CARIBBEAN ECOREGIONAL ASSESSMENT
PUERTO RICO

A view of forest interior near Rio Grande, the Caribbean National Forest Reserve
(Photo by Julio Figueroa-Colón)

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Terrestrial Biodiversity
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EXECUTIVE SUMMARY

Puerto Rico has a well-established protected areas system safeguarding good examples of tropical ecological systems that have survived human interference. Many fine studies by professional biologists and ecologists have contributed to a solid scientific infrastructure supporting biodiversity conservation in Puerto Rico. The Nature Conservancy, whose mission is conserving the Earth's biodiversity, promotes a science-based planning process to identify a network of conservation areas with a vision to protect 10% of representative major habitat types of the world. Since the initiation of the Caribbean Ecoregional Assessment Project in 2003, the Conservancy has been gathering biodiversity and socio-economic information relevant to conservation areas design. The major goal of the Project is to design a network of landscapes and seascapes that will protect Caribbean biodiversity over the long term. Puerto Rico's rich natural diversity and solid scientific infrastructure were the reasons that the Commonwealth was chosen as a pilot study area for developing and testing nuanced methods and tools before applying them to other parts of the Project area.

This report presents a preliminary terrestrial ecoregional plan for Puerto Rico and its archipelago. It will be integrated with reports of freshwater and marine components as soon as they become available. Results here offer a "picture" of the terrestrial biodiversity at a specific period of time, as suggested by the data sources. They should be updated periodically, because science-based conservation planning is a dynamic process of adapting data gathering, evaluation and decision-making to a changing landscape.

The general ecoregional assessment process applied to the Puerto Rican pilot study includes (1) identifying and mapping conservation targets; (2) assessing targets' ecological condition and impacts of human activities on targets; (3) setting conservation goals; (4) delineating a network of priority conservation areas; and (5) identifying gaps of biodiversity conservation in the current protected areas system—gap analysis. The purpose is to meet the following general conservation goals: protecting examples of all native ecosystem types across their environmental gradients**;** maintaining viable populations of all native species in natural patterns of abundance and distribution; and sustaining ecological and evolutionary processes, such as natural disturbance regimes, hydrological processes, nutrient cycles and biotic interactions. Mapping biodiversity provides the basis for conservation decision making (Richard Jeo, new info sheet, e-mail of 9/14/2004). We identified and mapped a range of *coarse filter* targets at the level of ecological systems using combinations of biophysical factors—climate, geology and elevation. We have also assessed the human impact on the condition of targets and mapped the relative intensity of instances of human activities.

Sixteen portfolios of the Commonwealth—the main island, Vieques, Culebra, and Mona—were generated with a software program called Marxan. We set area goals for individual conservation targets at 10% of historical extent and used the Marxan program to assemble portfolios under eight scenarios with a combination of the following parameters—with or without species occurrences data; with or without human impact; and locked or not locked in protected areas. The terrestrial portfolio that simulates the current situation, including the protected areas system, and that meets the area goals set for all coarse filter targets covers 169,260 ha. In addition to producing the optimal portfolio, Marxan generates a value called "irreplaceability" to measure the importance of an area in achieving the target goals. Thus irreplacability can be used to identify areas of rare biological elements and serve as guide to where actions should occur first. Irreplaceability values and gap analysis in this assessment suggest that we increase the representation of the moist vegetation on limestone, extrusive and sedimentary substrates and the dry vegetation on ultramafic and sedimentary substrates in the protected areas system.

Bidiversity and socio-economic information on Puerto Rico has been collected and entered into a database that will be made freely available to interested stakeholders via the internet (with the exception of sensitive or proprietary information). The information will be organized so that new data can be easily incorporated and maintained in a central location by The Nature Conservancy (Richard Jeo, new info sheet, e-mail of 9/14/2004). The Puerto Rico Ecoregional Assessment Project has so far gathered the following terrestrial info:

- Conservation target maps – historical and current extent of areas with vegetation
- Protected area maps (spatial extent and management type)
- Industrial agriculture maps (type and intensity)
- Tourism zones and a database of hotels (location and number of rooms)
- Urbanized areas, population density and projected population growth rate

Analytical tools that proved useful for identifying gaps in the existing protected area networks and for synthesizing the assembled biodiversity and socio-economic data to determine conservation priorities and promote sound resource management:

- Marxan portfolios of conservation areas—parameters in MARXAN can be adjusted to meet individual targets' conservation values and goals, allowing for quick and flexible production and comparison of multiple conservation scenarios.
- Conservation cost-surface model—predicting cumulative impact of human activities on conservation targets.
- Viability analysis—predicting ecological integrity of conservation targets based on experts' estimated current status of key ecological factors at targets' occurrences.
- Spatial pattern analysis using FRAGSTATS—quantifying habitat fragmentation of coarse filter targets.
- Connectivity analysis—assessments of landscape connectivity based on barriers to movement of organisms.
- Gap analysis—identification of critical habitats or species that are not represented in the official protected areas system.

With this project, we set forth what we consider the <u>most desirable</u> portfolio, shown in Figure 8, and list potentially viable habitat areas as priority conservation sites (Table 27) relying on the data on hand. But our ultimate goal is not "the portfolio," because a portfolio is always subject to change. TNC prefers to make freely accessible the baseline data system, science-based planning process, and analytical tools to agencies and local NGOs who will advance and improve the Puerto Rico protected areas system and contribute to the biodiversity conservation of the Caribbean Basin.

INTRODUCTION

Terrestrial Biodiversity Overview

The Commonwealth of Puerto Rico with its archipelago—Vieques, Culebra, Mona, Monita, Desecho, Culebrita, Caja de Muerto et al.—has a total land area of ca. 8,900 km^2, about the size of the state of Connecticut. Puerto Rico is distinguished by a wide range of environmental conditions. The Cordillera Central, an east-west oriented volcanic (clastic) mountain chain, straddles the central part of the island and reaches 1,388 m at its highest point. Other major mountain ranges are Sierra de Luquillo in the NE, Sierra de Cayey in the SE and Cordillera Jaicoa in the NW. The moisture-laden NE trade winds modified by aspects and elevation of mountain ranges create precipitation gradients largely on the NE-SW axis with moist to wet vegetation prevailing in the north and NE and dry vegetation in the rain shadow of the Cordillera Central, notably in the south and SW. The varied topography and complex geology are the cause of 28 geoclimatic zones (Figueroa-Colón 2003b, Table 1) in which vegetation and species have evolved and diversified.

Puerto Rico harbors a diverse flora and fauna with a high level of endemism. Many species are endemic to the West Indies in general, to the main island, to individual islands of the archipelago and to isolated areas within each island. With two ecoregions (Dinerstein et al. 1995, Table 1), the Commonwealth of Puerto Rico is characteriterized by 25 vegetation formations (Helmer et al. 2000, Table 2); 2,891 vascular plant species; and 396 vertebrate species—299 bird species, 36 mammal species, 18 amphibian species and 43 reptile species (Table 3). Endemism marks this rich terrestrial biota: reptiles (86%), amphibians (78%), birds (4%), and plants (8%). Moreover, Puerto Rico has the highest species diversity of herpetofauna per area in the Greater Antilles (Duellman 1999). The high diversity of herpetofauna may be related to the lack of terrestrial mammals in the island, leaving room for the species radiation of other faunal groups (review comments by Frank Wadsworth, e-mail of Feb.18, 2005).

Figueroa-Colón (1996a) examined the native flora of Puerto Rico and found that the mountain habitats harbor the highest number of endemic tree species within the Commonwealth. The trends of endemic tree species richness follow the humidity gradient—wet > moist > dry—or substrate gradient—volcanic > limestone > ultramafic. While there has been no documented loss of native plant species (Figueroa-Colón, pers. com., March 2003), several fauna species, e.g. the Mona giant turtle and Puerto Rican hutia, have become extinct. Furthermore, in the recent past extinction of local populations has been observed—lagarto de Culebra (*Anolis roosevelti*) (Rivero 1998), limpkin (*Aramus guarauna*) and white-necked crow (*Corvus leucognaphalus*) (review comments by Frank Wadsworth, e-mail of Feb.18, 2005).

The vegetation cover of Puerto Rico has undergone significant changes. In the 1940s, deforestation was the most intense, leaving only 6% forested land. With new economic and social trends agricultural activities lessened and by 1987, forests regenerated on abandoned agricultural fields, covering 35% of the island (Birdsey and Weaver 1987). The recent land cover map, based on 1991 Landsat TM imagery, indicates that now at least 41.6% of the main island is classified as forest (Helmer et al. 2002). This positive development is also reflected in the faunal populations, such as the spread of red-tailed hawks (*Buteo jamaicensis*), short-eared owls (*Asio* *flammeus*), Puerto Rican screech-owls (*Megascops nudipes*), loggerhead flycatchers (*Tyrannus caudifasciatus*), yellow-billed cuckoos (*Coccyzus americanus*), black-billed cuckoos (*Coccyzus erythropthalmus*), mangrove cuckoos (*Coccyzus minor*) and todies (*Todus mexicanus*). (Review comments by Frank Wadsworth, e-mail of Feb.18, 2005 and Leopoldo Miranda, e-mail of December 27, 2004.)

Modifications in the environment are considered the prime culprit of the faunal species extirpation. Other causes such as the introduced Indian mongoose (*Herpestes javanicus*) are believed to be responsible for the extinction of several species of lizards and snakes in the Caribbean (Henderson 1992). In Puerto Rico, ground nesting of brown booby (*Sula leucogaster*) is largely confined to Mona where there are no mongooses. The ruddy quail dove (*Geotrygon montana*) is said to have moved its nest from the ground to low shrubs because of mongooses. The whip-poor-will (*Caprimulgus vociferous*) survives nesting on the ground only in the dry forest where it is presumed that mongooses are uncommon (review comments by Frank Wadsworth, e-mail of Feb.18, 2005). Evidence also points to feral cats, dogs, pigs and goats, who often damage the native flora and fauna significantly (Rivero 1998).

Only a small part of the land of the Commonwealth of Puerto Rico (ca. 5.8%) is now under governmental protection. A preliminary analysis of the distribution of vegetation remnants and critical elements (rare or threatened plant and animal species) in Puerto Rico has confirmed the importance of the Forest Reserve network. Seventy percent of the ecosystems (geoclimatic regions), 87% of the critical plant species and 48% of the critical animal species occur in the reserves (Figueroa-Colón 2003c). Identifying priority areas that can be set aside for protection based on the occurrences of representative vegetation and faunal communities within distinct geoclimatic regions has been one of the most important tasks of the terrestrial team of the Ecoregional Assessment Project.

METHOD

General Approach

The terrestrial, freshwater and marine assessment teams of the Caribbean are developing a comprehensive portfolio of conservation areas in order to capture all significant and restorable biodiversity. The terrestrial team adheres to the general approach, outlined below, to assemble portfolios.

1. **Selection and mapping of conservation targets that represent the full range of terrestrial biodiversity**.
   Coarse filter conservation targets—ecological systems and vegetation formations—were identified and mapped with the help of spatial data sets of key environmental parameters that define the distribution of targets. Fine filter conservation targets—species groups or species—were singled out by examining a variety of species-occurrence databases. Both coarse and fine filter conservation targets were subsequently reviewed and their distribution verified in a series of experts' workshops.

2. **Incorporating the impact of human activities as "cost of biodiversity conservation" in the terrestrial portfolio.**
   The biodiversity cost involves generating a value that would essentially reflect the relative intensity of the human footprint per unit area. The higher the density or accumulation of human activities within a given area, the more difficult the long term conservation of biodiversity within that area.

3. **Using Marxan program to assemble a portfolio of conservation areas for Puerto Rico with deliberate conservation goals for individual targets.**
   We adopted Marxan (Ball & Possingham, 2000)—a computer program developed for reserve design—to help with portfolio assembly. Information about target distribution, location of protected areas, and location of various human activities was entered in Marxan. The entire project area was divided into hexagons of 260 ha which served as planning units to organize the data on target distribution.

   We set target conservation goals considering quantity, such as the size of proposed conservation areas for a specific target and quality, such as conditions of target occurrences. Based on the target conservation goals outlined by the terrestrial team and the cost value computed by the threat assessment team, Marxan assembled the optimal portfolio by selecting the necessary hexagons to meet the goals involving the least possible cost.

4. **Performing analyses to identify conservation gaps in the current protected area system.**
   A gap analysis was conducted to examine whether the current protected areas system adequately addresses target conservation goals. Results of viability analysis, connectivity analysis, fragmentation analysis, and experts' workshop were used to complement the proposed Marxan portfolio.

Biodiversity Assessment: Conservation Targets

The coarse filter terrestrial conservation targets and their occurrences were identified with the following two GIS overlays: (1) <u>geoclimatic regions</u> (Figueroa-Colón 1996b) revealed by the combination of the Holdridge Life Zones map (Ewel & Wetmore 1973) that provides biotemperature, precipitation and potential evapotranspiration ratio, and a simplified geological map (Figueroa-Colón 1996b), created by grouping different generic geological parent rocks by virtue of their soil-producing characteristics—**extrusive** volcanic rocks producing clay soils, **intrusive** igneous rocks producing sandy soils, **calcareous sedimentary** rocks producing relatively basic soils, **non-calcareous sedimentary rocks** producing relatively acidic soils, **ultramafic** rocks producing nutrient deficient, weathered soils and Quaternary **alluvial** deposits producing relatively nutrient-rich, loamy soils; and (2) <u>a recent land cover map</u> illustrating 25 vegetation formations of Puerto Rico (Helmer et al. 2002), Vieques and Culebra (IITF, e-mail of Olga Ramos on Feb. 10, 2004) with simplified vegetation classes—natural vegetation, non-natural vegetation and non-vegetation areas (see Table 2 for a list of vegetation formations and total area of individual vegetation formations; see also Appendix 1 for descriptions of individual vegetation formations).

The overlay of the natural vegetation class of the land cover map on Puerto Rico's 28 geoclimatic regions produced a map showing the distribution of currently remaining occurrences of terrestrial vegetation formations in each geoclimatic region (Keel et al. 2005, in preparation, Figure 1). Table 4 presents lists of current vegetation formations and their nested communities and species targets in individual geoclimatic regions. These vegetation remnants represent successions in each geoclimatic region and will eventually develop into the climax vegetation adapting to specific environmental conditions of individual geoclimatic regions. The preservation of the best vegetation remnants of each geoclimatic region should be a priority in order to allow successions to return to their original state. Thus vegetation remnants of each geoclimatic region can be treated collectively as one coarse filter ecosystem-level conservation target (Keel et al. 2005, in preparation). **Hereafter the name of a geoclimatic region will stand for ecosystem level target, that is, the collective vegetation remnants in a given geoclimatic region**. See Table 5 for descriptions of individual coarse filter ecosystem targets, and Appendix 2 for the distribution of vegetation patches of each coarse filter target and photos of current vegetation.

Mangroves and wetlands have been bracketed. Their distribution should be examined by the terrestrial as well as marine and freshwater teams, because mangroves and wetlands are part of aquatic systems where the hydrological regime plays a dominant role. In Puerto Rico and its archipelago there are 28 terrestrial coarse filter targets and another 2 terrestrial targets shared with the freshwater and marine teams (Figure 1).

Much species-level biodiversity, especially plant-species diversity, is captured by coarse filter targets. Species targets are those rare or threatened species assigned by The Natural Heritage Division of DNER with national conservation status—N1, N2 and N3 for species and T1, T2and T3 for subspecies/varieties. There are 195 plant targets (see Table 6) and 68 faunal targets (see Table 7). Descriptions of selected faunal species targets are presented in Table 8. For our portfolio design we selected only rare or threatened species with occurrences outside of the official protected areas—86 plant species (Table 17) and 28 faunal species (Table 16).

Viability Analysis

The terrestrial assessment team relied on biologists familiar with Puerto Rico biodiversity to assess the viability of individual conservation target occurrences. The experts were asked to list and prioritize the key ecological factors for each conservation target (see Table 9 & Table 10 for coarse filter targets, Table 11 & Table 12 for fauna targets) and to give estimates of maximum, minimum and most likely current key factor status at individual conservation target occurrences. The team used an iterative computer model to calculate viability and current biodiversity health of individual target occurrences. Target health, generally called "biodiversity health," is calculated as a weighted average of the deviations of the key factors' current status from the natural range of variation and expressed by a range of 0 to 1, with 1 indicating that all key factors are within the natural range of variability and the target is in perfect health. The value of biodiversity health allows us to compare the conditions of different occurrences of the same target and to associate the current status of occurrences with past and current human activities.

Threat Assessment

The threats assessment team, working in parallel with the terrestrial team, mapped Puerto Rico as a landscape of human activities. The team grouped human activities into three classes—protected areas that favor biodiversity conservation, and urban and agricultural areas that demand more serious conservation efforts. Urban areas include areas with infrastructure (e.g., canals, wastewater treatment plants and industries) and paved-over areas, such as roads. Agricultural areas involve areas where the natural environment has been modified and is being actively managed to produce crops for human consumption. The intensity of urban and agricultural activities was assessed during the June 2003 experts' workshop. The data layers of human activities specific to terrestrial areas were overlaid with target distribution maps to estimate the degree of impact of human activities on individual conservation targets and the cost to capture significant and restorable biodiversity.

The threats assessment team developed a basic cost surface model (Table 13) applicable to terrestrial/freshwater habitats and compatible with the Marxan program. To quantify the intensity of urban and agricultural activities, the team assumed that urban intensity is reflected in population density and that agricultural intensity is reflected in kilo calories (kcals) of inputs required for the production of different types of crops. Taking into account the understanding that the cumulative intensity of human activities is not a linear function, the team used a curve (Figure 2 & 3) to generate a function to facilitate the adding of urban and agricultural costs to achieve a unified cost value per unit area, such as the planning unit defined in the Marxan program. Using the following two functions, Urban function ($y = -0.0157x^3 + 0.1145x^2 + 0.0108x + 0.02$) and Agricultural function ($y = 0.0042x^3 + 0.0179x^2 + 0.0744x + .0007$), the team classified the intensity level into 6 classes for urban activities and 5 classes for agricultural activities, with the higher number indicating an incremental score of intensity level (Matthew McPherson, Basic Cost Surface, e-mail of 5/6/2004).

Fragmentation Analysis

To facilitate ecosystem management, an almost automated program, FRAGSTATS (McGarigal & Marks 1995), was used to perform spatial patterns analyses and measure degree of habitat fragmentation at landscape level.

Connectivity Analysis

Leidner et al. (in preparation, 2005) assess the spatial relationships among 30 coarse filter target occurrences to identify areas that are important for maintaining population dynamics via recruitment, genetic exchange, and long-distance rescue. To analyze connectivity between vegetation fragments, a modified series of programs developed by Urban (2003) was used. Three data sets were required for input: (1) the centers of each grouping of occurrences, called “nodes”; (2) the distances between each of these occurrences, called “edges”; and (3) the “least cost path distances” (LCPD) (Bunn et al. 2000) measuring the level of difficulty that species experience when traversing various kinds of natural, non-natural, or urban environments. The 30 coarse filter targets were grouped into four categories: wet/rain/moist, dry, mangrove and wetland. Other land area groupings include tillage agriculture, non-tillage agriculture, agroforestry, urban, saltwater and freshwater areas. To measure the degree of difficulty for a given group of targets to traverse across the other habitat types, we used a weighting system based on a scale of 1 to10, with 10 being the most difficult (Table 14).

The Thinedge program was used to examine the degree of connectivity based on a range of threshold dispersal distances. At each dispersal distance several measurements of connectivity were made. This program allows us to identify the distance over which a landscape is connected. The Sensinode program was used to measure the degree of change in recruitment, flux and traversability when each group of target occurrences is removed from the landscape. Recruitment (R) refers to the ability of an occurrence to recruit or produce individuals. It is based on the size and quality of the occurrence, a larger patch with higher quality can support more individuals, and will also serve as a source of more individuals for dispersal. Flux (F) is the measurement of “local connectivity” and is used as an indicator of the importance of a patch as a source or sink for propagules. This measurement is also dependant upon the distance between a given node and other nodes. Removing patches that are larger in size (and higher quality) and that are closer to other larger patches will result in greater change in F value for that node. Traversability (T) is the distance over which a landscape is connected. It represents areas that are “located in such a way as to bridge otherwise disconnected regions of the landscape” (Urban 2003). Removing patches that would connect otherwise isolated occurrences or groups of occurrences would result in greater change in T value.

Gap Analysis

The map of the official protected areas system was overlaid (one) on the coarse and fine filter target distribution maps to examine biodiversity gaps, and (two) on the map of the Least Cost Path Distances (see Figure 5) to examine connectivity gaps.

Marxan Runs and Conservation Goals

The 30 coarse filter conservation targets of Puerto Rico, reviewed by experts during a workshop held in San Juan on June 10-12, 2003, serve as building blocks for assembling a portfolio of conservation areas. On the basis of current land cover maps of Puerto Rico, including the main island and archipelago (Culebra, Vieques, Mona, Monita and Desecho), Helmer’s article on mapping and image interpretation (Helmer et al. 2002) and advice by Olga Ramos of IITF, we have been able to distinguish the general vegetation condition in its entire distribution range. We ranked the vegetation condition into 3 classes, with **1** indicating primary succession, **2**, secondary succession and **3**, mixed vegetation and land use (Table 15).

For the area goals of mangrove and wetland, the terrestrial team followed the decisions of the marine team and freshwater team respectively—65% of the current extent for mangrove and 25% for wetland. For all other terrestrial targets except for Dry-alluvial and Moist-alluvial, we set the goal of conserving 10% of the historical extent of each target in accordance with TNC's institutional mandate. "Historical extent" here refers to the theoretical or hypothetical vegetation area derived from the geoclimatic model. Geoclimatic regions therefore suggest the potential extent of individual vegetation types defined by climate, geology and unaffected by human interference (Keel et al. 2005, in preparation). The Dry-alluvial and Moist-alluvial, now with numerous scattered tiny vegetation remnants, present a formidable challenge for restoration. We set 30% of their current extent as our conservation goals. The Marxan program is set up so as to select individual target patches labeled with **1** first, followed by **2,** and subsequently by **3**, till the area goal is met. For example, to reach the conservation goal of 865.01 ha of moist vegetation on sedimentary substrate, Marxan will first select vegetation patches that were labeled "1". If the area of forest patches is less than 865.01 ha, the program will add patches of shrub or mixed forest/shrub/grassland that were labeled "2". If necessary, the Marxan program will add mixed vegetation and land use areas until the area goal of 865.01 ha is met (See Table 15).

The terrestrial team considered rare or threatened species of the Commonwealth identified by DNER. The occurrence maps of rare or threatened species (86 plant species [Table 17] and 28 faunal species [Table 16]) that <u>occur outside of official protected areas</u>, in conjunction with the map of coarse filter targets, constitute another input data set for separate Marxan runs. Portfolios of Marxan runs—one with coarse filter targets and another with both coarse <u>and</u> fine filter targets—were compared. We set a 100% conservation goal for rare or threatened species that occur outside of protected areas. We also overlaid the occurrence maps of all 195 rare or threatened plant species (Table 6), 13 species of cave-dwelling bats (occurrence data extrapolated from forest localities where the respective bat species have been caught while foraging) and 55 rare or threatened animal species (Table 7) on the portfolio based on coarse filter targets to examine to what degree fine filter targets can be captured.

Threat to conservation targets is expressed through cost surface. The cost surface incorporates the impact of agriculture, agriculture intensity, urban areas, roads, population density and industry. Protected area is another parameter that was incorporated in the Marxan program for portfolio assembly. After several test runs, a one-km sided hexagon covering 260 ha was selected as a unit, called planning unit, to organize and analyze data. This procedure resulted in 9,408 planning units for the Commonwealth of Puerto Rico. Various boundary lengths were also tested to encourage the clustering of conservation areas. The boundary length value of 0.0005 yielded the most sensible portfolio. We operated Marxan with eight scenarios: (1) with coarse filter targets, protected areas locked, and with cost surface; (2) with coarse filter targets, protected areas locked, and no cost surface; (3) with coarse filter targets, protected areas not locked, and with cost surface; (4) with coarse filter targets, protected areas not locked, and no cost surface; (5) with coarse <u>and</u> fine filter targets, protected areas locked, and with cost surface; (6) with coarse <u>and</u> fine filter targets, protected areas locked, and no cost surface; (7) with coarse <u>and</u> fine filter targets, protected areas not locked, and with cost surface; and (8) with coarse <u>and</u> fine filter targets, protected areas not locked, and no cost surface.

RESULTS and DISCUSSION

Gap Analysis

The gap analysis allows us to identify (1) targets that are not included in the protected areas system, and (2) targets that are insufficiently represented in the protected areas system, e.g., <10% of historical extent. Aware of the biodiversity gaps, we can improve the design of the protected areas system.

Overlaying the map of the protected areas system on individual coarse filter target distribution maps (see Appendix 2) shows that the vegetation remnants in 4 geoclimatic regions—Dry-ultramafic, LM-wet-alluvial, Moist-sedimentary and Wet-sedimentary (highlighted with **pink** in Table 18)—are not included in any of the current protected areas. Their inclusion in the protected areas system should be a top priority, labeled "1" in Table 18.

The vegetation remnants in another 4 geoclimatic regions—Dry-sedimentary, LM-wet-limestone, Moist-limestone and Moist-extrusive (highlighted with **yellow** in Table 18)—are not well represented in the protected areas system, that is, current vegetation remnants in the protected areas system make up less than 10 % of their historical extent. To set aside sufficient areas representing the vegetation on LM-Wet-limestone, Moist-limestone and Moist-extrusive for protection will be another priority, labeled "2" in Table 18. Realizing that an area of less than 1 ha of Dry-sedimentary is included in the protected areas system, we labeled Dry-sedimentary "1" instead.

The vegetation remnants in **Moist-alluvial**, **Moist-limestone**, **Moist-extrusive, Moist-intrusive** and Wet-alluvial geoclimatic regions (highlighted or partialy highlighted with **green** in Table 18) have less than 10% of their <u>high quality patches</u> included in the protected areas system**.** The fact that less than 10% of high quality moist life zone vegetation types—**Moist-alluvial**, **Moist-limestone**, **Moist-extrusive, Moist-intrusive—**were protected originated in Puerto Rico's land use history. Nearly all the coastal moist forests were converted to sugarcane fields before 1940 (review comments by Alexis Dragoni, e-mail of 1/13/2005). Adding high quality vegetation remnants to the current protected areas system in these geoclimatic regions would facilitate ecosystem management and reduce restoration cost. These targets, if not already included in "2", are labeled "3" in Table 18.

Overlaying the map of the protected areas system on the fine filter targets distribution map (Figure 4) shows that the rare or threatened species of Puerto Rico have been well inventoried. Except for *Anolis poncensis*, 263 taxa of rare or threatened flora and fauna have at least one of their occurrences included in the protected areas system (cf. the DNER database of June 2003). For 1,201 mapped rare or threatened species occurrences, 64% of flora and 71% of fauna occurrences are found in the protected areas system (Table 19).

Connectivity Analysis

Using Thinedge program, an analysis of all conservation targets that had more than four occurrences (Table 20) shows that the average distance at which there is a minimal connection in the landscape is 4.3 km and the average distance at which the landscape is completely connected is 41.2 km (Leidner et al. 2005, in preparation).

Figure 5 shows areas with high density of least cost paths. Overlaying these areas on the protected areas system reveals that a connectivity gap exists for eastern Puerto Rico (see Figure 6). The area around Aguas Buenas with moist vegetation on extrusive volcanic substrates (Figure 7, highlighted in yellow) has high density of least cost paths, which suggests that it is an important area with corridors. Moreover results of the Sensinode program show that the area around Aguas Buenas, if deforested or removed, has the greatest change in R and F values among all the target occurrences of Moist-extrusive, that is, the highest impact on recruitment and flux (see Table 21). This suggests that the Aguas Buenas area is important for recruiting due to its size and quality. The area is also a source or sinks for propagules due to its proximity to other target occurrences.

Fragmentation Analysis

Table 22 lists various metrics computed in FRAGSTATS for coarse filter targets on the main island (Steve Schill, e-mail of November 12, 2003).

The **area** metrics—**class area, percent of landscape** and **largest patch index**—show that Lower Montane (LM) wet–limestone and Rain–alluvial (highlighted with **red** in Table 22) are targets with very small total areas. They are unlikely to persist in the landscape for a long time. LM wet–alluvial and Dry–ultramafic (highlighted with **purple** in Table 22) are targets with total areas smaller than 100 ha. Both are severely fragmented, but the **largest patch index** shows that Dry-ultramafic (37 ha) has a better chance for recovery. The vegetation on ultramafic substrate can persist in a relatively small spatial area.

The **landscape configuration** metrics**—patch density, mean patch size, patch size coefficients of variation** and **patch size standard deviation —**show that each of the 9 ecosystem targets (Dry-alluvial, Dry-extrusive, Wetland, Wet-intrusive, Wet-extrusive, Moist-extrusive, Moist-intrusive, Moist-limestone and Moist-alluvial) has more than 5,000 patches. Dry-alluvial and Moist-alluvial are very fragmented (highlighted with **yellow** in Table 22). The total area of each target is comparatively small. As a result their **largest patch index** (<0.05) and **mean patch size** are small. The **patch size coefficient of variation** can be used to compare the patch size variability among landscapes for those targets with normal distribution about the mean. As patch size of targets in consideration is not always normally distributed, **the patch size coefficients of variation** and **patch size standard deviation** have been removed from Table 22.

Interpreting the **edge** metrics from a fragmentation perspective, we can compare **total edge** and **edge density** only of targets that are relatively similar in size. The higher the **edge density value** the greater the fragmentation of the target**.** For example, among Dry-alluvial, LM-Wet-Extrusive, Wet-Limestone and Wet-Ultramafic with similar **% land values,** from 0.39 to 0.55, Dry-alluvial shows the highest values of **total edge** (2,121 km) and **ed*ge* density** (1.711).

Among the **shape** metrics—**mean shape index (MSI), area-weighted MSI, mean patch fractal dimension (MPFD)** and **area-weighted MPFD**—we chose the **area-weighted MSI** to compare patch shape irregularity among targets and disregard the **MPFD** index because some of the targets have very small sample size, less than 20. The **area-weighted MSI** indicates that Moist-limestone, Moist-extrusive and Wet-extrusive (highlighted with **blue** in Table 22) have high values, indicating that their patch shapes are irregular, a sign of a more natural landscape configuration, in our case, a sign of more advanced succession.

Viability Analysis

A summary of the viability assessments of coarse filter targets is presented in Table 24. Vegetation patches in the Dry Holdridge Life Zone are in relatively poor ecological conditions, with relatively low biodiversity health value—0.59 for vegetation on alluvial, 0.6 for vegetation on sedimentary and 0.80 for vegetation on limestone derived substrates (highlighted with **yellow** in Table 24). In contrast, the vegetation in the Moist Holdridge Life Zone is in better condition, with biodiversity health value above 0.9, except for the remnants on alluvial deposits (biodiversity health value = 0.83). Results of viability analysis are consistent with results of fragmentation analysis indicating that low ecological integrity occurs in very fragmented remnants of Dry-alluvial and Moist-alluvial. Moreover vegetation remnants of Dry-alluvial and Moist-alluvial cover less than 10 % of their historical extent (see Table 15, cells highlighted with **pink**). The data suggest that traditionally the vegetation and biodiversity most affected by agriculture and/or human settlements were in the coastal areas of Dry and Moist Life Zones with fertile soils derived from alluvial deposits.

Results of the viability assessments of faunal targets are listed in Table 25. The Biodiversity Health Value (BH) = 0.8 is considered the threshold point indicating poor ecological conditions. Occurrences with BH<=0.8 consistently show that less than 50% of their key factors are within the natural range of variability (0.4~0.7). Faunal viability assessments indicate that habitats of shorebirds and waders represented by the indicator species Wilson's plover (*Charadrius wilsonia*) and habitats of Neotropical migrant passerines represented by the indicator species black-throated blue warbler (*Dendroica caerulescens*) are in poor quality with BH value lower than <=0.8. Some occurrences of Wilson's plover have BH value lower than 0.5 (See Table 26). Black-throated blue warbler (*Dendroica caerulescens*) is identified as an indicator of the role that the Caribbean plays in supporting migrant birds (Susan Koenig, pers. com., March 2004). The Insular Caribbean encompasses the majority of wintering habitats of black-throated blue warbler. Leopoldo Miranda (e-mail of 12/27/2004) pointed out that to take Wilson's plover as an indicator of connectivity between beaches, salt flats and coastal forests is not appropriate because Wilson's plover does not use forest habitats. (see Appendix 4 for reviewer's comments.)

Results of viability assessments indicate that the Puerto Rican Parrot (*Amazona vittata*) and White crowned pigeon (*Columba leucocephala*) are critically endangered with low BH values of 0.77 and 0.73 respectively (Table 25). This is consistent with DNER's conservation status rank—"N1" for *Amazona vittata* and " N2N3?" for *Columba leucocephala*. *Amazona vittata* has only one single population in El Yunque. This population hit a low of 13 individuals in 1975, but recovered to 36 in 1999. Establishing a second population in its historic range of Rio Abajo has been considered. Among the occurrences of *Columba leucocephala*, the populations in Mona, Culebra and Vieques are in good conditions, while those in the main island are mainly restricted to southern coastal areas with small forest patches (Susan Keonig, pers. com., March 2004). Of the seven sites observed, the Roosevelt Naval Station seems to be the only occurrence on the main island with relatively acceptable habitat condition (BH value = 8.1), although Leopoldo Miranda (e-mail of 12/27/2004) pointed out various healthy populations in the northern coast of the main island, e.g., Dorado, Toa Alta, Vega Alta and Vega Baja.

Terrestrial Portfolios

To obtain the optimal portfolio design for a given set of parameters that define a scenario, we had Marxan do 200 runs. The **optimal portfolio** of 200 runs, as opposed to the **irreplaceable portfolio**, is the set of planning units that is the least costly. It is the one that captures the largest number of targets with the least surface area. Out of 16 Marxan portfolios produced under 8 scenarios, we propose that the most desirable terrestrial portfolio would be the optimal solution that simulates the current situation. It is also the solution that locks in the official protected areas system. The most desirable terrestrial portfolio (Figure 8) considers only coarse filter targets. It includes 651 planning units (169,260 ha). When both coarse filter targets and fine filter targets (rare or threatened species that occur outside the protected areas system) are considered, the portfolio (Figure 9) includes 1,039 planning units. Coarse filter targets that are not included or insufficiently included in the current protected areas system are captured almost completely by the most desirable terrestrial portfolio (see Table 18). The percentages of the 25 vegetation formations included in the most desirable portfolio are listed in Table 2.

In addition to producing the optimal solution, Marxan also calculates the number of times that a planning unit was selected in each of the 200 runs, which became the measure of irreplaceability. Irreplaceability indicates the importance of a planning unit to achieving the target goals efficiently, because the biodiversity captured in that planning unit is unlikely to be captured elsewhere. The **irreplaceable portfolio** with protected areas being sampled randomly ("not locked") consist of 109 planning units when the coarse filter targets alone were considered (Figure 10), and 620 planning units when both coarse filter and fine filter targets were considered (Figure 11). The portfolio of Figure 11 shows dotted areas scattered all over the island with small clumps in the NE and southern coasts due to effects of aggregated species localities. No large or significant areas stand out. This is the reason that we put more emphasis on representing coarse filter targets when designing the portfolio.

Figure 12a presents results of the species targets occurrence maps that include 195 rare or threatened plant species (cf. the DNER database of June 2003), 13 cave-dwelling bat species (Susan Koenig, e-mail of 8/25/2004) and 55 rare or threatened animal species (cf. the DNER database of June 2003) overlaid on the most desirable portfolio. We examined the portfolio areas outside of the current protected area system (see Figure 12b) and assessed their biodiversity values in terms of coarse filter targets and rare or threatened species (Table 27). Among the selected sites in the portfolio, Culebra turns out to be rich in species targets, including species that are endemic solely to Culebra. Groups of fauna that need the most urgent protection are amphibians due to their high endemism (78%) and vulnerability to habitat changes and exotic predators.

A comparison of three optimal portfolios under different scenarios —Figure 13, 14, and 15— demonstrates that Marxan selects similar priority areas outside of protected areas. All 3 portfolios include sites in the NW (the transitional belt between Moist/Wet-limestone and Moist-extrusive/sedimentary regions), sites in the SW (the transitional belt between Moist/Wet-extrusive/intrusive and Moist/Wet-ultramafic regions), sites in the central east (mainly in the municipalities of Aguas Buenas and Guaynabo with large vegetation patches in recovery, see also Figure 16), and sites in the SE (areas of Sierra de Cayey in the northeastern Guayama). The current socioeconomic situation of the Aguas Buenas area was discussed in the workshop held on March 10-11, 2004, at San Juan. Connectivity analysis of all targets demonstrates that Aguas Buenas is the most important area for linking vegetation patches in the NE and those in the W (see Figure 6).

The general pattern of the three optimal portfolios that include both coarse and fine filter targets (see Figures 9, 14, and 15) is similar to that of the portfolio that was assembled by coarse filter targets first and then overlaid with fine filter targets occurrences (see Figure 12a). Comparing these four portfolios to the most desirable portfolio that does not consider fine filter targets (Figure 8), we noticed that the locations of selected sites in all five portfolios are quite similar. The portfolios that do include fine filter targets assign larger areas surrounding the selected sites, as seen in the site of the Guajataca Commonwealth Forest in the NW. The relatively stable portfolio patterns in different scenarios (Figure 8, 9, 12, 14 and 15) suggest that species occurrence data have a minor effect on choosing locations of priority sites (Keel et al. 2005, in preparation).

Marxan Portfolios: Pro and Con

To achieve its high efficiency, Marxan tends to pick transitional areas that represent many targets with the least surface area. To complement Marxan portfolios, we added several analyses in the hope that the results of connectivity analysis, fragmentation analysis and viability assessments will help to single out the areas important for corridors and ecological integrity. We suggest that Marxan be used first to provide a first-cut basic portfolio under standard parameters, and improve the portfolio subsequently by including results from various analyses and experts' workshops.

For example, in the March, 2004 workshop in San Juan, Alexis Dragoni pointed out that four large, high quality limestone forest patches, east of Guánica State Forest (see Figure 17), were not included in the Marxan portfolios. The viability values of these occurrences indicate that most key ecological factors in these target occurrences are within natural range of variability (Table 28) and that their biodiversity health values are high (0.94~1). Connectivity analysis reveals that these limestone forest patches are important for recruitment and flux (Table 29). We can use the results of viability and connectivity analyses to support experts' suggestions. Marxan is an additional and quite effective tool allowing us to objectively and quickly assemble portfolios of conservation areas and compare multiple conservation scenarios.

CONCLUSIONS

The use of models and application of analytical tools characterize the Caribbean Ecoregional Assessment Project. The Geoclimatic Model, Viability Model, connectivity analysis, fragmentation analysis and Marxan program were tested at various stages of the Project in data-rich Puerto Rico. The results in Puerto Rico have given us confidence that all the analytical tools developed can be applied to other islands.

The Geoclimatic Model has provided a solid framework for capturing biodiversity occurrences across environmental gradients. The relative stable patterns of optimal portfolios under 8 different scenarios indicate that the Geoclimatic Model adequately addresses the key environmental factors that determine vegetation types and the biodiversity they contain at the scale of ecosystem. Connectivity analyses single out areas important for corridors, recruitment, and biotic exchange under a given landscape context. Fragmentation analysis examines landscape patterns. Viability analysis adds experts' field knowledge of targets' occurrences to facilitate priority sites selection. Experts' estimates of the status of key ecological factors may also serve as guidance for managing or restoring habitats. The Marxan program greatly facilitates conservation portfolio design. By varying parameters to adapt to changing social conditions, such as conservation goals or socioeconomic impact, the program can generate a new portfolio in just 25 minutes. With advancing technology we are working towards automating computing parts of the analytical models, e.g., connectivity analysis and geoclimatic model, to help design portfolios in a more accurate, objective and timely fashion.

Comparing Marxan portfolios generated under different scenarios leads us to conclude that the <u>most desirable</u> portfolio (Figure 8) that considers coarse filter targets fills most of the biodiversity and connectivity gaps of the official protected areas system. By separating current vegetation remnants along the "condition" criterion, we can direct Marxan to assemble an optimal portfolio that includes most of the high-quality remnants (Keel et al. 2005, in preparation). We propose using the <u>most desirable</u> portfolio as a starting point and adjusting the outcomes or conservation priorities based on results obtained from connectivity analysis, viability assessment, fragmentation analysis and experts' workshop. In concrete terms, this study suggests that the following areas be set aside for conservation—Aguas Buenas vicinity, Wet/Moist-limestone forest east of Rio Abajo Forest Reserve, Moist and Dry-limestone forests east of Guanica Forest Reserve, and other areas listed in Table 27, such as Culebra.

Marxan is a convenient tool for designing a network of areas that promises to be the most cost-effective landscape configuration under a given set of constraints. Due to its high efficiency, Marxan tends to pick transitional areas that represent many targets in a most economic way. Occasionally, the transitional area may not be the most important area for conservation. The Marxan portfolios as well as their biodiversity values should therefore be reviewed by experts.

This study did not include field reconnaissance due to the short project life span. For ecosystem conservation, coarse filter targets such as vegetation maps are more important than the species distribution maps. The image data source for the land cover map dates back to 1991. An updated version with improved methodology to quickly produce an updated land cover map is badly needed. The abundant quality data from DNER and many knowledgeable field biologists in Puerto Rico have made the viability analysis possible. A significant project achievement is to bring all spatially referenced biological and ecological info together and make it accessible to conservation communities. The rapidly changing landscape should prompt more on-the-ground conservation activities that are guided with constantly updated info.

Due to the spatial scale of the ecoregional assessment project and the nature of the model approach, which tends to simplify the real world, we are aware of that we may have missed high biodiversity sites unrelated to geoclimatic parameters, as Frank Wadsworth (e-mail of 2/18/2005) rightly pointed out, "e.g., the areas dictated by topography (peaks, canyons, water-falls), caverns, sinkholes and abras between mogotes." Other components that we did not address in this project include threat assessments of exotic biota, global warming, and economic development trends. To remedy this, we would have to rely on collaborators conducting new studies in greater detail and finer scale.

Terrestrial biodiversity is only one aspect of Puerto Rico's biodiversity. The conservation portfolio of Puerto Rico and its archipelago should derive from the overlays of the optimal terrestrial, freshwater and marine portfolios chosen by individual teams. The current report addresses only the aspect of terrestrial biodiversity. We hope to see an integrated report in the near future.

Table 1. Ecoregions and corresponding geoclimatic zones of Puerto Rico (Sources: Dinerstein et al. 1995; Figueroa-Colón 1996b)

WWF Ecoregion	**Bedrock classe- Life Zone**	Alluvial	Limestone	Sedimentary	Volcanic-Extrusive	Volcanic-Intrusive	Ultramafic
Puerto Rican Dry Forests	Dry	X	X	X	X	X	X
PuertoRican Moist Forests	Moist	X	X	X	X	X	X
	Wet	X	X	X	X	X	X
	Rain	X	N/A	N/A	X	X	N/A
	Lower Montane/ Wet	X	X	N/A	X	X	X
	Lower Montane / Rain	N/A	N/A	N/A	X	X	N/A

Table 2. Twenty-five terrestrial vegetation formations of Puerto Rico (Source: IITF Forest and Land Cover Map of Puerto Rico 2000)

Vegetation – Formation (active or past land use are highlighted**)**	**Total Area (Ha.)**	**Total area (Ha.) in the official protected areas system**	**% natural veg. area in the official protected areas system (<=10% are highlighted)**	**Total area (Ha.) in the Pr_optimal portfolio.shp**	**% natural veg. area in the portfolio (<=10% are highlighted)**
Lowland dry semideciduous forest	16273.88	1224.19	7.52	2341.75	14.39
Lowland dry semideciduous woodland/shrubland	22745.04	2088.81	9.18	4008.4	17.62
Lowland dry mixed evergreen drought-deciduous shrubland with succulents	984.36	232.47	23.62	308.34	31.32
Lowland dry and moist, mixed seasonal evergreen sclerophyllous forest	3568.68	1503.71	42.14	1234.06	34.58

Lowland moist evergreen hemisclerophylous shrubland	90.38	40.16	44.43	68.66	75.97
Lowland moist seasonal evergreen forest	54497.11	1192.14	2.19	13791.78	25.31
Lowland moist seasonal evergreen forest/shrub	68026.1	493.03	0.72	17359.79	25.52
Lowland moist semi-deciduous forest	5188.56	403.72	7.78	279.52	5.39
Lowland moist semi-deciduous forest/shrub	1946.19	86.88	4.46	41.1	2.11
Lowland moist seasonal evergreen and semi-deciduous forest	25924.74	2890.66	11.15	9150.38	35.3
Lowland moist seasonal evergreen and semi-deciduous forest/shrub	26046.77	729.29	2.80	5479.71	21.04
Submontane and lower montane wet evergreen sclerophyllous forest	3102.84	2451.56	79.01	2325.41	74.94
Submontane and lower montane wet evergreen sclerophyllous forest/shrub	1927.7	1036.19	53.75	1090.32	56.56
Submontane wet evergreen forest	49716.92	5877.75	11.82	13247.12	26.65
Active sun/shade coffee, submontane and lower montane wet forest/shrub	26638.6	481.47	1.81	2722.23	10.22
Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee	52073.23	1024.37	1.97	5865.06	11.26
Lower montane wet evergreen forest - tall cloud forest	21638.67	9513.56	43.97	12754.19	58.94
Lower montane wet evergreen forest - mixed palm and elfin cloud forest	2954.12	2012.77	68.13	2153.24	72.89
Lower montane wet evergreen forest - elfin cloud forest	1071.57	607.49	56.69	621.19	57.97
Tidally and semi-permanently flooded evergreen sclerophyllous forest	6856.45	2523.33	36.80	3574.82	52.14
Seasonally flooded rainforest	313.95	200.88	63.98	225.32	71.77
Tidally flooded evergreen dwarf-shrubland and forb vegetation	51.77	0.34	0.66	0	0
Other emergent wetlands (including seasonally flooded pasture)	5742.15	1217.47	21.20	2078.68	36.2
Salt and mud flats	536.61	273.48	50.96	476.79	88.85
Pasture (including abandoned agricultural land)	324406.42	3543.60	1.09	25796.32	7.95

Table 3. Current diversity of Puerto Rican native terrestrial biota

Group	Total # of species	Rare or threatened species (DNER database, 2003)	# of endemic species	% of PR endemic species	Source

Vascular Plant	2891	409	236	**8**	Davis, S.D., et al. 1997
Mammal	36	7	0	0	Rodríguez-Duran, A. & T.H. Kunz, 2001; NatureServe database, 2004
Amphibian	18	11	14	**78**	NatureServe database, 2004
Reptile	43	14	37	**86**	Schwartz, A. & R. W. Henderson 1991
Birds	299	30	12	**4**	NatureServe database, 2004

Table 4. Cross-walk of Puerto Rican Geoclimatic regions to vegetation formations in the International Classification of Ecological Communities (ICEC) and IITF classification system

Caribbean Ecological System Targets: geoclimatic regions (Source: Figueroa-Colón 1996b & 2003b)	**Crosswalk to ICEC** (Source: Areces-Mallea, et al. 1999; Figueroa-Colón 2003c)	**Coarse filter targets: remaining vegetation formations / geoclimatic region** (Source: IITF Forest and Land Cover Map of Puerto Rico, 2000; Helmer et al. 2002)	**Keystone arboreal species** (Source: Figueroa-Colón 2003a; Ewel & Whitmore 1973)	**Nested Plant Targets: rare / endangered plant species with <=3 occurrences in PR** (Source: DNER database 2003; Figueroa-Colón 1996a & 2003a)	**Nested Faunal Targets** (Sources: División de Patrimonio Natural 1987; Ewel & Whitmore 1973)
Subtropical-dry vegetation-alluvial	• Hemisclerophyllous broad-leaved evergreen shrubland • Lowland microphyllous evergreen shrubland • Succulent extremely xeromorphic evergreen shrubland • Lowland drought-deciduous shrubland	• Lowland dry semideciduous forest • Lowland dry semideciduous woodland/shrubland	• *Bucida buceras* • *Guaiacum officinalis* • *Leucaena glauca*	*Not found.*	*Dermochelys coriacea*(G3), *Eretmochelys imbricata*(G3)

	• Lowland perennial forb vegetation • Lowland perennial forb vegetation				
Subtropical-dry vegetation-limestone	• Lowland semi-deciduous forest • Broad-leaved evergreen woodland • Hemisclerophyllous broad-leaved evergreen shrubland • Sclerophyllous broad-leaved evergreen shrubland • Succulent extremely xeromorphic evergreen shrubland • Lowland drought-deciduous shrubland • Medium-tall sod grassland	• Lowland dry semideciduous forest; • Lowland dry semideciduous woodland/shrubland; • Lowland dry mixed evergreen drought-deciduous shrubland with succulents	• *Hill forests: Pictetia aculeata, Gymnanthes lucida, Erythroxylon areolatum, Coccoloba venosa.* • *Gully forests: Guaiacum officinalis, Bursura simaruba*	*Abutilon commutatum, Agave eggersiana,Aristida chaseae, Bulbostylus curassavica, Caesalpinia culebrae, Caesalpinia monensis, Caesalpinia portoricensis, Catesbaea melanocarpa, Chamaesyce orbifolia, Cordia rupicola, Croton nummularaifolius, Cynanchum monense,Cyperus urbanii, Dalea carthagenensis var. portoricana, Erythrina eggersii, Eugenia boqueronensis, Eugenia glabrata, Eugenia woodburyana, Eupatorium oteroi, Harrisia portoricensis, Heliotropium guanicense, Jacquinia umbellate, Lantana strigosa,Leptocereus quadricostatus, Leptocereus gratianus, Malpighia setosa,*	*Caprimulgus noctitherus* (G1), *Agelaius xanthomus* (G1), *Peltophryne lemur* (G1), *Anolis cooki* (G2), *Eretmochelys imbricata* (G3)

				Mitracarpus maxwelliae, Mitracarpus polycladus, Myrciaria borinquena, Operculina triquetea, Opuntia borinquensis, Opuntia triacantha, Passiflora bilobata,Passiflora murucuya, Pilea richardii,Polygala hecathanta, Portulaca caulerpoides, Pseudophoenix sargentii ssp. sauna, Randia potoricensis, Sida eggersii, Stahlia monosperma, Trichilia triacantha.	
Subtropical-dry vegetation-sedimentary	Not found in Areces-Mallea et al. 1999.	• Lowland dry semideciduous forest; • Lowland dry semideciduous woodland/shrubland; • Lowland dry mixed evergreen drought-deciduous shrubland with succulents	*No data*	*Not found.*	*Not found.*
Subtropical-dry vegetation-ultramafic	Not found in Areces-Mallea et al. 1999.	• Lowland dry and moist, mixed seasonal evergreen sclerophyllous forest	*No data*	*Aristida chaseae,Aristida portoricensis, Eugenia woodburyana, Jacquinia umbellate, Trichilia triacantha.*	*Not found.*

Subtropical-dry vegetation-volcanic-extrusive	• Lowland drought deciduous shrubland • Medium-tall bunch grassland	• Lowland dry semideciduous forest; • Lowland dry semideciduous woodland/shrubland; • Lowland dry mixed evergreen drought-deciduous shrubland with succulents	• *Bucida buceras, Guazuma ulmiflora, Citharexylum fruticosum*	*Caesalpinia culebrae,Eugenia bellonis, Harrisia portoricensis, Justicia culebrae, Leptocereus gratianus, Lyonia truncata var. proctorii, Machaonia woodburyana, Myrciaria borinquena, Opuntia borinquensis, Opuntia triacantha, Peperomia myrtifolia, Pilea richardii, Zanthoxylum thomasiana.*	*Eretmochelys imbricata*(G3)
Subtropical-dry vegetation-volcanic-intrusive	Not found in Areces-Mallea et al. 1999.	• Lowland dry semideciduous forest; • Lowland dry semideciduous woodland/shrubland; • Lowland dry mixed evergreen drought-deciduous shrubland with succulents	• *Cordia nitida, Pictetia aculeata, Canella winterana.*	*Solanum conocarpum*	*Not found.*

Subtropical-moist vegetation-alluvial	• Submontane rain forest, broad-leaved evergreen woodland • Hemisclerophyllous broad-leaved evergreen shrubland • Lowland microphyllous evergreen shrubland • Lowland drought-deciduous shrubland • Medium-tall sod grassland • Lowland perennial forb vegetation	• Lowland moist evergreen hemisclerophylous shrubland • Lowland moist seasonal evergreen forest • Lowland moist seasonal evergreen forest/shrub	*Riverine forest: Pterocarpus officinale, Bucida buceras, Manilkara bidentata, Sideroxylon foetidissimum*	*Not found.*	*Columba inornata wetmorei* (G1), Columba leucocephala (G3), *Eretmochelys imbricata*(G3), *Dermochelys cariacea*(G3), *Dendrocygna arborea*(G3)
Subtropical-moist vegetation-limestone	• Submontane rain forest • Lowland semi-deciduous forest • Broad-leaved evergreen woodland • Lowland/ submontane broad-leaved drought-deciduous woodland • Broad-leaved evergreen shrubland • Lowland drought-deciduous shrubland • Medium-tall sod grassland	• Lowland moist semi-deciduous forest • Lowland moist semi-deciduous forest/shrub	*Gaussia attenuate (*an endemic palm and a conspicuous component of the limestone hill forests), *Coccoloba diversifolia, Licaria salicifolia, Bursera simaruba, Thouinia striata, Thespesia grandiflora*	*Adiantum vivesii*, *Agave eggersiana, Anthirhea portoricensis, Anthirhea sintenisii, Auerodendron pauciflorum, Banara vanderbiltii, Buxus portoricensis, Buxus vahlii, Calyptranthes estremerae, Calyptranthes thomasiana, Calyptronoma rivalis, Clidemia domingensis, Coccoloba pallida, Coccoloba tenuifolia, Cornutia obovata, Daphnopsis helleriana, Epidendrum kraenzlinii, Erythrina eggersii,*	*Diploglossus pleei* (G2G3), *Accipiter striatus venator* (G3T2)*, Mormoops blainvillii cinnamomeum* (G3T2)*, Epicrates inornatus* (G1G2), *Caprimulgus noctitherus*(G1), *Anolis occultus*(G2), *Pteronotus parnellii portoricensis* (G3T1), *Stenoderma rufum* (G2G3)

	• Lowland perennial forb vegetation.			*Eugenia underwoodii, Eupatorium borinquense, Eupatorium oteroi, Forchhammeria polystachya, Goetzia elegans, Henriettea membranifolia, Mappia racemosa, Myrcia paganii, Ottoschultzia rhodoxylon, Pleodendrum macranthum, Tectaria estremerana, Thelypteris hastata* var. *heterodoxa, Thelypteris verecunda, Thelypteris yaucoensis, Trichilia triacantha*.	
Subtropical-moist vegetation-sedimentary	Not found in Areces-Mallea et al. 1999	• Lowland moist seasonal evergreen forest • Lowland moist seasonal evergreen forest/shrub • Lowland moist semi-deciduous forest	• *No keystone species*	*Not found.*	*Anolis occultus*(G2)
Subtropical-moist vegetation-ultramafic	• Lowland/submontane broad-leaved drought -deciduous woodland	• Lowland dry and moist, mixed seasonal evergreen sclerophyllous forest	• *Tabebuia haemantha, Guettarda valenzuelana, Cassine xylocarpa*	*Alsophila brooksii, Aristida portoricensis, Buxus portoricensis, Calyptranthes thomasiana, Crescentia portoricensis, Diospyros revolute, Epidendrum kraenzlinii,*	*Caprimulgus noctitherus* (G1), *Stenoderma rufum darioi* (G2G3), *Eleutherodactylus eneidae*(G1G2), *Amphisbaena bakeri*(G2G3), *Diploglossus pleei*

				Ipomoea krugii, Trichilia triacantha.	(G2G3).
Subtropical-moist vegetation-volcanic-extrusive (or clay soils)	• Submontane rain forest • Semi-deciduous woodland • Broad-leaved evergreen shrubland • Lowland drought - deciduous shrubland • Medium-tall bunch grassland	• Lowland moist seasonal evergreen forest • Lowland moist seasonal evergreen forest/shrub • Lowland moist semi-deciduous forest	*Ceiba pentandra, Cedrela odorata, Calophylum brasiliense.*	*Agave eggersiana, Calyptronoma rivalis, Canna pertusa, Cassia mirabilis, Chrysophyllum bicolor, Clidemia domingensis, Coccoloba rugosa, Cornutia obovata, Cyperus urbanii, Dendropemon sintenisii, Dicliptera krugii, Diospyros sintenisii, Epidendrum kraenzlinii, Eugenia serrasuela, Galactia eggersii, Mariscus urbanii, Peperomia megalopoda, Pilea leptophylla, Pleodendrum macranthum, Pouteria hotteana, Psidium sintenisii, Psiguria trifoliate, Solanum mucronatum, Thelypteris yaucoensis, Tillandsia lineatispica, Vernonia proctori, Zanthoxylum thomasiana.*	*Columba inornata wetmorei*(G1), *Eleutherodactylus karlschmidti* (G1), *Eretmochelys imbricata* (G3).

Subtropical-moist vegetation-volcanic-intrusive (or sandy soils)	Not found in Areces-Mallea et al. 1999	• Lowland moist seasonal evergreen forest • Lowland moist seasonal evergreen forest/shrub • Lowland moist semi-deciduous forest	*Ceiba pentandra, Cedrela odorata, Calophylum brasiliense*	*Panicum stevensoniana, Shoepfia arenaria, Scleria doradoensis.*	*Epicrates inornatus* (G1G2), *E. monensis* (G2), *Dermochelys coriacea*(G3), *Eretmochelys imbricata*(G3).
Subtropical-wet vegetation-alluvial (or fertile loamy soils)	• Submontane rain forest	•	*Pterocarpus officinale, Sapium laurocerasus*	*Not found*	*Eleutherodactylus eneidae*(G1G2), *E. hedricki*(G2), *Amphisbaena bakeri*(G2G3), *Buteo platypterus brunnescens* (G3T2), *Accipiter straiatus venator* (G3T2).
Subtropical-wet vegetation-limestone	• Submontane rain forest	• Lowland moist seasonal evergreen forest • Lowland moist seasonal evergreen forest/shrub • Lowland moist semi-deciduous forest • Lowland moist semi-deciduous forest/shrub	• *Hieronyma clusiodes, Thespesia grandiflora, Ocotea leucoxylon*	*Clidemia portoricensis, Cordia bellonis, Dracontium polyphyllum, Pleodendrum macranthum, Thelypteris inabonensis.*	*Melanerpes portoricensis* (G3), *Buteo platypterus brunnescens* (G3T2), *Myiarchus antillarum*(G3).
Subtropical-wet vegetation-sedimentary	Not found in Areces-Mallea et al. 1999.	?	*No data*	*Not found.*	*Melanerpes portoricensis* (G3), *Myiarchus antillarum* (G3).

Subtropical-wet vegetation-ultramafic	• Broad-leaved evergreen shrubland	• Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee	• *Tabebuia haemantha, Calycogonium krugii, Linociera domingensis* • *Dacryodes excelsa, Sloanea berteriana, Meliosma herbertii, Tetragastris balsamifera, Buchenavia capitata, Guarea guidonea.*	*Alsophila brooksii*, *Calyptranthes peduncularis*, *Calyptranthes triflorum*, *Cordia bellonis, Crescentia portoricensis, Croton impressus, Diospyros revolute, Eugenia glabrata, Gesneria pauciflora, Lunania ekmanii, Mikania stevensiana, Myrcia maricaoensis, Phialanthus grandifolius, Phialanthus myrtilloides, Thelypteris hastata* var. *Heterodoxa*, *Xylosma pachyphyllum, Xylosma schaefferiodes*.	*Diploglossus pleei* (G2G3), *Accipiter striatus venator* (G3T2), *Anolis occultus* (G2), *Amphisbaena bakeri* (G2G3), *Eleutherodactylus eneidae*(G1G2).
Subtropical-wet vegetation-volcanic-extrusive	• Submontane rain forest • Broad-leaved evergreen shrubland • Short sod grassland	• Submontane wet evergreen forest • Submontane and lower montane wet evergreen sclerophyllous forest • Submontane and lower montane wet evergreen sclerophyllous forest/shrub • Submontane and lower	• *Dacryodes excelsa, Sloanea berteriana, Meliosma herbertii, Tetragastris balsamifera, Buchenavia capitata, Guarea guidonea.*	*Basiphyllea augustifolia, Brunfelsia portoricensis, Bunchosia nitida, Callicarpa ampla, Canna pertusa, Chione seminervis, Coccoloba rugosa, Conostegia hotteana, Cordia wagnerorum, Cyperus urbanii, Dicliptera krugii, Diospyros revoluta, Dracontium polyphyllum, Elaphoglossum serpens, Encyclia krugii, Eugenia*	*Eleutherodactylus eneidae*(G1G2), *E. jasperi*(G1). *E. karlschmidti*(G1), *E. hedricki*(G2), *Amazona vittata* (G1), *Epicrates inornatus* (G1G2), *Anolis occultus* (G2N2), *Accipiter striatus venator* (G3T2), *Buteo platypterus brunnescens* (G3T2)

		montane wet evergreen forest/shrub and active/abandoned shade coffee • Lower montane wet evergreen forest - tall cloud forest • Lower montane wet evergreen forest - mixed palm and elfin cloud forest • Lower montane wet evergreen forest - elfin cloud forest		*haematocarpa, Eupatorium droserolepis, Juglans jamaicensis, Justicia borinquensis, Laplacea portoricensis, Lepanthes eltorensis, Lunania ekmanii, Mariscus urbanii, Marlieria sintenisii, Marsdenia elliptica, Ossaea krugiana, Ossaea scabrosa, Peperomia wheeleri, Pilea multicaulis, Pleodendrum macranthum, Polystichum calderonensis, Pouteria hotteana, Solanum woodburyana, Styrax portoricensis, Thelypteris inabonensis, Xylosma schwaneckeanum.*	
Subtropical-wet vegetation-volcanic-intrusive	Not found in Areces-Mallea et al. 1999.	• Submontane wet evergreen forest • Submontane and lower montane wet evergreen sclerophyllous forest • Submontane and lower montane wet evergreen sclerophyllous	*Dacryodes excelsa, Sloanea berteriana, Meliosma herbertii, Tetragastris balsamifera, Buchenavia capitata, Guarea guidonea.*	*Callicarpa ampla*	*Accipiter striatus venator* (G3T2)

		forest/shrub • Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee • Lower montane wet evergreen forest - tall cloud forest • Lower montane wet evergreen forest - mixed palm and elfin cloud forest • Lower montane wet evergreen forest - elfin cloud forest			
Subtropical-rain vegetation-alluvial	Not found in Areces-Mallea et al. 1999.	• Submontane wet evergreen forest • Submontane and lower montane wet evergreen sclerophyllous forest • Submontane and lower montane wet evergreen sclerophyllous forest/shrub • Submontane	*No data*	*Not found.*	*Not found.*

		and lower montane wet evergreen forest/shrub and active/abandoned shade coffee • Lower montane wet evergreen forest - tall cloud forest • Lower montane wet evergreen forest - mixed palm and elfin cloud forest • Lower montane wet evergreen forest - elfin cloud forest			
Subtropical-rain vegetation-volcanic-extrusive	• Montane rain forest • Montane cloud forest • Broad-leaved evergreen shrubland	• Submontane wet evergreen forest • Submontane and lower montane wet evergreen sclerophyllous forest • Submontane and lower montane wet evergreen sclerophyllous forest/shrub • Submontane and lower montane wet	*Tabebuia rigida, Eugenia borinquensis, Heterotrichum cymosum, Gonocalyx portoricensis.*	*Gonocalyx concolor, Habernaria dussii.*	*Epicrates inornatus* (G1G2), *Buteo platypterus brunnescens* (G3T2)*, Myiarchus antillarum* (G3), *Falco peregrinus anatum* (G3*), Chlorostilbon maugaeus* (G3).

		evergreen forest/shrub and active/abandoned shade coffee • Lower montane wet evergreen forest - tall cloud forest • Lower montane wet evergreen forest - mixed palm and elfin cloud forest • Lower montane wet evergreen forest - elfin cloud forest			
Subtropical-rain vegetation-volcanic-intrusive	Not found in Areces-Mallea et al. 1999.	• Submontane wet evergreen forest • Submontane and lower montane wet evergreen sclerophyllous forest • Submontane and lower montane wet evergreen sclerophyllous forest/shrub • Submontane and lower montane wet evergreen forest/shrub and		*Not found.*	*Not found.*

		active/abandoned shade coffee • Lower montane wet evergreen forest - tall cloud forest • Lower montane wet evergreen forest - mixed palm and elfin cloud forest • Lower montane wet evergreen forest - elfin cloud forest			
Subtropical-lower montane-wet vegetation-alluvial	Not found in Areces-Mallea et al. 1999.	• Submontane wet evergreen forest • Submontane and lower montane wet evergreen sclerophyllous forest • Submontane and lower montane wet evergreen sclerophyllous forest/shrub • Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee	*No data*	*Not found.*	*Not found.*

		• Lower montane wet evergreen forest - tall cloud forest • Lower montane wet evergreen forest - mixed palm and elfin cloud forest • Lower montane wet evergreen forest - elfin cloud forest			
Subtropical-lower montane-wet vegetation-limestone	Not found in Areces-Mallea et al. 1999.	? Check map?	*No data*	*Not found.*	*Not found.*
Subtropical-lower montane-wet vegetation-ultramafic	• Montane rain forest	• Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee	*Magnolia portoricensis, Brunellia comocladifolia, Podocarpus coriacea, Tabebuia schumanniana.*	*Not found.*	*Not found.*
Subtropical-lower montane-wet vegetation-volcanic-extrusive	• Montane rain forest • Montane cloud forest • Broad-leaved evergreen shrubland • Short sod grassland.	• Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee	*Cyrilla racemiflora* (The hollow trunks of the *Cyrilla racemiflora* are the main nesting sites of *A.vittata vittata*), *Cyathea arborea, Prestoea Montana* (Pure stands of *Prestoea Montana* palm brakes are found in the steep	*Banara portoricensis, Brachionidium ciliolatum, Eugenia margarettae, Gonocalyx concolor, Habernaria dussii*, *Ternstroemia luquillensis*, *Ternstroemia subsessilis.*	Amazona vittata vittata (G1, The hollow trunks of the *Cyrilla racemiflora* are the main nesting sites of *A.vittata vittata*), *Eleutherodactylus eneidae*(G1G2), *E. jasperi*(G1). *E. portoricensis* (G3), *E. hedrick*i(G2),

			slopes), *Magnolia splendens, Croton poecilanthus, Matayba domingensis, Micropholis chrysophylloides.*		*Anolis occultus* (G2N2), *Accipiter striatus venator* (G3T2), *Buteo platypterus brunnescens* (G3T2). *Dendroica angelae* (elfin woods warbler) is endemic to cloud forest.
Subtropical-lower montane-wet vegetation-volcanic-intrusive	Not found in Areces-Mallea et al. 1999.	• Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee	*Cyrilla racemiflora, Cyathea arborea, Prestoea montana, Magnolia splendens, Croton poecilanthus, Matayba domingensis, Micropholis chrysophylloides.*	*Not found.*	*Amazona vittata vittata* (G1), *Anolis occultus* (G2), *Eleutherodactylus encidae* (G1G2), *Buteo platypterus brunnescens* (G3T2).
Subtropical-lower montane-rain vegetation-volcanic-extrusive	• Montane rain forest • Montane cloud forest • Broad-leaved evergreen shrubland.	• Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee	*Calycogonium squamulosum, Clusia krugiana, Eugenia borinquensis, Alsophila bryophylla.*	*Gonocalyx concolor, Habernaria dussii.*	*Eleutherodactylus eneidae*(G1G2), *E. locustus*(G1). *E. karlschmidti*(G1), *E. unicolor*(G1), *E. gryllus*(G2G3) *E. richmondi* (G2), *E. wrightmanae* (G3N3), *Anolis occultus* (G2N2), *Accipiter striatus venator* (G3T2), *Buteo platypterus brunnescens* (G3T2), *Stenoderma rufum dariori* (G2G3), *Dendroica angelae* (G1G2),

					Diploglossus pleei (G2G3), *Saurothera vieilloti* (G3), *Anthrqacothorax viridis* (G3), *Columba leucocephala* (G3), *Mormoops blainvillii cinnamomeum* (G3T2),*Falco peregrinus anatum* (G3), *Chlorostilbon maugaeus* (G3).
Subtropical-lower montane-rain vegetation-volcanic-intrusive	Not found in Areces-Mallea et al. 1999.	• Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee	*Calycogonium squamulosum, Clusia krugiana, Eugenia borinquensis, Alsophila bryophylla.*	*Not found.*	Stenoderma rufum dariori (G2G3).
Mangrove	• Tidally flooded broad-leaved evergreen sclerophyllous closed tree canopy • Tidally flooded broad-leaved evergreen shrubland	• Tidally and semi-permanently flooded evergreen sclerophyllous forest	*Avicennia germinans, Rhizophora mangle, Laguncularia racemosa*	*Not found.*	*Agelaius xanthomus* (G1), *Falco peregrinus anatum* (G3), *Melanerpes portoricensis* (G3), *Anas bahamensis* (G3G5), *Fulica caribaea* (G3), *Loxigilla portoriensis* (G3), *Sterna dougallii* (G3), *Chelonia mydas* (G3), *Eretmochelys imbricata* (G3), *Dendrocygna arborea* (G3), *Trichechus manatus manatus* (G2?).

Wetland vegetation (forest/ shrubland/ grassland)	• Seasonally flooded rain forest • Semi-permanently flooded broad-leaved evergreen sclerophyllous forest • Tidally flooded needle-leaved/microphyllous evergreen dwarf-shrubland • Lowland perennial forb vegetation • Tidally flooded perennial forb vegetation • Permanently flooded hydromorphic vegetation • Tidal permanently flooded hydromorphic rooted vegetation • Intermittently flooded sand beaches and shores.	• Seasonally flooded rainforest • Tidally flooded evergreen dwarf-shrubland and forb vegetation • Other emergent wetlands (including seasonally flooded pasture) • Salt and mud flats	• Swamp forests: *Pterocarpus officinale*, *Manilkara bidentata ssp*, *surinamensis*, *Calophyllum brasiliense, Roystonea sp.* • Dwarf shrubland on salt flats: *Batis maritima* • Forb vegetation: *Acrostichum aureum, Acrostichum danaeifolium*	*Not found.*	*Falco peregrinus anatum* (G3), *Dendrocygna arborea*(G3), *Agelaius xanthomus* (G1), *Porzana flaviventer* (G2G4), *Oxyrura dominica (G3), Dermochelys coriacea (G3), Epicrates inornatus, Chelonia mydas, Columba leucocephala (G3), Fulica caribaea* (G3).

Table 5. Puerto Rico ecosystem target descriptions

Caribbean Ecological systems / geoclimatic regions	**Life zone characteristics** (Source: Ewel and Whitmore 1973)	**Target Descriptions (**Source: Areces-Mallea et al. 1999; Dansereau 1966; Ewel and Whitmore 1973; DNER 1987)

Subtropical-dry vegetation-alluvial	**DRY LIFE ZONE**: Mean annual rainfall: 600 - 1000 (1100) mm. vegetation tends to form a complete ground cover, and almost entirely deciduous on most soils. Tree heights usually do not exceed 15 m. The crowns are broad, spreading, and flattened, with sparse foliage. Succulent or coriaceous leaves, thorns and spines are common. Vegetation commonly found in this life zone is drought-deciduous woodland dominated by *Bursera simaruba* and *Pilosocereus royenii, or Bucida buceras - Savia sessiliflora - Krugiodendron ferreum.* Bird species richness is higher than wetter life zones. Indicator tree species for the dry forest life zone include: *Bursera simaruba, Prosopis juliflora, Cephalocereus royenii, Pictetia aculeata, Bucida buceras, Guaiacum officinale, G. sanctum,Tamarindus indica, Acacia macracantha, A. farnesiana, Melicoccus bijugatus, Capparis spp.* **Example: Guanica Foerest Reserve**	Include *Coccoloba uvifera –Thespesia populnea* **hemisclerophyllous evergreen shrubland,** an oceanwards berm communities**;** *Pilosocereus royenii - Agave karatto* **succulent evergreen shrubland**; *Acacia macracantha - Acacia farnesiana* **drought-deciduous shrubland;** *Chamaesyce mesembrianthemifolia* **dwarf-shrubland;** *Ipomoea pes-caprae* **vine-shrubland;** *Sesuvium portulacastrum* **forb vegetation**. In low alluvial areas with saline soils, the vegetation is dominated by *Prosopis juliflora.* In areas with imperfect drainage, pure stands of *Parkinsonia aculeata* are found. Both *Prosopis juliflora*and *Parkinsonia aculeata* are introduced species.
Subtropical-dry vegetation-limestone	**DRY LIFE ZONE**	Soil is often only represented by accumulations of humus in the grykes of the limestone karst. **Semi-deciduous forest** dominated by *Coccoloba diversifolia - Bursera simaruba - Bucida buceras - Zanthoxylum martinicense* occurs. It has a canopy height of 5-15 m with some emergents. A lower layer may or may not present, and ground vegetation is sparse. Other vegetation communities include: *Randia aculeata - Didymopanax morototoni* **evergreen woodland**; various **evergreen shrublands:** *Melocactus intortus - Opuntia rubescens - Pilosocereus royenii - Stenocereus hystrix - Oplonia spinosa - Conocarpus erectus* evergreen shrubland**;** *Melocactus intortus - Conocarpus erectus - Krameria ixine - Comocladia dodonaea -*

		Croton discolor evergreen shrubland**;** *Coccoloba uvifera - Thespesia populnea* hemi-sclerophyllous evergreen shrubland**;** *Leucaena leucocephala* drought deciduous shrubland; and **sod grasslands** of *Arundinella confinis - Schizachyrium sanguineum var. sanguineum; Bouteloua repens****;*** *Dichanthium annulatum****;*** *Cenchrus myosuroides****;*** *Spartina patens***.** Along **shores**, *Conocarpus erectus - Strumpfia maritima - Suriana maritima* **sclerophyllous** evergreen **shrubland** on flat to sloping **limestone pavement** on SW coast**;** *Chamaesyce mesembrianthemifolia - Fimbristylis spadicea* **dwarf-shrubland** occurs along **rocky shores of limestone or sandstone**, and *Ipomoea pes-caprae - Canavalia rosea* **vine-shrubland vegetation** on **ocean shores**. **Trees** of the dry limestone forest include: Pisonia albida, Capparis cynophallophora, Pictetia aculeata, Guaiacum sanctum, Amyris elemifera, Bursera simaruba, Gymnanthes lucida, Thouinia portoricensis, Colubrina arborescens, Sarcomphalus reticulatus, Cephalocereus royenii, Opuntia rubescens, Bucida buceras, Dipholis salicifolia, Plumeria alba. **Example: Guanica Foerest Reserve.**
Subtropical-dry vegetation-sedimentary	**DRY LIFE ZONE**	No info. Surrounded by dry limestone vegetation. Much of the land has been heavily grazed in the past. The remaining brushy secondary vegetation provides winter habitat for many neotropical migrants (Nellis 1999).
Subtropical-dry vegetation-ultramafic	**DRY LIFE ZONE**	No info. Surrounded by dry limestone vegetation.

Subtropical-dry vegetation-volcanic-extrusive	**DRY LIFE ZONE**	Include *Leucaena leucocephala* **shrubland** and **bunch grasslands** dominated by *Leptochloopsis virgata; Leptocoryphium lanatum - Aristida portoricensis; Sporobolus indicus.*
Subtropical-dry vegetation-volcanic-intrusive	**DRY LIFE ZONE**	See above
Subtropical-lower montane-rain vegetation-volcanic-extrusive	**LOWER MONTANE – RAIN LIFE ZONE** Mean annual temperature:18.6^{0}C, mean annual precipitation 4533 mm, mean relative humidity 98.5%. Vegetation similar to lower montane-wet forest, but with greater abundance of epiphytes, palms, and tree ferns. The cloud forest, variously called elfin woodland, mossy forest, montane thicket, or dwarf forest, is characterized by gnarled trees less than 7 m tall, high basal area, small diameters, slow growth rates. Dwarf stature of trees may be attributed to strong winds and water-saturated soils. Trees are evergreen and sclerophyllous. Tree roots form a tight, complete mat on the surface, trunks covered with epiphytes. **Example: Baño de Oro Natural Area, Bosque Nacional del Caribe**	Lower Montane rain forests include **tree-fern forest** dominated by *Cyathea arborea - Cnemedaria horrida / Dicranopteris nervosa - Sticherus bifidus*; **Colorado forest** dominated by *Cyrilla racemiflora - Micropholis guyanensis - Micropholis garciniifolia - Ocotea spathulata* and *Magnolia splendens*; **Sierra palm forest** of *Prestoea montana / Cordia borinquensis - Miconia sintenisii* on steep slopes and wet soils at elevations of 500-1100 m; and **cloud forest** dominated by *Tabebuia rigida - Ocotea spathulata - Eugenia borinquensis - Calyptranthes krugii* in eastern Puerto Rico. **Shrublands** include *Clusia minor - Clusia clusioides* **montane broadleaf scrub** and **wind-sculpted scrub** dominated by *Eugenia borinquensis-Tabebuia rigida-Marcgravia sintenisii* with many endemic shrubs on summits of high peaks, at 900-1050 m elevations of the Luquillo Mountains;
Subtropical-lower montane-rain vegetation-	**LOWER MONTANE – RAIN LIFE ZONE**	See Lower Montane Rain Intrusive.

volcanic-intrusive		
Subtropical-lower montane-wet vegetation-alluvial	**LOWER MONTANE - WET LIFE ZONE:** Found between 700 -1000 m or above. Forest is characterized by open-crowned trees. Leaves tend to be coriaceous and grouped toward the ends of the branches. The forest is poorer in species than the lowland wet forest. Species common to this life zone include *Cyrilla racemiflora* (palo colorado), *Ocotea spathulata*, *Micropholis chrysophylloides*, and *M. garciniaefolia*.Common trees include *Ocotea spathulata*, *Eugenia borinquensis*, *Tabebuia rigida*, *Weinmannia pinnata*,and *Calycogonium squamulosum*. Decompositon is slow. **Example: Bosque Nacional del Caribe, Tres Picacho Forest Reserve, Toro Negro Forest Reserve, Guilarte Forest Reserve**	Small fragmented patches ranging from 5 to 18 ha., surrounded by LM-Wet-Extrusive vegetatin. See descriptions in LM-Wet-Extrusive.
Subtropical-lower montane-wet vegetation-limestone	**LOWER MONTANE - WET LIFE ZONE**	No Info. One patch of 12 ha., surrounded by LM-Wet-Extrusive vegetation.
Subtropical-lower montane-wet vegetation-ultramafic	**LOWER MONTANE - WET LIFE ZONE**	1 occurrence of 73.73 ha. Located above the "wet ultramafic." See "wet ultramafic", and include *Cyathea arborea, Cnemedaria horrida, / Dicranopteris nervosa - Sticherus bifidus* fern savanna in disturbed areas.

Subtropical-lower montane-wet vegetation-volcanic-extrusive	**LOWER MONTANE - WET LIFE ZONE**	Include **Colorado forest** dominated by *Cyrilla racemiflora - Micropholis guyanensis - Micropholis garciniifolia - Ocotea spathulata* and *Magnolia splendens*; **Sierra palm forest** of *Prestoea montana / Cordia borinquensis - Miconia sintenisii* on steep slopes and wet soils at elevations of 500-1100 m; **Sod grasslands of** *Isachne angustifolia- Scleria scandens- Clibadium erosum - Phytolacca rivinoides which* occur on montane meadows and land slide scars at upper elevations of the Luquillo Mountains. **Example: Bosque Nacional del Caribe, Tres Picacho Forest Reserve, Toro Negro Forest Reserve, Guilarte Forest Reserve.**
Subtropical-lower montane-wet vegetation-volcanic-intrusive	**LOWER MONTANE - WET LIFE ZONE**	See LM-Wet-Extrusive vegetation **Example: Bosque Nacional del Caribe, Toro Negro Forest Reserve, Guilarte Forest Reserve**
Subtropical-moist vegetation-alluvial	**MOIST LIFE ZONE**: Mean biotemperature 18 - 240C, Mean annual rainfall: 1000 (1100) - 2000 (2200 mm). With the exception of regions of serpentine- or limestone-derived soils, most of the land in this life zone remains in some form of non-forested use. Species common to the moist life zone are: *Roystonea borinquena* (endemic to Puerto Rico), *Tabebuia heterophylla* in abandoned fields or areas with mean annual precipitation exceeds 1600 mm, *Nectandra* and *Ocotea spp.* in older secondary forests, *Spathodea campanulata*(exotic), *Erythrina poeppigiana, Inga vera,* and *I. laurina*. Succession of *Croton lucidus (firebrush*)	Most forests on alluvial soils were cleared long ago for agriculture. Some remnants of alluvial swamp forest dominated by *Pterocarpus officinalis* are found along the north coast and SE of Puerto Rico. Include **disturbed successional forest** or known as **Trumpet-wood forest** at 0-250 m elevation, with *Cecropia peltata, Andira inermis,* and *Didymopanax morototoni* as major components**; successional** *Randia aculeata - Didymopanax morototoni* **woodland;** *Leucaena leucocephala* **shrubland; sod grasslands** dominated by *Axonopus compressus*, or *Spartina patens*, or *Stenotaphrum secundatum;* and **coastal strand or**

	shrubland and *Randia aculeata - Didymopanax morototoni* woodland observed in abandoned fields (Dansereau 1966) **Examples: Rio Abajo Forest, Maricao Forest Reserve, Susua Forest Reserve, Reserve Natural Cano San Christ.**	**berm communities** dominated by dwarf *Coccoloba uvifera, Thespesia populnea* shrubs**;** *Chamaesyce mesembrianthemifolia***;** *Ipomoea pes-caprae* **vine-shrubland;** and *Sesuvium portulacastrum* forb vegetation.
Subtropical-moist vegetation-limestone	**MOIST LIFE ZONE**	Mogote type: Tower-like karstic hills, up to 300-400 m, with steep slopes and plateaus, bare karstic rock and more or less eroded skeletal soils. Depending on the position and substrate, the vegetation can be similar to a deciduous forest with terrestrial bromeliads or diverse shrubs. The forest has a 5-10 m high open canopy. Vegetation include **disturbed successional forest** or known as **Trumpet-wood forest** at 0-250 m elevation, with *Cecropia peltata, Andira inermis*, and *Didymopanax morototoni* as major components**;** **Gateado forest** dominated by *Coccoloba diversifolia, Bursera simaruba, Bucida buceras, and Zanthoxylum martinicense* on magote sides and tops**;** *Leucaena leucocephala* **shrubland;** *Axonopus compressus* or *Stenotaphrum secundatum* **graslands.** Little and Wadsworth (1964) list the following 21 tree species as common members of the moist limestone hill forests: *Aiphanes acanthophylla, G. attenuata, Coccoloba diversifolia, C. pubescens, Licaria salicifolia, Zanthoxylum martinicense, Bursera simaruba, Cedrela odorata, Hyeronima clusioides, Sapium laurocerasus, Thouinia striata, Montezuma speciosissima, Ochroma pyramidale, Clusia rosea, Bucida buceras, Tetrazygia eleagnoides, Dipholis salicifolia, Sideroxylon foetidissimum, Guettarda scabra, Terebraria resinosa, Randia aculeata*. **Examples: Rio Abajo Forest**

Subtropical-moist vegetation-sedimentary	**MOIST LIFE ZONE**	No info. Surrounded by Moist Limestone and Moist Extrusive vegetation.
Subtropical-moist vegetation-ultramafic	**MOIST LIFE ZONE**	**Deciduous woodlands or Gumbolimbo savanna** dominated by *Bursera simaruba* occur on serpentine-derived soils (Nipe and Rosario series). Trees are slender, open-crowned, and usually less than 12 m tall. The forest floor is open, for the excessively drained soil supports little herbaceous growth. Most of the species are sclerophyllous and the vegetation is almost completely evergreen. Rich in woody flora. Common shrubs include *Pilosocereus royenii, Thouinia striata var. portoricensis, Plumeria alba, Croton lucidus, Pictetia aculeata*, and *Comocladia dodonaea*. **Example: Maricao Forest Reserve, Susua Forest Reserve.**
Subtropical-moist vegetation-volcanic-extrusive (or clay soils)	**MOIST LIFE ZONE**	Vegetation includes **disturbed successional forest** or known as **Trumpet-wood forest** at 0-250 m elevation, with *Cecropia peltata*, *Andira inermis*, and *Didymopanax morototoni* as major components; **Bucaro forest** dominated by *Bucida buceras* developed on lower slopes with better drained topography and less mature soils**; shrublands** dominated by *Croton lucidus* or *Leucaena leucocephala; and* grasslands dominated *by Schizachyrium gracile or Sporobolus indicus.* The forest canopy, 20--25 m high, is not closed. Emergents are common. The herb layer is dominated by terrestrial ferns. Lichens and bryophytes grow on trunks. About 70 % of canopy species are evergreen. Lianas are abundant. **Example: Reserve Natural Cano San Christ**

Subtropical-moist vegetation-volcanic-intrusive (or sandy soils)	**MOIST LIFE ZONE**	See above
Subtropical-rain vegetation-alluvial	**RAIN LIFE ZONE:** Mean annual precipitation > 3800 mm. Annual runoff is about 3400 mm. Species common to wet forest life zone are also found in rain forest life zone. *Prestoea montana* palms (with aerial roots, an adaptation to saturated soil) dominant on cove sites, *Nephelea portoricensis* tree ferns, and epiphytes are abundant. **Example: Bosque Nacional del Caribe (El Yunque)**	1 occurrence of 4.68 ha. Extending to wet alluvial, it is surrounded by Rain-extrusive vegetation which is adjacent to LM-rain-extrusive. **See descriptions of Rain-extrusive**, because the key ecological factor in el Yunque is "rain" not "soil" (pers.com. Alexis Dragoni, Nov. 2003)
Subtropical-rain vegetation-volcanic-extrusive	**RAIN LIFE ZONE**	Vegetation include **Tabonuco forest**, typically with a dense canopy 20-30 m tall, dominated by *Dacryodes excelsa, Sloanea berteriana,* and *Manilkara bidentata ssp. surinamensis;* **disturbed successional forest** or known as **Trumpet-wood forest** at 0-250 m elevation, with *Cecropia peltata, Andira inermis,* and *Didymopanax morototoni* as major components; and endemic monospecific ***Thespesia (=Montezuma) grandiflora* Forest** on hill slopes, which are prevalent following disturbance.
Subtropical-rain vegetation-volcanic-intrusive	**RAIN LIFE ZONE**	See Rain – Intrusive

Subtropical-wet vegetation-alluvial (or fertile loamy soils)	**WET LIFE ZONE:** Mean annual precipitation: 2000 - 4000 mm. Epiphytic ferns, bromeliads, and orchids are common. Forests are relatively rich in species, and the growth rates of successional trees are rapid.Commom species of this life zone include *Cyathea arborea, Gleichenia bifida (*on roadsides), *Dacryodes excelsa (*tabonuco), *Sloanea berteriana* (Motillo), *Manilkara bidentata* (bulletwood), and *Prestoea montana.* Species commonly found in the successional vegetation include: *Piper aduncum, Cecropia peltata, Didymopanax morototoni* and *Ochroma lagopus.* **Examples: Carite Forest Reserve, Toro Negro Commonwealth Forest Reserve, Luquillo experimental Forest (= Bosque Nacional del Caribe), Tres Picachos Forest Reserve**	See Rain- Extrusive.
Subtropical-wet vegetation-limestone	**WET LIFE ZONE**	**See Moist Limestone descriptions.** Puerto Rican karst forests, regardless of rainfall conditions, share common characteristics including physiognomy and leaf characteristics. They consist of drought-tolerant deciduous trees.Karstic forests are characterized by tree of small diameter, high tree density, and leaf scleromorphy. Trees in karst forests are generally shorter than trees in volcanic forests with the same rainfall but deeper soil; tree height of karstic forest increases along moisture gradient from less than 10 m to over 25 m. Foressts on the base of mogotes has a height of 25 to 30 m, a close canopy, shrubby, and herbaceous understories. Common species are *Dendropanax arboreus* and *Quararibea turbinate*. (Lugo et al. 2001) **Example: Rio Abajo Forest Reserve**.
Subtropical-wet vegetation-	**WET LIFE ZONE**	No info. Surrounded by Wet Lmestone and Wet Extrusive vegetation

sedimentary		
Subtropical-wet vegetation-ultramafic	**WET LIFE ZONE**	**Scrub communities** dominated by sclerophyllous *Schefflera gleasonii,* or broadleaf *Clusia minor* and *Clusia clusioides.* The serpentine vegetation in wet and moist life zones is similar except that wet serpentine vegetation is denser, lusher with more epiphytes. All speicies are evergreen and sclerophyllous. **Examples: Maricao Forest Reserve**.
Subtropical-wet vegetation-volcanic-extrusive	**WET LIFE ZONE**	Include **Tabonuco Forest** with **c**losed, 20 m high canopy, dominated by *Dacryodes excelsa-Sloanea berteriana-Manilkara bidentata ssp. surinamensis;* and **Firebrush scrub** dominated by *Croton lucidus* shrubs. *Cyathea arborea* and sierra palm *Prestoea montana* are occasional. **Examples: Carite Forest Reserve, Toro Negro Commonwealth Forest Reserve, Luquillo experimental Forest (= Bosque Nacional del Caribe), Tres Picachos Forest Reserve.**
Subtropical-wet vegetation-volcanic-intrusive	**WET LIFE ZONE**	Please see Wet-Extrusive **Example: Bosque del Pueblo**

Wetland vegetation (forest/ shrubland/ grassland)	Occurs in basins and plains along the coast; in the wide valleys of lowland rivers; or on rich black alluvial soils.	Include the following vegetation communities: *Pterocarpus officinalis - Manilkara bidentata ssp. surinamensis - Calophyllum brasiliense* **swamp forest;** *Annona glabra - Conocarpus erectus / Acrostichum aureum* **semi-permanently flooded evergreen sclerophyllous forest;** *Chrysobalanus icaco* **seasonally flooded shrubland;** *Batis maritima* **tidally flooded evergreen dwarf-shrubland;** *Gynerium sagittatum*, or *Phragmites australis* **seasonally flooded herbaceous vegtation;** *Brachiaria mutica - Eriochloa polystachya, or Hymenachne amplexicaulis - Panicum aquaticum* **semi-permanently flooded herbaceous vegetation;** and various **tidally flooded herbaceous vegetation** dominated by *Acrostichum aureum - Acrostichum danaeifolium*, *Bothriochloa pertusa*, *Fimbristylis spadicea*, and *Sporobolus virginicus - Paspalum vaginatum.*
Mangrove	Oceanward closed mangrove forest, frequently tidally flooded. (Mangrove scrub may not form a closed canopy) **Example: Refugio de Vida Silvestre de Boq, Boqueron Forest Reserve, Ceiba Forest Reserve**	**Tidally flooded forest and shrublands** dominated by *Conocarpus erectus, Rhizophora mangle, Rhizophora mangle - Eleocharis cellulose*, *Avicennia germinans - Sarcocornia perennis, Rhizophora mangle - Avicennia germinans, Rhizophora mangle - Avicennia germinans - Laguncularia racemosa- Batis maritime*, and *Suriana maritima - Gundlachia corymbosa - Borrichia arborescens - Conocarpus erectus.*

Table 6. Plant species targets

Scientific Name (plant species targets)	Common Name	Number of occurrences recorded in DNER database 2003
ABUTILON COMMUTATUM	TERCIOPELO	2

ADIANTUM VILLOSUM	HELECHO	4
ADIANTUM WILSONII	HELECHO	2
AECHMEA LINGULATA	BROMELIA	3
AECHMEA NUDICAULIS	BROMELIA	1
ALSOPHILA AMINTAE	HELECHO	5
ALSOPHILA BROOKSII	HELECHO ARBORESCENTE	5
AMARANTHUS AUSTRALIS	BLERO DE AGUA	2
AMBROSIA TENUIFOLIA	UNA HERBACEA	1
ANEMIA HIRSUTA	HELECHO	2
ANISEIA MARTINICENSIS	BEJUCO	4
ANTIRHEA PORTORICENSIS	QUINA	3
ANTIRHEA SINTENISII	QUINA	3
ARDISIA LUQUILLENSIS	MAMEYUELO	3
ARISTIDA CHASEAE	UNA YERBA	4
ARISTIDA PORTORICENSIS	MATOJO DE LAS MESAS, PELOS DEL DIAB	5
AUERODENDRON PAUCIFLORUM	ARBOL PEQUEÑO	1
BACCHARIS DIOICA	ARBUSTO	3
BANARA VANDERBILTII	ARBUSTO, PALO DE RAMON	3
BASIPHYLLAEA ANGUSTIFOLIA	ORQUIDEA	2
BRACHIONIDIUM CILIOLATUM	ORQUIDEA	2
BRACHIONIDIUM PARVUM	ORQUIDEA	1
BRUNFELSIA LACTEA	VEGA BLANCA	4
BRUNFELSIA PORTORICENSIS	UN ARBUSTO	5
BRUNSFELSIA DENSIFOLIA	ARBOL	2
BUCHNERA LONGIFOLIA	ESPIGA DE SAN ANTONIO	1
BULBOSTYLIS CURASSAVICA	UN JUNCO	4
BULBOSTYLIS JUNCIFORMIS	UN JUNCO	1
BURMANNIA CAPITATA	UNA HERBACEA	2
BUXUS VAHLII	DIABLITO DE TRES CUERNOS	4
BYRSONIMA SPICATA	MARICAO, DONCELLA	2
CAESALPINIA CULEBRAE	MATO AMARILLO (SMOOTH YELLOW NICKER)	3
CAESALPINIA MONENSIS	MATO NEGRO (BLACK NICKER)	1
CAESALPINIA PORTORICENSIS	MATO NEGRO	2
CALLICARPA AMPLA	CAPA ROSA, PENDULA CIMARRONA	3

CALYPTRANTHES DUMETORUM	UN ARBUSTO	2
CALYPTRANTHES LUQUILLENSIS	UN ARBUSTO	5
CALYPTRANTHES PEDUNCULARIS	UN ARBUSTO	2
CALYPTRANTHES PORTORICENSIS	UN ARBUSTO	2
CALYPTRANTHES THOMASIANA	UN ARBUSTO	1
CALYPTRANTHES TRIFLORA	UN ARBUSTO	3
CALYPTRANTHES WOODBURYI	UN ARBOL PEQUENO	5
CALYPTRANTHES ZUZYGIUM	UN ARBOL	1
CALYPTRONOMA RIVALIS	PALMA MANACA	9
CAMPYLOCENTRUM PACHYRRHIZUM	UNA ORQUIDEA	3
CHAMAECRISTA GLANDULOSA VAR MIRABILIS	UN ARBUSTO	8
CHAMAESYCE MONENSIS	LECHECILLO DE MONA, UN ARBUSTO	2
CHAMAESYCE ORBIFOLIA	LECHECILLO, UNA HERBACEA	2
CLIDEMIA PORTORICENSIS	CAMASEY	5
COCCOLOBA PALLIDA	UN ARBOL PEQUENO	1
COCCOLOBA RUGOSA	ORTEGON	14
COCCOLOBA SINTENISII VAR. ALBA	UVERO DE MONTE	1
COCCOLOBA TENUIFOLIA	UN ARBOL PEQUENO	1
CONOSTEGIA HOTTEANA	UN ARBOL	5
CORDIA BAHAMENSIS	UN ARBUSTO	1
CORDIA RUPICOLA	UN ARBOL PEQUENO	5
CORDIA WAGNERIORUM	UN ARBOL	1
CORNUTIA OBOVATA	NIGUA	5
CRESCENTIA PORTORICENSIS	HIGUERO DE SIERRA	9
CROTON NUMMULARIIFOLIUS	UN ARBUSTO	1
CYBIANTHUS SINTENISII	UN ARBUSTO	2
CYNANCHUM MONENSE	UN BEJUCO	3
CYPERUS FULIGINEUS	UN JUNCO	1
CYPERUS URBANII	UN JUNCO	3
CYRTOPODIUM PUNCTATUM	CANUELA, PINUELA	4
DALEA CARTHAGENENSIS VAR PORTORICAN	UN ARBUSTO	1
DAPHNOPSIS HELLERIANA	UN ARBOL PEQUENO O ARBUSTO	13
DENDROPEMON PURPUREUS	CABALLERO, CAPITANA, HICAQUILLO, PE	6
DICHANTHELIUM ACICULARE	UNA GRAMINEA	3
DICLIPTERA KRUGII	UNA HERBACEA	1

DIDYMOPANAX GLEASONI	YUQUILLA	4
DIGITARIA ARGILLACEA	UNA YERBA	1
DIOSPYROS SINTENISII	GUAYABOTA, GUAYABOTA NISPERO, TABEI	5
DROSERA CAPILLARIS	UNA HERBACEA INSECTIVORA, "PINK SUN	5
ECHINODORUS TENELLUS VAR LATIFOLIUS	UNA HERBACEA ACUATICA	3
ELEOCHARIS PACHYSTYLA	UN JUNCO	2
ELEOCHARIS ROSTELLATA	UN JUNCO	2
ENCYCLIA COCHLEATA VAR ALBA	CANUELA, ORQUIDEA NEGRA	1
ENTADA POLYPHYLLA	TAMARINDILLO	1
ERIOSEMA CRINITUM	UN ARBUSTO	1
ERYTHRINA EGGERSII	BRUCAYO, BUCARE, BUCAYO, COR	4
EUBRACHION AMBIGUUM	UN BEJUCO PARASITICO	1
EUGENIA BELLONIS	UN ARBUSTO PEQUENO	2
EUGENIA EGGERSII	GUASAVARA, GUAYABACON	4
EUGENIA HAEMATOCARPA	UVILLO	5
EUGENIA SESSILIFLORA	UN ARBUSTO O ARBOL PEQUEÑO	4
EUGENIA STEWARDSONII	UN ARBOL	2
EUGENIA WOODBURYANA	UN ARBOL PEQUENO	10
EUPATORIUM OTEROI	UN ARBUSTO	2
EUPHORBIA OERSTEDIANA	UNA HERBACEA	3
EURYSTYLES ANANASSOCOMOS	UNA ORQUIDEA	1
GAUSSIA ATTENUATA	PALMA DE LLUVIA	5
GESNERIA PAUCIFLORA	UNA HERBACEA	2
GOETZEA ELEGANS	MATABUEY, MANZANILLA	6
GYMNOPOGON FOLIOSUS	UNA YERBA	3
HARRISIA PORTORICENSIS	HIGO CHUMBO	4
HENRIETTEA MEMBRANIFOLIA	CAMASEY	2
ILEX COOKII	UN ARBOL PEQUENO	4
ILEX SINTENISII	UN ARBOL PEQUENO	2
ILEX URBANIANA	CUERO DE SAPO	4
IPOMOEA CARNEA SSP FISTULOSA	BATATILLA CARNOSA, AGUINALDO MORADO	2
JUGLANS JAMAICENSIS	NOGAL, NUEZ, PALO DE NUEZ	1
JUSTICIA CULEBRITAE	UNA HERBACEA	1
LAGENOCARPUS GUIANENSIS	UN JUNCO	1

LANTANA RETICULATA	UN ARBUSTO	1
LANTANA TRIFOLIA	UN ARBUSTO	1
LEPANTHES DODIANA	UNA ORQUIDEA	5
LEPANTHES ELTOROENSIS	UNA ORQUIDEA	2
LEPTOCEREUS GRANTIANUS	UN CACTUS (PITAHAYA)	1
LEPTOCEREUS QUADRICOSTATUS	SEBUCAN,PITAHAYA	11
LINDSAEA PORTORICENSIS	UN HELECHO	4
LIPARIS VEXILLIFERA	UNA ORQUIDEA	1
LYCASTE BARRINGTONIAE	UNA ORQUIDEA	1
LYCOPODIUM VERTICILLATUM	COLCHON DE POBRE	1
MAGNOLIA SPLENDENS	BELLA, LAUREL SABINO, SABINO	5
MARATTIA LAEVIS	UN HELECHO	4
MAYTENUS CYMOSA	UN ARBOL	2
MAYTENUS ELONGATA	CUERO DE SAPO	6
MAYTENUS PONCEANA	CUERO DE SAPO	4
MICONIA FOVEOLATA	CAMASEY	3
MICONIA PYCNONEURA	CAMASEY	4
MIKANIA STEVENSIANA	GUACO	3
MITRACARPUS MAXWELLIAE	UN ARBUSTO	1
MITRACARPUS POLYCLADUS	UN ARBUSTO	2
MYRCIA PAGANII	AUSU	3
MYRCIARIA BORINQUENA	UN ARBOL PEQUENO	2
MYRCIARIA MYRTIFOLIA	UN ARBOL PEQUENO	4
MYRICA HOLDRIDGEANA	PALO DE CERA	6
OCOTEA FOENICULACEA	LAUREL, PALO SANTO	3
OSMUNDA CINNAMOMEA	UN HELECHO	2
OSSAEA KRUGIANA	CAMASEY	2
OSSAEA SCABROSA	CAMASEY	2
OTTOSCHULZIA RHODOXYLON	PALO DE ROSA	16
OXANDRA LANCEOLATA	HAYA PRIETA	3
PANICUM STEVENSIANUM	UNA YERBA	1
PAVONIA PANICULATA	CADILLO ANARANJADO, CADILLO ALTEA	1
PEPEROMIA MYRTIFOLIA	UNA HERBACEA	1
PEPEROMIA WHEELERI	UNA HERBACEA	3
PERSEA KRUGII	CANELA	3

PILEA LEPTOPHYLLA	UNA HERBACEA	1
PIRIQUETA VISCOSA	UNA HERBACEA	2
PISONIA HELLERI	ESCAMBRON, UNA DE GATO	1
PLEODENDRON MACRANTHUM	CHUPACALLOS	4
POLYGALA COWELLII	ARBOL DE VIOLETA	19
POLYPODIUM SECTIFRONS	UN HELECHO	2
PORTULACA CAULERPOIDES	UNA HERBACEA	6
PROCKIA CRUCIS	GUASIMILLA	2
PSEUDOPHOENIX SARGENTII VAR SAONAE	UNA PALMA	1
PSIDIUM INSULANUM	UN ARBOL	1
PSIDIUM SINTENISII	HOJA MENUDA	2
PSYCHILIS KRUGII	UNA ORQUIDEA	3
RHYNCHOSPORA NITENS	UN JUNCO	2
RHYNCHOSPORA OLIGANTHA	UN JUNCO	2
RHYNCHOSPORA OLIGANTHA VAR BREVISET	UN JUNCO	3
RHYNCHOSPORA RARIFLORA	UN JUNCO	1
ROCHEFORTIA SPINOSA	ESPINO	1
ROLLINIA MUCOSA	ANON CIMARRON	4
SABAL CAUSIARUM	PALMA DE SOMBRERO	4
SABICEA CINEREA	UN BEJUCO LENOSO	3
SCHOEPFIA ARENARIA	ARANA - UN ARBOL PEQUENO	6
SCHOEPFIA CHRYSOPHYLLOIDES	UN ARBUSTO	2
SCHOEPFIA SCHREBERI	UN ARBOL	2
SCLERIA DORADOENSIS	UN JUNCO	5
SCLERIA GEORGIANA	UN JUNCO	3
SCLERIA PAUCIFLORA	UN JUNCO	1
SCLERIA VERTICILLATA	UN JUNCO	3
SCOLOSANTHUS GRANDIFOLIUS	ESPUELA DE GALAN	2
SESUVIUM MARITIMUM	VERDOLAGA DE MAR	1
SETARIA CHAPMANII	UNA YERBA	1
SETARIA MAGNA	UNA YERBA	2
SOLANUM CAMPECHIENSE	UNA HERBACEA	1
SOLANUM DRYMOPHILUM	ERUBIA	1
SOLANUM POLYGAMUM	UN ARBUSTO	1
SOLANUM WOODBURYI	UN ARBUSTO	4

SOPHORA TOMENTOSA	UN ARBUSTO	2
STAHLIA MONOSPERMA	COBANA NEGRA	9
STYRAX PORTORICENSIS	PALO DE JAZMIN	2
SYMPLOCOS LANATA	NISPERO CIMARRON	2
TERNSTROEMIA HEPTASEPALA	UN ARBOL PEQUEÑO	5
TERNSTROEMIA LUQUILLENSIS	PALO COLORADO	3
TERNSTROEMIA SUBSESSILIS	UN ARBUSTO O ARBOL PEQUEÑO	1
TILLANDSIA FLEXUOSA	UNA BROMELIA	3
TILLANDSIA LINEATISPICA	PINON - UNA BROMELIA	3
TILLANDSIA PRUINOSA	UNA BROMELIA	3
TILLANDSIA TENUIFOLIA VAR TENUIFOLI	UNA BROMELIA	8
TRICHILIA TRIACANTHA	BARIACO, MARICAO, GUAYABACON	7
URERA CHLOROCARPA	ORTIGA	3
VERNONIA PROCTORII	UN ARBUSTO	1
WALTHERIA CALCICOLA	UN ARBUSTO	3
XYLOSMA PACHYPHYLLUM	UN ARBUSTO	3
XYLOSMA SCHWANECKEANUM	CANDELA, PALO DE CANDELA, PALO COLO	3
ZANTHOXYLUM BIFOLIOLATUM	MARICAO	1
ZANTHOXYLUM THOMASIANUM	UN ARBOL PEQUENO	5
ZIZIPHUS RIGNONII	UN ARBUSTO	5
ZIZIPHUS TAYLORII	UN ARBUSTO	3

Table 7. Faunal species targets

Scientific Name (faunal species target)	**Common Name**	**# of occurrences recorded in DNER database 2003 and occurrences suggested by experts**
ACCIPITER STRIATUS VENATOR	FALCON DE SIERRA DE PR; HALCON	33
AGELAIUS XANTHOMUS	MARIQUITA DE PUERTO RICO	15
AMAZONA VITTATA	COTORRA PUERTORRIQUENA, PUERTO RICAN PARROT	3
AMPHISBAENA BAKERI	CULEBRA DE DOS CABEZAS	3

ANAS BAHAMENSIS	PATO QUIJADA COLORADA	5
ANOLIS COOKI	LAGARTIJO DEL SECO	12
ANOLIS CUVIERI	AN ANOLE	1
ANOLIS OCCULTUS	LAGARTIJO ENANO	9
ANOLIS PONCENSIS	AN ANOLE	2
ANOLIS ROOSEVELTI	LAGARTO DE CULEBRA	1
ANTHRACOTHORAX VIRIDIS	GREEN MANGO;ZUMBADOR VERDE	1
BUTEO PLATYPTERUS BRUNNESCENS	GUARAGUAO DE BOSQUE; GAVILAN	15
CAPRIMULGUS NOCTITHERUS	GUABAIRO PEQUENO	53
CARETTA CARETTA	CABEZON	5
CAVE-DWELLING BATS (Artibeus jamaicensis, Brachyphylla cavernum, Eptesicus fuscus, Erophylla sezekorni, Lasiurus borealis, Molossus molossus, Monophyllus redmani, Mormoops blainvillii, Noctilio leporinus, Pteronotus parnellii, Pteronotus quadridens, Stenoderma rufum, Tadarida brasiliensis)		19
CHARADRIUS ALEXANDRINUS TENUIROSTRI	PLAYERO BLANCO	2
CHARADRIUS WILSONIA (Shorebird)	WILSON'S PLOVER	22
CHELONIA MYDAS	PEJE BLANCO	27
COLUMBA INORNATA WETMOREI	PALOMA SABANERA DE PUERTO RICO	28
COLUMBA LEUCOCEPHALA	WHITE-CROWNED PIGEON	13
CYCLURA CORNUTA	IGUANA DE LA MONA	9
DENDROCYGNA ARBOREA (Waterfawl)	CHIRIRIA NATIVA; PATO NOCTURNO, WEST INDIAN WHISTLING DUCK	14
DENDROICA ANGELAE	REINITA DE BOSQUE ENANO	1
DENDROICA CAERULESCENS (Migrants)	BLACK-THROATED BLUE WARBLER	15
DERMOCHELYS CORIACEA	TINGLAR	50
ELEUTHERODACTYLUS COOKI	GUAJON, COQUI DE CAVERNAS	5
ELEUTHERODACTYLUS ENEIDAE	COQUI DE ENEIDA	11
ELEUTHERODACTYLUS GRYLLUS		1
ELEUTHERODACTYLUS HEDRICKI		4
ELEUTHERODACTYLUS JASPERI	COQUI DORADO	14
ELEUTHERODACTYLUS KARLSCHMIDTI	COQUI PALMEADO	8
ELEUTHERODACTYLUS LOCUSTUS	COQUI MARTILLITO	1
ELEUTHERODACTYLUS PORTORICENSIS		1
ELEUTHERODACTYLUS RICHMONDI	COQUI CAOBA	1
ELEUTHERODACTYLUS UNICOLOR		1

ELEUTHERODACTYLUS WIGHTMANAE	COQUI MELODIOSO	1
EPICRATES INORNATUS	BOA DE PUERTO RICO; CULEBRON	27
EPICRATES MONENSIS	BOA DE MONA; BOA DE ISLAS VIRGENES	8
ERETMOCHELYS IMBRICATA	CAREY; CAREY DE CONCHA	67
FULICA CARIBAEA	GALLINAZO NATIVO; GALLARETA PICO BL	13
LOXIGILLA PORTORICENSIS	PUERTO RICAN BULLFINCH;COME AME DE	2
MABUYA SLOANEI	LUCIA, SANTA LUCIA	8
MELANERPES PORTORICENSIS	PUERTO RICAN WOODPECKER;CARPINTERO	3
MONOPHYLLUS REDMANI PORTORICENSIS	MURCIELAGO DE FLORES DE PUERTO RICO	2
MORMOOPS BLAINVILLII CINNAMOMEUM	MURCIELAGO	3
MYIARCHUS ANTILLARUM	PUERTO RICAN FLYCATCHER;JUI DE PUER	3
NESOSPINGUS SPECULIFERUS	PUERTO RICAN TANAGER;LLOROSA DE PUE	1
OXYURA DOMINICA	PATO DOMINICO	6
OXYURA JAMAICENSIS	PATO CHORIZO	25
PELTOPHRYNE LEMUR	SAPO CONCHO	6
PORZANA FLAVIVENTER (Shorebird)	GALLITO AMARILLO, YELLOW-BREASTED CRAKE	5
PTERONOTUS PARNELLII PORTORICENSIS	MURCIELAGO BIGOTUDO	4
SPHAERODACTYLUS MICROPITHECUS	GUECO DE MONITO	2
STERNA ANTILLARUM	GAVIOTA CHICA	17
TACHYBAPTUS DOMINICUS	TIGUA; ZARAMAGULLóN CHICO	11
TRICHECHUS MANATUS MANATUS	MANATI	35

Table 8. Selected fauna species targets descriptions (Source: Rivero 1998; DNER database 2003; NatureServe database 2003; Koenig 2003)

Fauna Targets	**Common Name**	**Description**
Agelaius xanthomus (*I*cteridae**)**	Mariquita de Puerto Rico, Yellow-shouldered Black bird	Restricted to a few areas in Puerto Rico; range and abundance have declined from historical levels; total population is less than 2000; threatened by introduced species and shiny cowbird parasitism, protected by federal and state laws in Puerto Rico.
Amazona vittata	Cotorra Puertorriquena,	*Amazona vittata* is critically endangered and is one of the rarest birds in the world. In 1975, only 13 birds where known to survive in the wild. Despite intensive

	Puerto Rican Parrot	management, the wild population remains small, with only 36 birds counted in 1999.
Anolis roosevelti	Lagarto de Culebra, Culebra Island Giant Anole	It is the giant anole from Culebra, Vieques, Tortola, and St. John., a species only know from 8 preserved specimens. Recent visits to Culebra have failed to reveal additional specimens. Anolis roosevelti is considered to be one of the most primitive Anolis occurring in Puerto Rico.
*Caprimulgus noctitherus (*Caprimulgidae)	Guabairo Pequeno, Puerto Rico Nightjar	Total population consists of several hundred breeding pairs in a few small areas in Puerto Rico, threatened by habitat loss/degradation and predation by exotic mammals.
Columba inornata wetmorei	Paloma Sabanera de Puerto Rico; Plain Pigeon	Threatened by forest fragmentation/ conversion/degradation, disturbance by humans and livestock, and excessive/illegal hunting. The minimum size area required to maintain the forest-dependent columbids will afford the largest umbrella for habitat protection for smaller species.
Eleutherodactylus jasperi	Coquí Dorado, Coquí de Jasper, Golden Coqui	It is the only ovoviviparous frog in the Western Hemisphere. *Eleutherodactylus jasperi* is an inhabitant of bromeliads in Sierra de Cayey. It has never been found outside of Sierra de Cayey. Very rare or extinct due to loss of habitat from agriculture and fire.
Eleutherodactylus karlschmidti	Coquí Palmeado, Web-footed Coqui	The species was quite common on El Yunque but relatively rare along the Patillas-San Lorenzo line. It has also been recorded at the Maricao Reserve forest; Las Vegas, between Mayagüez and Maricao, Cuevas de Aguas Buenas, and near Las Piedras. All specimens have been collected above 400 ft. Unfortunately E. karlschmidti seems to have disappeared in the last 15 years and recent surveys have failed to confirm that any populations are extant. The causes of its disappearance unknown.
Eleutherodactylus locustus	Coquí Martillito, A Rain Frog	The species is limited in its distribution to El Yunque and the south-eastern mountains, east of Cayey. They are found in forest openings and forest margins along roads and trails. The species has not been collected below 900 ft.
Peltophryne lemur	Sapo Concho, Puerto Rican Crested Toad	It is the only native Puerto Rican toad.Young individuals are easy preys for larger toads, frogs, turtles, lizards, skinks, ameivas, rats and mongooses. Once it was thought in danger of extinction. Now it is protected by federal and local law. Hundreds of specimens were seen reproducing at Guánica, and several thousands

		have been released in areas of Quebradillas and Arecibo.
Sphaerodatylus micropithecus	Gueco de Monito, Monito Gecko	Restricted to Isla Monito, possibly threatened by predation by introduced rats; scarce, trend unknown.

Table 9. Key factors that maintain ecological integrity of terrestrial ecosystem targets

KEY FACTOR	DESCRIPTION OF KEY FACTOR	above the natural range of variation	below the natural range of variation
Size	Describes how large the target occurrence is (calculated from GIS information).	larger than historical patch size	smaller than historical patch size
interconnectivity	Describes how connected the target occurrences are (calculated from GIS - formula determined at later date).	greater connectivity than historical landscape	less connectivity than historical landscape
intraconnectivity	Describes how patchy a given occurrence is- in other words the continuity of a patch	more continuous than historical landscape	more patchy than historical landscape
microdisturbance regime	Describes the way in which small scale disturbances maintain the functionality of the target. These small scale disturbances include small-scale tree falls, gap dynamics, etc.	more disturbances and/or shorter intervals. This would include more tree falls and more gaps, which increases light availability within a forest.	less disturbances and/or greater intervals. This would include fewer tree falls and fewer gaps, which would decrease light availability in the understory of a forest.
Trophic structure	Describes predator/prey, competition, herbivory, and decomposition. Includes pollination and dispersal.	more complex trophic structure	Simplified/reduced trophic structure
Surface substrate	Describes microtopography, exposed bedrock, soil deposition, soil moisture, and nutrient cycling.	soil quality higher than historical quality (such as nutrient loading, increased deposition)	soil quality lower than historical quality (erosion, moisture depletion, nutrient deficiency)

Underground water level	Describes the status of the water table. It directly relates to water availability for plants	greater water availability	less water availability
Key species composition	Describes the presence/absence of invasive species, the impact of invasives on key species, and if key species present in appropriate numbers. Impacts community structure and function.	overabundance of key species	key species missing and/or depauperate
macrodisturbance regime	Describes the way in which large scale disturbances maintain the structure and functionality of the target. These large scale disturbances include hurricanes, fires, floods, etc	more disturbances and/or shorter intervals	fewer disturbances and/or greater intervals
Physiognomy	Describes the structure and complexity of the vegetation system	vegetation system more complex	Vegetation system less complex

Table 10. Key ecological factors associated with individual ecosystem targets

Environmental gradients (moisture, elevation, geology) within subtropical zone		**Ecological processes**				**Ecological states**					
Targets	**surface and substrate**	**hydrology regime**	**trophic structure**	**macro-disturbance**	**micro-disturbance**	**size**	**keystone species composition**	**physiognomy**	**age**	**connectivity**	**connectivity to ocean**
Dry Alluvial	x	x	x	x		x	x	x		x	
Dry limestone	x	x	x			x	x			x	x
Dry Sedimentary	x		x			x	x	x		x	
Dry	x	x	x	x	x	x		x		x	

ultramafic											
Dry volcanic extrusive	x	x	x			x	x	x			
Dry volcanic intrusive	X	x	x			x	x	x			
Moist alluvial	X	x	x		x		x	x			
Moist limestone	X	x	x			x	x	x		x	
Moist sedimentary	X	x	x		x			x			
Moist ultramafic	X	x	x	x	x	x		x		x	
Moist volcanic extrusive	X	x	x	x	x	x	x	x		x	
Moist volcanic intrusive	X	x	x	x			x	x		x	
Wet alluvial	X	x	x		x		x	x			
Wet limestone	X	x	x			x	x	x		x	
Wet sedimentary	X	x	x		x			x			
Wet ultramafic	X	x	x	x	x	x		x		x	
Wet volcanic extrusive	X	x	x	x	x	x	x	x		x	
Wet volcanic intrusive	X	x	x	x	x	x	x	x		x	
Lower montane wet alluvial	X	x	x	x	x	x	x	x		x	
Lower montane wet limestone	x	x	x			x	x	x		x	
Lower montane wet ultramafic	X	x	x	x	x	x		x		x	

Lower montane wet volcanic extrusive	X	x	x	x	x	x	x	x		x	
Lower montane wet volcanic intrusive	X	x	x	x	x		x	x		x	
Rain alluvial	X	x			x	x	x	x		x	
Lower montane rain volcanic extrusive	X	x			x	x	x	x		x	
Lower montane rain volcanic intrusive	X	x			x	x	x	x		x	
Rain volcanic extrusive	X	x			x	x	x	x		x	
Rain Volcanic Intrusive	X	x			x	x	x	x		x	
Wetlands	X	x	x		x	x	x		x	x	
Mangrove	X	x	x	x		x	x	x	x	x	x

Table 11. Key ecological factors that maintain faunal conservation target health (Koenig 2003)

KEY FACTOR	DESCRIPTION OF KEY FACTOR	Above the natural range of variation	Below the natural range of variation

Population size and age/stage structure	Size takes into account the number of individuals and the minimum number necessary for a viable population. This also describes the minimum dynamic area, the area needed to ensure survival or re-establishment after natural disturbance. Age (or stage) structure describes the relative proportions of individuals in different stages of their life cycle (e.g., immature, reproductively-active adult).	Population larger than historic size or age/stage classes over-represented (i.e., natural mortality of age classes disrupted so some ages/stages are disproportionally represented)	Population smaller than historic size or age structure simplified
Sex ratio	Ratio of females and males in the population	Excess of females	Fewer females than under natural conditions
Dispersal	Describes the ability of juveniles to disperse from their natal area or the ability of adults to disperse under natural environmental conditions (e.g., drought, flooding, territory exploration)	Natural barriers to dispersal are removed (i.e. corridors are created that did not occur under natural conditions)	Dispersal is limited by abiotic or biotic factors (e.g., habitat fragmentation, presence of competing or predatory species)
Site fidelity	Describes the ability of targets to remain in home ranges or successfully defend territories or return to a site following migration events. It also describes the size of the area as being large enough to support juveniles or adults that naturally maintain natal site fidelity	Greater numbers of individuals of the target remaining in a site, with a negative consequence on other targets or species occupying the same space	Reduced ability of the target to return to or remain in a home range or territory
Migration	Describes the ability of the target to migrate seasonally or annually among suitable locations in the landscape. This includes altitudinal migration and long-distance migration.	Natural barriers to migration are removed	Barriers to migration are increased; barriers may include a reduction in the number of corridors or destination habitats; reduced quality of resources along migration routes

Natural predator/prey dynamics	Describes the relationships in which natural predators mediate the abundance and distribution of prey populations	Overabundance or range expansion of native predators	Depleted numbers or absence of native predators in the range of the target (e.g., reduced trophic structure)
Natural mortality rates	Describes annual survival rates, including natural cyclical fluctuations, of age (or stage) classes. This factor must be considered in relation to natural reproductive rates and recruitment for population stability	Mortality exceeds natural rates and reproduction is inadequate to maintain the target	Mortality is below natural rates
Absence of non-native invasive species	Includes non-native species which may competitively interfere or exclude native targets or may be a predator or avian brood parasite of native targets	Fewer numbers (either individuals or species) of non-native invasive species	Greater numbers (either individuals or species) of non-native invasive species
Natural patterns/rates of disease transmission	Describes the natural patterns of transmission, prevalence, intensity, and density of pathogens and parasites for these island systems	Pathogens and parasites introduced and established at rates higher than natural, typically through human importation of plants and animals	Pathogens and parasites introduced and established at rates lower than natural rates
Habitat mosaic	Describes the different vegetation types, which, for example, may be required by different stages of a target's life cycle	Habitat types become more heterogenous	Habitat types become more homogenous
Habitat block size	Describes the minimum size area of habitat required for viable occurrence of populations or successful completion of life history events (e.g., breeding aggregations, roosting aggregations)	Habitat block size larger than historically	Habitat block size smaller than historically
Forest physiognomy	Describes the structure and complexity of the vegetation	Vegetation system more complex	Vegetation system less complex

Microhabitat diversity	Describes the small-scale variability in the habitat, including such things as presence of leaf litter & decomposing woody vegetation, rock crevices, small pools of water	More types of microhabitats are present	Microhabitat diversity becomes simplified/more homogenous
Nesting/breeding habitat gradient	Describes the availability of suitable substrates	Greater number of available nesting substrates	Fewer nesting substrates (including reduction of area size)
Disturbance regimes at breeding sites	Describes the way in which disturbance (or lack thereof) affects reproductive performance	Increased levels of disturbance at breeding sites	Fewer disturbances at nesting sites
Availability and stability of food resources	Describes the seasonal or annual availability of food resources, including availability following natural catastrophic events such as hurricanes	Overabundance of food resources which enable a higher carrying capacity of the target in the environment	Food supplies inadequate or not available throughout the year
Trophic diversity and species composition	Describes the components of the food web and the species composition within each level of producers, decomposers, and consumers	Greater trophic complexity or species composition than historically	Trophic diversity or species composition is reduced from historic conditions
Landscape connectivity	Describes the relationship between systems, such as terrestrial/aquatic connectivity; terrestrial/subterranean connectivity; breeding and foraging habitats	Greater connectivity between systems than historically	Landscape is more fragmented, ecosystems more isolated than historically
Hydrology regimes	Describes the surface and groundwater hydrologic regimes, including water flow and depth, seasonal and annual flooding, and soil moisture	More water available	Less water available
Water quality	Describes the condition of water resources, including temperature and pH, water turbidity/clarity, particulate and dissolved organic matter, and chemistry (nutrients, salinity)	Water quality is enhanced/improved from historic conditions	Water quality is degraded from historic conditions

Climatic gradients	Describes the gradient of abiotic factors, including temperature, relative humidity, light, wind, and oxygen-CO2 concentrations	Increase in amount, intensity or frequency of occurrence of the abiotic factors	Decline in the quality of climatic factors
Nutrient dynamics	Describes the cycles of vegetative / detritous inputs and other biological waste material (e.g. guano)	Increased levels of nutrients in the sytem	Decreased levels of nutrients in the system
Substrate geomorphic dynamics	Describes the natural conditions of sediment type and deposition, erosion, substrate profiles (e.g., beach dunes)	Geomorphic processes enhanced beyond natural rates (e.g., beach creation for tourism, to the exclusion/destruction of other natural substrates)	Geomorphic processes degraded from historic patterns (e.g., decreased deposition)

Table 12. Key factors associated with maintaining faunal target viability (Koenig 2003)

Key Factor	**Faunal Target**	Shorebirds	Migrant Birds	Psittacines	Columbids	Waterfowl	*Eleutherodactylus*	*Boa*	Iguana
Absence of non-native invasive species									
Availability and stability of food resources									
Climatic gradients									
Dispersal								x	
Disturbance at roosting & nesting sites		x							
Food resource availability		x	x		x	x		x	
Forest physiognomy				x			x	x	

Habitat block size			x						
Habitat mosaic			x		x	x	x		
Hydrology		x				x			
Landscape connectivity					x		x	x	
Microhabitat diversity/ microclimate							x		
Migration			x						
Natural mortality rates								x	x
Natural patterns/rates of disease transmission									
Natural predator/prey dynamics				x					x
Nesting/breeding habitat		x		x	x	x			x
Population size and age/stage structure				x	x				x
Water quality						x			

Table 13. Variables used for the basic cost surface

Data Source	**Type of Cost**	**Description**
PR Themes (urban77-91.shp)	Urban	Number of km2 within each planning unit covered by urban area.
PR Themes (industry77_91 grid)	Urban	Number of km2 within each planning unit covered by industrial area.
PR Themes (roads.shp)	Urban	The road lines were buffered based on the 4 classes (0-3) in the following manner: 50 meters for class 1 roads; 20 meters for class 2 roads; 15 meters for class 3 roads and 8 meters for class 0 roads. These were then summarized to provide number of km2 per planning unit covered by roads.
PR Themes (pr_tiger_block_pop_2000.shp)	Urban Intensity	The average population density per km2 was summarized per planning unit.
PR Themes (tourismintensity2003.shp)	Urban intensity	Tourism intensity was calculated by Matt and Kim using available data to reflect the population density of tourists per km2 per tourist zone. This was summarized by

		planning unit and added to population density above to derive a final population density value per planning unit capturing both the permanent and transient (tourist) population. This final population density value was used as the urban intensity score.
PR Themes (pr_ag_combined_04-22.shp)	Agriculture	This shapefile was developed by Kim by superimposing information provided in the PR expert workshop on the existing 1991 landuse map to derive a more updated and more finely stratified classification of agricultural areas. The agricultural area in km2 was summarized per planning unit.
PR Themes (pr_ag_combined_04-22.shp)	Agriculture Intensity	Kim and Matt used available literature to calculate the number of kcals of input per hectare per harvest for each different crop reflected in the agriculture coverage.

Table 14. Least Cost Path weightings

target class	dry	moist / wet / rain	mangroves	wetlands	Ocean	agro-forestry	tillage	non-tillage	urban	roads	fresh-water
Dry	1	3	3	3	8	3	5	4	10	4	4
moist/wet/rain	2	1	2	2	8	3	5	4	10	4	4
Mangroves	3	2	1	2	4	7	7	5	10	4	4
Wetlands	3	2	2	1	8	6	8	6	10	4	2

Table 15. Marxan input data set for terrestrial coarse filter (ecosystem) targets

PR Terrestrial Ecosystem Target	Marxan area goal (hactare,10% geoclimatic region for all targets except for the followings: 30% of current extent for Dry_Alluvial and Moist_Alluvial; 65% for Mangrove; 25% for Wetland-Terrestrial)	PR Coarse filter target Condition (1: Primary, 2: Secondary, 3: Mixed vegetation and land use)	Target Area (hectare)	Marxan area goal (hactare; red: the total target area is insufficient to meet the goal of 10% geoclimatic region)
Dry_alluvial	1030.38	Dry_alluvial 1	3067.60	1030.38
Dry_extrusive	3927.49	Dry_extrusive 1	9144.16	3927.49
Dry_intrusive	653.30	Dry_intrusive 1	2553.01	653.30
Dry_limestone	3902.28	Dry_limestone 1	17595.95	3902.28
Dry_sedimentary	156.04	Dry_sedimentary 1	135.95	135.95
Dry_ultramafic	67.30	Dry_sedimentary 3	44.36	20.09
LM_rain_extrusive	103.56	Dry_ultramafic 1	35.09	35.09
LM_rain_intrusive	12.20	Dry_ultramafic 3	5.99	5.99
LM_wet_alluvial	7.97	LM_rain_extrusive 1	1020.17	103.56
LM_wet_extrusive	751.53	LM_rain_intrusive 1	119.98	12.20
LM_wet_intrusive	297.22	LM_wet_alluvial 1	52.29	7.97
LM_wet_limestone	1.27	LM_wet_extrusive 1	6803.13	751.53
LM_wet_ultramafic	7.37	LM_wet_intrusive 1	2616.15	297.22
Moist_alluvial	2293.09	LM_wet_limestone 1	8.76	1.27
Moist_extrusive	20823.74	LM_wet_ultramafic 1	73.37	7.37
Moist_intrusive	5728.33	Moist_alluvial 1	5881.56	2293.09
Moist_limestone	11346.77	Moist_extrusive 1	56567.02	20823.74
Moist_sedimentary	865.01	Moist_intrusive 1	13457.53	5739.98
Moist_ultramafic	564.31	Moist_limestone 1	42179.30	11346.77
Rain_alluvial	0.47	Moist_sedimentary 1	847.06	847.06
Rain_extrusive	117.81	Moist_sedimentary 2	0.44	0.44
Rain_Intrusive	24.76	Moist_sedimentary 3	243.68	17.51
Wet_alluvial	562.37	Moist_ultramafic 1	3355.96	564.31
Wet_extrusive	14373.48	Rain_alluvial 1	4.68	0.47
Wet_intrusive	3399.52	Rain_extrusive 1	1064.99	117.81

Wet_limestone	649.28	Rain_intrusive 1	189.14	24.76
Wet_sedimentary	387.02	Wet_alluvial 1	2056.29	562.37
Wet_ultramafic	509.27	Wet_extrusive 1	34239.95	14373.48
Mangrove	**3856.12**	Wet_intrusive 1	6559.98	3399.52
Wetland_Terrestrial	**831.07**	Wet_limestone 1	4344.67	649.28
		Wet_sedimentary 1	233.37	233.37
		Wet_sedimentary 2	64.33	64.33
		Wet_sedimentary 3	58.60	58.60
		Wet_ultramafic 1	4854.94	509.27
		Mangrove 1	**5286.64**	**3856.12**
		Wetland_Terrestrial 1	**900.48**	**831.07**

Table 16. Fauna targets with occurrences outside the protected areas system (*DNER national conservation status rank: **N1**, critically imperiled, typically 5 or fewer occurrences or 1,000 or fewer individuals**; N2**, imperiled, typically 6 to 20 occurrences or 1,000 to 3,000 individuals**; N3**, vulnerable, rare, typically 21 to 100 occurrences or 3,000 to 10,000 indivivuals)

Species Scientific Name	# of Occurrences	DNER Conservation Status Rank*
AGELAIUS XANTHOMUS	6	N1
AMPHISBAENA BAKERI	2	N2N3
ANAS BAHAMENSIS	1	N2
ANOLIS COOKI	1	N2
ANOLIS OCCULTUS	1	N2
ANOLIS PONCENSIS	1	N2
ANOLIS ROOSEVELTI	1	N1
BUTEO PLATYPTERUS BRUNNESCENS	2	N2
CARETTA CARETTA	2	N3
COLUMBA INORNATA WETMOREI	22	N1
COLUMBA LEUCOCEPHALA	4	N2N3?
DENDROCYGNA ARBOREA	6	N2
ELEUTHERODACTYLUS COOKI	5	N2N3
ELEUTHERODACTYLUS ENEIDAE	1	N1N2
ELEUTHERODACTYLUS JASPERI	5	N1

ELEUTHERODACTYLUS KARLSCHMIDTI	5	N1
EPICRATES INORNATUS	10	N3
FULICA CARIBAEA	4	N2
MABUYA SLOANEI	2	N3?
MELANERPES PORTORICENSIS	1	N3B
MYIARCHUS ANTILLARUM	1	N2N3B
OXYURA DOMINICA	3	N2
OXYURA JAMAICENSIS	10	N3
PELTOPHRYNE LEMUR	5	N1
PORZANA FLAVIVENTER	1	N1N3
PTERONOTUS PARNELLII PORTORICENSIS	3	N1N2
STERNA ANTILLARUM	8	N2
TACHYBAPTUS DOMINICUS	5	N2

Table 17. Plant species targets with occurrences outside the protected areas system

Species Name	Number of Occurrences	DNER Conservation Status Rank
ADIANTUM VILLOSUM	2	N1
ADIANTUM WILSONII	1	N1
AECHMEA LINGULATA	1	N1
ANEMIA HIRSUTA	2	N1
ANISEIA MARTINICENSIS	2	N1
ANTIRHEA PORTORICENSIS	2	N2
ANTIRHEA SINTENISII	2	N1
ARISTIDA CHASEAE	1	N1?
ARISTIDA PORTORICENSIS	5	N1
AUERODENDRON PAUCIFLORUM	1	N1
BACCHARIS DIOICA	1	N1
BANARA VANDERBILTII	2	N1
BRUNFELSIA LACTEA	1	N1

BUXUS VAHLII	3	N1
BYRSONIMA SPICATA	1	N1Q
CAESALPINIA CULEBRAE	2	N1
CALYPTRONOMA RIVALIS	4	N3
CAMPYLOCENTRUM PACHYRRHIZUM	1	N1
CHAMAECRISTA GLANDULOSA VAR MIRABIL	2	N?T1
COCCOLOBA PALLIDA	1	N1Q
COCCOLOBA RUGOSA	9	N2
COCCOLOBA SINTENISII VAR. ALBA	1	N5T1
COCCOLOBA TENUIFOLIA	1	N1
CORDIA RUPICOLA	2	N1
CORNUTIA OBOVATA	2	N1
CYPERUS FULIGINEUS	1	N1
CYPERUS URBANII	2	N1
CYRTOPODIUM PUNCTATUM	3	N1
DAPHNOPSIS HELLERIANA	8	N2
DENDROPEMON PURPUREUS	4	N2
DICLIPTERA KRUGII	1	N1Q
DIOSPYROS SINTENISII	2	N2
DROSERA CAPILLARIS	4	N1
ECHINODORUS TENELLUS VAR LATIFOLIUS	2	N1
ELEOCHARIS PACHYSTYLA	1	N1
ENTADA POLYPHYLLA	1	N1
ERYTHRINA EGGERSII	2	N1
EUGENIA BELLONIS	1	N1
EUGENIA SESSILIFLORA	3	N1
EUGENIA STEWARDSONII	2	N1
EUGENIA WOODBURYANA	4	N1
EUPATORIUM OTEROI	1	N1Q
EUPHORBIA OERSTEDIANA	1	N1

GAUSSIA ATTENUATA	4	N3
GOETZEA ELEGANS	4	N1
HENRIETTEA MEMBRANIFOLIA	1	N1
ILEX URBANIANA	1	N1
IPOMOEA CARNEA SSP FISTULOSA	2	N1
LANTANA RETICULATA	1	N1
LEPTOCEREUS GRANTIANUS	1	N1
LEPTOCEREUS QUADRICOSTATUS	3	N1Q
LINDSAEA PORTORICENSIS	1	N1
MAYTENUS CYMOSA	1	N1
MAYTENUS PONCEANA	3	N1
MYRCIA PAGANII	2	N1Q
MYRCIARIA BORINQUENA	1	N1
MYRCIARIA MYRTIFOLIA	3	N1
OSMUNDA CINNAMOMEA	1	N1
OSSAEA SCABROSA	1	N1
OTTOSCHULZIA RHODOXYLON	7	N1
OXANDRA LANCEOLATA	3	N1
PAVONIA PANICULATA	1	N1
PEPEROMIA WHEELERI	2	N1
PERSEA KRUGII	2	N1
PILEA LEPTOPHYLLA	1	N1Q
PIRIQUETA VISCOSA	1	N1
PISONIA HELLERI	1	N1Q
POLYGALA COWELLII	13	N1
PORTULACA CAULERPOIDES	1	N1
PROCKIA CRUCIS	1	N1
ROCHEFORTIA SPINOSA	1	N1
ROLLINIA MUCOSA	2	N1
SABAL CAUSIARUM	2	N1

SABICEA CINEREA	2	N1Q
SCHOEPFIA ARENARIA	3	N2
SCLERIA DORADOENSIS	3	N1Q
SESUVIUM MARITIMUM	1	N1
SOLANUM DRYMOPHILUM	1	N1
STAHLIA MONOSPERMA	3	N2
TILLANDSIA LINEATISPICA	1	N1
TILLANDSIA TENUIFOLIA VAR TENUIFOLI	7	N1T1
TRICHILIA TRIACANTHA	2	N1
URERA CHLOROCARPA	1	N2
WALTHERIA CALCICOLA	1	N1
ZANTHOXYLUM THOMASIANUM	4	N1
ZIZIPHUS RIGNONII	5	N1

Table 18. Gap analysis of coarse filter targets (1= first priority; 2= second priority; 3= third priority).

Target name Condition((1: Primary, 2: Secondary, 3: Mixed vegetation and land use)	Target total area (ha) with vegetation	Am't in Protected Areas System (ha)	% in protected areas system	Recommended priority for protection	PR_high quality target areas captured in the Marxan portfolio
Dry_Alluvial 1	3067.6	1159.41	37.8		
Dry_Alluvial 2	76.16	31.7	41.63		
Dry_Alluvial 3	290.84	10.9	3.75		
Dry_Extrusive 1	9144.16	3560.93	38.94		
Dry_Extrusive 2	810.83	358.11	44.17		
Dry_Extrusive 3	1114.22	27.49	2.47		
Dry_Intrusive 1	2553.01	1889.07	73.99		
Dry_Intrusive 2	73.74	52.04	70.57		

Dry_Intrusive 3	72.58	1.08	1.49		
Dry_Limestone 1	17595.95	8514.67	48.39		
Dry_Limestone 3	910.82	31.94	3.51		
Dry_sedimentary 1	135.95	0.05	0.03	1	Inclded in both *irreplaceable and *optimal portfolios
Dry_sedimentary 3	44.36	0	0		
Dry_ultramafic 1	35.09	0	0	1	Included in both irreplaceable and optimal portfolios
Dry_ultramafic 3	5.99	0	0		
LM_rain_extrusive 1	1020.17	1020.17	100		
LM_rain_extrusive 2	6.96	6.96	100		
LM_rain_extrusive 3	3.24	3.24	100		
LM_rain_intrusive 1	119.98	119.98	100		
LM_rain_intrusive 2	0.04	0.04	100		
LM_rain_intrusive 3	1.86	1.86	100		
LM_wet_alluvial 1	52.29	0	0	1	Use PR_high quality patches.shp to select areas, because Marxan irreplaceable and optimal portfolio sincluded only 4.56 ha of LM_wet_alluvial mix palms & elfin forest and 3.15 ha of pasture
LM_wet_alluvial 2	0.06	0	0		
LM_wet_alluvial 3	5.14	0	0		
LM_wet_extrusive 1	6803.13	4701.89	69.11		
LM_wet_extrusive 2	159.17	41.57	26.12		
LM_wet_extrusive 3	364.94	94.35	25.85		
LM_wet_intrusive 1	2616.15	2130.61	81.44		
LM_wet_intrusive 2	67.16	21.14	31.48		
LM_wet_intrusive 3	138.27	84.84	61.36		
LM_wet_limestone 1	8.76	0.43	4.86	2	Note the largest patch=3.68 ha.
LM_wet_limestone 3	3.38	0	0		
LM_wet_ultramafic 1	73.37	73.37	100		
Mangrove 1	5286.64	2874.37	54.37		
Mangrove 2	338.29	130.54	38.59		
Mangrove 3	307.57	127.83	41.56		
Moist_alluvial 1	5881.56	231.67	3.94	3	

Moist_alluvial 2	105.66	22.97	21.74		
Moist_alluvial 3	1656.43	42.84	2.59		
Moist_extrusive 1	56567.02	426.67	0.75	2	Mostly included only in the optimal portfolio
Moist_extrusive 2	7.96	0.31	3.96		
Moist_extrusive 3	13359.43	48.91	0.37		
Moist_intrusive 1	13457.53	748.36	5.56	3	
Moist_intrusive 2	0.43	0.05	10.78		
Moist_intrusive 3	2579.91	39.46	1.53		
Moist_limestone 1	42179.3	1229.58	2.92	2	Included only in the optimal portfolio, but it missed the remnants in the south.
Moist_limestone 2	12.5	0.55	4.39		
Moist_limestone 3	6424.23	37.94	0.59		
Moist_sedimentary 1	847.06	0	0	1	Inclded in both irreplaceable and optimal portfolios
Moist_sedimentary 2	0.44	0	0		
Moist_sedimentary 3	243.68	0	0		
Moist_ultramafic 1	3355.96	1168.26	34.81		
Moist_ultramafic 3	245.48	30.2	12.3		
Rain_alluvial 1	4.68	4.68	100		
Rain_extrusive 1	1064.99	1064.99	100		
Rain_extrusive 2	107.12	107.12	100		
Rain_extrusive 3	4.95	4.95	100		
Rain_intrusive 1	189.14	189.14	100		
Rain_intrusive 2	57.86	57.86	100		
Rain_intrusive 3	0.64	0.64	100		
Wet_alluvial 1	2056.29	95.33	4.64	3	
Wet_alluvial 2	6.72	0.75	11.12		
Wet_alluvial 3	479.19	11.57	2.41		
Wet_extrusive 1	34239.95	7013.22	20.48		
Wet_extrusive 2	8743.59	679.08	7.77		
Wet_extrusive 3	6839.87	613.51	8.97		
Wet_intrusive 1	6559.98	1125.44	17.16		
Wet_intrusive 2	1564.07	130.77	8.36		

Wet_intrusive 3	1074.28	80.18	7.46		
Wet_limestone 1	4344.67	1438.96	33.12		
Wet_limestone 2	0.9	0.14	15.47		
Wet_limestone 3	354.94	43.91	12.37		
Wet_sedimentary 1	233.37	0	0	1	Inclded in both irreplaceable and optimal portfolios.
Wet_sedimentary 2	64.33	0	0		
Wet_sedimentary 3	58.6	0	0		
Wet_ultramafic 1	4854.94	2934.69	60.45		
Wet_ultramafic 2	0.99	0.01	0.7		
Wet_ultramafic 3	71.96	19.49	27.08		
Wetland_Terrestrial 1	900.48	435.13	48.32		
Wetland_Terrestrial 2	2077.92	861.41	41.46		
Wetland_Terrestrial 3	345.9	156.41	45.22		
Sum	**276534.77**	**48167.73**			
% of vegetated areas in the protected area system of the Commonwealth		**17.42**			

Table 19. Gap analysis for 1201 rare/threatened species target occurrences (source: DNER database 2003)

	Flora	**Fauna**
Occurrences **inside** protected areas	396	418
Occurrences **outside** protected areas	218	169
Total occurrences	614	587
% of occurrences **inside** protected areas	64%	71%
% of occurrences **outside** protected areas	36%	29%

Table 20. Thinedge results from all coarse filter conservation targets except for those with <= 4 occurrences (blue)

Target	Total # of occurrences	dt where there is >1 node in the largest component (point at which the graph has at least 1 edge)	transition phase	dt where there is only 1 graph component (minimal spanning tree)	longest edge (LCPD)
Dry-alluvial	46	3	4-10	65	209
Dry limestone	23	4	6-10	13	112
Dry Sedimentary	6	5	5-14	23	47
Dry volcanic extrusive	23	4	4-12	69	212
Dry volcanic intrusive	17	3	4-24	60	192
Dry ultramafic	2	-	-	-	-
Moist alluvial	75	1	5-14	22	198
Moist limestone	35	4	5-19	36	171
Moist sedimentary	12	3	5-14	23	108
Moist volcanic extrusive	54	5	5-20	26	200
Moist volcanic intrusive	48	5	6-16	23	188
Moist ultramafic	3	-	-	-	-
Wet alluvial	39	4	5-13	38	161
Wet limestone	8	7	7-18	19	50
Wet sedimentary	8	5	6-20	21	63
Wet volcanic extrusive	17	7	8-20	44	176
Wet volcanic intrusive	42	3	4-15	55	168
Wet ultramafic	1	-	-	-	-
Lower montane wet alluvial	4	-	-	-	-
Lower montane wet limestone	1	-	-	-	-
Lower montane wet volcanic extrusive	9	6	9-17	64	134
Lower montane wet volcanic intrusive	6	5	5-13	95	127
Lower montane wet ultramafic	1	-	-	-	-
Rain alluvial	1	-	-	-	-
Lower montane rain volcanic extrusive	2	-	-	-	-

Lower montane rain volcanic intrusive	2	-	-	-	-
Rain volcanic extrusive	1	-	-	-	-
Rain Volcanic Intrusive	1	-	-	-	-
Wetlands	24	3	17-35	46	187
Mangrove	39	4	5-29	41	197

Table 21. R and F values for each group of occurrences of Moist-extrusive (**14**: Aguas Buenas)

Moist Extrusive					
average over 9, 14, 30 km					
Node	R	F	Node	R	F
1	2.636	4.953	**27**	7.22	5.754667
2	3.212	5.005	**28**	0.296	0.822333
3	2.314	1.42	**29**	1.947	0.697667
4	6.538	15.447	**30**	0.306	0.073667
5	4.549	18.75733	**31**	3.82	1.673667
6	1.55	5.623	**32**	0.199	0.078
7	1.888	5.911667	**33**	0.784	1.414333
8	2.055	0.843333	**34**	2.434	0.557
9	1.154	2.567333	**35**	0.376	0.256
10	6.314	7.786	**36**	0.087	0.047333
11	4.254	7.526667	**37**	0.054	0.026333
12	0.404	0.866667	**38**	0.003	0.003
13	2.957	16.85333	**39**	0.014	0.044667
14	13.745	41.975	**40**	0.011	0.008
15	0.494	3.546	**41**	0.051	0.090333
16	0.488	2.181667	**42**	0.011	0.120333
17	1.478	5.812667	**43**	0.047	0.208
18	0.419	2.336667	**44**	0.021	0.116667
19	3.334	16.35733	**45**	0.073	0.038
20	0.752	3.551	**46**	0.054	0.072

21	2.188	5.297	**47**	0.037	0.033667
22	3.336	5.469333	**48**	0.04	0.078333
23	0.264	0.911667	**49**	0.012	0.026667
24	0.545	1.247667	**50**	0.09	0.181667
25	11.869	3.876333	**51**	0.095	0.328
26	3.183	1.128667			

Table 22. FLAGSTATS output (only coarse filter targets of the main island of Puerto Rico)

Target	Class Area = Total Target Area (**ha**)	Total Landscape Area (**ha**)	Number of Patches	Percent of Landscape = Class Area/Total Landscape Area x 100	Largest Patch Index (%) = area of the largest patch/Total Landscape Area x 100	Patch Density (No/100ha) = number of patches / total landscape area x 100	Mean Patch Size (ha) = Class area / # of patches	Total Edge (m)	Edge Density (m/ha)	Mean Shape Index	Area-Weighted MSI
Dry-alluvial	5327.28	1239451.6	4999	0.43	0.015	0.403	1.066	2121180	1.711	1.346	2.771
Dry-extrusive	10548.09	1239451.6	5235	0.851	0.113	0.422	2.015	3077400	2.483	1.38	5.939
Dry-intrusive	766.71	1239451.6	608	0.062	0.008	0.049	1.261	296760	0.239	1.388	2.888
Dry-limestone	14740.56	1239451.6	4188	1.189	0.276	0.338	3.52	2297700	1.854	1.344	4.597
Dry-sedimentary	502.65	1239451.6	285	0.041	0.009	0.023	1.764	184260	0.149	1.424	4.69
Dry-ultramafic	65.34	1239451.6	113	0.005	0.003	0.009	0.578	33600	0.027	1.289	2.573
LM-Rain-extrusive	1019.79	1239451.6	6	0.082	0.048	0	169.965	47700	0.038	1.84	2.693
LM-Rain-intrusive	119.7	1239451.6	6	0.01	0.003	0	19.95	15900	0.013	1.762	2.239
LM-Wet-alluvial	62.37	1239451.6	23	0.005	0.001	0.002	2.712	15840	0.013	1.4	1.815
LM-Wet-extrusive	6804.99	1239451.6	198	0.549	0.211	0.016	34.369	477540	0.385	1.527	6.067
LM-Wet-intrusive	2626.65	1239451.6	107	0.212	0.13	0.009	24.548	209160	0.169	1.523	3.969
LM-Wet-limestone	9	1239451.6	7	0.001	0.001	0.001	1.286	3180	0.003	1.373	1.692
LM-Wet-ultramafic	73.08	1239451.6	1	0.006	0.006	0	73.08	6000	0.005	1.98	1.98
Mangrove	6837.299	1239451.6	4680	0.552	0.047	0.378	1.461	1956960	1.579	1.301	4.2
Moist-alluvial	16367.04	1239451.6	21166	1.321	0.02	1.708	0.773	7661878	6.182	1.332	1.796
Moist-extrusive	88316.28	1239451.6	24586	7.125	0.609	1.984	3.592	20539440	16.571	1.408	11.906

Moist-intrusive	19131.66	1239451.6	10544	1.544	0.181	0.851	1.814	5802600	4.682	1.378	6.092
Moist-limestone	58283.3	1239451.6	12766	4.702	0.781	1.03	4.566	10693553	8.628	1.378	16.631
Moist-sedimentary	2012.039	1239451.6	1374	0.162	0.008	0.111	1.464	758999.8	0.612	1.415	3.07
Moist-ultramafic	3599.641	1239451.6	470	0.29	0.164	0.038	7.659	467040	0.377	1.379	8.004
Rain-alluvial	4.59	1239451.6	2	0	0	0	2.295	1740	0.001	1.64	2.13
Rain-extrusive	1050.93	1239451.6	27	0.085	0.061	0.002	38.923	118260	0.095	1.713	7.542
Rain-intrusive	186.84	1239451.6	30	0.015	0.013	0.002	6.228	41280	0.033	1.412	6.691
Wet-alluvial	2762.55	1239451.6	1736	0.223	0.007	0.14	1.591	1045980	0.844	1.458	2.676
Wet-extrusive	51712.11	1239451.6	33334	4.172	0.383	2.689	1.551	17735881	14.309	1.371	8.059
Wet-intrusive	10565.73	1239451.6	9963	0.852	0.058	0.804	1.06	4220100	3.405	1.336	4.419
Wetland	6701.579	1239451.6	6190	0.541	0.077	0.499	1.083	2196299	1.772	1.288	4.344
Wet-limestone	4916.97	1239451.6	447	0.397	0.305	0.036	11	523020	0.422	1.466	7.639
Wet-sedimentary	559.98	1239451.6	1027	0.045	0.002	0.083	0.545	319800	0.258	1.3	2.39
Wet-ultramafic	4844.79	1239451.6	34	0.391	0.389	0.003	142.494	208920	0.169	1.456	8.047

Table 23. Puerto Rican experts who participated in the viability assessment of terrestrial targets occurrences

Name	Expertise	Organization
Alexis Dragoni	Biologist	F. Biosferica
Jorge C. Trejo Torres	Biologist/Botanist	Ciudadanos del Karso
Leopoldo Miranda-Castro	Zoologist	USFWS
Luis A. Rivera	Tropical Vegetation Specialist	US Forest Service, Caribbean National Forest
Edgardo González	Research Forester	DNER, Forestry Research Division
Vicente Quevedo	Botanist	DNER, Natural Heritage Division
Daniel Dávila	Zoologist/Data Manager	DNER, Natural Heritage Division
Luis D. Beltrán-Burgos	Biologist/Environmental Planner	DNER, Natural Heritage Division
Jose Sustache	Botanist	DNER
Jose Luis Chavert	Zoologist	DNER, Endangered Species Program
Jose A. Salguero	Ornithologist	SOPI

Alberto Alvarez	Biologist	DNER
Rafael Joglar	Herpetologist	Department of Biology, University of Puerto Rico, Rio Piedras
Richard Thomas	Herpetologist	Department of Biology, University of Puerto Rico, Rio Piedras

Table 24. Results of viability assessment of coarse filter targets (BH = Biodiversity Health)

Target	Total # of occurrences	% of occurrences completed	Total target area (hactare)	% area where BH was evaluated	Area where BH was evaluated	Quality-weighted area where BH was evaluated	Average quality of areas where BH was evaluated
Dry_alluvial	46	100.00	2191.02	100.00	2191.02	1287.24	0.59
Dry_extrusive	23	8.70	6241.76	30.67	1914.651	1907.37533	0.9962
Dry_intrusive	17	0.00	411.62	0.00	0.00	0.00	NA
Dry_limestone	23	91.30	13094.20	99.90	13080.71	10459.94	0.80
Dry_sedimentary	6	66.67	180.37	87.04	157.00	94.96	0.60
Dry_ultramafic	2	100.00	42.49	100.00	42.49	41.96	0.99
LM_rain_extrusive	2	100.00	1035.59	100.00	1035.59	1024.06	0.99
LM_rain_intrusive	2	0.00	121.98	0.00	0.00	0.00	NA
LM_wet_alluvial	4	0.00	59.00	0.00	0.00	0.00	NA
LM_wet_extrusive	9	88.89	7376.24	99.60	7346.67	7315.57	1.00
LM_wet_intrusive	6	33.33	2837.74	43.01	1220.47	1211.07	0.99
LM_wet_limestone	1	100.00	12.71	0.00	0.00	0.00	NA
LM_wet_ultramafic	1	100.00	73.73	100.00	73.73	69.40	0.94
Mangrove	39	48.72	5913.23	82.86	4899.66	4868.85	0.99
Moist_alluvial	75	10.67	9548.80	17.60	1680.37	1401.74	0.83
Moist_extrusive	54	25.93	71373.28	39.40	28124.40	27402.04	0.97
Moist_intrusive	48	25.00	13501.75	53.92	7279.69	7037.66	0.97
Moist_limestone	35	37.14	49564.35	76.73	38030.11	36036.72	0.95
Moist_sedimentary	12	0.00	966.72	0.00	0.00	0.00	NA

Moist_ultramafic	3	66.67	3928.66	97.12	3815.62	3554.64	0.93
Rain_alluvial	1	0.00	4.68	0.00	0.00	0.00	NA
Rain_extrusive	1	100.00	1178.15	100.00	1178.15	1175.67	1.00
Rain_intrusive	1	0.00	247.64	0.00	0.00	0.00	NA
Wet_alluvial	39	0.00	2849.91	0.00	0.00	0.00	NA
Wet_extrusive	17	41.18	46587.64	64.80	30186.64	29977.85	0.99
Wet_intrusive	42	11.90	9239.70	62.24	5750.42	5184.85	0.90
Wet_limestone	8	37.50	4670.49	91.08	4254.04	3845.03	0.90
Wet_sedimentary	8	0.00	366.27	0.00	0.00	0.00	NA
Wet_ultramafic	1	100.00	5084.52	100.00	5084.52	4787.07	0.94
Wetland	24	0.00	5116.29	0.00	0.00	0.00	NA
SUM	**550**	**31.64**	**263820.52**	**59.64**	**157345.94**	**148683.69**	**0.94**

Table 25. Results of viability assessments of faunal targets (BH<= 0.8 informs conservation concern.)

Target	Total # of occurrences	# of occurrences evaluated	% of occurrences where BH was evaluated	Quality-weighted area where BH was evaluated	Average quality of areas where BH was evaluated
Mona Iguana (Cyclura corneta stejnegeri)	1	1	100	0.98	0.98
Mona Boa (*Epicrates monensis*)	3	3	100	0.86~1.00	0.94
Puerto Rican Boa (*Epicrates inornatus*)	27	4	14.81	0.86~1.00	0.95
*Eleutherodactylus cooki** (no key factor weighting)	5	1	20	1	1
Eleutherodactylus gryllus	3	3	100	0.95~1.00	0.98
Eleutherodactylus hedricki	4	2	50	0.95~1.00	0.98
Eleutherodactylus jasperi	14	1	7.14	1	1
Eleutherodactylus locustus	2	2	100	0.85~0.95	0.9
Eleutherodactylus monensis	-	1	-	1	1

Eleutherodactylus portoricensis	3	3	100	0.85~1	0.92
Eleutherodactylus richmondi	3	3	100	0.85~1	0.92
Eleutherodactylus unicolor	1	1	100	1	1
Eleutherodactylus wightmanae	3	3	100	0.90~1	0.95
Waterfowl	-	13	-	0.72~1	0.92
Wilson's Plover (*Charadrius wilsonia*)	-	7	-	0.49~1	0.78
Yellow-breasted Crake (*Porzana flaviventer*)	5	4	80	0.82~1	0.94
White-crowned Pigeon (*Patagioenas leucocephala*, formerly *Columba leucocephala*)	10	7	70	0.43~1	0.73
Puerto Rican Parrot (*Amazona vittata*)	3	1	100	0.77	0.77
Black-throated Blue Warbler (*Dendroica caerulescens*)	-	6	-	0.6~0.98	0.84

Table 26. Faunal targets occurrences with poor habitat quality

Target _occurrence #	**Occurrence name**	**Key Ecological Factors**	**Key factor weight**	**Key factor status-most likely (experts' estimate)**	**weighted biodiversity health status**	**Biodiversity Health /occurrence**
Waterfowl species representative: West Indian Whistling Duck (*Dendrocygna arborea*)						
Waterfowl_1 & 2	Torrecilla Loiza y Pinos	water quality	8	0.3	0.13	
Waterfowl_1 & 2	Torrecilla Loiza y Pinos	habitat mosaic	10	0.45	0.22	
Waterfowl_1 & 2	Torrecilla Loiza y Pinos	hydrology regime	10	0.35	0.19	
Waterfowl_1 & 2	Torrecilla Loiza y Pinos	nesting/breeding habitat	10	0.25	0.14	

Waterfowl_1 & 2	Torrecilla Loiza y Pinos	stability of food resources	8	0.3	0.13	
			46			**0.8**
Waterfowl_14	Aguirre Forest	water quality	8	0.25	0.11	
Waterfowl_14	Aguirre Forest	habitat mosaic	10	0.45	0.22	
Waterfowl_14	Aguirre Forest	hydrology regime	10	0.1	0.05	
Waterfowl_14	Aguirre Forest	nesting/breeding habitat	10	0.3	0.16	
Waterfowl_14	Aguirre Forest	stability of food resources	8	0.45	0.17	
						0.72
Waterfowl_15	Punta Santiago	water quality	8	0.25	0.11	
Waterfowl_15	Punta Santiago	habitat mosaic	10	0.3	0.16	
Waterfowl_15	Punta Santiago	hydrology regime	10	0.2	0.11	
Waterfowl_15	Punta Santiago	nesting/breeding habitat	10	0.3	0.16	
Waterfowl_15	Punta Santiago	stability of food resources	8	0.45	0.17	
						0.72
Wilson's plover (*Charadrius wilsonia*)						
Wilson's plover_1	Boquerón	Hydrology	10	0.1	0.07	
Wilson's plover_1	Boquerón	Food resource availability	10	0.1	0.07	
Wilson's plover_1	Boquerón	Disturbance at roosting & nesting sites	9	0.2	0.12	
Wilson's plover_1	Boquerón	Nesting habitat	9	0.4	0.24	
						0.49
Wilson's plover_2	Aguirre Forest	Hydrology	10	0.1	0.07	
Wilson's plover_2	Aguirre Forest	Food resource availability	10	0.1	0.07	
Wilson's plover_2	Aguirre Forest	Disturbance at roosting & nesting sites	9	0.2	0.12	
Wilson's plover_2	Aguirre Forest	Nesting habitat	9	0.4	0.24	
						0.49
Wilson's plover_3	Cabezas de San Juan	Hydrology	10	0.3	0.2	

Wilson's plover_3	Cabezas de San Juan	Food resource availability	10	0.3	0.2	
Wilson's plover_3	Cabezas de San Juan	Disturbance at roosting & nesting sites	9	0.3	0.18	
Wilson's plover_3	Cabezas de San Juan	Nesting habitat	9	0.3	0.18	
						0.75
White-crowned pigeon (*Patagioenas leucocephala,* formerly *Columba leucocephala)*						
White-crowned pigeon_1	Lago Tortuguero - Sabana Seca	Food resource availability	10	0.4	0.26	
White-crowned pigeon_1	Lago Tortuguero - Sabana Seca	Habitat mosaic	10	0.35	0.23	
White-crowned pigeon_1	Lago Tortuguero - Sabana Seca	Nesting habitat	10	0.3	0.2	
White-crowned pigeon_1	Lago Tortuguero - Sabana Seca	Population size	2	0.25	0.03	
White-crowned pigeon_1	Lago Tortuguero - Sabana Seca	Landscape connectivity	6	0.2	0.08	
						0.8
White-crowned pigeon_2	San Germán	Food resource availability	10	0.3	0.2	
White-crowned pigeon_2	San Germán	Habitat mosaic	10	0.25	0.16	
White-crowned pigeon_2	San Germán	Nesting habitat	10	0.2	0.13	
White-crowned pigeon_2	San Germán	Population size	2	0.15	0.02	
White-crowned pigeon_2	San Germán	Landscape connectivity	6	0.2	0.08	
						0.59
White-crowned pigeon_3	Aguirre Forest	Food resource availability	10	0.2	0.13	
White-crowned pigeon_3	Aguirre Forest	Habitat mosaic	10	0.2	0.13	
White-crowned pigeon_3	Aguirre Forest	Nesting habitat	10	0.2	0.13	
White-crowned pigeon_3	Aguirre Forest	Population size	2	0.2	0.03	
White-crowned pigeon_3	Aguirre Forest	Landscape connectivity	6	0.2	0.08	
						0.5

White-crowned pigeon_4	Maunabo	Food resource availability	10	0.2	0.13	
White-crowned pigeon_4	Maunabo	Habitat mosaic	10	0.15	0.1	
White-crowned pigeon_4	Maunabo	Nesting habitat	10	0.15	0.1	
White-crowned pigeon_4	Maunabo	Population size	2	0.15	0.02	
White-crowned pigeon_4	Maunabo	Landscape connectivity	6	0.2	0.08	
						0.43
Black-throated blue warbler (*Dendroica caerulescens*)						
Black-throated blue warbler_2	Bermeja	Migration	10	0.25	0.18	
Black-throated blue warbler_2	Bermeja	Habitat mosaic	10	0.25	0.18	
Black-throated blue warbler_2	Bermeja	Food resource availability	9	0.25	0.16	
Black-throated blue warbler_2	Bermeja	Habitat block size	6	0.2	0.09	
						0.6
Puerto Rican parrot (*Amazona vittata*)						
Puerto Rican parrot_1	El Yunque	Nesting/breeding habitat	10	0.5	0.27	
Puerto Rican parrot_1	El Yunque	Natural predator / prey dynamics	10	0.3	0.2	
Puerto Rican parrot_1	El Yunque	Forest physiognomy	9	0.5	0.24	
Puerto Rican parrot_1	El Yunque	Population size and age / stage structure	8	0.1	0.05	
						0.77

Table 27. Conservation targets that are found outside of the protected areas system but are included in the most desirable portfolio (Source: TNC target map 2004, DNER database 2003)

Site	Target (scientific name)	Target (common name)	Target (conservation status rank)	Endemism

West of Bosque Estatal de Rio Abajo	**Moist_limestone**			
	Calyptronoma rivalis	Palma manaca	N3	N endemic
	Byrsonima spicata	Maricao, Doncella	N1	N endemic
	Cornutia obovata	Nigua	N1	N endemic
	Antirhea sintenisii	Quina	N1	N endemic
	Melanerpes portoricensis	PR woodpecker, Carpintero	N3	
East of Bosque estatal de Rio Abajo	**Moist_limestone**			
	Cave community (bats)			
	Rollinia mucosa	Anon cimarron	N1	
	Anolis ocultus	Lagartijo enano	N2	N endemic
	Pteronotus parnellii portoricensis	Murciélago bigotudo	N1N2T1T2	
Aguas Buenas	**Moist_ extrusive (**Secondary vegetation)			
	Cave-dwelling-bats			
	Eleutherodactylus eneidae	Caqui de eneida	N1N2	N endemic
Cordillera Central (expansion of current protected areas)	**Moist_extrusive**			
Between Patillas & Maunabo	**Moist_extrusive**			
	Eleutherodactylus cooki (in adjacent planning unit)	Guajon, Coqui de cavernas	N2N3	N endemic
Nr. US Naval station Roosevelt Roads	**Dry_extrusive**			

	Eretmochelys imbricata	Carey, Carey de concha	N3	
	Agelaius xanthomus	Mariquita de Puerto Rico	N1	N endemic
	Dendrocygna arborea	Chiriria native, Pato nocturno	N2	
	Tachybaptus dominicus	Tigua, Zaramaguillon chico	N2	
	Trichechlis manatus manatus	Manati	N2	
Vieques (expansion of current protected areas)	**Dry_extrusive**			
Culebra	**Dry_extrusive**			
	Peperomia wheelef		N1	N endemic
	Justicia culebritae		N1	S endemic
	Caesalpinia culebrae	Mato Amarillo, Smooth yellow nicker	N1	N endemic
	Charadrius wilsonia	Wilson's plover		
	Columba leucocephala			
	Epicrates monensis	Boa de Mona, Boa de isles Virgenes	N1	
	Eretmochelys imbricata	Carey, Carey de concha	N3	
	Chelonia mydas	Peje blanco	N3	
	Dermochelys coriacea	Tinglar	N2	
	Anolis roosevelti	Lagarto de culebra	N1	S endemic
	Cabuya sloanei	Lucia, Santa Lucia	N3?	

	Caretta caretta	Cabezon	N3	
	Oxyura jamaicensis	Pato chorizo	N3	
	Fulica caribaea	Gallinazo nativo, Gallareta pico blanco	N2	
	Anas bahamensis	Pato quijada colorada	N2	
	Oxyura dominica	Pato dominico	N2	

Table 28. Assessments of the current status of key factors in occurrences of Dry-limestone and Moist-limestone

Target	Ocr. ID # (see Figure 17)	Key factor	Minimum	Most likely	maximum	Expert	date
Dry limestone	7	Size	0.35	0.45	0.55	Leopoldo Miranda	10/15/2003
Dry limestone	7	Connectivity	0.35	0.45	0.55	Leopoldo Miranda	10/15/2003
Dry limestone	7	trophic structure	0.45	0.5	0.55	Leopoldo Miranda	10/15/2003
Dry limestone	7	surface and substrate	0.4	0.55	0.7	Leopoldo Miranda	10/15/2003
Dry limestone	7	hydrological regime	0.1	0.25	0.4	Leopoldo Miranda	10/15/2003
Dry limestone	7	keystone species composition	0.35	0.5	0.55	Leopoldo Miranda	10/15/2003
Dry limestone	7	physiognomy	0.4	0.55	0.7	Leopoldo Miranda	10/15/2003
Dry limestone	7	connectivity to ocean (coastal)	0.35	0.5	0.55	Leopoldo Miranda	10/15/2003
Dry limestone	8	size	0.35	0.45	0.55	Leopoldo Miranda	10/15/2003
Dry limestone	8	connectivity	0.35	0.45	0.55	Leopoldo Miranda	10/15/2003
Dry limestone	8	trophic structure	0.45	0.5	0.55	Leopoldo Miranda	10/15/2003
Dry limestone	8	surface and substrate	0.4	0.55	0.7	Leopoldo Miranda	10/15/2003
Dry limestone	8	hydrological regime	0.1	0.25	0.4	Leopoldo Miranda	10/15/2003
Dry limestone	8	keystone species composition	0.35	0.5	0.55	Leopoldo Miranda	10/15/2003
Dry limestone	8	physiognomy	0.4	0.55	0.7	Leopoldo Miranda	10/15/2003

Dry limestone	8	connectivity to ocean (coastal)	0.25	0.45	0.5	Leopoldo Miranda	10/15/2003
moist limestone	24	trophic structure	0.4	0.6	0.75	Alexi Dragoni, Carlos Trejos	9/23/2003
moist limestone	24	surface and substrate	0.4	0.5	0.7	Alexi Dragoni, Carlos Trejos	9/23/2003
moist limestone	24	hydrology	0.3	0.5	0.7	Alexi Dragoni, Carlos Trejos	9/23/2003
moist limestone	24	keystone species	0.4	0.55	0.7	Alexi Dragoni, Carlos Trejos	9/23/2003
moist limestone	24	physiognomy	0.4	0.55	0.7	Alexi Dragoni, Carlos Trejos	9/23/2003

Table 29. R, F and T values for each group of occurrences of Dry-limestone (Node 6, 7, 8 and 9 are indicated in Figure 17.)

Dry Limestone Use R, F, and T-trans, or the COMBO				
average over 2, 5, 7, 8, 10, 11, 15, 21, 50, 113 km				
Node	**R**	**F**	**T-trans**	**COMBO**
1	1.405	0.4972	11.76471	0.59985
2	1.211	0.7789	0	0.6922
3	0.301	0.7826	2.941176	0.46655
4	3.719	1.8128	2.941176	1.83615
5	0.646	0.5275	2.941176	0.42525
6	24.851	16.9571	11.76471	14.6913
7	4.142	21.591	8.823529	11.831
8	2.661	19.1189	5.882353	10.2247
9	9.918	39.4768	5.882353	22.2179
10	1.144	3.236	2.941176	1.904
11	27.455	59.2229	8.823529	36.4752
12	0.391	0.9518	5.882353	0.57365
13	13.448	27.2847	2.941176	17.00435

14	0.308	0.6548	5.882353	0.4044
15	3.498	3.2373	8.823529	2.49315
16	0.141	0.0746	0	0.07255
17	2.611	0.9468	0	1.12615
18	1.835	0.5296	0	0.72355
19	0.085	0.0241	0	0.0333
20	0.002	0.002	2.941176	0.0015
21	0.07	0.0608	2.941176	0.0479
22	0.143	2.2214	2.941176	1.14645
23	0.015	0.0099	2.941176	0.0087

Figure 1. Terrestrial coarse filter conservation targets

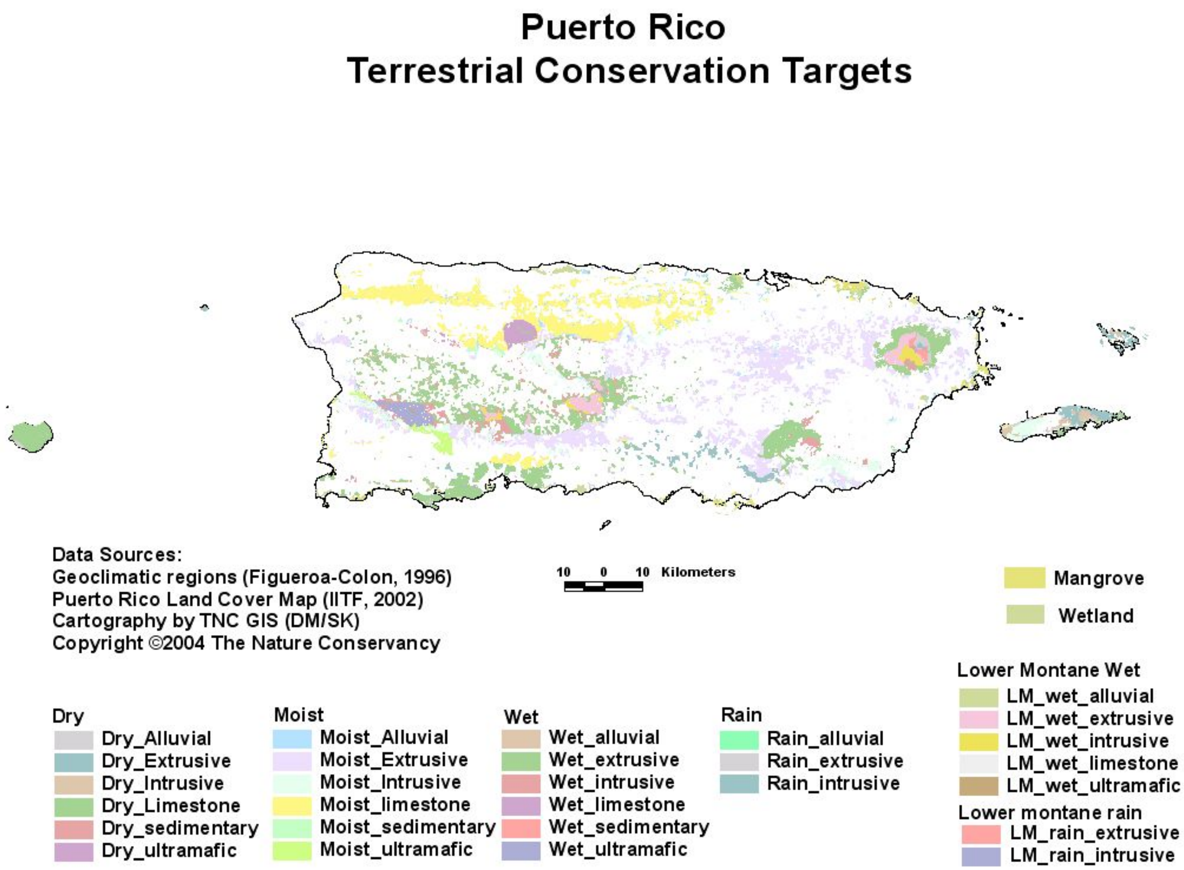
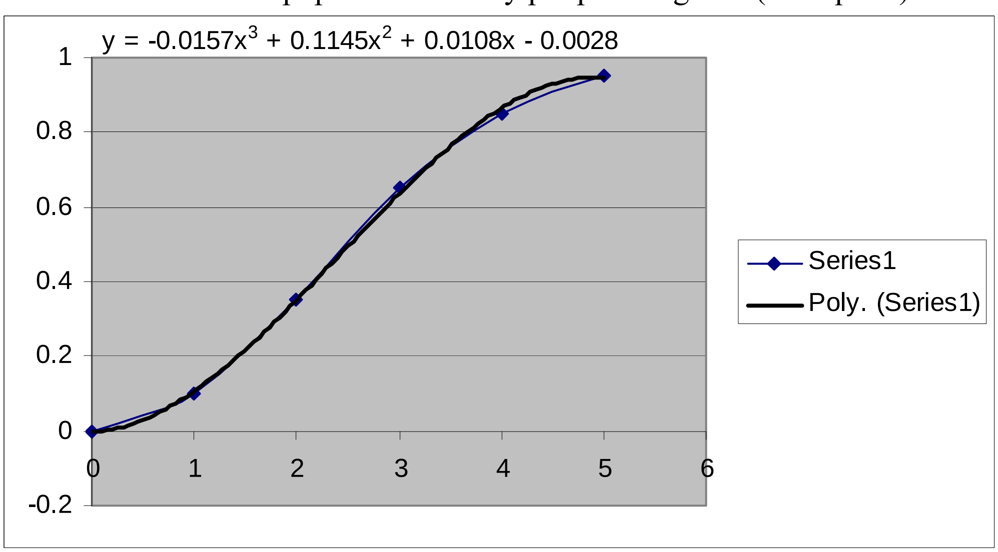
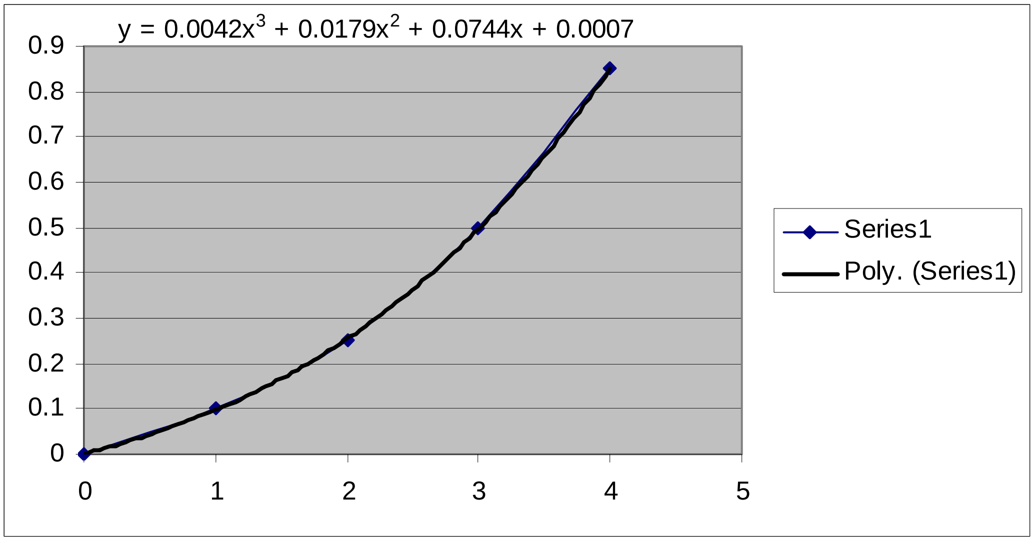


Figure 2. Urban Function: X = population density per planning unit (2.6 sq. km). Y= intensity.



	Urban
Class	**Intensity Value (y)**
0	0 – 0.1
1	> 0.1- 0.35
2	> 0.35 - 0.65
3	> 0.65 - 0.85
4	> 0.85 - 0.95
5	> 0.95

Figure 3. Agriculture Function: X = kcals of inputs for crop production per planning unit. Y = intensity.



	Agriculture
Class	**Intensity Value**
0	0 – 0.1
1	> 0.1- 0.25
2	> 0.25 - 0.5
3	> 0.5 - 0.85
4	> 0.85

Figure 4. Overlay of rare or threatened species occurrences on protected areas

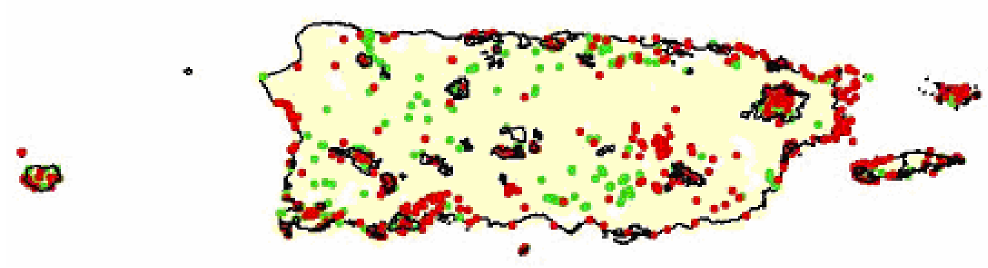


Figure 5. Least cost paths of all targets with occurrences > 4

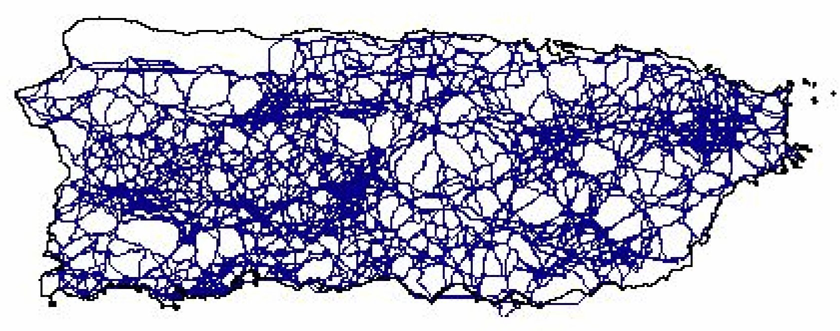


Figure 6. Overlay of protected areas on the map of least cost paths

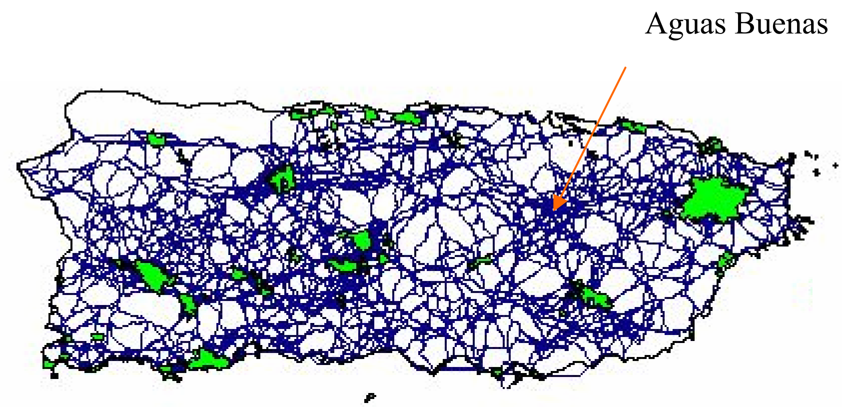


Figure 7. Distribution map of vegetation remnants in Moist-extrusive

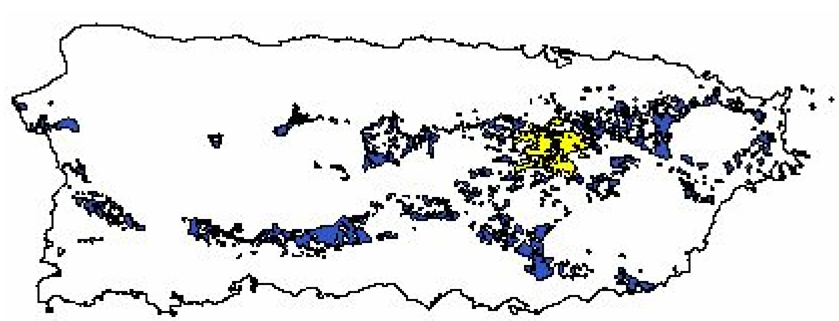


Figure 8. Terrestrial <u>most desirable</u> portfolio: no species data, protected areas locked and with cost surface

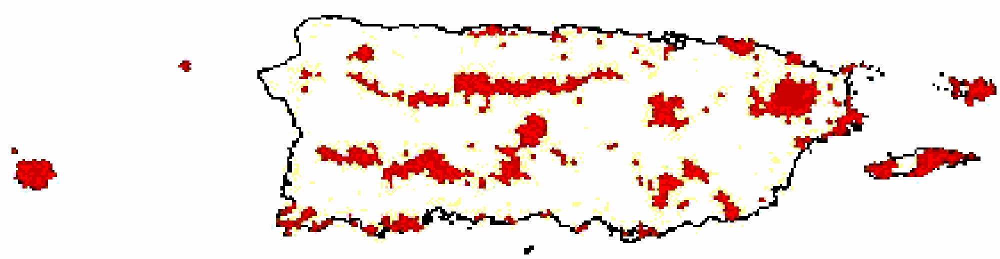


Figure 9. Terrestrial optimal portfolio: with species data, protected areas locked and with cost surface

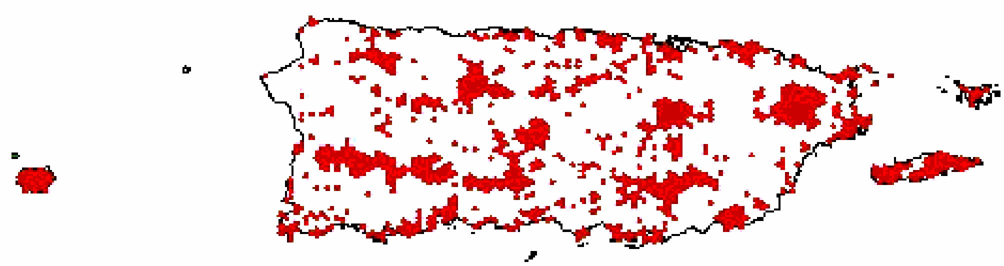


Figure 10. Terrestrial irreplaceable portfolio: no species data, protected areas not locked and with cost surface

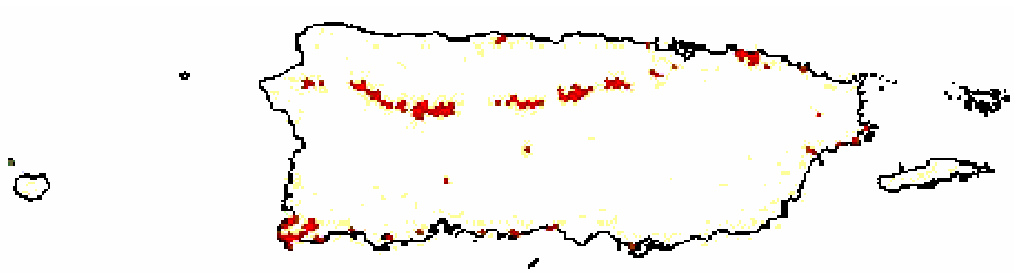


Figure 11. Terrestrial irreplaceable portfolio: with species data, protected areas not locked and with cost surface

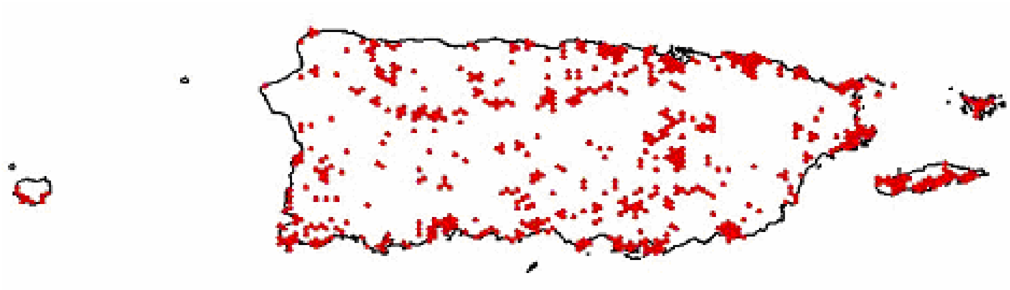


Figure 12a. Maps of rare or threatened species (red: animal species, green: plant species) overlaid on terrestrial most desirable portfolio (light purple)—no species data, protected areas locked and with cost surface

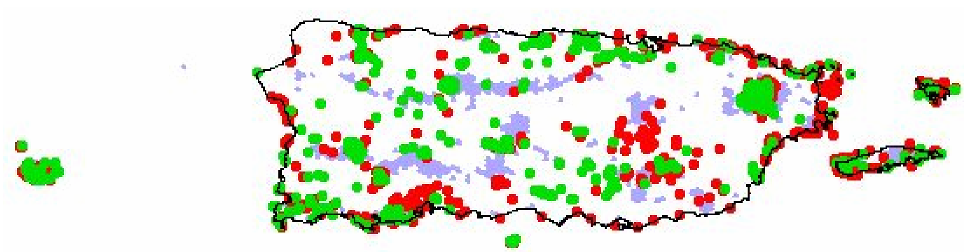


Figure 12b. Protected areas (outline) overlaid on **Figure 12a**

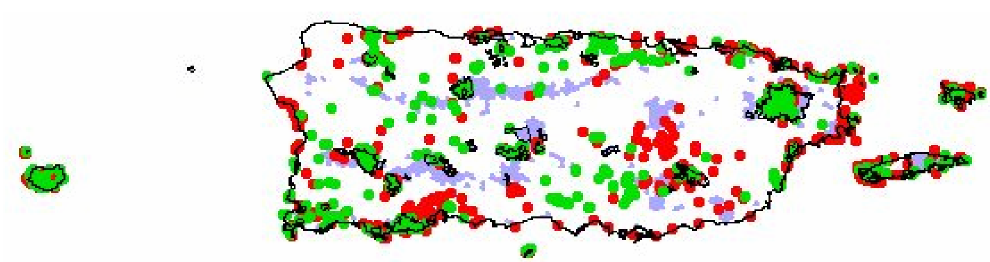


Figure 13. Protected areas overlaid on the optimal portfolio: no species data, protected areas not locked and with cost surface

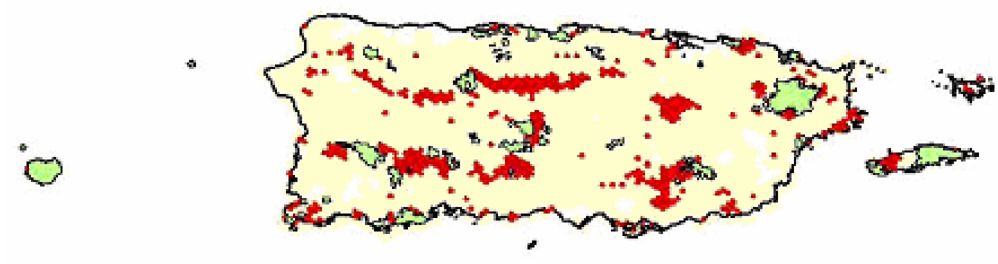


Figure 14. Protected areas overlaid on the optimal portfolio: with species data, protected areas not locked and with cost surface

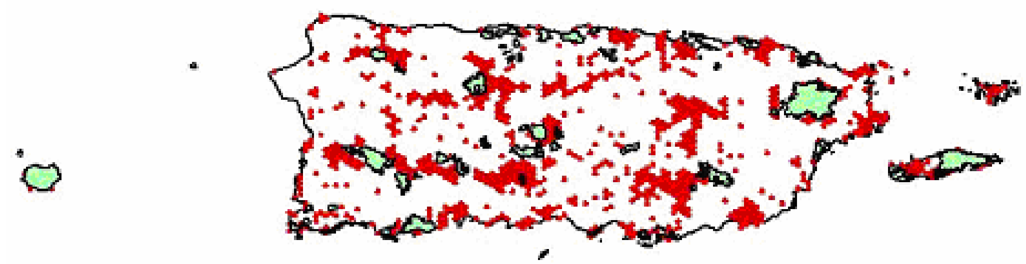


Figure 15. Protected areas overlaid on the optimal portfolio: with species data, protected areas not locked, no cost surface, and goal with 30% current target extent

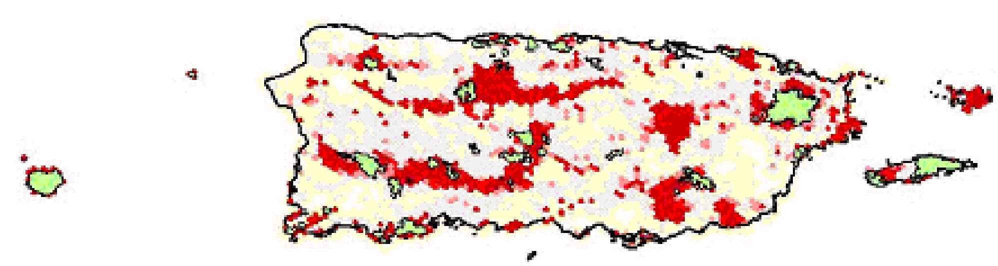


Figure 16. The most desirable portfolio (red) overlaid on municipalities (outline) and protected areas (green)

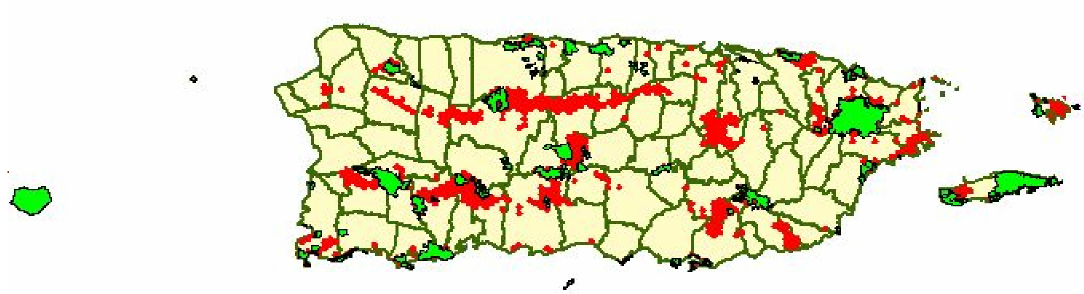
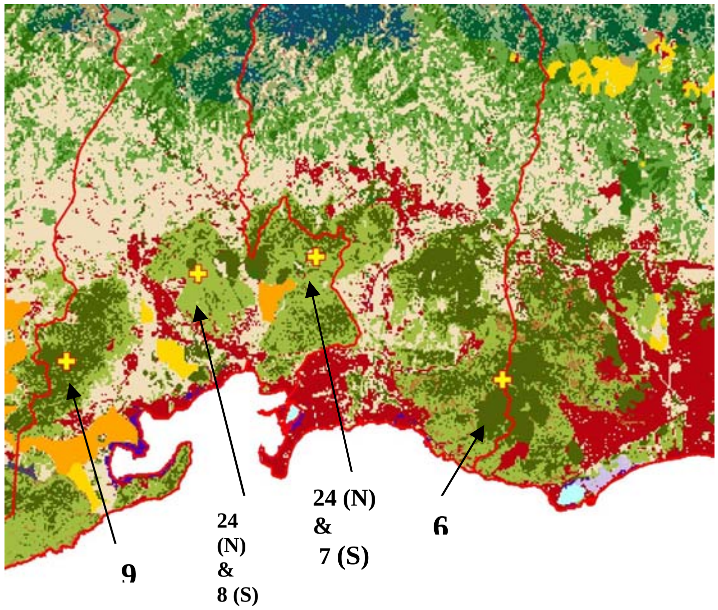


Figure 17. High quality patches (areas labeled with +) of Dry-limestone (**6, 7, 8,** and **9**; see also Table 29) and Moist-limestone (**24**, see also Table 28) near Guánica State Forest (Alexis Dragoni, e-mail of January 13, 2005)



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Appendix 1. Brief descriptions of Puerto Rico vegetation formations (adapted from Areces-Mallea et al. 1999)

1. **Lowland [dry] semideciduous forest (I.C.1.N.a.)**
   Typical canopy species include *Bucida buceras, Quararibea turbinata, Guapira fragrans, Zanthoxylum martinicense*, and *Ficus citrifolia*. Terrestrial and epiphytic ferns are frequent and include *Blechnum occidentale*, *Tectaria heracleifolia*, *Cyclopeltis semicordata*, and *Adiantum tenerum*. In northcentral and northwestern Puerto Rico, forests dominated or codominated by *Coccoloba diversifolia*. ***Coccoloba diversifolia - Bursera simaruba - Bucida buceras - Zanthoxylum martinicense*** occur at low elevations on limestone hills ("mogote" sides and tops). Characteristic species on mogote include also *Gaussia attenuata, Rondeletia inermis, Guettarda scabra, Eugenia confusa, Eugenia spp., Coccothrinax alta, Thrinax morrisii*, and *Aiphanes acanthophylla*.

2. **Lowland dry semideciduous woodland/shrubland (II.C.1.N.a.)**
   It is Bucaro woodland (sensu Dansereau, 1966), dominated by *Bucida buceras, Savia sessiliflora*, and *Krugiodendron ferreum*.

3. **Lowland dry mixed evergreen drought-deciduous shrubland (with succulents) (III.A.5. N.c., III.B.1.N.a. & II.B.1.N.a.)**
   Include cactus scrub dominated by *Melocactus intortus*, *Opuntia rubescens*, *Pilosocereus royenii*, *Stenocereus hystrix*, *Oplonia spinosa*, and *Conocarpus erectus*, and sparse shrubland on limestone pavement, in SW Puerto Rico, where *Melocactus intortus*, *Conocarpus erectus, Krameria ixine, Comocladia dodonaea*, and *Croton discolor* are common. May include also shrubland or thicket dominated by *Leucaena leucocephala*, or drought-deciduous woodland with common shrubs *Pilosocereus royenii, Thouinia striata var. portoricensis, Plumeria alba, Croton lucidus, Pictetia aculeata*, and *Comocladia dodonaea*.

4. **Lowland dry and moist, mixed seasonal evergreen sclerophyllous forest** (Cuba) In Puerto Rico, this type of vegetation, called "**sclerophyllous evergreen shrubland**," occurs on the SW coast. (S**ee III.A.1.N.c.)**
   On flat to sloping limestome pavement, matted dwarf-shrublands dominated by salt-pruned *Conocarpus erectus* are found. Other species include *Strumpfia maritime, Suriana maritima, Coccoloba uvifera*, and *Chamaesyce mesembrianthemifolia*.

5. **Lowland moist evergreen hemisclerophylous shrubland (III.A.1.N.b.)**
   Coastal strand or berm communities dominated by dwarfed *Coccoloba uvifera* and other salt aerosol sculpted shrubs, e.g., *Thespesia populnea.*

6. **Lowland moist seasonal evergreen forest (I.A.3.N.a.)**
   Lowland seasonal evergreen forests dominated or co-dominated by *Manilkara bidentata ssp. surinamensis*, occurring below 400 m altitude in areas of high rainfall. Other species include *Diospyros revoluta, Manilkara bidentata ssp. surinamensis, Pouteria multiflora, Mammea americana, Cassipourea elliptica, Faramea occidentalis, Petitia domingensis*, and *Quararibaea turbinate.* This forest type has been largely depleted. The disturbed stands

apparently belonging to this community can be observed at Dorado, and on the lower slopes of the Luquillo mountains.

7. **Lowland moist seasonal evergreen forest/shrub (II.A.1.N.a. & III.A.1.N.a.)**
   Croton lucidus shrubland occurs in wet lowlands. Second-growth woodlands are often dominated by *Randia aculeate* and *Didymopanax morototoni*. In littoral zone, shrubland of *Clusia minor and Clusia clusioides or* shrubland of *Colubrina spp., which includes Oplonia spinosa, Comocladia dodonaea, Reynosia uncinata,* and *Bromelia penguin,* are common. In coastal area *Tabebuia heterophylla* shrubland dominates.

8. **Lowland [moist] semi-deciduous forest (I.C.1.N.a.) (See 1.)**
   Forests occur at low elevations in NW and NC, on **limestone** hills, dominated or codominated by *Coccoloba diversifolia*. Other typical canopy species include *Bucida buceras*, *Quararibea turbinata*, *Guapira fragrans*, *Zanthoxylum martinicense*, and *Ficus citrifolia*. Terrestrial and epiphytic ferns are frequent and include *Blechnum occidentale, Tectaria heracleifolia, Cyclopeltis semicordata*, and *Adiantum tenerum*. On the **mogote** sides and tops, characteristic species include *Coccoloba diversifolia, Bursera simaruba*, *Bucida buceras*, and *Zanthoxylum martinicense, Rondeletia inermis, Guettarda scabra, Eugenia confusa*, *Eugenia spp.*, *Coccothrinax alta*, *Thrinax morrisii*, *Gaussia attenuata,* and *Aiphanes acanthophylla*.

9. **Lowland [moist] semi-deciduous forest/shrub (See 2.)**

10. **Lowland moist seasonal evergreen and semi-deciduous forest (See 6 & 1.)**

11. **Lowland moist seasonal evergreen and semi-deciduous forest/shrub (III.A.1.N.a.)**
    In NC and NW Puerto Rico, shrublands dominated by *Gymnanthes lucida*, develop in thin soils over **limestone** hills. *Eugenia monticola* is often co-dominant.

12. **Submontane and lower montane wet evergreen sclerophyllous forest (See 14 & 17)**

13. **Submontane and lower montane wet evergreen sclerophyllous forest/shrub (See 14, 18 &19)**

14. **Submontane wet evergreen forest (I.A.1.N.b.)**
    This forest has a dense canopy 20-30 m tall, dominated by *Dacryodes excelsa, Sloanea berteriana, Manilkara bidentata ssp. surianamensis*, and *Magnolia splendens*, with as many as 150 other tree species present, including *Tetrazygia urbanii*, *Ormosia krugii, Tabebuia heterophylla, Prestoea montana, Inga fagifolia, Hirtella rugosa,* and many others. It is also known as “Tabonuco forest” in Puerto Rico.

15. **Active sun/shade coffee, submontane and lower montane wet forest/shrub (See 16.)**

16. **Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee (forest, see I.A.1.N.b.; shrubland, see III.A.1.N.a.)**

This formation includes disturbed successional forests with *Cecropia peltata, Ochroma pyramidale, Andira inermis,* and *Didymopanax morototoni* as major components. Other associated species include *Acrocomia aculeata*, *Erythrina poeppigiana,and Casearia* spp. On hill slopes, forests dominated by the endemic *Thespesia (= Montezuma) grandiflora* may develop following disturbance.

Montane shrublands are dominated by *Clusia minor* and *Clusia clusioides* or *Schefflera gleasonii.* On summits of higher peaks (at elevations of 900-1050m), shrublands are dominated by *Eugenia borinquensis*, *Tabebuia rigida,* and ***Marcgravia sintenisii***. Associated tree species include *Ocotea spathulata* and *Henriettea squamulosum*. Dominant shrubs are *Eugenia borinquensis, Tabebuia rigida, Ocotea spathulata, Micropholis garciniifolia, Daphnopsis philippiana, Symphysia racemosa*, and *Ardisia luquillensis*. Most of the dominant shrubs are endemic either to the Luquillo Mountains of eastern Puerto Rico, or somewhat more widespread endemics of montane Puerto Rico.

17. Lower montane wet evergreen forest - tall cloud forest (I.A.1.N.c.)

It is also known as "Colorado Forest." Typical species include *Cyrilla racemiflora, Micropholis guyanensis, Micropholis garciniifolia, Ocotea spathulata, Magnolia splendens* (in Luquillo Mountains), *Magnolia portoricensis* (in the central mountains), *Didymopanax gleasonii, Micropholis chrysophylloides, Croton poecilanthus, and Prestoa montana.* It may include tree-fern forests dominated by *Cyathea arborea, Cnemedaria horrida, Dicranopteris nervosa, Sticherus bifidus, Odontosoria aculeata,* and *Palhinhaea cernua*.

18. Lower montane wet evergreen forest - mixed palm and elfin cloud forest (I.A.1.N.c.)

This forest occurs on steep slopes and wet soils at elevations of 500-1100m in Puerto Rico. *Prestoea montana* dominates the 8-15m canopy, with lesser amounts of *Croton poecilanthus, Henriettea squamulosum, Cordia borinquensis, Psychotria berteriana, Hillia parasitica, Cecropia peltata, Ocotea leucoxylon, Micropholis garciniifolia,* and *Miconia sintenisii*. Understory trees and shrubs include *Daphnopsis philippiana, Comocladia glabra, Hedyosmum arborescens, Alsophila bryophila*, and *Cesneria sintenisii*.

19. Lower montane wet evergreen forest - elfin cloud forest (I.A.1.N.d.)

Forests dominated by *Tabebuia rigida, Ocotea spathulata*, and *Eugenia borinquensis.* Other associated species include *Clusia krugiana, Haenianthus salicifolius, Ilex sideroxyloides, Alsophila bryophila, Prestoea montana, Psychotria berteriana, Calyptranthes krugii, Marliera sintenisii, Miconia sintenisii, Henriettea squamulosum,* and *Weinmannia pinnata.* Many of these species are endemic to the higher elevations of Puerto Rico.

20. Tidally and semi-permanently flooded evergreen sclerophyllous forest (I.A.5.N.d. and I.A.5.N.f.)

Freshwater or very slightly brackish depression or swale wetlands dominated by *Annona glabra*. Associated species include *Conocarpus erectus* and *Acrostichum aureum.* Physiognomy varies from dense canopies to open canopies, depending on hydrology and disturbance.

Tidally flooded forests are mangrove forests. Most oceanwards and frequently tidally flooded is a monospecific association with the pioneer *Rhizophora mangle* as the sole dominant.

Behind the belt of *Rhizophora mangle* forest, *Avicennia germinans* often dominates and *Batis maritima* is usually a common acompanying species. At the inner side of the mangrove belt, mostly in lagoons with concentrated saltwater, *Conocarpus erecta* is the dominant species (70-80% coverage). The most inland mangrove forest and least frequently tidally flooded is dominated by *Laguncularia racemosa* or mixtures of small stands of *Laguncularia racemosa, Rhizophora mangle, Avicennia germinans* and *Conocarpus erectus.* Wetland short forests typically associated with mangroves on the inland side, and generally not tidally flooded, except by storm floods, are dominated by *Thespesia populnea.*

21. Seasonally flooded rainforest (I.A.1.N.f.)

Freshwater swamps associated with rivers are dominated by *Pterocarpus officinalis*. In non riparian basins, *Manilkara bidentata* and *Calophyllum calaba* or *Roystonea sp.* are often associated with *Pterocarpus officinalis.*

22. Tidally flooded evergreen dwarf-shrubland and forb vegetation (III.A.1.N.h. V.A.1.N.i. V.B.1.N.e.)

Mangrove communities in highly stressed situation, e.g., rooting in solution cavities or shallow soils underlain by oolite or in hypersaline conditions, are dominated by sparse, stunted Avicennia germinans, or Conocarpus erectus, or Rhizophora mangle, or Laguncularia racemosa or a mixture of them. Other characteristic species include Suriana maritima, Gundlachia corymbosa,Borrichia arborescens, Cladium mariscus ssp. jamaicense, Salicornia virginica, and Batis maritima.

Marshes associated with mangrove shrublands or mangrove forests are dominated by giant ferns *Acrostichum aureum* and *Acrostichum danaeifolium.* Dominant species in littoral grasslands include *Sporobolus virginicus,* or *Fimbristylis spadicea, or Bothriochloa pertusa*, with scattered shrubs of *Capparis flexuosa, Lantana involucrata, Rauvolfia nitida, Coccoloba uvifera,* and *Sesuvium portulacastrum*. Marshes dominated by *Typha domingensis,* or *Fimbristylis spadicea,* or *Phragmites australis* is usually in nearly pure stands. Other marshes are dominated by *Brachiaria mutica-Eriochloa polystachya or Hymenachne amplexicaulis - Panicum aquaticum.*

23. Other emergent wetlands (including seasonally flooded grassland [/evergreen shrubland]) (grassland, see V.A.1.N.g., V.A.1.N.h., and V.A.1.N.i.; shrubland, see III.A.1.N.f. and III.A.1.N.g.)

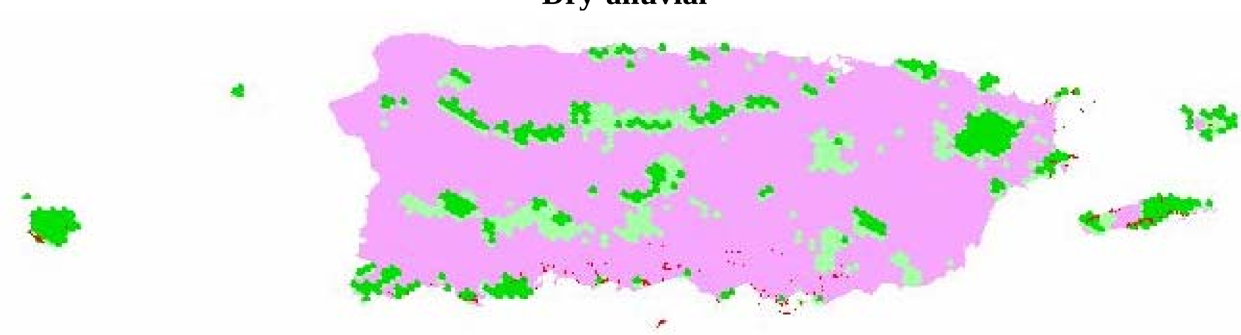
Freshwater wetlands—in shallow waters of lakes, ponds, and boggy areas, on muddy and peaty substrates—are dominated by *Eleocharis interstincta* and *Sagittaria lancifolia.* Riverside thickets are dominated by *Gynerium sagittatum*. This vegetation formation may include seasonally flooded evergreen shrubland dominated by *Chrysobalanus icaco* and *Blechnum serrulatum*; and nontidal, semipermanently flooded shrubland dominated by stunted *Rhizophora mangle*. The *Rhizophora* community occurs in seasonally to semipermanently flooded situations over oolite. Shrub cover is generally from 20-60 percent, and areas between the shrubs are dominated by *Eleocharis cellulosa,* with *Utricularia purpurea, Rhynchospora tracyi, Crinum americanum,* and *Chara sp.*

24. Salt and mud flats (IV.A.2.N.c)
Salt flats dominated by *Batis maritima.*

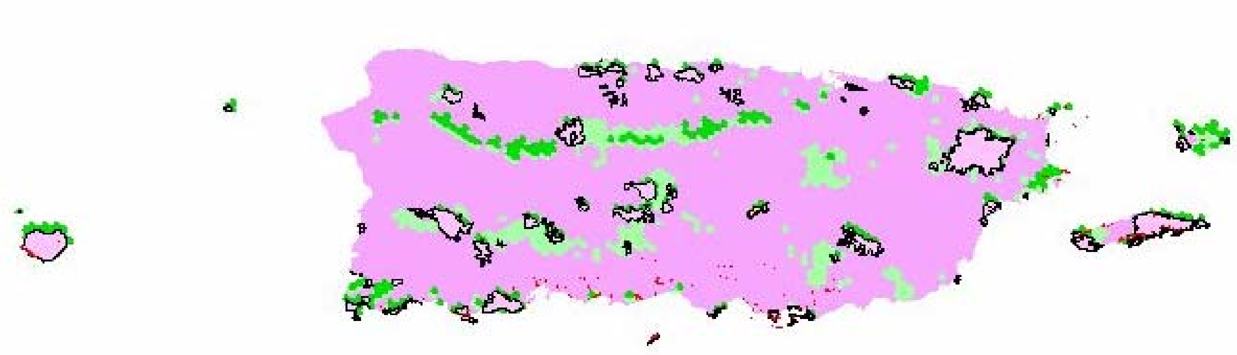
25. Pasture [including abandoned pasture or agriculture land, sod grassland (V.A.1.N.b.) and **bunch grassland (V.A.1.N.c.)]**
Andropogon bicornis, Arundinella confines, Schizachyrium sanguineum var. sanguineum, Axonopus compressus, Bouteloua repens, Cenchrus myosuroides, Dichanthium annulatum, Spartina patens, and *Stenotaphrum secundatum* are common in **medium-tall sod grassland**. **Short sod grassland** occurs in montane meadows and landslide scars at upper elevations of the Luquillo Mountains of eastern Puerto Rico. Dominant graminoids are *Isachne angustifolia* and *Scleria scandens* (= *Scleria canescens*) with *Clibadium erosum* and *Phytolacca rivinoides*. *Leptochloopsis virgata, Leptocoryphium lanatum, Aristida portoricensis, Schizachyrium gracile* and *Sporobolus indicus* are found in **medium-tall bunch grassland**.

Appendix 2. Distribution of 30 individual coarse filter targets in the protected areas system, the <u>most desirable</u> portfolio, and the irreplaceable portfolio. Photos of targets have been added when available. For each coarse-filter target (shown in red or red with pointer), two maps—one without protected areas outlined and one with protected areas outlined—are presented to illustrate the target patches captured by the <u>most desirable</u> portfolio (light green) and the irreplaceable portfolio (green). [The two portfolios are assembled under the scenario: with coarse filter targets, protected areas locked, and with cost surface.]

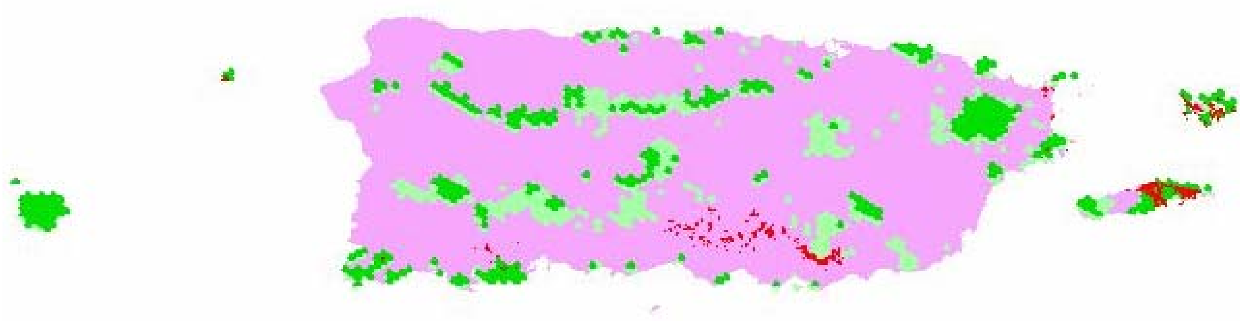
Dry-alluvial



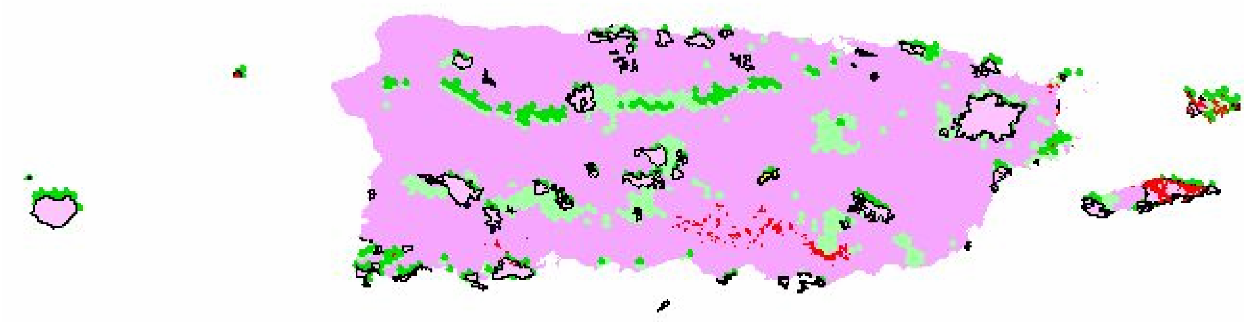
Dry-alluvial + Protected Areas



Dry_extrusive

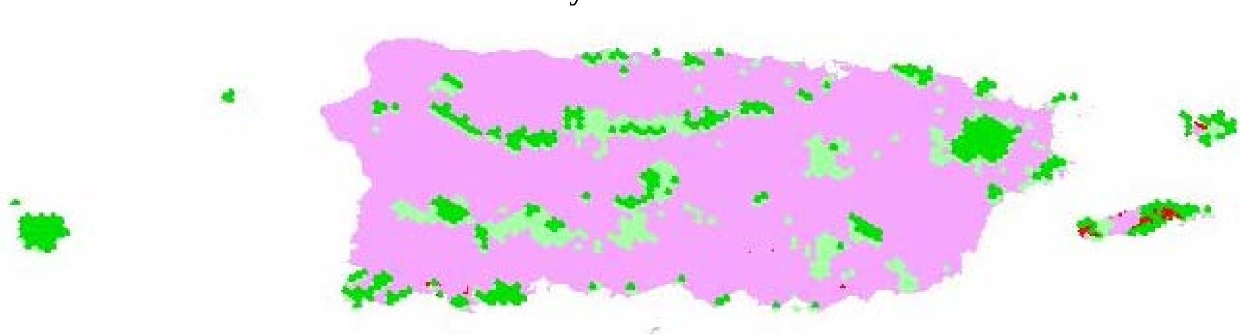


Dry-extrusive + Protected Areas

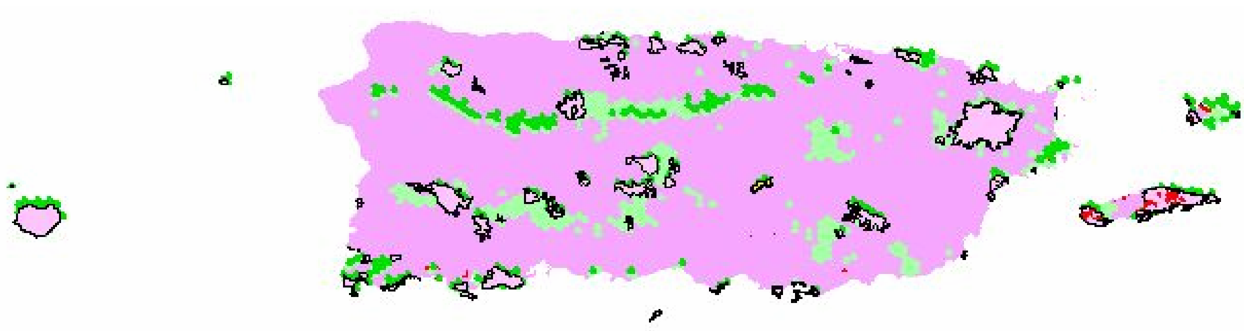


Overview of dry-volcanic–extrusive forest near Coamo, Puerto Rico. Note irregular canopy and deciduous *Bucida buceras* crowns. (Photo by Julio Figueroa-Colón)

Dry-intrusive

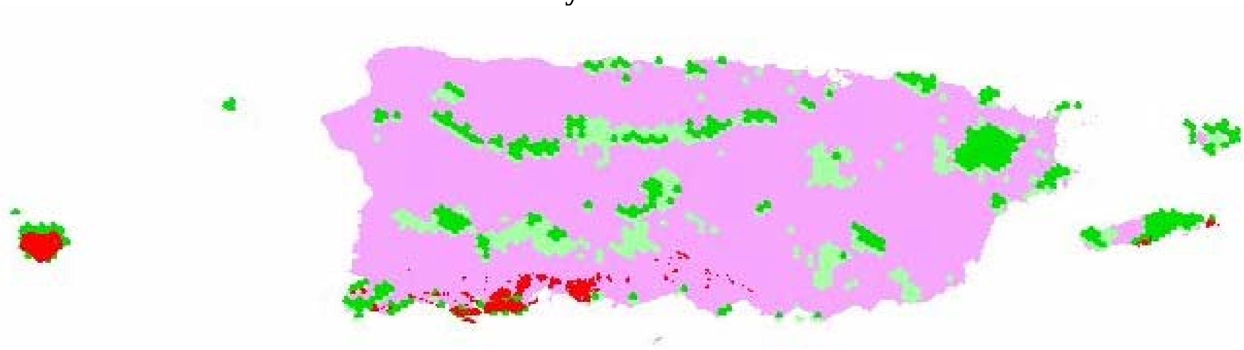


Dry-intrusive + Protected Areas

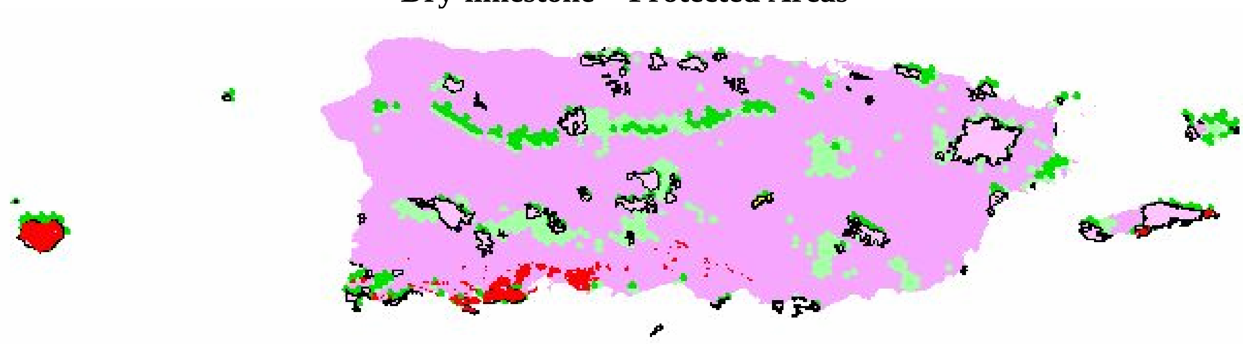


Overview of <u>dry-volcanic-intrusive</u> geoclimatic region west of Guayama, Puerto Rico.
(**Photo by Julio Figueroa-Colón**)

Dry-limestone



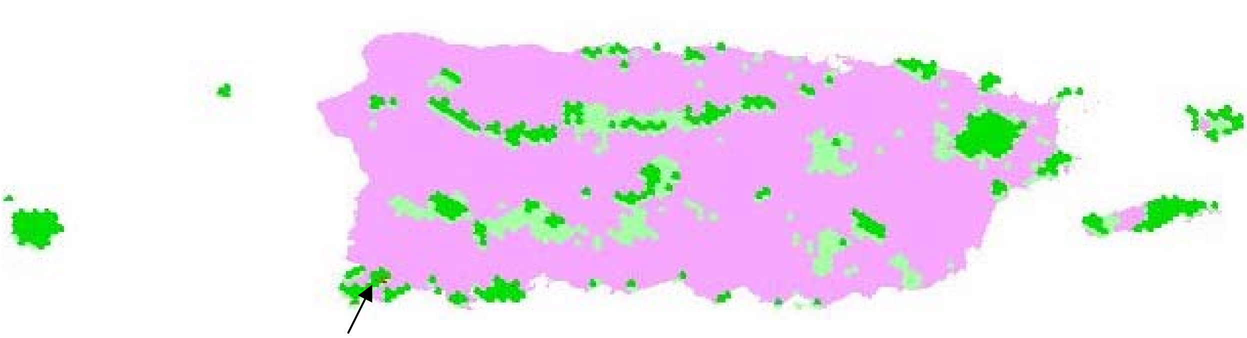
Dry-limestone + Protected Areas



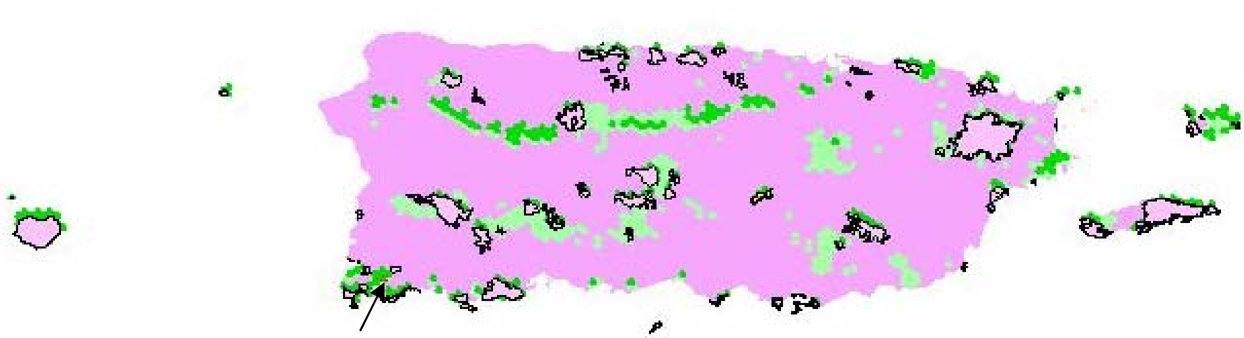
Dry-limestone (Interior view of <u>dry-limestone</u> geoclimatic region in Guanica, Puerto Rico. Note shallow soil and limestone substrate. (Photo by Julio Figueroa-Colón)

Coastal, rock-plate-facie of <u>dry-limestone</u> geoclimatic region in Guanica, Puerto Rico.
(Photo by Julio Figueroa-Colón)

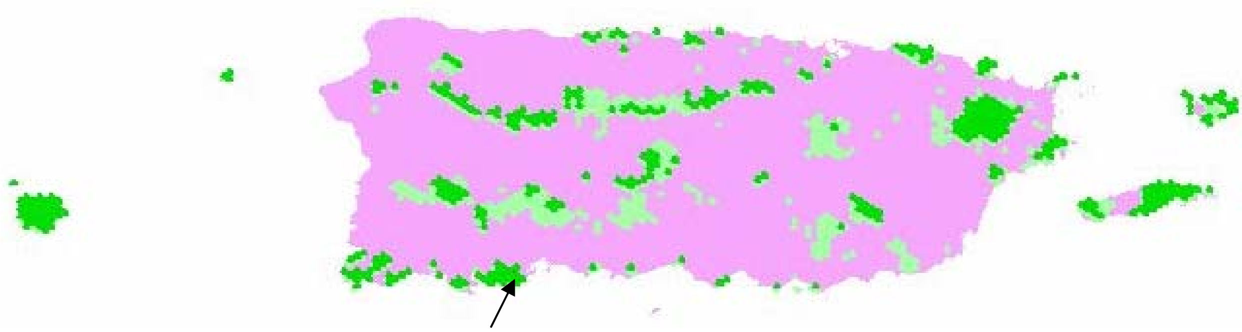
Dry-sedimentary



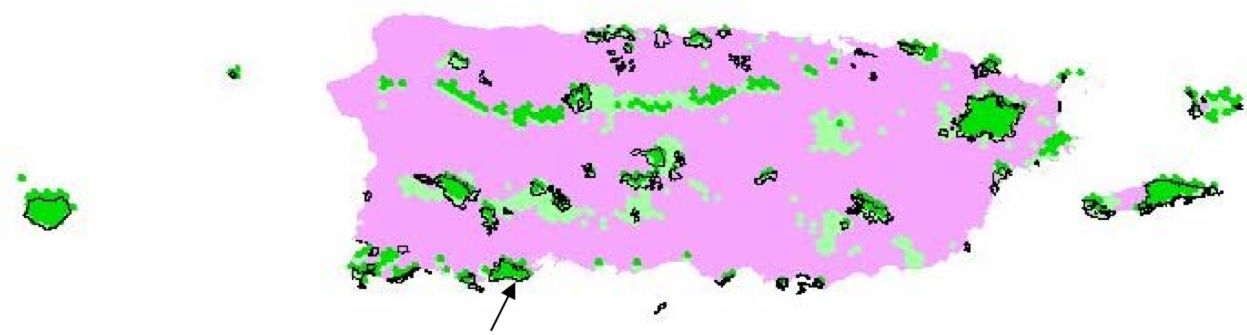
Dry-sedimentary + Protected Areas



Dry-ultramafic

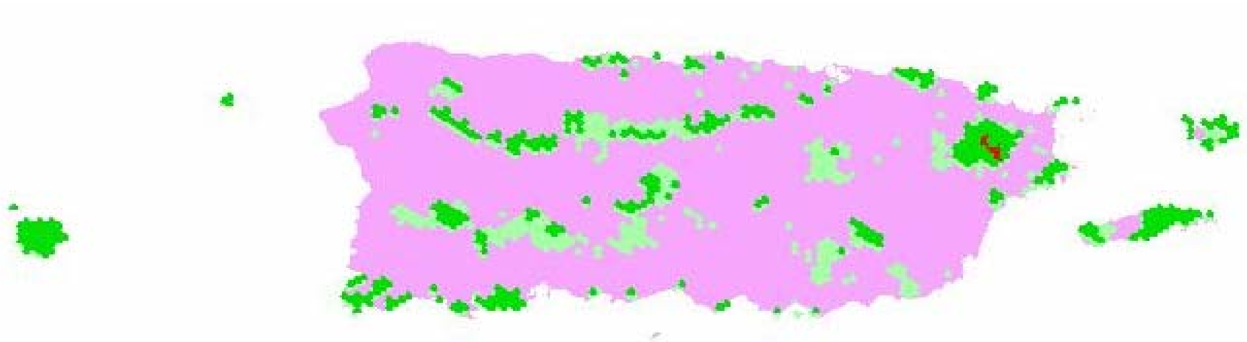


Dry-ultramafic +Protected Areas

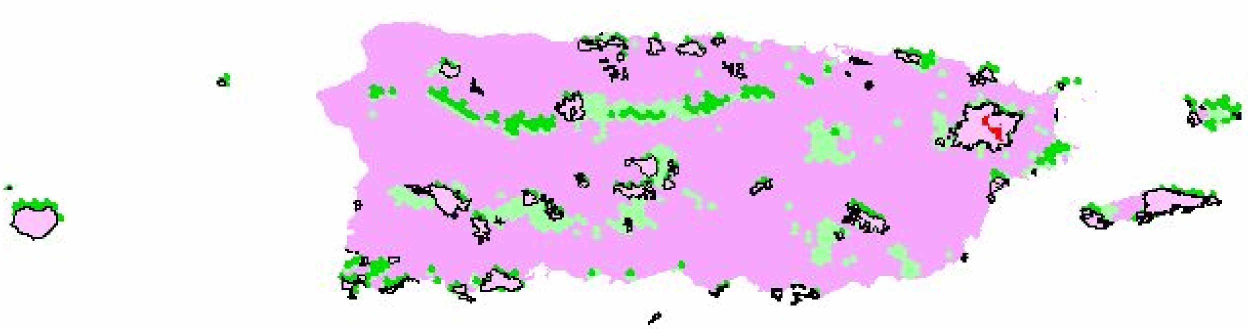


Dry-ultramafic vegetation near Lajas, Puerto Rico. Note dark mineral soisl and numerous serpentinite fragments. (Photo by Julio Figueroa-Colón)

Lower-montane-rain-extrusive

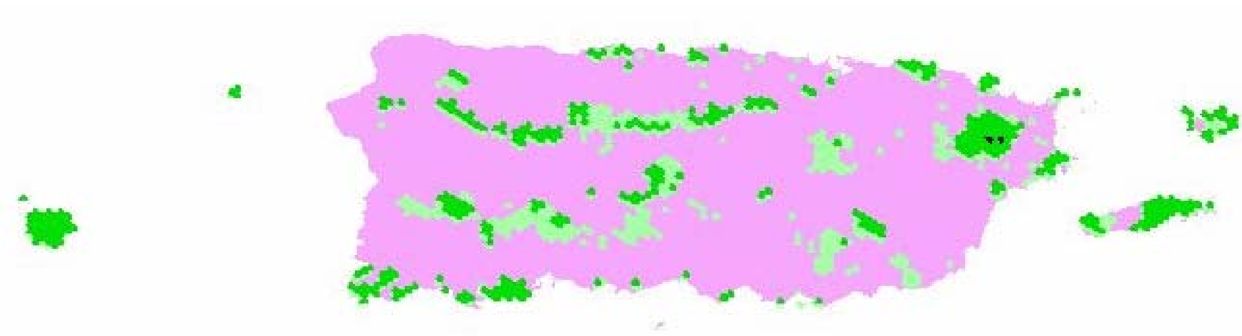


Lower-montane-rain-extrusive + Protected Areas



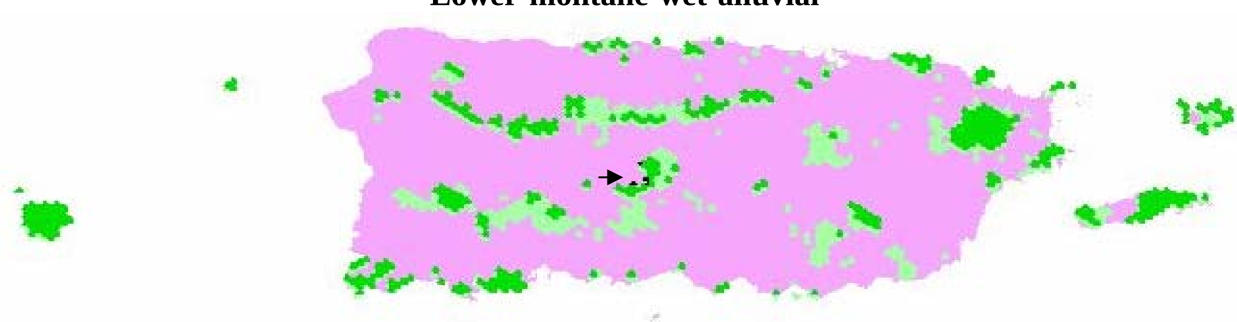
Interior of <u>lower montane-rain/volcanic-extrusive</u> forest within Caribbean National Forest Reserve near Rio Grande, Puerto Rico (Photo by Julio Figueroa-Colón).

Lower-montane-rain-intrusive

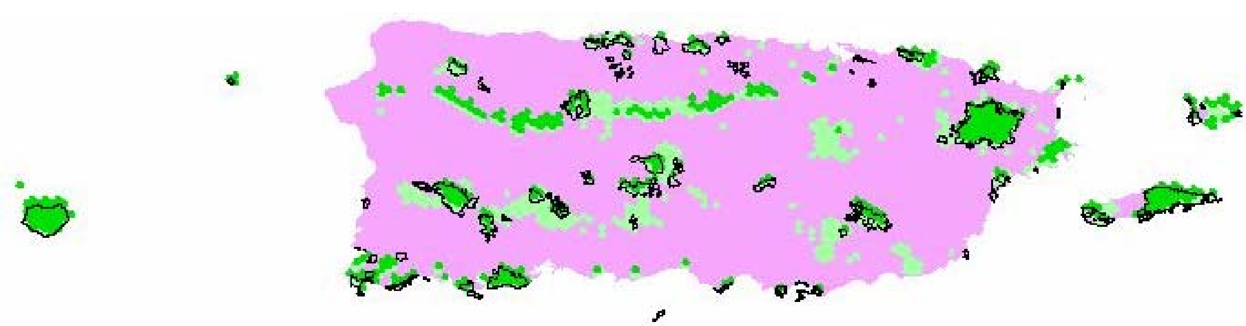


Lower-montane-rain-intrusive + Protected Areas

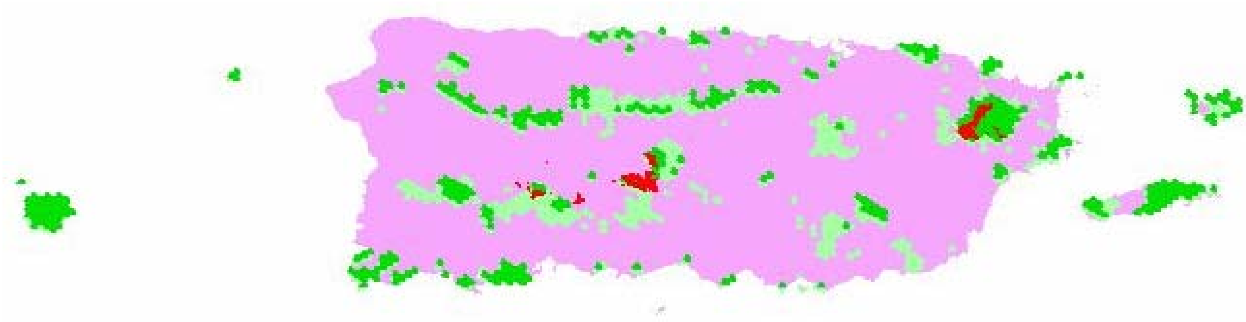
Lower-montane-wet-alluvial



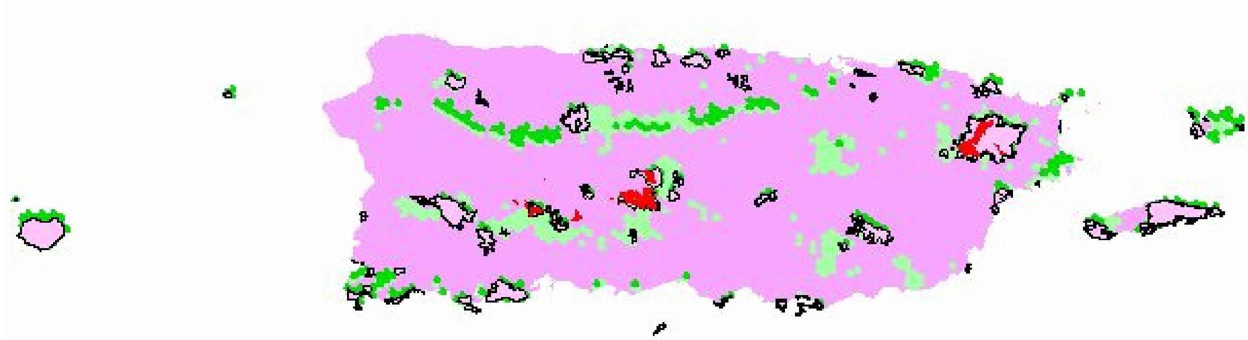
Lower-montane-wet-alluvial + Protected Areas



Lower-montane-wet-extrusive

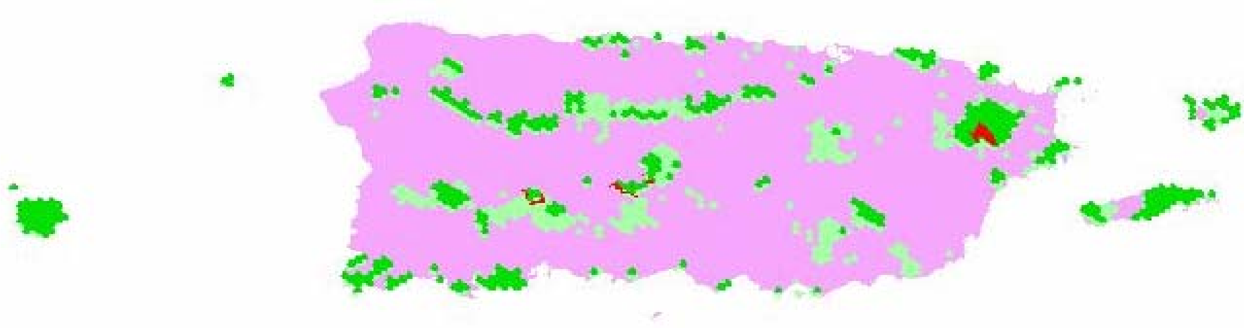


Lower-montane-wet-extrusive + Protected Areas

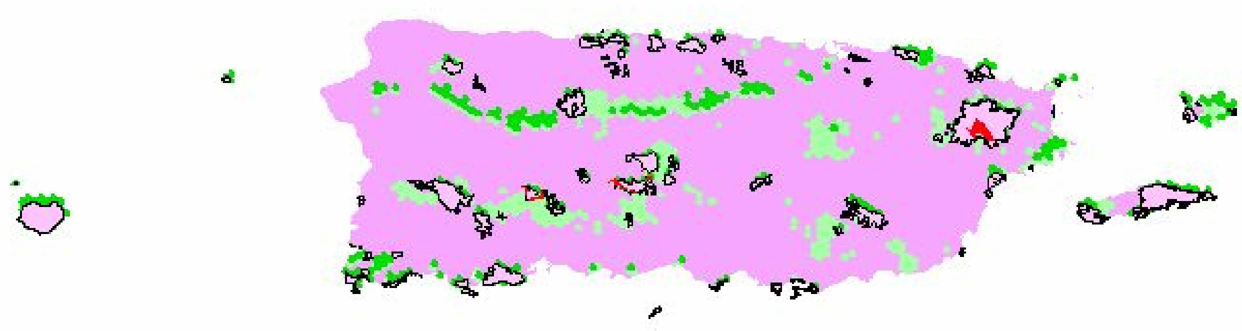


Interior of lower montane-wet-volcanic-extrusive forest within the Caribbean National Forest near Rio Grande, Puerto Rico. Note small general leaf size and high stem density.
(Photo by Julio Figueroa-Colón)

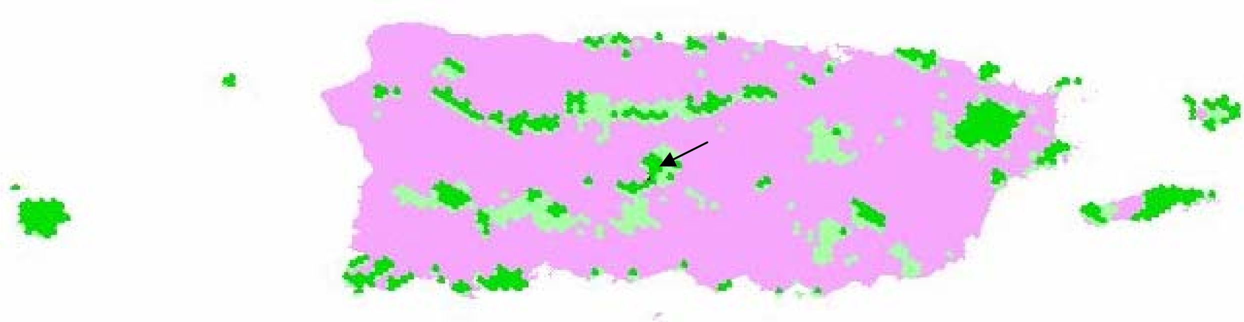
Lower-montane-wet-intrusive



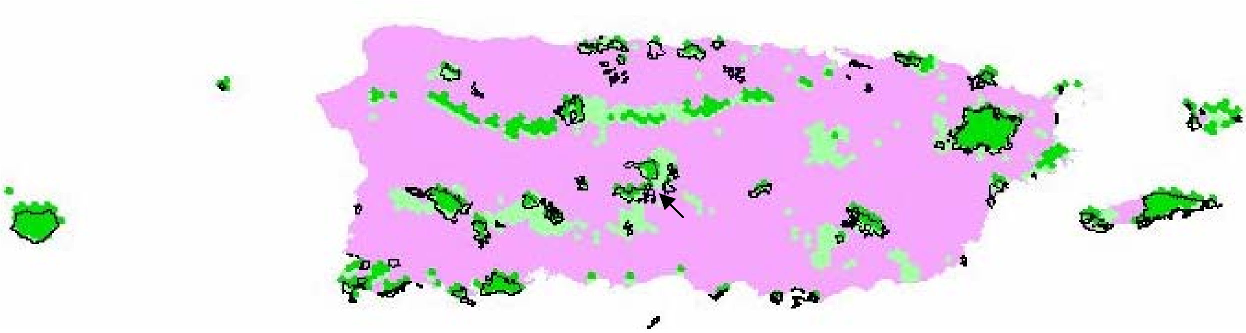
Lower-montane-wet-intrusive + Protected Areas



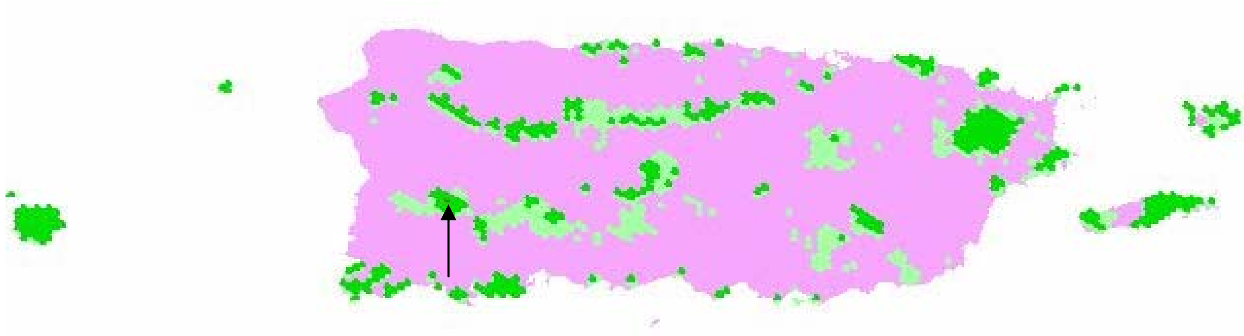
Lower-montane-wet-limestone



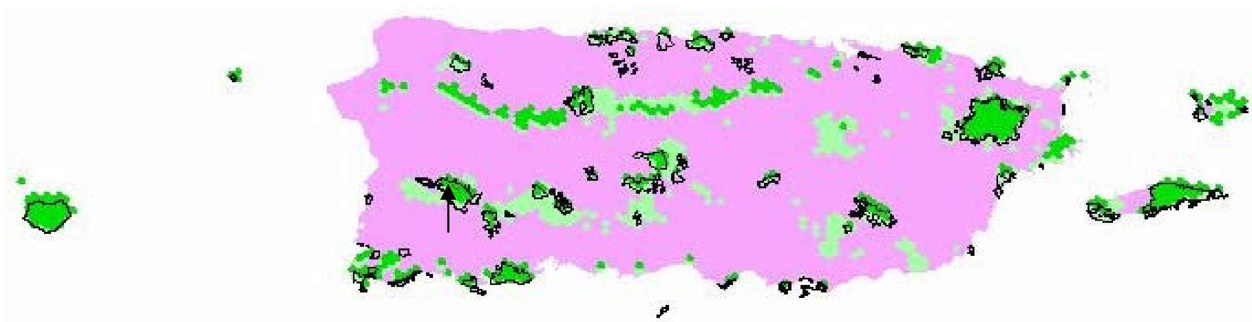
Lower-montane-wet-limestone + Protected Areas



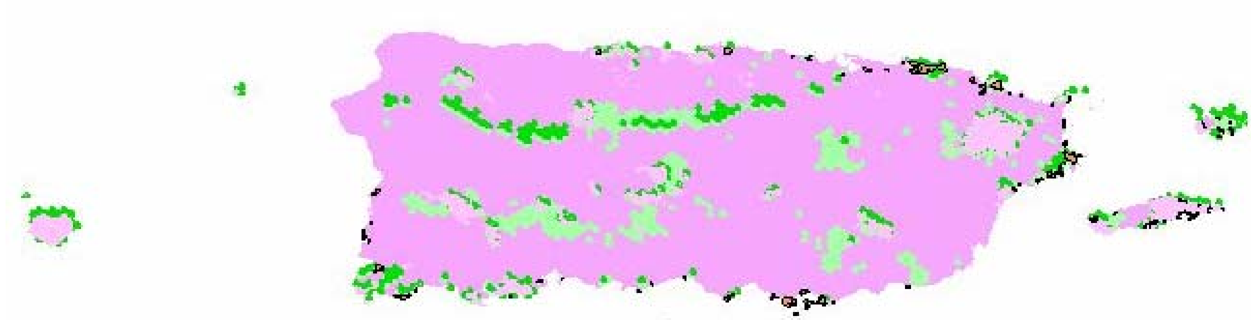
Lower-montane-wet-ultramafic



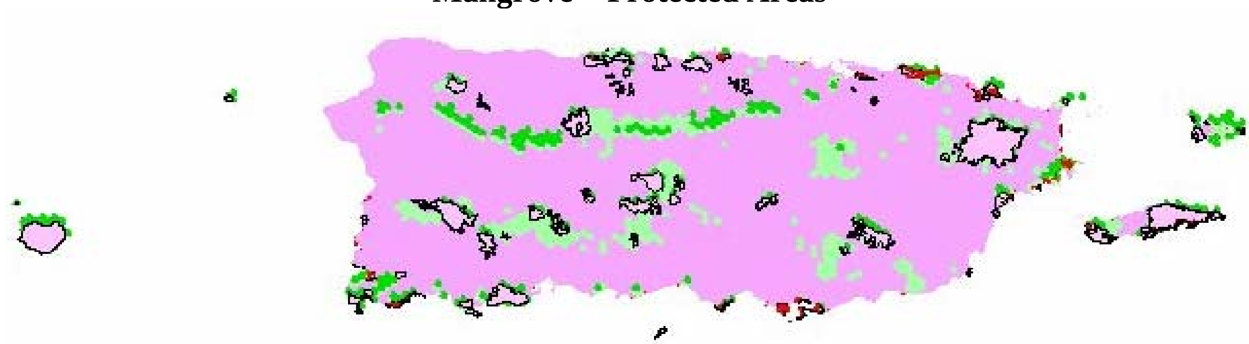
Lower-montane-wet-ultramafic + Protected Areas



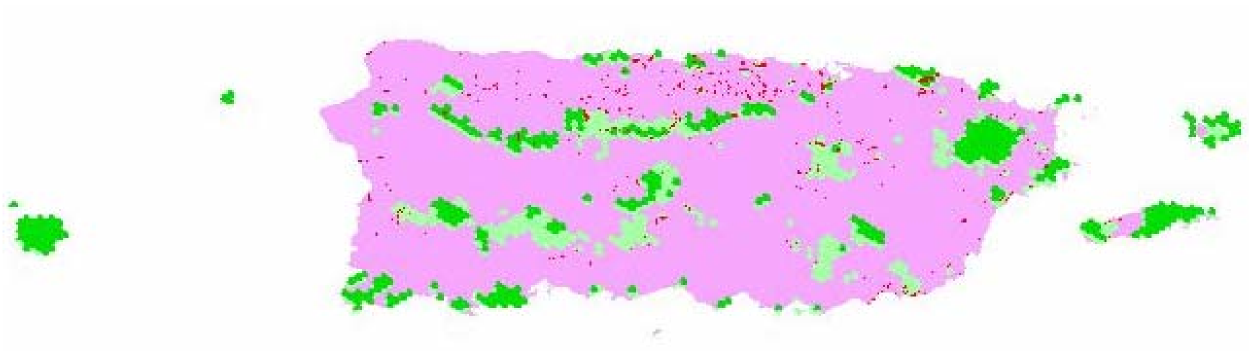
Mangrove



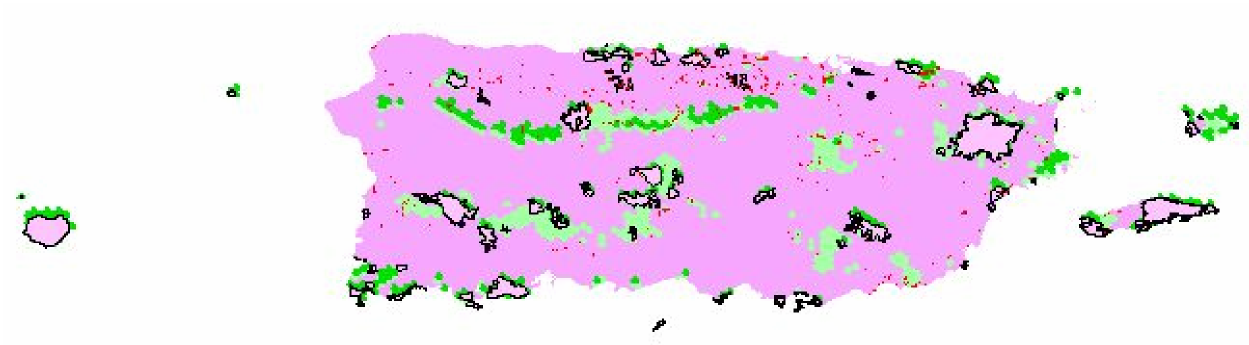
Mangrove + Protected Areas



Moist-alluvial

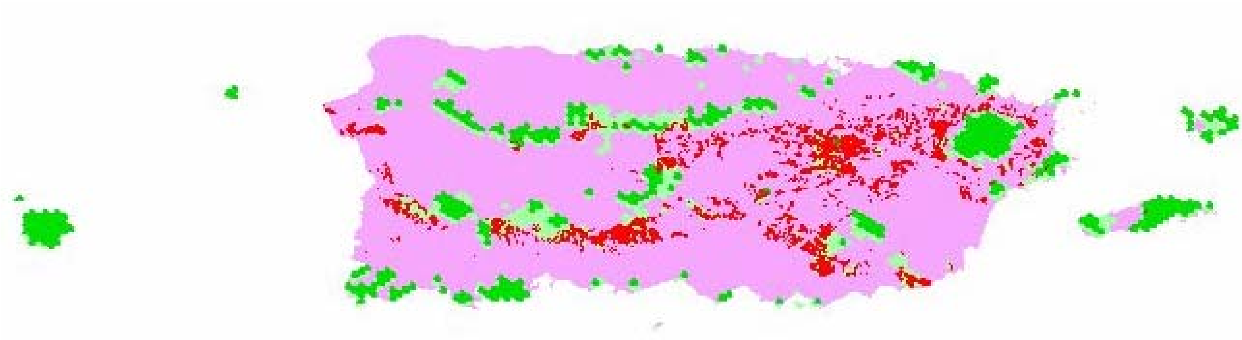


Moist-alluvial + Protected Areas

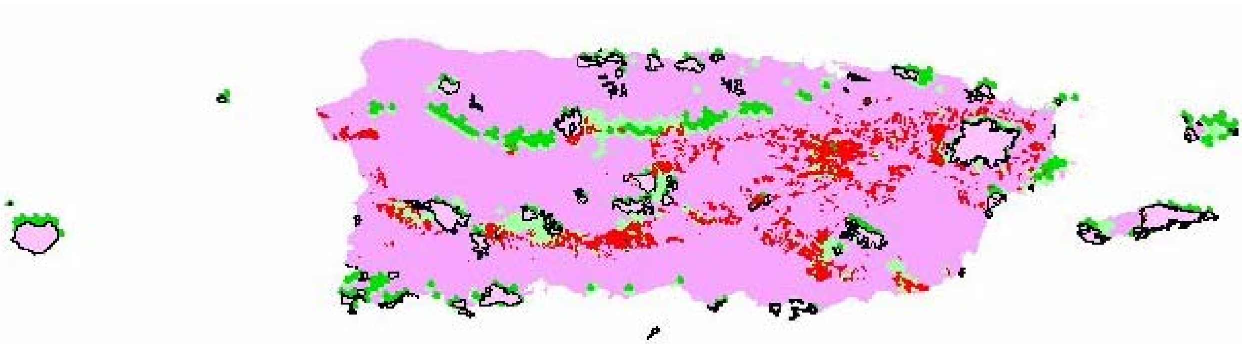


Interior of moist-alluvial forest near Luquillo, Puerto Rico. (Photo by Julio Figueroa-Colón)

Moist-extrusive

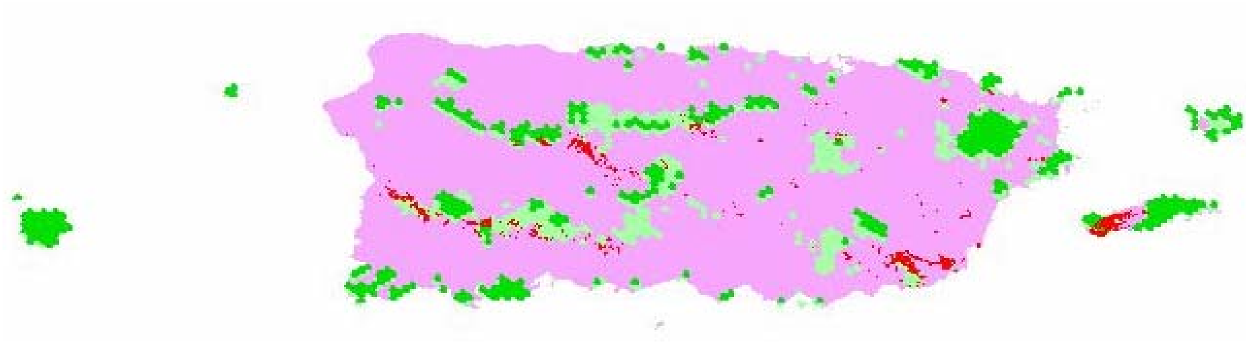


Moist-extrusive + Protected Areas

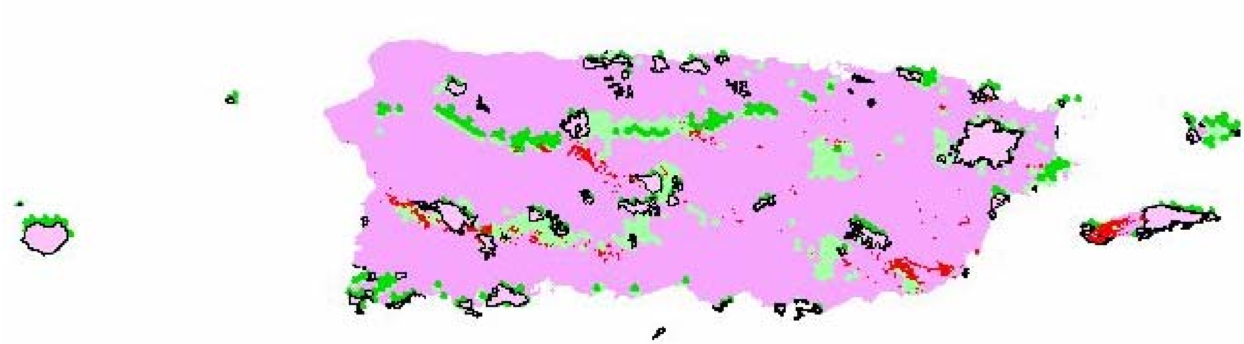


View of altered hillside with moist-extrusive forests near Adjuntas, Puerto Rico. (Photo by Julio Figueroa-Colón)

Moist-intrusive

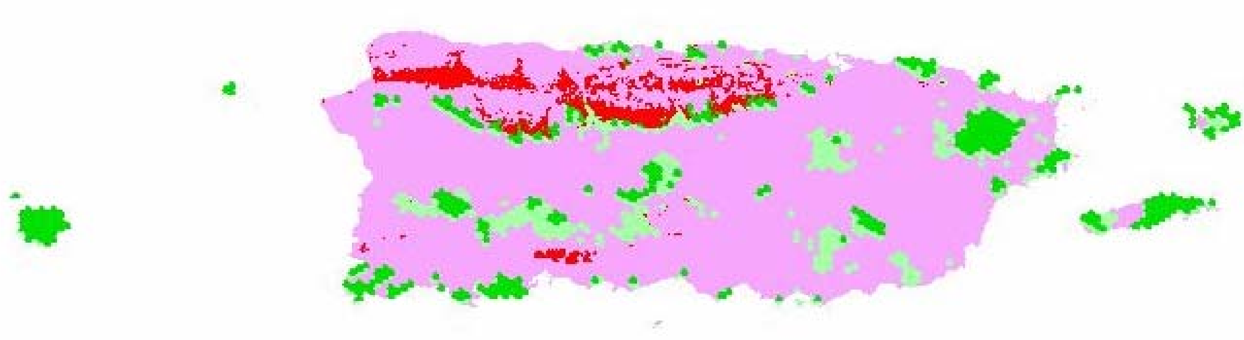


Moist-intrusive + Protected Areas

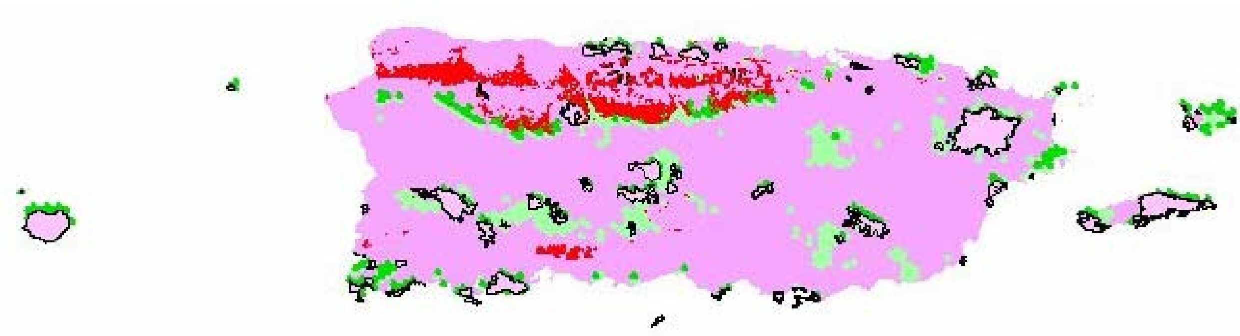


View of <u>moist-intrusive</u> hillside near Maunabo, Puerto Rico. Note large exposed granodioritic boulders in upper-center portion of photo. (Photo by Julio Figueroa-Colón)

Moist-limestone

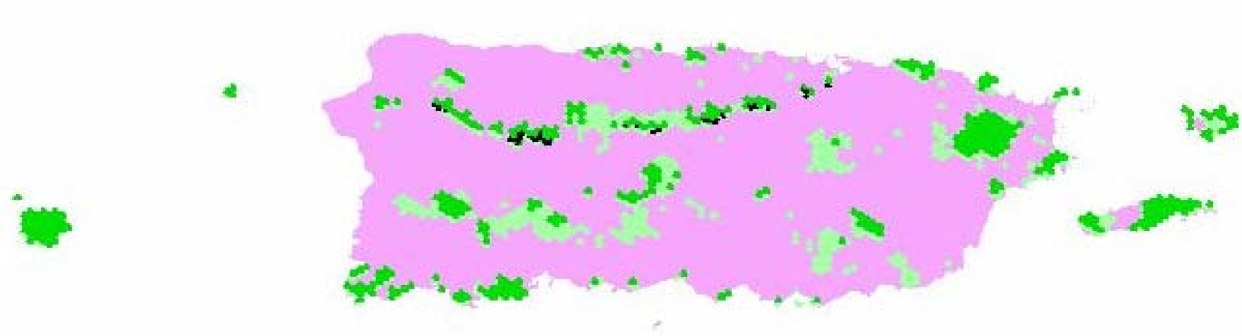


Moist-limestone + Protected Areas



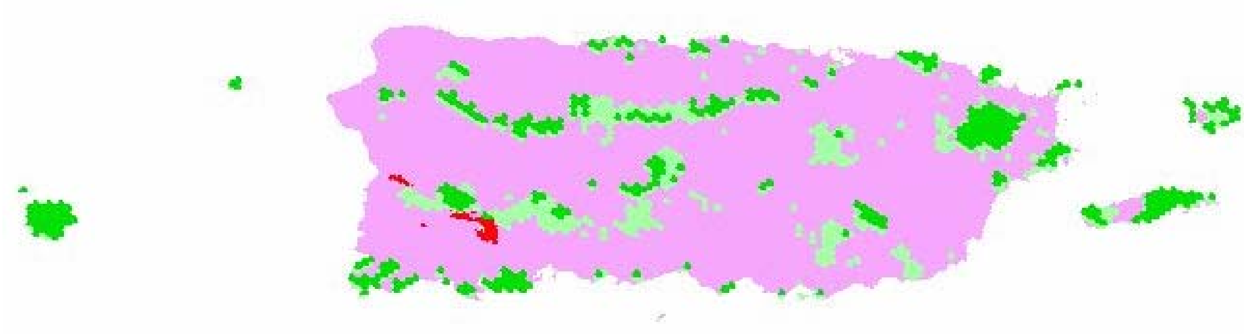
View of conic karst landscape with <u>moist-limestone</u> forest near Manati, Puerto Rico. (Photo by Julio Figueroa-Colón)

Moist-sedimentary

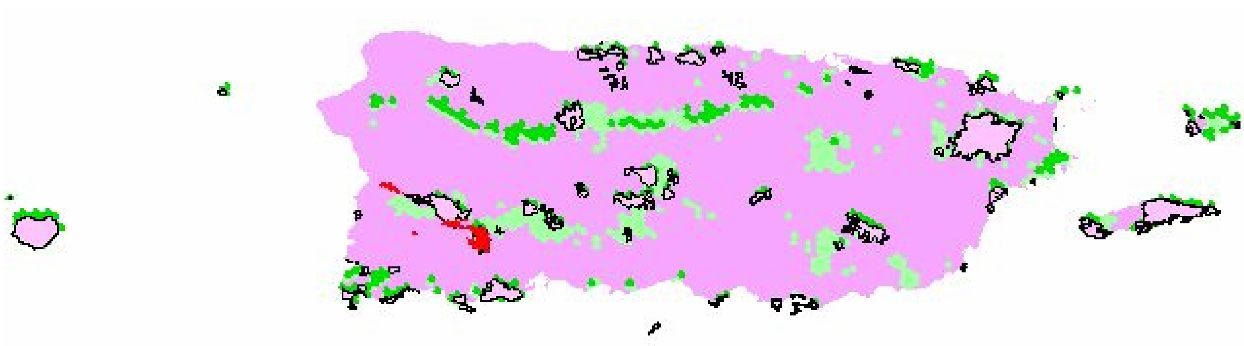


Moist-sedimentary + Protected Areas

Moist-ultramafic



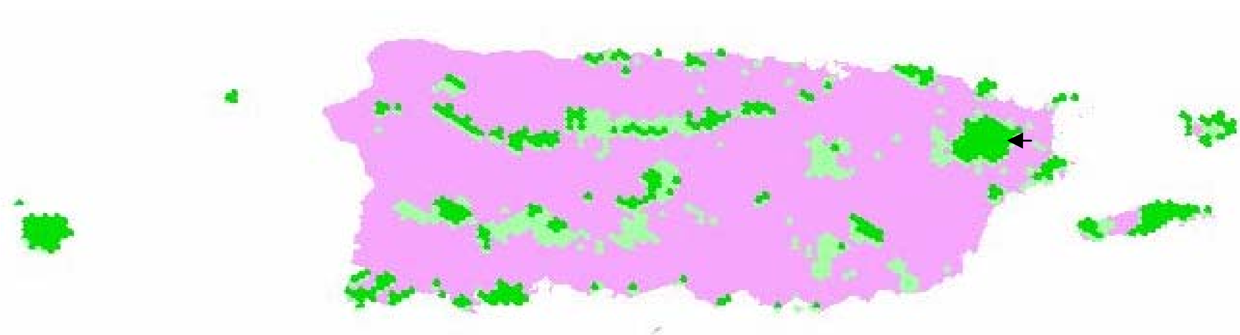
Moist-ultramafic + Protected Areas



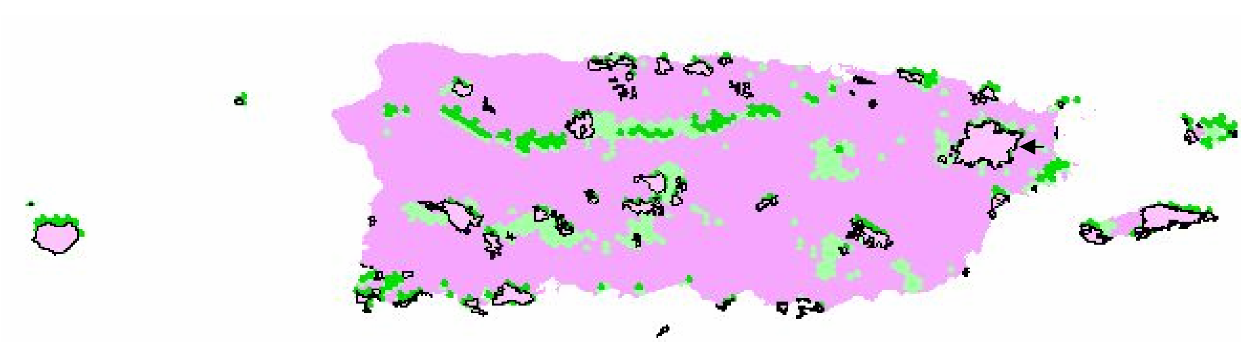
Overview of moist-ultramafic forest within the Susua Forest Reserve near Sabana Grande, Puerto Rico. (Photo by Julio Figueroa-Colón)

Moist-ultramafic forest near Sabana Grande, Puerto Rico. Note shallow soils and exposed serpentinite rock. (Photo by Julio Figueroa-Colón)

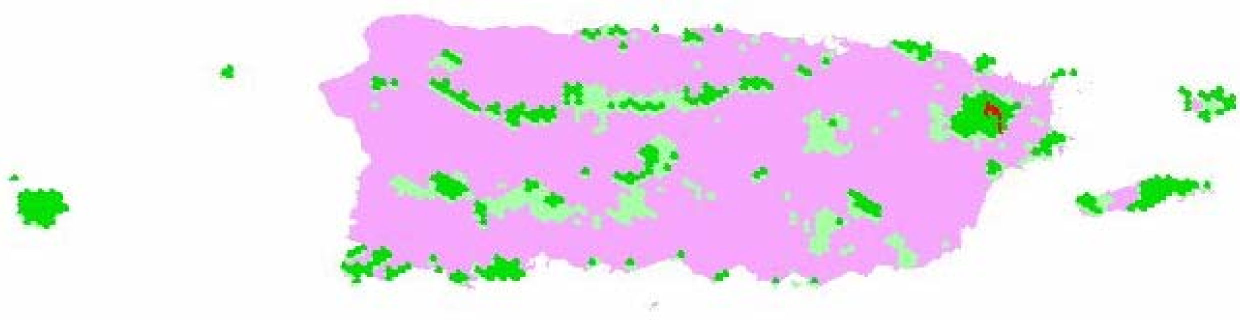
Rain-alluvial



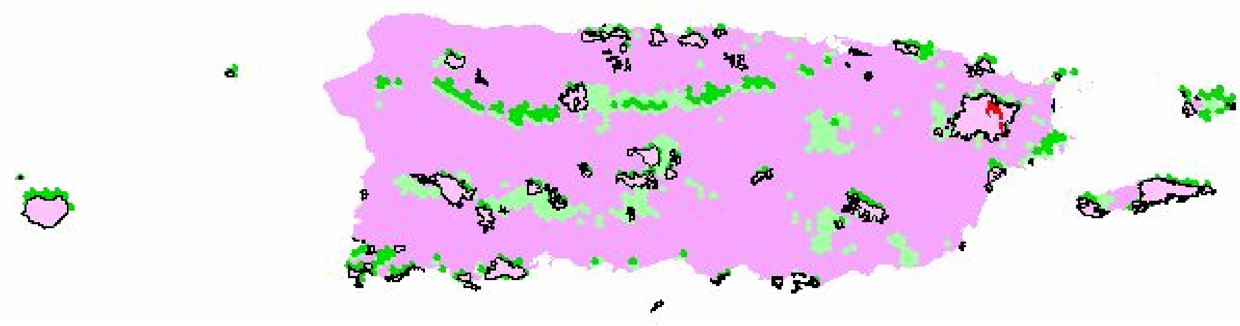
Rain-alluvial + Protected Areas



Rain-extrusive

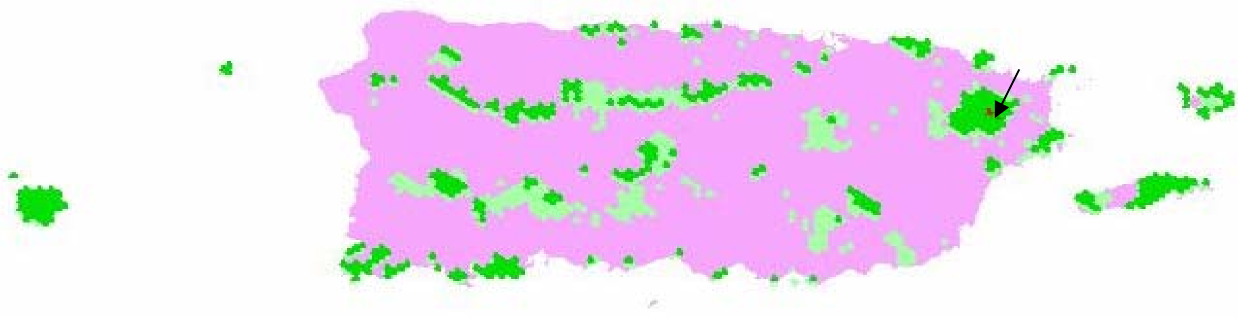


Rain-extrusive + Protected Areas

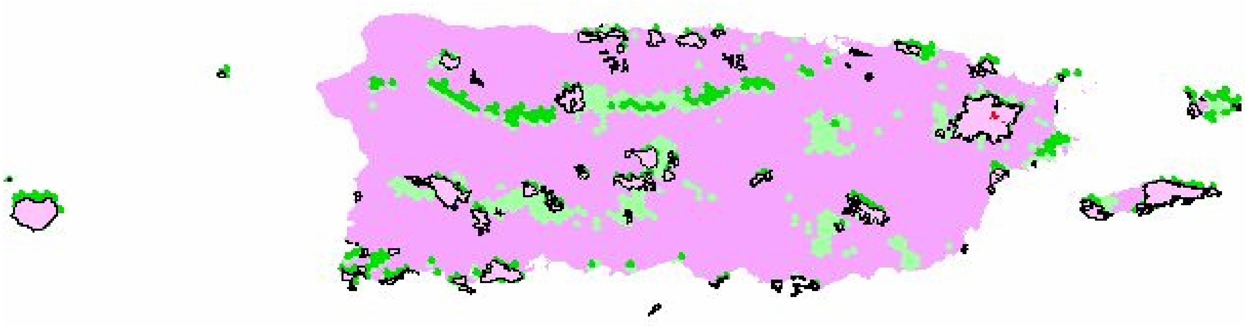


View of <u>rain-extrusive</u> forests within the Caribbean National Forest Reserve near Rio Grande, Puerto Rico. (Photo by Julio Figueroa-Colón)

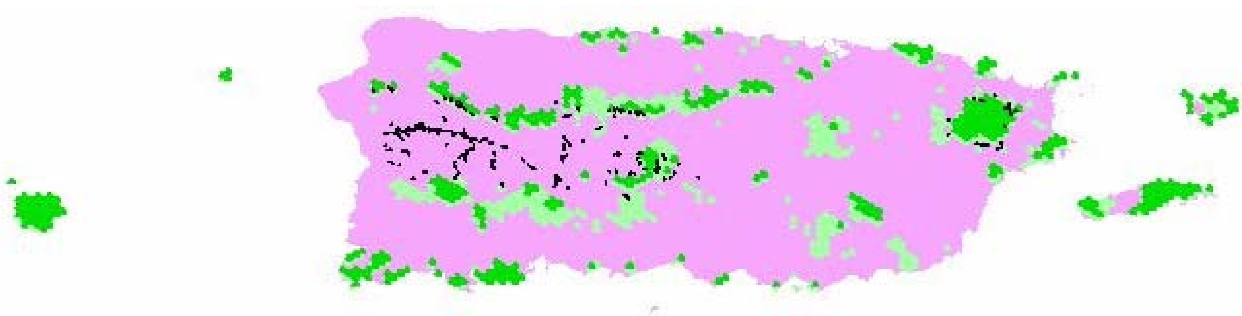
Rain-intrusive



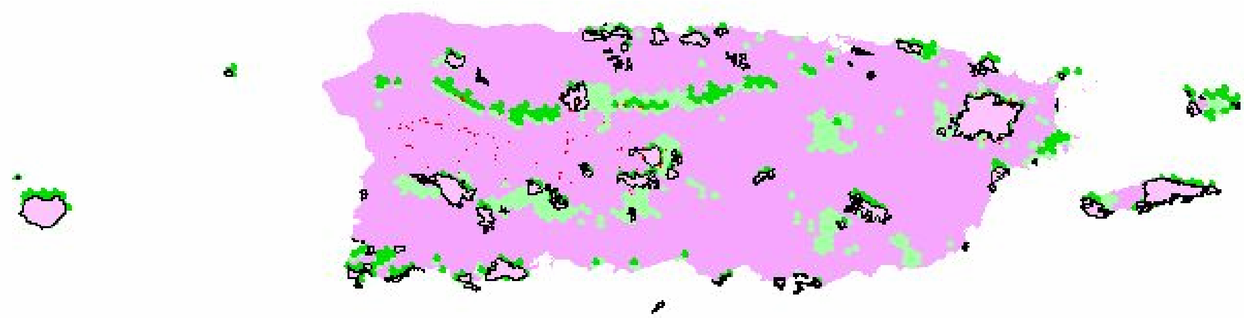
Rain-intrusive + Protected Areas



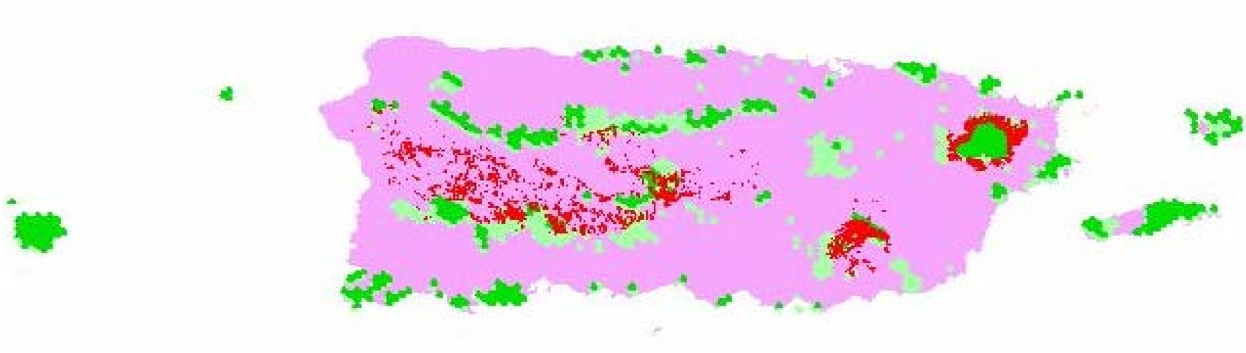
Wet-alluvial



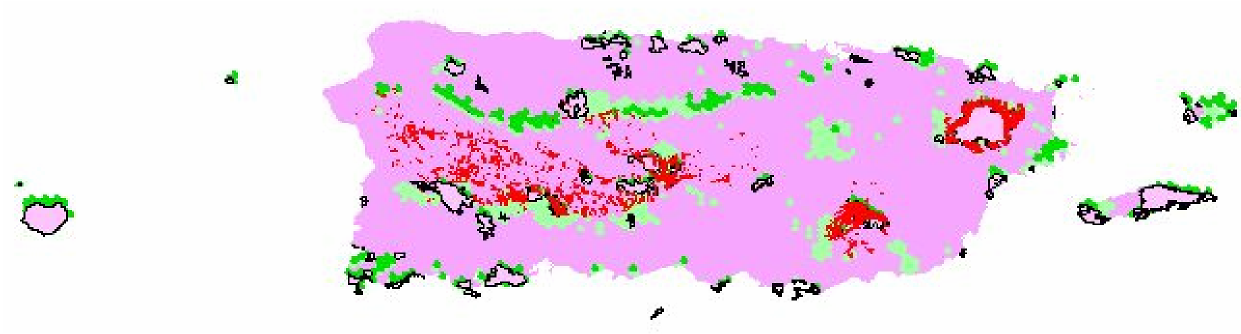
Wet-alluvial + Protected Areas



Wet-extrusive

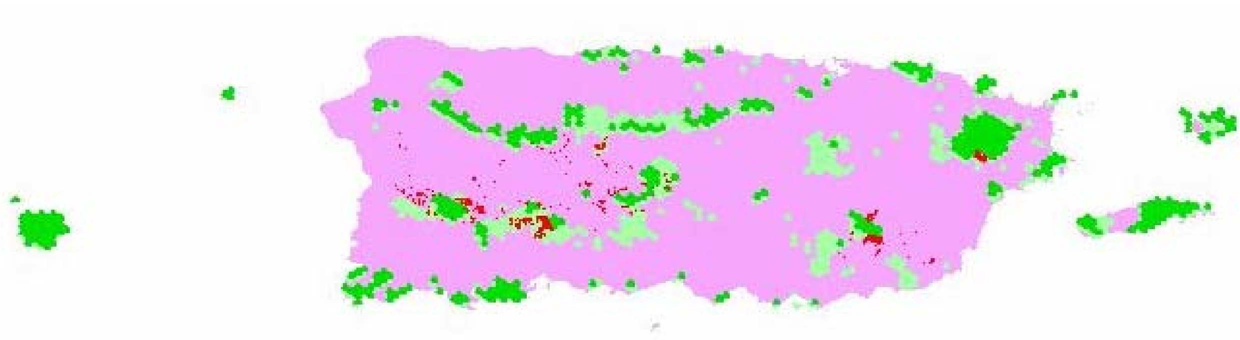


Wet-extrusive + Protected Areas

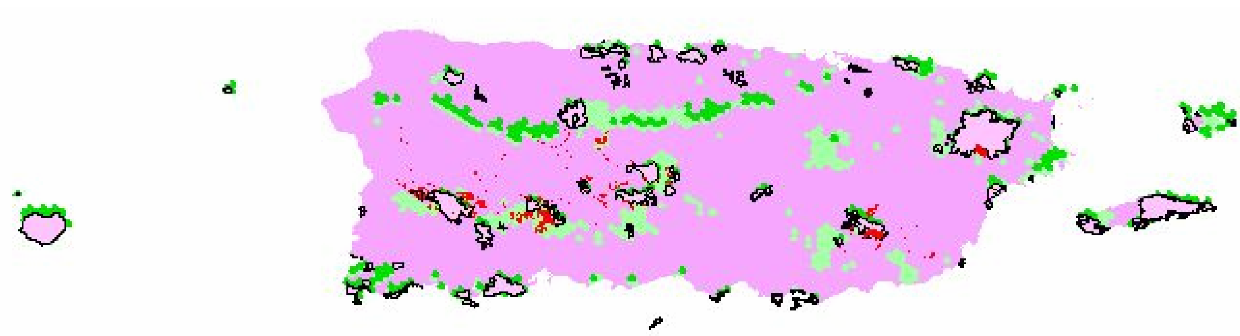


Interior view of wet-volcanic/extrusive forest within the Caribbean National Forest Reserve near Rio Grande, Puerto Rico. (Photo by Julio Figueroa-Colón)

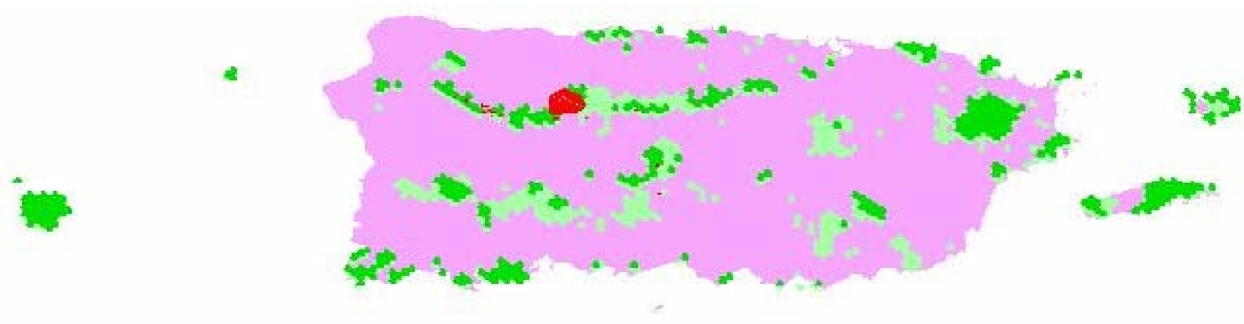
Wet-intrusive



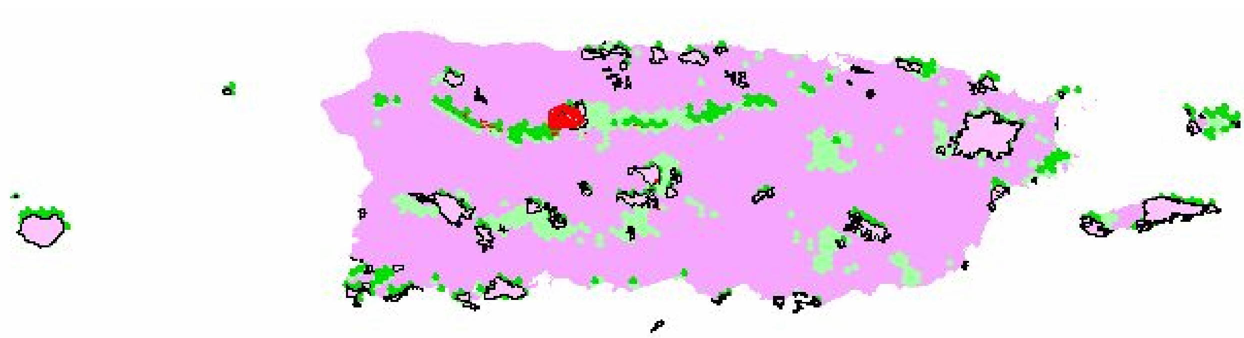
Wet-intrusive + Protected Areas



Wet-limestone

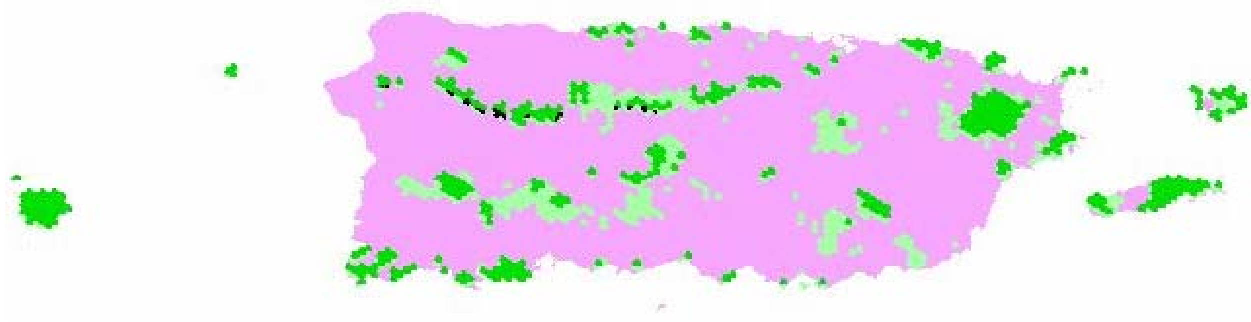


Wet-limestone + Protected Areas

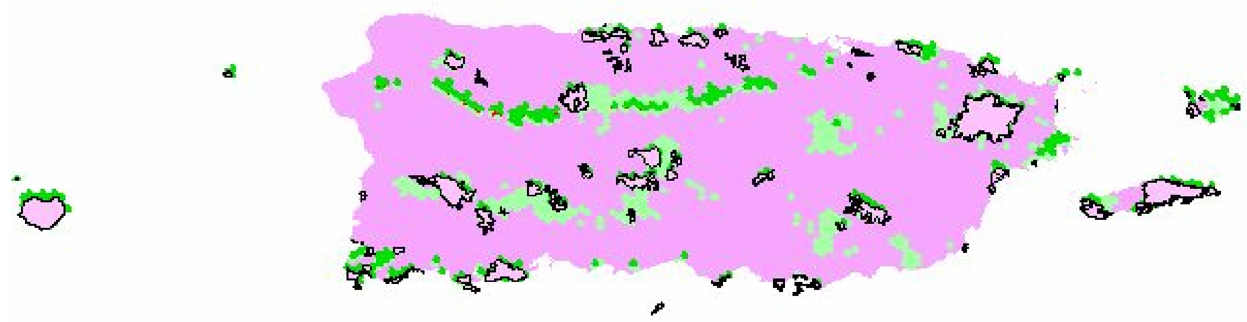


View of <u>wet-limestone</u> forest within the Rio Abajo Forest Reserve near Arecibo, Puerto Rico. (Photo by Julio Figueroa-Colón)

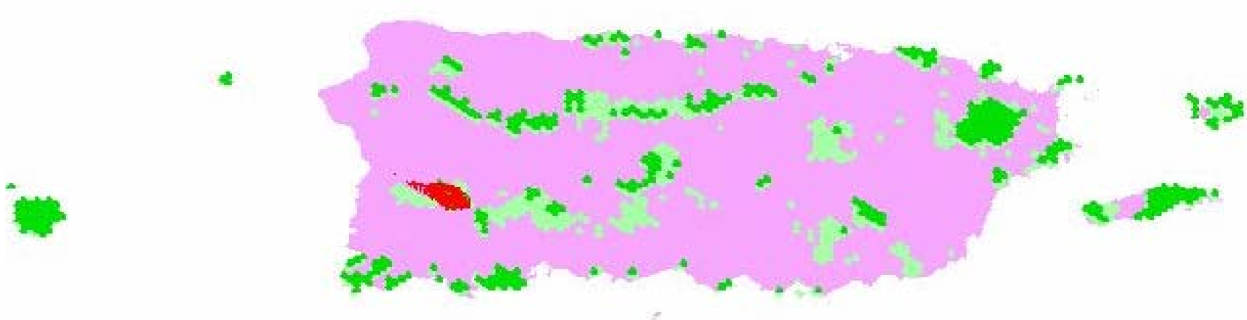
Wet-sedimentary



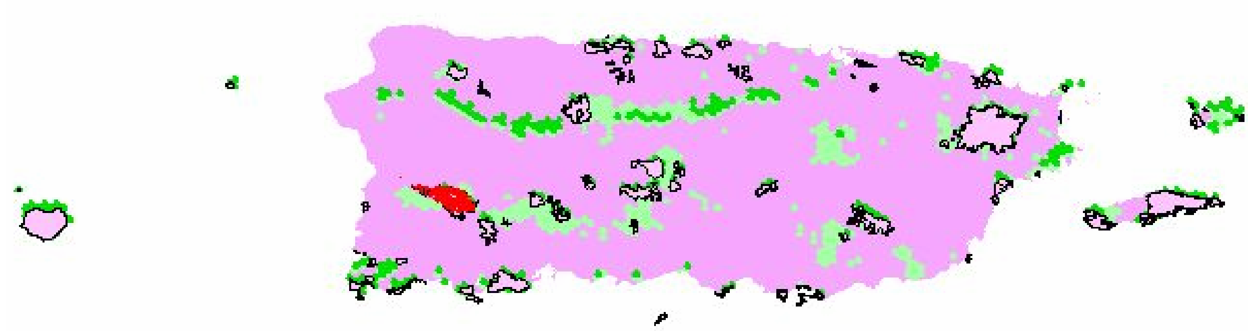
Wet-sedimentary + Protected Areas



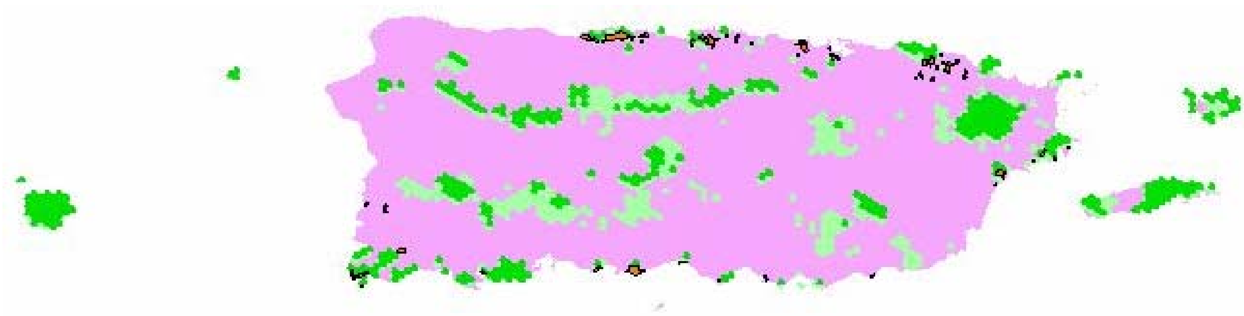
Wet-ultramafic



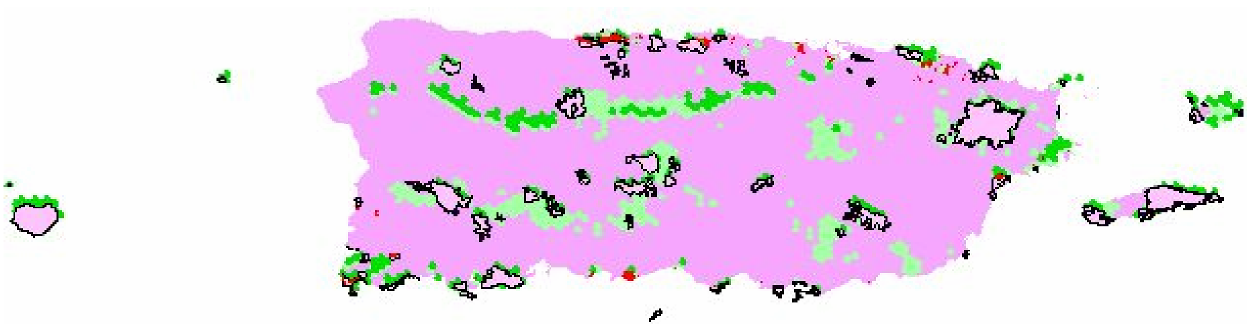
Wet-ultramafic + Protected Areas



Wetland



Wetland +Protected Areas



Appendix 3. List of workshop participants (June 10-12, 2003 and March 10-11, 2004)

	Name	Organization	Title
Terrestrial Workshop	Adrianne Tossas	PR Ornitological Society	
	Alberto Puente Rolón	Iniciativa Herpetologica	
	Alexis Dragoni	F. Biosferica	Coordinator
	Allison Leidner	The Nature Conservancy	Research Assistant
	Ariel Lugo	International Institute of Tropical Forestry	
	Armando Rodríguez Durán	Universidad Interamericana	Dean of A&Sci
	Bill Gould	International Institute of Tropical Forestry	
	Brook Edwards	International Institute of Tropical Forestry	GIS Technician
	Carlos Dias	USFWS	Director
	Carmen Guerrero	Fundacion Puertorriquena de Conservancion	Conservation Planner
	Carmen Hernández-Serrano	DNER, Forestry Division	Environmental Planner
	Dan Morse	The Nature Conservancy	GIS Specialist
	Daniel Dávila	DNER, Natural Heritage Division	Zoologist/Data Manager
	Edgardo González	DNER, Forestry Research Division	Research Forester
	Falin Joglar	University of Puerto Rico, Departament of Natural Sciences	
	Félix Lopez	USFWS	
	Jeffrey Glogiewicz	Consultores Forestales Inc.	
	John Thomlinson	University of Puerto Rico, Institute of Tropical Ecosystem Studies	
	Jorge Baez	Envirosurvey, Inc.	President
	Jorge C. Trejo Torres	Ciudadanos del Karso	Biologist/Botanist
	Jose A. Salguero	SOPI	President
	Jose Luis Chavert	DNER, Endangered Species Program	Direstor of Wildlife Division
	Jose Sustache	DNER	Herbarium Curator
	Julio Figueroa-Colón	Universidad Metropolitana	Ecologist
	Kathleen McGinley	International Institute of Tropical Forestry	International Relations Specialist
	Kim Thurlow	The Nature Conservancy	Research Assistant - Socio-Economic Team
	Kit Kernan	The Nature Conservancy	Senior Conservation Ecologist/Overall ERP Technical Lead
	Leopoldo Miranda-Castro	USFWS	Partners for Fish & Wildlife Coordinator PR & USVI
	Luis A. Rivera	US Forest Service, Caribbean National Forest	Tropical Vegetation Specialist
	Luis D. Beltrán-Burgos	DNER, Natural Heritage Division	Biologist/Environmental Planner
	Luis Jorge Rivera-Herrera	Ciudadanos del Karso	Environmental Scientist

	Magaly Figueroa	International Institute of Tropical Forestry	
	Maria Camacho-Rodriguez	DNER	Biologist
	Mathew McPhserson	The Nature Conservancy	Consultant
	Myrna Aponte	DNER	Biologist
	Olga Ramos	International Institute of Tropical Forestry	GIS Analist
	Peter Weaver	International Institute of Tropical Forestry	Research Forester
	Raquel Seybert	The Nature Conservancy	Puerto Rico ERP Coordinator
	Ricardo Garcia	Jardin Botaico	Taxonomo-Botanico
	Richard Jeo	The Nature Conservancy	ERP Project Director
	Robert Matos	Natural Reserves and Wildlife Refuges Division, DNER	
	Rossana Vidal	DNER, Forestry Division	Biologist
	Sebastian Martinuzzi	International Institute of Tropical Forestry	Biologist
	Shirley Keel	The Nature Conservancy	Senior Conservation Planner/ ERP Terrestrial Team Lead
	Stephanie Wear	The Nature Conservancy	Protected Areas Specialist/ERP Coordinator – USVI
	Steve Schill	The Nature Conservancy	GIS Team Lead
	Susan Koenig	Windsor Research Centre	Div. of Research
	Terry Hueth	International Institute of Tropical Forestry	
	Vicente Quevedo	DNER, Natural Heritage Division	Biologist
Socio-Economic Workshop	Aida Martinez Medina	DNER	DNER, Directora Patrimonio Natural
	Alexis Molinares	Fundación Enrique Martí Coll	
	Alida Ortíz	Consultores Educativos Ambientales	
	Ana Navarro	UPR-RUM, Programa Sea Grant	
	Carlos J. Adorno Irizarry	DNER, División de Consultas y Endosos	Tecnico, Consultas Y Endosos
	Carlos Padín	Universidad Metropolitana, Escuela de Asuntos Ambientales	
	Carlos Paniagua	EPA	Asesor Tecnico
	Carmen Guerrero	Conservation Planner	Fundacion Puertorriquena de Conservancion
	Carmen Hernández-Serrano	DNER, Forestry Division	Environmental Planner
	Carolyn Krupp	US Forest Service, Caribbean National Forest	
	Celso Rossi	DNER, División de Planificación de Recursos Terrestres	
	Cesar A. Vidal Franqui	EPA	Tecnico GIS, Consultant
	Clarimar Díaz Rivera	DNER	Planificadora Ambiental
	Damaris Delgado	DNER, Programa de Zona Costanera	

	Edmond A. Frederick	Autoridad de Tierras de Puerto Rico	Agronomo, Economista Y Planificador
	Edna Villanueva	US Environmental Protection Agency	
	Ernesto Díaz	DNER, Programa de Zona Costanera	Planificador Ambiental
	Félix Aponte	UPR, Escuela Graduada de Planificación	
	Félix Grana	DNER, Oficina del Administrador de Recursos Naturales	
	Fernando Silva	Fideicomiso de Conservación	
	Giovanna Fuentes	Departamento de Recursos Naturales y Ambientales	
	Iraida I. Rafols	Departamento de Agricultura, Oficina de Preservacion de Terrenos Agricolas	Agronoma
	Jose Castro	US Natural Resource Conservation Service	
	Jose Martínez	US Natural Resource Conservation Service	
	Jose Rivera Santana	Estudios Técnicos Inc.	
	José Seguinot	Universidad de Puerto Rico	
	Juan Dávila	Departamento de Agricultura de Puerto Rico	
	Juan Rosario	Misión Industrial de Puerto Rico	
	Julio Rodriguez	SEPRI	President
	Kim Thurlow	The Nature Conservancy	Research Assistant - Socio-Economic Team
	Lazlanie Ruiz Olmo	DNER	Biologa I
	Luis Jorge Rivera-Herrera	Ciudadanos del Karso	Environmental Scientist
	María Juncos	Universidad Metropolitana, Escuela de Asuntos Ambientales	
	Marian González	Comité Asesor en Asuntos Ambientales de la Gobernadora	
	Marianne Meyn	Misión Industrial de Puerto Rico	
	Marilyn Estades	DNER, División de Zona Costanera	
	Marisol Morales	USDA	
	Marlou Church	The Nature Conservancy	Socio-economic Team - Asesora Principal de Political de Agua
	Mathew McPhserson	The Nature Conservancy	Consultant
	Michelle Libby	The Nature Conservancy	Socio-economic Team Leader
	Nancy M. Vázquez Guilbert	DNER	Planificadora Ambiental
	Nuria Mercado	DNER	Planificadora Ambiental
	Other Invited		
	Other Invited		
	Pablo Cruz	US Forest Service, Caribbean National Forest	
	Pedro Gelabert	US Environmental Protection Agency	
	Raquel Seybert	The Nature Conservancy	Puerto Rico ERP Coordinator
	Ruperto Chaparro	UPR-RUM, Programa Sea Grant	

	Sandra Velázquez	PR Tourism Company	
	Silvette M. Mirand Abadia	EPA	Tecnico GIS, Consultant
	Tere Rodríguez	US Environmental Protection Agency	
	Wilfredo López	Legislatura de Puerto Rico	
	Yolanda Flores	Departamento de Agricultura, Oficina de Preservacion de Terrenos Agricolas	Agronoma

Appendix 4. Experts' suggestions that could not be incorporated in this project cycle but might prove useful in later project planning. (They are listed chronologically, in the order they were received.)

Leopoldo Miranda Castro, e-mail of 12/27/2004

1. Leopoldo writes that he does not know whether his suggestion is appropriate for this document. He thinks that a section should be incorporated presenting alternatives to land protection and management, for example, a discussion on different alternatives (restoration programs, easements, acquisition, etc.) for government agencies and private landowners to protect lands and manage natural resources.

2. Leopoldo suggests that we assess the viability of wader birds (e.g., snowy egret, great blue heron) rather than Wilson's plover. Supposedly, the wader birds are a more appropriate group of indicators for detecting connectivity between beach strands and coastal forests. Leopoldo points out that the habitats of Wilson's plover include beaches and salt flats, but not forests.

Frank Wadsworth, e-mail of 2/18/2005

On Threat Assessment

[Threat assessment] "seems to be based on the common assumption that H. sapiens in not a part of the world's biota. Much of what we do is not at a cost to biodiversity, and some things are in its favor, such as reservations. Should not the goal rather be that biodiversity is compatible with well-directed human presence? Is this not what we can hope for? This is not capitulation to business as usual. It means that we have to save all we can, and minimize (but accept) what we can't. Has anyone documented the "cost" of the loss of the passenger pigeon, or the great auk?"

"The three categories of land use seem to omit a large one, where agriculture has been abandoned, and nothing is being done. This includes a huge area of abandoned coffee, minor crops, and sugar cane, most of it in grass cover. Is the fact that these lands appear idle mean no threat? Some of these have been taken illogically for dense new residential settlements without expectation, warning, nor governmental resistance."

"The use of Kcal of energy to classify the threat to biodiversity from agriculture leads to a conclusion that methods using less energy are preferred environmentally. A sad possible social result could be increased de-emphasis on labor intensive farming, which, per se, is not necessarily harder on the environment, but whose loss is at the expense of human unemployment. The criterion itself seems to oppose agriculture of any sort, assuming that farming and biodiversity are incompatible. This simply requires that somebody send us more food from farms somewhere else."

On Marxan Portfolio

[The Marxan portfolio] “apparently categorizes Puerto Rico as though its biodiversity were designed in 260 ha hexagons, as might work in Wyoming. These units, while many, look large to capture very local distinct ecosystems in canyons or on peaks. If they pick up key species they certainly don’t show the limits of their habitat.”

William Gould, e-mail of 2/18/2005

1. “While climate and substrate undoubtedly control vegetation cover, many of the ecological units based on the intersection of climatic and substrate are hypothetically distinct in species composition but in reality the effects of land use and disturbance tend to homogenize the composition of the units. For many of these units the composition and habitat services have not been well described.”

2. “Generally the approach is OK but in order for the models to be useful they need to be developed from a combination of real data and expert opinion that can be validated, as opposed to just expert opinion.”