)**

Elevation range: 170-727 m (mean= 469 m)

Slope: 2-100% (mean= 40%, or 22 degrees)

Aspect (mean): South (161 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the LMWPVUF is about 3,550 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 28 °C, and the mean minimum temperature is 18°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

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Precipitation total: 3,550 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges):**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Soil series components in this ecological site include Ciales, Guayabota, Picacho, Utuado, Yunque, Zarzal

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

**State and Transition Models**

**COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

**Similar sites**



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- Lower Montane Wet Palustrine Volcanic Bottomland Forest (LMWPVBF), Lower Montane Rain Palustrine Volcanic Upland Forest (LMRPVUF), Lower Montane Rain Palustrine Volcanic Bottomland Forest (LMRPVBF), Subtropical Rain Palustrine Volcanic Bottomland Forest (SRPVBF), Subtropical Rain Palustrine Volcanic Upland Forest (SRPVUF), Subtropical Wet Palustrine Quaternary Upland Forest (SWPQUF).

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**SITE NAME: SUBTROPICAL RAIN PALUSTRINE VOLCANIC BOTTOMLAND FOREST  
(F270X...)**

MLRA 270-Humid Mountains and Valleys (100%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Subtropical Rain Palustrine Volcanic Bottomland Forest (SRPVBF) is the subtropical rain volcanic and volcanoclastic plain and lower slope forests in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SRPVBF falls within the National Vegetation Classification Groups G448 Caribbean Wet Montane Forest, D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna, G451 Caribbean Montane Cloud Forest Group, and G452 Caribbean Montane Elfin Thicket (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include mature primary Palo Colorado and secondary montane wet non-calcareous evergreen forest, mature primary Sierra Palm and secondary montane wet non-calcareous evergreen forest, mature secondary montane wet non-calcareous evergreen forest, mature primary elfin woodland and secondary montane wet non-calcareous evergreen cloud forest, and mature primary Tabonuco and secondary montane wet non-calcareous evergreen forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966) this ecological site occurs

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within the montane forest subzone (zone V) which includes forest, savanna, scrub, and grassland, and more than 18 vegetation communities.

### **Ecological Site Concept:**

The SRPVBF has an extension of 42 km<sup>2</sup> (~0.5% of the island) and it occurs in the lowest landscape position of the top of the mountains (Fig.1). This ecological site is a palustrine wetland (Miller and Lugo 2009) occurring within the subtropical rainforest life zone, associated with the wettest conditions and volcanic geology in the central mountains of Puerto Rico. This ecological site is not found in the USVI. The subtropical rain forest life zone, where this ecological site occurs, is characterized by the high amount of rainfall that receives annually, abundant runoff, low temperatures, constant wet soil, high relative humidity, low light due to cloud formation, fog, acid soils, and oxygen stress that inhibits root respiration which influences the vegetation that grows in this site. Many trees, shrubs, and herbaceous species adapted to this ecological site are hydrophilic that can tolerate wet and anoxic soil conditions. Although the environmental conditions in this ecological site are quite different from those in the wet forest, the vegetation (in terms of species composition) found here is very similar to the vegetation found in the surrounding subtropical wet forest (Ewel and Whitmore 1973). In this ecological site as in the wet forests of Puerto Rico, it is common to find azonal associations of Tabonuco forest (*Dacryodes-Sloanea*), Palo Colorado forest (*Cyrilla-Micropholis*), elfin woodland (*Tabebuia-Eugenia-Ocotea*) also called dwarf or cloud forest, and Sierra Palm forest (*Prestoea montana*). Even though these associations are similar among the wettest ecological sites at higher elevations all-over the island, the species relative abundance and general physiognomy of the forest varies

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among them. For example, trees at the upper elevations of the rainforest are stunted or 'dwarfed' due to the exposure to continuous winds, very wet soils, and low transpiration rates that impedes nutrients flow from the soil to the leaves (Weaver 1973). Besides the presence of the “dwarf” forest, another characteristic of the subtropical rainforest is the high abundance of sierra palms, epiphytes, and the spiny tree-fern *Nephelea portoricensis* (Ewel and Whitmore 1973). The SRPVBF can be found in El Yunque National Forest and the States Forests of Carite, Monte Guilarte, Toro Negro, and Tres Picachos.

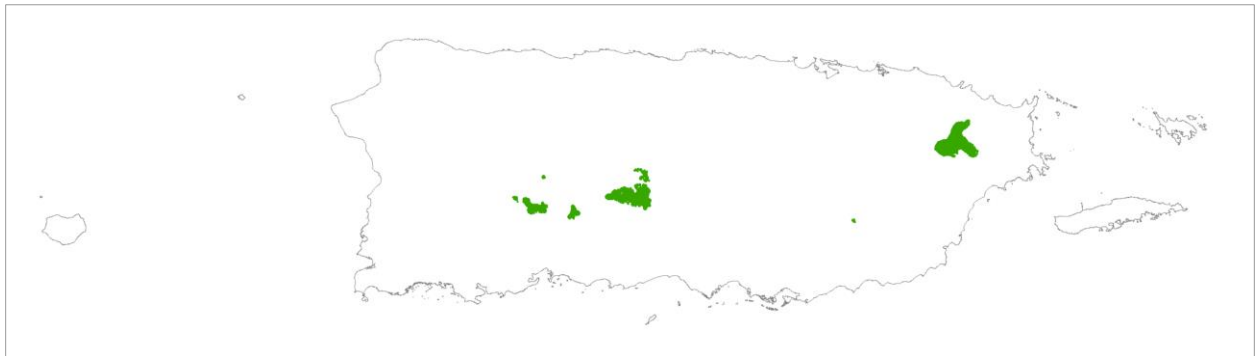


Figure 1. Distribution of the Subtropical Rain Palustrine Volcanic Bottomland Forest in Puerto Rico.

**Dominant plant species:**

Dominant tree species within this ecological site included *Prestoea acuminata*, *Cecropia schreberiana*, and *Coffea arabica* (Ex) (Marcano-Vega 2019). Secondary important species (about 20) include *Myrcia deflexa*, *Ditta myricoides*, *Miconia pycnoneura*, *Torralsasia cuneifolia* (Marcano-Vega 2019). Eight out of 14 tree assemblages identified for Puerto Rico,

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occur within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

**Species assemblages:**

1. ***Guarea guidonia***, ***Dendropanax arboreus***, ***Mangifera indica*** (Ex), *Artocarpus altilis* (Ex), *Cordia sulcata*, *Quaraibea turbinata*, *Erythrina poepiggiana* (Ex), *Cordia alliodora*.
2. ***Spathodea campanulata*** (Ex).
3. ***Syzygium jambos*** (Ex), *Zanthoxylum martinicense*, *Schefflera morototonii*, *Croton rigidus*, *Calophyllum antillanum* (Ex).
4. ***Cecropia schreberiana***, ***Citrus sinensis*** (Ex), *Inga laurina*, *Cyathea arborea*, *Persea amaricana* (Ex).
5. ***Casearia sylvestris***, ***Psidium guajava***, ***Coffea arabica*** (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*.
6. ***Tabebuia heterophylla***, ***Casearia arborea***, *Roystonea borinquena*, *Myrcia citrifolia*.
7. ***Prestoea montana***, ***Micropholis garciniifolia***, ***Sloanea berteriana***, *Micropholis chrysophylloides*, *Henriettea suamulosum*, *Byrsonima spicata*, *Dacryodes excelsa*, *Psychotria berteriana*, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.
8. ***Casearia guianensis***, ***Andira inermis***, ***Guazuma ulmifolia***, *Guapira fragans*, *Myrcia*

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*splendens*, *Cupania americana*.

- **Other trees:** *Prestoea montana*, *Cyathea arborea*, *Calyptranthes krugii*, *Ocotea spatulata*, *Micropholis guyanensis*, *Miconia pachyphylla*, *M. foveolata*, *Haenanthus salicifolius*, *Myrica horlidgeana*, *Ditta myricoides*, *Hediousmum arborescens*, *Daphnopsis philippiana*, *Magnolia portonicensis*, *Symplocos micrantha*, *Torralsasia cuneifolia*, *Cecropia peltata*, *Didymopanax morototoni*.
- **Shrubs:** *Cyathea arborea*, *Gesneria portoricensis*.
- **Herbs, cactus, succulents:** *Werauhia sintenisii*, *Isachne angustifolia*, *Pilea sp.*, *Arthrostylidium sarmentosum*, *Adiantum sp.*, *Hilla parasitica*, *Guzmania sp.*, *Selaginella sp.*, *Gonocalyx portoricensis*, *Nephelea portoricensis*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slope (81%)

Steep slope (11%)

Top (5%)

Plains (3%)

### Physiographic features (characteristics ranges)

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Elevation range: 375 m to 1,308 m (mean= 873 m)

Slope: 0-156% (mean= 31%, or 17 degree)

Aspect (mean): South (184 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SRPVBF is about 3,162 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 26°C, and the mean minimum temperature is 15°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 3,162 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges)**

### **Monthly temperature (average minimum/maximum)**

## INFLUENCING WATER FEATURES

Creeks and streams formations, continuous wet soils.

## REPRESENTATIVE SOIL FEATURES

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Acid and saturated soils, mineral soils with layers of peat, iron, and clay (hardpan). Soil series components in this ecological site include Icacos, Moteado, and Palm.

### **Surface texture**

### **Soil features**

Family particle size:

### **Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

### **State and Transition Models**

### **COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

### **Similar sites**

- Subtropical Rain Palustrine Volcanic Upland Forest (SRPVUF)
- Subtropical Wet Palustrine Quaternary Upland Forest (SWPQUF)
- Subtropical Wet Palustrine Volcanic Upland Forest (SWPVUF)



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**SITE NAME: SUBTROPICAL RAIN PALUSTRINE VOLCANIC UPLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (100%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Subtropical Rain Palustrine Volcanic Upland Forest (SRPVUF) is the subtropical rain volcanic and volcanoclastic ridge and upper slope forests in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SRPVUF falls within the National Vegetation Classification Groups G448 Caribbean Wet Montane Forest, G451 Caribbean Montane Cloud Forest Group, and G452 Caribbean Montane Elfin Thicket (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include mature primary Sierra Palm and secondary montane wet non-calcareous evergreen forest, mature secondary montane wet non-calcareous evergreen forest, mature primary Palo Colorado and secondary montane wet non-calcareous evergreen forest, mature primary elfin woodland and secondary montane wet non-calcareous evergreen cloud forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966) this ecological site occurs within the montane forest subzone (zone V) which includes forest, savanna, scrub, and grassland, and more than 18 vegetation communities.

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### **Ecological Site Concept:**

The SRPVBF has an extension of 62 km<sup>2</sup> (<1% of the island) and it occurs in the highest landscape position of the top of the mountains (Fig.1). This ecological site is a palustrine wetland (Miller and Lugo 2009) occurring within the subtropical rainforest life zone, associated with the wettest conditions and volcanic geology in the central mountains of Puerto Rico. This ecological site is not found in the USVI. The subtropical rain forest life zone, where this ecological site occurs, is characterized by the high amount of rainfall that receives annually, abundant runoff, low temperatures, constant wet soil, high relative humidity, low light due to cloud formation, fog, acid soils, and oxygen stress that inhibits root respiration which influences the vegetation that grows in this site. Many trees, shrubs, and herbaceous species adapted to this ecological site are hydrophilic that can tolerate wet and anoxic soil conditions. Although the environmental conditions in this ecological site are quite different from those in the wet forest, the vegetation (in terms of species composition) found here is very similar to the vegetation found in the surrounding subtropical wet forest (Ewel and Whitmore 1973). In this ecological site as in the wet forests of Puerto Rico, it is common to find azonal associations of Tabonuco forest (*Dacryodes-Sloanea*), Palo Colorado forest (*Cyrilla-Micropholis*), elfin woodland (*Tabebuia-Eugenia-Ocotea*) also called dwarf or cloud forest, and Sierra Palm forest (*Prestoea montana*). Even though these associations are similar among the wettest ecological sites at higher elevations all-over the island, the species relative abundance and general physiognomy of the forest varies among them. For example, trees at the upper elevations of the rainforest are stunted or 'dwarfed' due to the exposure to continuous winds, very wet soils, and low transpiration rates that impedes nutrients flow from the soil to the leaves (Weaver 1973). Besides the presence of the “dwarf” forest, another characteristic of the subtropical rainforest is the high abundance of sierra palms,

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epiphytes, and the spiny tree-fern *Nephelea portoricensis* (Ewel and Whitmore 1973). The SRPVUF can be found in El Yunque National Forest and the States Forests of Carite, Monte Guilarte, Toro Negro, and Tres Picachos.

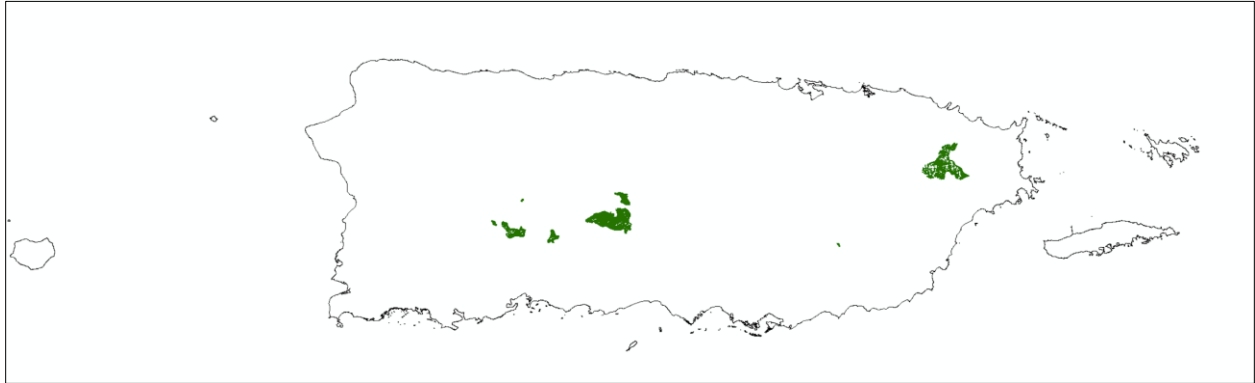


Figure 1. Distribution of the Subtropical Rain Palustrine Volcanic Upland Forest in Puerto Rico.

### **Dominant plant species:**

There was no FIA plot occurring on this ecological site but the vegetation found here is very similar (in terms of species composition) to that in the SRPVBF where dominant tree species include *Prestoea acuminata*, *Cecropia schreberiana*, and *Coffea arabica* (Ex) (Marcano-Vega 2019). As for the ecological sites occurring at higher elevations (lower montane ecological sites) two species assemblages occur within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

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Species assemblages:

1. *Prestoea montana*, *Micropholis garciniifolia*, *Sloanea berteriana*, *Micropholis chrysophylloides*, *Henriettea suamulosum*, *Byrsonima spicata*, *Dacryodes excelsa*, *Psychotria berteriana*, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.
  2. *Casearia guianensis*, *Andira inermis*, *Guazuma ulmifolia*, *Guapira fragans*, *Myrcia splendens*, *Cupania americana*.
  3. *Cecropia schreberiana*, *Citrus sinensis* (Ex), *Inga laurina*, *Cyathea arborea*, *Persea amaricana* (Ex).
- **Other trees:** *Prestoea montana*, *Calyptanthes krugii*, *Ocotea spatulata*, *Micropholis guyanensis*, *Miconia pachyphylla*, *M. foveolata*, *Haenanthus salicifolius*, *Myrcia horlidgeana*, *Ditta myricoides*, *Hediosmum arborescens*, *Daphnopsis philippiana*, *Magnolia portoricensis*, *Symplocos micrantha*, *Torrabasia cuneifolia*, *Cyathea arborea*
  - **Shrubs:** *Cyathea arborea*, *Gesneria portoricensis*.
  - **Herbs, cactus, succulents:** *Werauhia sintenisii*, *Isachne angustifolia*, *Pilea* sp., *Arthrostylidium sarmentosum*, *Adiantum* sp., *Hilla parasitica*, *Guzmania* sp., *Selaginella* sp., *Gonocalyx portoricensis*, *Nephelea portoricensis*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Steep slope (67%)

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Side slope (11%)

Top (22%)

**Physiographic features (characteristics ranges)**

Elevation range: 375 m to 1,323 m (mean= 893 m)

Slope: 0-128% (mean= 39%, or 21 degree)

Aspect (mean): South (185 degrees)

**CLIMATIC FEATURES**

Climate: The mean annual precipitation in the SRPVUF is about 3,144 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 26°C, and the mean minimum temperature is 15°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 3,144 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

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## **Monthly temperature (average minimum/maximum)**

### INFLUENCING WATER FEATURES

Creeks and streams formations, continuous wet soils.

### REPRESENTATIVE SOIL FEATURES

Acid and saturated soils, mineral soils with layers of peat, iron, and clay (hardpan). Soil series components in this ecological site include Agueybana, Chiquito, Cuchillas, Los Guineos, Maricao, Rubias, Yunque.

### **Surface texture**

### **Soil features**

Family particle size:

### **Soil features (characteristic ranges)**

### ECOLOGICAL DYNAMICS OF THE SITE

### **State and Transition Models**

### **COMMUNITY 1.1- State 1-Reference**

### ECOLOGICAL SITES INTERPRETATION

### SUPPORTING INFORMATION

### **Similar sites**

- Subtropical Rain Palustrine Volcanic Upland Forest (SRPVBF)
- Subtropical Wet Palustrine Quaternary Upland Forest (SWPQUF)

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- Subtropical Wet Palustrine Volcanic Upland Forest (SWPVUF)
  - Lower Montane Wet Palustrine Volcanic Upland Forest (LMWPVUF)
  - Lower Montane Wet Palustrine Volcanic Bottomland Forest (LMWPVBF)
  - Lower Montane Rain Palustrine Volcanic Upland Forest (LMRPVUF)
  - Lower Montane Rain Palustrine Volcanic Bottomland Forest (LMRPVBF)

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**SITE NAME: SUBTROPICAL WET PALUSTRINE VOLCANIC UPLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (99%), MLRA 271- Semiarid Mountains and Valleys (1%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Subtropical Wet Palustrine Volcanic Upland Forest (SWPVUF) was developed after collapsing two landscape units classified for Puerto Rico (Gould et al. 2008): the subtropical wet volcanic and volcanoclastic upper slope and the subtropical wet volcanic and volcanoclastic ridge. The SWPVUF mostly falls within the National Vegetation Classification Group G448 Caribbean Wet Montane Forest and D094 Caribbean and Central American Lowland Shrubland, Grassland, and Savanna (U.S. National Vegetation Classification 2019). According to a USDA Forest Service land cover map (Gould et al. 2007), dominant vegetation covers within this ecological site include montane wet evergreen abandoned and active coffee plantation, moist grasslands and pastures, mature secondary montane wet non-calcareous evergreen forest, montane wet non-calcareous evergreen shrubland and woodland, young secondary montane wet non-calcareous evergreen forest. In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the montane forest (zone V) which includes forest, savanna, scrubs, grassland, and about eleven vegetation communities.



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### Ecological Site Concept:

The SWPVUF has an extension of 1,006 km<sup>2</sup> (~11% of the island), and most of it occurs in the upper landscape positions of the wet forest occurring along the central mountains of Puerto Rico (Fig. 1). This ecological site is not found in the USVI. The vegetation in this ecological site is rich in species with some characteristic groups adapted to abundant moisture such as epiphytic ferns, tree ferns (*Cyathea arborea*), bromeliads, and orchids (Ewel and Whitmore 1973). There is a zonal association in the wet forest known as the Tabonuco type, dominated by *Dacryodes excelsa* (motillo), and other secondary important species such as *Sloanea berteriana*, and *Manilkara bidentata* (ausubo) (Ewel and Whitmore 1973). However, much of this ecological site is covered by successional vegetation as a result of past agriculture (mostly shade-grown coffee plantations) and later abandonment. Species such as *Piper aduncum*, *Cecropia peltata*, *Didymopanax morototoni*, *Prestoea montana*, and *Ochroma lagopus* are abundant in successional forests on this ecological site (Ewel and Whitmore 1973). The SWVBF can be found in the State Forests of Tres Picachos, Carite, Maricao, Monte Guilarte, Rio Abajo, Toro Negro, and within El Yunque National Forest.

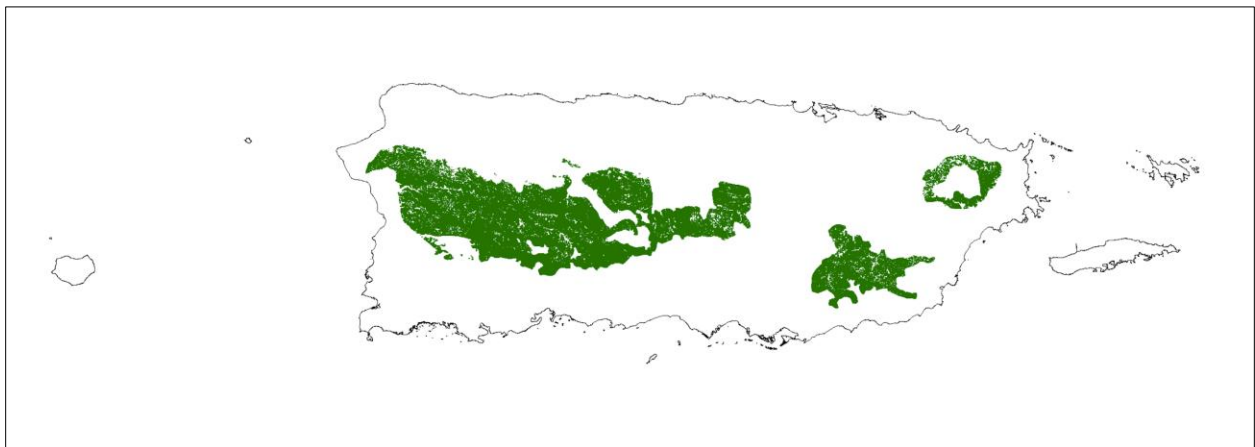


Figure 1. Distribution of the Subtropical Wet Palustrine Volcanic Upland Forest.

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### Dominant plant species:

Dominant species within this ecological site are *Guarea guidonia*, *Cecropia schreberiana*, *Syzygium jambos*, *Cyathea arborea*, *Ocotea leucoxylon*, *Schefflera morototonii*, *Syzygium jambos*, *Cyathea arborea*, *Ocotea leucoxylon* (Marcano-Vega 2019). Eight out of fourteen tree assemblages were described for this ecological site in Puerto Rico (Brandeis et al. 2009).

Assemblages are listed below in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### Species assemblages:

1. ***Guarea guidonia***, ***Dendropanax arboreus***, ***Mangifera indica*** (Ex), *Artocarpus altilis* (Ex), *Cordia sulcata*, *Quararibea turbinata*, *Erythrina poeppigiana* (Ex), *Cordia alliodora*.
2. ***Spathodea campanulata*** (Ex), *Terminalia catappa* (Ex).
3. ***Cecropia schreberiana***, ***Citrus xsinensis*** (Ex), *Inga laurina*, *Cyathea arborea*, *Persea americana* (Ex).
4. ***Syzygium jambos*** (Ex), *Zanthoxylum martinicense*, *Schefflera morototonii*, *Croton rigidus*, *Calophyllum antillanum* (Ex).
5. ***Casearia sylvestris***, ***Psidium guajava***, ***Coffea arabica*** (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*.
6. ***Tabebuia heterophylla***, ***Casearia arborea***, *Roystonea borinquena*, *Myrcia citrifolia*.

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7. *Prestoea montana*, *Micropholis garciniifolia*, *Sloanea berteriana*, *Micropholis chrysipholloides*, *Henriettea squamulosum*, *Byrsonima spicata*, *Dacryodes excelsa*, *Psychotria berteriana*, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.
8. *Casearia guianensis*, *Andira inermis*, *Guazuma ulmifolia*, *Guapira fragans*, *Myrcia splendens*, *Cupania americana*.
- **Other trees:** *Dacryodes excelsa*, *Cyathea arborea*, *Sloanea berteriana*, *Manilkara bidentata*, *Piper aducum*, *Cecropia peltata*, *Dyimopanax morototoni*, *Ochroma lagopus*, *Prestoea montana*.
  - **Shrubs:** *Gonzalagunia spicata*, *Miconia laevigata*, *Clidemia hirta*, *Solanum torvum*, *Cestrum citrifolium*.
  - **Herbs, cactus, succulents:** *Marcgravia rectifolia*, *Ipomoea sp.*, *Thillandsia bulbosa*, *T. polystachia*, *Solanum americanum*, *Tolumnia variegata*, *Ionopsis utricularioides*

## PHYSIOGRAPHIC FEATURES

### Landforms

Steep slopes/mogote side (60%)

Tops (26%)

Side slopes/mogote valley (13%)

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### **Physiographic features (characteristics ranges)**

Elevation range: 16 m -1,168 m (mean= 464 m)

Slope: 0-169% (mean= 38%, or 20 degrees)

Aspect (mean): South (180 degrees)

### **CLIMATIC FEATURES**

Climate: The mean annual precipitation in the SWPVUF is about 2,100 millimeters. Rainfall is distributed throughout the year, with peaks on May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 15°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 2,100 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges):**

### **Monthly temperature (average minimum/maximum)**

### **INFLUENCING WATER FEATURES**

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## REPRESENTATIVE SOIL FEATURES

Soil components include, 1) INTRUSIVE: Ingenio, Limones, Lirios, Pandura, Patillas, Pellejas, Teja, 2) EXTRUSIVE: Adjuntas, Aibonito, Alonso, Anones, Consejo, Consumo, Corozal, Daguao, Daguey, Humatas, Jagueyes, Maraguez, Morado, Mucara, Naranjito, Plata, Yunes.

### **Surface texture**

### **Soil features**

Family particle size:

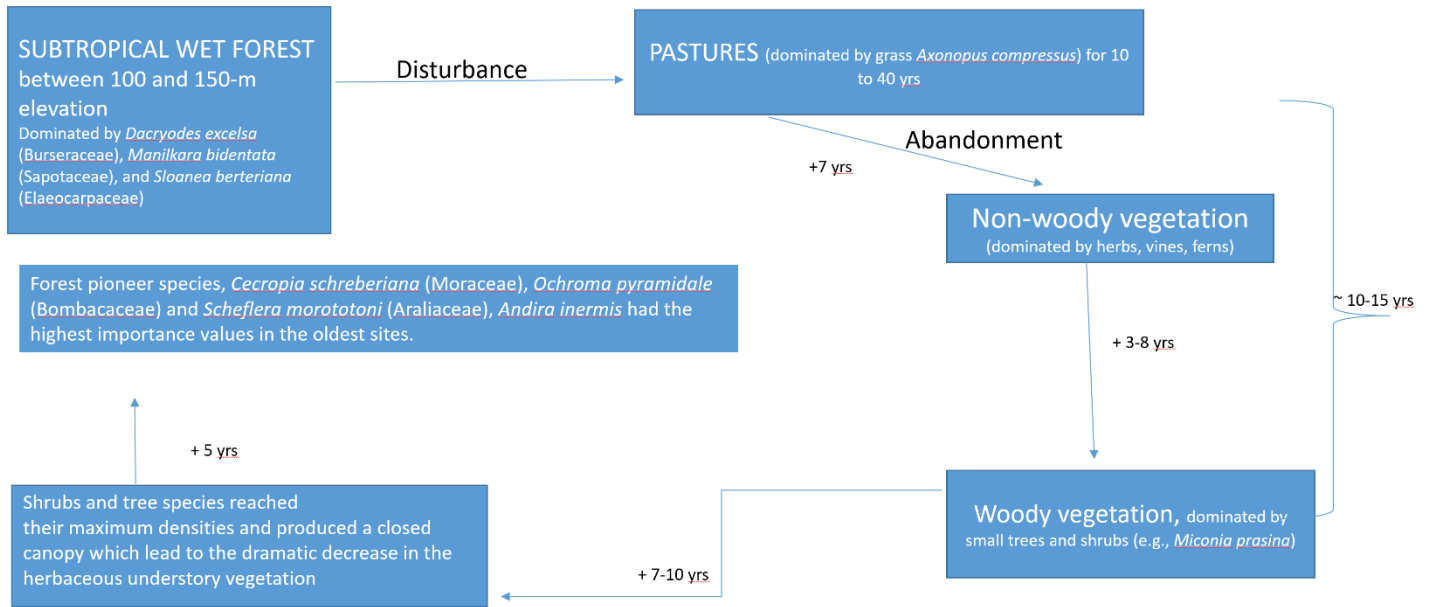
### **Soil features (characteristic ranges)**

## ECOLOGICAL DYNAMICS OF THE SITE

### **State and Transition Models**

### **COMMUNITY 1.1- State 1-Reference**

## ECOLOGICAL SITES INTERPRETATION



Forest recovery in abandoned cattle pastures along an elevational gradient in Northeastern Puerto Rico (information extracted from Aide et al. 1996).

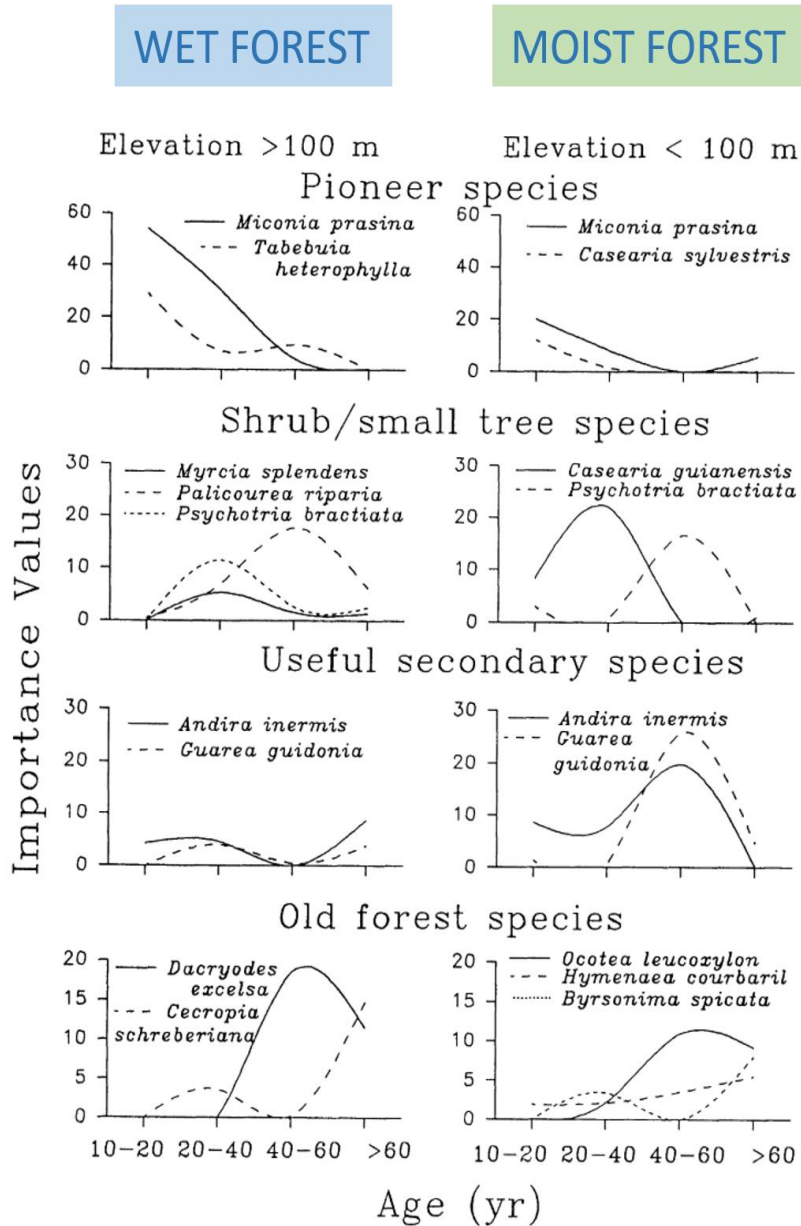


FIGURE 5. A comparison of changes in importance values with site age for common pioneer, shrub/small tree, useful secondary species with valuable wood, and old forest species between low (<100 m) and high (>100 m) elevation sites. Curves are cubic spline interpolations (Sigmaplot 1989) based on the average importance values of all sites in each age class.

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## SUPPORTING INFORMATION

### **Similar sites**

- Subtropical Wet Quaternary Bottomland Forest (SWQBF)
- Subtropical Wet Volcanic Bottomland Forest (SWVBF)



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**SITE NAME: SUBTROPICAL WET VOLCANIC BOTTOMLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (99%), MLRA 272- Humid Coastal Plains (1%)

Occurrence: Puerto Rico (mainisland)

Site stage: Provisional

### **Classification Relationship**

The Subtropical Wet Volcanic Bottomland Forest (SWVBF) was developed after collapsing two landscape units classified for Puerto Rico (Gould et al. 2008): the subtropical wet volcanic and volcanoclastic lower slope and the subtropical wet volcanic and volcanoclastic plain. The SWVBF mostly falls within the National Vegetation Classification Group D094 Caribbean and Central American Lowland Shrubland, Grassland, and Savanna, and G448 Caribbean Wet Montane Forest (U.S. National Vegetation Classification 2019). According to a USDA Forest Service land cover map (Gould et al. 2007), dominant vegetation covers within this ecological site include montane wet evergreen abandoned and active coffee plantation, moist grasslands and pastures, montane wet non-calcareous evergreen shrubland and woodland, young secondary montane wet non-calcareous evergreen forest, mature secondary montane wet non-calcareous evergreen forest, mature primary Tabonuco and secondary montane wet noncalcareous evergreen forest. In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the montane forest (zone V) which includes forest, savanna, scrubs, grassland, and about eleven vegetation communities.

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### Ecological Site Concept:

The SWVBF has an extension of 739 km<sup>2</sup> (~8% of the island), and most of it occurs in the lower landscape positions of the wet forest occurring along the central mountains of Puerto Rico (Fig. 1). This ecological site is not found in the USVI. The vegetation in this ecological site is rich in species with some characteristic groups adapted to abundant moisture such as epiphytic ferns, tree ferns (*Cyathea arborea*), bromeliads, and orchids (Ewel and Whitmore 1973). There is a zonal association in the wet forest known as the Tabonuco type, dominated by *Dacryodes excelsa* (motillo), and other secondary important species such as *Sloanea berteriana*, and *Manilkara bidentata* (ausubo) (Ewel and Whitmore 1973). However, much of this ecological site is covered by successional vegetation as a result of past agriculture (mostly shade-grown coffee plantations) and later abandonment. Species such as *Piper aduncum*, *Cecropia peltata*, *Didymopanax morototoni*, *Prestoea montana*, and *Ochroma lagopus* are abundant in successional forests on this ecological site (Ewel and Whitmore 1973). The SWVBF can be found in the State Forests of Tres Picachos, Carite, Maricao, Monte Guilarte, Rio Abajo, Toro Negro, and within El Yunque National Forest.

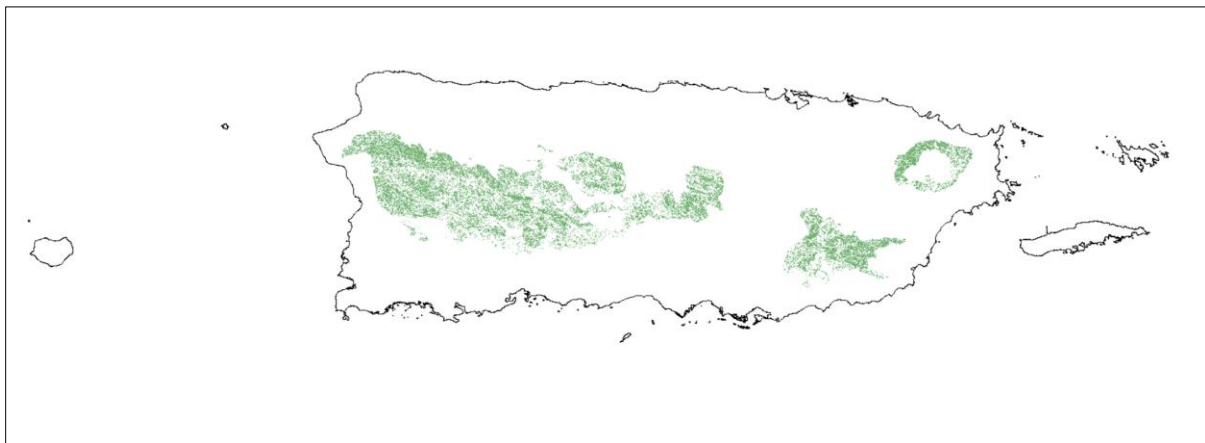


Figure 1. Distribution of the Subtropical Wet Volcanic Bottomland Forest.

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### **Dominant plant species:**

Dominant species within this ecological site are *Guarea guidonia*, *Ocotea leucoxyton*, and *Cecropia schreberiana* (Marcano-Vega 2019). Secondary important species include more than 70 species such as *Syzygium jambos*, *Tabebuia heterophylla*, *Prestoea acuminata*, *Mangifera indica*, *Dendropanax arboreus*, *Coffea liberica*, among others (Marcano-Vega 2019). Eight out of fourteen tree assemblages were described for this ecological site in Puerto Rico (Brandeis et al. 2009). Assemblages are listed below in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### **Species assemblages:**

1. ***Guarea guidonia***, ***Dendropanax arboreus***, ***Mangifera indica*** (Ex), *Artocarpus altilis* (Ex), *Cordia sulcata*, *Quararibea turbinata*, *Erythrina poepiggiana* (Ex), *Cordia alliodora*.
2. ***Spathodea campanulata*** (Ex), *Terminalia catappa* (Ex).
3. ***Cecropia schreberiana***, ***Citrus xsinensis*** (Ex), *Inga laurina*, *Cyathea arborea*, *Persea americana* (Ex).
4. ***Syzygium jambos*** (Ex), *Zanthoxylum martinicense*, *Schefflera morototonii*, *Croton rigidus*, *Calophyllum antillanum* (Ex).
5. ***Casearia sylvestris***, ***Psidium guajava***, ***Coffea arabica*** (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia*

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*elaeagnoides*, *Piper amalago*.

6. *Tabebuia heterophylla*, *Casearia arborea*, *Roystonea borinquena*, *Myrcia citrifolia*.

7. *Prestoea montana*, *Micropholis garciniifolia*, *Sloanea berteriana*, *Micropholis chrysipholloides*, *Henriettea squamulosum*, *Byrsonima spicata*, *Dacryodes excelsa*, *Psychotria berteriana*, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.

8. *Casearia guianensis*, *Andira inermis*, *Guazuma ulmifolia*, *Guapira fragans*, *Myrcia splendens*, *Cupania americana*.

- **Other trees:** *Dacryodes excelsa*, *Cyathea arborea*, *Sloanea berteriana*, *Manilkara bidentata*, *Piper aducum*, *Cecropia peltata*, *Dyimopanax morototoni*, *Ochroma lagopus*, *Prestoea montana*, *Guarea guidonia*.
- **Shrubs:** *Gonzalagunia spicata*, *Miconia laevigata*, *Clidemia hirta*, *Solanum torvum*, *Cestrum citrifolium*.
- **Herbs, cactus, succulents:** *Marcgravia rectifolia*, *Ipomoea sp.*, *Thillandsia bulbosa*, *T. polystachia*, *Solanum americanum*, *Tolumnia variegata*, *Ionopsis utricularioides*

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slopes/mogote valley (79%)

Steep slopes/mogote side (12%)

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Tops (6%)

Plains (3%)

Wetlands (0%)

**Physiographic features (characteristics ranges)**

Elevation range: 7 m -1,069 m (mean= 429 m)

Slope: 0-130% (mean= 30%, or 16 degrees)

Aspect (mean): South (178 degrees)

**CLIMATIC FEATURES**

Climate: The mean annual precipitation in the SWVBF is about 2,116 millimeters. Rainfall is distributed throughout the year, with peaks on May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 15°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 2,116 mm

**Monthly precipitation (characteristic ranges)**

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**Monthly temperature (characteristic ranges):**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Intrusive: Candelero, Cayagua, Mayo

Extrusive: El Verde, Juncal, Luquillo, Moca

**Surface texture**

**Soil features**

Family particle size:

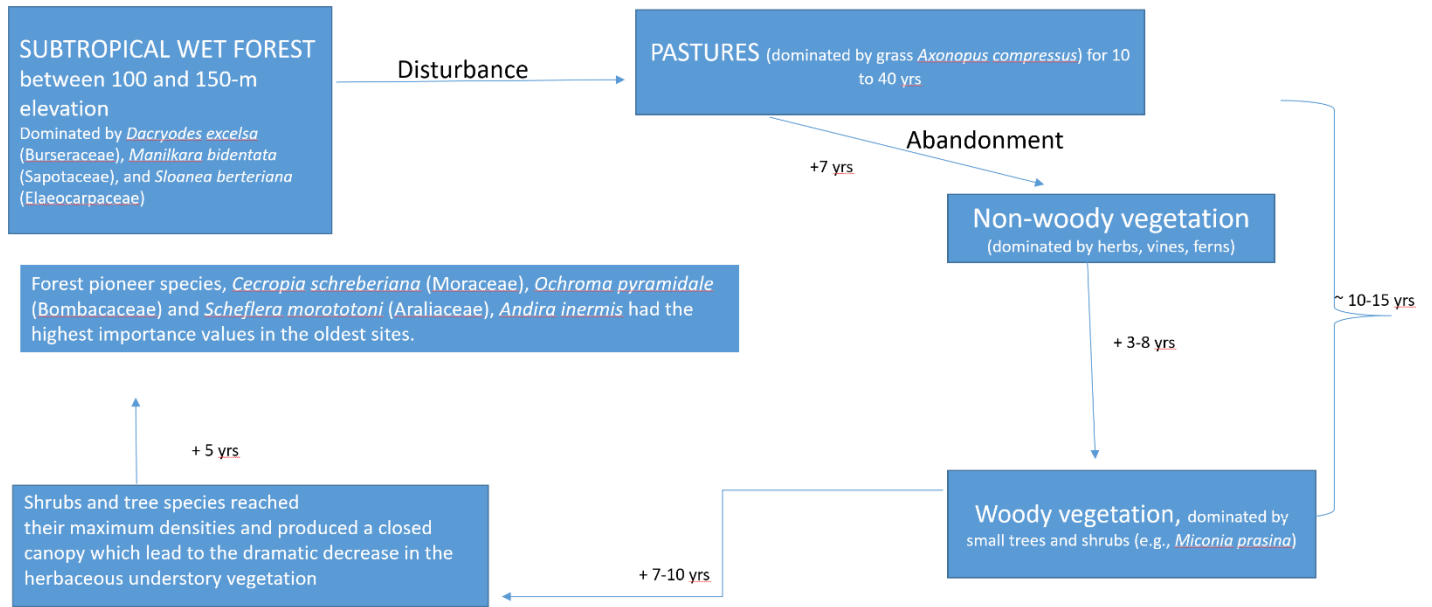
**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

**State and Transition Models**

**COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION



Forest recovery in abandoned cattle pastures along an Elevational Gradient in Northeastern Puerto Rico (information extracted from Aide et al. 1996).

## WET FOREST

## MOIST FOREST

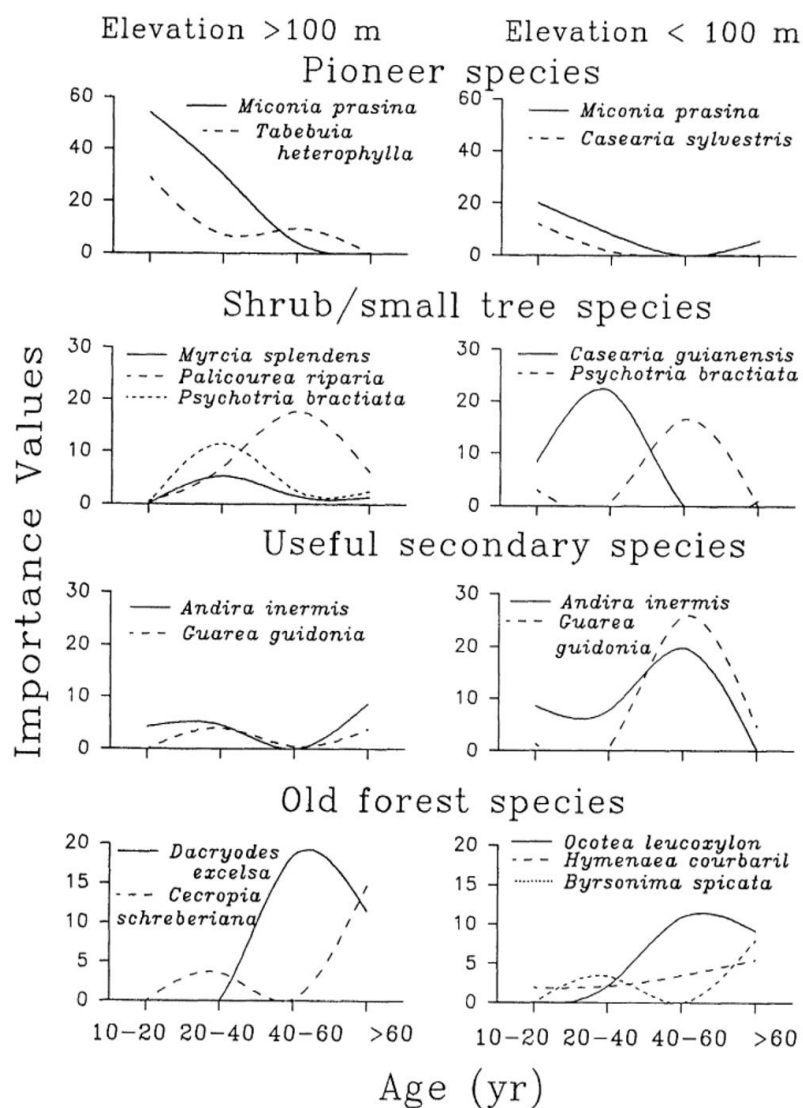


FIGURE 5. A comparison of changes in importance values with site age for common pioneer, shrub/small tree, useful secondary species with valuable wood, and old forest species between low (<100 m) and high (>100 m) elevation sites. Curves are cubic spline interpolations (Sigmaplot 1989) based on the average importance values of all sites in each age class.

## SUPPORTING INFORMATION

### Similar sites

- Subtropical Wet Quaternary Bottomland Forest (SWQBF)
- Subtropical Wet Volcanic Upland Forest (SWVUF)



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SITE NAME: **SUBTROPICAL WET PALUSTRINE QUATERNARY UPLAND FOREST**  
(F270X...)

MLRA 270-Humid Mountains and Valleys (99%), MLRA 272-Humid Coastal Plains (1%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Subtropical Wet Palustrine Quaternary Upland Forest (SWPQUF) was developed after collapsing the subtropical wet quaternary upper slope and the subtropical wet quaternary ridge in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SWPQUF mostly falls within the National Vegetation Classification Group G448 Caribbean Wet Montane Forest, D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna, and G454 Caribbean Moist Lowland-Submontane Forest Group (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include moist grasslands and pastures, montane wet alluvial shrubland and woodland, montane wet evergreen abandoned and active coffee plantation, montane wet alluvial shrubland and woodland and young secondary montane wet alluvial evergreen forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the montane forest (zone V) which includes forest, savanna, scrub, grassland, and about eleven vegetation communities.

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### **Ecological Site Concept:**

The SWPQUF has an extension of 13 km<sup>2</sup> (less than 1% of the island), and most of it occurs in the upper landscape positions of the wet forest occurring along the central mountains of Puerto Rico, especially in the northwest of the island (Fig. 1). This ecological site is not found in the USVI. The vegetation in this ecological site is rich in species with some characteristic groups adapted to abundant moisture such as epiphytic ferns, tree ferns (*Cyathea arborea*), bromeliads, and orchids (Ewel and Whitmore 1973). There is a zonal association in the wet forest known as the Tabonuco type, dominated by *Dacryodes excelsa* (motillo), and other secondary important species such as *Sloanea berteriana*, and *Manilkara bidentata* (ausubo) (Ewel and Whitmore 1973). However, much of this ecological site is covered by successional vegetation as a result of past agriculture (mostly shade-grown coffee plantations) and later abandonment. Species such as *Piper aduncum*, *Cecropia peltata*, *Didymopanax morototoni*, *Prestoea montana*, and *Ochroma lagopus* are abundant in successional forests on this ecological site (Ewel and Whitmore 1973). The SWPQUF can be found in the State Forests of Tres Picachos, Maricao, Rio Abajo, Toro Negro, and El Yunque National Forest.

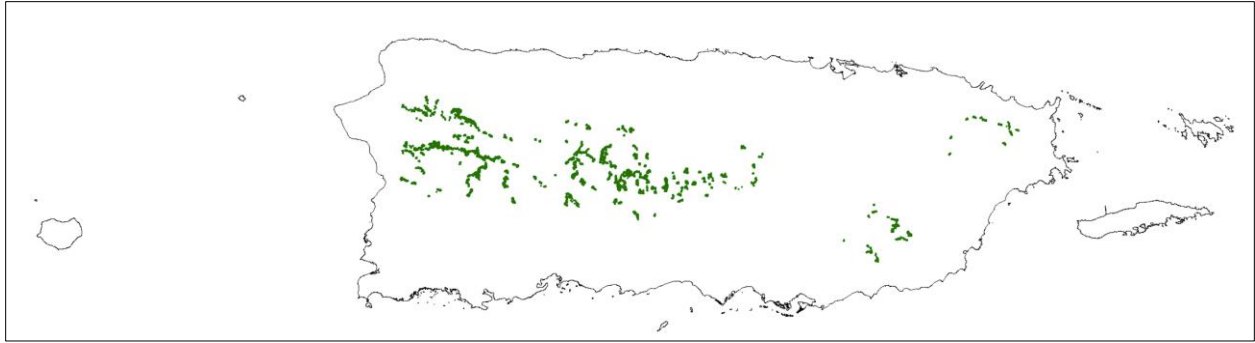


Figure 1. Distribution of the Subtropical Wet Palustrine Quaternary Upland Forest in Puerto Rico.

**Dominant plant species:**

None of the FIA plots occur on this ecological site. Eight out of 14 tree assemblages identified for Puerto Rico, occurred within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

**Species assemblages:**

1. ***Guarea guidonia***, ***Dendropanax arboreus***, ***Mangifera indica*** (Ex), *Artocarpus altilis* (Ex), *Cordia sulcata*, *Quararibea turbinata*, *Erythrina poeppigiana* (Ex), *Cordia alliodora*.
2. ***Spathodea campanulata*** (Ex), *Terminalia catappa* (Ex).
3. ***Cecropia schreberiana***, ***Citrus xsinensis*** (Ex), *Inga laurina*, *Cyathea arborea*, *Persea*

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*americana* (Ex).

4. ***Syzygium jambos*** (Ex), *Zanthoxylum martinicense*, *Schefflera morototonii*, *Croton rigidus*, *Calophyllum antillanum* (Ex).
  5. ***Casearia sylvestris***, ***Psidium guajava***, ***Coffea arabica*** (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*.
  6. ***Tabebuia heterophylla***, ***Casearia arborea***, *Roystonea borinquena*, *Myrcia citrifolia*.
  7. ***Prestoea montana***, ***Micropholis garciniifolia***, ***Sloanea berteriana***, ***Micropholis chrysipholloides***, ***Henriettea squamulosum***, ***Byrsonima spicata***, ***Dacryodes excelsa***, ***Psychotria berteriana***, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.
  8. ***Casearia guianensis***, ***Andira inermis***, ***Guazuma ulmifolia***, *Guapira fragans*, *Myrcia splendens*, *Cupania americana*.
- **Other trees:** *Dacryodes excelsa*, *Cyathea arborea*, *Sloanea berteriana*, *Manilkara bidentata*, *Piper aducum*, *Cecropia peltata*, *Dyimopanax morototoni*, *Ochroma lagopus*, *Prestoea montana*.
  - **Shrubs:** *Gonzalagunia spicata*, *Miconia laevigata*, *Clidemia hirta*, *Solanum torvum*, *Cestrum citrifolium*.
  - **Herbs, cactus, succulents:** *Marcgravia rectifolia*, *Ipomoea* sp., *Thillandsia bulbosa*, *T. polystachia*, *Solanum americanum*, *Tolumnia variegata*, *Ionopsis utricularioides*.

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## PHYSIOGRAPHIC FEATURES

### **Landforms**

Steep slopes/mogote side (54%)

Side slopes/mogote valley (30%)

Tops (15%)

Plains (1%)

### **Physiographic features (characteristics ranges)**

Elevation range: 10-1,078 m (mean= 323 m)

Slope: 0-116% (mean= 36%, or 19 degrees)

Aspect (mean): South (185 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SWPQUF is about 2,070 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 15°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

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Freeze-free periods: NA

Precipitation total: 2,070 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges):**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Soil component data was not available for this ecological site.

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

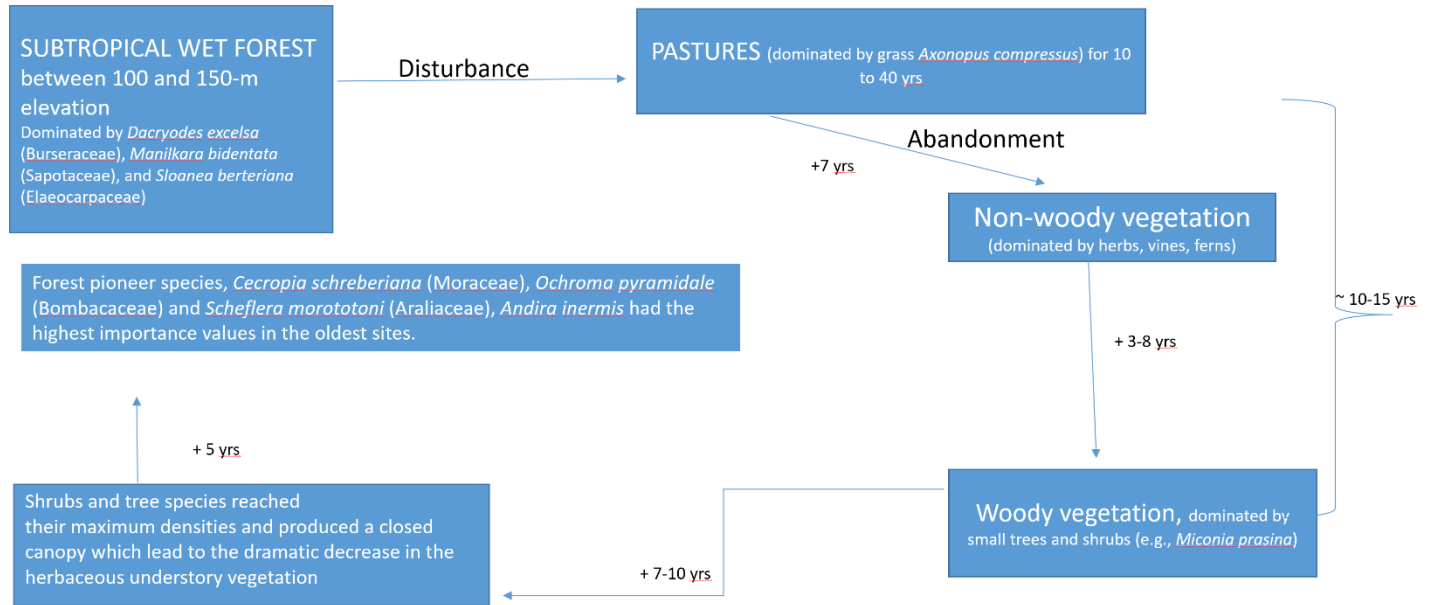
**State and Transition Models**

**COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

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## SUPPORTING INFORMATION



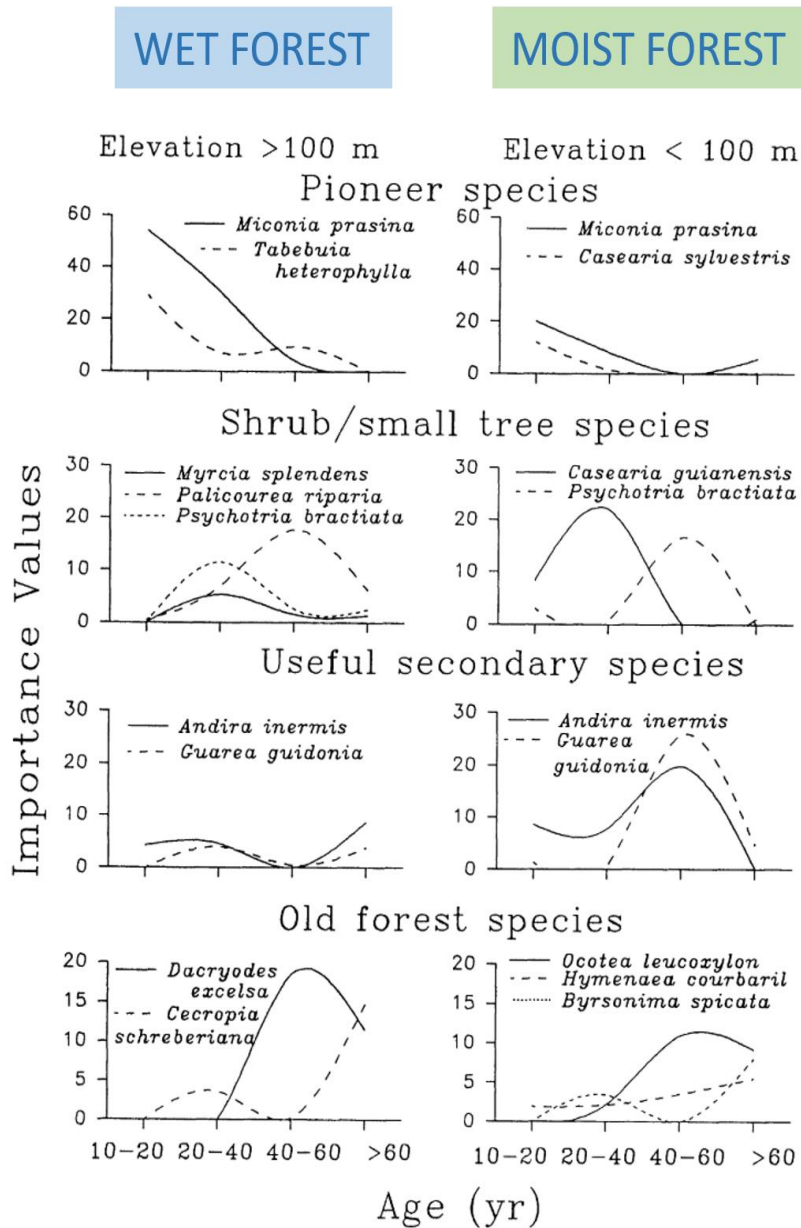


FIGURE 5. A comparison of changes in importance values with site age for common pioneer, shrub/small tree, useful secondary species with valuable wood, and old forest species between low (<100 m) and high (>100 m) elevation sites. Curves are cubic spline interpolations (Sigmaplot 1989) based on the average importance values of all sites in each age class.

### Similar sites

- Subtropical Wet Quaternary Bottomland Forest (SWQBF)
- Subtropical Wet Volcanic Bottomland Forest (SWVBF)
- Subtropical Wet Palustrine Volcanic Upland Forest (SWPVBF)



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**SITE NAME: SUBTROPICAL WET QUATERNARY BOTTOMLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (95%), MLRA 272-Humid Coastal Plains (5%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Subtropical Wet Quaternary Bottomland Forest (SWQBF) was developed after collapsing the subtropical wet quaternary lower slope and the subtropical wet quaternary plain in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SWQBF mostly falls within the National Vegetation Classification Group G448 Caribbean Wet Montane Forest and D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include moist grasslands and pastures, montane wet alluvial shrubland and woodland, montane wet evergreen abandoned and active coffee plantation, and young secondary montane wet alluvial evergreen forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the montane forest (zone V) which includes forest, savanna, scrub, grassland, and about eleven vegetation communities.

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### Ecological Site Concept:

The SWQBF has an extension of 61 km<sup>2</sup> (less than 1% of the island), and most of it occurs in the lower landscape positions of the wet forest occurring along the central mountains of Puerto Rico, especially in the northwest of the island (Fig. 1). This ecological site is not found in the USVI.

The vegetation in this ecological site is rich in species with some characteristic groups adapted to abundant moisture such as epiphytic ferns, tree ferns (*Cyathea arborea*), bromeliads, and orchids (Ewel and Whitmore 1973). There is a zonal association in the wet forest known as the Tabonuco type, dominated by *Dacryodes excelsa* (motillo), and other secondary important species such as *Sloanea berteriana*, and *Manilkara bidentata* (ausubo) (Ewel and Whitmore 1973). However, much of this ecological site is covered by successional vegetation as a result of past agriculture (mostly shade-grown coffee plantations) and later abandonment. Species such as *Piper aduncum*, *Cecropia peltata*, *Didymopanax morototoni*, *Prestoea montana*, and *Ochroma lagopus* are abundant in successional forests on this ecological site (Ewel and Whitmore 1973). The SWQBF can be found in the State Forests of Tres Picachos, Carite, Maricao, Monte Guilarte, Rio Abajo, Toro Negro, and El Yunque National Forest.

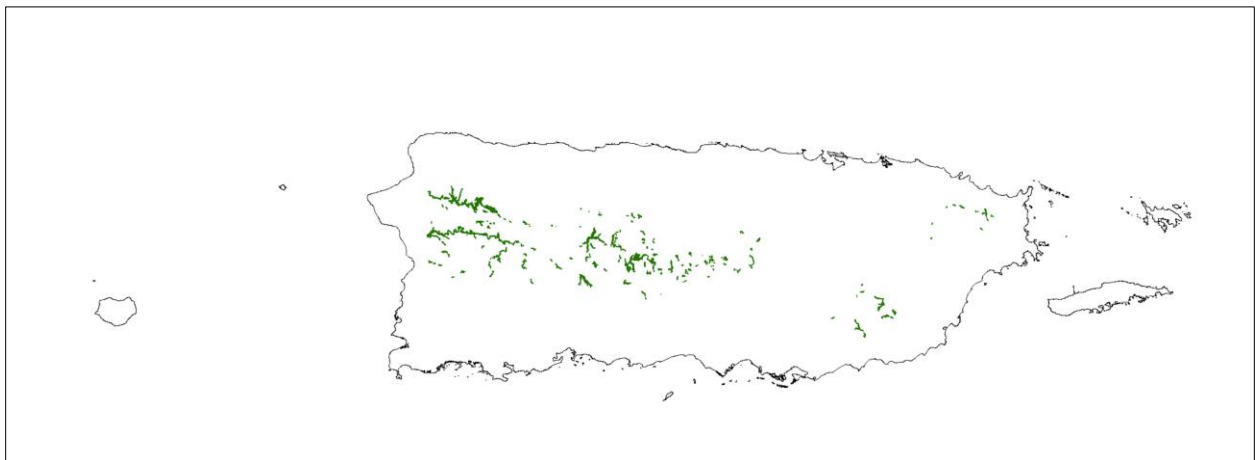


Figure 1. Distribution of the Subtropical Wet Quaternary Bottomland Forest in Puerto Rico.

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### Dominant plant species:

Dominant tree species within this ecological site in Puerto Rico included *Spathodea campanulata*, *Guarea guidonia*, *Senna siamea*, *Albizia procera* (Marcano-Vega 2019). Eight out of 14 tree assemblages identified for Puerto Rico, occurred within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### Species assemblages:

1. *Guarea guidonia*, ***Dendropanax arboreus***, ***Mangifera indica*** (Ex), *Artocarpus altilis* (Ex), *Cordia sulcata*, *Quararibea turbinata*, *Erythrina poeppigiana* (Ex), *Cordia alliodora*.
2. ***Spathodea campanulata*** (Ex), *Terminalia catappa* (Ex).
3. ***Cecropia schreberiana***, ***Citrus xsinensis*** (Ex), *Inga laurina*, *Cyathea arborea*, *Persea americana* (Ex).
4. ***Syzygium jambos*** (Ex), *Zanthoxylum martinicense*, *Schefflera morototonii*, *Croton rigidus*, *Calophyllum antillanum* (Ex).
5. ***Casearia sylvestris***, ***Psidium guajava***, ***Coffea arabica*** (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*.
6. ***Tabebuia heterophylla***, ***Casearia arborea***, *Roystonea borinquena*, *Myrcia citrifolia*.

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7. *Prestoea montana*, *Micropholis garciniifolia*, *Sloanea berteriana*, *Micropholis chrysipholloides*, *Henriettea squamulosum*, *Byrsonima spicata*, *Dacryodes excelsa*, *Psychotria berteriana*, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.
8. *Casearia guianensis*, *Andira inermis*, *Guazuma ulmifolia*, *Guapira fragans*, *Myrcia splendens*, *Cupania americana*.
- **Other trees:** *Dacryodes excelsa*, *Cyathea arborea*, *Sloanea berteriana*, *Manilkara bidentata*, *Piper aducum*, *Cecropia peltata*, *Dyimopanax morototoni*, *Ochroma lagopus*, *Prestoea montana*.
  - **Shrubs:** *Gonzalagunia spicata*, *Miconia laevigata*, *Clidemia hirta*, *Solanum torvum*, *Cestrum citrifolium*.
  - **Herbs, cactus, succulents:** *Marcgravia rectifolia*, *Ipomoea sp.*, *Thillandsia bulbosa*, *T. polystachia*, *Solanum americanum*, *Tolumnia variegata*, *Ionopsis utricularioides*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slopes/mogote valley (40%)

Plains (38%)

Steep slopes/mogote side (19%)

Tops (2%)

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### **Physiographic features (characteristics ranges)**

Elevation range: 6-1,040 m (mean= 258 m)

Slope: 0-105% (mean= 17%, or 10 degrees)

Aspect (mean): South (181 degrees)

### **CLIMATIC FEATURES**

Climate: The mean annual precipitation in the SWQBF is about 2,002 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 13°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 2,002 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges):**

### **Monthly temperature (average minimum/maximum)**

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## INFLUENCING WATER FEATURES

## REPRESENTATIVE SOIL FEATURES

A representative soil component in this ecological site is Estacion.

### **Surface texture**

### **Soil features**

Family particle size:

### **Soil features (characteristic ranges)**

## ECOLOGICAL DYNAMICS OF THE SITE

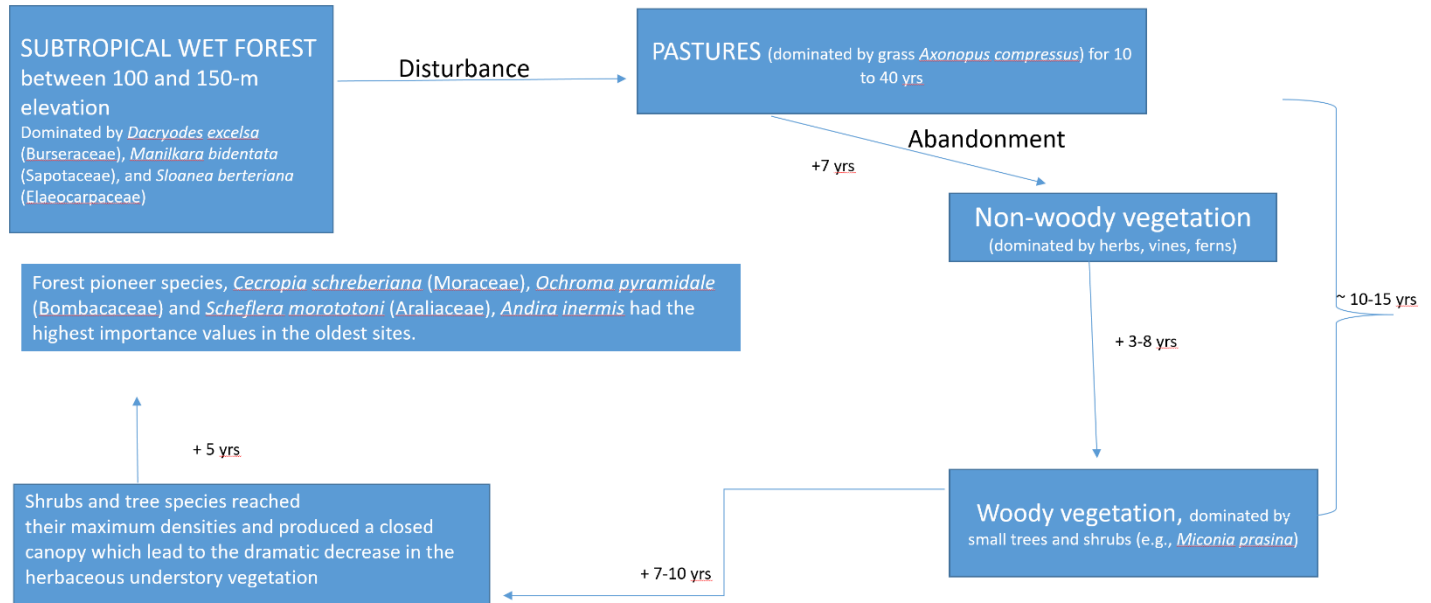
### **State and Transition Models**

### **COMMUNITY 1.1- State 1-Reference**

## ECOLOGICAL SITES INTERPRETATION

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## SUPPORTING INFORMATION



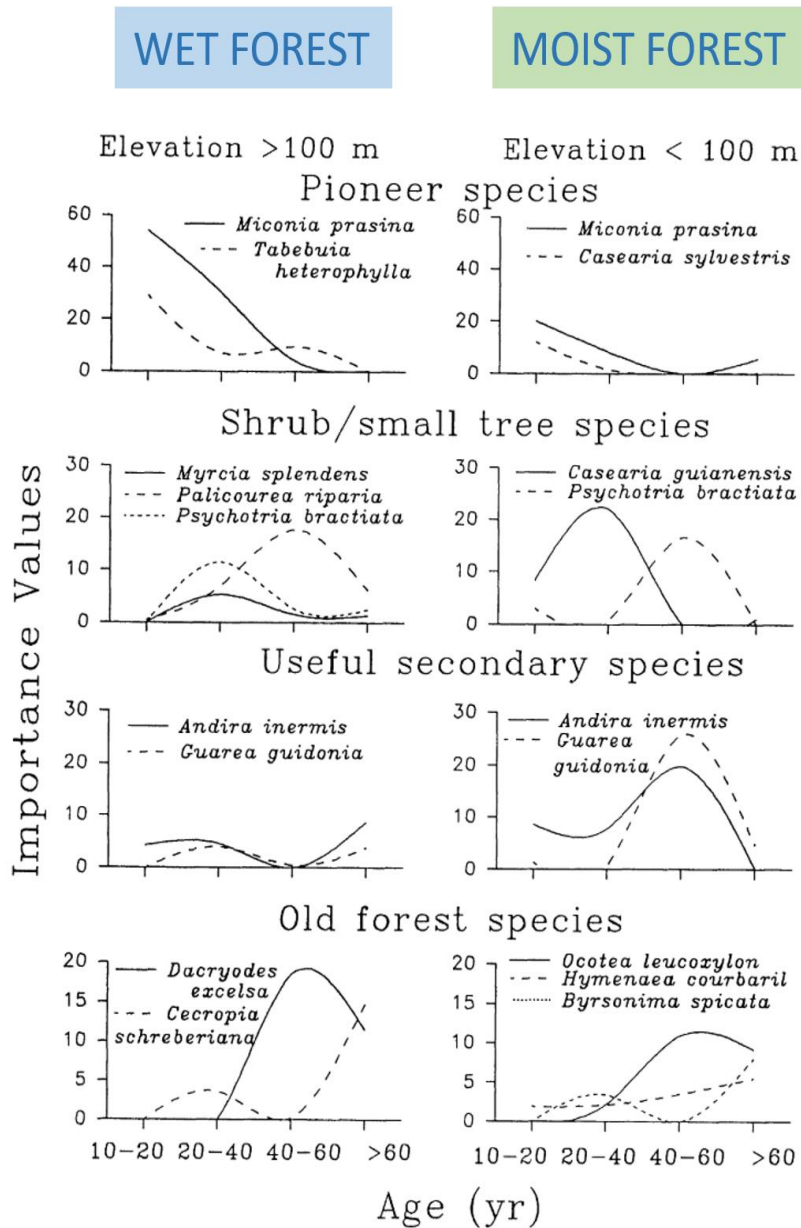


FIGURE 5. A comparison of changes in importance values with site age for common pioneer, shrub/small tree, useful secondary species with valuable wood, and old forest species between low (<100 m) and high (>100 m) elevation sites. Curves are cubic spline interpolations (Sigmaplot 1989) based on the average importance values of all sites in each age class.

### Similar sites

- Subtropical Wet Quaternary Upland Forest (SWQUF)
- Subtropical Wet Volcanic Bottomland Forest (SWVBF)



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**SITE NAME: SUBTROPICAL WET SERPENTINE BOTTOMLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (100%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Subtropical Wet Serpentine Bottomland Forest (SWSBF) was developed after collapsing the subtropical wet ultramaphic lower slope and the subtropical wet ultramaphic plain in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SWSBF mostly falls within the National Vegetation Classification Group G448 Caribbean Wet Montane Forest (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include mature secondary montane wet serpentine evergreen forest, montane wet evergreen abandoned and active coffee plantation, and young secondary montane wet serpentine evergreen forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the montane forest (zone V) which includes forest, savanna, scrub, grassland, and about eleven vegetation communities.

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### **Ecological Site Concept:**

The SWSBF has an extension of 8.3 km<sup>2</sup> (less than 1% of the island), and most of it is restricted to the southwestern mountain area of Puerto Rico (Fig. 1). The vegetation in this ecological site is very rich with several endemic species that only occur in association with the serpentine derived-soils. The trees are slender, open-crowned, and usually less than 12 m tall, while the forest floor is open, with little herbaceous growth (Ewel and Withmore 1973). Serpentine areas, described for the Subtropical Wet Forest zone are also found associated with the Subtropical Moist Forest zone, but in the former the vegetation is greener, denser, and with higher abundance of epiphytes. The species are almost all evergreen and sclerophyllous, giving the impression of an anomalous wet desert or dry rainforest (Ewel and Withmore 1973). The SWSBF mostly occurs within the Maricao State Forest and riparian areas of the Susúa State Forest, while serpentine areas associated with the moist forest are more common in the Susua State Forest.



Figure 1. Distribution of the Subtropical Wet Serpentine Bottomland Forest in Puerto Rico.

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### **Dominant plant species:**

None of the FIA plots surveyed during the period 2011 to 2014 (Marcano-Vega 2019) overlapped with this ecological site, but overlapped a similar site at a higher elevation (see description for SWSUF). Three out of 14 tree assemblages identified for Puerto Rico occurred within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### **Species assemblages:**

1. *Neolaugeria resinosa*, *Guettarda scabra*, *Eugenia monticola*, *Tabebuia haemantha*, *Pimenta racemosa*, *Randia aculeata*, *Clusia rosea*, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*.
  2. *Casearia sylvestris*, *Psidium guajava*, *Coffea arabica* (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*.
  3. *Prestoea montana*, *Micropholis garciniifolia*, *Sloanea berteriana*, *Micropholis chrysipholloides*, *Henriettea squamulosum*, *Byrsonima spicata*, *Dacryodes excelsa*, *Psychotria berteriana*, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.
- **Other trees:** *Guarea guidonia*, *Miconia mirabilis*, *Buchenavia tetraphylla*, *Garcinia*

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*hessii*, *Clusia rosea*, *Clusia minor*, *Licaria brittoniana*, *Eugenia confusa*, *Eugenia dominguensis*, *Eugenia padronii*, *Tetragastris balsamifera*. *Prestoea acuminata*, *Tabebuia schumaniana*, *Cecropia schreberiana*, *Clusia calophyllum*, *Chrysophyllum pauciflorum*, *Guettarda pungens*, *G. ovalifolia*, *Neolaugeria resinosa*, *Andira inermis*.

- **Shrubs:** *Cyathea arborea* (tree fern), *Calyptranthes triflora*, *Gonzalagunia spicata*, *Palicourea guianensis*, *Randia aculeata*, *Rondeletia inermis*, *Koanophyllum polyodon*, *Cyathea horrida*, *Alsophila sp.*
- **Herbs, cactus, succulents:** *Thillandsia sp.*, *Epidendrum sp.*, *Vanilla poitaei*, *Arthrostylidium sarmentosum*, *Paspalum sp.*, *Poitea punicea*, *Mikania fragilis*, *Bidens urbanii*, *Zamia portoricensis*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slopes/mogote valley (67%)

Steep slopes/mogote side (27%)

Tops (5%)

Plains (1%)

Wetlands (0%)

### Physiographic features (characteristics ranges)

Elevation range: 84-845 m (mean= 475 m)

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Slope: 2-105% (mean= 34%, or 18 degrees)

Aspect (mean): South (182 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SWSBF is about 2,071 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 15°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 2,116 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges):**

### **Monthly temperature (average minimum/maximum)**

## INFLUENCING WATER FEATURES

## REPRESENTATIVE SOIL FEATURES

Soil series components in this ecological site include Estacion, El Descanso and Hoconuco.

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**Surface texture****Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

**State and Transition Models****COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

**Similar sites**

- Subtropical Wet Serpentine Upland Forest (SWSUF)

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**SITE NAME: SUBTROPICAL WET SERPENTINE UPLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (100%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Subtropical Wet Serpentine Upland Forest (SWSUF) was developed after collapsing the subtropical wet ultramaphic upper slope and the subtropical wet ultramaphic ridge in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SWSBF mostly falls within the National Vegetation Classification Group G448 Caribbean Wet Montane Forest (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include mature secondary montane wet serpentine evergreen forest, young secondary montane wet serpentine evergreen forest, and montane wet evergreen abandoned and active coffee plantation (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the montane forest (zone V) which includes forest, savanna, scrub, grassland, and about eleven vegetation communities.

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### **Ecological Site Concept:**

The SWSUF has an extension of 43 km<sup>2</sup> (less than 1% of the island), and most of it is restricted to the southwestern mountain area of Puerto Rico (Fig. 1). The vegetation in this ecological site is very rich with several endemic species that only occur in association with the serpentine derived-soils. The trees are slender, open-crowned, and usually less than 12 m tall, while the forest floor is open, with little herbaceous growth (Ewel and Withmore 1973). Serpentine areas, described for the Subtropical Wet Forest zone are also found associated with the Subtropical Moist Forest zone, but in the former the vegetation is greener, denser, and with higher abundance of epiphytes. The species are almost all evergreen and sclerophyllous, giving the impression of an anomalous wet desert or dry rainforest (Ewel and Withmore 1973). The SWSBF mostly occurs within the Maricao State Forest.

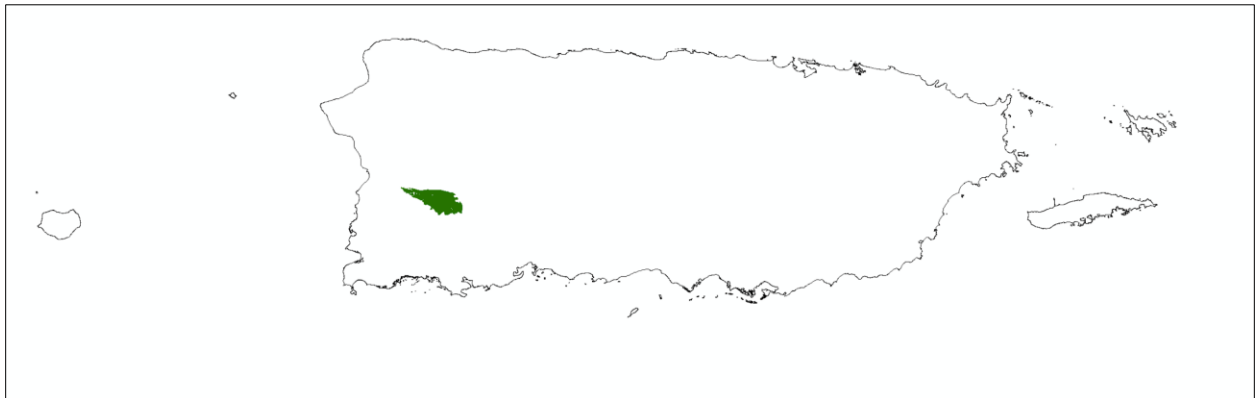


Figure 1. Distribution of the Subtropical Wet Serpentine Upland Forest in Puerto Rico.



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### Dominant plant species:

Dominant tree species within this ecological site in Puerto Rico included *Guettarda scabra*, *Eucalyptus robusta*, *Homalium racemosum*, *Clusia rosea*, *Neolaugeria resinosa*, *Swietenia mahagoni*, *Micropholis guyanensis*, *Antirhea obtusifolia*, *Cassipourea guianensis*, *Podocarpus coriaceus*, *Alchornea latifolia*, *Sloanea amygdalina*, *Prestoea acuminata* (Marcano-Vega 2019). Three out of 14 tree assemblages identified for Puerto Rico occurred within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### Species assemblages:

1. ***Neolaugeria resinosa***, ***Guettarda scabra***, ***Eugenia monticola***, ***Tabebuia haemantha***, ***Pimenta racemosa***, ***Randia aculeata***, ***Clusia rosea***, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*.
2. *Casearia sylvestris*, ***Psidium guajava***, *Coffea arabica* (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*.
3. ***Prestoea montana***, ***Micropholis garciniifolia***, ***Sloanea berteriana***, ***Micropholis chrysiphylloides***, ***Henriettea squamulosum***, ***Byrsonima spicata***, ***Dacryodes excelsa***, ***Psychotria berteriana***, *Alchornea latifolia*, *Cordia borinquensis*, *Clusia clusioides*, *Myrcia citrifolia*.

- 
- **Other trees:** *Guarea guidonia*, *Miconia mirabilis*, *Buchenavia tetraphylla*, *Garcinia hessii*, *Clusia rosea*, *Clusia minor*, *Licaria brittoniana*, *Eugenia confusa*, *Eugenia domingensis*, *Eugenia padronii*, *Tetragastris balsamifera*. *Prestoea acuminata*, *Tabebuia schumaniana*, *Cecropia schreberiana*, *Clusia calophyllum*, *Chrysophyllum pauciflorum*, *Guettarda pungens*, *G. ovalifolia*, *Neolaugeria resinosa*, *Andira inermis*.
  - **Shrubs:** *Cyathea arborea* (tree fern), *Calyptanthus triflora*, *Gonzalagunia spicata*, *Palicourea guianensis*, *Randia aculeata*, *Rondeletia inermis*, *Koanophyllum polyodon*, *Cyathea horrida*, *Alsophila sp.*
  - **Herbs, cactus, succulents:** *Thillandsia sp.*, *Epidendrum sp.*, *Vanilla poitaei*, *Arthrostylidium sarmentosum*, *Paspalum sp.*, *Poitea punicea*, *Mikania fragilis*, *Bidens urbanii*, *Gleichenia bifida*

## PHYSIOGRAPHIC FEATURES

### Landforms

Steep slopes/mogote side (79%)

Tops (15%)

Side slopes/mogote valley (6%)

### Physiographic features (characteristics ranges)

Elevation range: 89-884 m (mean= 455 m)

Slope: 2-133% (mean= 42%, or 22 degrees)

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Aspect (mean): South (191 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SWSUF is about 2,134 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 31 °C, and the mean minimum temperature is 18°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 2,134 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges):**

### **Monthly temperature (average minimum/maximum)**

## INFLUENCING WATER FEATURES

## REPRESENTATIVE SOIL FEATURES

Soil series components in this ecological site include Aljibe, Cerro Gordo, Guama, Indiera

### **Surface texture**

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**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

**State and Transition Models****COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

**Similar sites**

- Subtropical Wet Serpentine Bottomland Forest (SWSBF)

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**SITE NAME: SUBTROPICAL MOIST ESTUARINE WETLAND (F272X...)**

MLRA 272- Humid Coastal Plains (95%), MLRA 270-Humid Mountains and Valleys (5%)

Occurrence: Puerto Rico, Vieques

Site stage: Provisional

### **Classification Relationship**

The Subtropical Moist Estuarine Wetland (SMEW) is the subtropical moist saline wetland in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SMEW falls within the National Vegetation Classification Group G004 Rhizophora Mangle Forest Group and D094 Caribbean and Central American Lowland Shrubland, Grassland, and Savanna (U.S. National Vegetation Classification 2019). According to a USDA Forest Service land cover map of Puerto Rico (Gould et al. 2007), dominant vegetation covers within this ecological site include mangrove forest and shrubland, seasonally flooded herbaceous saline wetlands, and emergent herbaceous saline wetlands. In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the Littoral subzone (zone Ia) which includes meadow steppe, desert, savanna and forest, and more than 50 vegetation communities.

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### Ecological Site Concept:

The SMEW has an extension of 101 km<sup>2</sup> (~1% of the island), and it occupies the lowest landscape positions of the moist forest in the littoral zone in the north, southeast, and southwest of Puerto Rico, and Vieques (Fig. 1). Plants adapted to estuarine wetlands are tolerant to salinity, and to flooded periods with reduced oxygen (Miller and Lugo 2009). Woody species from saline wetlands form the typical mangrove forest or estuarine forested swamps dominated by *Rhizophora mangle* (red mangrove) and *Avicennia germinans* (black mangrove), which are the most extensive estuarine forested wetlands in Puerto Rico (Miller and Lugo 2009). Saline wetlands also include estuarine emergent marshes dominated by a mixture of herbaceous vegetation and woody plants such as *Typha dominguensis* and *Laguncularia racemosa* (white mangrove), respectively. Other saline wetland includes the estuarine coastal flats typical of the salt flats with direct access to the seawater and exposed to the highest concentration of salt, dominated by *A. germinans*, and herbaceous species such as *Sesuvium portulacastrum*, *Salicornia perennis*, and *Batis maritima*. The SMEW can be found in the Piñones, Ceiba, and Boquerón State Forests.

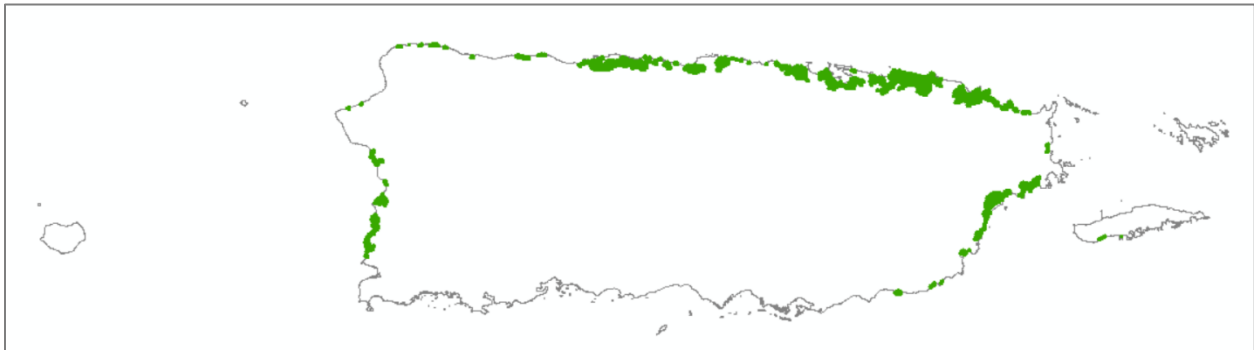


Figure 1. Distribution of the Subtropical Moist Estuarine Wetland in Puerto Rico.

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## Dominant plant species:

Four species of trees dominate the only FIA plot occurring within this ecological site: *Avicennia germinans*, *Rhizophora mangle*, *Laguncularia racemosa*, and *Bucida buceras* (Marcano-Vega 2019). Some species might be duplicated as the information was acquired from different sources.

Ex= exotics.

- **Other trees:** *Annona glabra*, *Hibiscus pernambucensis* (Ex), *Thespesia populnea* (Ex).
- **Shrubs:** *Croton* sp. *Lantana* sp. *Pavonia spicata*, *Lonchocarpus dominguensis*, *Erithalis fruticosa*, *Bontia daphnoides*, *Conocarpus erectus*, *Dalbergia ecastaphyllum*, *Caesalpinia bonduc*.
- **Herbaceous, cactus, succulents:** *Rhabdadenia biflora*, *Acrostichum aureum*, *Stenotaphrum secundatum*, *Acrostichum daneaefolius*, *Cladium jamaicense*, *Polipodium* spp, *Thelepteris* spp., *Tillandsia fasciculata*, *T. utriculata*, *Anthurium acaule*, *Paullinia pinnata*, *Heteropteris laurifolia*, *Hippocratea volubilis*, *Ichnantus pallens*, *Panicum laxum*, *Sesuvium portulacastrum*, *Philoxereus vermiculares*, *Batis maritima*, *Heliotropium curassavicum*, *Paspalum vaginatum*, *Fimbristylis cymosa*, *Crinum asiaticum* (Ex), *Hymenocallis caribaea*, *Sporobolus coromandelianus* (Ex), *Spartina patens*, *Blutaparon vermiculare*, *Sesuvium maritimum*

## PHYSIOGRAPHIC FEATURES

### Landforms

Wetlands (98%)

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Plains (2%)

**Physiographic features (characteristics ranges)**

Elevation range: -0.2 m to 22 m (mean= 1 m)

Slope: 0-44% (mean= 2%, or 1 degree)

Aspect (mean): East (76 degrees)

**CLIMATIC FEATURES**

Climate: The mean annual precipitation in the SMEW is about 1,524 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 19°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,524 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**



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## INFLUENCING WATER FEATURES

Temporally inundated systems, brackish (salinity greater than 0.5 ppt), and acid water (PH<5.5).

## REPRESENTATIVE SOIL FEATURES

Peat and organic soils. Soil components include: Atolladero, Durados, Garrachales, Jareales, Joyuda, Palmar, Pinones, Saladar, Tiburones, Vigia.

### **Surface texture**

### **Soil features**

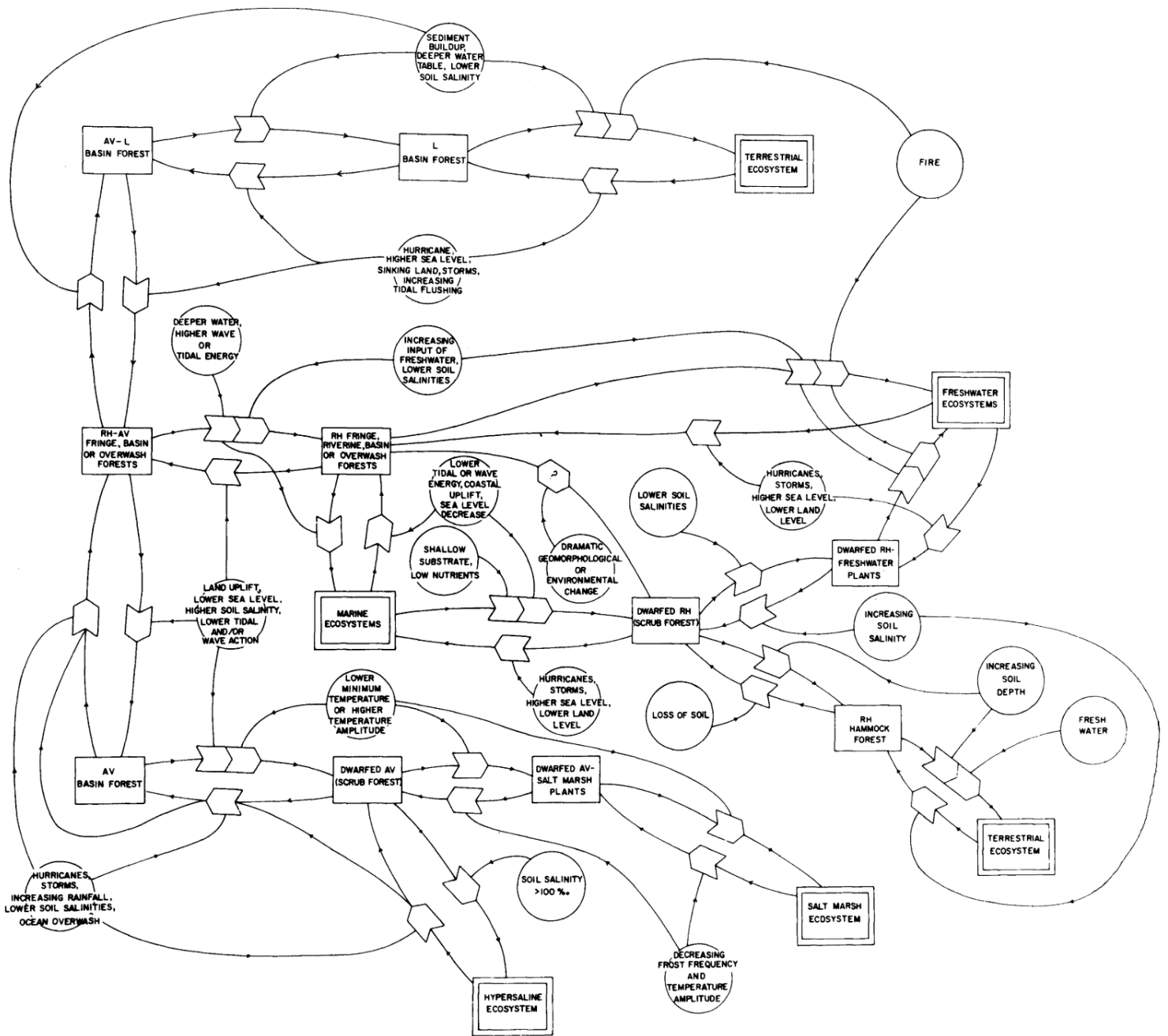
Family particle size:

### **Soil features (characteristic ranges)**

## ECOLOGICAL DYNAMICS OF THE SITE

### **State and Transition Models**

The diagram below was extracted from Lugo (2016).



**FIGURE 2.** Summary diagram depicting possible mangrove successional pathways and the factors responsible for each of the pathways. Boxes represent the mangrove xere (RH is *Rhizophora*, L is *Laguncularia*, and AV is *Avicennia*). Large arrows show the direction of succession, and they connect with the physical factor(s) believed to be responsible for the pathway (circles). More than one factor is given in many cases, suggesting that one or a combination of circumstances may stimulate a given pathway. Boxes with double walls represent non-mangrove ecosystems. The actual species composition of these systems depends on climate, substrate, and/or hydroperiod. Notice that all successional pathways are reversible. In general, the succession in the upper part of the diagram responds to changes in the depth of the water table; the succession in the center of the diagram responds to decreasing soil salinities and/or nutrients; and the succession in the lower part of the diagram responds to increasing soil salinity or to decreasing air temperature. Marine ecosystems succeed mangroves when the ocean water is too deep for the establishment of *Rhizophora* seedlings or when wave or tidal energies exceed the tolerance of mangroves. The role of each system (box) in changing the environment is not shown. The probability of succession following a given pathway depends on the intensity of the causative factor. It is possible that some successional changes do not occur often, particularly where intense or "dramatic" changes in the environment are required. This diagram is based on personal observations and reports in the literature cited and should be considered hypothetical until validated by research.

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## **COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

### **Similar sites**

- Subtropical Dry Estuarine Wetland (SDEW)

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**SITE NAME: SUBTROPICAL MOIST LIMESTONE BOTTOMLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (57%), MLRA 272- Humid Coastal Plains (43%)

Occurrence: Puerto Rico, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Moist Limestone Bottomland Forest (SMLBF) was developed after collapsing the subtropical moist limestone lower slope and the subtropical moist limestone plains in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SMLBF falls within the National Vegetation Classification Group Caribbean and Central American Lowland Shrubland, Grassland and Savanna (D094) and Caribbean Seasonal Evergreen Moist Lowland Forest Group (G455) (U.S. National Vegetation Classification 2019). According to a USDA Forest Service land cover map of Puerto Rico (Gould et al. 2007), dominant vegetation covers within this ecological site include moist grasslands and pastures, mature secondary moist limestone evergreen and semideciduous forest, young secondary moist limestone evergreen and semideciduous forest, and moist limestone shrubland and woodland. In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the seasonal evergreen forest (zone II) which includes forest and scrubs, and about 20 vegetation communities.

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### **Ecological Site Concept:**

The SMLBF has an extension of 474 km<sup>2</sup> (~5% of the island), and it occupies the lower landscape positions of the moist forest associated with the limestone hills of northern Puerto Rico. Although the subtropical moist forest Ecological Life Zone occurs in the three islands that conform the USVI (St. Thomas, St. John, and St. Croix), there is not a land cover class in the subtropical moist forest associated with the limestone geology for these islands (Gould et al. 2013). However, a vegetation assemblage conformed by *Leucaena leucocephala*, and *Samanea saman* has been described for the moist/wet forest in association with the limestone geology in the USVI (Brandeis et al. 2009). This ecological site supports a variety of vegetation communities and a unique species compositions representative of the subtropical moist forest associated with limestone parent materials (China and Helmer 2003). Unlike the moist forest occurring in the quaternary plains, moist forest in the limestone is better preserved as it is less suitable for agriculture, especially on the tops of the hills where soils are less fertile (Ewel and Whitmore 1973, Rivera and Aide 1998). Before the abandonment of agriculture, which peaked by the 1940's, alluvial terraces and sinkholes in the karst region were the principal features used for humans' settlements, pasture, agriculture, and coffee plantations (Rivera and Aide 1998). Currently, urban development including road construction, fires, dumping, and the extraction of geologic material continue jeopardizing this unique ecosystem. The karst physiography encompasses one of the most biodiverse regions in Puerto Rico as it provides habitat for several endemic and endangered species, comprises the largest aquifer on the island, and the largest portion of mature forest, coastal wetlands, estuaries, and underground system of caves across the island (Lugo et al. 2001). Because of its high ecological value which includes species of conservation concern in several taxonomic groups, the northern karst region has been designated

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as a Special Planning Zone with restricted zones set aside for conservation (PRAPEC 2013). Among the dominant species in this ecological site are *Guarea guidonia*, *Bursera simaruba*, *Andira inermis*, and the exotics *Spathodea campanulata* (see Appendix 2 for the 50 most dominant species) (Brandeis 2006). One study found that *S. campanulata* stands occurred predominantly at lower and mid-elevations, on less steep lower slopes, floodplains, and bottomlands (Brandeis 2006). Another study found distinct tree communities between hilltops and valleys, with significantly more non-native species in valleys and significantly more endemic species on hilltops and hillsides (Aukema et al. 2007). The SMLBF can be found in the State Forests of Rio Abajo, Guajataca, Cambalache, de Vega, and Tres Picachos.

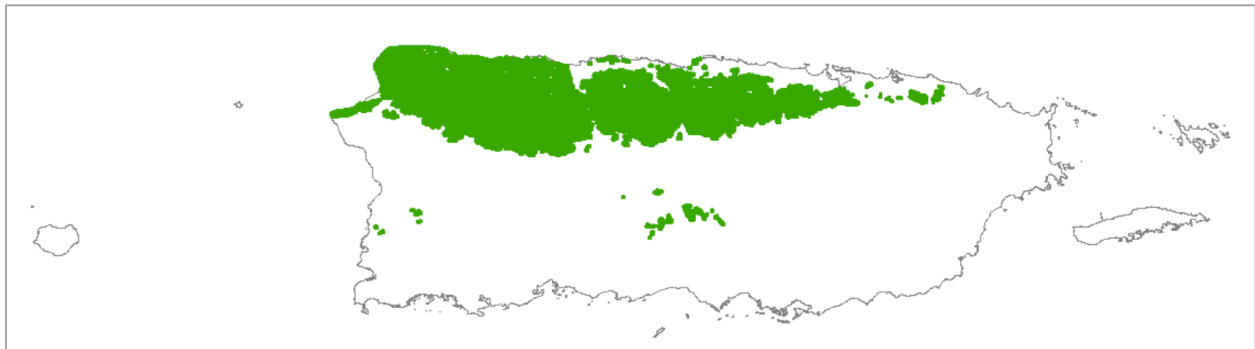


Figure 1. Distribution of the Subtropical Moist Limestone Bottomland Forest in Puerto Rico.

**Dominant plant species:**

Most common tree species occurring within FIA plots in this ecological site in Puerto Rico are: *Citharexylum fruticosum*, *Randia aculeata*, *Spathodea campanulata*, *Guarea guidonia*, *Casearia guianensis* (Marcano-Vega 2019). Secondary important species included *Andira inermis*, *Ficus*

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*citrifolia*, and *Inga vera*, among others (Marcano-Vega 2019). Eleven out of 14 tree assemblages were described for this ecological site in Puerto Rico, while in the USVI only one assemblage with two species, *Leucaena leucocephala* and *Samanea saman* (Brandeis et al. 2009).

Assemblages found in Puerto Rico are listed below in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources

### Species assemblages:

1. *Spathodea campanulata* (Ex), *Terminalia catappa* (Ex)
2. ***Bursera simaruba***, ***Bucida buceras***, ***Amyris elemifera***, ***Coccoloba diversifolia***, *Ocotea sintenisii*, *Myrsine coriácea*, *Licaria parvifolia*, *Senna siamea* (Ex), *Pictetia aculeata*, *Ocotea coriácea*
3. ***Casearia sylvestris***, ***Psidium guajava***, ***Coffea arabica*** (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*
4. ***Syzygium jambos*** (Ex), *Zanthoxylum martinicense*, *Schefflera morototonii*, *Croton rigidus*, *Calophyllum antillanum* (Ex)
5. ***Guarea guidonia***, ***Dendropanax arboreus***\*, ***Mangifera indica*** (Ex), *Artocarpus altilis* (Ex), *Cordia sulcata*, *Quararibea turbinata*, *Erythrina poeppigiana* (Ex), *Cordia alliodora*
6. ***Neolaugeria resinosa***, ***Guettarda scabra***, ***Eugenia monticola***, ***Tabebuia haemantha***, ***Pimenta racemosa***, ***Randia aculeata***, ***Clusia rosea***, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*

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7. *Citharexylum fruticosum*, *Exostema caribaeum*, *Ardisia obovata*, *Zanthoxylum martinicense*, *Pithecellobium dulce* (Ex), *Swietenia mahogany* (Ex)
  8. *Casearia guianensis*, *Andira inermis*, *Guazuma ulmifolia*, *Guapira fragans*, *Myrcia splendens*, *Cupania americana*
  9. *Cecropia schreberiana*, *Citrus sinensis* (Ex), *Inga laurina*, *Cyathea arborea*, *Persea americana* (Ex).
  10. *Thouinia striata*, *Ficus citrifolia*, *Petitia domingensis*, *Trichilia pallida*, *Eugenia rhombea*, *Coccoloba microstachya*
  11. *Tabebuia heterophylla*, *Casearia arborea*, *Roystonea borinquena*, *Myrcia citrifolia*.
- **Other trees:** *Bursera simaruba*, *Bucida buceras*, *Calophyllum callaba*, *Roystonea borinquena*, *Clusia rosea*, *Syzygium jambos*, *Licaria parvifolia*, *Ocotea leucoxylon*, *Ocotea sinfensisii*, *Casearia silvestris*, *Casearia guianensi*, *Casearia decandra*, *Andira inermis*, *Spathodea campanulata*, *Guarea guidonia*, *Cupania americana*, *Tabebuia heterophylla*, *Dendropanax arboreus*, *Chrysophyllum argenteum*, *Hura crepitans*, *Thespesia grandiflora*, *Drypetes glauca*, *Casearia sylvestri*, *Casuarina equisetifolia*, *Ceiba pentandra*, *Xanthoxylum martinicensis*, *Spondias mombin*, *Nectandra coriacea*, *Mammea americana*, *Lonchocarpus dominguensis*, *Tetrazygia elaeagnoides*, *Sabinea florida*, *Ardisia obovata*, *Phyllanthus* sp., *Guettarda scabra*, *Dipholis salicifolia*, *Coccoloba diversifolia*, *Eugenia rhombea*, *Calophyllum calaba*, *Thouinia striata* var. *striata*, *Neolaugeria resinosa*, *Guarae gidonia*, *Sapium laurocerasus*, *Comocladia glabra*, *Rondeletia inermis*, *Spathodea campanulata*, *Guarea guidonia*, *Cupania americana*, *Dendropanax arboreus*, *Chrysophyllum argenteum*, *Hura crepitans*, *Thespesia grandiflora*,



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*Drypetes glauca, Casearia sylvestri, Tetrazygia elaeagnoides, Sabinea florida, Ardisia obovata, Phyllanthus sp., Terebraria resinosa, Andira inermis, Cupania americana, Nectandra sintenisii.*

- **Shrubs:** *Ardisia obovata, Trichilia pallida, Dendropanax arboreus, Casearia spp., Nea buxifolia, Pisonia aculeata.*
- **Herbaceous, cactus, succulents:** *Anthurium crenatum, Paspalum sp., Polypodium sp., Pitcairnia angustifolia. Paspalum sp.*

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slopes/mogote valley (40%)

Plains (38%)

Steep slopes/mogote side (19%)

Tops (2%)

Wetlands (0%)

### Physiographic features (characteristics ranges)

Elevation range: -0.8 m to 1,054 m (mean= 156m)

Slope: 0-203% (mean= 22%, or 12 degrees)

Aspect (mean): South (176 degrees)

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## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SMLBF is about 1,772 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 17°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,772 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges)**

### **Monthly temperature (average minimum/maximum)**

## INFLUENCING WATER FEATURES

The northern karst zone of Puerto Rico comprises the largest freshwater aquifer of the island (Lugo et al. 2001).

## REPRESENTATIVE SOIL FEATURES

Soil components include Camaguey, Cidral, Naranjo, Perchas, Santa Clara, Santoni, Tanama.

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## Surface texture

## Soil features

Family particle size:

## Soil features (characteristic ranges)

### ECOLOGICAL DYNAMICS OF THE SITE

The table below describes the dominant species in secondary forests in this ecological site after the abandonment of coffee plantations and pastures (Rivera and Aide 1998).

Table 1  
The density (stems ha<sup>-1</sup>), basal area (m<sup>2</sup> ha<sup>-1</sup>), and mean importance value of the top 10 dominant species ( $\geq 1.0$  cm dbh) in abandoned coffee and pastures

Species	Family	Range of density	Mean density	Range of basal area	Mean basal area	Mean importance values
<b>Coffee</b>						
<i>G. guidonia</i>	Meliaceae	333–1250	707	0.86–31.7	12.4	36.0
<i>C. arabica</i>	Rubiaceae	100–1400	510	0.01–0.24	0.1	8.4
<i>Dendropanax arboreus</i>	Araliaceae	0–900	272	0–2.34	0.33	5.2
<i>Montezuma speciosissima</i>	Malvaceae	0–167	48	0–7.95	1.97	4.6
<i>Trichilia palida</i>	Meliaceae	0–9.50	213	0–3.43	0.46	4.5
<i>Ocotea leucoxyton</i>	Lauraceae	0–700	112	0–8.82	1.1	3.9
<i>Cordia alliodora</i>	Boraginaceae	0–100	22	0–5.53	0.98	3.9
<i>Cecropia schreberiana</i>	Moraceae	0–100	15	0–21.5	1.9	3.1
<i>Cupania americana</i>	Sapindaceae	0–400	61	0–4.3	0.67	2.4
<i>Andira inermis</i>	Leguminosae	0–250	60	0–7.9	1.18	2.3
<b>Pastures</b>						
<i>S. campanulata</i>	Bignoniaceae	50–8233	2136	0.05–38.6	18.9	39.9
<i>G. guidonia</i>	Meliaceae	0–2050	865	0–12.4	3.2	14.2
<i>Casearia guianensis</i>	Flacourtiaceae	0–2800	744	0–2.2	0.47	6.0
<i>Thouinia striata</i>	Sapindaceae	0–2900	418	0–4.63	0.78	5.4
<i>A. inermis</i>	Meliaceae	50–800	259	0.01–5.5	1.1	5.0
<i>Spondias mombin</i>	Anacardiaceae	0–100	20	0–23.3	2.6	3.9
<i>Cas. sylvestris</i>	Flacourtiaceae	0–1400	401	0–0.67	0.3	3.3
<i>Cup. americana</i>	Sapindaceae	0–600	135	0–3.2	0.47	3.1
<i>Parathesis crenulata</i>	Myrsinaceae	0–960	190	0–0.03	0.04	2.5
<i>O. leucoxyton</i>	Lauraceae	0–467	197	0–1.84	0.4	2.5

- For example, *G. guidonea* had the highest mean density and accounted for 23.7% of stems in the coffee sites, while in the pasture sites the exotic *S. campanulata* had the highest mean density and accounted for 33.2% of the stems. *S. campanulata* was uncommon in coffee plantations, but *G. guidonea* was a second dominant species in

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pasture sites (Rivera and Aide 1998).

- Secondary forests in the karst region appear to recover faster in comparison with secondary forest in other geological soil formations of Puerto Rico (Rivera and Aide 1998). Abandoned coffee plantations in the karst region subtropical moist forest also have recovered faster in comparison with plantations in other areas of Puerto Rico (Rivera and Aide 1998).
- In the karst region, the dominant pioneer species was *S. campanulata*, while in the pastures in eastern Puerto Rico, shrub species were the most important pioneer species (Rivera and Aide 1998).
- Although the differences in the rate of recovery in these abandoned coffee plantations could be due to different climates, the topography of the karst region may have also contributed to the rapid recovery. The unique topography of the karst region may be the most important factor contributing to the rapid recovery of secondary forest. The abrupt topography of the mogotes restricted the majority of agriculture to the valleys and vegetation that survived on the steep slopes and top of mogotes were important seed sources (Rivera and Aide 1998).
- The presence of many caves and bats is probably another important factor that has accelerated forest recovery in this area (Rivera and Aide 1998).
- Forest has recovered in the karst region because deforestation occurred at a small spatial scale, seed sources were close to disturbed areas, and the disperser community (birds and bats) was able to remain in the area during the period of agriculture (Rivera and Aide 1998).

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## **State and Transition Models**

### **COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

#### **Similar sites**

- Subtropical Moist Limestone Upland Forest

Full list of the 50 most important species in the northern karst belt forest of Puerto Rico  
(Brandeis 2006).

Table 2. Importance values for the 50 most important species in the northern karst belt forest of Puerto Rico, in tree ( $D_{BH} \geq 12.5$  cm), sapling ( $2.5 \leq D_{BH} < 12.5$ ), and seedling ( $D_{BH} > 2.5$  cm and height  $\geq 30$  cm) size categories.

Scientific name with authority	Origin	Tree IV	Sapling IV	Seedling IV
<i>Spathodea campanulata</i> Beauv.	I	23.77	9.69	3.20
<i>Bursera simaruba</i> (L.) Sarg.	N	5.05	2.73	0.92
<i>Guarea guidonia</i> (L.) Sleumer	N	4.46	3.37	3.58
<i>Andira inermis</i> (W. Wright) Kunth ex DC.	N	4.25	1.77	3.50
<i>Tabebuia heterophylla</i> (DC.) Britt.	N	3.14	3.62	2.78
<i>Calophyllum antillanum</i> Britt.	I	2.89	1.61	2.66
<i>Ficus citrifolia</i> P. Mill.	N	2.69	0.73	0.46
<i>Neolaugeria resinosa</i> (Vahl) Nicols.	N	2.53	1.46	0.45
<i>Zanthoxylum martinicense</i> (Lam.) DC.	N	2.30	0.48	0.28
<i>Thouinia striata</i> Radlk.	N	2.26	4.12	2.25
<i>Bucida buceras</i> L.	N	2.22	1.29	1.09
<i>Coccoloba diversifolia</i> Jacq.	N	2.21	2.94	2.15
<i>Dendropanax arboreus</i> (L.) Dcne. & Planch. ex Britt.	N	1.91	1.34	1.54
<i>Cecropia schreberiana</i> Miq.	N	1.78	1.73	0.19
<i>Clusia rosea</i> Jacq.	N	1.77	0.45	0.88
<i>Inga laurina</i> (Sw.) Willd.	N	1.62	0.13	0.17
<i>Roystonea borinquena</i> O.F. Cook	N	1.60	0.00	0.60
<i>Citharexylum fruticosum</i> L.	N	1.55	2.85	1.02
<i>Syzygium jambos</i> (L.) Alston	I	1.42	3.03	1.99
<i>Inga vera</i> Willd.	N	1.27	0.58	0.70
<i>Cinnamomum elongatum</i> (Vahl ex Nees) Kosterm.	N	1.23	0.63	1.20
<i>Terminalia catappa</i> L.	I	1.21	0.00	0.13
<i>Senna siamea</i> (Lam.) Irwin & Barneby	I	1.18	0.94	0.08
<i>Persea americana</i> P. Mill.	I	1.08	0.00	0.07
<i>Albizia procera</i> (Roxb.) Benth.	I	1.01	0.00	0.22
<i>Petitia domingensis</i> Jacq.	N	0.99	0.00	0.07
<i>Casearia sylvestris</i> Sw.	N	0.90	3.35	3.72
<i>Adenantha pavonina</i> L.	I	0.88	1.63	0.50
<i>Licaria parvifolia</i> (Lam.) Kosterm.	N	0.81	1.26	0.55
<i>Sideroxylon salicifolium</i> (L.) Lam.	N	0.77	0.00	0.25
<i>Mangifera indica</i> L.	I	0.73	0.00	0.07
<i>Erythrina poeppigiana</i> (Walp.) O.F. Cook	I	0.72	0.00	0.15
<i>Cupania americana</i> L.	N	0.70	0.90	1.48
<i>Mammea americana</i> L.	N	0.69	0.18	0.14
<i>Ocotea coriacea</i> (Sw.) Britt.	N	0.67	0.67	1.08
<i>Delonix regia</i> (Bojer ex Hook.) Raf.	I	0.63	0.16	0.15
<i>Citrus sinensis</i> (L.) Osbeck	I	0.62	0.30	0.07
<i>Myrsine coriacea</i> (Sw.) R. Br. ex Roemer & J.A. Schultes	N	0.61	2.17	1.19
<i>Tetrazygia elaeagnoides</i> (Sw.) DC.	N	0.60	3.05	1.49
<i>Alchornea latifolia</i> Sw.	N	0.59	0.13	0.15
<i>Sapium laurocerasus</i> Desf.	N	0.55	0.72	0.15
<i>Ocotea leucoxydon</i> (Sw.) De Laness.	N	0.44	0.47	0.68
<i>Eugenia biflora</i> (L.) DC.	N	0.41	1.67	2.12
<i>Guapira fragrans</i> (Dum.-Cours.) Little	N	0.40	0.93	0.98
<i>Exothea paniculata</i> (Juss.) Radlk.	N	0.40	0.16	0.42
<i>Chrysophyllum cainito</i> L.	N	0.39	0.14	0.15
<i>Pimenta racemosa</i> var. <i>racemosa</i>	N	0.37	1.00	0.69
<i>Buchenavia tetraphylla</i> (Aubl.) Howard	N	0.32	0.00	0.08
<i>Ocotea sintenisii</i> (Mez) Alain	N	0.31	0.47	0.23

I = introduced species, N = native species.

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**SITE NAME: SUBTROPICAL MOIST LIMESTONE UPLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (69%), MLRA 272- Humid Coastal Plains (31%)

Occurrence: Puerto Rico, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Moist Limestone Upland Forest (SMLUF) was developed after collapsing the subtropical moist limestone upper slope and the subtropical moist limestone ridge in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SMLUF mostly falls within the National Vegetation Classification Group G455 Caribbean Seasonal Evergreen Moist Lowland Forest and D094 Caribbean and Central American Lowland Shrubland, Grassland, and Savanna (U.S. National Vegetation Classification 2019). According to a USDA Forest Service land cover map of Puerto Rico (Gould et al. 2007), dominant vegetation covers within this ecological site include mature secondary moist limestone evergreen and semideciduous forest, moist grasslands and pastures, young secondary moist limestone evergreen and semideciduous forest. In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the seasonal evergreen forest (zone II) which includes forest and scrubs, and about 20 vegetation communities.

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### **Ecological Site Concept:**

The SMLUF has an extension of 756 km<sup>2</sup> (~8% of the island), and it occupies the upper landscape positions of the moist forest associated with the limestone hills of northern Puerto Rico. Although the subtropical moist forest Ecological Life Zone occurs in the three islands that conform the USVI (St. Thomas, St. John, and St. Croix), there is not a land cover class in the subtropical moist forest associated with the limestone geology for these islands (Gould et al. 2013). However, a vegetation assemblage conformed by *Leucaena leucocephala*, and *Samanea saman* has been described for the moist/wet forest in association with the limestone geology in the USVI (Brandeis et al. 2009). This ecological site supports a variety of vegetation communities and a unique species compositions representative of the subtropical moist forest associated with limestone parent materials (China and Helmer 2003). Unlike the moist forest occurring in the quaternary plains, moist forest in the limestone is better preserved as it is less suitable for agriculture, especially on the tops of the hills where soils are less fertile (Ewel and Whitmore 1973, Rivera and Aide 1998). Before the abandonment of agriculture, which peaked by the 1940's, alluvial terraces and sinkholes in the karst region were the principal features used for humans' settlements, pasture, agriculture, and coffee plantations (Rivera and Aide 1998). Currently, urban development including road construction, fires, dumping, and the extraction of geologic material continue jeopardizing this unique ecosystem. The karst physiography encompasses one of the most biodiverse regions in Puerto Rico as it provides habitat for several endemic and endangered species, comprises the largest aquifer on the island, and the largest portion of mature forest, coastal wetlands, estuaries, and underground system of caves across the island (Lugo et al. 2001). Because of its high ecological value which includes species of conservation concern in several taxonomic groups, the northern karst region has been designated



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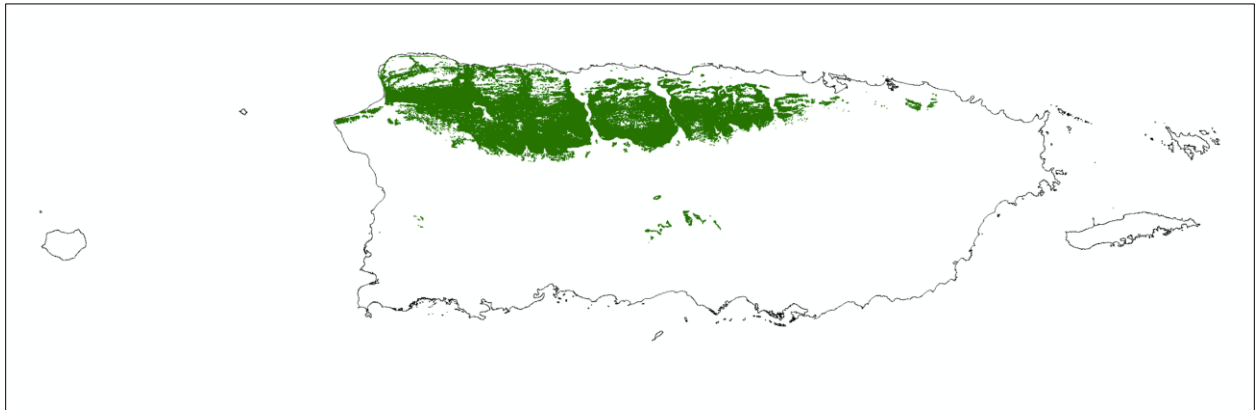


Figure 1. Distribution of the Subtropical Moist Limestone Upland Forest in Puerto Rico.

**Dominant plant species:**

Most common tree species occurring within FIA plots in this ecological site in Puerto Rico are *Spathodea campanulata*, *Tetrazygia elaeagnoides*, *Tabebuia heterophylla*, *Leucaena*

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*leucocephala*, *Andira inermis*, *Bursera simaruba*, *Eugenia biflora* (Marcano-Vega 2019). Eleven out of 14 tree assemblages were described for this ecological site in Puerto Rico, while in the USVI only one assemblage with two species, *Leucaena leucocephala* and *Samanea saman* (Brandeis et al. 2009). Assemblages found in Puerto Rico are listed below in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources

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  10. *Thouinia striata*, *Ficus citrifolia*, *Petitia domingensis*, *Trichilia pallida*, *Eugenia rhombea*, *Coccoloba microstachya*
  11. *Tabebuia heterophylla*, *Casearia arborea*, *Roystonea borinquena*, *Myrcia citrifolia*.

- **Other trees:** *Bursera simaruba*, *Goussia attenuata*, *Thouinia striata* var. *striata*, *Neolaugeria resinosa*, *Coccoloba pubescens*, *Calophyllum calaba*, *Clusia rosea*, *Ficus* spp., *Dendropanax arboreus*, *Comocladia glabra*, *Myrsine guianensis*, *Rondeletia inermis*, *Goussia attenuata*, *Tetrazygia eleagnoides*, *Sabinea florida*, *Ardisia obovata*, *Phyllanthus* sp., *Ilex nitida*, *Terebraria resinosa*, *Phyllanthus* sp., *Cupania americana*, *Zanthoxylum martinicense*, *Guettarda scabra*, *Rapanea ferruginea*, *Sabinea florida*, *Bucida buceras*, *Tetrazygia eleagnoides*, *Clusia rosea*, *Plumeria obtusa*, *Syderoxylon cubense*, *Ficus* spp., *Goussia attenuata*, *Coccothrinax alta*, *Ardisia obovata*, *Myrica cerifera*, *Coccoloba pyrifolia*, *Coccoloba costata*, *Rondeletia inermis*, *Swietenia macrophylla*, *Tectona grandis*, *Goussia attenuata*, *Aiphanes acanthophylla*, *Coccoloba diversifolia*, *Licaria salicifolia*, *Zanthoxylum martinicense*, *Cedrela odorata*, *Hyeronima clusioides*, *Sapium laurocerasus*, *Thouinia striata*, *Thespesia grandiflora*, *Ochroma pyramidale*, *Clusia rosea*, *Bucida buceras*, *Tetrazygia eleagnoides*, *Sideroxylon*

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*foetidissimum, Guettarda scabra, Terebraria resinosa, Randia aculeata, Picramnia pentandra, Myrcia leptoclada, Tabebuia heterophylla.*

- **Shrubs:** *Nea buxifolia, Pisonia aculeata*
- **Herbaceous, cactus, succulents:** *Paspalum sp., Polypodium sp., Pitcairnia angustifolia, Bromelia pinguin.*

## PHYSIOGRAPHIC FEATURES

### Landforms

Steep slopes/mogote side (64%)

Tops (22%)

Side slopes/mogote valley (11%)

Plains (2%)

### Physiographic features (characteristics ranges)

Elevation range: 0 m to 1,087 m (mean= 196m)

Slope: 0-247% (mean= 33%, or 18 degrees)

Aspect (mean): South (175 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SMLUF is about 1,780 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to

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March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 17°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,780 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

The northern karst zone of Puerto Rico comprises the largest freshwater aquifer of the island (Lugo et al. 2001).

REPRESENTATIVE SOIL FEATURES

Soil components include Colinas, La Tea, Los Penones, San Sebastian, Soller.

**Surface texture**

**Soil features**

Family particle size:

## Soil features (characteristic ranges)

### ECOLOGICAL DYNAMICS OF THE SITE

The table below describes the dominant species in secondary forests in this ecological site after the abandonment of coffee plantations and pastures (Rivera and Aide 1998).

Table 1  
The density (stems ha<sup>-1</sup>), basal area (m<sup>2</sup> ha<sup>-1</sup>), and mean importance value of the top 10 dominant species ( $\geq 1.0$  cm dbh) in abandoned coffee and pastures

Species	Family	Range of density	Mean density	Range of basal area	Mean basal area	Mean importance values
<b>Coffee</b>						
<i>G. guidonia</i>	Meliaceae	333–1250	707	0.86–31.7	12.4	36.0
<i>C. arabica</i>	Rubiaceae	100–1400	510	0.01–0.24	0.1	8.4
<i>Dendropanax arboreus</i>	Araliaceae	0–900	272	0–2.34	0.33	5.2
<i>Montezuma speciosissima</i>	Malvaceae	0–167	48	0–7.95	1.97	4.6
<i>Trichilia palida</i>	Meliaceae	0–9.50	213	0–3.43	0.46	4.5
<i>Ocotea leucoxyton</i>	Lauraceae	0–700	112	0–8.82	1.1	3.9
<i>Cordia alliodora</i>	Boraginaceae	0–100	22	0–5.53	0.98	3.9
<i>Cecropia schreberiana</i>	Moraceae	0–100	15	0–21.5	1.9	3.1
<i>Cupania americana</i>	Sapindaceae	0–400	61	0–4.3	0.67	2.4
<i>Andira inermis</i>	Leguminosae	0–250	60	0–7.9	1.18	2.3
<b>Pastures</b>						
<i>S. campanulata</i>	Bignoniaceae	50–8233	2136	0.05–38.6	18.9	39.9
<i>G. guidonia</i>	Meliaceae	0–2050	865	0–12.4	3.2	14.2
<i>Casearia guianensis</i>	Flacourtiaceae	0–2800	744	0–2.2	0.47	6.0
<i>Thouinia striata</i>	Sapindaceae	0–2900	418	0–4.63	0.78	5.4
<i>A. inermis</i>	Meliaceae	50–800	259	0.01–5.5	1.1	5.0
<i>Spondias mombin</i>	Anacardiaceae	0–100	20	0–23.3	2.6	3.9
<i>Cas. sylvestris</i>	Flacourtiaceae	0–1400	401	0–0.67	0.3	3.3
<i>Cup. americana</i>	Sapindaceae	0–600	135	0–3.2	0.47	3.1
<i>Parathesis crenulata</i>	Myrsinaceae	0–960	190	0–0.03	0.04	2.5
<i>O. leucoxyton</i>	Lauraceae	0–467	197	0–1.84	0.4	2.5

- For example, *G. guidonea* had the highest mean density and accounted for 23.7% of stems in the coffee sites, while in the pasture sites the exotic *S. campanulata* had the highest mean density and accounted for 33.2% of the stems. *S. campanulata* was uncommon in coffee plantations, but *G. guidonea* was a second dominant species in pasture sites (Rivera and Aide 1998).
- Secondary forests in the karst region appear to recover faster in comparison with

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secondary forest in other geological soil formations of Puerto Rico (Rivera and Aide 1998). Abandoned coffee plantations in the karst region subtropical moist forest also have recovered faster in comparison with plantations in other areas of Puerto Rico (Rivera and Aide 1998).

- In the karst region, the dominant pioneer species was *S. campanulata*, while in the pastures in eastern Puerto Rico, shrub species were the most important pioneer species (Rivera and Aide 1998).
- Although the differences in the rate of recovery in these abandoned coffee plantations could be due to different climates, the topography of the karst region may have also contributed to the rapid recovery. The unique topography of the karst region may be the most important factor contributing to the rapid recovery of secondary forest. The abrupt topography of the mogotes restricted the majority of agriculture to the valleys and vegetation that survived on the steep slopes and top of mogotes were important seed sources (Rivera and Aide 1998).
- The presence of many caves and bats is probably another important factor that has accelerated forest recovery in this area (Rivera and Aide 1998).
- Forest has recovered in the karst region because deforestation occurred at a small spatial scale, seed sources were close to disturbed areas, and the disperser community (birds and bats) was able to remain in the area during the period of agriculture (Rivera and Aide 1998).

## State and Transition Models

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**COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

**Similar sites**

- Subtropical Moist Limestone Bottomland Forest (SMLBF)



Full list of the 50 most important species in the northern karst belt forest of Puerto Rico  
(Brandeis 2006).

Table 2. Importance values for the 50 most important species in the northern karst belt forest of Puerto Rico, in tree ( $D_{BH} \geq 12.5$  cm), sapling ( $2.5 \leq D_{BH} < 12.5$ ), and seedling ( $D_{BH} > 2.5$  cm and height  $\geq 30$  cm) size categories.

Scientific name with authority	Origin	Tree IV	Sapling IV	Seedling IV
<i>Spathodea campanulata</i> Beauv.	I	23.77	9.69	3.20
<i>Bursera simaruba</i> (L.) Sarg.	N	5.05	2.73	0.92
<i>Guarea guidonia</i> (L.) Sleumer	N	4.46	3.37	3.58
<i>Andira inermis</i> (W. Wright) Kunth ex DC.	N	4.25	1.77	3.50
<i>Tabebuia heterophylla</i> (DC.) Britt.	N	3.14	3.62	2.78
<i>Calophyllum antillanum</i> Britt.	I	2.89	1.61	2.66
<i>Ficus citrifolia</i> P. Mill.	N	2.69	0.73	0.46
<i>Neolaugeria resinosa</i> (Vahl) Nicols.	N	2.53	1.46	0.45
<i>Zanthoxylum martinicense</i> (Lam.) DC.	N	2.30	0.48	0.28
<i>Thouinia striata</i> Radlk.	N	2.26	4.12	2.25
<i>Bucida buceras</i> L.	N	2.22	1.29	1.09
<i>Coccoloba diversifolia</i> Jacq.	N	2.21	2.94	2.15
<i>Dendropanax arboreus</i> (L.) Dcne. & Planch. ex Britt.	N	1.91	1.34	1.54
<i>Cecropia schreberiana</i> Miq.	N	1.78	1.73	0.19
<i>Clusia rosea</i> Jacq.	N	1.77	0.45	0.88
<i>Inga laurina</i> (Sw.) Willd.	N	1.62	0.13	0.17
<i>Roystonea borinquena</i> O.F. Cook	N	1.60	0.00	0.60
<i>Citharexylum fruticosum</i> L.	N	1.55	2.85	1.02
<i>Syzygium jambos</i> (L.) Alston	I	1.42	3.03	1.99
<i>Inga vera</i> Willd.	N	1.27	0.58	0.70
<i>Cinnamomum elongatum</i> (Vahl ex Nees) Kosterm.	N	1.23	0.63	1.20
<i>Terminalia catappa</i> L.	I	1.21	0.00	0.13
<i>Senna siamea</i> (Lam.) Irwin & Barneby	I	1.18	0.94	0.08
<i>Persea americana</i> P. Mill.	I	1.08	0.00	0.07
<i>Albizia procera</i> (Roxb.) Benth.	I	1.01	0.00	0.22
<i>Petitia domingensis</i> Jacq.	N	0.99	0.00	0.07
<i>Casearia sylvestris</i> Sw.	N	0.90	3.35	3.72
<i>Adenantha pavonina</i> L.	I	0.88	1.63	0.50
<i>Licaria parvifolia</i> (Lam.) Kosterm.	N	0.81	1.26	0.55
<i>Sideroxylon salicifolium</i> (L.) Lam.	N	0.77	0.00	0.25
<i>Mangifera indica</i> L.	I	0.73	0.00	0.07
<i>Erythrina poeppigiana</i> (Walp.) O.F. Cook	I	0.72	0.00	0.15
<i>Cupania americana</i> L.	N	0.70	0.90	1.48
<i>Mammea americana</i> L.	N	0.69	0.18	0.14
<i>Ocotea coriacea</i> (Sw.) Britt.	N	0.67	0.67	1.08
<i>Delonix regia</i> (Bojer ex Hook.) Raf.	I	0.63	0.16	0.15
<i>Citrus sinensis</i> (L.) Osbeck	I	0.62	0.30	0.07
<i>Myrsine coriacea</i> (Sw.) R. Br. ex Roemer & J.A. Schultes	N	0.61	2.17	1.19
<i>Tetrazygia elaeagnoides</i> (Sw.) DC.	N	0.60	3.05	1.49
<i>Alchornea latifolia</i> Sw.	N	0.59	0.13	0.15
<i>Sapium laurocerasus</i> Desf.	N	0.55	0.72	0.15
<i>Ocotea leucoxydon</i> (Sw.) De Laness.	N	0.44	0.47	0.68
<i>Eugenia biflora</i> (L.) DC.	N	0.41	1.67	2.12
<i>Guapira fragrans</i> (Dum.-Cours.) Little	N	0.40	0.93	0.98
<i>Exothea paniculata</i> (Juss.) Radlk.	N	0.40	0.16	0.42
<i>Chrysophyllum cainito</i> L.	N	0.39	0.14	0.15
<i>Pimenta racemosa</i> var. <i>racemosa</i>	N	0.37	1.00	0.69
<i>Buchenavia tetraphylla</i> (Aubl.) Howard	N	0.32	0.00	0.08
<i>Ocotea sintenisii</i> (Mez) Alain	N	0.31	0.47	0.23

I = introduced species, N = native species.

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**SITE NAME: SUBTROPICAL MOIST PALUSTRINE WETLAND (F272X...)**

MLRA 272- Humid Coastal Plains (88%), MLRA 270-Humid Mountains and Valleys (12%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Subtropical Moist Palustrine Wetland (SMPW) is the subtropical moist non-saline wetland in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). Most of the SMPW falls within the National Vegetation Classification Group D094 Caribbean and Central American Lowland Shrubland, Grassland, and Savanna (U.S. National Vegetation Classification 2019). Most of the vegetation cover within this ecological site is represented by seasonally flooded herbaceous non-saline wetlands (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the Littoral subzone (zone Ia) which includes meadow steppe, desert, savanna and forest, and more than 50 vegetation communities.

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## Ecological Site Concept:

Palustrine wetlands can be found in the proximity of water reservoirs, lagoons, river channels, and flooded flats. Palustrine systems in Puerto Rico have been classified into 10 groups according to the following environmental factors: water regime, water chemistry, soils, and elevation (DRNA unknown year). In addition, six palustrine/estuarine systems also occur on the island (DRNA unknown year). Each of the palustrine wetlands have a representative vegetation assemblage or dominant species. Palustrine wetlands include montane thickets dominated by the vegetation associations occurring at higher elevations (above 300 m.a.s.l) such as Palo Colorado (*Cyrilla-Micropholis*), Sierra Palm, (*Prestoea-Cyathea, Alsophila*), and elfin forest (*Tabebuia-Ocotea-Calygonium*), also forested wetlands include *Manilkara bidentata* (ausubo) forest occurring at broader elevations (0-600m). A typical palustrine forested swamp in the lowlands is the *Pterocarpus* forest dominated by the swamp bloodwood tree (*Pterocarpus officinalis*) (Miller and Lugo 2009). The *Pterocarpus* forest can form associations with the white mangrove *Laguncularia racemosa*. Other palustrine wetlands include the seasonal evergreen forest occurring in the foothills of the mogotes (limestone hills) where the water accumulates and soils are hydric. This forest is dominated by *Nectandra antillana* and *Roystonea borinquena*. Other palustrine wetlands are those semi-permanent or permanently inundated occurring in the margins of rivers and water reservoirs, dominated by *Gynerium sagittatum* and *Bambusa vulgaris*, *Cyathea arborea*, and *Tabebuia rigida*. These are the environments that have been mostly used in Puerto Rico for crops such as sugarcane (*Scharrum officinatum*) and rice (*Oriza sativa*). One additional palustrine wetland is conformed by a mixture of native and exotic species but the second ones at a much higher proportion dominated by species such as *Casuarina equisetifolia* and *Spathodea campanulata*, among others (DRNA unknown year). The SMPW has an

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extension of 217 km<sup>2</sup> (~2% of the island), and it occupies the lowest landscape position of the moist forest in the littoral zone, in the north, east, and west of Puerto Rico (Fig. 1). The SMPW can be found in Boquerón, Guajataca, de Vega, Piñones, Ceiba, and Cambalache State Forests.

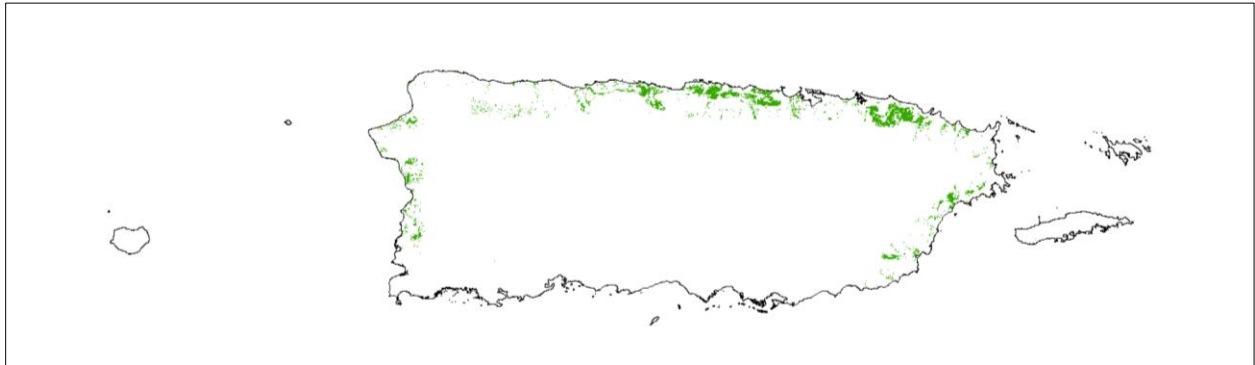


Figure 1. Distribution of the Subtropical Moist Palustrine Wetland in Puerto Rico.

#### **Dominant plant species:**

None of the FIA plots occurred within this ecological site.

- **Trees:** *Pterocarpus officinalis*, *Bucida buceras*, *Roystonea borinquena*, *Guarea guidonea*, *Calophyllum calaba*, *Cedrela odorata*, *Alchornea latifolia*, *Sapium laurocerasus*, *Annona glabra*, *Tabebuia heterophylla*, *Acromia media*, *Lycaria parvifolia*, *Dendropanax arboreus*.
- **Shrubs:** *Randia aculeata*, *Psychotria pubescens*, *Psychotria nervosa*, *Sesbania sericea*, *Casearia* spp., *Palicourea crocea*, *Aeschynomene sensitiva*.
- **Herbaceous, cactus, succulents:** *Typha dominguensis*, *Phragmites australis*, *Sagittaria lancifolia*, *Cladium jamaicens*, *Eleocharis* sp., *Acrostichum danaeifolium*, *Paspalum*

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*virgatum*, *P. millegrana*, *P. plicatulum*, *P. secans*, *P. densum*, *Cyperus odoratus*,  
*C. surimanensis*, *C. giganteus*, *Panicum laxum*, *Ludwigia octovalvis*, *Sesbania sericea*,  
*Scleria*, *Rhynchospora*.

## PHYSIOGRAPHIC FEATURES

### **Landforms**

Wetlands (90%)

Plain (6%)

Side slope (3%)

Steep slope (1%)

### **Physiographic features (characteristics ranges)**

Elevation range: 0 m to 222 m (mean= 18 m)

Slope: 0-40% (mean= 4%, or 7 degrees)

Aspect (mean): Southeast (145 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SMPW is about 1,626 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 18°C. Monthly temperatures are similar throughout the year, with higher temperatures

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occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,626 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

**INFLUENCING WATER FEATURES**

Temporarily or permanently inundated systems.

**REPRESENTATIVE SOIL FEATURES**

Soil series components include: Atolladero, Durados, Garrochales, Jareales, Joyuda, Martin

Pena, Palmar, Pinones, Tiburones, Vigia

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

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Drainage class:

Permeability class:

Surface fragment cover  $\leq 3\%$ :

ECOLOGICAL DYNAMICS OF THE SITE

**State and Transition Models**

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**SITE NAME: SUBTROPICAL MOIST QUATERNARY BOTTOMLAND FOREST (F272X...)**

MLRA 272- Humid Coastal Plains (68%), MLRA 270-Humid Mountains and Valleys (32%)

Occurrence: Puerto Rico, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Moist Quaternary Bottomland Forest (SMQBF) was developed after collapsing the subtropical moist quaternary lower slope, and the subtropical moist quaternary plains in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SMQBF falls within the National Vegetation Classification Group D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna, G454 Caribbean Moist Lowland-Submontane Forest Group, and 7 Agricultural Vegetation (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include moist grasslands and pastures, hay and row crops, young secondary lowland moist alluvial evergreen forest, and lowland moist alluvial shrubland and woodland (Gould et al. 2007). According to the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the lowland rainforest (zone I in the map) which includes forest, savanna, scrubs, and prairies, and about 37 vegetation communities.

### **Ecological Site Concept:**

The SMQBF has an extension of 1,041 km<sup>2</sup> (~12% of the island), and it occupies the lower landscape positions of the moist forest occurring in the north, east, central east, and west of Puerto Rico (Fig. 1). Although Humid MLRAs were not described for the USVI, in the three islands the subtropical moist forest is present (Ewel and Withmore 1973). The USVI land cover map includes some classifications that could be representative of this ecological site such as the



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lowland moist non-calcareous and alluvial forests, woodlands, and shrubs (Gould et al. 2013). The SMQBF supports a variety of vegetation communities' representatives of the subtropical moist forest life zone. Islandwide, the moist forest life zone forest has the largest extension in Puerto Rico (Ewel and Whitmore 1973), but due to its suitable weather and topography, it has been historically cleared for agriculture and urban development (Miller and Lugo 2009). Grasses, in both natural and improved pastures within this life zone, used to be the dominant landscape in the subtropical moist forest of Puerto Rico for several years. Because deforestation in the uplands have been less severe than at lower elevations (Kennaway and Helmer 2007), the vegetation communities found in this ecological site at higher elevations (Subtropical Moist Quaternary Upland Forest) provide a baseline of species that could potentially grow in primary or secondary mature moist forests at lower elevations and flatter topographies. Forest remnants in this ecological site are characterized by a mixture of natives and exotic species (Brandeis et al. 2009), and deciduous trees with heights of up to 20 meters tall and rounded crowns (Miller & Lugo, 2009). Among the dominant species in this assemblage are *Guarea guidonea*, and *Dendropanax arboreus*, and the exotic mango tree (*Mangifera indica*). This ecological site can be found in the State Forests of Boquerón, de Vega, Cambalache, Piñones, Ceiba, and Carite.

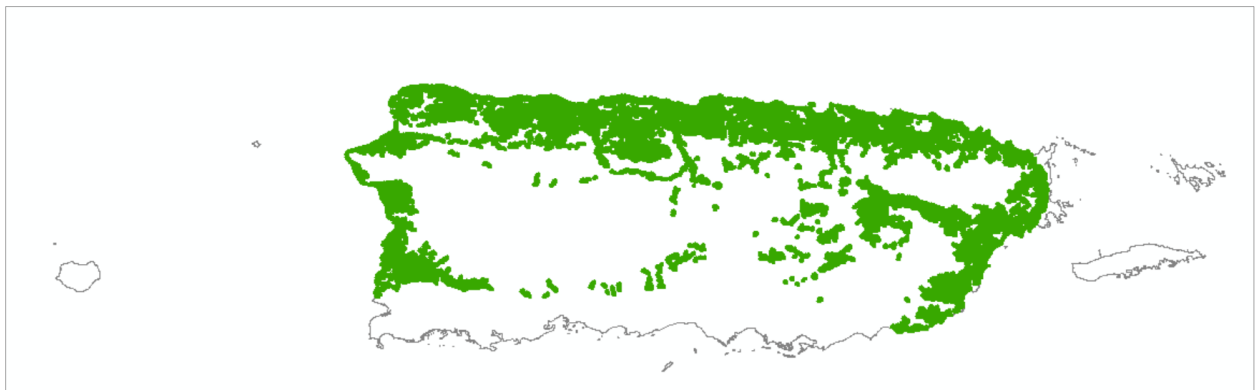


Figure 1. Distribution of the Subtropical Moist Quaternary Bottomland Forest in Puerto Rico.

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## Dominant plant species:

Dominant vegetation within FIA plots located in this ecological site in Puerto Rico include *Tabebuia heterophylla*, *Chrysobalanus icaco*, *Mangifera indica*, *Andira inermis*, *Guettarda scabra*, and *Myrcia splendens* (Marcano-Vega 2019). A secondary important species within FIA was *Miconia prasina*. In the USVI, the registered species included *Andira inermis*, *Bursera simaruba*, *Casearia guianensis*, *Cordia rickseckeri*, *Daphnopsis americana*, *Eugenia biflora*, *Guapira fragrans*, *Guettarda scabra*, *Hymenaea courbaril*, *Inga laurina*, *Myrcia citrifolia*, *Nectandra coriacea*. In addition, 12 out of 14 vegetation assemblages identified for Puerto Rico occur in this ecological site (Brandeis et al. 2009), whereas in the USVI 6 out of 8 assemblages described for these islands are present here (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### Puerto Rico

1. ***Guarea guidonia***, ***Dendropanax arboreus***, ***Mangifera indica*** (Ex), *Artocarpus altilis* (E), *Cordia sulcata*, *Quararibea turbinata*, *Erythrina poeppigiana* (Ex), *Cordia alliodora*
2. ***Spathodea campanulata*** (Ex), *Terminalia catappa* (Ex)
3. ***Casearia sylvestris***, ***Psidium guajava***, ***Coffea arabica*** (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*
4. ***Leucaena leucocephala***, *Albizia procera* (Ex)
5. ***Tabebuia heterophylla***, ***Casearia arborea***, *Roystonea borinquena*, *Myrcia citrifolia*
6. ***Casearia guianensis***, ***Andira inermis***, ***Guazuma ulmifolia***, *Guapira fragrans*, *Myrcia splendens*, *Cupania americana*

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7. *Citharexylum fruticosum*, *Exostema caribaeum*, *Ardisia obovata*, *Zanthoxylum martinicense*, *Pithecellobium dulce* (Ex), *Swietenia mahogany* (Ex)
  8. *Thouinia striata*, *Ficus citrifolia*, *Petitia domingensis*, *Trichilia pallida*, *Eugenia rhombea*, *Coccoloba microstachya*
  9. *Syzygium jambos* (Ex), *Zanthoxylum martinicense*, *Schefflera morototonii*, *Croton rigidus*, *Calophyllum antillanum* (Ex)
  10. *Neolaugeria resinosa*, *Guettarda scabra*, *Eugenia monticola*, *Tabebuia haemantha*, *Pimenta racemosa*, *Randia aculeata*, *Clusia rosea*, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*
  11. *Bursera simaruba*, *Bucida buceras*, *Amyris elemifera*, *Coccoloba diversifolia*, *Ocotea sintenisii*, *Myrsine coriácea*, *Licaria parvifolia*, *Senna siamea* (Ex), *Pictetia aculeata*, *Ocotea coriácea*
  12. *Acacia farnesiana* (Ex), *Prosopis pallida* (Ex)

#### USVI

1. *Eugenia monticola*, *Capparis baducca*, *Bursera simaruba*, *Maytenus laevigata*, *Sabinea florida*, *Ocotea coriacea*, *Bourreria succulenta*, *Chionanthus compactus*, *Cordia alliodora*, *Krugiodendron ferreum*
2. *Leucaena leucocephala*, *Samanea saman*
3. *Casearia guianensis*, *Zanthoxylum monophyllum*, *Citharexylum fruticosum*, *Ziziphus mauritiana* (Ex), *Trichilia hirta*, *Zanthoxylum martinicense*, *Acacia macracantha* (Ex), *Andira inermis*, *Randia aculeata*, *Swietenia mahagoni* (Ex)
4. *Acacia muricata*, *Pisonia subcordata*, *Eugenia cordata*, *capparis cynophallophora*, *Myrciaria floribunda*, *Amyris elemifera*, *Guettarda scabra*, *Bucida buceras*
5. *Acacia farnesiana* (Ex), *Albizia lebbbeck* (Ex), *Inga laurina*
6. *Guapira fragrans*, *Capparis indica*, *Cassine xylocarpa*, *Tabebuia heterophylla*, *capparis hastata*

- 
- **Other trees:** *Bucida buccera*, *Calophyllum calaba*, *Roystonea borinquena*, *Clusia rosea*, *Coccoloba uvifera*, *Cocos nucifera*, *Casuarina equisetifolia*, *Syzygium jambos*, *Licaria parvifolia*, *Ocotea leucoxylon*, *Ocotea sintenisii*, *Ardisia obovata*, *Andira inermis*, *Spathodea campanulata*, *Conocarpus erectus*, *Thouinia striata* var. *striata*, *Neolaugeria resinosa*, *Guarea guidonia*, *Sapium laurocerasus*, *Comocladia glabra*, *Conocarpus erectus*, *Coccoloba uvifera*, *Cassine xylocarpa*.
  - **Shrubs:** *Sesbania sericea*, *Machaerium lunatum*, *Mimosa casta*, *Suriana maritima*, *Trichilla pallida*, *Dendropanax arboreus*, *Casearia* spp., *Pisonia aculeata*.
  - **Herbaceous, cactus and succulents:** *Andropogon gerardii*, *Ludwigia octovalvis*, *Thelyptelis interrupta*, *Neptunia plena*, *Brachiaria mutica*, *Cyperus imbricatus*, *Cyperus ligularis*, *Echicochloa polystachya*, *Paspalidium geminatum*, *Paspalum lillegrana*, *Paspalum vaginatum*, *Polypodium* sp., *Pitcairnia angustifolia*, *Hymenocallis caribea*, *Chamaesyce buxifolia*, *Fimbristylis cymosa*, *Ernodia littoralis*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Plains (81%)

Side slopes/mogote valley (14%)

Wetlands (3%)

Steep slopes/mogote side (2%)

Tops (0%)

### Physiographic features (characteristics ranges)

Elevation range: -1.7 to 644 m (mean= 82m)

Slope: 0-122% (mean= 13%, or 7 degrees)

Aspect (mean): South (174 degrees)

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## CLIMATIC FEATURES

*Climate:* The mean annual precipitation in the SMQBF is about 1,670 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 15°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,670 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges)**

### **Monthly temperature (averages)**

## INFLUENCING WATER FEATURES

## REPRESENTATIVE SOIL FEATURES

Soil series components for this ecological site include:

1) WELL-DRAINED BLANKET SAND DEPOSIT: Almirante, Arecibo, Bejucos, Caracoles, Carrizales, Corozo, Islote, Rio Lajas, Torres 2) RESTRICTED-DRAINAGE BLANKET SAND DEPOSIT: Aceitunas, Algarrobo, Bayamon, Cotito, Coto, Espinosa, Guanajibo, Guerrero, Jobos, Maleza, Matanzas, Rio Piedras, Voladora, 3) WELL-DRAINED FLUVIAL AND ALLUVIAL: Dique, Humacao, Montegrande, Parcelas, Reilly, Rio Arriba, Santa Clara, Toa, Vega Alta, Via, Vivi, 4) RESTRICTED-DRAINAGE FLUVIAL AND ALLUVIAL: Bajura, Candelero, Coloso,

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Corcega, Fajardo, Fortuna, Igualdad, Lares, Mabi, Maunabo, Sabana Seca, Santoni, Talante, Vega Baja.

### **Surface texture**

### **Soil features**

Family particle size:

### **Soil features (characteristic ranges)**

## **ECOLOGICAL DYNAMICS OF THE SITE**

### *Ecological dynamics*

Original vegetation in the coastal plains is uncertain as it was cleared in the 1800s. Even at the time of Gleason and Cooks's investigation (1926), little was left of the original lowland moist forest. By the date of this publication (1966), the lowland forest was even more depleted (Danserau and Buell 1966). Site age had the strongest effect on the recovery of forest structure (species richness, diversity, and basal area), but elevation had a strong effect on species composition (Aide et al. 1996). Naturalized tree species play a significant role in the recovery and secondary forest succession in Puerto Rico (Brandeis et al. 2009). All assemblages here were found on sites that had formerly been pastures or herbaceous agriculture (Brandeis et al. 2009).

### **State and Transition Models**

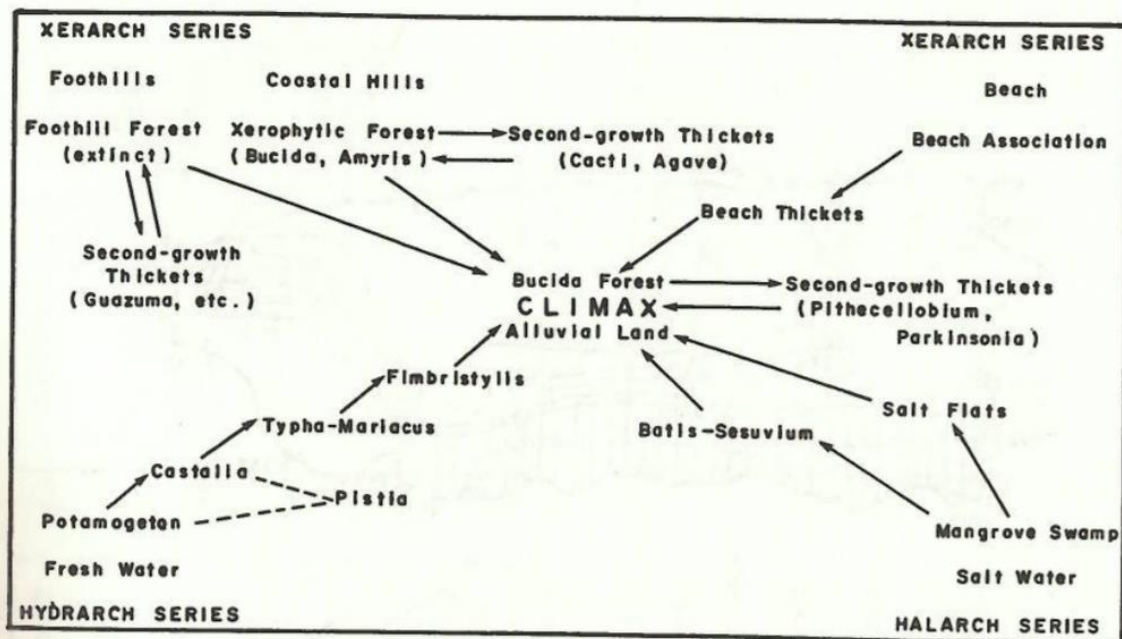


Figure 2. Succession in moist environments of Puerto Rico according to Gleason and Cook 1926.

### COMMUNITY 1.1- State 1-Reference

- Early descriptions and surveys of relic sites suggest that *Manilkara bidentata* (Sapotaceae), *Calophyllum calaba* (Gutiferae), *Hymenaea courbaril* (Leguminosae), *Byrsonima spicata* (Malpighiaceae), and *Tabebuia heterophylla* (Bignoniaceae) were important species (Wadsworth 1950) (Aide et al. 1996).
- Old forest species at elevations <100m= *Ocotea leucoxylon*, *Hymenaea courbaril*, *Byrsonima spicata*, *Guarea guidonia*, *Andira inermis* (Aide et al. 1996).
- Old forest species at elevations  $\geq 100$ m= *Dacryodes excelsa*, *Cecropia schreberiana*, *Andira inermis* (Aide et al. 1996).
- Between 200 and 600 m *Dacryodes excelsa*, *Manilkara bidentata*, and *Sloanea*

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*berteriana* (Elaeocarpaceae) are the dominant tree species in relatively undisturbed forest, and *Cecropia schreberiana* and *Schefflera morototoni* (Araliaceae) are the most common pioneer species (Lugo 1985).

**Disturbances: Forest clearing, grazing, hurricanes**

**COMMUNITY 1.2-** Pastures or herbaceous agriculture (mostly sugar cane).

**COMMUNITY 1.3-** Pioneers species such as *Myconia prasina*, *Casearia sylvestris*

**COMMUNITY 1.4-** Shrubs and small tree species, *Casearia guianensis*, *Psychotria bractiata*,

**COMMUNITY 1.5-** Useful secondary species, *Andira inermis*, *Guarea guidonia*

**COMMUNITY 1.6-** Old forest species, *Ocotea leucoxylon*, *Hymenaea courbaril*, *Byrsonima spicata*



ECOLOGICAL SITE INTERPRETATION (forest succession in the moist forest in relation to years since agriculture abandonment and elevation).

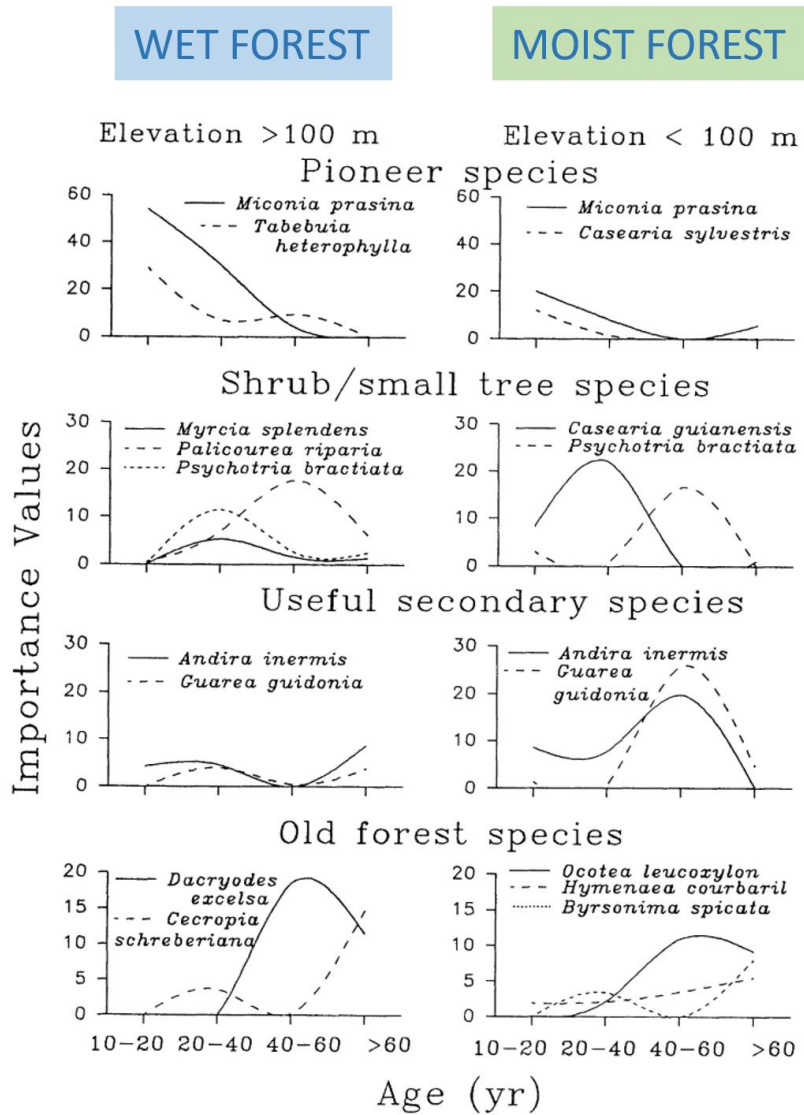


FIGURE 5. A comparison of changes in importance values with site age for common pioneer, shrub/small tree, useful secondary species with valuable wood, and old forest species between low (<100 m) and high (>100 m) elevation sites. Curves are cubic spline interpolations (Sigmaplot 1989) based on the average importance values of all sites in each age class.

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## SUPPORTING INFORMATION

### **Similar sites**

- Subtropical Moist Quaternary Upland Forest (SMQUF)

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**SITE NAME: SUBTROPICAL MOIST QUATERNARY UPLAND FOREST (F272X...)**

MLRA 272- Humid Coastal Plains (60%), MLRA 270-Humid Mountains and Valleys (39%)

Occurrence: Puerto Rico, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Moist Quaternary Upland Forest (SMQUF) was developed after collapsing two landscape units classified for Puerto Rico, the subtropical moist quaternary upper slope and the subtropical moist quaternary ridge in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SMQF falls within the National Vegetation Classification Group D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna, G455 Caribbean Seasonal Evergreen Moist Lowland Forest Group, G454 Caribbean Moist Lowland-Submontane Forest Group, while others vegetation groups are less abundant ( $\leq 2\%$ ) (U.S. National Vegetation Classification 2019). According to a USDA Forest Service land cover map of Puerto Rico (Gould et al. 2007), dominant vegetation covers within this ecological site include moist grasslands and pastures, mature secondary moist limestone evergreen and semideciduous forest, mature secondary lowland moist alluvial evergreen forest, young secondary lowland moist alluvial evergreen forest, young secondary moist limestone evergreen and semideciduous forest, and lowland moist alluvial shrubland and woodland. According to the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the lowland rainforest (zone I in the map) which includes forest, savanna, scrubs, and prairies, and about 37 vegetation communities.

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### Ecological Site Concept:

The SMQUF has an extension of 87 km<sup>2</sup> (~1% of the island), and it occupies the upper landscape positions of the moist forest occurring in the north, east, central east, and west of Puerto Rico (Fig. 1). Although Humid MLRAs were not described for the USVI, in the three islands the subtropical moist forest is present (Ewel and Withmore 1973). The USVI land cover map includes some classifications that could be representative of this ecological site such as the lowland moist non-calcareous and alluvial forests, woodlands, and shrubs (Gould et al. 2013). This ecological site supports a variety of vegetation communities' representatives of the subtropical moist forest life zone. Islandwide, the moist forest life zone forest has the largest extension in Puerto Rico (Ewel and Whitmore 1973), but due to its suitable weather and topography, it has been historically cleared for agriculture and urban development (Miller and Lugo 2009). Grasses, in both natural and improved pastures within this ecological life zone, used to be the dominant landscape in the subtropical moist forest of Puerto Rico for several years. Because deforestation in the uplands has been less severe than at lower elevations (Kennaway and Helmer 2007), the vegetation communities found in this ecological site provide a baseline of species that could potentially grow in primary or secondary mature moist forests at lower elevations. Forest remnants in the subtropical moist forest life zone are characterized by deciduous trees with heights of up to 20 meters tall and rounded crowns (Miller & Lugo 2009). This ecological site is characterized by a mixture of natives and exotic species (Brandeis et al. 2009). Among the dominant species in this assemblage are *Guarea guidonea*, and *Dendropanax arboreus*, and the exotic mango tree (*Mangifera indica*). This ecological site can be found in the State Forests of de Vega, Cambalache, Río Abajo, and Carite.

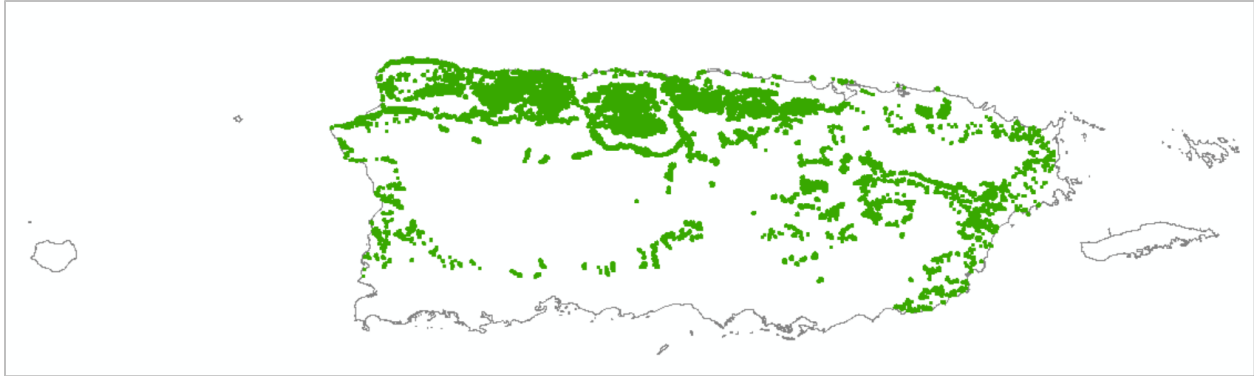


Figure 1. Distribution of the Subtropical Moist Quaternary Upland Forest in Puerto Rico.

**Dominant plant species:**

Dominant tree species within this ecological site in Puerto Rico included *Spathodea campanulata*, *Andira inermis*, *Guarea guidonia*, *Miconia prasina*, *Schefflera morototonii*, and *Casearia guianensis* (Marcano-Vega 2019). In the USVI, tree species found in FIA plots within this ecological site included *Andira inermis*, *Bursera simaruba*, *Casearia guianensis*, *Cordia rickseckeri*, *Daphnopsis americana*, *Eugenia biflora*, *Guapira fragrans*, *Guettarda scabra*, *Hymenaea courbaril*, *Inga laurina*, *Myrcia citrifolia*, and *Nectandra coriacea* (Marcano-Vega 2019). Twelve out of 14 tree assemblages identified for Puerto Rico, occurred within this ecological site (Brandeis et al. 2009) whereas in the USVI 6 out of 8 assemblages described for these islands occur within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

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Puerto Rico:

1. *Guarea guidoni*, *Dendropanax arboreus*, *Mangifera indica* (Ex), *Artocarpus altilis* (Ex), *Cordia sulcata*, *Quararibea turbinata*, *Erythrina poeppigiana* (Ex), *Cordia alliodora*
2. *Spathodea campanulata* (Ex), *Terminalia catappa* (Ex)
3. *Casearia sylvestris*, *Psidium guajava*, *Coffea arabica* (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*
4. *Leucaena leucocephala*, *Albizia procera* (Ex)
5. *Tabebuia heterophylla*, *Casearia arborea*, *Roystonea borinquena*, *Myrcia citrifolia*
6. *Casearia guianensis*, *Andira inermis*, *Guazuma ulmifolia*, *Guapira fragans*, *Myrcia splendens*, *Cupania americana*
7. *Citharexylum fruticosum*, *Exostema caribaeum*, *Ardisia obovata*, *Zanthoxylum martinicense*, *Pithecellobium dulce* (Ex), *Swietenia mahogany* (Ex)
8. *Thouinia striata*, *Ficus citrifolia*, *Petitia domingensis*, *Trichilia pallida*, *Eugenia rhombea*, *Coccoloba microstachya*
9. *Syzygium jambos* (Ex), *Zanthoxylum martinicense*, *Schefflera morototonii*, *Croton rigidus*, *Calophyllum antillanum* (Ex)
10. *Neolaugeria resinosa*, *Guettarda scabra*, *Eugenia monticola*, *Tabebuia haemantha*, *Pimenta racemosa*, *Randia aculeata*, *Clusia rosea*, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*
11. *Bursera simaruba*, *Bucida buceras*, *Amyris elemifera*, *Coccoloba diversifolia*, *Ocotea sintenisii*, *Myrsine coriácea*, *Licaria parvifolia*, *Senna siamea* (Ex), *Pictetia aculeata*, *Ocotea coriácea*
12. *Acacia farnesiana* (Ex), *Prosopis pallida* (Ex)

USVI

1. *Eugenia monticola*, *Capparis baducca*, *Bursera simaruba*, *Maytenus laevigata*, *Sabinea florida*, *Ocotea coriacea*, *Bourreria succulenta*, *Chionanthus compactus*, *Cordia alliodora*, *Krugiodendron ferreum*

- 
2. *Leucaena leucocephala*, *Samanea saman*
  3. *Casearia guianensis*, *Zanthoxylum monophyllum*, *Citharexylum fruticosum*, *Ziziphus mauritiana* (Ex), *Trichilia hirta*, *Zanthoxylum martinicense*, *Acacia macracantha* (Ex), *Andira inermis*, *Randia aculeata*, *Swietenia mahagoni* (Ex)
  4. *Acacia muricata*, *Pisonia subcordata*, *Eugenia cordata*, *Capparis cynophallophora*, *Myrciaria floribunda*, *Amyris elemifera*, *Guettarda scabra*, *Bucida buceras*
  5. *Acacia farnesiana* (Ex), *Albizia lebbbeck* (Ex), *Inga laurina*
  6. *Guapira fragrans*, *Capparis indica*, *Cassine xylocarpa*, *Tabebuia heterophylla*, *Capparis hastata*

**Other trees:** *Nectandra* sp., *Inga laurina*, *Cedrela odorata*, *Ficus laevigata*, *Thouinia striata* var. *striata*, *Calophyllum calaba*, *Ficus* spp., *Rauvolfia nitida*, *Guettarda pungens*, *Comocladia glabra*, *Myrsine cubana*, *Inga vera*, *Cedrela odorata*, *Delonix regia*, *Cecropia peltata*, *Didymopanax morototoni*, *Tetrazygia eleagnoides*, *Plumeria obtusa*, *Syderoxylon cubense*, *Gaussia attenuata*, *Coccothrinax barbadensis*, *Coccoloba pyrifolia*, *Coccoloba costata*.

**Shrubs:** Members of the *Melastomaceae*, *Piperaceae*, and *Rubiaceae*, *Rondeletia inermis*, *Thrinax morrisii*, *Oplonia spinosa*, *Thrinax morrisii*, *Rondeletia inermis*, *Ardisia obovata*, *Myrica cerifera*, *Eupatorium* sp., *Croton* sp., *Lantana* sp.

**Herbaceous, cactus, succulents:** *Thillandsias* sp., *Cyperus* sp., *Metastelma leptocladum*, *Anthurium crenatum*, *Smilax havanensis*, *Smilax dominguensis*, *Metastelma leptocladum*,

## PHYSIOGRAPHIC FEATURES

### Landforms

Steep slopes/mogote side (56%)

Side slopes/mogote valley (19%)

Tops (14%)

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Plains (10%)

Wetlands (0%)

**Physiographic features (characteristics ranges)**

Elevation range: 0-733 m (mean= 139 m)

Slope: 0-184% (mean= 29%, or 16 degrees)

Aspect (mean): South (187 degrees)

**CLIMATIC FEATURES**

*Climate:* The mean annual precipitation in the SMQUF is about 1,642 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 15°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,642 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

**INFLUENCING WATER FEATURES**

**REPRESENTATIVE SOIL FEATURES**

Soil series components for this ecological site include:



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1) WELL-DRAINED BLANKET SAND DEPOSIT: Almirante, Arecibo, Bejucos, Caracoles, Carrizales, Corozo, Islote, Rio Lajas, Torres 2) RESTRICTED-DRAINAGE BLANKET SAND DEPOSIT: Aceitunas, Algarrobo, Bayamon, Cotito, Coto, Espinosa, Guanajibo, Guerrero, Jobos, Maleza, Matanzas, Rio Piedras, Voladora, 3) WELL-DRAINED FLUVIAL AND ALLUVIAL: Dique, Humacao, Montegrande, Parcelas, Reilly, Rio Arriba, Santa Clara, Toa, Vega Alta, Via, Vivi, 4) RESTRICTED-DRAINAGE FLUVIAL AND ALLUVIAL: Bajura, Candelero, Coloso, Corcega, Fajardo, Fortuna, Igualdad, Lares, Mabi, Maunabo, Sabana Seca, Santoni, Talante, Vega Baja.

### **Surface texture**

### **Soil features**

Family particle size:

### **Soil features (characteristic ranges)**

#### **ECOLOGICAL DYNAMICS OF THE SITE**

Original vegetation in the coastal plains is uncertain as it was cleared in the 1800s. Even at the time of Gleason and Cooks's investigation (1926), little was left of the original lowland moist forest. By the date of this publication (1966), the lowland forest was even more depleted (Danserau and Buell 1966). Site age had the strongest effect on the recovery of forest structure (species richness, diversity, and basal area), but elevation had a strong effect on species composition (Aide et al. 1996). Naturalized tree species play a significant role in the recovery and secondary forest succession in Puerto Rico (Brandeis et al. 2009). All assemblages here were found on sites that had formerly been pastures or herbaceous agriculture (Brandeis et al. 2009).

## State and Transition Models

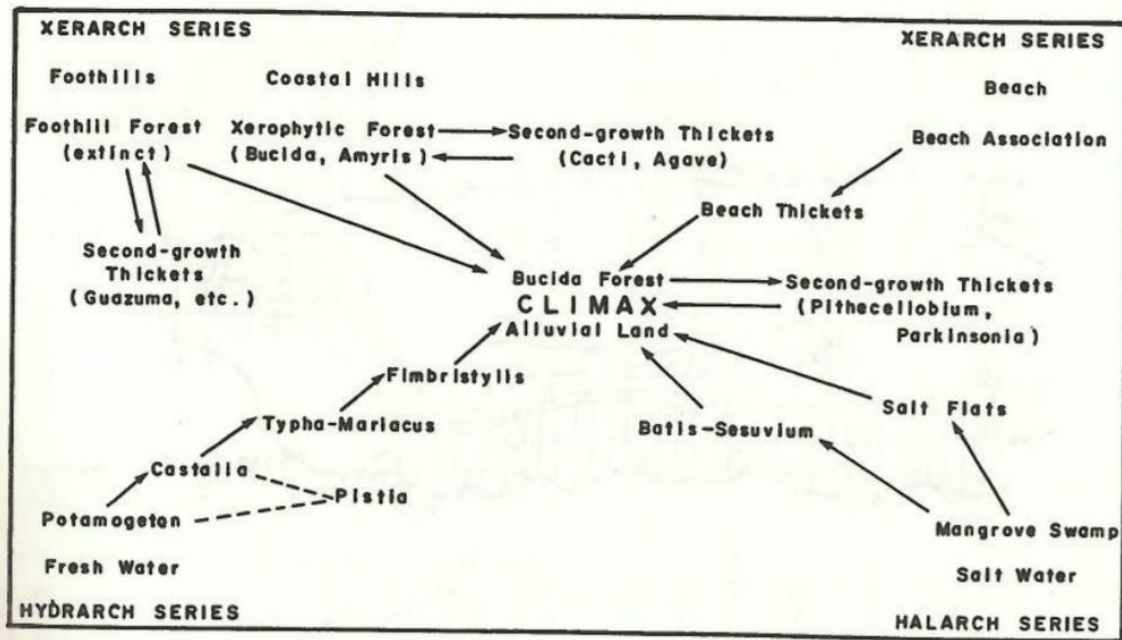


Figure 2. Succession in moist environments of Puerto Rico according to Gleason and Cook 1926.

### COMMUNITY 1.1- State 1-Reference

- Early descriptions and surveys of relic sites suggest that *Manilkara bidentata* (Sapotaceae), *Calophyllum calaba* (Guttiferae), *Hymenaea courbaril* (Leguminosae), *Byrsonima spicata* (Malpighiaceae), and *Tabebuia heterophylla* (Bignoniaceae) were important species (Wadsworth 1950) (Aide et al. 1996).
- Old forest species at elevations <100m= *Ocotea leucoxylon*, *Hymenaea courbaril*, *Byrsonima spicata*, *Guarea guidonia*, *Andira inermis* (Aide et al. 1996).
- Old forest species at elevations  $\geq 100\text{m}$ = *Dacryodes excelsa*, *Cecropia schreberiana*, *Andira inermis* (Aide et al. 1996).

- 
- Between 200 and 600 m *Dacryodes excelsa*, *Manilkara bidentata*, and *Sloanea berteriana* (Elaeocarpaceae) are the dominant tree species in relatively undisturbed forest, and *Cecropia schreberiana* and *Schefflera morototoni* (Araliaceae) are the most common pioneer species (Lugo 1985).

**Disturbances: Forest clearing, grazing, hurricanes**

**COMMUNITY 1.2-** Pastures or herbaceous agriculture (mostly sugar cane).

**COMMUNITY 1.3-** Pioneers species such as *Myconia prasina*, *Casearia sylvestris*

**COMMUNITY 1.4-** Shrubs and small tree species, *Casearia guianensis*, *Psychotria bractiata*,

**COMMUNITY 1.5-** Useful secondary species, *Andira inermis*, *Guarea guidonia*

**COMMUNITY 1.6-** Old forest species, *Ocotea leucoxylon*, *Hymenaea courbaril*, *Byrsonima spicata*

**SUPPORTING INFORMATION**

**Similar sites**

- Subtropical Moist Quaternary Bottomland Forest (SMQBF).

ECOLOGICAL SITE INTERPRETATION (forest succession in the moist forest in relation to years since agriculture abandonment and elevation).

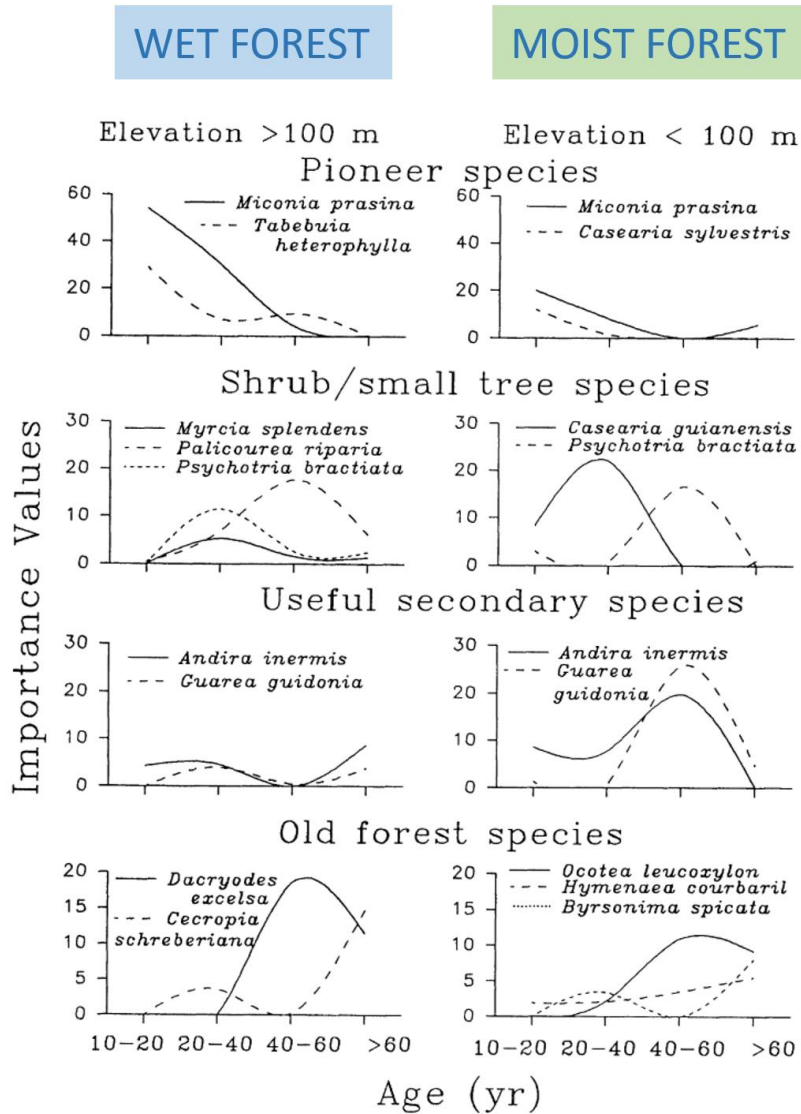


FIGURE 5. A comparison of changes in importance values with site age for common pioneer, shrub/small tree, useful secondary species with valuable wood, and old forest species between low (<100 m) elevation sites. Curves are cubic spline interpolations (Sigmaplot 1989) based on the average importance values of all sites in each age class.

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SITE NAME: **SUBTROPICAL MOIST SANDY BEACH FOREST (F272X...)**

MLRA 272-Humid Coastal Plains

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

Sandy beaches in Puerto Rico have been mapped by the USDA Forest Service land cover map, and includes fine to coarse sandy beaches, mixed sand and gravel (Gould et al. 2008).

### **Ecological Site Concept:**

Sandy beaches in Puerto Rico (including those in Vieques, Culebra, Mona, and Caja de Muertos) occupy an approximate area of 12 km<sup>2</sup> and extend along 1,086 km (Gould et al. 2008). Puerto Rico has 1,225 units of beaches for the 2010 period, representing the most occurring coastal type at the Island (Barreto 2017). These beaches are mainly short and narrower beaches, with a lunate shape located between rocky shorelines. Sandy beaches are classified according to their sand sediments as biogenic ( $\geq 75\%$  calcium carbonate component), terrigenous ( $\geq$  terrigenous component as minerals/rock fragments) and mixed biogenic and terrigenous sediments (between 26 to 74 % both components) (Barreto 2017). The composition of the sediments plus the local environmental conditions affect the vegetation growing in these sandy beaches. The physical

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nature of the beach determines the type of vegetation present (Miller and Lugo 2009). Beach plants have physiologic and physiognomic adaptations to thrive in this dynamic and shifting environment that include strong winds, ocean spray, waves and salinity. Plant adaptations to beach environments include spreading roots, large and thick leaves, and in the case of herbs the development of asexual methods of reproduction such as rhizomes, and succulent stems to retain water (Miller and Lugo 2009). The identification of vegetation-sediment relationships was beyond the scope of this report, but we identified two major sandy beaches and hence ecological sites across the island. The sandy beaches occurring in the MLRA 270-Humid Coastal Plains (Subtropical Moist Sandy Beach Forest, SB-Moist), and the sandy beaches occurring in the MLRA 273-Semiarid Coastal Plains (Subtropical Dry Sandy Beach, SB-Dry). These sandy beaches occurring in drier environments can be found in the south of Puerto Rico (Guanica), Mona Island, Culebra, Vieques, and in the US Virgin Islands. Although sandy beaches were separated into these two major ecological sites we do not expect major differences in terms of species composition, but in the relative abundance and dominance of the individual species. In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site occurs within the Littoral subzone (zone Ia) which includes meadow steppe, desert, savanna and forest, and more than 50 vegetation communities.

**Dominant plant species:**

None of the FIA plots occurred within this ecological site. Beach grasses generally dominate front dunes, and have an important role as dune stabilizers with their rhizomes and runners (Miller and Lugo 2009). If the front dune is stable, it may promote the development of an

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evergreen hedge in the foredune. This scrub is dominated by xerophytic woody species such as *Borrchia arborescens*, *Chrysobalanus icaco*, *Smilax coriacea* and *Coccoloba uvifera* (Miller and Lugo 2009). At the top of the dune other woody species may include *Plumeria alba*, *Anthacanthus spinosus*, while other woody species such as *Scleria microcarpa*, *Calophyllum brasiliense*, *Annona glabra*, *Coccoloba uvifera* may occur in the rear dune, under drier conditions. In depressed areas with salt accumulation, salt-tolerant species such as *Salicornia bigelovii* and *Batis maritima* are common. In addition, other trees and shrubs may be present in this ecological site naturally or planted to reduce erosion. The most common woody species along beaches of Puerto Rico include *Terminalia catappa* (Ex), *Coccoloba uvifera*, *Chrysobalanus icaco*, *Thespesia populnea*, *Dalbergia ecastaphyllum*, *Cocos nucifera* (Ex), *Suriana maritima*, *Casuarina equisetifolia* (Ex), *Conocarpus erectus*, and *Bursera simaruba* (Miller and Lugo 2009)..

- **Other trees:** *Thespesia populnea* (Ex), *Dalbergia ecastaphyllum*, *Hibiscus pernambucensis* (Ex).
- **Shrubs:** *Gundlachia corymbosa*, *Scaevola plumieri*, *Borrchia arborescens*, *Croton* sp. , *Lantana* sp, *Chrysobalanus icaco*, *Dalbergia ecastaphyllum*, *Yucca aloifolia*, *Dodonaea viscosa*, *Erithalis fruticosa*, *Conocarpus erectus*, *Caesalpinia bonduc*, *Scaevola sericea* (Ex), *Chamaesyce mesembrianthemifolia*, *Argusia gnaphalodes*, *Ernodea littoralis littoralis*, *Stemodia maritima*.
- **Herbaceous species, cactus, succulents:** *Paspalum vaginatum*, *Sporobolus virginicus*, *Sesuvium portulacastrum*, *Salicornia bigelovi*, *Batis maritima*, *Ipomoea pes-caprae*, *I. stolonifera*, *Canavalia maritima*, *Remirea maritima*, *Fymbristylis cymosa*, *Sporobolus*

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*virginicus, Euphorbia buxifolia, Fimbristylis spadicea, Borrchia arborescens, Spartina patens, Bromelia pinguin, Spartina patens, Cenchrus echinatus, Chamaesyce buxifolia, Fimbristylis cymosa, Cyperus planifolius, Cakile lanceolata, Stenotaphrum secundatum, Heliotropium curassavicum, Crinum asiaticum (Ex), Hymenocallis caribaea, Dactyloctenium aegyptium (Ex),Blutaparon vermiculare,Sesuvium maritimum*

## PHYSIOGRAPHIC FEATURES

### **Landforms**

Plains (100%)

### **Physiographic features (characteristics ranges)**

## CLIMATIC FEATURES

Climate:

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total:

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges)**



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**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Soil series components include Agiadilla, Catano, and Espinal.

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

**State and Transition Models**

**COMMUNITY 1.1- State 1-Reference**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

**Similar sites**

- Subtropical Dry Sandy Beach Forest (SB-Dry).

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**SITE NAME: SUBTROPICAL MOIST VOLCANIC BOTMOLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (82%), MLRA 270-Semiarid Mountains and Valleys (10%),  
MLRA 272- Humid Coastal Plains (7%), MLRA 273-Semiarid Coastal Plains (1%)

Occurrence: Puerto Rico, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Moist Volcanic Botomland Forest (SMVBF) was developed after collapsing two landscape units classified for Puerto Rico, the subtropical moist volcanic lower slope and the subtropical moist volcanic plain in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SMVUF falls within the National Vegetation Classification Group D094 Caribbean and Central American Lowland Shrubland, G454 Caribbean Moist Lowland-Submontane Forest Group, and G455 Caribbean Seasonal Evergreen Moist Lowland Forest Group (U.S. National Vegetation Classification 2019). According to a USDA Forest Service land cover map of Puerto Rico (Gould et al. 2007), dominant vegetation covers within this ecological site include moist grasslands and pastures, young secondary lowland moist non-calcareous evergreen forest, lowland moist non-calcareous shrubland and woodland, mature secondary lowland moist non-calcareous evergreen forest. According to the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the lowland rainforest (zone I in the map) which includes forest, savanna, scrubs, and prairies, and about 37 vegetation communities.

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### Ecological Site Concept:

The SMVBF has an extension of 1,446 km<sup>2</sup> (~16% of the island), and it occupies the lower landscape positions of the moist forest widely distributed across the island but mostly occurring in the east portion (Fig. 1). Although Humid MLRAs have not been described for the USVI, it is known that humid forests also occur in these islands (Ewel and Whitmore 1973). This ecological site supports a variety of vegetation communities' representatives of the subtropical moist forest life zone. Islandwide, the moist forest life zone forest has the largest extension in Puerto Rico (Ewel and Whitmore 1973), but due to its suitable weather and topography, it has been historically cleared for agriculture and urban development (Miller and Lugo 2009). Grasses, in both natural and improved pastures within this ecological life zone, used to be the dominant landscape in the subtropical moist forest of Puerto Rico for several years. Because deforestation in the uplands has been less severe than at lower elevations (Kennaway and Helmer 2007), the vegetation communities found in this ecological site provide a baseline of species that could potentially grow in primary or secondary mature moist forests at lower elevations. Forest remnants in the subtropical moist forest life zone are characterized by deciduous trees with heights of up to 20 meters tall and rounded crowns (Miller & Lugo 2009). This ecological site is characterized by a mixture of natives and exotic species (Brandeis et al. 2009). Among the dominant species in this assemblage are *Guarea guidonea*, and *Dendropanax arboreus*, and the exotic mango tree (*Mangifera indica*). This ecological site can be found in the State Forests of Carite, Cerrillos, Ceiba, Monte Choca, Río Abajo, Maricao, Susúa, Boquerón, and Tres Picachos.

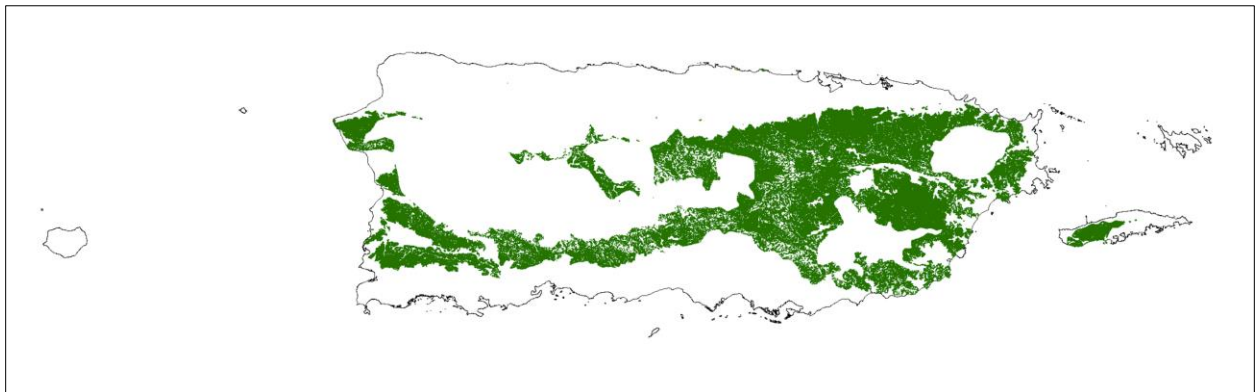


Figure 1. Distribution of the Subtropical Moist Volcanic Bottomland Forest in Puerto Rico.

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## Dominant plant species:

Dominant tree species within this ecological site in Puerto Rico included *Casearia guianensis*, *Spathodea campanulata*, *Bursera simaruba*, *Zanthoxylum monophyllum*, *Melicoccus bijugatus*, *Eugenia rhombea*, *Erythrina berteriana*, *Citharexylum fruticosum*, *Guarea guidonia*, *Spathodea campanulata* (Marcano-Vega 2019). In the USVI, tree species found in FIA plots within this ecological site included *Bourreria succulenta*, *Citharexylum spinosum*, *Cordia rickseckeri*, *Guapira fragrans*, *Krugiodendron ferreum*, *Zanthoxylum martinicense* (Marcano-Vega 2019). Twelve out of 14 tree assemblages identified for Puerto Rico, occurred within this ecological site (Brandeis et al. 2009) whereas in the USVI 7 out of 8 assemblages described for these islands occur within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### Puerto Rico

1. ***Guarea guidoni***, ***Dendropanax arboreus***, ***Mangifera indica*** (Ex), *Artocarpus altilis* (Ex), *Cordia sulcata*, *Quararibea turbinata*, *Erythrina poeppigiana* (Ex), *Cordia alliodora*
2. ***Spathodea campanulata*** (Ex), *Terminalia catappa* (Ex)
3. ***Casearia sylvestris***, ***Psidium guajava***, ***Coffea arabica*** (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*
4. ***Leucaena leucocephala***, *Albizia procera* (Ex)
5. ***Tabebuia heterophylla***, ***Casearia arborea***, *Roystonea borinquena*, *Myrcia citrifolia*
6. ***Casearia guianensis***, ***Andira inermis***, ***Guazuma ulmifolia***, *Guapira fragrans*, *Myrcia splendens*, *Cupania americana*
7. ***Citharexylum fruticosum***, ***Exostema caribaeum***, ***Ardisia obovata***, ***Zanthoxylum martinicense***, *Pithecellobium dulce* (Ex), *Swietenia mahogany* (Ex)
8. ***Thouinia striata***, *Ficus citrifolia*, *Petitia domingensis*, *Trichilia pallida*, *Eugenia rhombea*, *Coccoloba microstachya*

- 
9. *Syzygium jambos* (Ex), *Zanthoxylum martinicense*, *Schefflera morototonii*, *Croton rigidus*, *Calophyllum antillanum* (Ex)
  10. *Neolaugeria resinosa*, *Guettarda scabra*, *Eugenia monticola*, *Tabebuia haemantha*, *Pimenta racemosa*, *Randia aculeata*, *Clusia rosea*, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*
  11. *Bursera simaruba*, *Bucida buceras*, *Amyris elemifera*, *Coccoloba diversifolia*, *Ocotea sintenisii*, *Myrsine coriácea*, *Licaria parvifolia*, *Senna siamea* (Ex), *Pictetia aculeata*, *Ocotea coriácea*
  12. *Acacia farnesiana* (Ex), *Prosopis pallida* (Ex)

#### USVI

1. *Eugenia monticola*, *Capparis baducca*, *Bursera simaruba*, *Maytenus laevigata*, *Sabinea florida*, *Ocotea coriacea*, *Bourreria succulenta*, *Chionanthus compactus*, *Cordia alliodora*, *Krugiodendron ferreum*
  2. *Leucaena leucocephala*, *Samanea saman*
  3. *Casearia guianensis*, *Zanthoxylum monophyllum*, *Citharexylum fruticosum*, *Ziziphus mauritiana* (Ex), *Trichilia hirta*, *Zanthoxylum martinicense*, *Acacia macracantha* (Ex), *Andira inermis*, *Randia aculeata*, *Swietenia mahagoni* (Ex)
  4. *Acacia muricata*, *Pisonia subcordata*, *Eugenia cordata*, *capparis cynophallophora*, *Myrciaria floribunda*, *Amyris elemifera*, *Guettarda scabra*, *Bucida buceras*
  5. *Acacia farnesiana* (Ex), *Albizia lebbek* (Ex), *Inga laurina*
  6. *Guapira fragrans*, *Capparis indica*, *Cassine xylocarpa*, *Tabebuia heterophylla*, *capparis hastata*
- **Other trees:** *Bucida buceras*, *Calophyllum callaba*, *Roystonea borinquena*, *Clusia rosea*, *Calophyllum calaba*, *Thouinia striata* var. *striata*, *Neolaugeria resinosa*, *Guarea guidonia*, *Sapium laurocerasus*.

- 
- **Shrubs:** *Syzygium jambos*, *Licaria parvifolia*, *Ocotea leucoxylon*, *Ocotea sinfenisii*, *Ardisia obovata*, *Pisonia aculeata*, *Trichilla pallida*, *Dendropanax arboreus*, *Casearia spp.*, *Comocladia glabra*.
  - **Herbaceous, cactus, succulents:** *Paspalum sp.*, *Polypodium sp.*, *Pitcairnia angustifolia*

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slopes/mogote valley (69%)

Plains (18%)

Steep slopes/mogote side (7%)

Tops (5%)

### Physiographic features (characteristics ranges)

Elevation range: 0- 900 m (mean= 218 m)

Slope: 0-216% (mean= 24%, or 13 degrees)

Aspect (mean): South (176 degrees)

## CLIMATIC FEATURES

*Climate:* The mean annual precipitation in the SMVBF is about 1,735 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 16°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### Annual climate normal (averages)

Frost-free periods: NA

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Freeze-free periods: NA

Precipitation total: 1,735 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Soil series components for this ecological site are:

1) INTRUSIVE: Humacao, Parcelas, 2) EXTRUSIVE: Cabo Rojo, Daguao variant, Juncos, Lares, Mabi, Montegrande, Rio Arriba, Vega Alta, Via, Voladora.

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

State and Transition Models

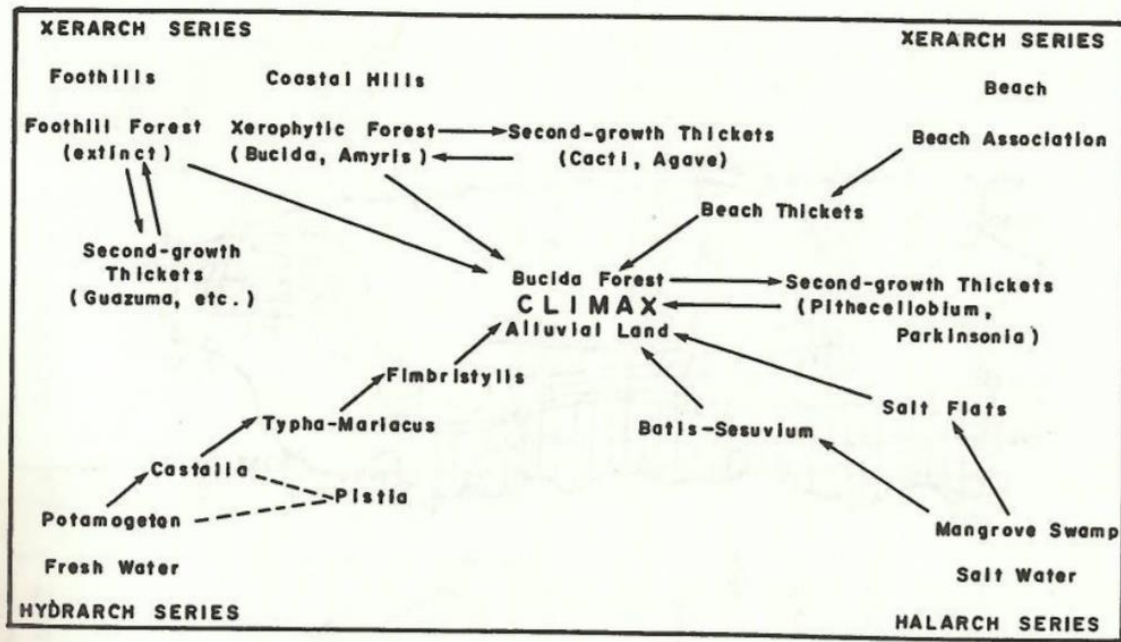


Figure 2. Succession in moist environments of Puerto Rico according to Gleason and Cook 1926.

COMMUNITY 1.1- State 1-Reference



ECOLOGICAL SITE INTERPRETATION (forest succession in the moist forest in relation to years since agriculture abandonment and elevation).

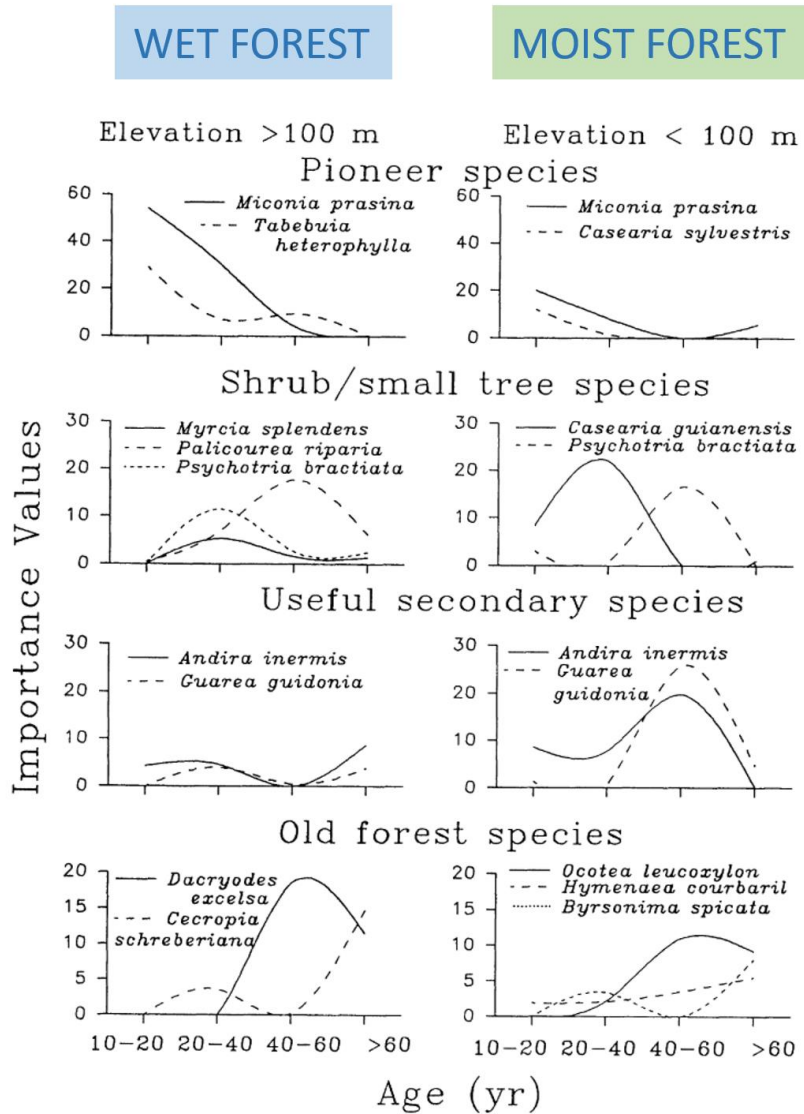


FIGURE 5. A comparison of changes in importance values with site age for common pioneer, shrub/small tree, useful secondary species with valuable wood, and old forest species between low (<100 m) and high (>100 m) elevation sites. Curves are cubic spline interpolations (Sigmaplot 1989) based on the average importance values of all sites in each age class.

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## SUPPORTING INFORMATION

### **Similar sites**

- Subtropical Moist Volcanic Upland Forest (SMVUF)
- Subtropical Moist Quaternary Bottomland Forest (SMQBF)
- Subtropical Moist Quaternary Upland Forest (SMQBF)

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**SITE NAME: SUBTROPICAL MOIST VOLCANIC UPLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (88%), MLRA 270-Semiarid Mountains and Valleys (10%),  
MLRA 272- Humid Coastal Plains (2%)

Occurrence: Puerto Rico, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Moist Volcanic Upland Forest (SMVUF) was developed after collapsing two landscape units classified for Puerto Rico, the subtropical moist volcanic upper slope and the subtropical moist volcanic ridge in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SMVUF falls within the National Vegetation Classification Group G454 Caribbean Moist Lowland-Submontane Forest Group, D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna, and G455 Caribbean Seasonal Evergreen Moist Lowland Forest Group (U.S. National Vegetation Classification 2019). According to a USDA Forest Service land cover map of Puerto Rico (Gould et al. 2007), dominant vegetation covers within this ecological site include moist grasslands and pastures, mature secondary lowland moist non-calcareous evergreen forest, young secondary lowland moist non-calcareous evergreen forest, lowland moist non-calcareous shrubland and woodland, and lowland moist abandoned and active coffee plantations. According to the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the lowland rainforest (zone I in the map) which includes forest, savanna, scrubs, and prairies, and about 37 vegetation communities.

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### Ecological Site Concept:

The SMVUF has an extension of 1,191 km<sup>2</sup> (~13% of the island), and it occupies the upper landscape positions of the moist forest widely distributed across the island but mostly occurring in the east portion (Fig. 1). Although Humid MLRAs have not been described for the USVI, it is known that humid forests also occur in these islands (Ewel and Whitmore 1973). This ecological site supports a variety of vegetation communities' representatives of the subtropical moist forest life zone. Islandwide, the moist forest life zone forest has the largest extension in Puerto Rico (Ewel and Whitmore 1973), but due to its suitable weather and topography, it has been historically cleared for agriculture and urban development (Miller and Lugo 2009). Grasses, in both natural and improved pastures within this ecological life zone, used to be the dominant landscape in the subtropical moist forest of Puerto Rico for several years. Because deforestation in the uplands has been less severe than at lower elevations (Kennaway and Helmer 2007), the vegetation communities found in this ecological site provide a baseline of species that could potentially grow in primary or secondary mature moist forests at lower elevations. Forest remnants in the subtropical moist forest life zone are characterized by deciduous trees with heights of up to 20 meters tall and rounded crowns (Miller & Lugo 2009). This ecological site is characterized by a mixture of natives and exotic species (Brandeis et al. 2009). Among the dominant species in this assemblage are *Guarea guidonea*, and *Dendropanax arboreus*, and the exotic mango tree (*Mangifera indica*). This ecological site can be found in the State Forests of Carite, Cerrillos, Ceiba, Monte Choca, Río Abajo, Maricao, Susúa, and Tres Picachos.

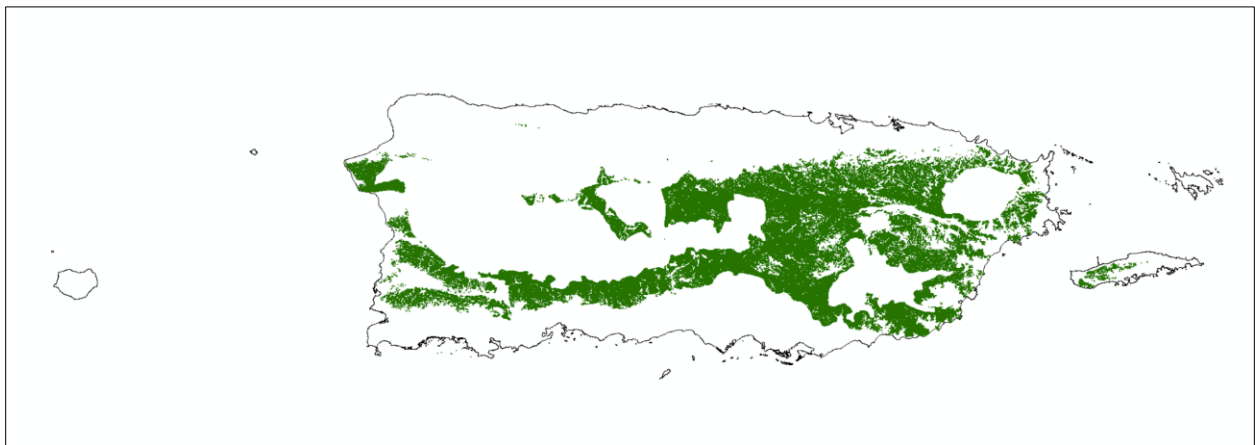


Figure 1. Distribution of the Subtropical Moist Volcanic Upland Forest in Puerto Rico.

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### Dominant plant species:

Dominant tree species within this ecological site in Puerto Rico included *Casearia guianensis*, *Spathodea campanulata*, *Andira inermis*, *Guarea guidonia*, *Casearia sylvestris*, *Tabebuia heterophylla*, *Hymenaea courbaril*, and *Mangifera indica* (Marcano-Vega 2019). In the USVI, tree species found in FIA plots within this ecological site included *Bourreria succulenta*, *Citharexylum spinosum*, *Cordia rickseckeri*, *Guapira fragrans*, *Krugiodendron ferreum*, *Zanthoxylum martinicense* (Marcano-Vega 2019). Twelve out of 14 tree assemblages identified for Puerto Rico, occurred within this ecological site (Brandeis et al. 2009) whereas in the USVI 7 out of 8 assemblages described for these islands occur within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

#### Puerto Rico

1. ***Guarea guidoni***, ***Dendropanax arboreus***, ***Mangifera indica*** (Ex), *Artocarpus altilis* (Ex), *Cordia sulcata*, *Quararibea turbinata*, *Erythrina poeppigiana* (Ex), *Cordia alliodora*
2. ***Spathodea campanulata*** (Ex), *Terminalia catappa* (Ex)
3. ***Casearia sylvestris***, ***Psidium guajava***, ***Coffea arabica*** (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*
4. ***Leucaena leucocephala***, *Albizia procera* (Ex)
5. ***Tabebuia heterophylla***, ***Casearia arborea***, *Roystonea borinquena*, *Myrcia citrifolia*
6. ***Casearia guianensis***, ***Andira inermis***, ***Guazuma ulmifolia***, *Guapira fragrans*, *Myrcia splendens*, *Cupania americana*

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7. *Citharexylum fruticosum*, *Exostema caribaeum*, *Ardisia obovata*, *Zanthoxylum martinicense*, *Pithecellobium dulce* (Ex), *Swietenia mahogany* (Ex)
  8. *Thouinia striata*, *Ficus citrifolia*, *Petitia domingensis*, *Trichilia pallida*, *Eugenia rhombea*, *Coccoloba microstachya*
  9. *Syzygium jambos* (Ex), *Zanthoxylum martinicense*, *Schefflera morototonii*, *Croton rigidus*, *Calophyllum antillanum* (Ex)
  10. *Neolaugeria resinosa*, *Guettarda scabra*, *Eugenia monticola*, *Tabebuia haemantha*, *Pimenta racemosa*, *Randia aculeata*, *Clusia rosea*, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*
  11. *Bursera simaruba*, *Bucida buceras*, *Amyris elemifera*, *Coccoloba diversifolia*, *Ocotea sintenisii*, *Myrsine coriácea*, *Licaria parvifolia*, *Senna siamea* (Ex), *Pictetia aculeata*, *Ocotea coriácea*
  12. *Acacia farnesiana* (Ex), *Prosopis pallida* (Ex)

#### USVI

1. *Eugenia monticola*, *Capparis baducca*, *Bursera simaruba*, *Maytenus laevigata*, *Sabinea florida*, *Ocotea coriacea*, *Bourreria succulenta*, *Chionanthus compactus*, *Cordia alliodora*, *Krugiodendron ferreum*
2. *Leucaena leucocephala*, *Samanea saman*
3. *Casearia guianensis*, *Zanthoxylum monophyllum*, *Citharexylum fruticosum*, *Ziziphus mauritiana* (Ex), *Trichilia hirta*, *Zanthoxylum martinicense*, *Acacia macracantha* (Ex), *Andira inermis*, *Randia aculeata*, *Swietenia mahagoni* (Ex)
4. *Acacia muricata*, *Pisonia subcordata*, *Eugenia cordata*, *capparis cynophallophora*, *Myrciaria floribunda*, *Amyris elemifera*, *Guettarda scabra*, *Bucida buceras*
5. *Acacia farnesiana* (Ex), *Albizia lebbek* (Ex), *Inga laurina*
6. *Guapira fragrans*, *Capparis indica*, *Cassine xylocarpa*, *Tabebuia heterophylla*, *capparis hastata*

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- **Other trees:** *Thouinia striata* var. *striata*, *Neolaugeria resinosa*, *Coccoloba pubescens*, *Calophyllum calaba*, *Clusia rose*, *Ficus* spp., *Rauvolfia nitida*
  - **Shrubs:** *Dendropanax arboreus*, *Comocladia glabra*, *Myrsine guainensis*, *Ardisia obovata*, *Myrica cerifera*, *Coccoloba pyrifolia*, *Coccoloba costate*
  - **Herbaceous, cactus, succulents:** *Paspalum* sp., *Polypodium* sp., *Pitcairnia angustifolia*

## PHYSIOGRAPHIC FEATURES

### Landforms

Steep slopes/mogote side (58%)

Tops (28%)

Side slopes/mogote valley (14%)

### Physiographic features (characteristics ranges)

Elevation range: 4- 924 m (mean= 264 m)

Slope: 0-253% (mean= 36%, or 19 degrees)

Aspect (mean): South (182 degrees)

## CLIMATIC FEATURES

*Climate:* The mean annual precipitation in the SMVUF is about 1,783 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 16°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

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**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,783 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Soil series components for this ecological site are:

-EXTRUSIVE: Alonso, Anones, Caguabo, Catalina, Consumo, Daguey, Humatas, Junquitos, Malaya, Morado, Mucara, Naranjito, Quebrada, Sabana.

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE



State and Transition Models

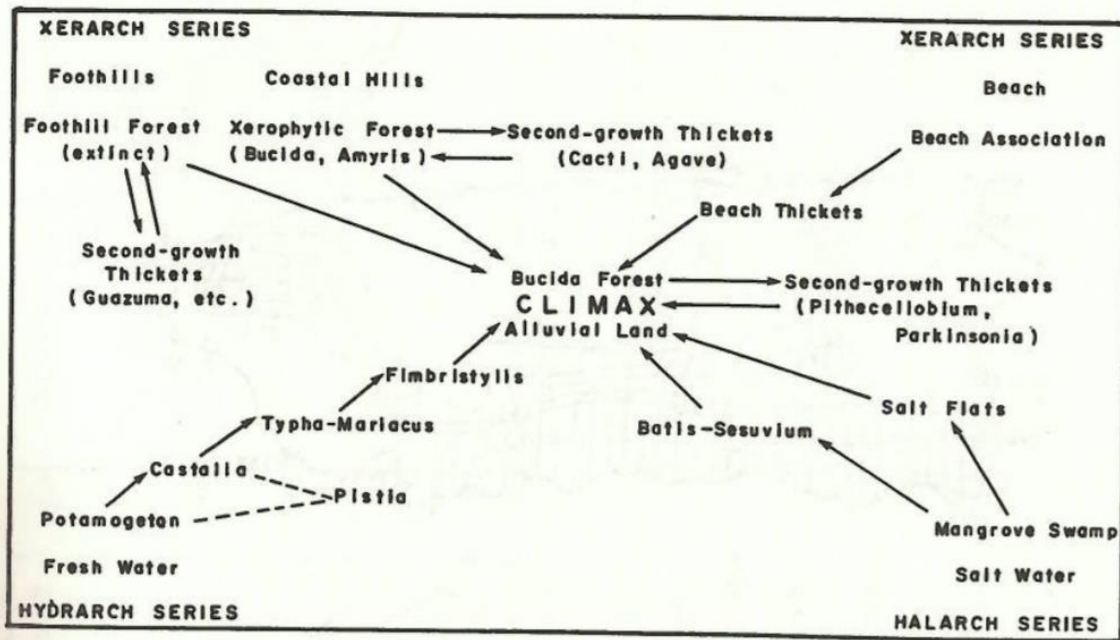


Figure 2. Succession in moist environments of Puerto Rico according to Gleason and Cook 1926.

ECOLOGICAL SITE INTERPRETATION (forest succession in the moist forest in relation to years since agriculture abandonment and elevation).

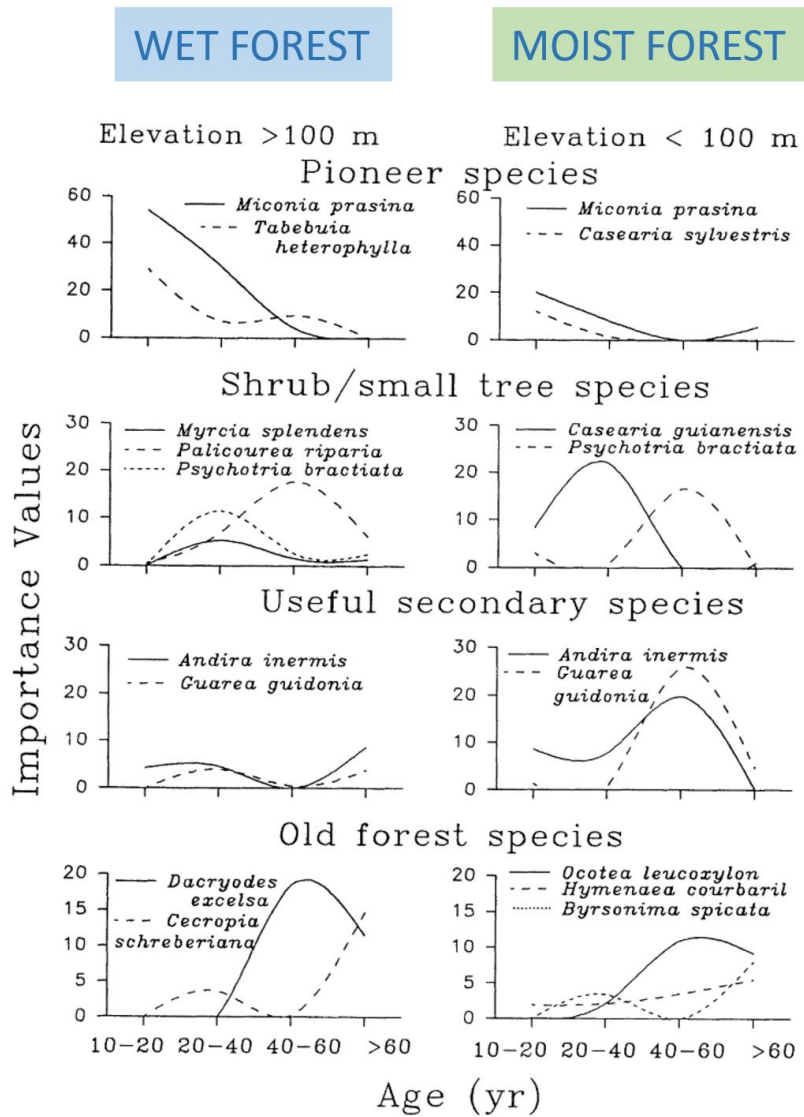


FIGURE 5. A comparison of changes in importance values with site age for common pioneer, shrub/small tree, useful secondary species with valuable wood, and old forest species between low (<100 m) and high (>100 m) elevation sites. Curves are cubic spline interpolations (Sigmaplot 1989) based on the average importance values of all sites in each age class.

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## SUPPORTING INFORMATION

### **Similar sites**

- Subtropical Moist Volcanic Bottomland Forest (SMVBF)
- Subtropical Moist Quaternary Bottomland Forest (SMQBF)
- Subtropical Moist Quaternary Upland Forest (SMQBF)

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SITE NAME: **SUBTROPICAL DRY ESTUARINE WETLAND (F273X...)**

MLRA 273- Semiarid Coastal Plains (67%), MLRA 272-Humid Coastal Plains (18%), MLRA 271-Semiarid Mountains and Valleys (15%).

Occurrence: Puerto Rico, Vieques, Culebra, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Dry Estuarine Wetland (SDEW) is the subtropical dry saline wetlands in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SDEW falls within the National Vegetation Classification Group G004 *Rhizophora* mangrove Forest Group, G585 Caribbean Dry Broadleaf Forest, D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna, and others classes with lower percentages (U.S. National Vegetation Classification 2019). According to a USDA Forest Service Land Cover Map of Puerto Rico (Gould et al. 2007), dominant vegetation covers within this ecological site include mangrove forest and shrubland, seasonally flooded herbaceous saline wetlands, young secondary lowland dry alluvial semideciduous forest, and lowland dry alluvial shrubland and woodland, while other vegetation classes are less abundant. In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site occurs within the Littoral subzone (zone Ia) which includes meadow steppe, desert, savanna and forest, and more than 50 vegetation communities.

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### **Ecological Site Concept:**

The SDEW has an extension of 63 km<sup>2</sup> (<1% of the island), and it occupies the lowest landscape positions of the dry forest in the south littoral zone of Puerto Rico, Vieques and Culebra (Fig. 1). This ecological site also occurs in the USVI, represented by the wetland classes (e.g., forested wetlands, seasonally flooded saline forest) in the USVI Land Cover map developed by the USDA (Gould et al. 2013). The intensity of wave action, rainfall, and freshwater runoff determine the characteristics of the wetlands (Cintrón et al 1978). For example, wetlands in the south of Puerto Rico, like those within this ecological site, occur in low wave energy beaches, and with lower freshwater inputs from runoff and precipitation (dry forest) in comparison to wetlands in the north of the island. Plants adapted to estuarine wetlands are tolerant to salinity, and exposure of flooded periods with reduced oxygen (Miller and Lugo 2009). Woody species from saline wetlands form the typical mangrove forest or estuarine forested swamps dominated by *Rhizophora mangle* (red mangrove), and *Avicennia germinans* (black mangrove), which are the most extensive estuarine forested wetlands in Puerto Rico (Miller and Lugo 2009). Saline wetlands also include estuarine emergent marshes dominated by a mixture of herbaceous vegetation and woody plants such as *Typha dominguensis* and *Laguncularia racemosa* (white mangrove), respectively. Other saline wetlands includes estuarine coastal flats typical of the salt flats with direct access to the seawater and exposed to the highest concentration of salt, dominated by *A. germinans*, and herbaceous species such as *Sesuvium portulacastrum*, *Salicornia perennis*, and *Batis maritima*. The dominant wetland type on the south coast is the fringe mangrove forest dominated by the red mangrove (*Rhizophora mangle*) (Cintrón et al. 1978). In Puerto Rico, the SMEW can be found mostly in the south and southeast within Guánica

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and Boqueron State Forests, but also occurs in the east within the State Forest of Aguirre, Ceiba, and also in Vieques and Culebra.

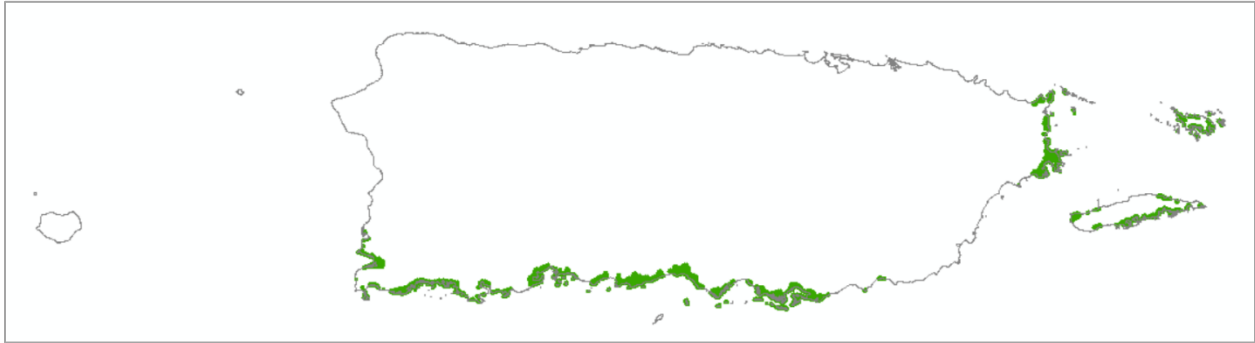


Figure 1. Distribution of the Subtropical Dry Estuarine Wetland in Puerto Rico.

**Dominant plant species:**

Only one FIA plot occurred within this ecological site in Puerto Rico, where the exotic *Prosopis pallida* was the dominant species, particularly in drier areas away from the coastline (Mercano-Vega 2019). In the case of the USVI the dominant species was *Leucaena leucocephala*. Some species might be duplicated as the information was acquired from different sources. Ex= exotic.

- **Other trees:** *Rhizophora mangle*, *Bucida buceras*, *Avicennia germinans*, *Laguncularia racemosa*, *Prosopis pallida*, *Parkinsonia aculeata*, *Crescentia cujete*, *Conocarpus erectus*, *Annona glabra.*, *Stahlia monosperma*, *Hibiscus pernambucensis (Ex)*, *Thespesia populnea (Ex)*.
- **Shrubs:** *Achrostichum aureum*, *Erithalis fruticosa*, *Bontia daphnoides*, *Conocarpus erectus*, *Dalbergia ecastaphyllum*, *Caesalpinia bonduc*.

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- **Herbaceous species, cactus, succulents:** *Rhabdadenia biflora*, *Bouteloua juncea*, *Cenchrus ciliaris*, *C. incertus*, *Lasiacis divaricata*, *Macfadyena unguis-cati*, *Sida glabra*, *Sida acuta*, *Thilandsia utriculata*, *T. fasciculata*, *Batis maritima*, *Sporobolus virginicus*, *Cyperus planifolius*, *Batis maritima*, *Sesuvium portulacastrum*, *Panicum maximum*, *Uniola virgata*, *Aristida adscensionis*, *Agave sisalana*, *Commocladia dodonea*, *Opuntia stricta*, *Opuntia rubescens*, *Opuntia repens*, *Pilosocereus royenii*, *Stenocereus fimbriatus*, *Melocactus intortus*, *Leptocereus quadricostatus*, *L. grantianus*, *Hylocereus trigonus*, *Cephalocereus royenii*, *Stenotaphrum secundatum*, *Heliotropium curassavicum*, *Paspalum vaginatum*, *Fimbristylis cymosa*, *Crinum asiaticum (Ex)*, *Hymenocallis caribaea*, *Sporobolus coromandelianus (Ex)*, *Spartina patens*, *Blutaparon vermiculare*, *Sesuvium maritimum*, *Sesuvium portulacastrum*

## PHYSIOGRAPHIC FEATURES

### **Landforms**

Wetlands (92%)

Plains (6%)

Side slope mogote (1%)

### **Physiographic features (characteristics ranges)**

Elevation range: -5m to 26m (mean= 1.5m)

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Slope: 0-35% (mean= 3%, or 2 degree)

Aspect (mean): East (95 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SDEW is about 895 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 20°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,524 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges)**

### **Monthly temperature (average minimum/maximum)**

## INFLUENCING WATER FEATURES

Temporally inundated systems, brackish (salinity greater than 0.5 ppt), and acid water (PH<5.5).

## REPRESENTATIVE SOIL FEATURES



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Peat and organic soils, coastal alluvial soils. Soil series components include: Boqueron, Manglillo, Serrano, Sandy Point (USVI), Sugar beach (USVI).

### **Surface texture**

### **Soil features**

Family particle size:

### **Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

### **State and Transition Models**

The diagram below was extracted from Lugo (2016).

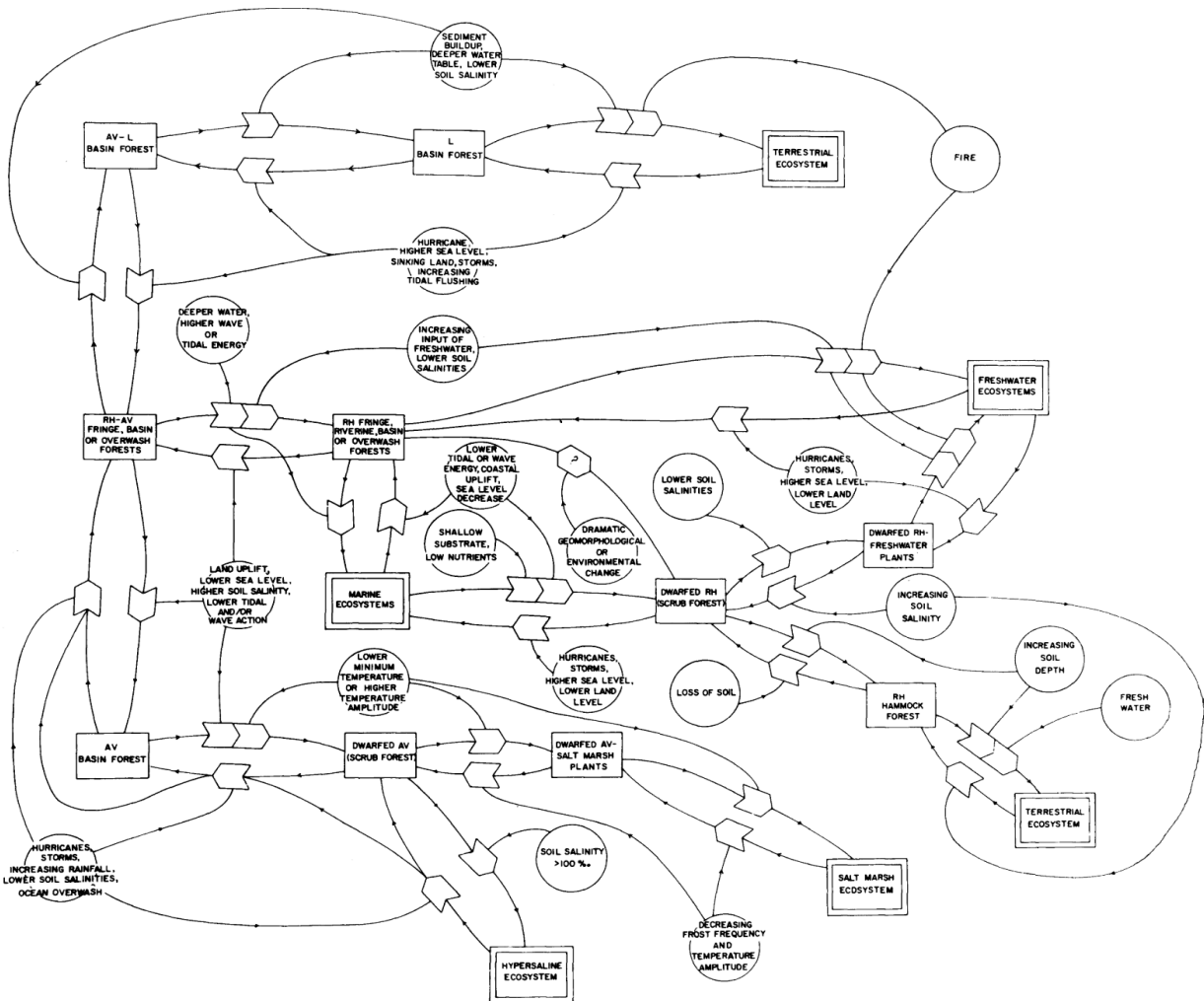


FIGURE 2. Summary diagram depicting possible mangrove successional pathways and the factors responsible for each of the pathways. Boxes represent the mangrove xere (RH is *Rhizophora*, L is *Laguncularia*, and AV is *Avicennia*). Large arrows show the direction of succession, and they connect with the physical factor(s) believed to be responsible for the pathway (circles). More than one factor is given in many cases, suggesting that one or a combination of circumstances may stimulate a given pathway. Boxes with double walls represent non-mangrove ecosystems. The actual species composition of these systems depends on climate, substrate, and/or hydroperiod. Notice that all successional pathways are reversible. In general, the succession in the upper part of the diagram responds to changes in the depth of the water table; the succession in the center of the diagram responds to decreasing soil salinities and/or nutrients; and the succession in the lower part of the diagram responds to increasing air temperature. Marine ecosystems succeed mangroves when the ocean water is too deep for the establishment of *Rhizophora* seedlings or when wave or tidal energies exceed the tolerance of mangroves. The role of each system (box) in changing the environment is not shown. The probability of succession following a given pathway depends on the intensity of the causative factor. It is possible that some successional changes do not occur often, particularly where intense or "dramatic" changes in the environment are required. This diagram is based on personal observations and reports in the literature cited and should be considered hypothetical until validated by research.

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## ECOLOGICAL SITES INTERPRETATION

### SUPPORTING INFORMATION

#### **Similar sites**

- Subtropical Moist Estuarine Wetland (SMEW).

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SITE NAME: **SUBTROPICAL DRY LIMESTONE BOTTOMLAND FOREST (F271X...)**

MLRA 271-Semiarid Mountains and Valleys (63%), MLRA 273- Semiarid Coastal Plains (31%), MLRA 270-Humid Mountains and Valleys (6%)

Occurrence: Puerto Rico, Mona, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Dry Limestone Bottomland Forest (SDLBF) is the subtropical dry limestone plain and the subtropical dry limestone lower slope forest according to the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SDLBF falls within the National Vegetation Classification Group G585 Caribbean Dry Broadleaf Forest and D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include mature secondary lowland dry limestone semi-deciduous forest, lowland dry limestone woodland and shrubland, dry grasslands and pastures, and young secondary lowland dry limestone semi-deciduous forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966) this ecological site occurs within the Semi-deciduous forest subzone (zone III) which includes forest, savanna, scrub, and desert, and more than 18 vegetation communities.

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### Ecological Site Concept:

The SDLBF has an extension of 251 km<sup>2</sup> (~3% of the island), associated with the limestone of the south and southwest of Puerto Rico, and the islands of Mona and Monito. This ecological site also occurs in the USVI represented in the land cover map by the subtropical dry limestone classes (Gould et al. 2013). The vegetation in this ecological site is mostly a deciduous closed woodland that tends to form a complete ground cover (Ewel and Whitmore 1973). Dansereau (1966) classified the general area as a semi-deciduous forest with a regional climax dominated by *Bucida buceras* forest. Similarly, Cook and Gleason (1928) considered *Bucida buceras* to be the dominant tree on the southern coastal plain and the adjacent foothills. The vegetation in this ecological zone exhibits several adaptations to the xeric environment such as thorns, spines, small and succulent leaves, and low and flattened canopies. Fire is a common source of disturbance in this xeric forest. The SDLBF can be found in Boquerón and Guánica State Forests, Caja de Muertos and Mona and Monito Island Natural Reserves. A systematic inventory of the flora in the Guanica Natural Reserve provides an exhaustive description of the vegetation found there (Monsegur 2009).

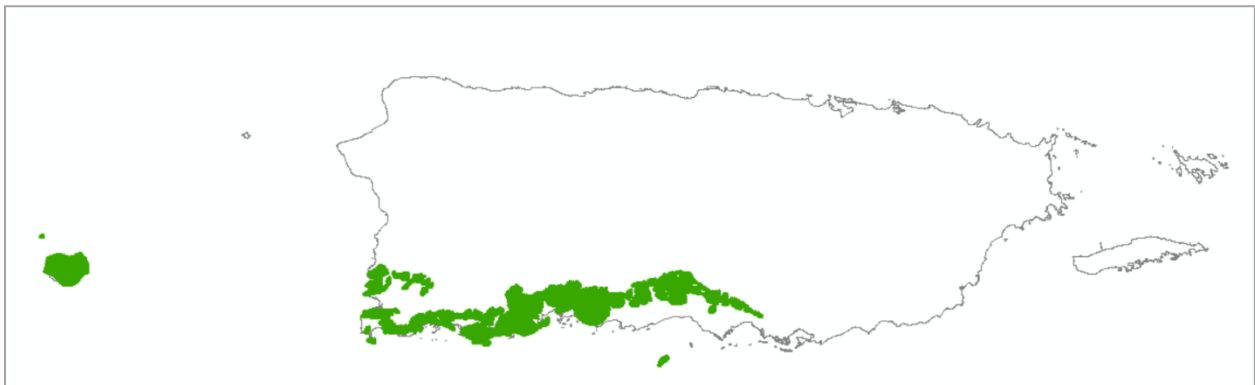


Figure 1. Distribution of the Subtropical Dry Limestone Bottomland Forest in Puerto Rico.

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### **Dominant plant species:**

Dominant species in FIA plots within this ecological site in Puerto Rico include: *Bursera simaruba*, *Leucaena leucocephala*, *Bourreria succulenta*, *Amyris elemifera*, *Coccoloba microstachya*, *Tabebuia heterophylla*, *Reynosia uncinata*, and *Antirhea acutata*. Secondary important species included *Bucida buceras*, *Coccoloba diversifolia*, *Eugenia rhombea*, among others (Marcano-Vega 2019). About 38 species were found within FIA plots located in this ecological site in the USVI (e.g, *Bourreria succulenta*, *Eugenia pseudopsidium*, *Guapira fragrans*, *Leucaena leucocephala*, *Swietenia mahagoni*, *Acacia farnesiana*, *Canella winteriana*, *Capparis flexuosa*, *Capparis indica*, *Colubrina arborescens*, *Erythroxylum rotundifolium*, *Eugenia monticola*, *Pithecellobium unguis-cati*, *Tabebuia heterophylla*, *Tamarindus indica*, *Trema micranthum*, *Acacia muricata*, *Adelia ricinella*, *Amyris elemifera*, *Bourreria succulenta*, *Bursera simaruba*). In addition, 7 out of 14 tree species assemblages identified for Puerto Rico, were described for this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### **Species assemblages:**

1. ***Leucaena leucocephala***, *Albizia procera* (Ex)
2. ***Bursera simaruba***, ***Bucida buceras***, ***Amyris elemifera***, ***Coccoloba diversifolia***, *Ocotea sintenisii*, *Myrsine coriacea*, *Licaria parvifolia*, *Senna siamea* (Ex), *Pictetia aculeata*, *Ocotea coriacea*.

- 
3. *Acacia farnesiana* (Ex), *Albizia lebbbeck* (Ex)
  4. *Citharexylum fruticosum*, *Swietenia mahagoni* (Ex), *Ziziphus mauritiana* (Ex),  
*Tamarindus indica* (Ex)
  5. *Thouinia striata*, *Ficus citrifolia*, *Petitia domingensis*, *Trichilia pallida*, *Eugenia rhombea*, *Coccoloba microstachya*.
  6. *Tabebuia heterophylla*, *Casearia arborea*, *Roystonea borinquena*, *Myrcia citrifolia*.
  7. *Casearia sylvestris*, *Psidium guajava*, *Coffea arabica* (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*.
- **Other trees:** *Bucida buceras*, *Ateramnus lucidus*, *Bursera simaruba*, *Pisonia albida*,  
*Amyris elemifera*, *Exostema caribaeum*, *Coccoloba diversifolia*, *Thouinia striata* var,  
*portoricensis*, *Tabebuia heterophylla*, *Pictetia aculeata*, *Krugiodendron ferreum*,  
*Antirhea acutata*, *Guaiacum sanctum*, *Guaiacum officinale*, *Eugenia foetida*, *Bursera simaruba*,  
*Prosopis pallida*, *Leucaena glauca*, *Tamarindus indica*, *Acacia macracantha*,  
*Acacia farnesiana*, *Melicoccus bijugatus*, *Capparis cynophallophora*, *Swietenia mahogany*,  
*Pictetia aculeata*, *Gymnanthes lucida*, *Sarcomphalus reticulatus*, *Ficus laevigata*, *Pisonia albida*.
  - **Shrubs:** *Agave sisilana*, *Plumeria alba*, *Thrinax morrisii*, *Croton betulinus*, *Croton discolor*,  
*Croton lucidus*, *Euphorbia lactea*, *Corchorus hirsutus*, *Gossypium hirsutum*,  
*Helicteres jamaicensis*, *Melochia tomentosa*, *Walteria indica*, *Pictetia aculeata*, *Dipholis salicifolia*,  
*Pithecellobium unguis-cati*, *Lantana involucrata*, *Crossopetalum rhacoma*,  
*Colubrina arborescens*, *Chamaesyce articulata*, *Suriana maritima*, *Coccoloba*

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*diversifolia*, *Croton rigidus*, *Croton lucidis*, *Exostema caribaeum*, *Savia sessiliflora*,  
*Varronia angustifolia*, *Schaefferia frutescens*, *Hypelate trifoliata*, *Reynosa uncinata*,  
*Samyda dodecandra*, *Citharexylum fruticosum*, *Plumeria alba*, *Bernaria dichotoma*,  
*Krugiodendron ferreum*, *Cassine xylocarpa*, *Comocladia dodonea*, *Canella winterana*,  
*Jacquinia betterii*, *Strumpfia maritima*, *Krameria ixina*.

- **Herbs, cactus, succulents:** *Bromelia pinguin*, *Tragia volubilis*, *Leptocereus quadricostatus*, *Melocactus intortus*, *Opuntia repens*, *Opuntia stricta*, *Pilocereus royenii*, *Bouteloua juncea*, *Cenchrus ciliaris*, *C. incertus*, *Lasiacis divaricata*, *Macfadyena unguis-cati*, *Sida glabra*, *Sida acuta*, *Tillandsia utriculata*, *T. fasciculata*, *Spartina patens*, *Sesuvium maritimum*, *Sesuvium portulacastrum*, *Batis maritima*, *Agave sisalana*, *Comocladia dodonea*, *Opuntia stricta*, *Opuntia rubescens*, *Opuntia repens*, *Pilosocereus royenii*, *Stenocereus fimbriatus*, *Melocactus intortus*, *Leptocereus quadricostatus*, *L. grantianus*, *Hylocereus trigonus*, *Cephalocereus royenii*

## PHYSIOGRAPHIC FEATURES

### Landforms

Plains (48%)

Side slope mogote (46%)

Steep slope mogote (3%)

Top mogote (3%)



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### **Physiographic features (characteristics ranges)**

Elevation range: -0.3 m to 595 m (mean= 72 m)

Slope: 0-133% (mean= 18%, or 10 degree)

Aspect (mean): South (180 degrees)

### **CLIMATIC FEATURES**

Climate: The mean annual precipitation in the SDLBF is about 1,012 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 17°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,012 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges)**

### **Monthly temperature (average minimum/maximum)**

### **INFLUENCING WATER FEATURES**

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## REPRESENTATIVE SOIL FEATURES

Soil components include Ensenada, Guayacan, Juana Diaz, Parguera, Pozo Blanco, Hesselberg (USVI), Hogensborg (USVI), Sion (USVI).

### Surface texture

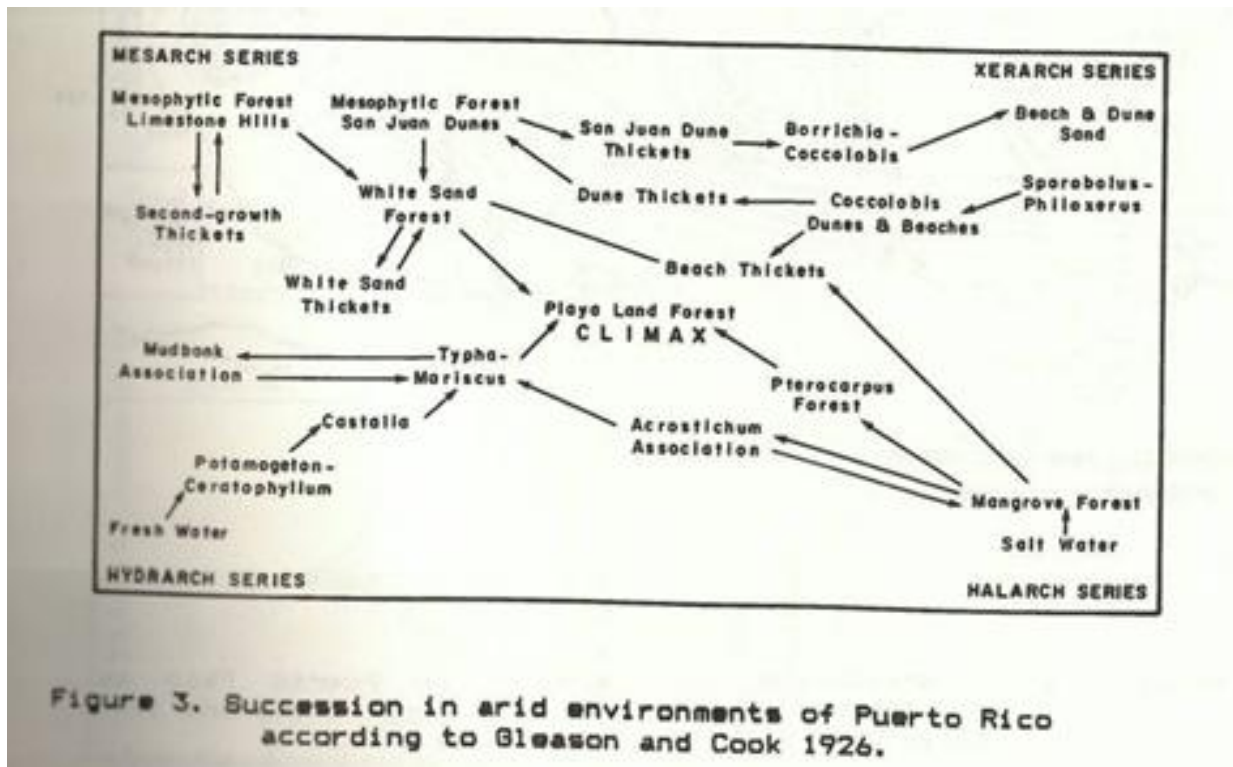
### Soil features

Family particle size:

### Soil features (characteristic ranges)

## ECOLOGICAL DYNAMICS OF THE SITE

### State and Transition Models



### COMMUNITY 1.1- State 1-Reference

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## ECOLOGICAL SITES INTERPRETATION

### SUPPORTING INFORMATION

#### **Similar sites**

- Subtropical Dry Limestone Upland Forest (SDLUF)

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SITE NAME: **SUBTROPICAL DRY LIMESTONE UPLAND FOREST (F271X...)**

MLRA 271-Semiarid Mountains and Valleys (82%), MLRA 273- Semiarid Coastal Plains (10%), MLRA 270-Humid Mountains and Valleys (8%)

Occurrence: Puerto Rico, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Dry Limestone Upland Forest (SDLUF) is the subtropical dry limestone ridge and the subtropical dry limestone upper slope forest according to the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SDLUF falls within the National Vegetation Classification Group G585 Caribbean Dry Broadleaf Forest and D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include mature secondary lowland dry limestone semi-deciduous forest, lowland dry limestone woodland and shrubland, dry grasslands and pastures, and young secondary lowland dry limestone semi-deciduous forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966) this ecological site occurs within the Semi-deciduous forest subzone (zone III) which includes forest, savanna, scrub, and desert, and more than 18 vegetation communities.

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### Ecological Site Concept:

The SDLUF has an extension of 94 km<sup>2</sup> (1% of the island), associated with the limestone of the south and southwest of Puerto Rico. This ecological site also occurs in the USVI represented in the land cover map by the subtropical dry limestone classes (Gould et al. 2013). The vegetation in this ecological site is mostly a deciduous closed woodland that tends to form a complete ground cover (Ewel and Whitmore 1973). Dansereau (1966) classified the general area as a semi-deciduous forest with a regional climax dominated by *Bucida buceras* forest. Similarly, Cook and Gleason (1928) considered *Bucida buceras* to be the dominant tree on the southern coastal plain and the adjacent foothills. The vegetation in this ecological zone exhibits several adaptations to the xeric environment such as thorns, spines, small and succulent leaves, and low and flattened canopies. Fire is a common source of disturbance in this xeric forest. The SDLUF can be found in Boquerón and Guánica State Forests. A systematic inventory of the flora in the Guanica Natural Reserve provides an exhaustive description of the vegetation found there (Monsegur 2009).

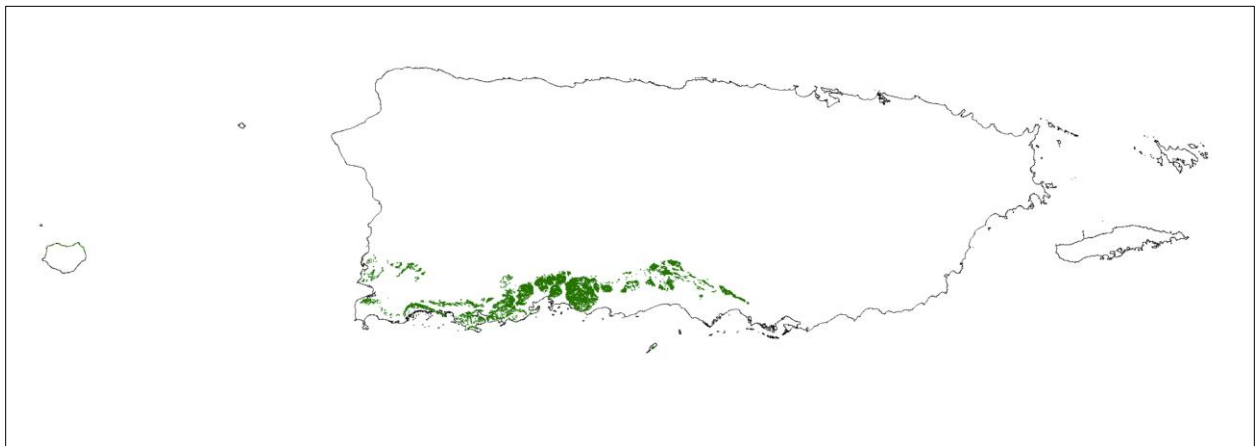


Figure 1. Distribution of the Subtropical Dry Limestone Upland Forest in Puerto Rico.

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### **Dominant plant species:**

Dominant species in FIA plots within this ecological site in Puerto Rico include *Amyris elemifera*, *Coccoloba microstachya*, *Bursera simaruba*, *Thouinia striata*, *Gymnanthes lucida*, *Bucida buceras*, *Thouinia striata*, *Krugiodendron ferreum*, *Pisonia albida*, *Exostema caribaeum*, *Bourreria succulenta*, *Leucaena leucocephala*, *Pithecellobium unguis-cati*, *Colubrina arborescens*, *Prosopis pallida*, among others (Marcano-Vega 2019). About 38 species were found within FIA plots located in this ecological site in the USVI including *Bourreria succulenta*, *Eugenia pseudopsidium*, *Guapira fragrans*, *Leucaena leucocephala*, *Swietenia mahagoni*, *Acacia farnesiana*, *Canella winteriana*, *Capparis flexuosa*, *Capparis indica*, *Colubrina arborescens*, *Erythroxylum rotundifolium*, *Eugenia monticola*, *Pithecellobium unguis-cati*, *Tabebuia heterophylla*, *Tamarindus indica*, and others (Marcano-Vega 2019). In addition, 7 species assemblages were described for this ecological site in Puerto Rico and 3 for the USVI (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### **Species assemblages:**

#### Puerto Rico

1. ***Leucaena leucocephala***, *Albizia procera* (Ex)
2. ***Bursera simaruba***, ***Bucida buceras***, ***Amyris elemifera***, ***Coccoloba diversifolia***, *Ocotea sintenisii*, *Myrsine coriacea*, *Licaria parvifolia*, *Senna siamea* (Ex), *Pictetia aculeata*, *Ocotea coriacea*.

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3. *Acacia farnesiana* (Ex), *Albizia lebbbeck* (Ex)
  4. *Citharexylum fruticosum*, *Swietenia mahagoni* (Ex), *Ziziphus mauritiana* (Ex),  
*Tamarindus indica* (Ex)
  5. *Thouinia striata*, *Ficus citrifolia*, *Petitia domingensis*, *Trichilia pallida*, *Eugenia rhombea*, *Coccoloba microstachya*.
  6. *Tabebuia heterophylla*, *Casearia arborea*, *Roystonea borinquena*, *Myrcia citrifolia*.
  7. *Casearia sylvestris*, *Psidium guajava*, *Coffea arabica* (Ex), *Ormosia krugii*, *Eugenia biflora*, *Thespesia grandiflora*, *Buchenavia tetraphylla*, *Hymenaea courbaril*, *Tetrazygia elaeagnoides*, *Piper amalago*.

#### USVI

1. *Leucaena leucocephala*, *Samanea saman*
  2. *Acacia farnesiana* (Ex), *Albizia lebbbeck* (Ex), *Inga laurina*
  3. *Cordia alba*, *Melicoccus bijugatus*, *Croton astroides*, *Eugenia rhombea*, *Adelia ricinella*,  
*Tecoma stans*.
- **Other trees:** *Exostema caribaeum*, *Pisonia albida*, *Bourreria succulenta*, *Cephalocereus royenii*, *Amyris elemifera*, *Krugiodendron ferreum*, *Bucida buceras*, *Pictetia aculeata*,  
*Thouinia striata var portoricensis*, *Zanthoxylum flavum*, *Pithecellobium unguis-cati*,  
*Guaiacum officinale*, *Bursera simaruba*, *Comocladia dodonaea*, *Randia aculeata*,  
*Capparis cynophallophora*, *Bucida buceras*, *Coccoloba uvifera*, *Gymnanthes lucida*, *Leucaena leucocephala*, *Bucida buceras*, *Bursera simaruba*, *Exostema caribaeum*,  
*Coccoloba microstachya*, *Reynosa uncinata*, *Cephalocereus royenii*, *Amyris elemifera*,

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*Ateramnus lucidus, Pictetia aculeata, Thouinia striata var. portoricensis, Coccoloba uvifera, C,Guaiacum officinale,Gymnanthes lucida, Pisonia albida.*

- **Shrubs:** *Agave sisilana, Plumeria alba, Thrinax morrisii, Croton betulinus, Croton discolor, Croton lucidus, Thouinia striata Radlk.var.portoricensis.*
- **Herbs, cactus, succulents:** *Bromelia pinguin, Tragia volubilis, Leptocereus quadricostatus, Melocactus intortus, Opuntia repens, Opuntia stricta, Pilocereus royenii.*

## PHYSIOGRAPHIC FEATURES

### Landforms

Top mogote (42%)

Steep slope mogote (41%)

Side slope mogote (16%)

Plains (1%)

### Physiographic features (characteristics ranges)

Elevation range: 7 m to 618 m (mean= 118 m)

Slope: 0-129% (mean= 32%, or 18 degree)

Aspect (mean): South (175 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SDLUF is about 1,135 millimeters. Rainfall is



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distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 18°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,135 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Soil components include Aguilita, Altamira, Costa, Duey, Guanabano, La Covana, Pitahaya, San German, Seboruco, Tuque, Yauco, Arawak (USVI).

**Surface texture**

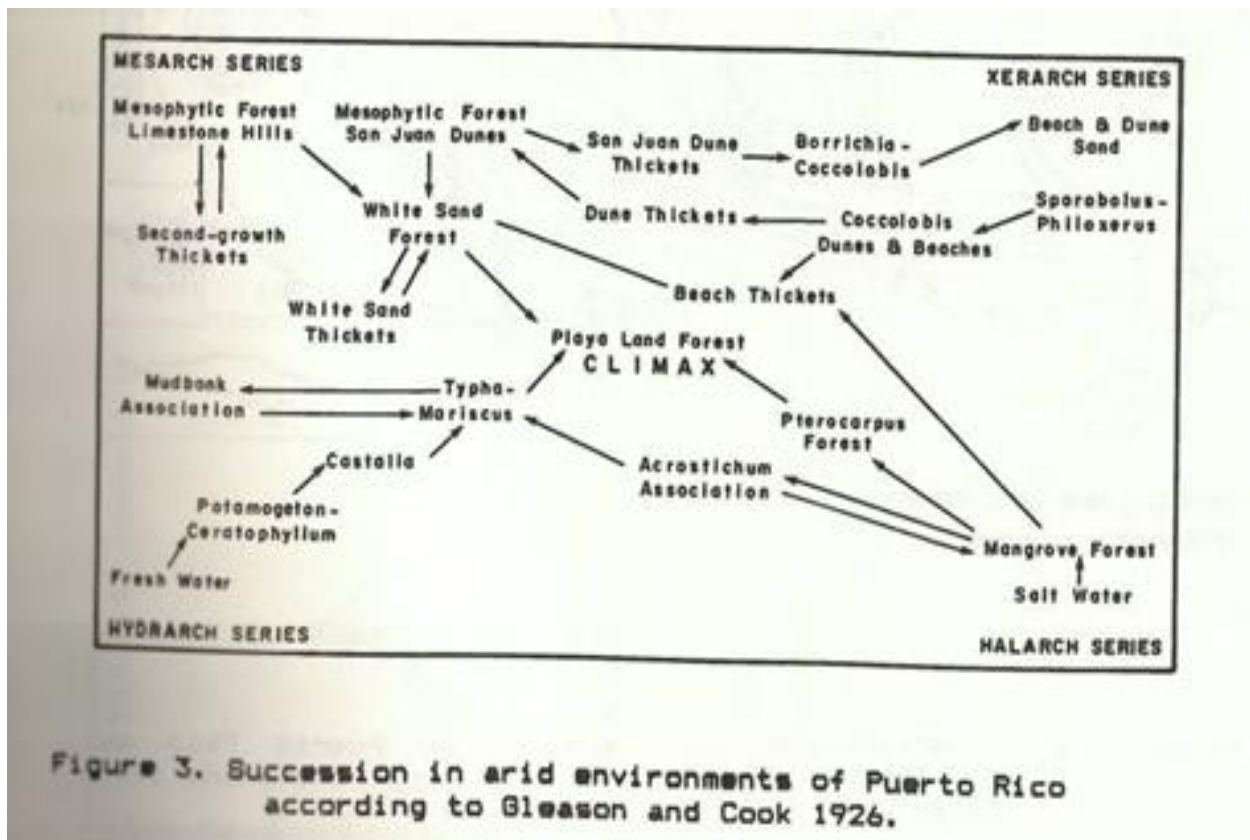
**Soil features**

Family particle size:

Soil features (characteristic ranges)

ECOLOGICAL DYNAMICS OF THE SITE

State and Transition Models



COMMUNITY 1.1- State 1-Reference

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

Similar sites

- Subtropical Dry Limestone Bottomland Forest (SDLBF)

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SITE NAME: **SUBTROPICAL DRY AND MOIST SERPENTINE BOTTOMLAND FOREST**  
**(F270X...)**

MLRA 270-Humid Mountains and Valleys (41%), MLRA 271- Semiarid Mountains and Valleys (38%),  
272-Humid Coastal Plains (21%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Subtropical Dry and Moist Serpentine Bottomland Forest (SDMSBF) is the subtropical dry and moist ultramafic plain and lower slope according to the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SDMSBF falls within the National Vegetation Classification Group G455 Caribbean Seasonal Evergreen Moist Lowland Forest Group, and D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include young secondary dry and moist serpentine semideciduous forest, mature secondary dry and moist serpentine semideciduous forest, moist grasslands and pastures, dry and moist serpentine woodland and shrubland (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966) this ecological site occurs within the Semi-deciduous forest subzone (zone III) which includes forest, savanna, scrub, and desert, and more than 18 vegetation communities.

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### **Ecological Site Concept:**

The SDMSBF has an extension of 28 km<sup>2</sup> (<1% of the island), and is associated with the serpentine geology in the southwest of Puerto Rico. This ecological site has an interesting evergreen forest association due to the edaphic and climatic conditions found here (e.g., Nipe and Rosario series), and a transition of life zone between moist and dry life zones (Ewel and Whitmore 1973). This ecological site occurs in the warmest portion of the moist forest ecological life zone and the the cool portion of the dry forest ecological life zone. Because of the diversity of the environmental characteristics, the vegetation of this ecological site is extremely rich, with many endemic species, little herbaceous growth due to the excessively drained soils, slender trees, with open-crowned and usually less than 12 m. This ecological site does not support agriculture or forestry (Ewel and Whitmore 1973). The SDMSUF can be found in Guánica, Maricao, and Susúa State Forests.

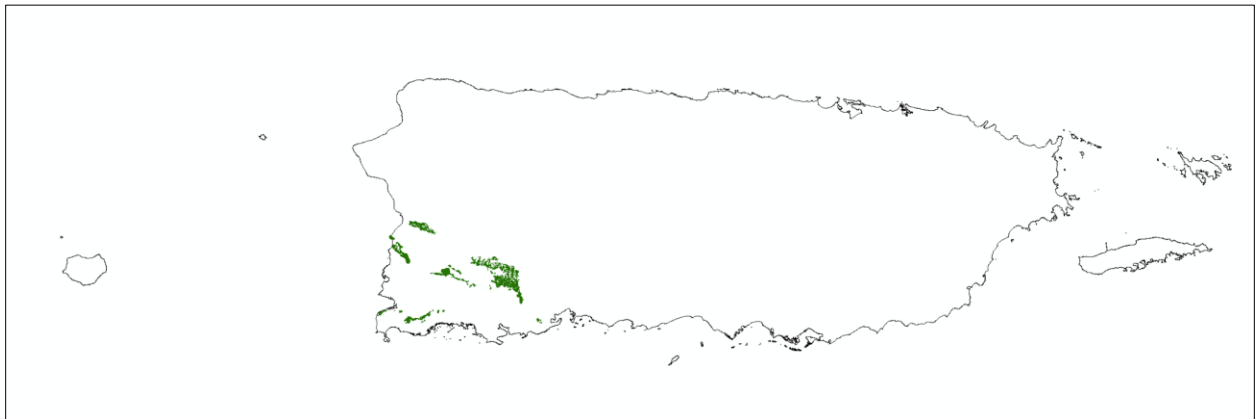


Figure 1. Distribution of the Subtropical Dry and Moist Serpentine Bottomland Forest in Puerto Rico.

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### Dominant plant species:

Dominant species in FIA plots within this ecological site in Puerto Rico include *Zanthoxylum monophyllum*, *Byrsonima spicata*, *Eugenia monticola*, *Nectandra coriacea*, *Senna siamea*, *Faramea occidentalis*, *Acrocomia media*, *Zanthoxylum martinicense* (Marcano-Vega 2019). In addition, 3 out of 14 tree species assemblages identified for Puerto Rico, were described for this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### Species assemblages:

1. *Leucaena leucocephala*, *Albizia procera* (Ex)
  2. *Neolaugeria resinosa*, *Guettarda scabra*, ***Eugenia monticola***, ***Tabebuia haemantha***, ***Pimenta racemosa***, ***Randia aculeata***, ***Clusia rosea***, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*
  3. ***Citharexylum fruticosum***, ***Exostema caribaeum***, ***Ardisia obovata***, ***Zanthoxylum martinicense***, *Pithecellobium dulce* (Ex), *Swietenia mahagoni* (Ex).
- **Other trees:** *Ouratea littoralis*, *Bucida buceras*, *Ateramnus lucidus*, *Bursera simaruba*, *Pisonia albida*, *Amyris elemifera*, *Exostema caribaeum*, *Coccoloba diversifolia*, *Thouinia striata* var, *portoricensis*, *Tabebuia heterophylla*, *Pictetia aculeata*, *Krugiodendron ferreum*, *Antirhea acutata*, *Guaiacum sanctum*, *Eugenia foetida*, *Bourreira*

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*succulenta, Coccoloba uvifera, Comocladia dodonaea, Guaiacum officinale, Gymnanthes lucida, Leucaena leucocephala*

- **Shrubs:** *Agave sisilana, Plumeria alba, Thrinax morrisii, Croton betulinus, Croton discolor, Croton lucidus, Thouinia striata Radlk.var.portoricensis.*
- **Herbs, cactus, succulents:** *Bromelia pinguin, Tragia volubilis, Leptocereus quadricostatus, Melocactus intortus, Opuntia repens, Opuntia stricta, Pilocereus royenii.*

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slope mogote (70%)

Plain (16%)

Steep slope mogote (9%)

Top (5%)

### Physiographic features (characteristics ranges)

Elevation range: 0 m to 510 m (mean= 133 m)

Slope: 0-97% (mean= 22%, or 12 degree)

Aspect (mean): South (168 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SDMSBF is about 1,391 millimeters. Rainfall is

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distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 18°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,391 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

- Delicias

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

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## ECOLOGICAL DYNAMICS OF THE SITE

### **State and Transition Models**

## ECOLOGICAL SITES INTERPRETATION

## SUPPORTING INFORMATION

### **Similar sites**

- Subtropical Dry and Moist Serpentine Upland Forest (SDMSUF)



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SITE NAME: **SUBTROPICAL DRY AND MOIST SERPENTINE UPLAND FOREST (F270X...)**

MLRA 270-Humid Mountains and Valleys (63%), MLRA 271- Semiarid Mountains and Valleys (22%),  
272-Humid Coastal Plains (4%)

Occurrence: Puerto Rico

Site stage: Provisional

### **Classification Relationship**

The Subtropical Dry and Moist Serpentine Upland Forest (SDMSUF) is the subtropical dry and moist ultramafic ridge and upper slope according to the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SDMSUF falls within the National Vegetation Classification Group G455 Caribbean Seasonal Evergreen Moist Lowland Forest Group, and D094 Caribbean and Central American Lowland Shrubland, Grassland and Savanna (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include young secondary dry and moist serpentine semideciduous forest, mature secondary dry and moist serpentine semideciduous forest, dry and moist serpentine woodland and shrubland, and moist grasslands and pastures (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966) this ecological site occurs within the Semi-deciduous forest subzone (zone III) which includes forest, savanna, scrub, and desert, and more than 18 vegetation communities.

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### **Ecological Site Concept:**

The SDMSUF has an extension of 34 km<sup>2</sup> (<1% of the island), and is associated with the serpentine geology in the southwest of Puerto Rico. This ecological site has an interesting evergreen forest association due to the edaphic and climatic conditions found here (e.g., Nipe and Rosario series), and a transition of life zone between moist and dry life zones (Ewel and Whitmore 1973). This ecological site occurs in the warmest portion of the moist forest ecological life zone and the the cool portion of the dry forest ecological life zone. Because of the diversity of the environmental characteristics, the vegetation of this ecological site is extremely rich, with many endemic species, little herbaceous growth due to the excessively drained soils, slender trees, with open-crowned and usually less than 12 m. This ecological site does not support agriculture or forestry (Ewel and Whitmore 1973). The SDMSUF can be found in the Susúa State Forest.

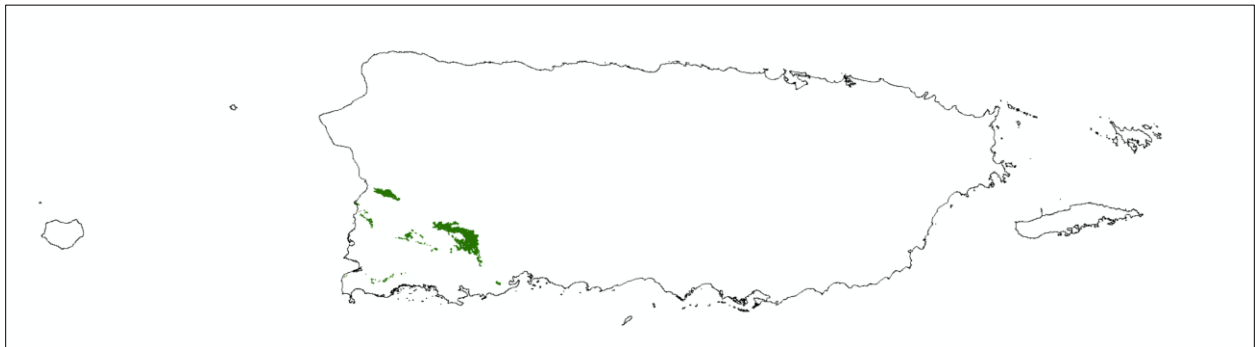


Figure 1. Distribution of the Subtropical Dry and Moist Serpentine Upland Forest in Puerto Rico.

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### **Dominant plant species:**

Dominant species in FIA plots within this ecological site in Puerto Rico include *Coccoloba microstachya*, *Tabebuia haemantha*, *Cassine xylocarpa*, *Bourreria succulenta*, *Bursera simaruba*, *Guettarda pungens*, *Guettarda scabra*, *Swietenia mahagoni*, *Tabebuia heterophylla*, *Gyminda latifolia*, *Neolaugeria resinosa* (Marcano-Vega 2019). In addition, 3 out of 14 tree species assemblages identified for Puerto Rico, were described for this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### **Species assemblages:**

1. *Leucaena leucocephala*, *Albizia procera* (Ex)
  2. *Neolaugeria resinosa*, *Guettarda scabra*, *Eugenia monticola*, *Tabebuia haemantha*, *Pimenta racemosa*, *Randia aculeata*, *Clusia rosea*, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*
  3. *Citharexylum fruticosum*, *Exostema caribaeum*, *Ardisia obovata*, *Zanthoxylum martinicense*, *Pithecellobium dulce* (Ex), *Swietenia mahagoni* (Ex).
- **Other trees:** *Randia aculeata*, *Ouratea littoralis*

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## PHYSIOGRAPHIC FEATURES

### **Landforms**

Steep slope mogote (58%)

Top (31%)

Side slope mogote (11%)

### **Physiographic features (characteristics ranges)**

Elevation range: 18 m to 526 m (mean= 178 m)

Slope: 1-86% (mean= 36%, or 20 degree)

Aspect (mean): South (179 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SDMSUF is about 1,457 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 18°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

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Precipitation total: 1457 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Soil components include El Cacique, La Taina, Maresua, Nipe, Rosario, Santa Marta, Melones, Bermeja, Casabe, Cerro Mariquita, El Papayo.

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

**State and Transition Models**

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

**Similar sites**

- Subtropical Dry and Moist Serpentine Bottomland Forest (SDMSBF)

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**SITE NAME: SUBTROPICAL DRY PALUSTRINE WETLAND (F273X...)**

MLRA 273- Semiarid Coastal Plains (85%), MLRA 271-Semiarid Mountains and Valleys (12%), 272-Humid Coastal Plains (2%)

Occurrence: Puerto Rico, Vieques, Culebra, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Dry Palustrine Wetland (SDPW) is the subtropical dry non-saline wetland in the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). Most of the SDPW falls within the National Vegetation Classification Group D094 Caribbean and Central American Lowland Shrubland, Grassland, and Savanna, Group 7Agriculture, and Group G585 Caribbean Dry Broadleaf Forest (U.S. National Vegetation Classification 2019). Most of the vegetation cover within this ecological site is represented by seasonally flooded herbaceous non-saline wetlands, hay and row crops, and lowland dry riparian forest, among other classes (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site is within the Littoral subzone (zone Ia) which includes meadow steppe, desert, savanna and forest, and more than 50 vegetation communities.

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### Ecological Site Concept:

The SDPW has an extension of 79 km<sup>2</sup> (~1% of the island), and it occupies the lowest landscape position of the dry forest in the littoral zone, in the south, and east of Puerto Rico including Vieques and Culebra (Fig. 1). This ecological site may also occur in the USVI. Palustrine wetlands can be found in the proximity of water reservoirs, lagoons, river channels, and flooded flats. Palustrine wetlands include forested swamps, palustrine emergent marshes, and palustrine aquatic beds (Miller and Lugo 2009). Palustrine systems in Puerto Rico have been classified into 10 groups according to the following environmental factors: water regime, water chemistry, soils, and elevation (DRNA unknown year). In addition, six palustrine/estuarine systems also occur on the island (DRNA unknown year). Each of the palustrine wetlands have a representative vegetation assemblage or dominant species. A typical palustrine forested swamp in the lowlands is the *Pterocarpus* forest dominated by the swamp bloodwood tree (*Pterocarpus officinalis*) (Miller and Lugo 2009). The *Pterocarpus* forest can form associations with the white mangrove *Laguncularia racemosa*. Other palustrine wetlands include the seasonal evergreen forest occurring in the foothills of the mogotes (limestone hills) where the water accumulated and soils are hydric. This forest is dominated by *Nectandra antillana* and *Roystonea borinquena*. Other palustrine wetlands are those semi-permanent or permanently inundated occurring in the river and water reservoir margins, dominated by *Gynerium sagittatum* and *Bambusa vulgaris*, *Cyathea arborea*, and *Tabebuia rigida*. These are the environments that have been mostly used in Puerto Rico for crops such as sugarcane (*Scharrum officinatum*) and rice (*Oriza sativa*). One additional palustrine wetland is the one formed by a mixture of native and exotic species but the second one at a much higher proportion dominated by species such as *Casuarina equisetifolia* and

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*Spathodea campanulata*, among others (DRNA unknown year). The SWPW can be found in Aguirre, Boquerón, and Guánica State Forests.

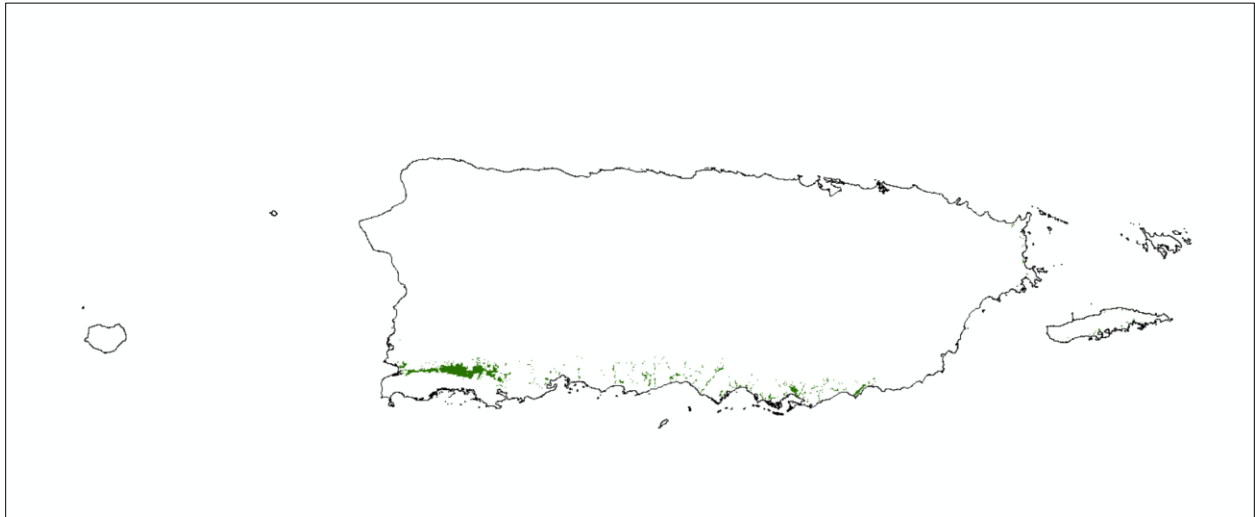


Figure 1. Distribution of the Subtropical Dry Palustrine Wetland in Puerto Rico.

**Dominant plant species:**

Dominant tree species in this ecological site in Puerto Rico included *Prosopis pallida*, *Guapira fragrans*, *Terminalia catappa*, *Casearia guianensis*, *Samanea saman*, *Rondeletia inermis*, *Acacia farnesiana*, *Capparis cynophallophora*, *Pithecellobium dulce*, and *Bursera simaruba* (Marcano-Vega 2019). While secondary abundant species within this ecological site included *Acacia farnesiana*, *Capparis cynophallophora*, *Pithecellobium dulce*, *Bursera simaruba*, *Leucaena leucocephala*, *Spondias purpurea*, and *Zanthoxylum monophyllum*. Some species might be duplicated as the information was acquired from different sources.



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- **Other trees:** *Vachelia macracantha*, *Gossypium hirsutum*, *Guazuma ulmifolia*.
  - **Shrubs:**
  - **Herbaceous, cactus, succulents:** *Bouteloua juncea*, *Centhrus ciliaris*, *C. incertus*, *Lasiacis divaricata*, *Macfadyena unguis-cati*, *Sida glabra*, *Sida acuta*, *Thilandsia utriculata*, *T. fasciculata*, *Cyperus alternifolius*, *Cyperus ligularis*, *Typha dominguensis*, *Eichornia sp.*, *Najas marina*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Wetlands (91%)

Plain (8%)

Side slope (1%)

### Physiographic features (characteristics ranges)

Elevation range: 0 m to 223 m (mean= 19 m)

Slope: 0-40% (mean= 4%, or 3 degrees)

Aspect (mean): Southeast (155 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SDPW is about 974 millimeters. Rainfall is

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distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 19°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 974 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

**INFLUENCING WATER FEATURES**

Temporarily or permanently inundated systems.

**REPRESENTATIVE SOIL FEATURES**

Soil series components include: Boqueron, Machuelo, Reparada, Olivares (Lajas valley).

**Surface texture**

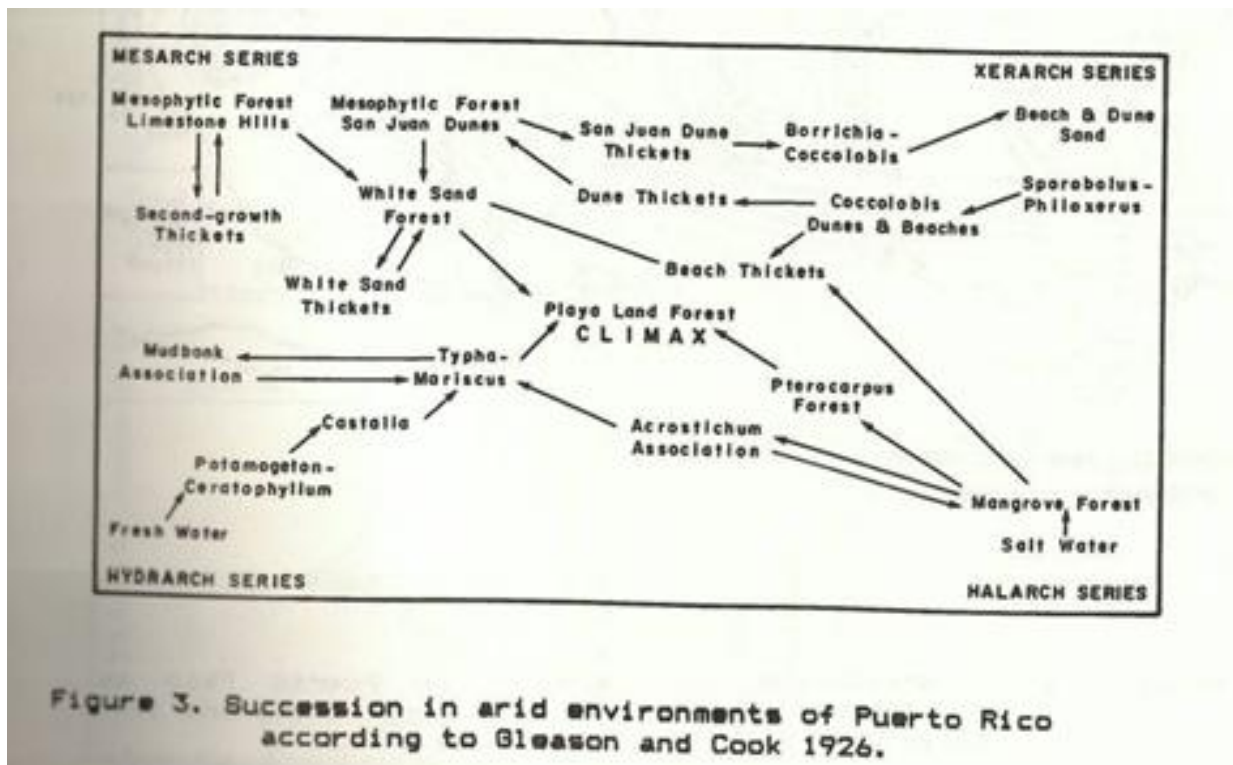
**Soil features**

Family particle size:

Soil features (characteristic ranges)

ECOLOGICAL DYNAMICS OF THE SITE

State and Transition Models



Similar sites

- Subtropical Moist Palustrine Wetland (SMPW)

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SITE NAME: **SUBTROPICAL DRY QUATERNARY BOTTOMLAND FOREST (F273X...)**

MLRA 273- Semiarid Coastal Plains (70%), MLRA 271-Semiarid Mountains and Valleys (27%), MLRA 272-Humid Coastal Plains (2%), 270-Humid Mountains and Valleys (1%)

Occurrence: Puerto Rico, Mona, Vieques, Culebra, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Dry Quaternary Bottomland Forest (SDQBF) is the subtropical dry quaternary plain and the subtropical dry quaternary lower slope forest according to the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SDQBF falls within the National Vegetation Classification Group D094 Caribbean and Central American Lowland Shrubland, Grassland, and Savanna, 7 Agricultural Vegetation, G585 Caribbean Dry Broadleaf Forest (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include dry grasslands and pastures, hay and row crops (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966) this ecological site occurs within the Semi-deciduous forest subzone (zone III) which includes forest, savanna, scrub, and desert, and more than 18 vegetation communities.

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### Ecological Site Concept:

The SDQBF has an extension of 524 km<sup>2</sup> (~6% of the island), and occurs in the south and east of the island, Mona, Vieques, and Culebra. This ecological site is also present in the USVI (Gould et al. 2013). The vegetation in this ecological site is mostly a deciduous closed woodland that tends to form a complete ground cover (Ewel and Whitmore 1973). The vegetation in this ecological zone exhibits several adaptations to the xeric environment such as thorns, spines, small and succulent leaves, and low and flattened canopies. Fire is a common source of disturbance in this xeric forest. Some typical species in this life zone in Puerto Rico and the USVI include *Bursera simaruba*, *Prosopis juliflora*, *Cephalocereus royenii*, *Bucida buceras*, *Pictetia aculeata*, *Guaiacum officinale*, *Guaiacum sanctum*, *Leucaena glauca*, *Tamarindus indica*, *Acacia macracantha*, *Acacia farnesiana*, *Melicoccus bijugatus* and five species of *Capparis*. Sp. (Ewel and Whitmore 1973). Some low alluvial areas in the south coast of Puerto Rico contain saline soils (e.g., Santa Isabel series) and the vegetation on those sites is dominated by *Prosopis juliflora* and *Parkinsonia aculeata* (Ewel and Whitmore 1973). Coastal alluvial soils in the south promote the growth of mangrove forest including *Rhizophora mangle*, *Avicennia nitida*, and *Laguncularia racemosa* form parts of the coastal associations in this ecological site. The SDQBF can be found in Boquerón, Guánica, Aguirre and Ceiba State Forests. A systematic inventory of the flora in the Guanica Natural Reserve provides an exhaustive description of the vegetation found there (Monsegur 2009).

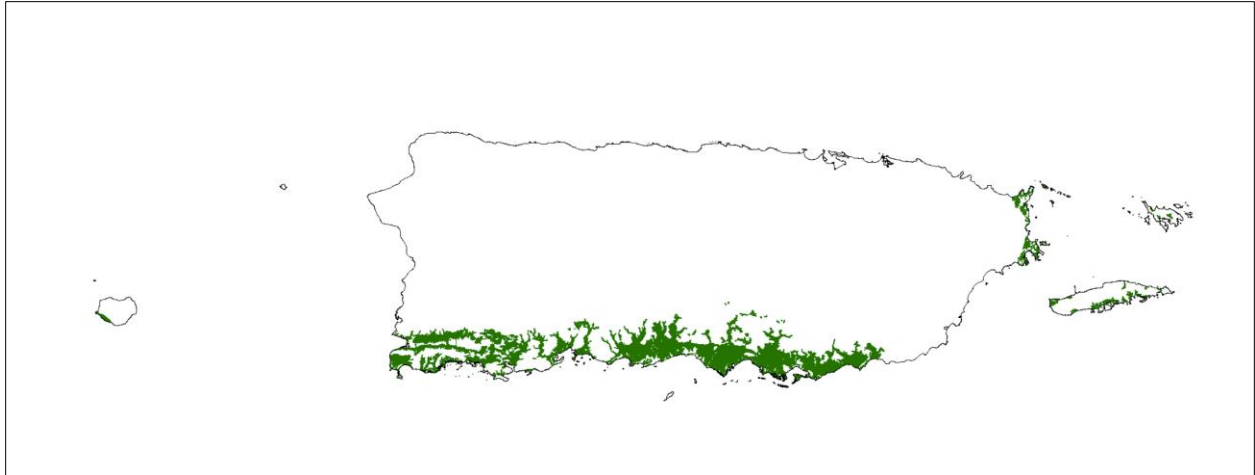


Figure 1. Distribution of the Subtropical Dry Quaternary Bottomland Forest in Puerto Rico.

**Dominant plant species:**

Dominant species in FIA plots within this ecological site in Puerto Rico include *Leucaena leucocephala*, *Guapira fragrans*, *Prosopis pallida*, *Pithecellobium unguis-cati*, *Acacia farnesiana*, *Pithecellobium dulce*, *Guazuma ulmifolia* (Marcano-Vega 2019). Whereas species found within FIA plots located in this ecological site in the USVI included *Acacia muricata*, *Bouyeria succulenta*, *Capparis cynophallophora*, *Pilosocereus royenii*, *Pisonia subcordata*, *Randia aculeata*. In addition, 5 out of 14 tree species assemblages occur in this ecological site in Puerto Rico, while the eight assemblages identified for the USVI are present within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

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**Species assemblages:**

Puerto Rico

1. *Leucaena leucocephala*, *Albizia procera* (Ex)
2. *Acacia farnesiana*, *Prosopis pallida*, *Albizia lebeck*
3. *Bursera simaruba*, *Bucida buceras*, *Amyris elemifera*, *Coccoloba diversifolia*, *Ocotea sintenisii*, *Myrsine coriacea*, *Licaria parvifolia*, *Senna siamea* (Ex), *Pictetia aculeata*, *Ocotea coriacea*.
4. *Casearia guianensis*, *Andira inermis*, *Guazuma ulmifolia*, *Guapira fragans*, *Myrcia splendens*, *Cupania americana*.
5. *Neolaugeria resinosa*, *Guettarda scabra*, *Eugenia monticola*, *Tabebuia haemantha*, *Pimenta racemosa*, *Randia aculeata*, *Clusia rosea*, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*

USVI

1. *Leucaena leucocephala*, *Samanea saman*
2. *Casearia guianensis*, *Zanthoxylum monophyllum*, *Citharexylum fruticosum*, *Ziziphus mauritiana* (Ex), *Trichilia hirta*, *Zanthoxylum martinicense*, *Acacia macracantha* (Ex), *Andira inermis*, *Randia aculeata*, *Swietenia mahagoni* (Ex)
3. *Eugenia monticola*, *Capparis baducca*, *Bursera simaruba*, *Maytenus laevigata*, *Sabinea florida*, *Ocotea coriacea*, *Bourreria succulenta*, *Chionanthus compactus*, *Cordia alliodora*, *Krugiodendron ferreum*
4. *Prosopis pallida*
5. *Acacia muricata*, *Pisonia subcordata*, *Eugenia cordata*, *capparis cynophallophora*, *Myrciaria floribunda*, *Amyris elemifera*, *Guettarda scabra*, *Bucida buceras*
6. *Acacia farnesiana* (Ex), *Albizia lebeck* (Ex), *Inga laurina*

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7. *Guapira fragrans*, *Capparis indica*, *Cassine xylocarpa*, *Tabebuia heterophylla*, *capparis hastata*
  8. *Cordia alba*, *Melicoccus bijugatus*, *Croton astroides*, *Eugenia rhombea*, *Adelia ricinella*, *Tecoma stans*.

- **Other trees:** *Exostema caribaeum*, *Pisonia albida*, *Bourreiria succulenta*, *Cepalocereus royenii*, *Amyris elemifera*, *Krugiodendron ferreum*, *Bucida buceras*, *Pictetia aculeata*, *Thouinia striata var portoricensis*, *Zanthoxylum flavum*, *Pithcellobium unguis-cati*, *Guaiacum officinale*, *Bursera simaruba*, *Comocladia dodonea*, *Randia aculeata*, *Capparis cynophallophora*, *Bucida buceras*, *Coccoloba uvifera*, *Gymnanthes lucida*, *Rhizophora mangle*, *Avicennia nitida*, *Laguncularia racemosa*, *Ateramnus lucidus*, *Bursera simaruba*, *Pisonia albida*, *Exostema caribaeum*, *Coccoloba uvifera*, *Thouinia striata var, portoricensis*, *Tabebuia heterophylla*, *Pictetia aculeata*, *Krugiodendron ferreum*, *Antirhea acutata*, *Guaiacum sanctum*, *Guaiacum officinale*, *Eugenia foetida*, *Eugenia rhombea*, *Prosopis pallida*, *Leucaena glauca*, *Tamarindus indica*, *Acacia macracantha*, *Acacia farnesiana*, *Melicoccus bijugatus*, *Capparis sp.*, *Swietenia mahogany*, *Annona glabra*, *Terminalia catappa*, *Crescentia cujete*, *Conocarpus erectus*, *Cocos nucifera*, *Ficus laevigata*, *Capparis cynophallophora*, *Pilosocereus royenii*.
- **Shrubs:** *Agave sisilana*, *Plumeria alba*, *Thrinax morrisii*, *Croton betulinus*, *Croton discolor*, *Croton lucidus*, *Thouinia striata Radlk.var.portoricensis*, *Euphorbia lactea*, *Corchorus hirsutus*, *Gossypium hirsutum*, *Helicteres jamaicensis*, *Melochia tomentosa*, *Walteria indica*, *Pictetia aculeata*, *Pithecellobium unguis-cati*, *Lantana involucrata*, *Crossopetalum rhacoma*, *Colubrina arborescens*, *Chamaesyce articulata*,



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*Suriana maritima*, *Coccoloba diversifolia*, *Croton rigidus*, *Croton lucidis*, *Exostema caribaeum*, *Savia sessiliflora*, *Varronia angustifolia*, *Schaefferia frutescens*, *Hypelate trifoliata*, *Reynosa uncinata*, *Samyda dodecandra*, *Citharexylum fruticosum*, *Plumeria alba*, *Bernaria dichotoma*, *Krugiodendron ferreum*, *Cassine xylocarpa*, *Comocladia dodonaea*, *Canella winterana*, *Jacquinia betterii*, *Strumpfia maritima*, *Krameria ixina*, *Borrichia arborescens*, *Coccoloba krugii*.

- **Herbs, cactus, succulents:** *Bromelia pinguin*, *Tragia volubilis*, *Leptocereus quadricostatus*, *Melocactus intortus*, *Opuntia repens*, *Opuntia stricta*, *Pilocereus royenii*, *Bouteloua juncea*, *Cenchrus ciliaris*, *C. incertus*, *Lasiacis divaricata*, *Macfadyena unguis-cati*, *Sida glabra*, *Sida acuta*, *Tillandsia utriculata*, *T. fasciculata*, *T. recurvata*, *Dendropogon usneoides*, *Encyclia papilionacea*, *Batis maritima*, *Savia sessiliflora*, *Agave sisalana*, *Opuntia stricta*, *Opuntia dillenii*, *Opuntia rubescens*, *Opuntia repens*, *Pilosocereus royenii*, *Stenocereus fimbriatus*, *Melocactus intortus*, *Leptocereus quadricostatus*, *L. grantianus*, *Hylocereus trigonus*, *Cactus intortus*, *Cephalocereus royenii*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Plains (86%)

Side slope mogote (7%)

Wetlands (7%)

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### **Physiographic features (characteristics ranges)**

Elevation range: -2 m to 420 m (mean= 34 m)

Slope: 0-86% (mean= 10%, or 6 degree)

Aspect (mean): South (157 degrees)

### **CLIMATIC FEATURES**

Climate: The mean annual precipitation in the SDQBF is about 1,033 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 19°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,033 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges)**

### **Monthly temperature (average minimum/maximum)**

### **INFLUENCING WATER FEATURES**

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Water is limited, agriculture is possible with irrigation. The better soils in this ecological site are under cultivation. The repeated use of irrigation can result in salt accumulation in the upper soil horizons (Ewel and Whitmore 1973).

## REPRESENTATIVE SOIL FEATURES

Soil components include Aguirre, Fe, Fraternidad, Guanica, San Anton, Santa Isabel, Teresa (Lajas).

### **Surface texture**

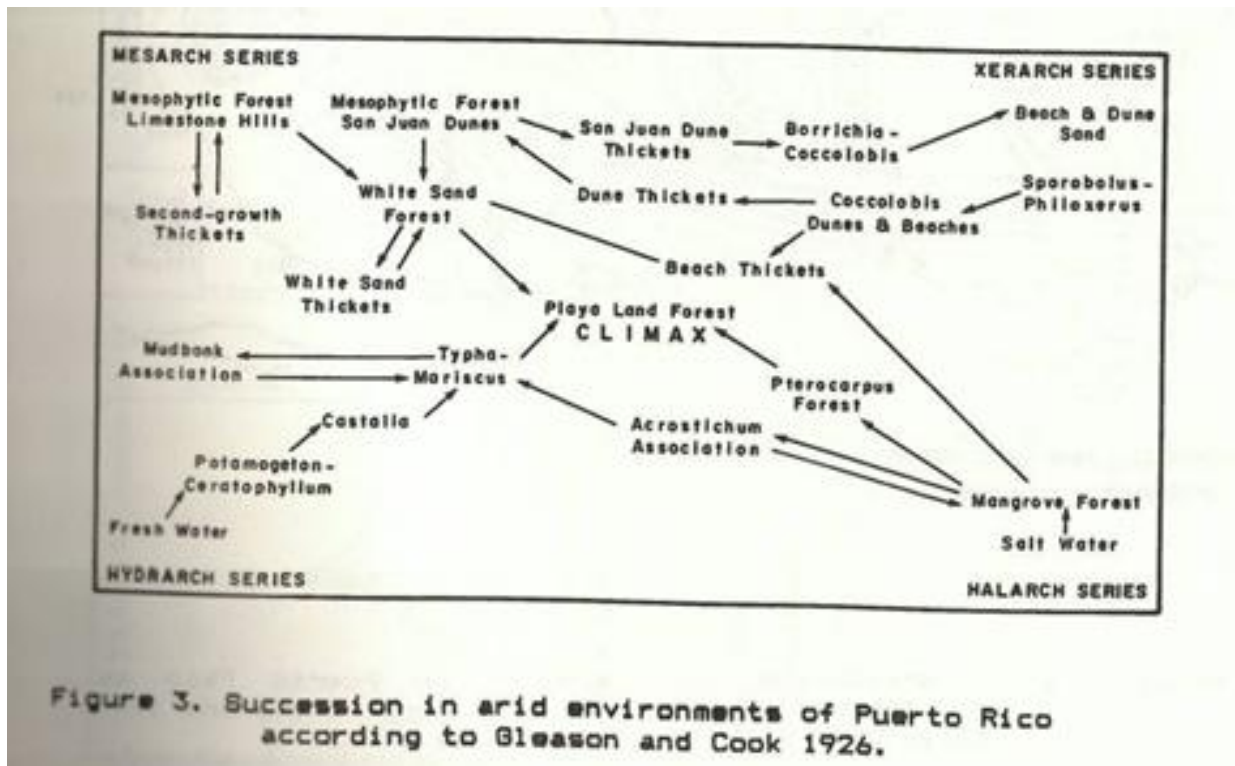
### **Soil features**

Family particle size:

### **Soil features (characteristic ranges)**

## ECOLOGICAL DYNAMICS OF THE SITE

### **State and Transition Models**



## COMMUNITY 1.1- State 1-Reference

## ECOLOGICAL SITES INTERPRETATION

## SUPPORTING INFORMATION

### Similar sites

- Subtropical Dry Quaternary Upland Forest (SDQUF)
- Subtropical Dry Volcanic Upland Forest (SDVUF)

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SITE NAME: **SUBTROPICAL DRY QUATERNARY UPLAND FOREST (F271X...)**

MLRA 271-Semiarid Mountains and Valleys (66%), MLRA 273- Semiarid Coastal Plains (16%), MLRA 272-Humid Coastal Plains (15%), 270-Humid Mountains and Valleys (3%)

Occurrence: Puerto Rico, Vieques, Culebra, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Dry Quaternary Upland Forest (SDQUF) is the subtropical dry quaternary ridge and the subtropical dry quaternary upper slope forest according to the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SDQUF mostly falls within the National Vegetation Classification Group G585 Caribbean Dry Broadleaf Forest and D094 Caribbean and Central American Lowland Shrubland, Grassland, and Savanna (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include dry grasslands and pastures, lowland dry alluvial shrubland and woodland, lowland dry non-calcareous shrubland and woodland, and young secondary lowland dry alluvial semi-deciduous forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966) this ecological site occurs within the Semi-deciduous forest subzone (zone III) which includes forest, savanna, scrub, and desert, and more than 18 vegetation communities.

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### Ecological Site Concept:

The SDQUF has an extension of 3 km<sup>2</sup> (<1% of the island), and occurs in the south and east of the island, Vieques, and Culebra. This ecological site is also present in the USVI (Gould et al. 2013). The vegetation in this ecological site is mostly a deciduous closed woodland that tends to form a complete ground cover (Ewel and Whitmore 1973). The vegetation in this ecological zone exhibits several adaptations to the xeric environment such as thorns, spines, small and succulent leaves, and low and flattened canopies. Fire is a common source of disturbance in this xeric forest. Some typical species in this life zone in Puerto Rico and the USVI include *Bursera simaruba*, *Prosopis juliflora*, *Cephalocereus royenii*, *Bucida buceras*, *Pictetia aculeata*, *Guaiacum officinale*, *Guaiacum sanctum*, *Leucaena glauca*, *Tamarindus indica*, *Acacia macracantha*, *Acacia farnesiana*, *Melicoccus bijugatus* and five species of *Capparis*. Sp. (Ewel and Whitmore 1973). Some low alluvial areas in the south coast of Puerto Rico contain saline soils (e.g., Santa Isabel series) and the vegetation on those sites is dominated by *Prosopis juliflora* and *Parkinsonia aculeata* (Ewel and Whitmore 1973). Coastal alluvial soils in the south promote the growth of mangrove forest including *Rhizophora mangle*, *Avicennia nitida*, and *Laguncularia racemosa* form parts of the coastal associations in this ecological site.

The SDQUF can be found in Boquerón and Guánica State Forests. A systematic inventory of the flora in the Guanica Natural Reserve provides an exhaustive description of the vegetation found there (Monsegur 2009).

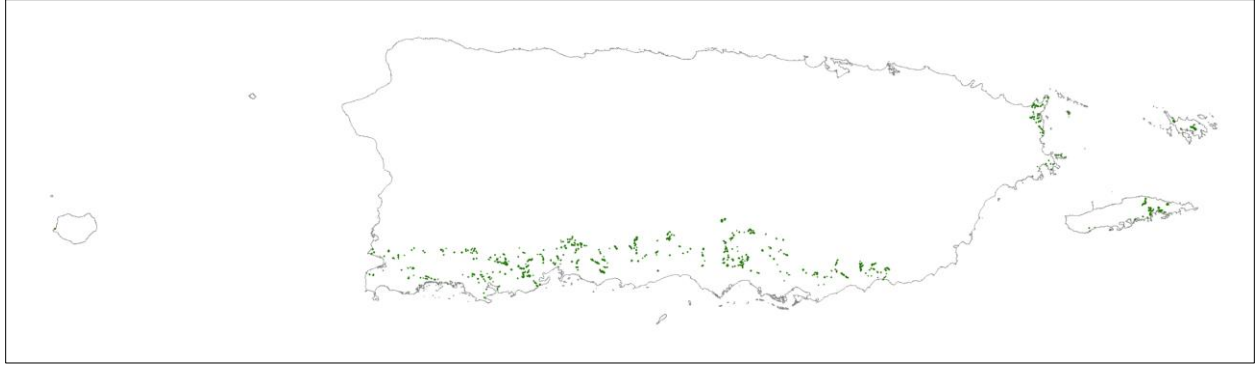


Figure 1. Distribution of the Subtropical Dry Quaternary Upland Forest in Puerto Rico.

### **Dominant plant species:**

None of the FIA plots occur within this ecological site in Puerto Rico, however in the USVI species found within FIA plots included *Acacia muricata*, *Bourreria succulenta*, *Capparis cynophallophora*, *Pilosocereus royenii*, *Pisonia subcordata*, *Randia aculeata* (Marcano-Vega 2019). In addition, 5 out of 14 tree species assemblages occur in this ecological site in Puerto Rico, while the eight assemblages identified for the USVI are present within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### **Species assemblages:**

Puerto Rico

- 1. *Leucaena leucocephala*, *Albizia procera* (Ex)**

- 
2. *Acacia farnesiana*, *Prosopis pallida*, *Albizia lebbbeck*
  3. *Bursera simaruba*, *Bucida buceras*, *Amyris elemifera*, *Coccoloba diversifolia*, *Ocotea sintenisii*, *Myrsine coriacea*, *Licaria parvifolia*, *Senna siamea (Ex)*, *Pictetia aculeata*, *Ocotea coriacea*.
  4. *Casearia guianensis*, *Andira inermis*, *Guazuma ulmifolia*, *Guapira fragans*, *Myrcia splendens*, *Cupania americana*.
  5. *Neolaugeria resinosa*, *Guettarda scabra*, *Eugenia monticola*, *Tabebuia haemantha*, *Pimenta racemosa*, *Randia aculeata*, *Clusia rosea*, *Casearia decandra*, *Bourreria succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*

#### USVI

1. *Leucaena leucocephala*, *Samanea saman*
2. *Casearia guianensis*, *Zanthoxylum monophyllum*, *Citharexylum fruticosum*, *Ziziphus mauritiana (Ex)*, *Trichilia hirta*, *Zanthoxylum martinicense*, *Acacia macracantha (Ex)*, *Andira inermis*, *Randia aculeata*, *Swietenia mahagoni (Ex)*
3. *Eugenia monticola*, *Capparis baducca*, *Bursera simaruba*, *Maytenus laevigata*, *Sabinea florida*, *Ocotea coriacea*, *Bourreria succulenta*, *Chionanthus compactus*, *Cordia alliodora*, *Krugiodendron ferreum*
4. *Prosopis pallida*
5. *Acacia muricata*, *Pisonia subcordata*, *Eugenia cordata*, *capparis cynophallophora*, *Myrciaria floribunda*, *Amyris elemifera*, *Guettarda scabra*, *Bucida buceras*
6. *Acacia farnesiana (Ex)*, *Albizia lebbbeck (Ex)*, *Inga laurina*
7. *Guapira fragrans*, *Capparis indica*, *Cassine xylocarpa*, *Tabebuia heterophylla*, *capparis hastata*
8. *Cordia alba*, *Melicoccus bijugatus*, *Croton astroides*, *Eugenia rhombea*, *Adelia ricinella*, *Tecoma stans*.



- 
- **Other trees:** *Exostema caribaeum*, *Pisonia albida*, *Bourreira succulenta*, *Cephalocereus royenii*, *Amyris elemifera*, *Krugiodendron ferreum*, *Bucida buceras*, *Pictetia aculeata*, *Thouinia striata var portoricensis*, *Zanthoxylum flavum*, *Pithcellobium unguis-cati*, *Guaiacum officinale*, *Bursera simaruba*, *Comocladia dodonea*, *Randia aculeata*, *Capparis cynophallophora*, *Bucida buceras*, *Coccoloba uvifera*, *Gymnanthes lucida*, *Leucaena leucocephala*, *Bucida buceras*, *Bursera simaruba*, *Exostema caribaeum*, *Coccoloba mycrostachia*, *Reynosa uncinata*, *Plumeria alba*, *Cephalocereus royenii*, *Amyris elemifera*, *Ateramnus lucidus*, *Pictetia aculeata*, *Thouinia striata var. portoricensis*, *Bourreira succulenta*, *Comocladia dodonaea*, *Guaiacum officinale*.
  - **Shrubs:** *Agave sisilana*, *Plumeria alba*, *Thrinax morrisii*, *Croton betulinus*, *Croton discolor*, *Croton lucidus*, *Thouinia striata Radlk.var.portoricensis*.
  - **Herbs, cactus, succulents:** *Bromelia pinguin*, *Tragia volubilis*, *Leptocereus quadricostatus*, *Melocactus intortus*, *Opuntia repens*, *Opuntia stricta*, *Pilocereus royenii*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slope (39%)

Steep slope (33%)

Tops (25%)

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Plains (3%)

Wetlands (1%)

**Physiographic features (characteristics ranges)**

Elevation range: 0 m to 462 m (mean= 67 m)

Slope: 0-140% (mean= 32%, or 17 degree)

Aspect (mean): South (179 degrees)

**CLIMATIC FEATURES**

Climate: The mean annual precipitation in the SDQUF is about 1,100 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 19°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,100 mm

**Monthly precipitation (characteristic ranges)**

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**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

Water is limited, agriculture is possible with irrigation. The better soils in this ecological site are under cultivation. The repeated use of irrigation can result in salt accumulation in the upper soil horizons (Ewel and Whitmore 1973).

REPRESENTATIVE SOIL FEATURES

Soil components include: 1) RESTRICTED DRAINAGE: Carib (USVI), Solitude(USVI), Coamo, Constancia, Cortada, Cuyon, Fraternidad, Guamani, Guayabo, Jacaguas, Jacana, Palmarejo, Paso Seco, Poncena, Pozo Blanco, San Anton, Vayas, Vives. 2) WELL-DRAINED: Cinnamom Bay (USVI), Glynn (USVI), Lameshur (USVI), Amelia, Arenales, Bahia, Cartagena, Cintrona, La Luna, Llanos, Llanos Costa, Machete, Maguayo, Montalva, Sosa.

**Surface texture**

**Soil features**

Family particle size:

**Soil features (characteristic ranges)**

ECOLOGICAL DYNAMICS OF THE SITE

**State and Transition Models**

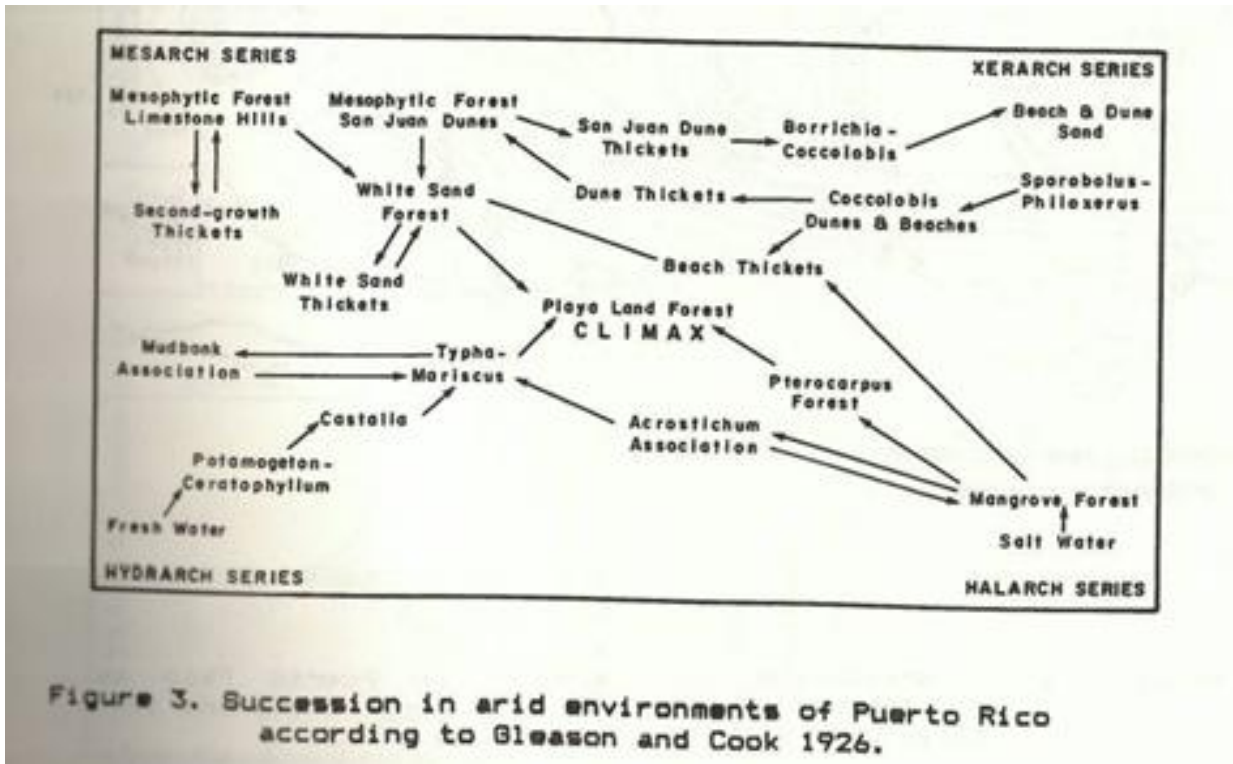


Figure 3. Succession in arid environments of Puerto Rico according to Gleason and Cook 1926.

## COMMUNITY 1.1- State 1-Reference

## ECOLOGICAL SITES INTERPRETATION

## SUPPORTING INFORMATION

### Similar sites

- Subtropical Dry Quaternary Botomland Forest (SDQBF)
- Subtropical Dry Volcanic Upland Forest (SDVUF)

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SITE NAME: **SUBTROPICAL DRY SANDY BEACH FOREST (F273X...)**

MLRA 273-Semiarid Coastal Plains

Occurrence: Puerto Rico, Mona, Vieques, Culebra, USVI

Site stage: Provisional

### **Classification Relationship**

Sandy beaches in Puerto Rico have been mapped by the USDA Forest Service land cover map, and includes fine to coarse sandy beaches, mixed sand and gravel (Gould et al. 2008).

### **Ecological Site Concept:**

Sandy beaches in Puerto Rico (including those in Vieques, Culebra, Mona, and Caja de Muertos) occupy an approximate area of 12 km<sup>2</sup> and extend along 1,086 km (Gould et al. 2008). Puerto Rico has 1,225 units of beaches for the 2010 period, representing the most occurring coastal type at the Island (Barreto 2017). These beaches are mainly short and narrower beaches, with a lunate shape located between rocky shorelines. Sandy beaches are classified according to their sand sediments as biogenic ( $\geq 75\%$  calcium carbonate component), terrigenous ( $\geq$  terrigenous component as minerals/rock fragments) and mixed biogenic and terrigenous sediments (between 26 to 74 % both components) (Barreto 2017). The composition of the sediments plus the local environmental conditions affect the vegetation growing in these sandy beaches. The physical

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nature of the beach determines the type of vegetation present (Miller and Lugo 2009). Beach plants have physiologic and physiognomic adaptations to thrive in this dynamic and shifting environment that include strong winds, ocean spray, waves and salinity. Plant adaptations to beach environments include spreading roots, large and thick leaves, and in the case of herbs the development of asexual methods of reproduction such as rhizomes, and succulent stems to retain water (Miller and Lugo 2009). The identification of vegetation-sediment relationships was beyond the scope of this report, but we identified two major sandy beaches and hence two ecological sites at the provisional stage. The sandy beaches occurring in the MLRA 270-Humid Coastal Plains (Subtropical Moist Sandy Beach Forest, SB-Moist), and the sandy beaches occurring in the MLRA 273-Semiarid Coastal Plains (Subtropical Dry Sandy Beach, SB-Dry). These sandy beaches occur in drier environments can be found in the south and southwest of Puerto Rico (Guanica, Cabo Rojo), Mona Island, Culebra, Vieques, and the US Virgin Islands. Although sandy beaches were separated into these two major groups we do not expect major differences in terms of species composition, but in the relative abundance and dominance of the individual species. Overall, sandy beaches in this ecological site have a mineralogy of calcareous origin, composed of seashells, and coral reefs fragments. In terms of soils some are shared with the soils in the sandy beaches in the north of the island, but many others are characteristics of this type of environment (Matos pers. comm). In terms of vegetation, this type of sandy beach shares most of the species that occur in the moist sandy beach ecological site, but they have a notorious dominance of other species which are almost absent in the north coast such as *Suriana maritima*, a very common shrub in Mona Island, Cabo Rojo, and Guanica (Diez pers. comm). In the map of vegetation zones developed by Danserau and Buell (1966), this ecological site occurs within the

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Littoral subzone (zone Ia) which includes meadow steppe, desert, savanna and forest, and more than 50 vegetation communities.

**Dominant plant species:**

None of the FIA plots occurred within this ecological site.

Beach grasses generally dominate front dunes, and have an important role as dune stabilizers with their rhizomes and runners (Miller and Lugo 2009). If the front dune is stable, it may promote the development of an evergreen hedge scrub in the foredune, dominated by xerophytic woody species such as *Borrchia arborescens*, *Chrysobalanus icaco*, *Smilax coriacea* and *Coccoloba uvifera* (Miller and Lugo 2009). At the top of the dune other woody species may include *Plumeria alba*, *Anthacanthus spinosus*, while other woody species such as *Scleria microcarpa*, *Calophyllum brasiliense*, *Annona glabra*, *Coccoloba uvifera* may occur in the rear dune, under drier conditions. In depressed areas with salt accumulation, salt-tolerant species such as *Salicornia bigelovii* and *Batis maritima* are common. In addition, other trees and shrubs may be present in this ecological site naturally or planted as a management measure to reduce erosion. The most common woody species along beaches of Puerto Rico include *Coccoloba uvifera*, *Chrysobalanus icaco*, *Thespesia populnea* (Ex), *Dalbergia ecastaphyllum*, *Cocos nucifera* (Ex), *Suriana maritima*, *Casuarina equisetifolia* (Ex), *Conocarpus erectus*, and *Bursera simaruba* (Miller and Lugo 2009).

- **Other trees:** *Hippomane mancinella*, *Thespesia populnea* (Ex), *Coccoloba uvifera*, *Terminalia catappa*, *Cocos nucifera* (Ex), *Casuarina equisetifolia* (Ex), *Dalbergia ecastaphyllum*, *Calophyllum brasiliense*, *Hibiscus pernambucensis* (Ex).

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- **Shrubs:** *Suriana maritima*, *Gundlachia corymbosa*, *Scaevola plumieri*, *Croton sp.* ,  
*Lantana sp.*, *Jacquinia armillaris*, *Borrchia arborescens*, *Dodonaea viscosa*,  
*Chrysobalanus icaco*, *Erithalis fruticosa*, *Conocarpus erectus*, *Dalbergia ecastaphyllum*,  
*Caesalpinia bonduc*, *Scaevola sericea (Ex)*, *Chamaesyce mesembrianthemifolia*, *Argusia*  
*gnaphalodes*, *Ernodea littoralis littoralis*, *Stemodia maritima*.
  - **Herbaceous species, cactus, succulents:** *Paspalum vaginatum*, *Sporobolus virginicus*,  
*Sesuvium portulacastrum*, *Sesuvium maritimum*, *Salicornia bigelovi*, *Batis maritima*,  
*Ipomoea pes-caprae*, *Ipomea imperati*, *Canavalia maritima*, *Remirea maritima*,  
*Fimbristylis cymosa*, *Sporobolus virginicus*, *Euphorbia buxifolia*, *Fimbristylis spadicea*,  
*Borrchia arborescens*, *Spartina patens*, *Fimbristylis spadicea*, *Bromelia pinguin*,  
*Spartina patens*, *Canavalia rosea*, *Cenchrus sp.*, *Chamaesyce buxifolia*, *Fimbristylis*  
*cymosa*, *Cyperus planifolius*, *Opuntia pubescens*, *Melocactus intortus*, *Cephalocereus sp.*,  
*Scleria microcarpa*, *Stenotaphrum secundatum*, *Heliotropium curassavicum*, *Ramirea*  
*maritima*, *Crinum asiaticum (Ex)*, *Hymenocallis caribaea*, *Dactyloctenium aegyptium*  
*(Ex)*, *Blutaparon vermiculare*

## PHYSIOGRAPHIC FEATURES

### Landforms

Plains (100%)

### Physiographic features (characteristics ranges)

## CLIMATIC FEATURES



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Climate:

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total:

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

INFLUENCING WATER FEATURES

REPRESENTATIVE SOIL FEATURES

Soil series components include Bahia Salinas, Meros, Jaucas, Redhook (USVI).

**Surface texture**

**Soil features**

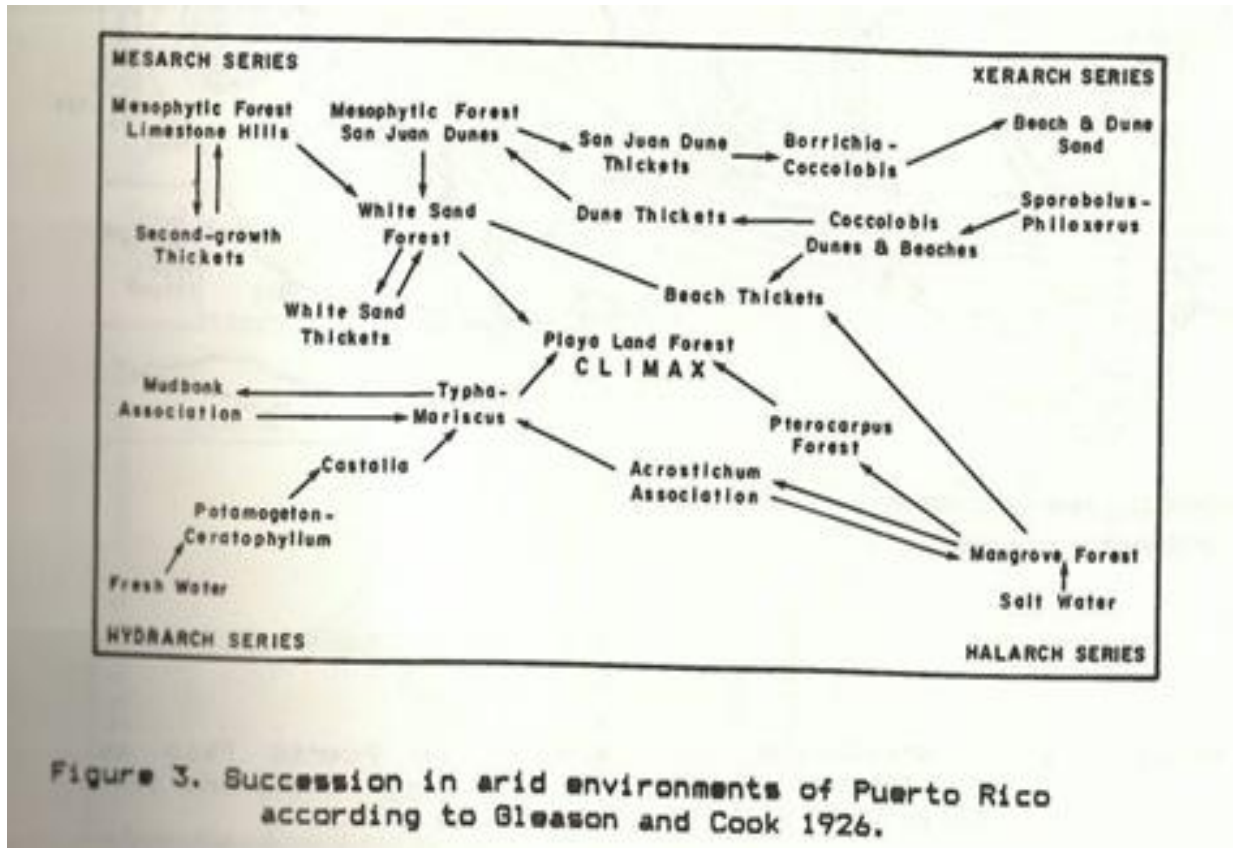
Family particle size:

**Soil features (characteristic ranges)**

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## ECOLOGICAL DYNAMICS OF THE SITE

### State and Transition Models



### COMMUNITY 1.1- State 1-Reference

### ECOLOGICAL SITES INTERPRETATION

### SUPPORTING INFORMATION

#### Similar sites

- Subtropical Moist Sandy Beach Forest (SB-Moist).

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SITE NAME: **SUBTROPICAL DRY VOLCANIC BOTTOMLAND FOREST (F271X...)**

MLRA 271-Semiarid Mountains and Valleys (76%), MLRA 273- Semiarid Coastal Plains (18%), MLRA 272-Humid Coastal Plains (4%), 270-Humid Mountains and Valleys (3%)

Occurrence: Puerto Rico, Vieques, Culebra, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Dry Volcanic Bottomland Forest (SDVBF) is the subtropical dry volcanic plain and the subtropical dry volcanic lower slope forest according to the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SDVBF falls within the National Vegetation Classification Group G585 Caribbean Dry Broadleaf Forest and D094 Caribbean and Central American Lowland Shrubland, Grassland, and Savanna (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include dry grasslands and pastures, lowland dry non-calcareous shrubland and woodland, and mature secondary lowland dry noncalcareous semideciduous forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966) this ecological site occurs within the Semi-deciduous forest subzone (zone III) which includes forest, savanna, scrub, and desert, and more than 18 vegetation communities.

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### Ecological Site Concept:

The SDVBF has an extension of 325 km<sup>2</sup> (~4% of the island), and occurs in the south and east of the island, Vieques and Culebra. This ecological site also occurs in the USVI represented in the land cover map by the subtropical dry non-calcareous forest classes (Gould et al. 2013). The vegetation in this ecological site is mostly a deciduous closed woodland that tends to form a complete ground cover (Ewel and Whitmore 1973). The vegetation in this ecological zone exhibits several adaptations to the xeric environment such as thorns, spines, small and succulent leaves, and low and flattened canopies. Fire is a common source of disturbance in this xeric forest. Some typical species in this life zone include *Bursera simaruba*, *Prosopis juliflora*, *Cephalocereus royenii*, *Bucida buceras*, *Pictetia aculeata*, *Guaiacum officinale*, *Guaiacum sanctum*, *Leucaena glauca*, *Tamarindus indica*, *Acacia macracantha*, *Acacia farnesiana*, *Melicoccus bijugatus* and five species of *Capparis*. *Sp.* (Ewel and Whitmore 1973). The SDVBF can be found in Boquerón and Guánica State Forests. A systematic inventory of the flora in the Guanica Natural Reserve provides an exhaustive description of the vegetation found there (Monsegur 2009).

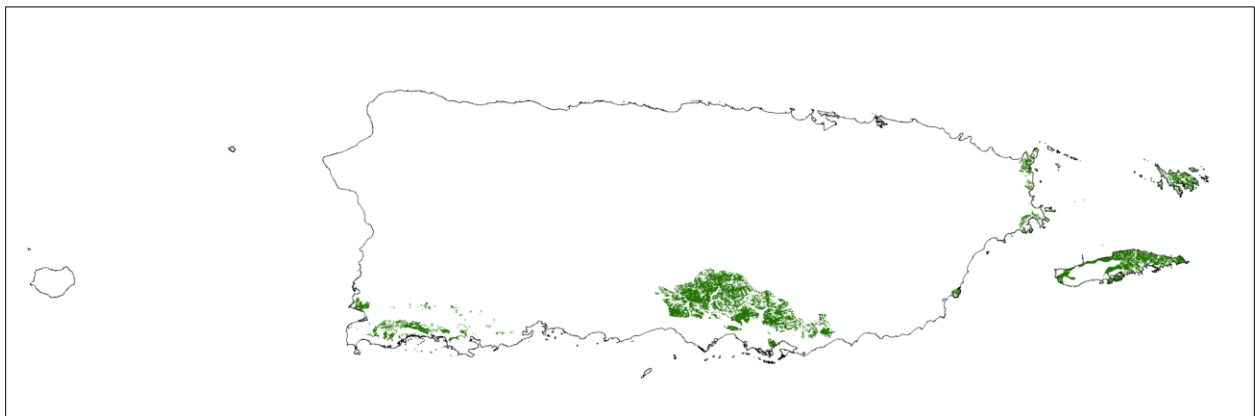


Figure 1. Distribution of the Subtropical Dry Volcanic Bottomland Forest in Puerto Rico.

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### **Dominant plant species:**

Dominant species in FIA plots within this ecological site in Puerto Rico include *Prosopis pallida*, *Poitea florida*, *Pithecellobium unguis-cati*, *Adelia ricinella*, *Coccoloba rugosa*, *Ouratea littoralis*, *Leucaena leucocephala* (Marcano-Vega 2019). Whereas species found within FIA plots located in this ecological site in the USVI included *Acacia muricata*, *Bourreria succulenta*, *Capparis cynophallophora*, *Pilosocereus royenii*, *Pisonia subcordata*, *Randia aculeata*. In addition, 5 out of 14 tree species assemblages occur in this ecological site in Puerto Rico, while the eight assemblages identified for the USVI are present within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### **Species assemblages:**

#### Puerto Rico

1. ***Leucaena leucocephala***, *Albizia procera* (Ex)
2. ***Acacia farnesiana***, ***Prosopis pallida***, *Albizia lebbek*
3. ***Bursera simaruba***, ***Bucida buceras***, ***Amyris elemifera***, ***Coccoloba diversifolia***, *Ocotea sintenisii*, *Myrsine coriacea*, *Licaria parvifolia*, *Senna siamea* (Ex), *Pictetia aculeata*, *Ocotea coriacea*.
4. ***Casearia guianensis***, ***Andira inermis***, ***Guazuma ulmifolia***, *Guapira fragans*, *Myrcia splendens*, *Cupania americana*.

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5. *Neolaugeria resinosa*, *Guettarda scabra*, *Eugenia monticola*, *Tabebuia haemantha*,  
*Pimenta racemosa*, *Randia aculeata*, *Clusia rosea*, *Casearia decandra*, *Bourreria  
succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*

## USVI

1. *Leucaena leucocephala*, *Samanea saman*
  2. *Casearia guianensis*, *Zanthoxylum monophyllum*, *Citharexylum fruticosum*, *Ziziphus mauritiana* (Ex), *Trichilia hirta*, *Zanthoxylum martinicense*, *Acacia macracantha* (Ex), *Andira inermis*, *Randia aculeata*, *Swietenia mahagoni* (Ex)
  3. *Eugenia monticola*, *Capparis baducca*, *Bursera simaruba*, *Maytenus laevigata*,  
*Sabinea florida*, *Ocotea coriacea*, *Bourreria succulenta*, *Chionanthus compactus*, *Cordia  
alliodora*, *Krugiodendron ferreum*
  4. *Prosopis pallida*
  5. *Acacia muricata*, *Pisonia subcordata*, *Eugenia cordata*, *capparis cynophallophora*,  
*Myrciaria floribunda*, *Amyris elemifera*, *Guettarda scabra*, *Bucida buceras*
  6. *Acacia farnesiana* (Ex), *Albizia lebbbeck* (Ex), *Inga laurina*
  7. *Guapira fragrans*, *Capparis indica*, *Cassine xylocarpa*, *Tabebuia heterophylla*, *capparis  
hastata*
  8. *Cordia alba*, *Melicoccus bijugatus*, *Croton astroides*, *Eugenia rhombea*, *Adelia ricinella*,  
*Tecoma stans*.
- **Other trees:** *Exostema caribaeum*, *Pisonia albida*, *Bourreira succulenta*, *Cepalocereus royenii*, *Amyris elemifera*, *Krugiodendron ferreum*, *Bucida buceras*, *Pictetia aculeata*,  
*Thouinia striata var portoricensis*, *Zanthoxylum flavum*, *Pithecellobium unguis-cati*,  
*Guaiacum officinale*, *Bursera simaruba*, *Comocladia dodonaea*, *Randia aculeata*,  
*Capparis cynophallophora*, *Bucida buceras*, *Coccoloba uvifera*, *Gymnanthes lucida*,

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*Leucaena leucocephala*, *Ateramnus lucidus*, *Coccoloba diversifolia*, *Antirhea acutata*,  
*Guaiacum sanctum*, *Eugenia foetida*.

- **Shrubs:** *Agave sisalana*, *Plumeria alba*, *Thrinax morrisii*, *Croton betulinus*, *Croton discolor*, *Croton lucidus*, *Thouinia striata* Radlk. var. *portoricensis*.
- **Herbs, cactus, succulents:** *Bromelia pinguin*, *Tragia volubilis*, *Leptocereus quadricostatus*, *Melocactus intortus*, *Opuntia repens*, *Opuntia stricta*, *Pilocereus royenii*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Side slope mogote (56%)

Plains (37%)

Steep slope mogote (3%)

Top mogote (3%)

### Physiographic features (characteristics ranges)

Elevation range: -2 m to 583 m (mean= 100 m)

Slope: 0-116% (mean= 17%, or 9 degree)

Aspect (mean): South (176 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SDVBF is about 1,139 millimeters. Rainfall is

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distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature is 18°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

### **Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,012 mm

### **Monthly precipitation (characteristic ranges)**

### **Monthly temperature (characteristic ranges)**

### **Monthly temperature (average minimum/maximum)**

### **INFLUENCING WATER FEATURES**

Water is limited, agriculture is possible with irrigation.

### **REPRESENTATIVE SOIL FEATURES**

Soil components include Parasol (intrusive), Amelia, Coamo, Cuyon, Guayama variant, Jacana, Llanos, Llanos Costa, Maguayo, Montalva, Poncena.

### **Surface texture**

### **Soil features**



Family particle size:

Soil features (characteristic ranges)

ECOLOGICAL DYNAMICS OF THE SITE

State and Transition Models

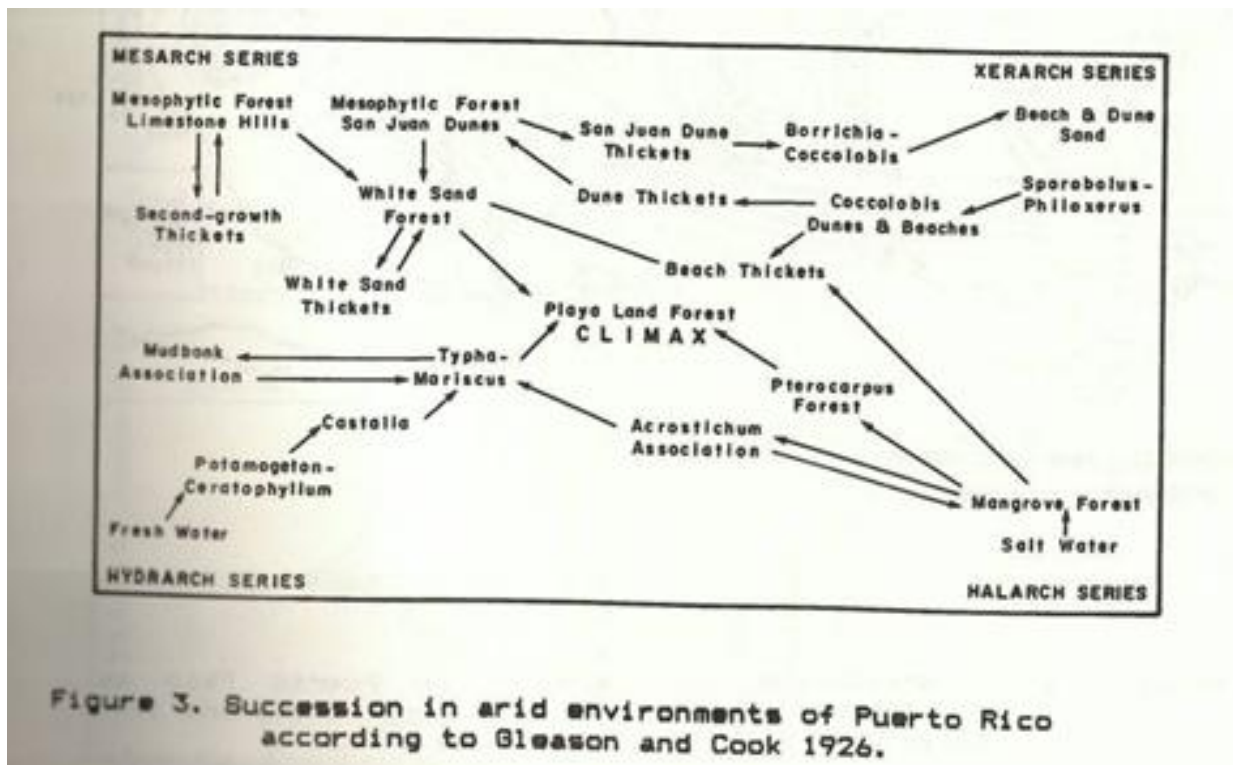


Figure 3. Succession in arid environments of Puerto Rico according to Gleason and Cook 1926.

COMMUNITY 1.1- State 1-Reference

ECOLOGICAL SITES INTERPRETATION

SUPPORTING INFORMATION

Similar sites

- Subtropical Dry Volcanic Upland Forest (SDVUF)

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SITE NAME: **SUBTROPICAL DRY VOLCANIC UPLAND FOREST (F271X...)**

MLRA 271-Semiarid Mountains and Valleys (82%), MLRA 273- Semiarid Coastal Plains (11%), MLRA 272-Humid Coastal Plains (4%), 270-Humid Mountains and Valleys (4%)

Occurrence: Puerto Rico, Vieques, Culebra, USVI

Site stage: Provisional

### **Classification Relationship**

The Subtropical Dry Volcanic Bottomland Forest (SDVUF) is the subtropical dry volcanic ridge and the subtropical dry volcanic upper slope forest according to the map of Landscape Units of Puerto Rico developed by the USDA Forest Service (Gould et al. 2008). The SDVUF falls within the National Vegetation Classification Group G585 Caribbean Dry Broadleaf Forest and D094 Caribbean and Central American Lowland Shrubland, Grassland, and Savanna (U.S. National Vegetation Classification 2019). Dominant vegetation covers within this ecological site include dry grasslands and pastures, lowland dry non-calcareous shrubland and woodland, mature secondary lowland dry noncalcareous semideciduous forest, and young secondary lowland dry noncalcareous semideciduous forest (Gould et al. 2007). In the map of vegetation zones developed by Danserau and Buell (1966) this ecological site occurs within the Semi-deciduous forest subzone (zone III) which includes forest, savanna, scrub, and desert, and more than 18 vegetation communities.

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### Ecological Site Concept:

The SDVUF has an extension of 126 km<sup>2</sup> (~1% of the island), and occurs in the south and east of the island, Vieques and Culebra. This ecological site also occurs in the USVI represented in the land cover map by the subtropical dry non-calcareous forest classes (Gould et al. 2013). The vegetation in this ecological site is mostly a deciduous closed woodland that tends to form a complete ground cover (Ewel and Whitmore 1973). The vegetation in this ecological zone exhibits several adaptations to the xeric environment such as thorns, spines, small and succulent leaves, and low and flattened canopies. Fire is a common source of disturbance in this xeric forest. Some typical species in this life zone include *Bursera simaruba*, *Prosopis juliflora*, *Cephalocereus royenii*, *Bucida buceras*, *Pictetia aculeata*, *Guaiacum officinale*, *Guaiacum sanctum*, *Leucaena glauca*, *Tamarindus indica*, *Acacia macracantha*, *Acacia farnesiana*, *Melicoccus bijugatus* and five species of *Capparis*. Sp. (Ewel and Whitmore 1973). The SDVUF can be found in Guánica State Forests. A systematic inventory of the flora in the Guanica Natural Reserve provides an exhaustive description of the vegetation found there (Monsegur 2009).

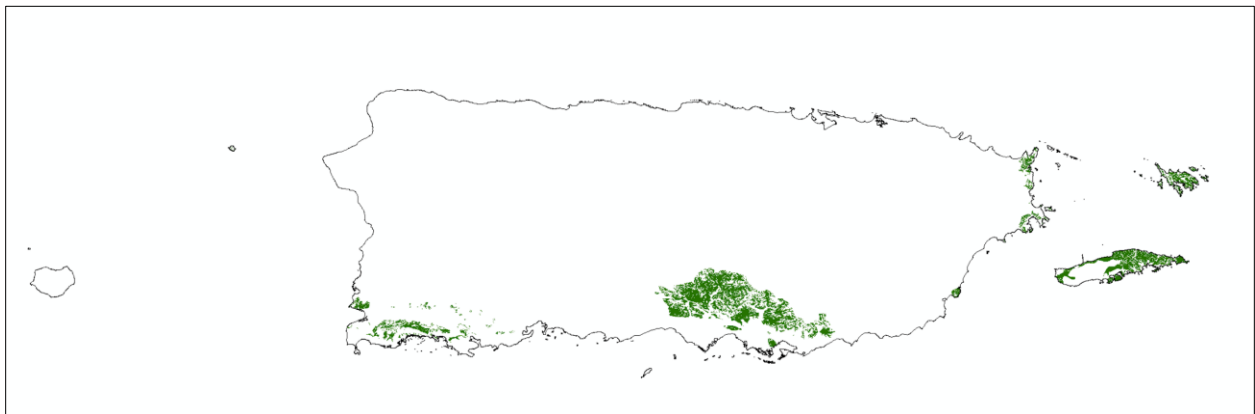


Figure 1. Distribution of the Subtropical Dry Volcanic Upland Forest in Puerto Rico.

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### Dominant plant species:

Dominant species in FIA plots within this ecological site in Puerto Rico include *Guapira fragrans*, *Bursera simaruba*, *Erythroxylum rotundifolium*, *Eugenia monticola*, *Pictetia aculeata*, *Adelia ricinella*, *Randia aculeata*, *Prosopis pallida*, *Bourreria succulenta*, *Cassine xylocarpa*, *Adelia ricinella*, *Acacia farnesiana* (Marcano-Vega 2019). Whereas species found within FIA plots located in this ecological site in the USVI included *Acacia muricata*, *Bourreria succulenta*, *Capparis cynophallophora*, *Pilosocereus royenii*, *Pisonia subcordata*, *Randia aculeata*. In addition, 5 out of 14 tree species assemblages occur in this ecological site in Puerto Rico, while the eight assemblages identified for the USVI are present within this ecological site (Brandeis et al. 2009). Assemblages are listed in decreasing order of importance, dominant species within each assembly are indicated in bold, and exotics with an “Ex”. Some species might be duplicated as the information was acquired from different sources.

### Species assemblages:

Puerto Rico

1. ***Leucaena leucocephala***, *Albizia procera* (Ex)
2. ***Acacia farnesiana***, ***Prosopis pallida***, *Albizia lebeck*
3. ***Bursera simaruba***, ***Bucida buceras***, ***Amyris elemifera***, ***Coccoloba diversifolia***, *Ocotea sintenisii*, *Myrsine coriacea*, *Licaria parvifolia*, *Senna siamea* (Ex), *Pictetia aculeata*, *Ocotea coriacea*.
4. ***Casearia guianensis***, ***Andira inermis***, ***Guazuma ulmifolia***, *Guapira fragrans*, *Myrcia splendens*, *Cupania americana*.

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5. *Neolaugeria resinosa*, *Guettarda scabra*, *Eugenia monticola*, *Tabebuia haemantha*,  
*Pimenta racemosa*, *Randia aculeata*, *Clusia rosea*, *Casearia decandra*, *Bourreria  
succulenta*, *Ocotea floribunda*, *Annona muricata*, *Homalium racemosum*

## USVI

1. *Leucaena leucocephala*, *Samanea saman*
  2. *Casearia guianensis*, *Zanthoxylum monophyllum*, *Citharexylum fruticosum*, *Ziziphus mauritiana* (Ex), *Trichilia hirta*, *Zanthoxylum martinicense*, *Acacia macracantha* (Ex), *Andira inermis*, *Randia aculeata*, *Swietenia mahagoni* (Ex)
  3. *Eugenia monticola*, *Capparis baducca*, *Bursera simaruba*, *Maytenus laevigata*,  
*Sabinea florida*, *Ocotea coriacea*, *Bourreria succulenta*, *Chionanthus compactus*, *Cordia alliodora*, *Krugiodendron ferreum*
  4. *Prosopis pallida*
  5. *Acacia muricata*, *Pisonia subcordata*, *Eugenia cordata*, *capparis cynophallophora*,  
*Myrciaria floribunda*, *Amyris elemifera*, *Guettarda scabra*, *Bucida buceras*
  6. *Acacia farnesiana* (Ex), *Albizia lebbbeck* (Ex), *Inga laurina*
  7. *Guapira fragrans*, *Capparis indica*, *Cassine xylocarpa*, *Tabebuia heterophylla*, *capparis hastata*
  8. *Cordia alba*, *Melicoccus bijugatus*, *Croton astroides*, *Eugenia rhombea*, *Adelia ricinella*,  
*Tecoma stans*.
- **Other trees:** *Exostema caribaeum*, *Pisonia albida*, *Bourreira succulenta*, *Cepalocereus royenii*, *Amyris elemifera*, *Krugiodendron ferreum*, *Bucida buceras*, *Pictetia aculeata*,  
*Thouinia striata var portoricensis*, *Zanthoxylum flavum*, *Pithcellobium unguis-cati*,  
*Guaiacum officinale*, *Bursera simaruba*, *Comocladia dodonea*, *Randia aculeata*,  
*Capparis cynophallophora*, *Bucida buceras*, *Coccoloba uvifera*, *Gymnanthes lucida*,  
*Leucaena leucocephala*

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- **Shrubs:** *Agave sisalana*, *Plumeria alba*, *Thrinax morrisii*, *Croton betulinus*, *Croton discolor*, *Croton lucidus*, *Thouinia striata* Radlk.var.portoricensis.
  - **Herbs, cactus, succulents:** *Bromelia pinguin*, *Tragia volubilis*, *Leptocereus quadricostatus*, *Melocactus intortus*, *Opuntia repens*, *Opuntia stricta*, *Pilocereus royenii*.

## PHYSIOGRAPHIC FEATURES

### Landforms

Steep slope (48%)

Top (35%)

Side slope (16%)

Plains (1%)

### Physiographic features (characteristics ranges)

Elevation range: 0 m to 642 m (mean= 177 m)

Slope: 0-129% (mean= 32%, or 18 degree)

Aspect (mean): South (184 degrees)

## CLIMATIC FEATURES

Climate: The mean annual precipitation in the SDVUF is about 1,275 millimeters. Rainfall is distributed throughout the year, with peaks in May and October, while the period December to March is dryer. The mean maximum temperature is 32 °C, and the mean minimum temperature

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is 18°C. Monthly temperatures are similar throughout the year, with higher temperatures occurring from May to September, when temperatures start to decrease due to cold fronts from the north.

**Annual climate normal (averages)**

Frost-free periods: NA

Freeze-free periods: NA

Precipitation total: 1,275 mm

**Monthly precipitation (characteristic ranges)**

**Monthly temperature (characteristic ranges)**

**Monthly temperature (average minimum/maximum)**

**INFLUENCING WATER FEATURES**

Water is limited, agriculture is possible with irrigation.

**REPRESENTATIVE SOIL FEATURES**

Soil components include: 1) INTRUSIVE: Jealously (USVI), Vieques (Vieques), 2) OTHERS: Bermeja, Callabo, Cerro Mariquita, Descalabrado, El Papayo, Guayama, Mariana, 3) EXTRUSIVE USVI: Annaberg, Cramer, Dorothea, Fredriskdal, Maho Bay, Southgate, Susannaberg, Victory.

**Surface texture**

**Soil features**

Family particle size:

Soil features (characteristic ranges)

Drainage class:

Permeability class:

Surface fragment cover  $\leq 3\%$ :

## ECOLOGICAL DYNAMICS OF THE SITE

### State and Transition Models

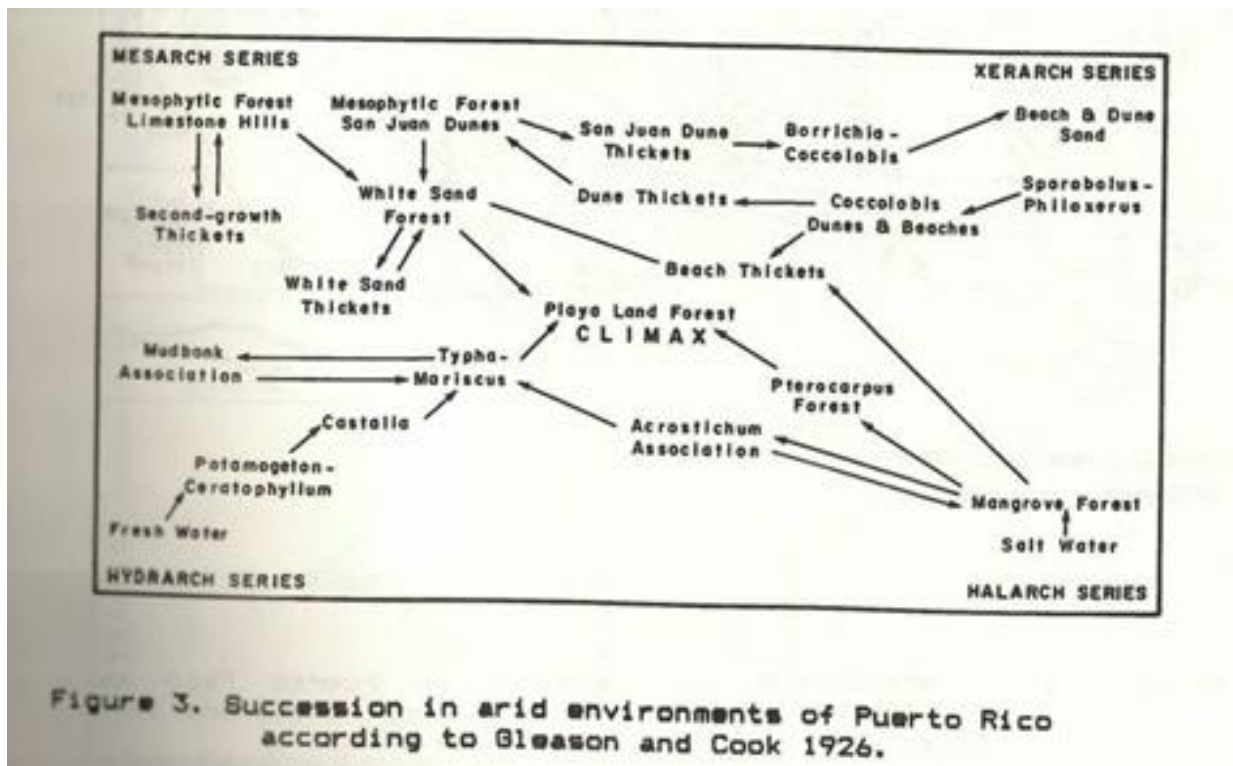


Figure 3. Succession in arid environments of Puerto Rico according to Gleason and Cook 1926.

### COMMUNITY 1.1- State 1-Reference

## ECOLOGICAL SITES INTERPRETATION



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## SUPPORTING INFORMATION

### **Similar sites**

- Subtropical Dry Volcanic Bottomland Forest (SDVBF)