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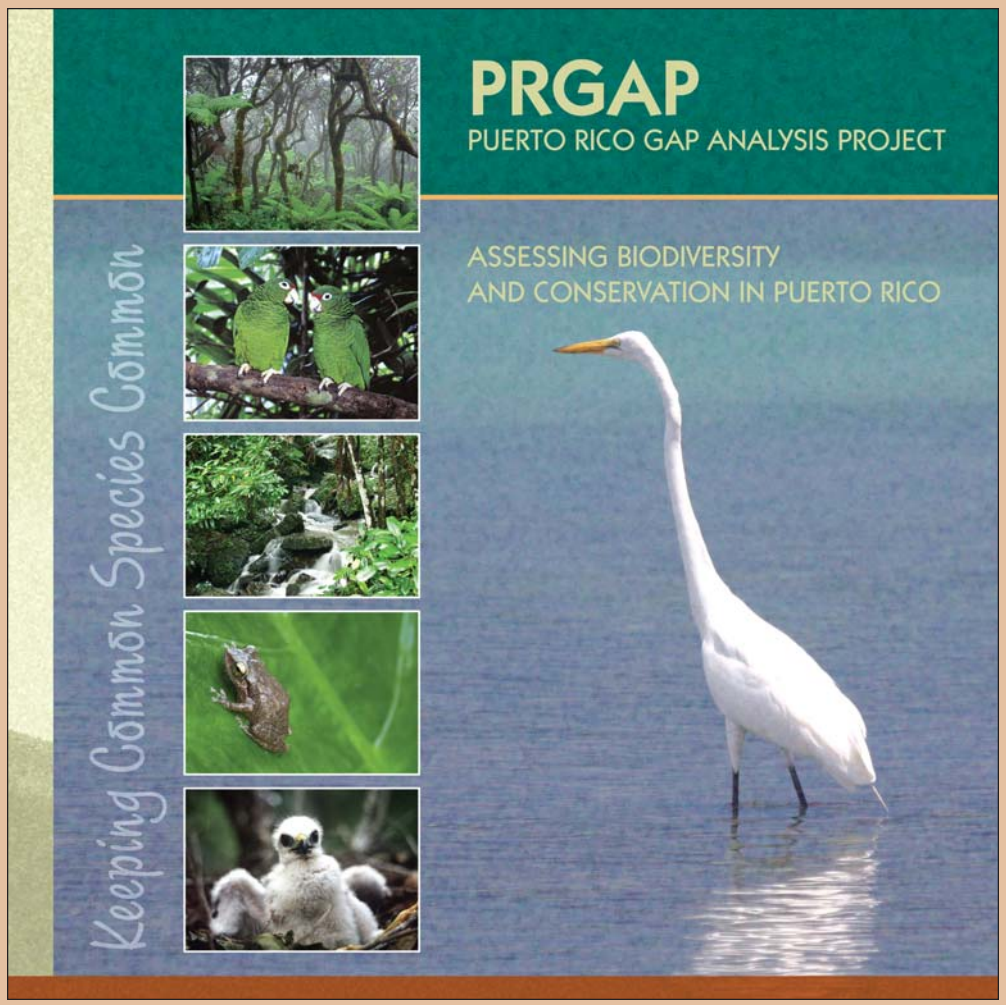
The Puerto Rico Gap Analysis Project

Volume 1: Land Cover, Vertebrate Species Distributions, and Land Stewardship

William A. Gould, Caryl Alarcón, Brick Fevold, Michael E. Jiménez, Sebastián Martinuzzi, Gary Potts, Maya Quiñones, Mariano Solórzano, and Eduardo Ventosa



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Abstract

Gould, William A.; Alarcón, Caryl; Fevold, Brick; Jiménez, Michael E.; Martinuzzi, Sebastián; Potts, Gary; Quiñones, Maya; Solórzano, Mariano; Ventosa, Eduardo. 2008. The Puerto Rico Gap Analysis Project. Volume 1: Land cover, vertebrate species distributions, and land stewardship. Gen. Tech. Rep. IITF-GTR-39. Río Piedras, PR: U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry. 165 p.

Puerto Rico faces a number of problems common to much of the world. Population is increasing while land area is not, and there are reassessments of land use policy and practice to accommodate growing populations, shifting economies, and changing public value systems. Puerto Rico shares similarities with the Eastern United States with its history of agricultural abandonment, relatively high population density, and abundance of "forested" suburban areas in the wildland-urban interface. Puerto Rico has affinities with other tropical regions with high biodiversity and an abundance of rare species. Puerto Rico shares similarities with small islands with space limitations, an abrupt terrestrial-marine interface, and species diversity controlled by the isolation of the island as well as climatic, evolutionary, and historical factors. The Puerto Rico Gap Analysis Project documents Puerto Rico's land cover, vertebrate occurrences and natural history information, and land stewardship. The report has four major components: land cover mapping, documentation of vertebrate species distributions, documentation of land stewardship practices with respect to conservation, and an integrated analysis of these three elements. Our current reserve system protects a number of important habitats and species and includes 7.6 percent of Puerto Rico. Expanding this to 15 percent would be more in line with internationally accepted conservation goals. Abandoned agricultural land serves as habitat for a number of species and buffers older forests, wetlands, riparian areas, and reserves. These lands have excellent potential for restoration. Recommendations include expanded reserves in the coastal plain, particularly coastal hills and the matrix of wetland and upland vegetation; regulation of development in the periphery of existing reserves; and developing viable corridors to connect the upland and coastal reserves.

Keywords: Biodiversity, conservation, tropical ecology, vertebrate diversity, land cover, Puerto Rico

Summary

The Puerto Rico Gap Analysis Project (PRGAP) is a comprehensive assemblage of information on Puerto Rico's land cover, vertebrate occurrences and natural history information, and land stewardship. It is based on methods developed by the national Gap Analysis Program (GAP) to determine the degree to which animal species and natural communities are represented in the current mix of conservation lands. Those species or communities not well represented are considered conservation "gaps." The PRGAP provides geographic and ecological information on the status of not only threatened or rare species, but the common species of Puerto Rico.

The PRGAP project has four major components: land cover mapping, documentation of vertebrate species distributions, documentation of land stewardship practices with respect to conservation, and an integrated analysis of these three elements.

Land Cover

We developed a land cover map of Puerto Rico using recent (1999–2003) satellite imagery and information on climate, geology, topography, hydrology, and land use history. We defined 70 land cover classes in a hierarchical classification scheme based on whether the cover is natural vegetation, developed, or agricultural and on whether the natural vegetation is closed forest, woodland, shrubland, or grassland. Forest and grassland classes are further defined as dry, moist, wet, or flooded. These units are then differentiated as occurring on soils derived from limestone, alluvial, serpentine, or noncalcareous substrates. A number of forest types are further classified as to the forest age (i.e., primary, mature secondary, or young secondary forests). Wetlands are classified as forested or herbaceous, saline or nonsaline, and seasonally flooded or emergent. Finally, where information is available, we present the dominant plant communities and species representative of these land cover units.

We classified 53 percent of Puerto Rico as predominantly woody vegetation, 35 percent as grassland or herbaceous agriculture, 11 percent as developed land, and about 1 percent each of water and natural barrens. Of the woody areas, low and mid-elevation moist forests cover 26 percent, upper elevation wet forests cover 18 percent, dry forests cover 7 percent, and flooded mangrove and *Pterocarpus* forests cover 1 percent of the island. Coastal wetlands cover less than 4 percent of the island. Forty-two percent of the wetlands are saline and 58 percent are freshwater. Mangroves and *Pterocarpus* swamps cover 1 percent of the island, 67 km^2 and 2.6

km^2, respectively. Seventy-four percent of the wetlands are dominated by herbaceous vegetation, and 92 percent of these are seasonally flooded. Of the herbaceous wetlands, 77 percent are nonsaline and 23 percent are saline.

Vertebrates

Over 470 vertebrate species have been recorded in Puerto Rico and its adjacent islands including terrestrial and aquatic birds, reptiles, amphibians, and mammals. Of these, 426 are terrestrial vertebrate species. Many of these are migratory, wintering, accidental or vagrant species that do not breed regularly or at all on the island. We have developed a database that contains taxonomic information, residence status, and conservation status of all these species. We predicted the distributions of 98 bird, 47 reptile, 18 amphibian, and 14 mammal species including all native resident endemic and endangered terrestrial vertebrates and some introduced species. Migratory birds, sea turtles, and marine and freshwater aquatic species will be included in future analyses.

Species ranges were mapped by using a network of 24-km^2 hexagons that cover Puerto Rico and its adjacent islands. Each hexagon was attributed with the species probability of occurrence in one of eight categories. Species probability of occurrence information is derived from published literature, unpublished data sets, museum records, and expert opinion.

Species distributions were mapped by identifying predicted habitat within the species range based on literature and expert review. The resulting maps of predicted species distribution are a result of the integration of information from both the vertebrate database and land cover mapping. We combined species distribution information to develop species richness maps. The resulting biodiversity patterns indicate that forested parts of the landscape are the habitats with the highest predicted species richness. Urban and barren areas are the habitats with the lowest species richness. Individual taxonomic groups show distinct patterns.

We also looked at the species richness within the network of 24-km^2 hexagons used to document species occurrences. This analysis indicates that the highest levels of habitat heterogeneity and resulting biodiversity are in coastal areas with a mix of wetlands, grassland, and forested coastal hills. The coastal area is also extremely vulnerable to development, as the topography is less steep, it is close to urban areas and existing infrastructure, and nonwetlands on the coastal plain and coastal hills are primarily unprotected. Development is prohibited in the wetlands, but development adjacent to wetlands can destroy the diverse matrix of habitats and affect hydrologic patterns, altering species composition and biodiversity.

Land Stewardship

The national GAP currently uses a scale of 1 to 4 to denote relative degree of maintenance of biodiversity for stewardship areas. A status of "1" denotes the highest, most permanent level of maintenance, and "4" represents the lowest level of biodiversity management, or unknown status (Crist et al. 1995, Edwards et al. 1995, Scott et al. 1993).

Although land stewardship, management, and land use are very dynamic, we have identified 77 stewardship areas that receive some management for conservation (GAP status 1 through 3). Land ownership of these areas is shared among 20 organizations, with the Puerto Rico Department of Natural and Environmental Resources (DNER) being the primary landowner. Management of land stewardship areas is shared among 20 organizations, with the DNER, the U.S. Forest Service, and the U.S. Fish and Wildlife Service being the primary governmental land managers and the Conservation Trust of Puerto Rico being the primary nongovernmental land manager.

Of the total land area of Puerto Rico, 7.6 percent receives some management for conservation (GAP status 1, 2, or 3) with 7.4 percent of the total land area receiving good management of conservation (GAP status 1 or 2). Fifty-nine percent of the stewardship areas are managed by Commonwealth agencies, 30 percent by federal agencies, and 11 percent by nongovernmental or private agencies.

Gap Analyses–Land Cover

Eight of our 70 land cover classes have less than 1 percent of their area represented in GAP status 1 or 2 conservation areas; they cover 43 percent of the island. They are primarily subject to human use such as agriculture, housing, and other development. Moist grasslands and pastures cover nearly one quarter of the island and are primarily active pasture and abandoned agricultural land. Given the resilience of the natural vegetation in Puerto Rico, this land cover type has potential for management for reforestation or as natural grasslands and open space.

Twenty-seven land cover units have between 1 and 10 percent of their area represented in GAP status 1 or 2 conservation areas. They account for 44 percent of the island. They range from an extent of less than 1 percent to over 6 percent of the island and include a number of young secondary forest and woodland land cover classes, as well as artificial and natural barrens, active and abandoned shade coffee plantations, dry grasslands and pastures, riparian forests, and four mature secondary forest classes.

Four land unit classes have between 10 and 20 percent of their area represented in GAP status 1 or 2 conservation areas. They account for 1.7 percent of the island and include two woodland-shrubland classes that typically occur on abandoned agricultural land, dryland riparian forest, and palm plantations.

Fourteen land cover classes have between 20 and 50 percent of their area represented in GAP status 1 or 2 conservation areas and account for 6.1 percent of the island's total area. They include a number of ecologically important areas including beaches and shorelines, mature forests, wetlands, mangrove complexes, and Sierra palm forest.

Seventeen land cover units are over 50 percent protected under GAP status 1 and 2. They account for 5.1 percent of the island. They include important primary and mature secondary forest types in the Luquillo Mountains, freshwater *Pterocarpus* swamps, forests on serpentine substrates, and a number of dryland habitats unique to Mona Island and the Guánica Biosphere Reserve.

Gap Analyses–Vertebrates

Four species have less than 1 percent of their habitat protected under GAP status 1 or 2. These include two species of Gecko common in urban areas; one bird, *Carduelis cucullata,* which is nonnative; and *Eleutherodactylus cooki*, the guajón or rock coqui, which has limited habitat, none of which is protected.

One recently discovered species not fully included in the PRGAP analysis, is the coqui llanero, or plains coqui (*Eleutherodactylus juanariveroii*) (Ríos-López and Thomas 2007).

Seventy-seven species have 1 percent to less than 10 percent of their habitat protected under GAP status 1 or 2. Many are widespread although not necessarily common and occur in disturbed habitats. A few, such as the blind snake *Typhlops platycephalus*, have limited habitat (15 percent of the island), the majority unprotected (98 percent of its habitat).

Thirty-two species have 10 percent to less than 20 percent of their habitat protected under GAP status 1 or 2. These species are a mix of those with widespread and those with limited habitat extent.

Forty-three species have 20 percent to less than 50 percent of their habitat protected under GAP status 1 or 2. All of these species have habitat extent limited to less than 11 percent of the island. A number of endangered species are in this group, and many are limited to less extensive habitats such as saline and freshwater ponds and wetlands or high mountain areas.

Twenty-one species have at least 50 percent of their predicted habitat protected under GAP status 1 or 2. These include a number of species found only on forest reserves or particular protected satellite islands (Mona and Desecheo). All of these species have very limited habitat and none exceed 2 percent of the island.

Forty-seven species are listed as either federally threatened or endangered or given partial status, or are locally listed by the DNER as vulnerable, endangered, critically endangered, or data deficient. The extent of habitat for 70 percent of these species is typically below 5 percent of the island's total area. Eighty-three percent of the species have a habitat extent below 20 percent of the island's total area. *Eleutherodactylus cooki*, the guajón or rock coqui, is the least protected, with no protected habitat. Ten species have less than 10 percent of their habitat protected and 18 species have less than 20 percent of their habitat protected. Five species are found only in reserves with 100 percent of their current distribution protected. Distributions for these species could be expanded outside reserves if suitable habitat is protected or restored and species reintroductions are encouraged.

Puerto Rico is at a crossroads in terms of land use transition, as much of what was formerly agricultural land is now experiencing more intense, and possibly irreversible urban-associated development. Our current reserve system is well located and protects a number of important habitats and species. However, this system needs to be expanded from 7.6 percent to at least 15 percent of the island's area to be more in line with internationally accepted conservation goals. Our abandoned agricultural land is often a matrix of forested and open green space that serves as habitat for a number of species and buffers older forests, wetlands, riparian areas, and our current reserves. These lands have excellent potential for restoration. We recommend expanded reserves in the coastal plain, particularly coastal hills and the matrix of wetland and upland vegetation; better regulation of development in the periphery of existing reserves to maintain the integrity of hydrologic systems in wetlands; and protecting viable corridors and buffer zones to connect the upland and coastal reserves.

Resumen

El Proyecto Gap de Puerto Rico (Puerto Rico Gap Analysis Project—PRGAP) es una colección comprensiva de información sobre la cubierta del suelo de Puerto Rico, distribución e historia natural de vertebrados, y áreas de manejo. Está basado en la metodología desarrollada por el programa nacional GAP de los Estados Unidos para determinar el grado en el cual especies y sus comunidades naturales están representadas en los terrenos que están actualmente protegidos. Las especies o comunidades que no estén bien representadas son consideradas "gaps" o agujeros en el plan de conservación. El PRGAP provee información geográfica y ecológica en el estatus de, no solo las especies endémicas o en peligro de extinción, sino de todas las especies de Puerto Rico, incluyendo las comunes y exóticas.

El PRGAP tiene cuatro componentes principales: mapeo de la cobertura del terreno, documentación de las distribuciones de especies vertebradas, documentación de las prácticas de conservación en áreas de manejo, y un análisis integrando estos tres elementos.

Cobertura del Terreno

Desarrollamos un mapa de cobertura del terreno de Puerto Rico utilizando imágenes de satélite recientes (1999–2003) e información sobre clima, geología, topografía, hidrología, e historia del uso del terreno. Definimos 70 clases de cobertura del terreno en un esquema jerárquico de clasificación basado en las siguientes coberturas básicas: vegetación natural, desarrollo urbano, o agricultura. La vegetación natural se clasificó en bosque cerrado, bosque abierto, arbustos o pastizales. Las clasificaciones de bosque cerrado y pastizales son definidas más a fondo en seco, húmedo, mojado o inundado.

Estas unidades son entonces diferenciadas entre si ocurren en suelos derivados de caliza, aluvial, serpentina o substratos no calcáreos. Varios de los tipos de bosque cerrado fueron clasificados de acuerdo a su edad (por ejemplo primario, secundario maduro, o joven secundario). Los manglares fueron clasificados en arbolado, herbáceo, salino o no salino, y temporalmente inundado o emergente. Finalmente, información sobre comunidades de flora dominante, y especies representativas de la unidad de cobertura de terreno, fue incorporada cuando ésta estaba disponible.

Clasificamos el 53 por ciento de Puerto Rico como predominantemente vegetación leñosa, y 35 por ciento como pastizales o agricultura herbácea. Clasificamos 11 por ciento como terrenos desarrollados y alrededor de 1 por ciento como agua y terreno descubierto natural. De las 70 unidades de clasificación 49

están dominadas por vegetación leñosa. De éstas, 26 por ciento cubren bosque húmedo de baja y mediana elevación, 18 por ciento cubre bosque mojado de alta elevación, 7 por ciento cubre bosque seco, y 1 por ciento cubre manglar inundado y bosques de *Pterocarpus*. Los humedales costeros cubren menos del 4 por ciento de la isla y el 42 por ciento de los mismos son salinos y el 58 por ciento son humedales de agua dulce. Los humedales costeros-arbóreos cubren 1 por ciento de la isla y están representados por manglares y pantanos *Pterocarpus* de agua dulce. Por otro lado, el 74 por ciento de los humedales están dominados por vegetación herbácea, y 92 por ciento de estos son temporalmente inundados. De los humedales herbáceos, 77 por ciento son no-salinos, y 23 por ciento son salinos.

Vertebrados

Datos sobre 470 especies de vertebrados han sido recolectados para Puerto Rico y sus islas adyacentes incluyendo 98 aves terrestres y acuáticas, 47 reptiles, 18 anfibios y 14 mamíferos. De estas, 426 son vertebrados terrestres y muchas son especies migratorias, accidentales que no se reproducen en la isla, o solo lo hacen en raras ocasiones. Desarrollamos una base de datos que contiene información taxonómica, estatus de residencia, y estatus de conservación de todas las especies registradas. Se crearon predicciones de distribución de un subconjunto de especies incluyendo todas las especies nativas residentes y endémicas terrestres y algunas especies exóticas. Esperamos incluir las aves migratorias, las tortugas marinas, las especies acuáticas marinas o de agua dulce, y los animales domésticos en análisis futuros.

Las distribuciones conocidas de las especies fueron mapeadas utilizando una red de hexágonos, de 24 km^2 cada uno, que cubre a Puerto Rico e islas adyacentes. Cada hexágono fue clasificado en una de ocho categorías de probabilidad de presencia. Información sobre la probabilidad de presencia de una especie es derivada de literatura publicada, bases de datos no publicadas, registros de museos, y opinión experta.

Mapeamos las distribuciones de hábitat de las especies estableciendo una predicción de sus hábitats dentro de su distribución geográfica, basada en la literatura científica y la revisión de expertos. Por lo tanto, los 177 mapas de distribuciones predichas de las especies fueron el resultado de la integración de información de la base de datos de vertebrados y el mapa de cobertura de terreno.

Desarrollamos mapas de riqueza de especies usando esta información para identificar patrones de biodiversidad. Los patrones de biodiversidad resultantes indican que las áreas boscosas del paisaje son las más ricas en diversidad de

especies, con hasta 73 especies. Las áreas urbanas y las áreas estériles muestran la menor riqueza con tan pocas como 7 especies. Los distintos grupos taxonómicos demuestran patrones distintos de distribución.

También examinamos la riqueza de las especies dentro de la misma red de hexágonos, de 24 km^2 cada uno, usada para documentar la presencia de especies. Este análisis indica que los niveles más altos de diversidad de hábitat y resultante biodiversidad se encuentran en áreas costeras que contienen una mezcla de humedales, pastizales y lomas costeras boscosas. El área costera es extremadamente vulnerable al desarrollo urbano debido a la topografía menos montañosa del lugar. El desarrollo urbano está generalmente prohibido en los humedales, pero el desarrollo en áreas adyacentes puede destruir la matriz de diversidad del hábitat y afectar los patrones hidrológicos. Esto a su vez altera la composición de especies y la biodiversidad.

Áreas de Manejo

El GAP Nacional actualmente usa una escala de 1 al 4 para denominar el grado relativo de mantenimiento de biodiversidad en áreas con planes de manejo existentes. Un estatus de "1" significa el más alto y permanente nivel de mantenimiento, y 4 representa el nivel más bajo de manejo de la biodiversidad, o la falta de información sobre el área.

Aunque la tenencia, el manejo y el uso de los terrenos son bastante dinámicos en Puerto Rico identificamos un grupo de 77 áreas de manejo que reciben algún tipo de manejo para la conservación (estatus de GAP del 1 al 3), bajo la tenencia de unas 20 organizaciones con el DRNA siendo el propietario principal. El manejo de estas áreas es compartido entre 20 organizaciones con el Departamento de Recursos Naturales y Ambientales, El Servicio Forestal Federal de los Estados Unidos y el Servicio de Pesca y Vida Silvestre de los Estados Unidos siendo los principales manejadores gubernamentales, y el Fideicomiso de Conservación de Puerto Rico siendo el principal manejador no gubernamental. Siete punto seis por ciento de todas las tierras en Puerto Rico recibe algún tipo de manejo para la conservación (estatus de GAP 1, 2 o 3), con un 7.4 por ciento recibiendo buen manejo (estatus de GAP 1 o 2). Cincuenta y nueve por ciento de las áreas de manejo están manejadas por agencias del Estado Libre Asociado de Puerto Rico, 30 por ciento por agencias federales, y 11 por ciento por agencias privadas o no gubernamentales.

Análisis “Gap”–Cobertura de Terreno

Ocho de las 70 clases de cobertura de terreno tienen menos de 1 por ciento de su área representada en tierras con estatus de conservación de GAP 1 o 2; estas cubren el 43 por ciento de la isla. Dada la perseverancia de la vegetación natural en Puerto Rico, este tipo de cobertura tiene el potencial de manejo para la reforestación o como pastos naturales y espacio abierto.

Veinte y siete unidades de cobertura de terreno tienen entre 1 a 10 por ciento de su área representada en tierras con estatus de conservación GAP 1 o 2. Éstas cubren 44 por ciento de la superficie de la isla y contienen varias clases de bosques secundarios jóvenes, bosques abiertos terrenos expuestos naturales y artificiales, plantaciones de café de sombra activas y abandonadas, pastizales secos, bosques ribereños, y cuatro clases de bosque secundario maduro.

Cuatro unidades de cobertura de terreno tienen entre 10 a 20 por ciento de su área representada en tierras con estatus de conservación de GAP 1 o 2, y representan el 1.7 por ciento de la isla. Éstas incluyen dos clases de bosque abierto y arbustos—los cuales suelen ocurrir en tierras agrícolas abandonadas, bosque ribereño seco, y plantaciones de palmas.

Catorce clases de cobertura de terreno tienen entre 20 a 50 por ciento de su área representada por los estatus de conservación de áreas Gap 1 o 2 y representan el 6.1 por ciento del área total de la isla. Estos incluyen un número de áreas ecológicamente importantes tales como playas, orilla costera, bosques maduros, humedales, complejos de manglares y bosque de Palma de Sierra. Diecisiete unidades de cobertura de terreno están sobre el 50 por ciento de protección bajo los estatus GAP 1 o 2. Estos representan un 5.1 por ciento de la isla. Éstas incluyen importantes bosques de tipo primario y secundario en la Cordillera de Luquillo, pantanos de agua de dulce de *Pterocarpus*, bosques de suelos serpentinos, y varias áreas de hábitat seco únicos de la Isla de Mona y de la Reserva de la Biosfera de Guánica.

Análisis “Gap”–Vertebrados

Cuatro especies tienen menos del 1 por ciento de su hábitat protegido bajo el estatus de conservación de áreas GAP 1 o 2.

Una especie descubierta recientemente, provisionalmente reconocida, y no incluida todavía en el análisis PRGAP, es el coquí llanero (*Eleutherodactylus juanariveroii*). La distribución de este coquí es muy limitada y no se encuentra bajo ninguna protección.

Setenta y siete especies cuentan con 1 a 10 por ciento de su hábitat protegido bajo los estatus GAP 1 o 2. Muchas de estas especies tienen una distribución amplia a lo largo de la isla aunque no son necesariamente comunes y ocurren en hábitat perturbado.

Treinta y dos especies tienen 10 a 20 por ciento de su hábitat protegido bajo los estatus de GAP 1 o 2. Estas especies se podrían describir como un balance entre aquellas de amplia distribución y aquellas de distribución limitada.

Cuarenta y tres especies cuentan con 20 a 50 por ciento de su hábitat protegido bajo el estatus de conservación de áreas GAP 1 o 2. Muchas están limitadas a sistemas naturales de menor extensión como charcas de agua dulce o salada, humedales o áreas montañosas elevadas.

Veintiuna especies tienen al menos 50 por ciento de su hábitat predicho protegido bajo el estatus de conservación de áreas GAP 1 o 2. Esto incluye varias especies que se encuentran solamente en reservas forestales o en islas protegidas (Mona y Desecheo). Todas estas especies cuentan con una extensión de hábitat muy limitado que no supera en ninguno de los casos el dos por ciento de la isla.

Cuarenta y siete especies están federalmente listadas ya sea como amenazadas, en peligro o de estatus parcial, o localmente listadas por el DRNA como vulnerables, amenazadas, en peligro crítico, o con insuficiencia de datos. La extensión de hábitat para el 70 por ciento de estas especies está típicamente bajo el 5 por ciento del área total de la isla. *Eleutherodactylus cooki*, el coquí guajón, es la menos protegida pues no cuenta con hábitat protegido. Diez especies cuentan con menos del 10 por ciento de su hábitat protegido y 18 tienen menos del 20 por ciento.

Puerto Rico se encuentra entre la espada y la pared en términos de transición del uso de terrenos ya que las tierras, que en el pasado estaban destinadas a la agricultura, hoy en día están experimentando un uso más intenso, posiblemente irreversible, relacionado al desarrollo urbano. Nuestro sistema de reservas actual está bien ubicado y protege a variedad de especies y ecosistemas. Sin embargo, este sistema necesita expandirse de menos de un ocho por ciento a al menos un 15 por ciento de la superficie de la isla para estar más de acuerdo con las metas de conservación aceptadas a nivel internacional. Las tierras agrícolas abandonadas se han ido transformando en una miscelánea de espacios verdes forestados y abiertos que sirve como hábitat para muchas especies y amortiguan a los bosques maduros,

humedales, zonas ribereñas, y a las reservas actuales de los efectos antropogénicos. Estas tierras tienen un potencial magnífico de restauración. Recomendamos la expansión de reservas en las planicies costeras, particularmente las colinas costeras y la matriz de humedales y vegetación elevada.

También recomendamos una mejor regulación de los desarrollos urbanos en la periferia de las reservas existentes para mantener la integridad de los sistemas hidrológicos en los humedales. Finalmente recomendamos el establecimiento y mantenimiento de corredores viables y zonas de amortiguamiento que conecten las tierras altas con las reservas costeras.

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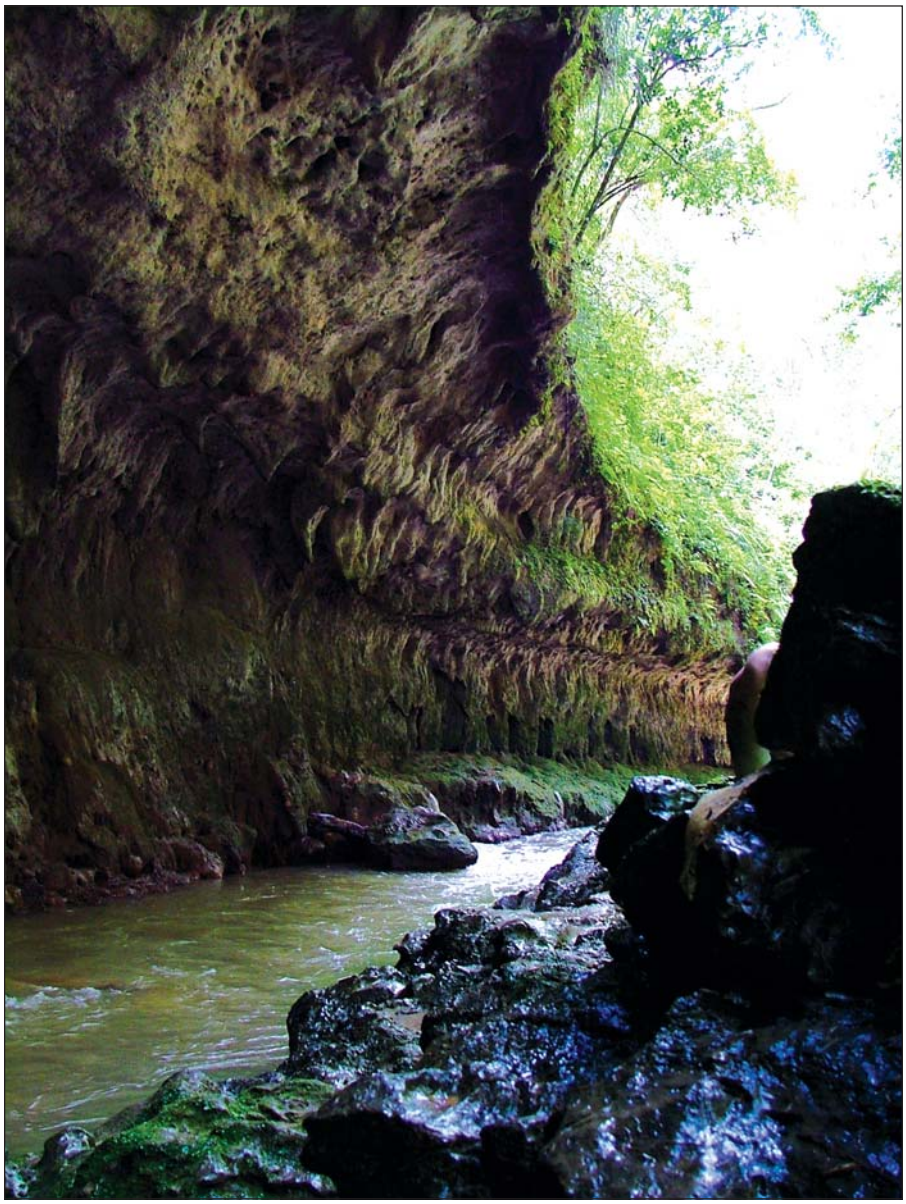

Mariano Solórzano

Tanama River

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Introduction

The Puerto Rico Gap Analysis Project (PRGAP) is a comprehensive assemblage of information on Puerto Rico's land cover, vertebrate occurrences and natural history information, and land stewardship. It is based on methods developed by the national Gap Analysis Program (GAP) to determine the degree to which animal species and natural communities are represented in the current mix of conservation lands. Those species or communities not well represented are considered conservation "gaps." The PRGAP provides geographic and ecological information on the status of not only threatened or rare species, but the common species of Puerto Rico.

The current status of the PRGAP is summarized in a series of four volumes.

Volume 1: Land cover, vertebrate species distributions, and land stewardship, provides an overview and analysis of the primary data sets used in gap analysis.

Volume 2: Species accounts, provides detailed taxonomic, natural history, conservation status, and bibliographic information on all vertebrate species addressed in this report.

Volume 3: Species occurrences, provides range maps with 24-km^2 resolution for each species based on documented occurrences.

Volume 4: Species predicted distributions, provides species distribution maps with 15-m^2 resolution for each species based on documented occurrences and presence of suitable habitat.

Volume 1 begins with an overview of the Gap Analysis Program (GAP) mission, concept, and limitations. This is followed by a description of the key factors controlling biodiversity, including the climate, physiography, ecology, and land use history of Puerto Rico. Three subsequent sections describe the primary data layers associated with a gap analysis: land cover, vertebrate species distributions, and land stewardship. Each of these sections describes the methods, results, and discussions of the related data. A fourth section includes an analysis of the distribution of species and habitats with respect to conservation management (i.e., a "gap" analysis). Finally, this volume describes the management implications of the analysis results and provides information on how to acquire and use the data.

The Gap Analysis Program Mission

The mission of GAP is to prevent conservation crises by providing conservation assessments of plant communities and native animal species and to facilitate the application of this information to land management activities. This is accomplished by meeting the following five objectives:

1. Map current land cover.
2. Map the predicted distribution of selected terrestrial vertebrates.
3. Document the representation of land cover types and animal species in areas managed for the long-term maintenance of biodiversity.
4. Make GAP project information available to the public and those charged with land use research, policy, planning, and management.
5. Build institutional cooperation in the application of this information to state and regional management activities.

To meet these objectives, it is necessary that GAP operate at the state, commonwealth, or regional level while maintaining consistency with national standards. Participation by a wide variety of cooperators is necessary and can lead to understanding and acceptance of the data and the development of relationships that will lead to cooperative conservation planning.

State Objectives—
The Puerto Rico GAP had a number of additional objectives. We adapted methodology of the national GAP to meet the needs of Puerto Rico, an archipelago of tropical islands with a unique social, economic, and ecological environment. Puerto Rico's environment includes diverse bioclimatic zones, considerable ecological variation over small distances, a high degree of development pressure, a small national heritage database of species occurrences, and a long history of ecological research but few published descriptions of natural vegetation at the plant community level. Most land management for conservation is being done by the Puerto Rico Department of Natural and Environmental Resources (DNER) followed by the U.S. Department of Agriculture Forest Service (USFS) and the U.S. Fish and Wildlife Service (USFWS).

Our state-level objectives were to:

- Develop a coverage of 24-km^2 hexagons (fig. 1) for use in occurrence and range mapping that accommodates the scale of landscape variation in Puerto Rico (Gould et al. 2008b).

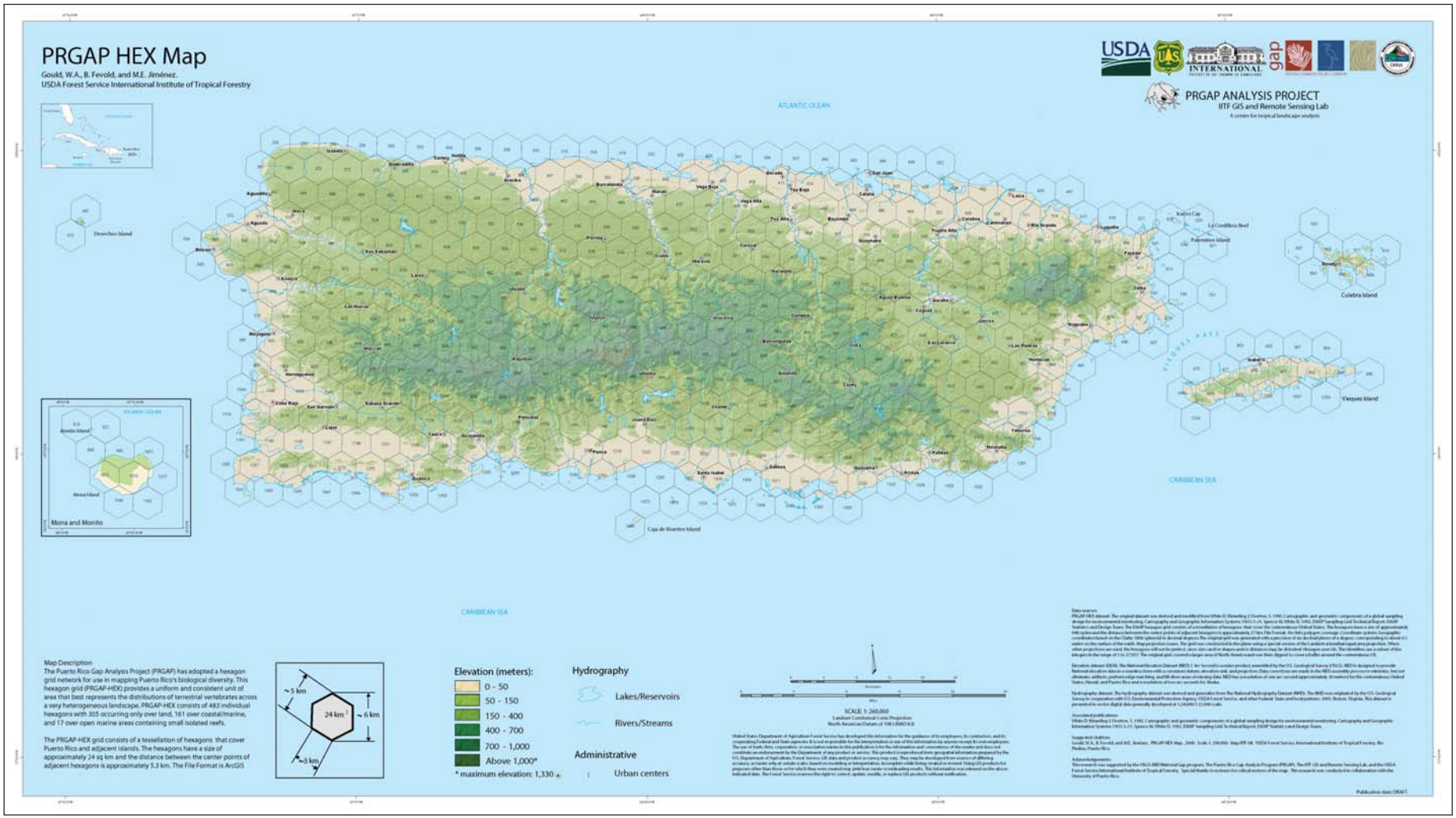

Figure 1—The Puerto Rico Gap Analysis Project has adapted a hexagon grid network for use in mapping Puerto Rico's biological diversity. This hexagon grid (PRGAP-HEX) provides a uniform unit of area that can be used to represent the range and occurrence of vertebrate species across a very heterogeneous landscape. The PRGAP-HEX grid consists of 483 individual hexagons with 305 occurring only over land, 161 over coastal areas, and 17 over open marine areas with small reefs and cays. Each hexagon includes 24 km^2. The PRGAP-HEX is a modification of the Forest Inventory and Analysis grid developed by the U.S. Forest Service (Gould et al. 2008b).

- Develop contacts and collaborations with conservation agencies and groups in Puerto Rico in order to receive input and communicate our findings in ways useful to immediate conservation concerns.
- Develop databases of species occurrences, scientific literature related to species habitats and distributions, and species natural history information that are dynamic and will have a useful life beyond the completion of PRGAP.
- Compile and develop new information on natural vegetation at the plant community level, and crosswalk these descriptions with past vegetation work in Puerto Rico, using federal guidelines (FGDC 1997) and other descriptive hierarchies.
- Collaborate in all phases of the project with the primary land management agency in Puerto Rico, the DNER.
- Develop a project that can serve as a foundation for the development of a Puerto Rico-United States Virgin Islands GAP and Caribbean GAP.
- Develop a bilingual (Spanish and English) project.

The Gap Analysis Concept

The Gap Analysis Program brings together the problem-solving capabilities of federal, state, and private scientists to tackle the difficult issues of land cover mapping, animal habitat characterization, and biodiversity conservation assessment at the state, regional, national, and international levels. The program seeks to facilitate cooperative development and use of information.

Much of the following discussion was taken verbatim from Davis et al. 1995, Edwards et al. 1995, and Scott et al. 1993. The gap analysis process provides an overview of the distribution and conservation status of several components of biodiversity. It uses the distribution of actual vegetation and predicted distribution of terrestrial vertebrates and, when available, invertebrate taxa. Digital map overlays in a geographic information system (GIS) are used to identify individual species, species-rich areas, and vegetation types that are unrepresented or underrepresented in existing management areas. It functions as a preliminary step to the more detailed studies needed to establish actual boundaries for planning and management of biological resources on the ground. These data and results are then made available to the public so that institutions as well as individual landowners and managers may become more effective stewards through more complete knowledge of the management status of these elements of biodiversity. The GAP, by focusing on higher levels of biological organization, is likely to be both cheaper

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The endemic Puerto Rican flycatcher *Myarchus antillarum* is known locally as the Juí de Puerto Rico.

and more likely to succeed than conservation programs focused on single species or populations (Scott et al. 1993).

Biodiversity inventories can be visualized as "filters" designed to capture elements of biodiversity at various levels of organization. The filter concept has been applied by The Nature Conservancy, which established Natural Heritage Programs in all 50 states and the Commonwealth of Puerto Rico. The Nature Conservancy employs a fine filter of rare species inventory and protection and a coarse filter of community inventory and protection (Jenkins 1985, Noss 1987). It is postulated that 85 to 90 percent of species can be protected by the coarse filter without having to inventory or plan reserves for those species individually. A fine filter is then applied to the remaining 15 to 10 percent of species to ensure their protection. Gap analysis is a coarse-filter method because it can be used to quickly and cheaply assess the other 85 to 90 percent of species. The GAP is not designed to identify and aid protection of elements that are rare or of very restricted distribution; rather it is designed to help "keep common species common" by identifying risk far in advance of actual population decline.

The intuitively appealing idea of conserving most biodiversity by maintaining examples of all natural community types is now widely recognized, and numerous approaches to the spatial identification of biodiversity in association with natural community type have been described (Kirkpatrick 1983, Margules et al. 1988, Nicholls and Margules 1993, Pressey and Nicholls 1989). Furthermore, the spatial scales at which organisms use the environment differ tremendously among species and relate to body size, food habits, mobility, and other factors. Hence, no coarse filter will be a complete assessment of biodiversity protection status and needs. However, species that fall through the pores of the coarse filter, such as narrow endemics and wide-ranging mammals, can be captured by the safety net of the fine filter. Community-level (coarse-filter) protection is a complement to, not a substitute for, protection of individual rare species.

Gap analysis is essentially an expanded coarse-filter approach (Noss 1987) to biodiversity protection. The land cover types mapped in GAP serve directly as a coarse filter, the goal being to assure adequate representation of all native vegetation community types in biodiversity management areas. Landscapes with great vegetation diversity often are those with high edaphic (soil or substrate) variety or topographic relief. When elevational diversity is very great, a nearly complete spectrum of vegetation types known from a biological region may occur within a relatively small area. Such areas provide habitat for many species, including those that depend on multiple habitat types to meet life history needs (Diamond 1986,

Noss 1987). By using landscape-sized samples (Forman and Godron 1986) as an expanded coarse filter, gap analysis searches for and identifies biological regions where unprotected or underrepresented vegetation types and animal species occur.

More detailed analyses were not part of this project, but are areas of research that both PRGAP and GAP as a national program is pursuing. For example, a second filter could combine species distribution information to identify a set of areas in which all, or nearly all, mapped species are represented. There is a major difference between identifying the richest areas in a region (many of which are likely to be neighbors and share essentially the same list of species) and identifying areas in which all species are represented. The latter task is most efficiently accomplished by selecting areas whose species lists are most different or complementary. Areas with different environments tend to also have the most different species lists for a variety of taxa. As a result, a set of areas with complementary sets of species for one higher taxon (e.g., mammals) often will also do a good job representing most species of other higher taxa (e.g., trees, butterflies). Species with large home ranges, such as large carnivores, or species with very local distributions may require individual attention. Additional data layers can be used for a more holistic conservation evaluation. These include indicators of stress or risk (e.g., human population growth, road density, rate of habitat fragmentation, distribution of pollutants) and the locations of habitat corridors between wildlands that allow for natural movement of wide-ranging animals and the migration of species in response to climate change.

General Limitations

The following are general project limitations; specific limitations for the data are described in the respective sections:

1. The GAP data are derived from remote sensing and modeling to make general assessments about conservation status. Any decisions based on the data must be supported by ground-truthing and more detailed analyses.

2. The GAP is not a substitute for threatened and endangered species listing and recovery efforts. A primary argument in favor of gap analysis is that it is proactive: it seeks to recognize and manage sites of high biodiversity value for the long-term maintenance of populations of native species and communities before they become critically rare. Thus, it should help to reduce the rate at which species require listing as threatened or endangered. Those species that are already greatly imperiled, however, still require individual efforts to assure their recovery.

3. The GAP data products and assessments represent a snapshot in time generally representing the date of the satellite imagery. Updates are planned on a 5- to 10-year cycle, but users of the data must be aware of the static nature of the products.

4. The GAP is not a substitute for a thorough national biological inventory. As a response to rapid habitat loss, gap analysis provides a quick assessment of the distribution of vegetation and associated species before they are lost, and provides focus and direction for local, regional, and national efforts to maintain biodiversity. The process of improving knowledge in systematics, taxonomy, and species distributions is lengthy and expensive. That process must be continued and expedited, however, in order to provide the detailed information needed for a comprehensive assessment of our Nation's biodiversity. Vegetation and species distribution maps developed for GAP can be used to make such surveys more cost effective by stratifying sampling areas according to expected variation in biological attributes.

Study Area

A brief description of Puerto Rico—

The Caribbean has a number of large and small islands fostering endemic species and a tropical climate that promotes high species diversity. It is considered a global biodiversity hotspot (Myers et al. 2000). Puerto Rico, located at the junction of the Greater and Lesser Antilles in the Caribbean basin, is in the center of this region. The archipelago of the Commonwealth of Puerto Rico is made up of the main island of Puerto Rico (about 160 km long by 50 km wide), the islands of Culebra and Vieques to the east, the islands of Mona, Monito, and Desecheo to the west, and a number of smaller cays. Puerto Rico has 9000 km^2 of terrestrial land surface. The dominant physiographic features of the island include the Central Mountain Range running east-west, a region of karst hills in the northwest, and the Luquillo Mountains of the northeast. Fifty-three percent of the island is mountainous, 25 percent plains, 20 percent hills, 1 percent plateau, and 1 percent lakes and rivers (fig. 2). The topography of the island has a strong control on the climate, with the wetter regions on the windward, northern side of the mountains, and drier climate in the leeward rain shadow. Six life zones (sensu Holdridge 1967) have been described for Puerto Rico (fig. 3) including subtropical dry, lowland moist, subtropical wet, lower montane wet, subtropical rain, and lower montane rain forest zones (Ewel

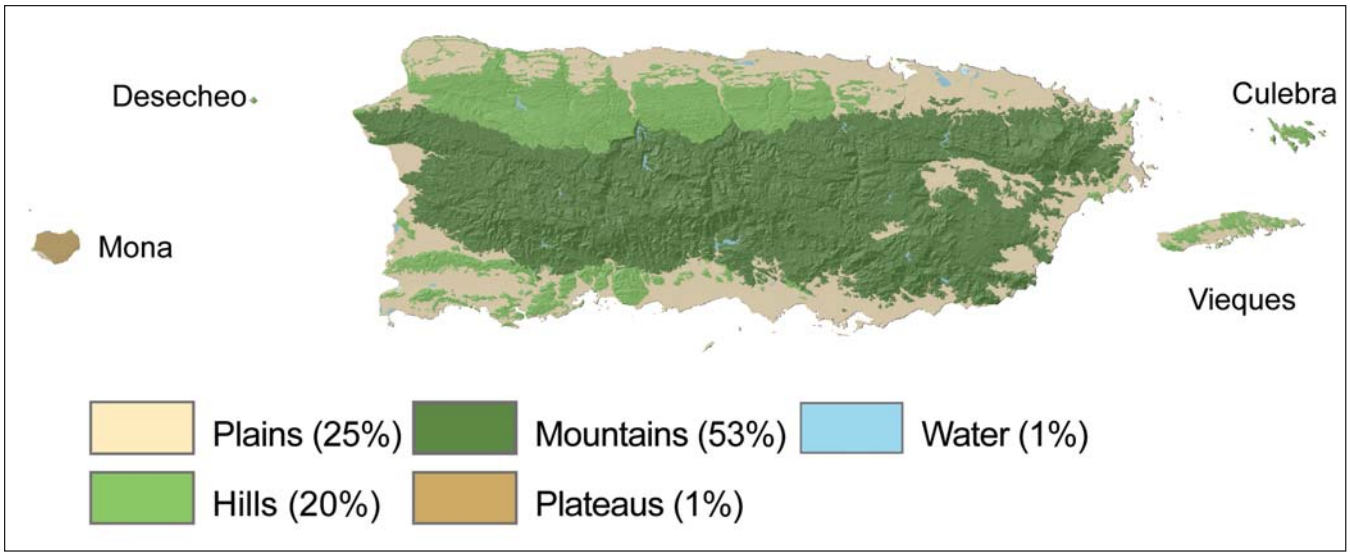


Figure 2—Physiography of Puerto Rico (Gould et al. 2008a).

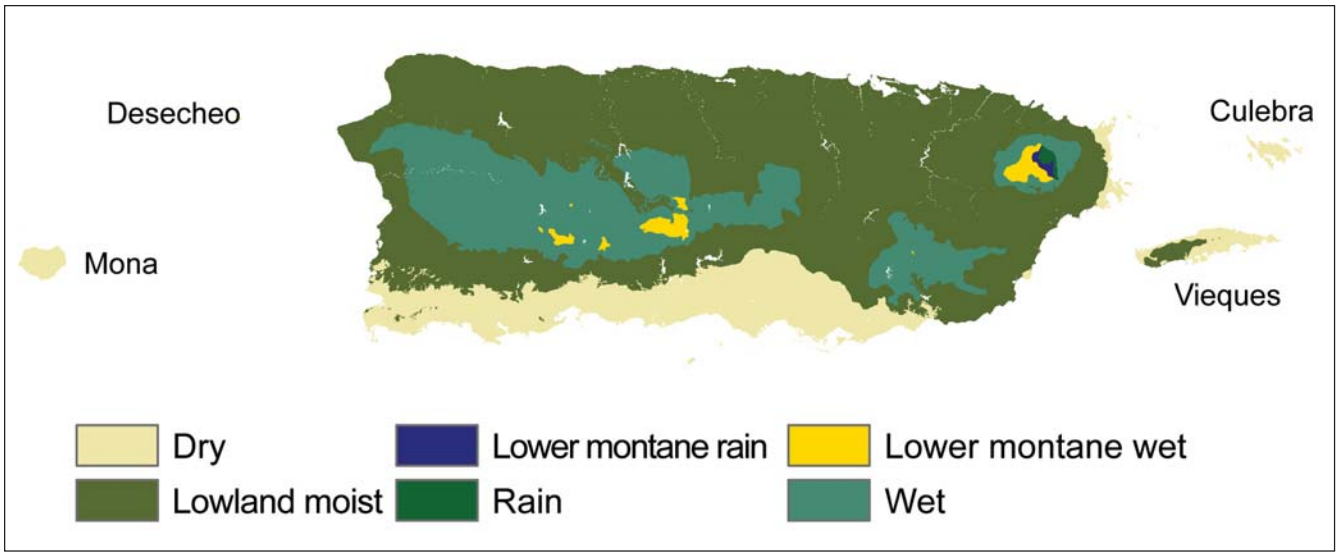


Figure 3—Subtropical life zones of Puerto Rico (modified from Ewel and Whitmore 1973).

and Whitmore 1973). Mean annual rainfall ranges from below 900 mm in the subtropical dry life zone to over 4000 mm in the subtropical wet rain forest. Mean annual temperatures exhibit a narrow range from 22 to 25 ºC with temperatures decreasing with elevation (Daly et al. 2003). Seasonality in rainfall is most pronounced in the subtropical dry life zone. Peak rainfall throughout the island is found in April and May and October to December (Daly et al. 2003).

Puerto Rico is experiencing rapid urban expansion, increasing population pressures, and dynamic land cover change (Aide and Grau 2004, Birdsey and Weaver 1982, Chinea 2002, Grau et al. 2003, Helmer 2004, Helmer et al. 2002, Lopez et al. 2001, Lugo and Helmer 2004, Martinuzzi et al. 2006, Rivera and Aide 1998). In the 19th century, most of Puerto Rico was deforested and converted to agricultural use, with 6 percent remaining forested and another 6 percent as shade coffee plantations (Franco et al. 1997). Toward the latter part of the 20th century, forested area increased in Puerto Rico to 35 to 42 percent, primarily through a transition from an agrarian to an industrialized society (Birdsey and Weaver 1987, Franco et al. 1997, Helmer et al. 2002). Agricultural abandonment and development continue to increase, and our mapping efforts indicate current woody vegetation cover of over 50 percent. Levels of development and urbanization include 11 percent developed land surface with a high level of urban sprawl (figs. 4 and 5), 16 percent urban-use area, and 36 percent densely populated rural or suburban area (fig. 6) (Martinuzzi et al. 2007a). This dynamic landscape, in which 4 million people live and in which conservation management decisions must be made, has parallels to temperate landscapes where urbanization encroaches on regenerated forests, and tropical landscapes where urbanization is beginning to outpace agricultural deforestation.

Puerto Rico has a range of forest types whose composition is controlled by four key elements: climatic gradients, substrate differences, topographic patterns, and human and natural disturbance (Britton and Wilson 1924, Dansereau 1966, Gould et al. 2006, Lugo 2005, Weaver 1991). Climatic gradients are related to an elevational rise from sea level up to 1340 m on the central cordillera of the island, the northeasterly trade winds, and the rain shadow effect of the mountains (fig. 7). The climatic control of dry, moist, and wet forest types in Puerto Rico represents the

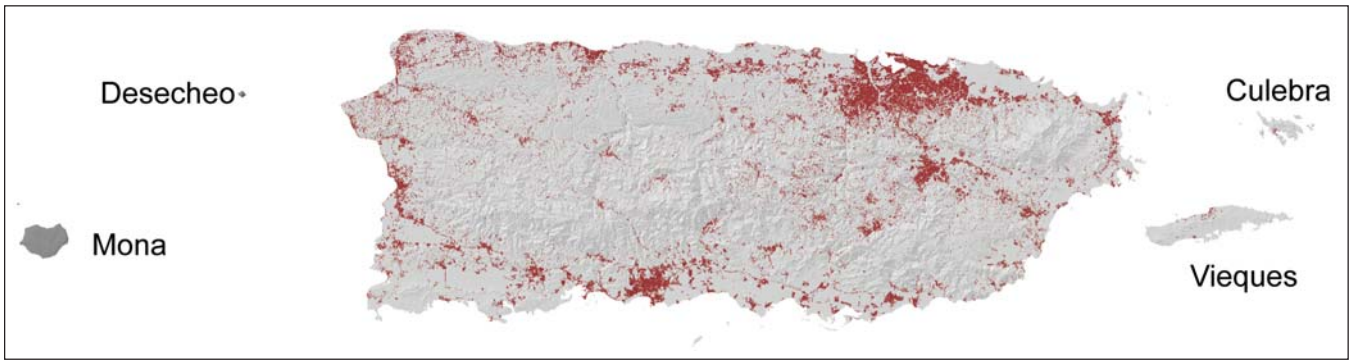


Figure 4—Developed or built-up areas of Puerto Rico (in red) include over 11 percent of the area (Martinuzzi et al. 2007a).

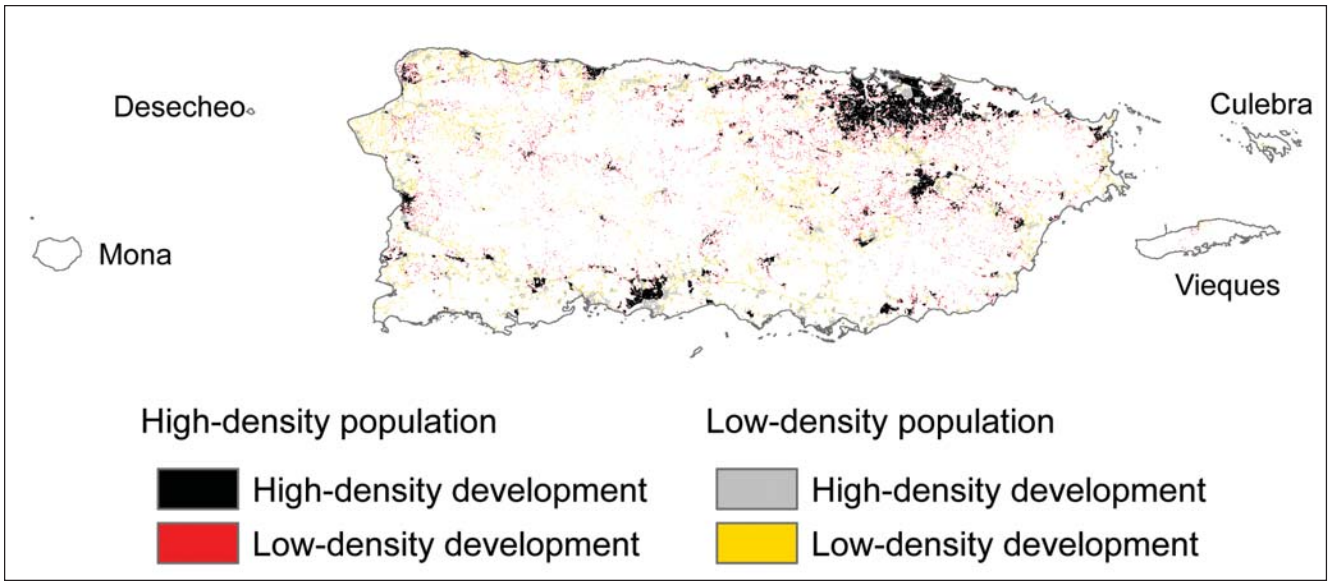


Figure 5—Developed or built-up areas of Puerto Rico in relative categories of high and low density of population as well as high and low density of developed area (Martinuzzi et al. 2007a).

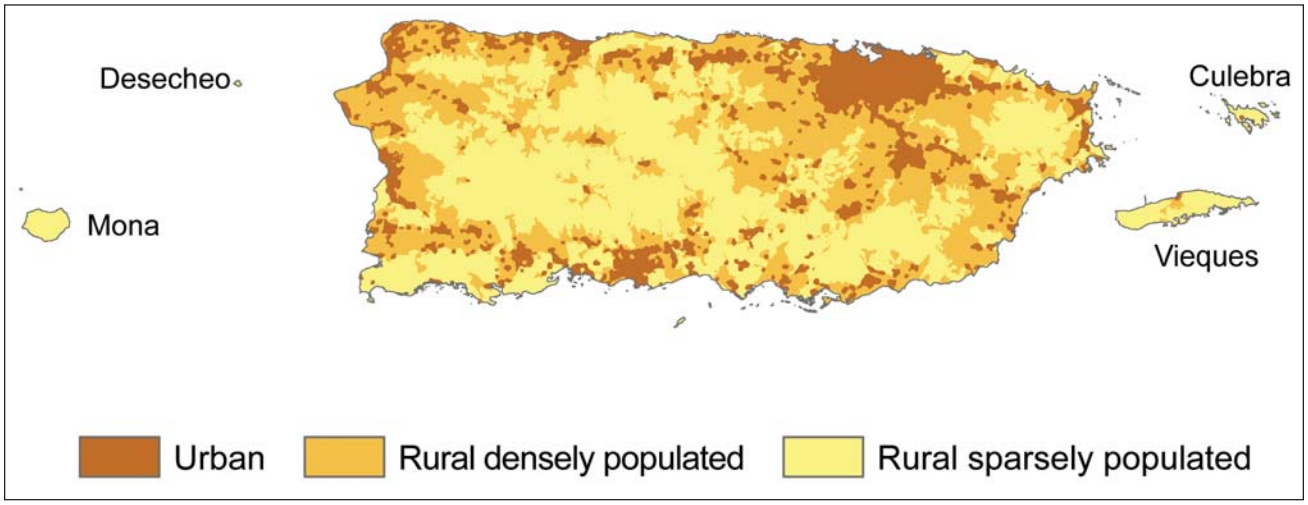


Figure 6—Urban and rural land use classes in Puerto Rico (Martinuzzi et al. 2007a).

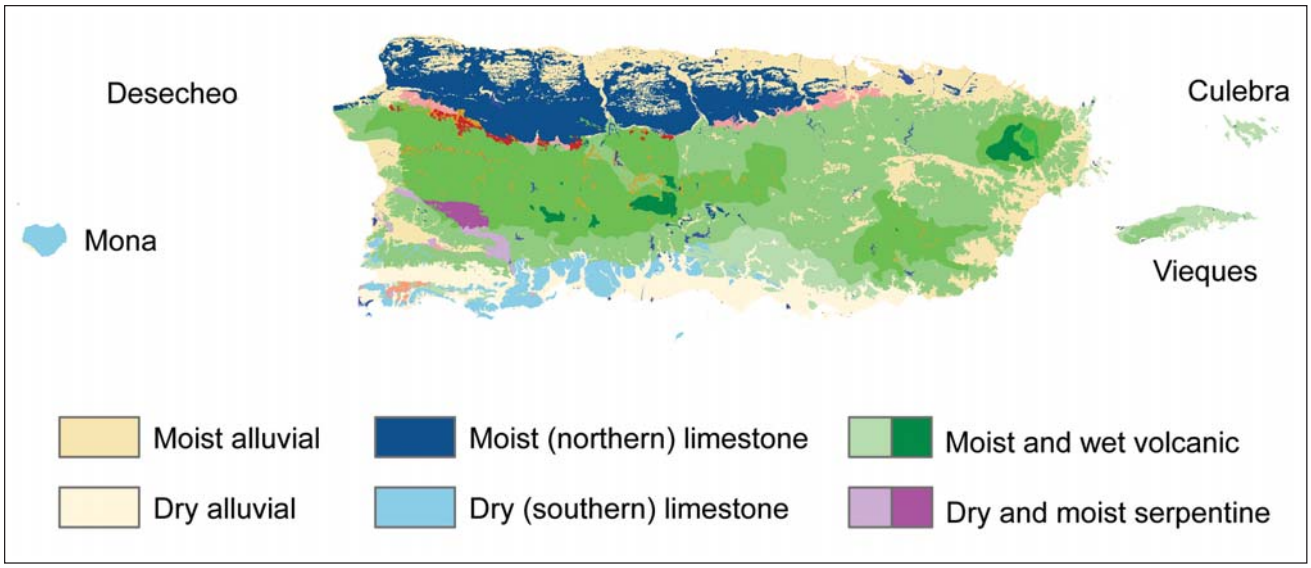


Figure 7—There are sixteen geoclimatic zones in Puerto Rico. The eight most extensive include the northern (moist) and southern quaternary deposits (primarily alluvial) and limestone areas, the moist and wet volcanic areas, and the moist and dry serpentine areas in the central mountains. Based on Holdridge life zones (Ewel and Whitmore 1973) and geologic terrain units (Bawiec 2001).

highest level of control on species composition and associated attributes such as diversity and productivity (Lugo 1988). Diverse geologic substrates include volcanic, limestone, and serpentine bedrock and colluvial, alluvial, and marine quaternary deposits (figs. 8 and 9). Eleven of the twelve U.S. Geological Survey (USGS) soil great groups are found in Puerto Rico (Mount and Lynn 2004). Within these broad landscape features, plant community composition is controlled by topographic effects on soil moisture and soil development (slope position) and by disturbance, including land use history, flooding, fire, landslides, and hurricanes, with each inducing unique effects and subsequent secondary succession.

The resulting landscape in Puerto Rico is a mosaic of (1) primary forests that have not experienced deforestation—according to Wadsworth (1951) and Birdsey and Weaver (1982), less than 1 percent of the landscape supported climax vegetation by 1950; (2) mature secondary forests (> 25 years old)—less than 20 percent of the island; (3) young secondary forests and shrublands (< 25 years old)—more than 30 percent of the island; (4) agriculture, grasslands, and active and abandoned pastures—over 30 percent; and (5) developed areas and urban forests—over 15 percent of the island. The mature secondary upland forests are primarily found in the upland forest reserves, which occupy about 4 percent of the island. These protected areas harbor our greatest wealth of native, endemic, and endangered plant species (Figueroa and Woodbury 1996). Lowland flooded forests occupy about 1 percent of the landscape and are typically protected as wetlands.

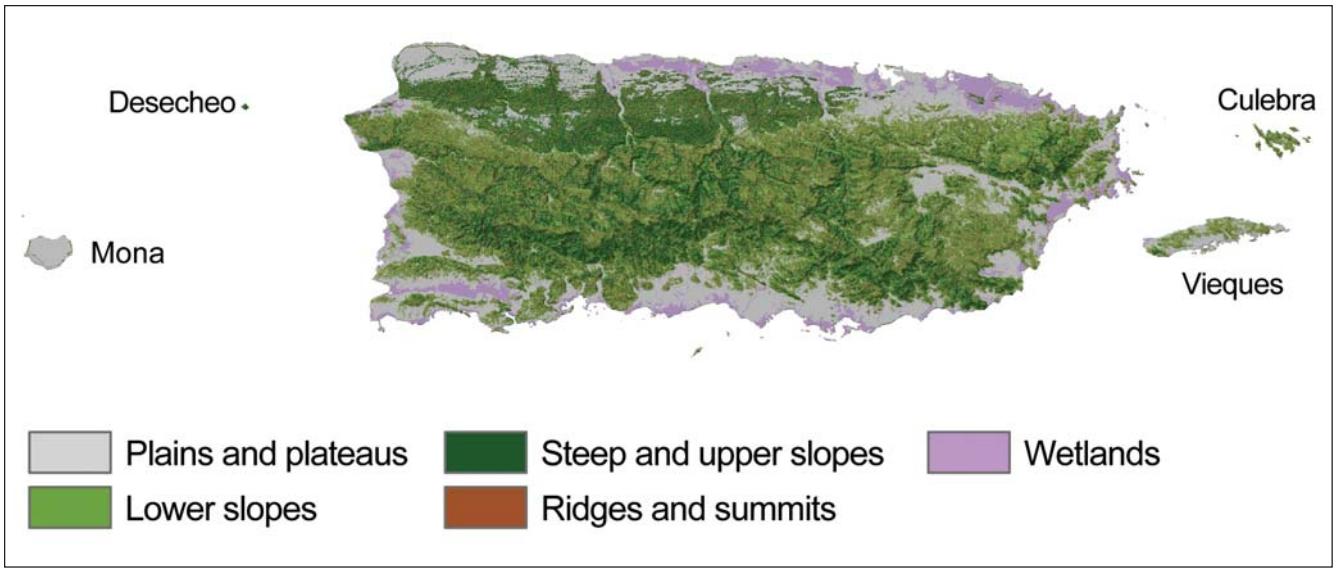


Figure 8—Topographic positions that are important controls on plant community composition (from Gould et al. 2008d and Martinuzzi et al. 2007b).

Mariano Solórzano

Bromeliads are a common component of the palm forests on the upper slopes of the Luquillo Mountains in Puerto Rico.

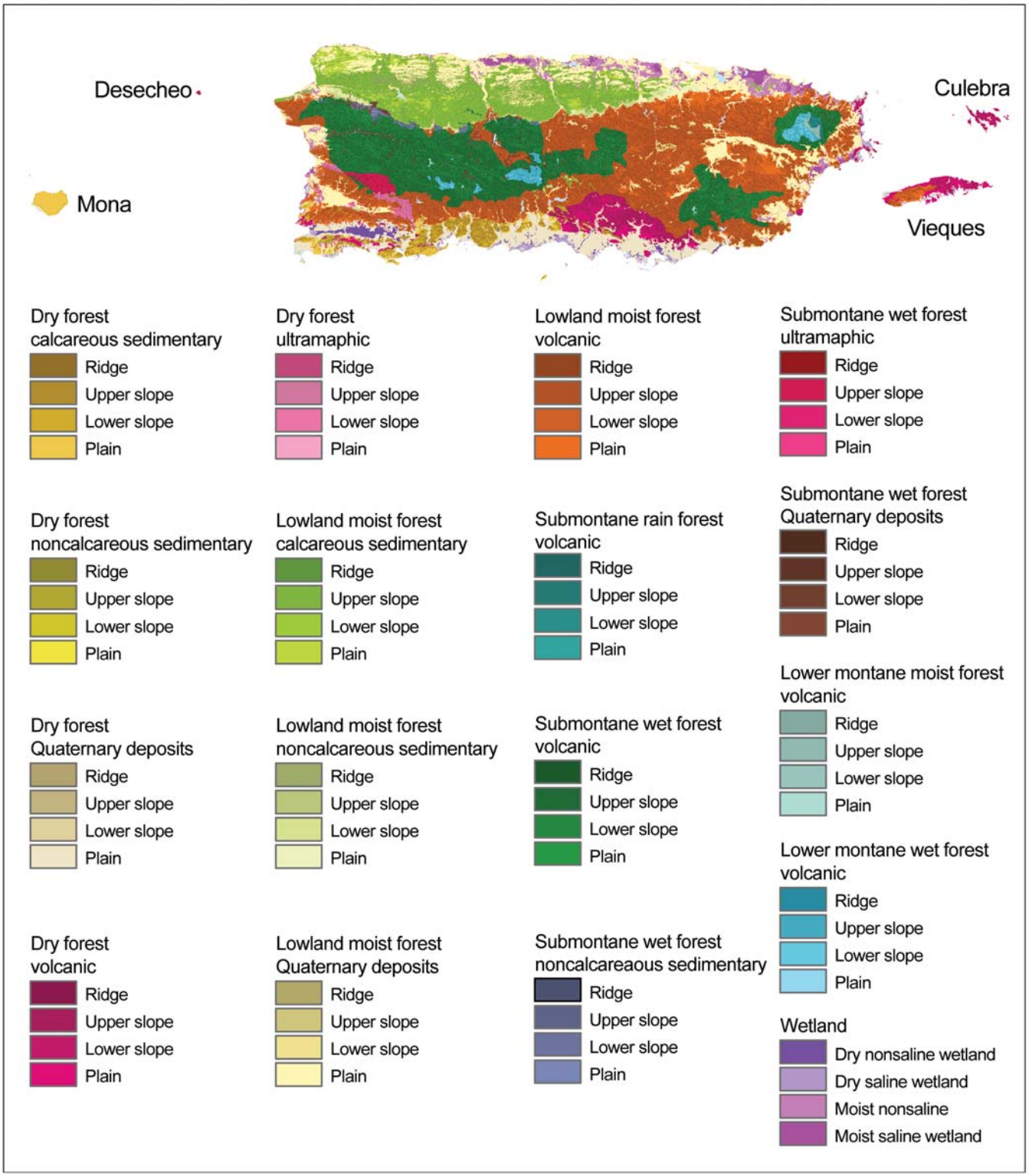


Figure 9—A classification of 69 landscape units of Puerto Rico using climate, substrate, and topography, the primary controls on natural vegetation cover (Gould et al. 2008c).

The fauna of Puerto Rico includes 436 species (app. 2). Three hundred twenty-eight are birds, 57 reptiles, 27 mammals, and 24 amphibians. Of these, 387 are terrestrial, 69 endemic, and 27 threatened or endangered. The birds include 43 introduced species with about 34 of these reproducing in the wild (Delannoy 2005) and 98 resident species, including 19 endemic species. The reptiles are important ecologically and serve as both prey and predator on a number of organisms and in most habitats on the islands. Joglar (2005) indicated that nearly one quarter of the native nonmarine reptiles are threatened or endangered with extinction. The majority of the terrestrial mammals, particularly all of the native species, are bats, which include 13 species in Puerto Rico (Gannon et al. 2005). The amphibians are important ecologically and culturally in Puerto Rico. The tree frogs, or coquís, are a national symbol as well as one of the most important nocturnal predators on the island because of their abundance. Puerto Rican amphibians have high species diversity but a low number of families and genera, a high degree of endemism, and a number of threatened and endangered species (Joglar 2005). The Puerto Rico GAP has analyzed 177 of the terrestrial vertebrates, including all of the resident, endangered, and endemic species. Excluded species can be incorporated in the future. These include migratory birds, and recently established exotics.

Land Cover Classification and Mapping

The GAP commits a high level of effort to mapping natural land cover. Generally, land cover mapping is done by adopting or developing a land cover classification system, delineating areas of relative homogeneity, then labeling these areas using categories defined by the classification system. More detailed attributes of the individual areas are added as more information becomes available, and a process of validating both spatial pattern and labels is applied for editing and revising the map. This is done in an iterative fashion, with the results from one step causing reevaluation of results from another step. Finally, an assessment of the overall accuracy of the data is conducted. The final assessment of accuracy will show where improvements should be made in future updates (Stoms 1994).

In its “coarse filter” approach to conservation biology (e.g., Jenkins 1985, Noss 1987), gap analysis relies on maps of dominant natural land cover types as the most fundamental spatial component of the analysis (Scott et al. 1993) for terrestrial environments. For the purposes of the GAP, most of the land surface of interest (natural) can be characterized by its dominant vegetation.

Vegetation patterns are an integrated reflection of the physical and chemical factors that shape the environment of a given land area (Whittaker 1965). They also are determinants for overall biological diversity patterns (Franklin 1993, Levin 1981, Noss 1990), and they can be used as a currency for habitat types in conservation evaluations (Austin 1991, Specht 1975). As such, dominant vegetation types need to be recognized over their entire ranges of distribution (Bourgeron et al. 1994) for beta-scale analysis (sensu Whittaker 1960, 1977). These patterns cannot be acceptably mapped from any single source of remotely sensed imagery. Reliance on ancillary data, previous maps, and field surveys is necessary. The central concept is that the physiognomic and floristic characteristics of vegetation across the land surface can be used to define biologically meaningful biogeographic patterns. There may be considerable variation in the floristics of subcanopy vegetation layers (community association) that are not resolved when mapping at the level of dominant canopy vegetation types (alliance), and there is a need to address this part of the diversity of nature. As information accumulates from field studies on patterns of variation in understory layers, it can be attributed to the mapped units of vegetation alliances.

Land cover classifications rely on specified attributes, such as the structural features of plants, their floristic composition, or environmental conditions, to consistently differentiate categories (Küchler and Zonneveld 1988). The criteria for a land cover classification system for GAP are:

- Ability to distinguish areas of different dominant vegetation.
- Utility for modeling animal species habitats.
- Suitability for use within and among biogeographic regions.
- Applicability to Landsat Enhanced Thematic Mapper plus (ETM+) imagery both for rendering a base map and to extract basic patterns (GAP relies on a wide array of information sources; ETM+ offers a convenient meso-scale base map in addition to being one source of actual land cover information).
- A framework that can interface with classification systems used by other organizations and nations to the greatest extent possible.
- Capability to fit, both categorically and spatially, with classifications of other themes such as agricultural and built environments.

For GAP in general, the system that fits best is referred to as the National Vegetation Classification System (NVCS) (FGDC 1997). The origin of this system was referred to as the UNESCO/TNC system (Lins and Kleckner 1996) because it

is based on the structural characteristics of vegetation derived by Mueller-Dombois and Ellenberg (1974), adopted by the United Nations Educational, Scientific, and Cultural Organization (UNESCO 1973) and later modified for application to the United States by Driscoll et al. (1983, 1984). The Nature Conservancy and the Natural Heritage Network (Grossman et al. 1994) have been using this system in recent years with partial funding supplied by GAP. The basic assumptions and definitions for this system have been described by Jennings (1993).

Classification of the PRGAP land cover follows a hierarchical structure separating vegetated from nonvegetated areas; forests, woodlands, and shrublands from grasslands; and differentiating the composition of these vegetated areas based on climate, substrate, topographic position, and age of forest types. These units are then related to described formations, alliances, and associations to the extent descriptions are available in the literature. We have been careful not to attribute names of alliances or associations where there is uncertainty in the source or reliability of these names, and the degree of floristic information derived from field studies. Alliance and association names are given only where there is supporting documentation of the composition of these syntaxa in the literature. Community descriptions with a full suite of species presence and abundance are not common for Puerto Rico, and the dynamic and diverse nature of the vegetation make these difficult to extrapolate. Alliance descriptions are more widely available, but primarily for the mature forest types. Information on the composition and variation in herbaceous vegetation (excepting Dansereau 1966) and young secondary forests has not been systematically done for the island.

Land Cover Classification Methods

The Puerto Rico Gap land cover mapping is based on two types of information: (1) spectral and spatial information from satellite imagery and (2) ancillary or additional data on the kinds of environmental factors that control vegetation composition, i.e., climate, substrate, topography, and disturbance. The spectral information was derived from Landsat 7 ETM+ imagery, and our initial task was to develop a cloud-free data set of this imagery (Martinuzzi et al. 2006). Clouds are a common feature of visible and infrared remotely sensed images collected from Puerto Rico, as from many other tropical, humid, and coastal regions of the world. Cloud-free data acquisition for a single date is extremely difficult for the entire island, particularly for higher elevations where a high percentage of the protected

forest resources are located. Up to now, the continued presence of clouds in imagery has forced researchers to conduct most projects only when low cloud cover images are available (years 1985, 1991, and 1992). We have developed simple semi-automated procedures to generate cloud and cloud-shadow masks in tropical regions for use in the creation of cloud-free composite Landsat 7 ETM+ imagery using multiple recent images acquired at different times over the same region. Our goals in developing these methods were to make use of spectral and geographic information to facilitate the identification of cloud cover, separate cloud and topographic shadows, and minimize the masked areas needed to eliminate these features from a scene. Ultimately, we developed mosaics of the four Landsat ETM+ path-rows that cover Puerto Rico, using the best imagery for each area.

In addition to the cloud and cloud-shadow masking method, we have incorporated processes for the creation of the final set of images. We sought to minimize differences in reflectance owing to atmospheric conditions by correcting for Rayleigh (atmospheric) scatter and differences in seasonality of vegetation by using, whenever possible, imagery acquired during the same season. We also improved our future ability to separate subpixel features (some urban or mangrove areas) by enhancing the spatial resolution, incorporating the higher (15-m^2) resolution of the panchromatic band of Landsat 7 ETM+.

Mapping standards and data sources—

Mapping was based on Landsat 7 ETM+ imagery acquired between 1999 and 2003, and pan sharpened to 15-m^2 resolution. Most of the imagery used was from 2001 and 2003. A 15-m^2 pixel resolution is the minimum mapping unit (MMU) of the PRGAP land cover. We developed a 96.5-percent cloud-free data set by compositing 18 images from four Landsat 7 ETM+ path-rows (4-47, 4-48, 5-47, and 5-48) (Martinuzzi et al. 2006). For our analysis, we developed individual mosaics of the area covered by each path-row using the best imagery for each area. We used IKONOS imagery from 2001 and 2002 to manually interpret the remaining cloud-covered areas.

Land cover map development—

Our land cover layer includes spectral information from 1999-2003 Landsat 7 ETM+ imagery corrected for atmospheric distortion, clouds, and cloud shadows, and pan-sharpened to a 15-m^2 resolution. Most of the imagery used was from the years 2001-2003. Pixel classification was performed on the four mosaics (northeast, northwest, southeast, and southwest Puerto Rico) by using ERDAS Imagine 8.7 (imagery processing software) unsupervised classification to distinguish the major

spectral classes. These were then mosaicked and stratified by information on the primary factors controlling vegetation composition: i.e., climate, substrate, topography, and disturbance. Additionally, we incorporated information from site visits, visual interpretation of aerial photography and IKONOS (Earth observation satellite) imagery, and comparison of classification results with published information on vegetation for known sites. Image stratification was based on information that allowed us to delimit sharp ecological boundaries with strong controls on vegetation composition, including geologic substrates (Bawiec 2001), and wetland classes. Wetlands were delimited as forested or nonforested, seasonally or permanently flooded, and saline or nonsaline by interpretation of the National Wetland Inventory (NWI) digital database (USFWS 2005). Climatic boundaries include a combination of the Holdridge life zones (Ewel and Whitmore 1973) and modeling using aspect, which is related to rainfall and soil moisture patterns. We developed a landforms model to delimit ridge, slope, valley, plains, and depressions in Puerto Rico and used that to identify topographic positions and related variation in vegetation composition (Gould et al. 2006, Martinuzzi et al. 2007b). We also assessed information from previous vegetation mapping efforts (Cintrón 1991, Helmer et al. 2002, Ramos-González 2001, Ramos-González and Lugo 1994) as an aid in interpreting classes. Our forest age class was determined by comparing our forested areas with those considered forest or nonforest in the 1997 island-wide vegetation map (Ramos-González and Lugo 1994). Areas considered pasture in 1997 and forest in our mapping are designated as young (< 25-year-old) forests. Mona Island, an uninhabited natural reserve, was mapped using different methods than the other islands. We first stratified the island into its primary central limestone plateau and a small area of coastal plain. Within these areas we used the variation in spectral signal from recent Landsat imagery (15-m^2 resolution), variation in the normalized difference of vegetation index (NDVI) (Goward et al. 1985), previous mapping efforts (Cintrón 1991), and an ongoing effort to map the forested sinkholes in the central plateau to develop a map of the island. Finally, we used IKONOS image interpretation to refine the delimitation of small features including mangrove and *Pterocarpus* swamps, agricultural lands such as row crops and palm plantations, barrens, and some riparian vegetation.

Land Cover Classification Results

The PRGAP land cover of Puerto Rico includes 70 land cover units (table 1, app. 3 and 4). Puerto Rico, Vieques, Culebra, Mona, and the smaller islands have a terrestrial extent (including lakes, rivers, and saline lagoons) of 8949 km^2.

Table 1—The Puerto Rico Gap Analysis Project land cover classes and their area and percentage of Puerto Rico's total area

Land cover classes	Area	
	Hectares	*Percent*
Puerto Rico terrestrial extent	894 913	100.0
Forest, woodland, and shrubland	471 866	52.7
Forest	353 892	39.6
Mature forest	177 036	19.8
Young secondary forest	176 856	19.8
Woodland and shrubland	117 974	13.2
Dry	67 523	7.6
Dry forest	35 407	4.0
Mature dry forest	22 918	2.6
Young secondary forest	12 489	1.4
Woodland and shrubland	32 117	3.6
Alluvial deposits	10 130	1.1
Mature secondary lowland dry alluvial semideciduous forest	1548	0.2
Young secondary lowland dry alluvial semideciduous forest	2881	0.3
Lowland dry alluvial shrubland and woodland	4472	0.5
Lowland dry riparian forest	806	0.1
Lowland dry riparian shrubland and woodland	423	0.1
Calcareous substrates	28 741	3.2
Mature secondary lowland dry limestone evergreen forest	982	0.1
Mature secondary lowland dry limestone semideciduous forest	10 669	1.2
Young secondary lowland dry limestone semideciduous forest	3922	0.4
Lowland dry limestone woodland and shrubland	8181	0.9
Lowland dry limestone shrubland	4694	0.52
Lowland dry cactus shrubland	47	< 0.1
Coastal dwarf woodland and shrubland	103	< 0.1
Lowland dry limestone cliffside semideciduous forest	12	< 0.1
Lowland dry limestone cliffside shrubland and woodland	49	< 0.1
Abandoned dry forest plantation	81	< 0.1
Noncalcareous substrates	24 013	2.7
Mature secondary lowland dry noncalcareous semideciduous forest	7062	0.8
Young secondary lowland dry noncalcareous semideciduous forest	3645	0.4
Lowland dry noncalcareous shrubland and woodland	13 306	1.5
Ultramafic serpentine substrates	4640	0.5
Mature secondary dry and moist serpentine semideciduous forest	1839	0.2
Young secondary dry and moist serpentine semideciduous forest	1960	0.2
Dry and moist serpentine woodland and shrubland	841	0.1
Moist	236 768	26.5
Moist forest	176 258	19.7
Mature moist forest	90 041	10.1
Young secondary moist forest	86 217	9.6
Moist woodland and shrubland	60 510	6.8

Table 1—The Puerto Rico Gap Analysis Project land cover classes and their area and percentage of Puerto Rico's total area (continued)

Land cover classes	Area	
	Hectares	*Percent*
Alluvial deposits	15 497	1.7
Mature secondary lowland moist alluvial evergreen forest	2256	0.3
Young secondary lowland moist alluvial evergreen forest	6675	0.8
Lowland moist alluvium shrubland and woodland	5141	0.6
Lowland moist riparian forest	916	0.1
Lowland moist riparian shrubland and woodland	508	0.1
Calcareous substrates	72 255	8.1
Mature secondary moist limestone evergreen and semideciduous forest	46 423	5.2
Young secondary moist limestone evergreen and semideciduous forest	15 492	1.7
Moist limestone shrubland and woodland	10 338	1.2
Noncalcareous substrates	149 017	16.7
Mature secondary lowland moist noncalcareous evergreen forest	40 446	4.5
Young secondary lowland moist noncalcareous evergreen forest	52 981	6.0
Lowland moist noncalcareous shrubland and woodland	44 523	5.0
Lowland moist abandoned and active coffee plantations	11 068	1.2
Wet	158 614	17.7
Wet forest	133 266	14.9
Mature wet forest	55 116	6.2
Young secondary wet forest	78 150	8.7
Wet woodland and shrubland	25 348	2.8
Alluvial deposits	2501	0.3
Mature secondary montane wet alluvial evergreen forest	613	0.1
Young secondary montane wet alluvial evergreen forest	988	0.1
Montane wet alluvial shrubland and woodland	900	0.1
Noncalcareous substrates	151 724	17.0
Mature secondary montane wet noncalcareous evergreen forest	25 207	2.8
Montane wet evergreen abandoned and active coffee plantation	54 859	6.1
Mature primary and secondary montane wet noncalcareous evergreen tabonuco forest	8715	1.0
Mature primary and secondary montane wet noncalcareous evergreen palo colorado cloud forest	3712	0.4
Mature primary and secondary montane wet noncalcareous evergreen sierra palm forest	11 953	1.3
Mature primary and secondary montane wet noncalcareous evergreen elfin woodland cloud forest	1537	0.2
Young secondary montane wet noncalcareous evergreen forest	21 651	2.4
Montane wet evergreen noncalcareous shrubland and woodland	24 090	2.7
Ultramafic serpentine substrates	4389	0.5
Mature secondary montane wet serpentine evergreen forest	3379	0.4
Young secondary montane wet serpentine evergreen forest	651	0.1
Wet serpentine shrubland and woodland	358	< 0.1
Flooded forests	8960	1.0
Mangrove forest and shrubland	8700	1.0
Freshwater *Pterocarpus* swamp	261	< 0.1

Table 1—The Puerto Rico Gap Analysis Project land cover classes and their area and percentage of Puerto Rico's total area (continued)

Land cover classes	Area	
	Hectares	*Percent*
Grasslands	286 407	32.0
Dry	42 389	4.7
Dry grasslands and pastures	42 176	4.7
Dry cactus grassland and shrubland	213	< 0.1
Moist	218 945	24.5
Moist grasslands and pastures	218 945	24.5
Wet	23 090	2.6
Seasonally flooded herbaceous nonsaline wetlands	18 225	2.0
Seasonally flooded herbaceous saline wetlands	4865	0.6
Flooded	1984	0.2
Emergent herbaceous nonsaline wetlands	1102	0.1
Emergent herbaceous saline wetlands	882	0.1
Agriculture	26 257	2.9
Hay and row crops	25 764	2.9
Woody agriculture and plantations	492	0.1
Natural barrens	3576	0.4
Rocky cliffs and shelves	397	< 0.1
Gravel beaches and stony shoreline	82	< 0.1
Fine to coarse sandy beaches, mixed sand and gravel beaches	1155	0.1
Riparian and other natural barrens	449	0.1
Salt and mudflats	1493	0.2
Artificial barrens	8694	1.0
Artificial barrens	8674	1.0
Salt production	20	< 0.1
Developed areas	89 573	10.0
High-density urban development	52 335	5.9
Low-density urban development	37 237	4.2
Water	8540	1.0
Freshwater	4434	0.5
Saline water	4005	0.5
Aquaculture	101	< 0.1

Forest, woodland, and shrubland—

Fifty-three percent (4719 km^2) of Puerto Rico is covered predominantly by woody vegetation, and 49 land cover units are described as dominated by woody vegetation. Of these, low- and mid-elevation moist woody vegetation covers 27 percent (2368 km^2), upper elevation wet woody vegetation covers 18 percent (1586 km^2), dry woody vegetation covers 8 percent (675 km^2), and flooded mangrove and *Pterocarpus* forests cover 1 percent (90 km^2) of the islands. We have classified 40 percent (3539 km^2) of the woody vegetation as forest (> 60 percent tree cover), and

13 percent (1180 km^2) as woodland (< 60 percent tree cover) or shrubland (> 25 percent cover small trees or shrubs). Mature (> 25-year-old) and young secondary (< 25-year-old) forests each cover 20 percent of the islands. Dry, moist, wet, and flooded forests cover 4 percent, 20 percent, 15 percent, and 1 percent of the islands, respectively. Mature dry, moist, wet, and flooded forests cover 3 percent, 10 percent, 6 percent, and 1 percent of the islands, respectively. The most abundant forest types are the montane wet evergreen secondary forest, including active and abandoned coffee plantations, and young secondary lowland moist forest on noncalcareous substrates. These each cover 6 percent of the islands (549 km^2 and 530 km^2, respectively).

Grassland—

Thirty-five percent (3127 km^2) of Puerto Rico has been classified as grassland (32 percent) or herbaceous agriculture (3 percent). Dry, moist, wet, and flooded grasslands make up 5 percent, 25 percent, 3 percent, and less than 1 percent, respectively, of the area. Nearly all of the moist and dry grasslands are maintained by disturbance. They may have continuous or intermittent cattle grazing and may burn frequently, particularly the dry grasslands. Natural barrens make up less than 1 percent of the area. These are a small but important component of the landscape, both for human use and as wildlife habitat. Natural barrens include the stony and sandy beaches, rocky cliffs and shelves, active riparian flood plains, and salt- and mudflats.

Wetlands—

Coastal wetlands cover 4 percent of the island (340 km^2). Forty-two percent of these are saline wetlands and 58 percent freshwater wetlands. Seventy-four percent of the wetlands are dominated by herbaceous vegetation (251 km^2), and 92 percent of these (230 km^2) are seasonally flooded. Of the herbaceous wetlands, 77 percent are nonsaline (193 km^2) and 23 percent are saline (58 km^2). Forested coastal wetlands cover 1 percent of the island; 67 km^2 are mangroves and 3 km^2 are freshwater *Pterocarpus* swamps. About 1 percent of the area has been classified as either fresh or saline water.

Developed areas—

We classified 11 percent (983 km^2) of Puerto Rico as developed (10 percent) or artificially barren (1 percent). This is a very dynamic component of the landscape and has likely increased since the imagery for mapping was acquired. Development does not occur equally around the region and is concentrated in the coastal plain and lower hills (Martinuzzi et al. 2007a, Pares et al. in press).

Land Cover Classification Accuracy Assessment

The purpose of accuracy assessment is to allow a potential user to determine the map's "fitness for use" for their application. It is impossible for the original cartographer to anticipate all future applications of a land cover map, so the assessment should provide enough information for the user to evaluate fitness for their unique purpose. This can be described as the degree to which the data quality characteristics collectively suit an intended application. The information reported includes details on the database's spatial, thematic, and temporal characteristics and their accuracy.

Assessment data are valuable for purposes beyond their immediate application to estimating accuracy of a land cover map. The reference data are therefore made available to other agencies and organizations for use in their own land cover characterization and map accuracy assessments (see "Data Availability" for access information). The data set will also serve as an important training data source for later updates.

Even though we have reached an endpoint in the mapping process where products are made available to others, the gap analysis process should be considered dynamic. We envision that maps will be refined and updated on a regular schedule. The assessment data will be used to refine GAP maps iteratively by identifying where the land cover map is inaccurate and where more effort is required to bring the maps up to accuracy standards. In addition, the field sampling may identify new classes that were not identified at all during the initial mapping process.

Methods—

We used island-wide 1-m^2-resolution color IKONOS imagery from 2001-2002, including Vieques, Culebra, Mona, and the smaller cays to evaluate the thematic accuracy of the 2003 land cover map of Puerto Rico and the surrounding islands, derived from 18 Landsat 7 ETM+ scenes collected from 1999 to 2003.

A feasibility appraisal was conducted prior to the accuracy assessment, which concluded that the accuracy assessment should be conducted on the six original classes obtained through the unsupervised classification. The final 70 PRGAP land cover units were created through modeling of the original classes in combination with geological, climatological, and other auxiliary data. Therefore, the 70-unit classification was simplified to six classes. The six classes were chosen as they represented the main classes originally separated spectrally through the 18 Landsat 7 ETM+ scenes prior to the extensive modeling process. Furthermore, the recoded

six land cover classes simplified the accuracy assessment process and helped to reduce image interpretation errors when using the reference IKONOS imagery (table 2).

The use of alternative methods for the accuracy assessment of GAP land cover products has previously been recommended by the GAP where the collection of ground data has been considered impractical. Lin and Laporte (2003) assessed IKONOS and aerial videography for use in accuracy assessment, and the National Aeronautics and Space Administration (NASA) aerial photos have been found suitable for the accuracy assessment where large study areas and staff resources made reliance on field data impractical (Helmer et al. 2002, Zhu et al. 2000).

A remote-sensing specialist, GIS specialist, and a research ecologist with an indepth knowledge of the vegetation of Puerto Rico were available for image interpretation of the IKONOS imagery, helping to reduce inaccuracy. Additionally, tone, shape, size, pattern, texture, shadow, and association as well as true- and false-color composites were all used as criteria for visual interpretation. Image interpretation training using the IKONOS imagery included creating small reference subsets of each class that could be used as a base for image interpretation.

Sample size—

Prior to conducting the accuracy assessment, we determined the minimum number of sample points required so that our calculated classification accuracy would have an allowable error of 5 percent at the 95-percent confidence interval. An assumed error range was used to calculate the minimum number of samples required to achieve the specified allowable error. For this calculation, we assumed that the overall accuracy of the land cover map was between 70 and 85 percent. The number of sample points was calculated using the following equation based on binomial probability theory (Fitzpatrick-Lins 1981):

$$N = \frac{Z^2 pq}{E^2}$$

Where

N = number of samples

p = expected or calculated accuracy (percent)

$q = 100 - p$

E = allowable error

Z = standard normal deviate for the 95-percent two-tail confidence level (1.96).

Table 2–Absolute and relative areas of the Puerto Rico Gap Analysis Project land cover classes

Land cover	Area	
	Hectares	*Percent*
Forest (except mangrove)	345 132.0	39
Woodland and shrubland	117 974.4	13
Mangrove	8 699.5	1
Grassland, pasture, agriculture	312 663.9	35
Urban and barren	101 844.5	11
Water	8 540.3	1
Total	894 913.0	100

For the lowest expected map accuracy of 70 percent with an allowable error of 5 percent, 323 sample points were required, whereas for a map accuracy of 85 percent with an allowable error of 5 percent, 196 sample points were required (table 3).

We then decided to use the lowest expected land cover map accuracy (70 percent) in determining the minimum number of sample points (~ 323) for the accuracy assessments. A stratified random sampling technique was considered the most appropriate for the land cover accuracy assessment. Table 4 identifies the allocation of the sample points to the different land cover categories. However, some classes were not appointed an adequate number of sample points because the area covered by some of the smaller land cover classes is negligible compared to the rest of the classes. Therefore, the minimum sample size was set to 20 for these classes (Maingi et al. 2002, van Genderen and Lock 1977), therefore increasing our total number of sample points from 323 to 358.

Three hundred and fifty-eight sample points were randomly allocated to the PRGAP land cover classes as shown above. To avoid bias, image interpreters did not know what classifications had been assigned to the sample points in the PRGAP land cover. The corresponding reference sample points were then analyzed in the IKONOS imagery and allocated to one of the six classes. Some of the sample points fell in areas of cloud cover within the reference IKONOS imagery; these points were removed and new reference points were selected through stratified sampling until the allocated sample number for each class was attained. An ERDAS imagine 9.0 was used to generate an error matrix, accuracy totals, and kappa statistics.

Table 3—Minimum number of sample points (N_1) required to achieve an allowable error of 5 percent (E_1) at the 95-percent confidence interval

N_1	*p*	*q*
323	70	30
288	75	25
246	80	20
196	85	15

Note: Z = 1.96 (standard normal deviate for the 95-percent two-tailed confidence interval), *p* = expected percentage accurracy, q = 100 - *p* , E_1^2 = 25 (square of allowable error).

Table 4—Minimum number of sample points per land cover class stratified by area

Land cover	Area		Estimated number of samples	Final number of samples
	Hectares	*Percent*		
Forest (except mangrove)	345 132	39	125	125
Woodland and shrubland	117 974	13	43	43
Mangrove	8 700	1	3	20
Grassland, pasture, agriculture	312 664	35	113	113
Urban and barren	101 845	11	37	37
Water	8 540	1	3	20
Total	894 913	100	323	358

Land cover accuracy assessment results—

The results of the IKONOS-based 2003 PRGAP land cover accuracy assessment (tables 5 and 6) show an overall accuracy of 84.92 percent and a kappa value of 0.8, which indicates substantial agreement (Landis and Koch 1977). However, there is significant variability in the producer's and user's accuracy. The producer's accuracy (PA) relates to the probability that a reference sample (IKONOS-interpreted land cover class) will be correctly mapped and measures the errors of omission, whereas the user's accuracy (UA) indicates the probability that a sample from the land cover map matches the reference data and measures the error of commission. The producer's accuracy ranges from 52.54 percent to 100 percent and the user's accuracy ranges from 72.09 percent to 95 percent (table 6). Overall, accuracy

Table 5—Error matrix of IKONOS-based accuracy assessment of the Puerto Rico Gap Analysis Project major land cover classes

Land cover class	Error matrix						Total number of pixels
	(1)	(2)	(3)	(4)	(5)	(6)	
(1) Forest (except mangrove)	**108**	9	0	6	2	0	**125**
(2) Woodland and shrubland	8	**31**	0	3	1	0	**43**
(3) Mangrove	0	0	**19**	0	0	1	**20**
(4) Grassland, pasture, agriculture	2	16	0	**93**	2	0	**113**
(5) Urban and barren	0	2	0	1	**34**	0	**37**
(6) Water	0	1	0	0	0	**19**	**20**
Total	118	59	19	103	39	20	358

Note: The reference data are from IKONOS 2001–2002 imagery. The number of correctly identified pixels are in the diagonal portion of the matrix and misidentified pixels are in the row or column of the land cover type in which they occur in the IKONOS imagery.

Table 6—Accuracy of land cover classifications of the Puerto Rico Gap Analysis Project

Land cover class	RT	CT	NC	PA	UA	Kappa
				– – – Percent – – –		
Forest (except mangrove)	118	125	108	91.53	86.40	0.7971
Woodland and shrubland	59	43	31	52.54	72.09	0.6659
Mangrove	19	20	19	100.00	95.00	0.9472
Grassland, pasture, agriculture	103	113	93	90.29	82.30	0.7515
Urban and barren	39	37	34	87.18	91.89	0.9090
Water	20	20	19	95.00	95.00	0.9470
Total	358	358	304			
Overall Kappa statistics (KHAT value)						0.8007
Overall accuracy (percent)						84.92

Note: RT = reference pixels, CT = classified pixels, NC = number pixels correctly classified, PA = producer's accuracy (samples correctly mapped), US = user's accuracy (mapped point matches data).

assessment for five of the six recoded classes tended to fall in a similar range: from 87 percent to 100 percent for the producer's accuracy and from 82 percent to 95 percent for the user's accuracy. However, for the open forest and shrubland class, the PA fell to 52 percent and the UA to 72, indicating a degree of misclassification. With any land cover classification produced from satellite imagery, misclassification often results from subpixel spatial variability and spatial and spectral resolution limitations.

Puerto Rico provides a diverse, dynamic, fragmented, and significantly heterogeneous landscape for land cover classification. Even with spatial resolution enhancement of the Landsat 7 ETM+ reflectance bands from 30 m^2 to 15 m^2, features at the subpixel level and mixed pixelsy—e.g., confusion between urban, barren and sands, or water and closed forest—provided a significant problem.

Another issue that influenced land cover accuracy results is the misregistration between the imagery used to create land cover classification and the reference data used in the accuracy assessment. This is especially predominant when land cover accuracy assessments are completed by using aerial photography, videography, or, as in this case, other satellite imagery. The PRGAP land cover used 18 Landsat 7 ETM+ images, which were mosaicked to create an island-wide cloud-free composite. The mosaic was then segmented into six geoclimatic zones to reduce spectral variability and assist classification. With different preprocessing steps taken in both the Landsat 7 ETM+ imagery set and the IKONOS imagery, juxtaposed with variation in spatial and spectral characteristics of each data set, perfect registration between the imagery was complex; therefore, some of the error in the accuracy could be due to misregistration rather than misclassification.

Even though the six recoded PRGAP land cover units provided a significant aid to image interpretation when using IKONOS imagery as a reference for the accuracy assessment, it is still possible that some error is due to the inability to confidently image-interpret a sample unit. This is particularly true in Puerto Rico, where there are gradients between shrubland and forest that are difficult to distinguish.

Land Cover Classification Limitations

The land cover of Puerto Rico is a matrix of very stable and very dynamic elements in terms of species composition. The dynamic nature is due to both human use and land cover change, the ability of woody vegetation to quickly replace abandoned pastures, and dynamism related to natural disturbance, particularly hurricanes and fire. Stable elements include those that were unsuitable for agriculture and adapted to the regime of natural disturbances. These include the coastal mangroves, extremely wet cloud forest vegetation, and extremely dry vegetation on rocky coastal areas. Vegetation description in Puerto Rico has a long history and much detail for some parts of the island, particularly the Luquillo Mountains. Other, more disturbed areas are less well described, and in general, description at the plant community level, including all woody and herbaceous species present, is limited. Little classification other than Dansereau (1966) attempted detailed plant community description for the herbaceous communities on the island. The current

land cover and classification represents the land cover at the time of image acquisition (2003) and is an attempt to link these units with available published descriptions to the finest scale at which they are available.

Predicted Vertebrate Distributions and Species Richness

All species range maps are predictions about the occurrence of those species within a particular area (Csuti 1994). Traditionally, the predicted occurrences of most species begin with samples from collections made at individual point locations. Most species range maps are small scale (e.g., >1:10,000,000) and derived primarily from point data to construct field guides. These are suitable, at best, for approximating distribution at the regional level or counties. The purpose of the GAP vertebrate species maps is to provide more precise information about the current predicted distribution of individual native species according to actual habitat characteristics within their general ranges and to allow calculation of predicted area of distributions and associations to specific habitat characteristics.

The GAP maps are produced at a nominal scale of 1:100,000 or better and are intended for applications at the landscape or "gamma" scale (heterogeneous areas generally covering 1000 to 1 million hectares and made up of more than one kind of natural community). Applications of these data to site- or stand-level analyses (site—a microhabitat, generally 10 to 100 m^2; stand—a single habitat type, generally 0.1 to 1000 ha) (Whittaker 1977, see also Stoms and Estes 1993) will likely reveal the limitations of using this process to incorporate differences in habitat quality (e.g., understory condition) or necessary microhabitat features such as standing dead trees.

Gap analysis uses the predicted distributions of animal species to evaluate their conservation status relative to existing land management (Scott et al. 1993). However, the maps of species distributions may be used to answer a wide variety of management, planning, and research questions relating to individual species or groups of species. In addition to the maps, great utility may be found in the consolidated specimen collection records and literature that are assembled into databases used to produce the maps. Perhaps most importantly, as a first effort in developing such detailed distributions, they should be viewed as testable hypotheses to be confirmed or refuted in the field. We encourage biologists and naturalists to conduct such tests and report their findings in the appropriate literature and to the GAP such that new data may improve future iterations.

Before this effort, there were no maps available, digital or otherwise, showing the likely present-day distribution of species by habitat type across their ranges. Because of this, ordinary species (i.e., those not threatened with extinction nor managed as game animals) are generally not given sufficient consideration in land use decisions in the context of large geographic regions or in relation to their actual habitats. Their decline, because of incremental habitat loss, results in one threatened or endangered species "surprise" after another. Frequently, the occurrence records that exist for species with a wide range are artificially truncated by state or other politically-based boundaries. As a result, creating a consistent spatial framework for storing, retrieving, manipulating, analyzing, and updating our knowledge about the status of a given animal species is one of the most necessary and basic elements for preventing further erosion of our biological resources.

Although there is a wealth of ecological and natural history information for Puerto Rico, it is not available in a centralized location of consistent quality or format. A great deal of the PRGAP effort was in compiling this information to develop species occurrence, range, and predicted distribution databases and maps. We created a relational database for the PRGAP to manage data on species occurrences, species habitat information, and literature citations (see volume 2). Each animal species represented in the PRGAP relational database is associated with a unique identifier (PRGAPSppID) that is used to link (relate) the species to records on its occurrence, habitat preferences, and conservation status, which are stored in multiple tables contained in the database. The objective is to identify, through documented sources or expert opinion, those physiographic and biological elements with which a species is associated. Predicting species geographic distributions requires building a database that identifies all the major physiographic and biological elements considered to influence the occurrence of a species across its range. Published books, scientific papers, and reports about the ecology and life history of individual species or groups of species are the primary sources for information about the habitats in which a species can be expected to occur. Official Internet sources, unpublished documents, and articles contained in popular media were also used, but are considered less credible. Accuracy assessment was conducted for each species by incorporating an expert opinion and review process.

Vertebrate Mapping Methods

PRGAP species list—

Over 470 vertebrate species (excluding fish) have been recorded in Puerto Rico and its adjacent islands including those that occur in terrestrial, terrestrial aquatic, and

marine environments (app. 2). Of these, about 436 are terrestrial vertebrate species. Many of these are identified as migratory, wintering, accidental, or vagrant species that do not breed regularly or at all in Puerto Rico. The PRGAP only considered species that are known to breed in the project area, and that are regularly occurring nonaccidentals (Csuti and Crist 1998). Csuti and Crist (1998) suggested, as a general definition, that "regular breeders" are those species breeding in the state during at least 5 of the past 10 years. However, this is often difficult to document.

The species list for the PRGAP project final analysis was compiled in cooperation with the DNER, the USFWS, and several nongovernmental sources. This list does not include most of the nonnative species that are known to occur in Puerto Rico. However, because several nonnative species are known to influence the distribution or densities of native species or are valued as game species, we elected to include a group of those that are considered regularly occurring in Puerto Rico. Our final list of 177 species included 18 amphibians, 98 birds, 14 mammals, and 47 reptiles (fig. 10).

Mapping Standards and Data Sources—

The PRGAP mapped predicted species distributions in accordance with the standards of the GAP handbook as of 13 January, 2000. All GIS modeling of species distributions was conducted on Dell workstations running ERDAS Imagine and ArcINFO 9.0.

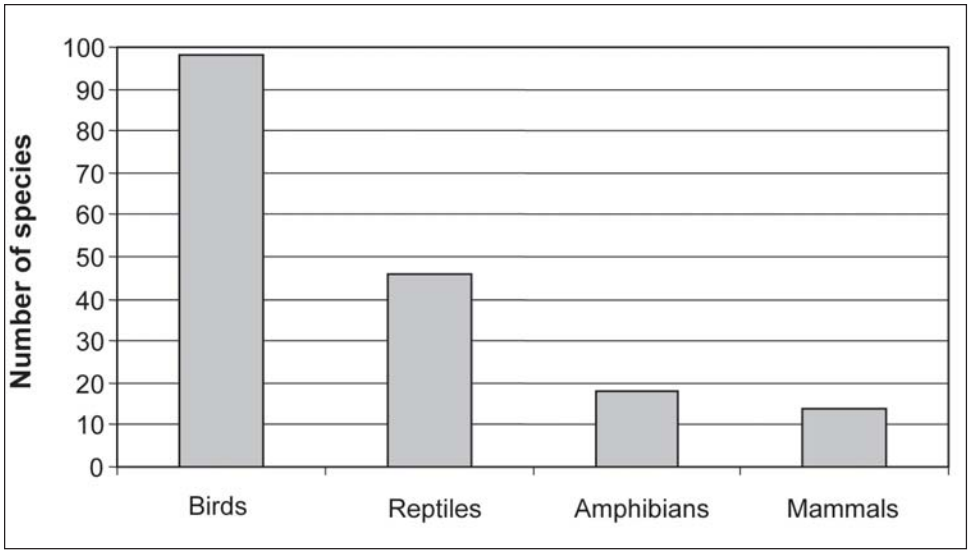


Figure 10—Terrestrial vertebrate species by taxonomic group included in the Puerto Rico Gap analysis.

Minimum Mapping Unit (MMU)—

The PRGAP recognizes two mapping unit scales that are related to (1) defining a species geographic range determined by its probability of occurrence or (2) a predicted species distribution based on associated range, habitat, and life history variables. The PRGAP has adopted a hexagon grid network for use in mapping Puerto Rico's biological diversity. This hexagon grid (PRGAP-HEX) provides a uniform unit of area that can be used to represent the range and occurrence of vertebrate species across a very heterogeneous landscape. Each hexagon has an area of 24 km^2, which is the MMU for species geographic range distributions (fig. 11). The PRGAP-HEX grid consists of 483 individual hexagons with 305 occurring only over land, 161 over coastal areas, and 17 over open marine areas with small reefs and cays. The hexagon shape is based on the U.S. Environmental Protection Agency's (USEPA) Environmental Monitoring and Assessment Program (EMAP) typically used in gap analysis. However, EMAP represents only the conterminous United States, and in lieu of EMAP coverage in the Caribbean, the PRGAP-HEX grid (fig. 1) was developed by the USFS by tessellating the larger hexagonal grid used in Caribbean Forest Inventory and Analysis (FIA).

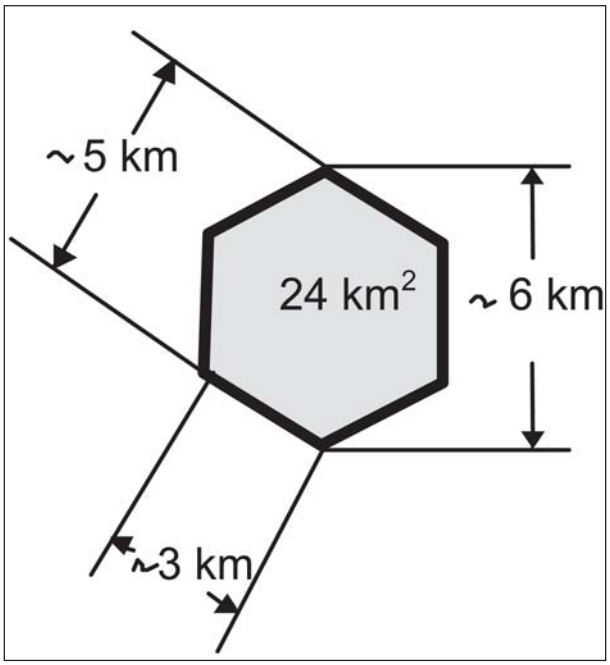


Figure 11—A 24 km^2 hexagon was used as the minimum mapping unit for species geographic range distributions.

The second mapping unit scale is derived from the 15-m^2-pixel resolution reflected in the PRGAP land cover layer (fig. 12), and that is used in mapping species habitat and predicted distribution. The PRGAP uses a 15-m^2-pixel resolution as the MMU for mapping predicted species distributions.

Mapping species geographic distribution—

To map a species geographic distribution, each hexagon was attributed with one of eight categories for probability of occurrence of that species (table 7). Species probability of occurrence information is derived from published literature, unpublished data sets, museum records, and expert opinion. A species record of occurrence may be confirmed when associated with a credible observation, including the location, observation date, and observer's name. Records may be probable based on published range maps, location descriptions, or expert opinion, or predicted based on the occurrence of habitat and expert opinion that the species is likely to occur. Most of the records are for birds, followed by reptiles, amphibians, and mammals (fig. 13).

Collecting species data—

We used a great variety of sources to develop species geographic ranges and their predicted distributions based on habitat availability as inferred from PRGAP land cover. Vertebrate occurrence data were gathered from DNER and include records collected for the Critical Wildlife Areas Report, element occurrence records on threatened and endangered species managed by the DNER's Natural Heritage Program, and from their long-term pigeon and dove survey. In addition, we included occurrence records obtained from:

- USGS Patuxent Wildlife Research Center—10 years of the USGS Breeding Bird Survey Program.
- National Audubon Society Christmas Bird Count.
- USGS Cooperative Unit karst study with North Carolina State University.
- Luquillo Experimental Forest long-term ecological research studies.
- Puerto Rico Ornithological Society Puerto Rico Breeding Bird Atlas project.
- Smithsonian Museum of Natural History.
- University of Puerto Rico, Mayagüez and Humacao campuses.
- IITF staff and scientists.
- University and independent researchers.
- Peer-reviewed publications, research reports, books, and published maps.

Iván Vicens

The Antillian crested hummingbird *Orthorhyncus cristatus* is known as the Zumbador Crestado locally.

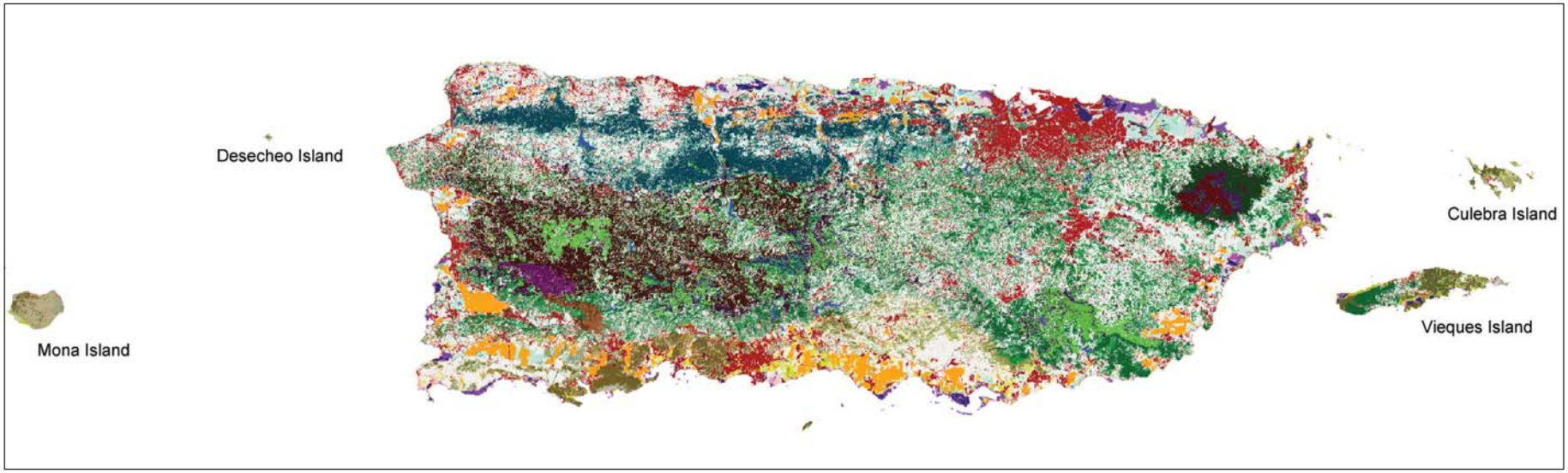


Figure 12—Land cover of Puerto Rico. Developed at 15-m^2 resolution using Landsat 7 ETM+ imagery acquired in 1999-2003 and ancillary data (legend follows).

Forest, woodland and shrubland

Dry forests

Alluvial substrates

- Mature secondary lowland dry alluvial semideciduous forest
- Young secondary lowland dry alluvial semideciduous forest
- Lowland dry alluvial shrubland and woodland
- Lowland dry riparian forest
- Lowland dry riparian shrubland woodland

Calcareous substrates

- Mature secondary lowland dry limestone evergreen forest
- Mature secondary lowland dry limestone semideciduous forest
- Young secondary lowland dry limestone semideciduous forest
- Lowland dry limestone woodland and shrubland
- Lowland dry limestone shrubland
- Lowland dry cactus shrubland
- Coastal dwarf woodland and shrubland
- Lowland dry limestone cliffside semideciduous forest
- Lowland dry limestone cliffside shrubland and woodland
- Abandoned dry forest plantation

Noncalcareous substrates

- Mature secondary lowland dry noncalcareous semideciduous forest
- Young secondary lowland dry noncalcareous semideciduous forest
- Lowland dry noncalcareous shrubland and woodland

Ultramafic serpentine substrates

- Mature secondary dry and moist serpentine semideciduous forest
- Young secondary dry and moist serpentine semideciduous forest
- Dry and moist serpentine woodland and shrubland

Moist forests

Alluvial substrates

- Mature secondary lowland moist alluvial evergreen forest
- Young secondary lowland moist alluvial evergreen forest
- Lowland moist alluvial shrub and woodland
- Lowland moist riparian forest
- Lowland moist riparian shrubland and woodland

Calcareous substrates

- Mature secondary moist limestone evergreen and semideciduous forest
- Young secondary moist limestone evergreen and semideciduous forest
- Moist limestone shrubland and woodland

Noncalcareous substrates

- Mature secondary lowland moist noncalcareous evergreen forest
- Young secondary lowland moist noncalareous evergreen forest
- Lowland moist noncalareous shrubland and woodland
- Lowland moist abandoned and active coffee plantations

Wet forests

Alluvial substrates

- Mature secondary montane wet alluvial evergreen forest
- Young secondary montane wet alluvial evergreen forest
- Montane wet alluvial shrubland and woodland

Noncalcareous substrates

- Mature secondary montane wet noncalcareous evergreen forest
- Montane wet evergreen abandoned and active coffee plantation
- Mature primary and secondary montane wet noncalcareous evergreen tabonuco forest
- Mature primary and secondary montane wet noncalcareous evergreen palo colorado cloud forest
- Mature primary and secondary montane wet noncalcareous evergreen sierra palm forest
- Mature primary and secondary montane wet noncalcareous evergreen elfin woodland cloud forest
- Young secondary montane noncalareous evergreen forest
- Montane wet noncalcareous evergreen shrubland and woodland

Ultramafic serpentine substrates

- Mature secondary montane wet serpentine evergreen forest
- Young secondary montane wet serpentine evergreen forest
- Wet serpentine shrubland and woodland

Flooded forests

- Mangrove forest and shrubland
- Freshwater *pterocarpus* swamp

Grasslands

Dry grasslands

- Dry grasslands and pastures
- Dry cactus grassland and shrubland

Moist grasslands

- Moist grasslands and pastures

Wet grasslands

- Seasonally flooded herbaceous nonsaline wetlands
- Seasonally flooded herbaceous saline wetlands

Flooded grasslands

- Emergent herbaceous nonsaline wetlands
- Emergent herbaceous saline wetlands

Agriculture

- Hay and row crops
- Woody agriculture and plantations

Natural barrens

- Rocky cliffs and shelves
- Gravel beaches and stony shoreline
- Fine to coarse sandy beaches, mixed sand and gravel beaches
- Riparian and other natural barrens
- Salt and mudflats

Artificial barrens

- Artificial barrens
- Salt production

Developed areas

- High-density urban development
- Low-density urban development

Water

- Freshwater
- Saline water
- Aquaculture

Table 7—Confidence level assigned to hexagon records for each species

Confidence level	Taxon	Description
Confirmed	All	Confidently assumed or known to occur in the hexagon. Sources include species locality records and expert opinion.
Predicted	All	Predicted to occur based on a combination of presence of suitable habitat and historical record or presence in adjacent hexagon. Sources include expert opinion only.
Probable	All	Probable occurrence based on a strong likelihood. Sources include expert opinion, published range maps, or range descriptions.
Historical included	All	Confidently assumed or known to have occurred in the hexagon prior to 1970 and considered as valid for recent distribution. Sources include species locality records and expert opinion.
Historical excluded	All	Confidently assumed or known to have occurred in the hexagon prior to 1970 but considered invalid for recent distribution. Sources include species locality records and expert opinion.
Questionable	All	Occurrence within hexagon was still in question after expert review. Hexagons coded as questionable are not included in species current range distribution. Sources include expert opinion only.
Excluded	All	Documented occurrence was excluded by expert review after having been coded as confirmed, predicted, or probable. Sources include expert opinion only.
Absent	All	Considered absent from hexagon based on no documented records of occurrence and expert opinion. Sources include locality records and expert opinion.

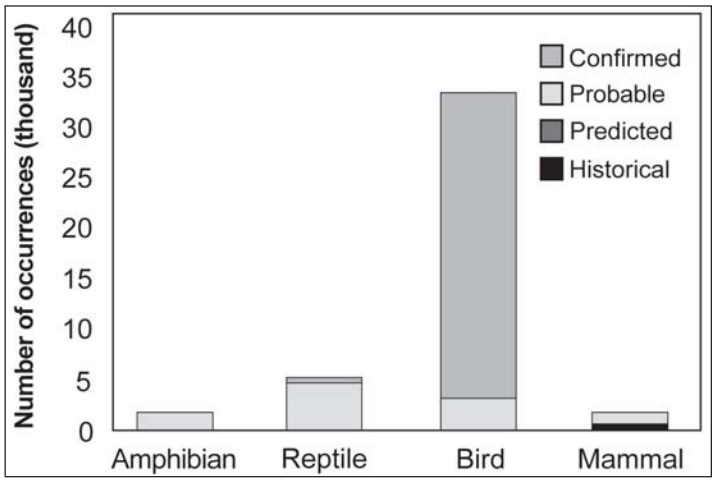


Figure 13—Occurrence records for each taxonomic group in the Puerto Rico Gap Analysis Project database.

These last sources were particularly useful when mapping reptiles, amphibians, and bats. All of this information is maintained in the PRGAP relational database.

Approximating species geographic range extent—
For each species included in our analysis, we mapped its geographic distribution by intersecting the species occurrence records with our PRGAP-HEX base map; the hexagon cell represents the minimum mapping unit for interpreting species geographic range extent. The hexagon was preferred over other mapping units for three reasons. First, the uniform shape and size is important when comparing relative measures of density associated with species diversity. Second, the hexagon's geometric properties allow it to be easily aggregated or tessellated to conform to the convex shape of the Earth's surface. Third, and equally important, the hexagon border is determined arbitrarily and overcomes many problems associated with delineating species range by county (Boone 1996) or other politically-based boundaries. An additional reason for using the PRGAP-HEX base map to delineate species range extents is that each hexagon is spatially related to data collected by the Caribbean FIA Program. This provides for an opportunity to conduct future analyses of vertebrate biological diversity, forest inventory and use, tree species diversity, and forest health.

Each vertebrate occurrence record with latitude and longitude coordinates was attributed to a single hexagon that, in turn, was classified as "confirmed" or "historical included" depending on the date of record (table 7). Museum or other records with locality information that could be assigned to a single hexagon were also designated "confirmed" or "historical included." Published distribution maps and descriptions, and locality records that intersect more than one hexagon were also used to attribute hexagons. However, this process was less straightforward requiring different methods or steps depending on the record's unique case. In these cases, the hexagons intersecting these locality records were attributed or classified as "probable" (table 7).

Methods specific to birds—
Breeding bird surveys represented a very important source of bird distribution data. Observations from BBS routes were attributed to all the hexagons that were intersected by the routes. These hexagons were classified as "confirmed." The following references also represented valuable tools for mapping bird distributions: Biaggi (1977), Oberle (2000), Raffaele (1983), and Raffaele et al. (1998).

We selected all the hexagons that intersected the distribution localities or areas described in these references, and attributed them an occurrence classification of "probable" (table 7).

Methods specific to reptiles and amphibians—
Valuable amphibian distribution information came from the following references: Joglar (1998), Rivero (1998), and Schwartz and Henderson (1991). Point distribution maps from some of these references were electronically scanned, points of occurrence digitized, and then buffered (buffer distance differed depending upon the inherent error associated with each respective published map) to reflect processing error. The respective buffered points were then intersected with a complete species hexagon distribution data set (which includes hexagons still categorized as "absent") to augment the current distribution status. All hexagons selected using this process were attributed as "probable."

Methods specific to mammals—
A valuable source of bat distribution information was provided by Dr. M. Gannon of Penn State University, and subsequently from Gannon et al. (2005). We digitized the point locations from the distribution maps in this book. We assigned a buffer to each of the digitized points depending on the observation or record description that Gannon et al. (2005) provided. The buffers were intersected with the complete species hexagon data sets to complement the existing distribution records, and subsequently attributed with an occurrence category of "probable."

Wildlife habitat relationships—
Species habitat models were based on species life-history information obtained from the literature and from expert review. The information used to develop species habitat models has been documented in the PRGAP-VERT database, where we compiled all available information on species taxonomic classification, conservation status, worldwide distribution, distribution in Puerto Rico, associations with vegetation or floristics, geologic substrates, soils, climate or rainfall patterns, elevation, topography, habitat structure, or other terrain features. We also documented information on species migratory, reproductive, and demographic patterns, dietary habits, habitat use, and activity patterns. This information, as well as a specific wildlife habitat model, is reported in volume 2 for each species.

Modeling of vertebrate species distributions for PRGAP—
Species habitat models were linked to specific mapped land cover units or other information for which we have reliable spatial information. The predicted distributions include all habitats within hexagons with confirmed, probable, or predicted occurrences, and in adjacent hexagons when there is contiguous habitat.

Javier Mercado

The barred anole *Anolis straulus* is know locally as the Lagartijo Manchado.

Vertebrate Distribution Results

Hexagon occurrence maps (see volume 3) provide a comprehensive set of species occurrences for Puerto Rico. They indicate that although there are a number of widespread species occurring nearly everywhere, there are also significant patterns of coastal or montane species, species restricted to dry or wet environments, and species restricted to particular islands. They also indicate the need for island-wide systematic surveys and more comprehensive sampling of several species.

Predicted distribution maps (see volume 4) also provide a new body of information that is available for future analysis. They highlight the importance of the diversity of habitats on the island, from wetlands to dry lands, from grassland to forests, and the matrix of habitats that include mangrove and dry forests, forest edges, and tracts of dense forest. Predicted distribution maps include information on species taxonomy, conservation status, habitat model, natural history, major literature sources, and, for many species, a photograph.

Amphibians—
We mapped the geographic distribution (see hexagon occurrence maps) of 18 amphibian species based on associated occurrence records. The majority of Puerto Rico's amphibians are in the genus *Eleutherodactylus*, the coquís of Puerto Rico. As an example, *Eleutherodactylus portoricensis* is the Puerto Rican coquí, with a range above 200 m in the central mountains (fig. 14) and habitat that includes forest, woodland, and shrubland within this range (fig. 15).

Birds—
We mapped the distribution of 98 bird species. As an example, the yellow-shouldered blackbird, *Agelaius xanthomus*, is an uncommon and endangered species that is mostly restricted to the drier coastal areas (fig. 16) and inhabits forests, woodlands, shrublands and open areas adjacent to forest (fig. 17).

Mammals—
We mapped the distribution of 14 mammal species, including the 13 bats found on the islands. As an example, the Jamaican fruit-eating bat, *Artibeus jamaicensis,* is common throughout the island (fig. 18) and inhabits forests, woodlands, shrublands, and adjacent grasslands (fig. 19).

Reptiles—
We mapped the distribution of 47 reptile species. As an example, the Puerto Rican boa, *Epicrates inornatus,* is widespread in its distribution, but uncommon (fig. 20). It inhabits moist and wet forested areas or dense dry forest near water (fig. 21).

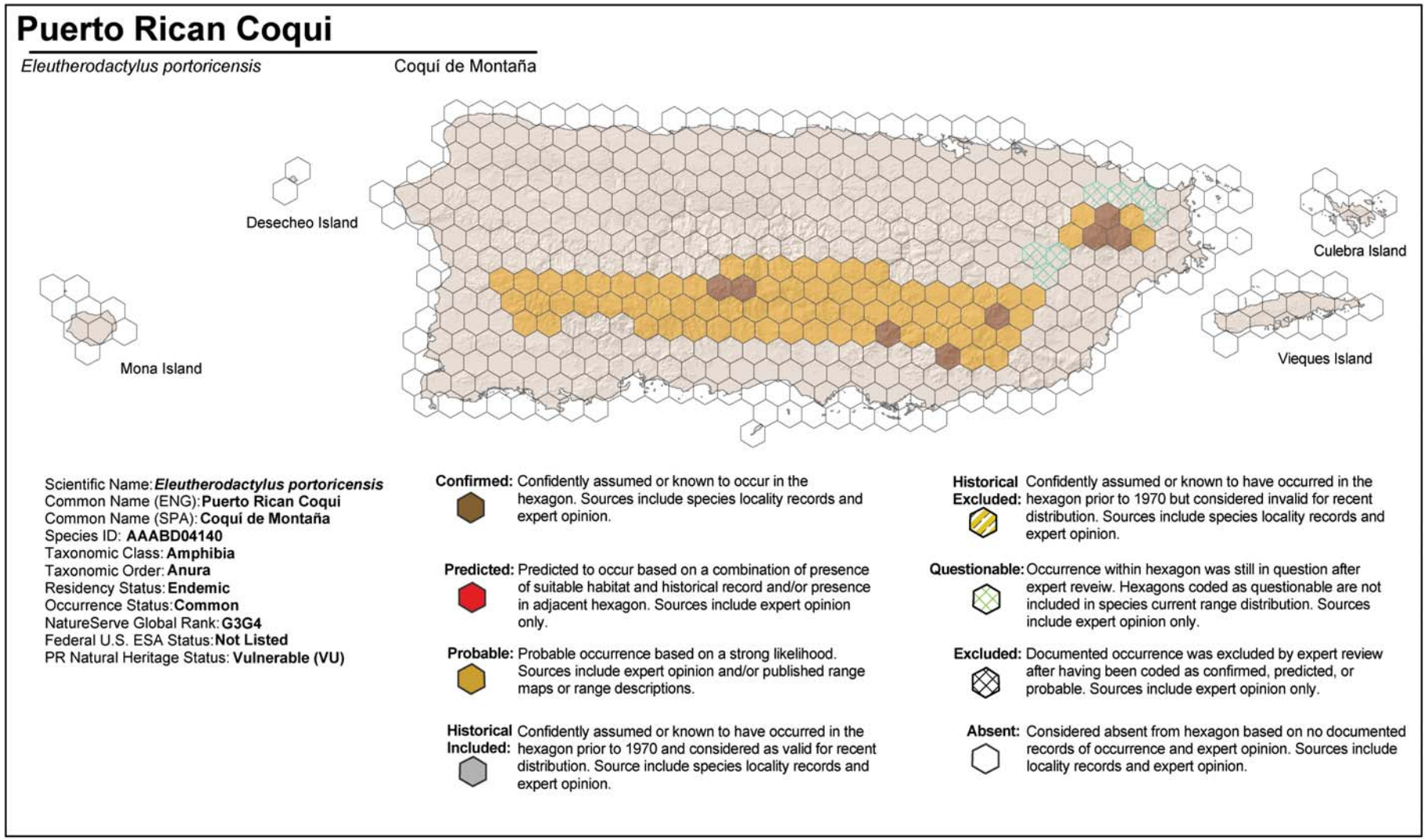
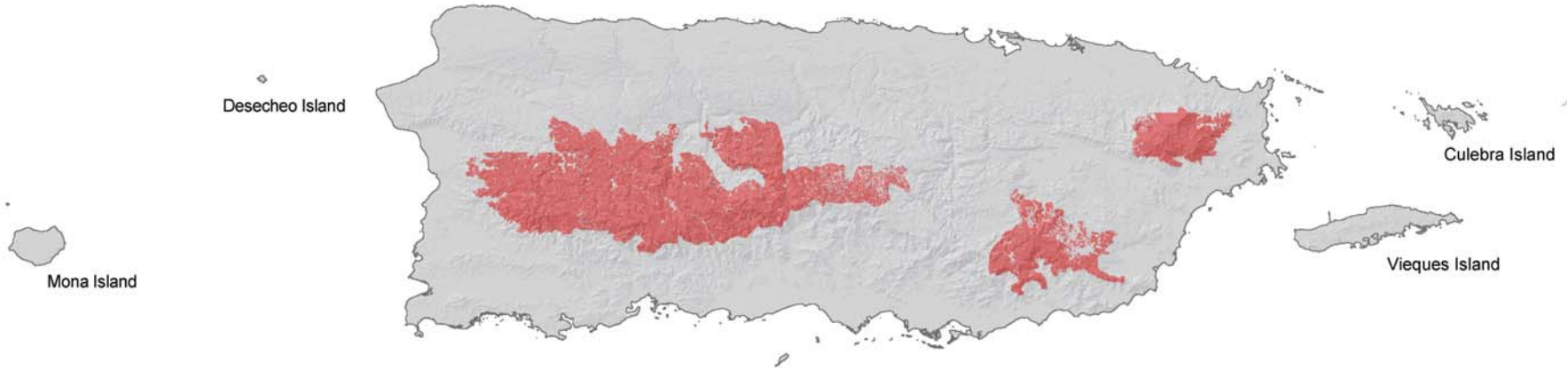


Figure 14—*Eleutherodactylus portoricensis* hexagon occurrence map.

Puerto Rican Coqui

Eleutherodactylus portoricensis Coqui de Montaña



Scientific Name: ***Eleutherodactylus portoricensis***
Common Name (ENG): **Puerto Rican Coqui**
Common Name (SPA): **Coquí de Montaña**
Species ID: **AAABD04140**
Taxonomic Class: **Amphibia**
Taxonomic Order: **Anura**
Residency Status: **Endemic**
Occurances Status: **Common**
NatureServe Global Rank: **G3G4**
Federal U.S. ESA Status: **Not Listed**
PR Natural Heritage Status: **Vulnerable (VU)**

Photo courtesy of Javier Mercado

Species Predicted Habitat:

Predicted habitat model includes the following land cover types: forest, woodland, and shrubland at or above 200 m of elevation. This species habitat include 14.2 percent (127184 ha) of the island, of which 17.6 percent occurs in protected areas (PRGAP Status 1 and 2).

Species Accounts Summary:

The Puerto Rican coqui is mostly found in the island uplands[4]. It can be found in the uplands from Maricao State Forest in west to the region of El Yunque or Sierra de Luquillo in east. It has been heard in the forest of El Verde. Carite, Toro Negro[1,2,4]. It has also been heard in the tabonuco forest at Los Tres Picachos State Forest, palo and dwarf forests[2,3]. This species inhabitats mountain forests, such as music upland broadleaf forests, and it can be found in shrubs, palms, herbaceous plants, bromeliads, tree holes, and under rocks, trunks, roots, and leafage [2,4]. It feeds on terrestrial and leaf-litter insects, spiders, acarids, and other invertebrates[2,4].

1. Drewy, G.E. and A.S. Rand, 1983. Characteristics of an acoustic community: Puerto Rican frogs of the genus *Eleutherodactylus.* Copeia, Vol. 1983, p. 941-953.
2. Joglar L. R. 1998. Los Coquies de Puerto Rico, Su Historia Naturally Conservación. Editorial de la Universidad de Puerto Rico. 232 p.
3. Miranda-Castro, L., Puente-Rolón, A. and Vegas-Castillo, S. 2000. First list of the vertebrates of Los Tres Picachos State Forest, Puerto Rico with data on relative abundance and altitudinal distribution. Carribean Journal of Science. 36 (1-2) 117-126.
4. Schwartz, A. and W. R. Henderson 1991. Amphibians and Reptiles of the West Indies. Descriptions, Distractions, and Natural History, Univ. Press Flordia, Gainesville, FL 720 p.

Figure 15—*Eleutherodactylus portoricensis* predicted distribution map.

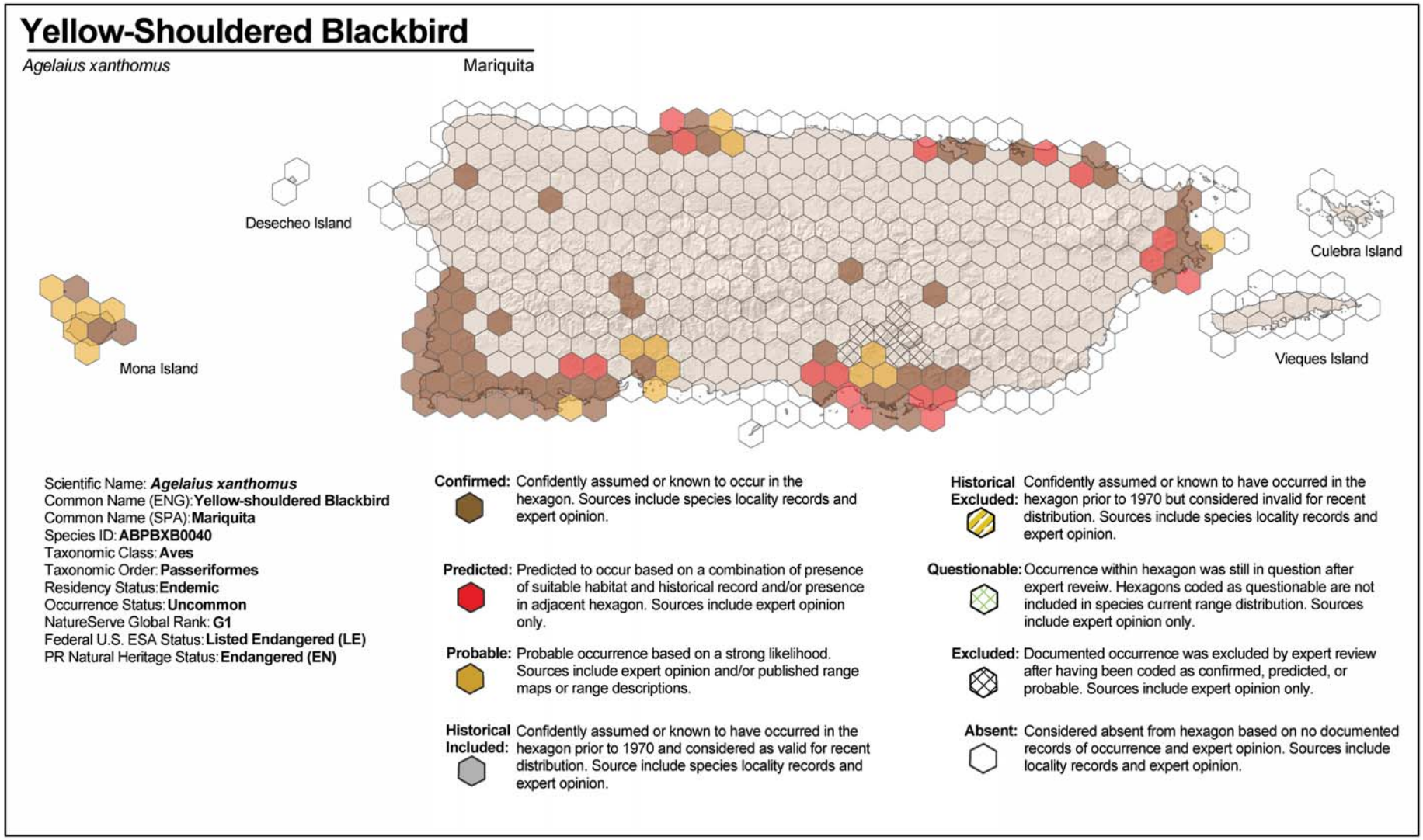
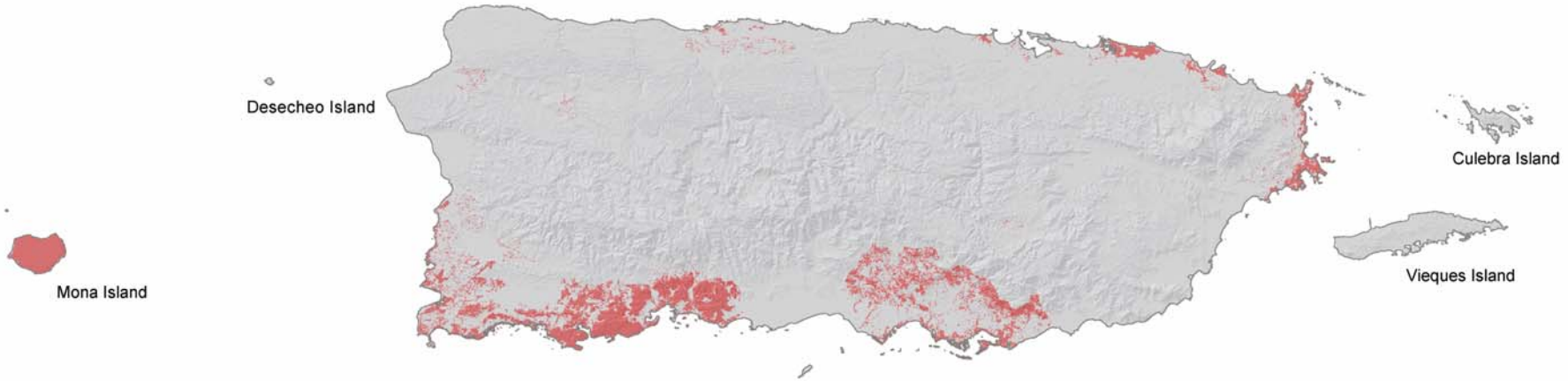


Figure 16–*Agelaius xanthomus* hexagon occurrence map.

Yellow-Shouldered Blackbird

Agelaius xanthomus Mariquita



Scientific Name: ***Agelaius xanthomus***
Common name (ENG): **Yellow-shouldered Blackbird**
Common Name (SPA): **Mariquita**
Species ID: **ABPBX0040**
Taxonomic Class: **Aves**
Taxonomic Order: **Passeriformes**
Residency Status: **Endemic**
Occurrence Status: **Uncommon**
NatureServe Global Rank: **G1**
Federal U.S. ESA Status: **Listed Endangered (LE)**
PR Natural Heritage Status: **Endangered (EN)**

Photo courtesy of T.A. Carlo

Species Predicted Habitat:

Predicted habitat model includes the following land cover types: mangroves, mud and salt flats; dry forest, woodland and shrubland; coconut plantation; coastal cliffs; low-density urban areas; and dry grassland adjacent to forest (within 30 m). Typically in lowlands at or below 400 m of elevation. This species habitat includes 6.8 percent (61 073 ha) of the island, of which 24.4 percent occurs in protected areas (PRGAP Status 1 and 2).

Species Account: Summary

The yellow-shouldered blackbird used to be common and considered widespread in the past[3]. Present distribution probably includes the southwest of the island in a narrow coastal zone from Guánica to Boca Prieta, western Puerto Rico[4], the towns of Salinas and Guyama in southern Puerto Rico, Mona and Monito Islands. The population in the town of Ceiba, eastern Puerto Rico, seems to be on the brink of extirpation according to recent surveys by the Department of Natural and Environmental Resources[2]. This bird is mostly associated with mangrove habitat[1], arid scrublands, coconut and royal palm plantations, tree-bordered lowland pastures, mud flats, salt flats, offshore red mangrove cays, black mangrove forests, dry costal forest, suburban areas, and coastal cliffs[1,3].

1. López-Ortiz, R., Ventosa-Febles, E.A., Reitsma, L.R., Hengstenberg, D., and Deluca, W. 2002. Increasing nest success in the yellow-shouldered blackbird *Agelaius xanthomus* in southwest Puerto Rico. Biological Conservation 108(2):259-263.
2. López-Ortiz, Ricardo. Personal communication. August 15, 2006.
3. Post, W. and J.W. Wiley. 1976. The yellow-shouldered blackbird: present and future. American Birds. 30:13-20.
4. Post, W., and Wiley, J.M. 1977. The shiny cowbird in the West Indies. The Condor. 79(1): 119-121

Figure 17—*Agelaius xanthomus* predicted distribution map.

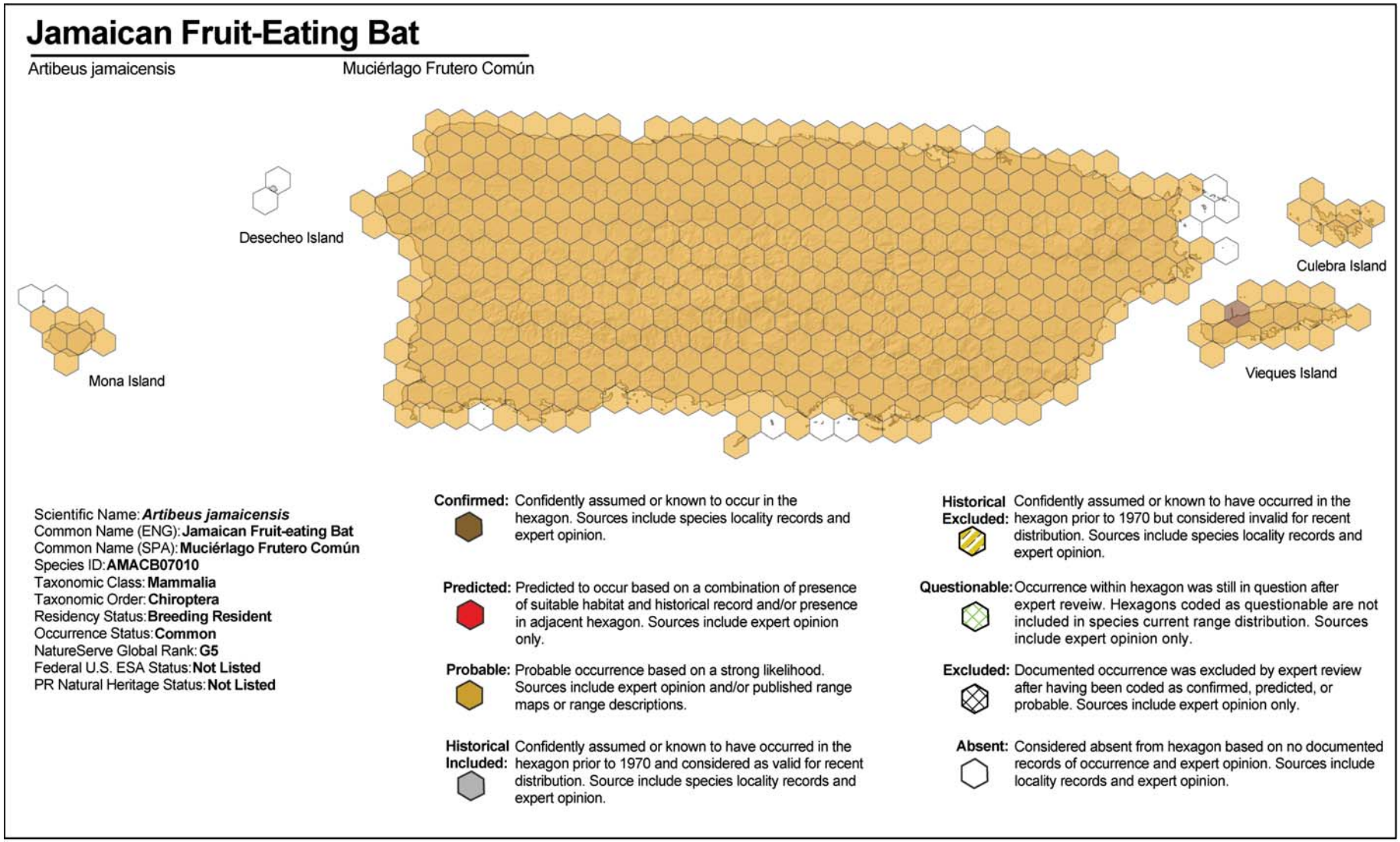


Figure 18—*Artibeus jamaicensis* hexagon occurrence map.

Jamaican Fruit-Eating Bat

Artibeus jamaicensis Muciérlago Frutero Común

Scientific Name: ***Artibeus jamaicensis***
Common Name (ENG): **Jamaica Fruit-eating Bat**
Common Name (SPA): **Muciérlago Frutero Común**
Species ID: **AMACB07010**
Taxonomic Class: **Mammalia**
Taxonomic Status: **Chiroptera**
Residency Status: **Breeding Resident**
Occurrence Status: **Common**
NatureServe Global Rank: **G5**
Federal U.S. ESA Status: **Not Listed**
PR Natural Heritage Status: **Not Listed**

Species Predicted Habitat:

Predicted habitat model includes the following land cover types: forests, woodlands, shrublands, grassland adjacent to forests, and low-density urban areas. This species habitat includes 71.2 percent (636621 ha of the island, of which 8.8 percent occurs in protected areas (PRGAP Status 1 and 2).

Species Accounts Summary:

The Jamaican fruit-eating bat has described as widespread in Puerto Rico where is appears to be mostly a cave dewller[2], occupying both hot and cool caves. It has, however, been sighted in foilage and man-made structure[3]. It also Occurs in Vieques, Culebra, Mona, and Caja de Muertos Islands[1]. It has been observed in a number of caves, in places such as Aguas Buenas, Corozal, and Río Encantado[2,3]. It's distribution in Puerto Rico includes areas in the subtropical moist forest[2]. *A. jamaicensis* feeds mostly on fruits but it is also known to feed on insects, nectar, and leaves[2].

1. Gannon, M.R., A. Kurta, A. Rodríguez-Durán, and M.R. Willig. 2005. Bats Puerto Rico–an island focus and a Caribbean perspective. Texas Tech University Press 239 p.
2. Rodrígue Durán, A. and Vázquez, R. 2001. The *bat Artibues jamaicensis* in Puerto Rico (West Indies): seasonality of diet, activity, and effect of a hurricane. Acta Chiropterologica. 3:53-61.
3. Rodrígue-Durán, A. 1998. Nonrandom aggregations and distribution of cave-dwelling bats in Puerto Rico. Journal of Mammalogy. 79:141-146.

Figure 19—*Artibeus jamaicensis* predicted distribution map.

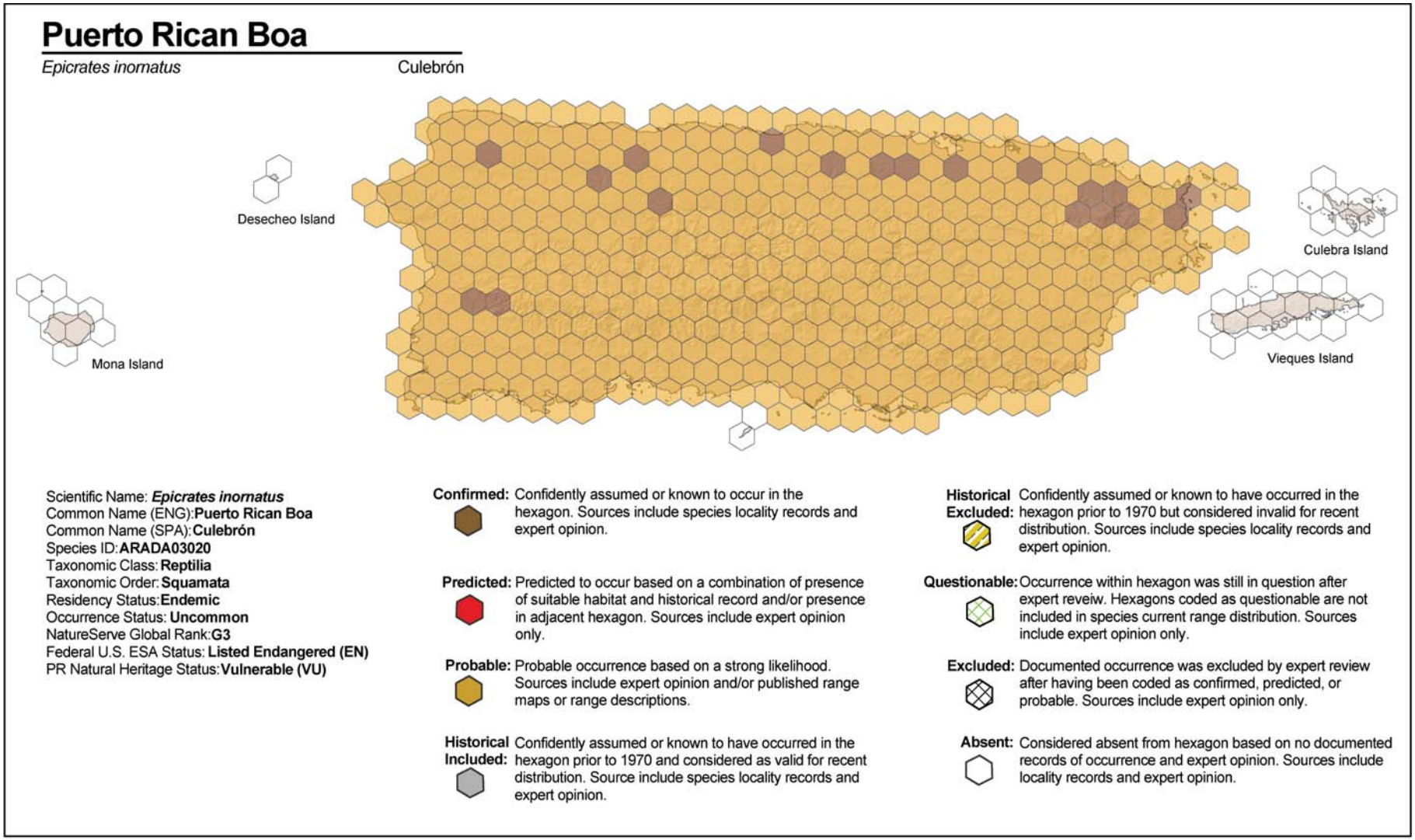
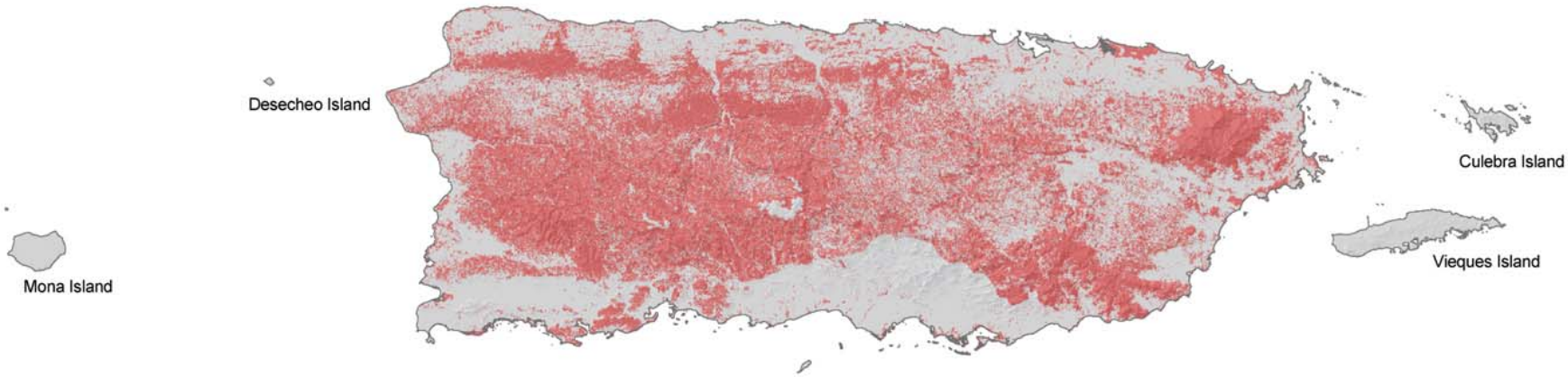


Figure 20—*Epicrates inornatus* hexagon occurrence map.

Puerto Rican Boa

Epicrates inornatus Culebrón



Scientific Name: ***Epicrates inornatus***
Common Name (ENG): **Puerto Rican Boa**
Common Name (SPA): **Culebrón**
Species ID: **ARADA03020**
Taxonomic Class: **Reptilia**
Taxonomic Order: **Squamata**
Residency Status: **Endemic**
Occurrence Status: **Uncommon**
NatureServe Global Rank: **G3**
Federal U.S. ESA Status: **Listed Endangered (EN)**
PR Natural Heritage Status: **Vulnerable (VU)**

Photo courtesy of Javier Mercado

Species Predicted Habitat:

Predicted habitat model includes the following land cover types: moist and wet forest, woodland, and shrubland mangrove, *Pterocarpus*, and mature dry forest and dry forest near water bodies, at or below 1000 m of elevation. This species habitat includes 46.3% (414379 ha) of the island, of which 9% occurs in protected areas (PRGAP Status 1 and 2).

Species Accounts Summary:

The Puerto Rican boa is more commonly found in the northern lime stone karsts belt extending from the town of Bayamón west to Aguadilla and less abundant in the dry southern region[1], although there are collection records from towns of Cabo Rojo, Lajas, Ponce, Salinas, and Guayama[1]. For this reason, it is believed that this boa is widespread in its mainland distribution[3]. It occupies wet montane forest to dry forest environments[1] and also lowland wet forest, mangrove forest, wet limestone karst, and offshore cays, remnant coastal rainforest, pastureland with patches of exotic trees, tabonuco and palo colorado forest types, plantations, and second-growth forests[3]. It is know to feed on domestic fowl, bath, rodents, lizards, insects, and other invertebrates[1,2].

1. Rivero, J.A. 1998. Los anfibios y reptiles de Puerto Rico/The amphibians and reptiles of Puerto Rico. Segunda Ed. Universidad de Puerto Rico. Editorial Universitaria, San Juan, Puerto Rico. 510 p.
2. Schwartz, A. and W.R. Henderson 1991. Amphibians and reptiles of the West Indies. Descriptions, distributions, and natural history. Gainesville, FL: Univ. Press Florida, 720 p.
3. Wiley, W. James. 2003 Habitat association, size, stomach contents, and reproductive condition of Puerto Rico boas (*Epicrates inornatus*). Caribbean Journal of Science. 39(2): 189-194.

Figure 21—*Epicrates inornatus* predicted distribution map.

Javier Mercado

The Coquis are an important national symbol of the ecological richness of Puerto Rico.

Vertebrate Richness

The GAP has often been associated with the mapping of species-rich areas or "hot-spots." Richness maps identify numbers of elements that co-occur by geographic location. These are color coded or shaded in intensity from the highest numbers of co-occurrence (richness) to the lowest. Areas with the greatest species richness may or may not indicate best conservation opportunities. They may occur in already protected areas or may represent mostly species that are currently protected or not at risk. Still, they are often a useful starting point to examine conservation opportunities in combination with other analyses described in this report's "Introduction" and "Analysis" sections. They may be useful for other applications such as identifying places of interest for wildlife observation and study.

Species richness is depicted for all mapped taxa at a 15-m^2-pixel resolution where each pixel is associated with a habitat type and by a color that represents the number of vertebrate species potentially using that habitat, a measure of alpha diversity (Whittaker 1977) (fig. 22). Warmer colors (reds) indicate higher vertebrate species richness (higher alpha diversity), cooler colors (blues) lower vertebrate species richness (lower alpha diversity). This is a good indicator of potential species richness of a habitat type and possibly the relative habitat quality. Vertebrate species richness is also mapped at the hexagon resolution of 24 km^2 (fig. 23) and colors reflect the number of habitats for each hexagon and the relative beta diversity, or difference in vertebrate species composition between habitats (Whittaker 1997). Richness per pixel (alpha diversity) and per hexagon (beta diversity) may show very different patterns. Mountain forested habitats tend to be more species rich (higher alpha diversity), but coastal regions, with greater heterogeneity of habitats, may have higher beta diversity.

Amphibian species richness patterns show higher diversity in the forested mountain regions (figs. 24 and 25). Bird species richness patterns (figs. 26 and 27) show higher diversity in coastal areas with a mix of open and closed forest habitats. Mammal species richness (primarily bats) patterns indicate greater richness in the northern limestone region where karst topography and caves occur (figs. 28 and 29). Reptile species richness (alpha diversity) is higher in the forested areas; beta diversity for reptiles is highest in areas with a mix of either wet or dry forests or a matrix of forest and grassland (figs. 30 and 31).

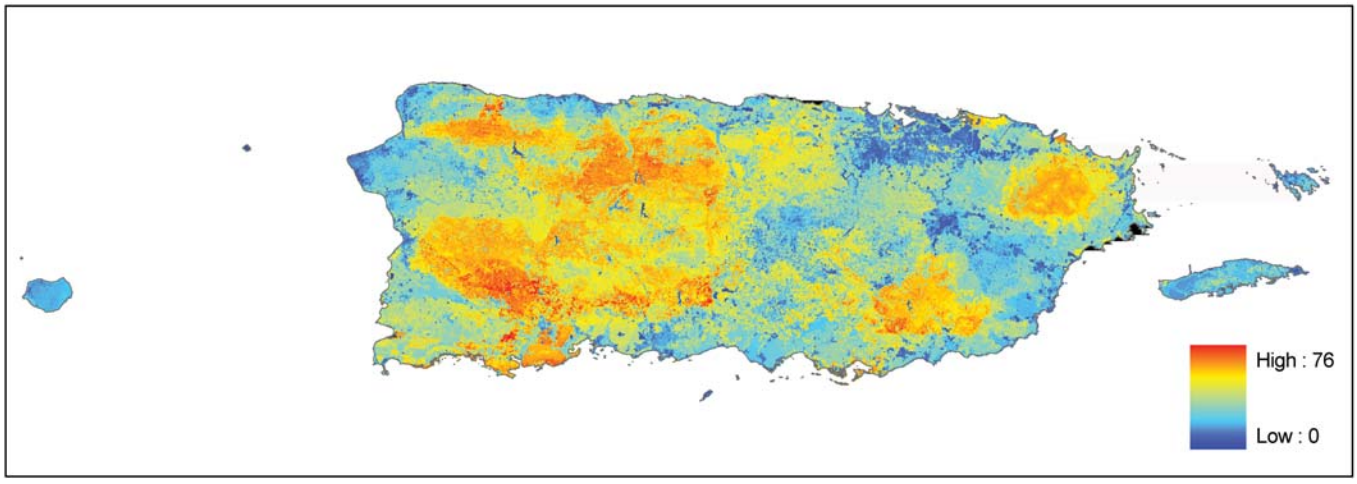


Figure 22—Predicted resident, endemic, and endangered terrestrial vertebrate species richness per 15-m^2 pixel.

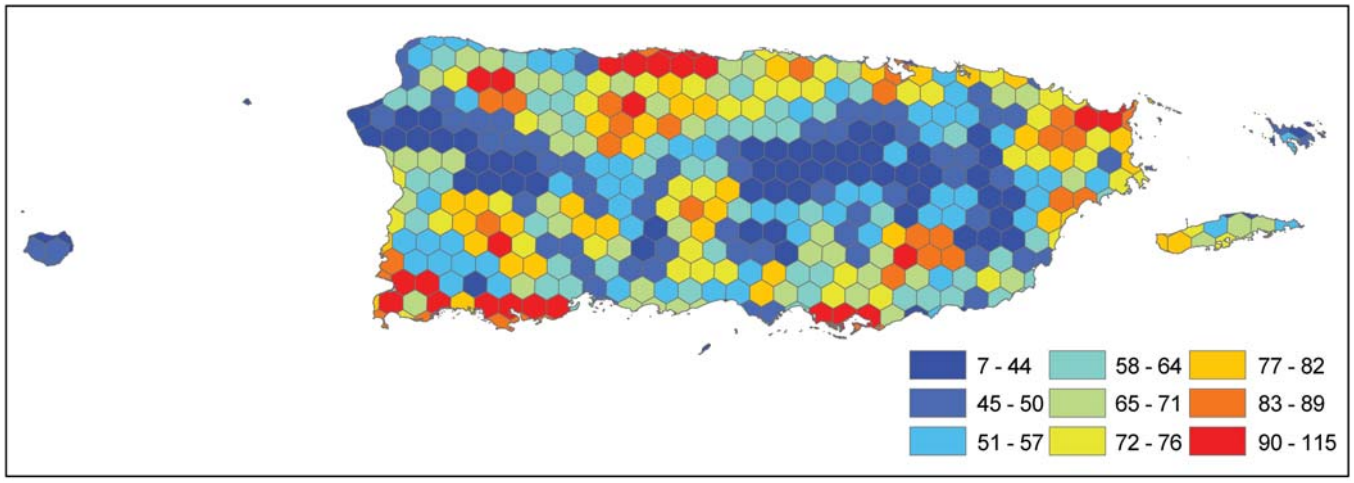


Figure 23—Predicted terrestrial vertebrate resident, endemic, and endangered species richness per 24-km^2 hexagon.

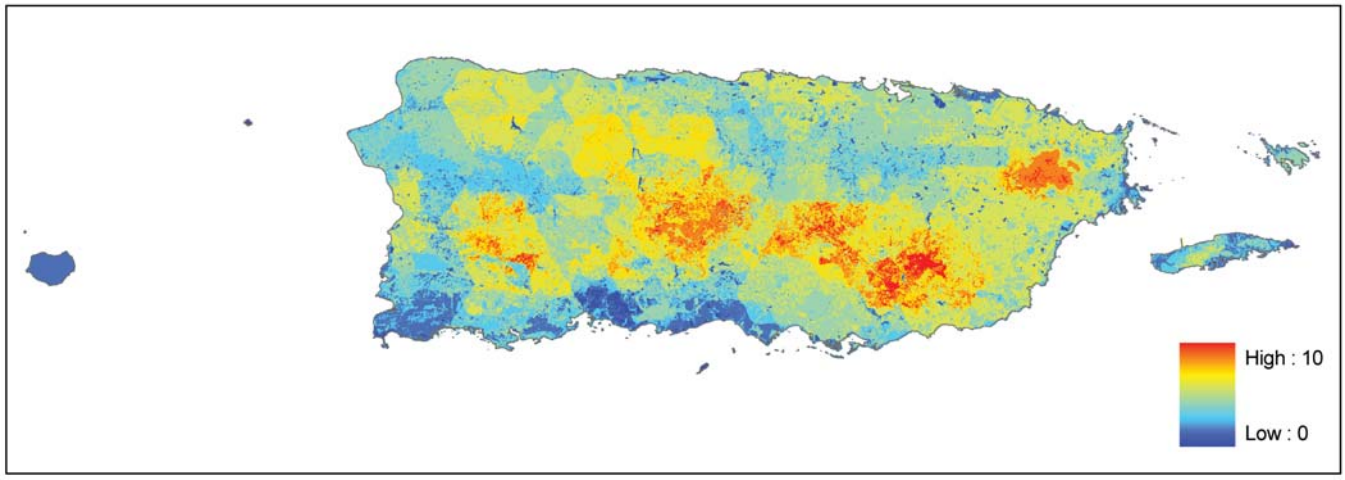


Figure 24—Predicted amphibian species richness per 15-m^2 pixel.

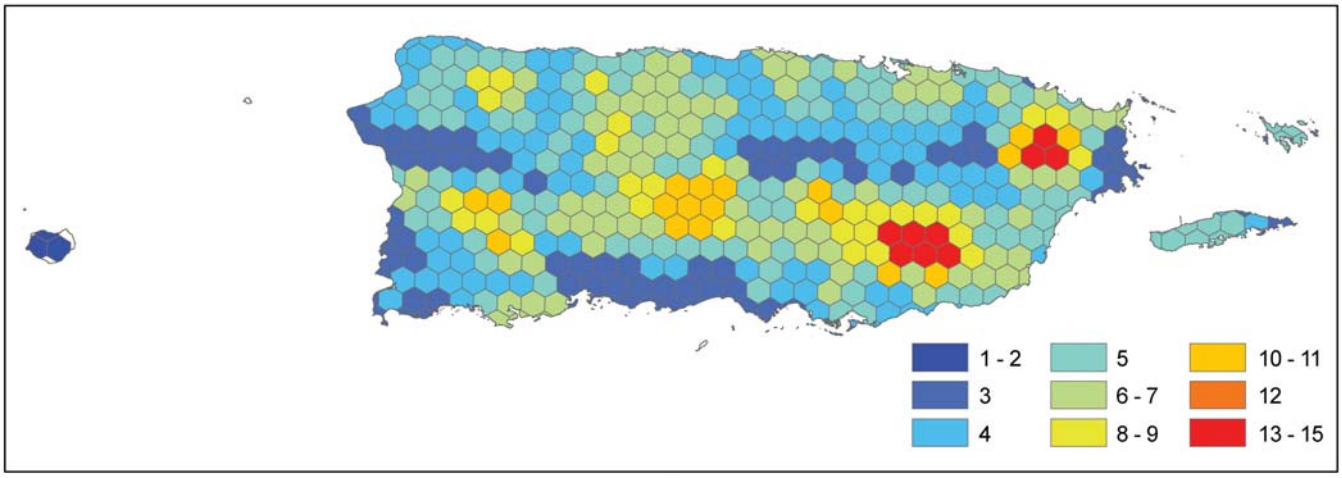


Figure 25—Predicted amphibian species richness per 24-km^2 hexagon.

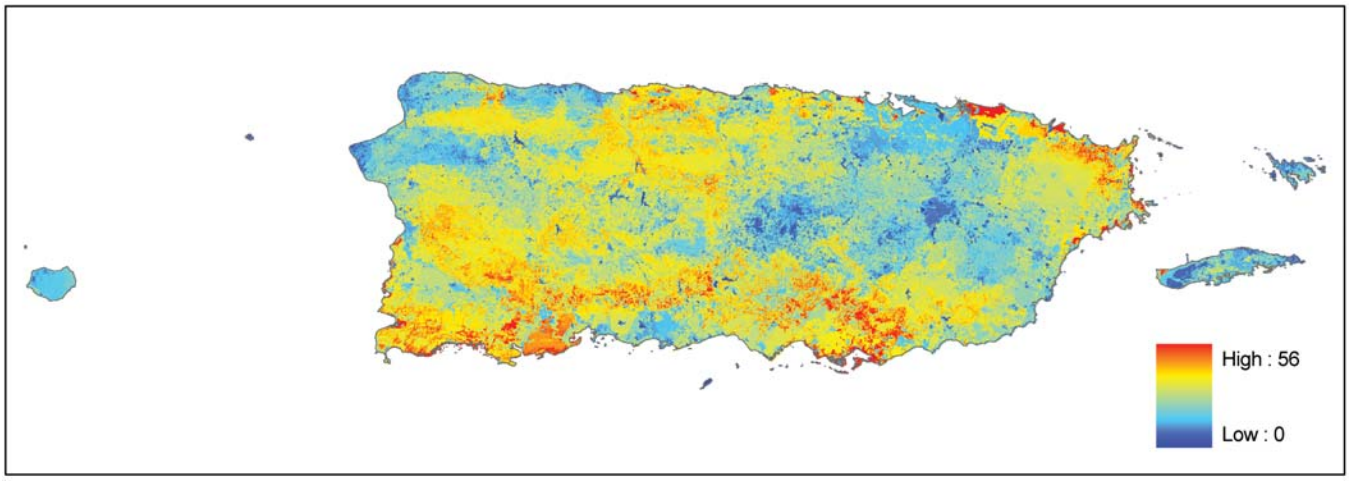


Figure 26—Predicted bird species richness per 15-m^2 pixel.

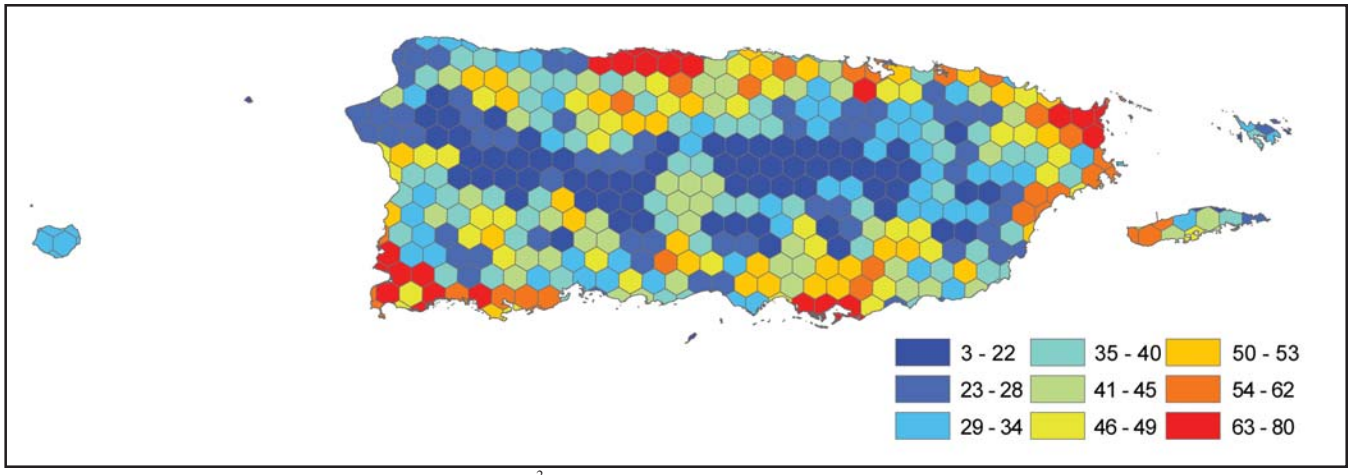


Figure 27—Predicted bird species richness per 24-km^2 hexagon.

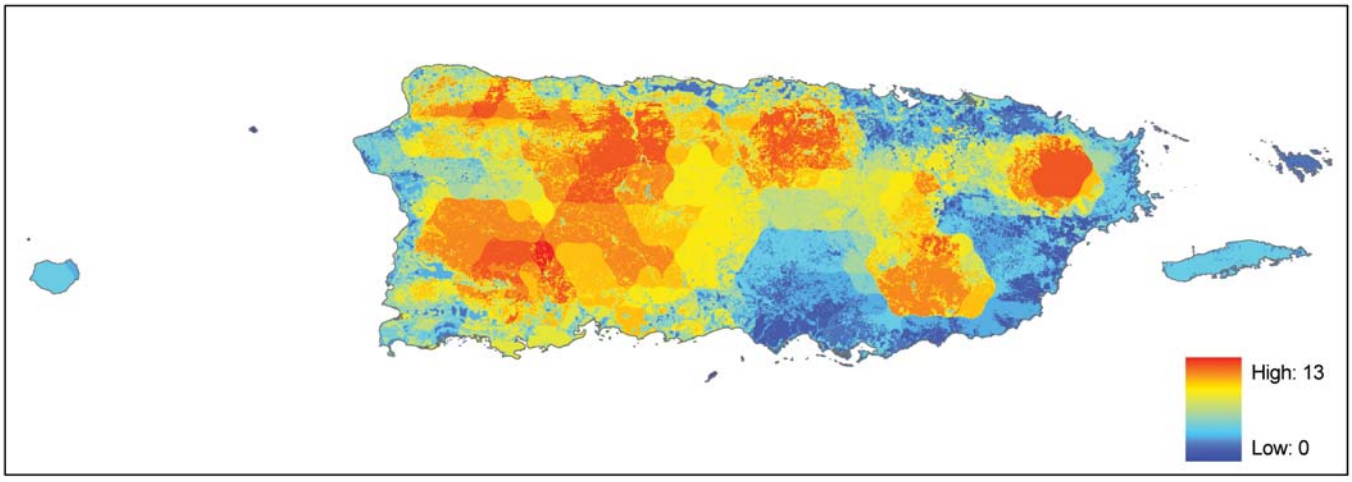


Figure 28—Predicted mammal species richness per 15-m^2 pixel.

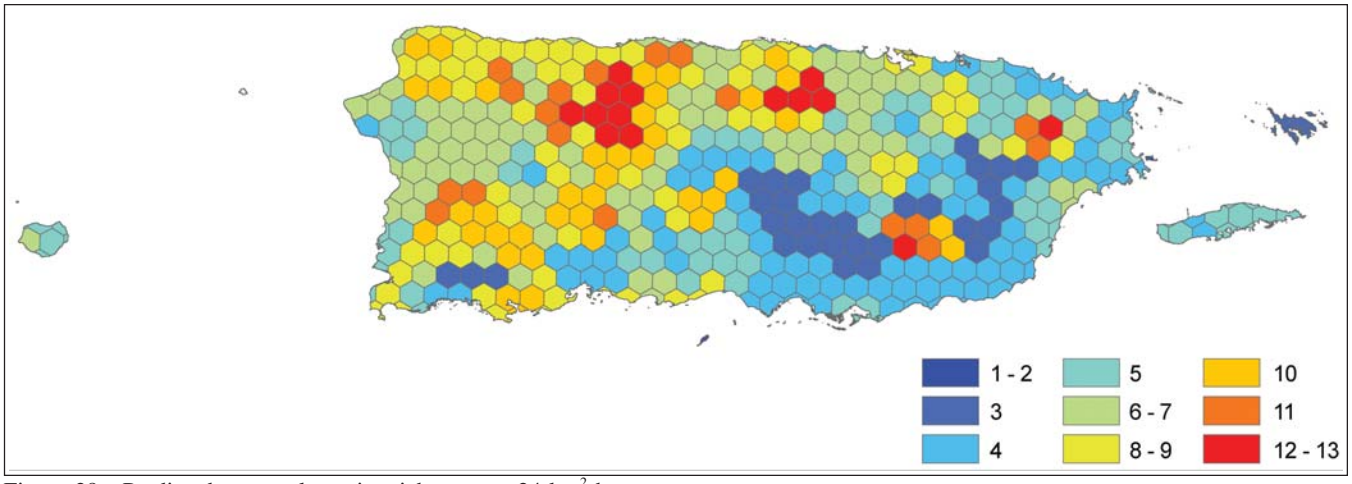


Figure 29—Predicted mammal species richness per 24-km^2 hexagon.

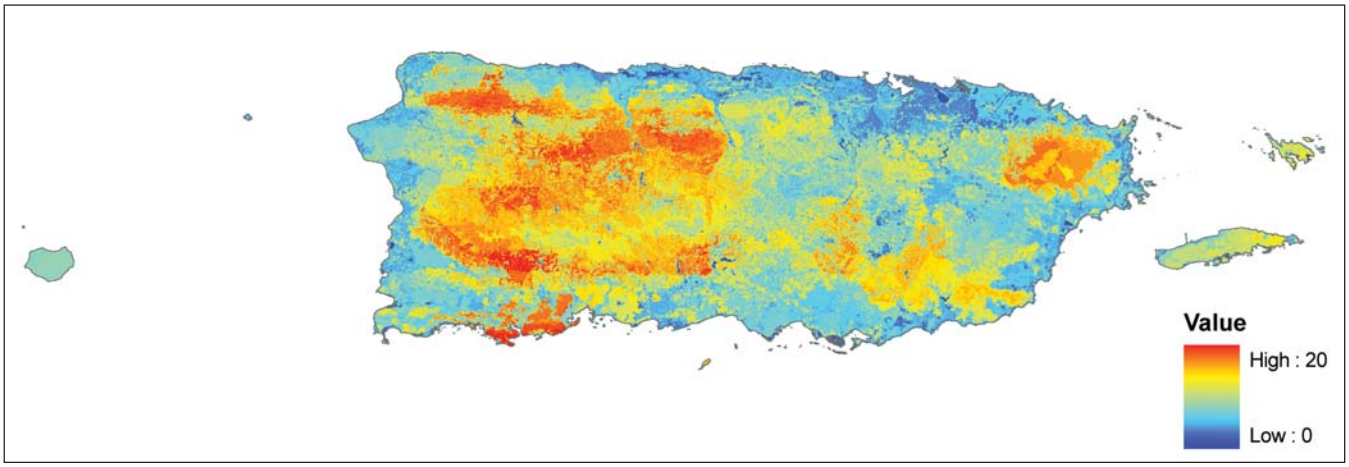


Figure 30—Predicted reptile species richness per 15-m^2 pixel.

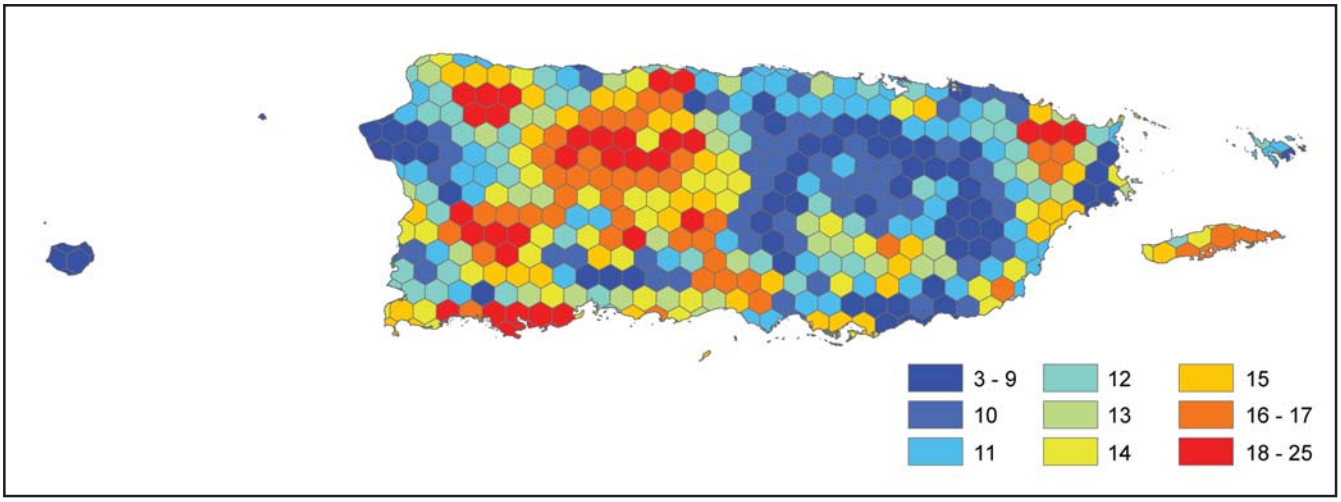


Figure 31—Predicted reptile species richness per 24-km^2 hexagon.

Vertebrate Distribution Accuracy Assessment

Assessing the accuracy of the predicted vertebrate distributions is subject to many of the same problems as assessing land cover maps, as well as a host of more serious challenges related to both the behavioral aspects of species and the logistics of detecting them. These are described further in the "Background" section of the GAP handbook on the national GAP home page. It is, however, necessary to provide some measure of confidence in the results of the gap analysis for all species collectively, if not individually or by taxonomic group (comparison to stewardship

Tomás A. Carlo

The endemic Puerto Rican Tody *Todus mexicanus* can be seen in the island's Central Mountains.

and management status), and to allow users to judge the suitability of the distribution maps for their own uses. We, therefore, feel it is important to provide users with a statement about the accuracy of predicted vertebrate distributions within the limitations of available resources and practicalities of such an endeavor. We acknowledge that distribution maps are never finished products but are continually updated as new information is gathered. This reflects not only an improvement over the modeling process, but also the opportunity to map true changes in species distributions over time. However, we feel that assessing the accuracy of the current maps provides useful information about their reliability to potential users.

Our goal was to produce maps that predict distribution of terrestrial vertebrates and, from that, total species richness and species content with an accuracy of 80 percent or higher. Failure to achieve this accuracy indicates the need to refine the data sets and models used for predicting distribution.

Vertebrate Data Limitations

We compiled all available information on species occurrences and obtained expert review on the majority of species distributions. We did not set aside a data set for accuracy assessment, but as new information and site species lists become available it would be advisable to conduct such an accuracy assessment.

Land Stewardship

To fulfill the analytical mission of GAP, we compare the mapped distribution of elements of biodiversity with different categories of land ownership and management. These comparisons are a start in assessing the likelihood of future threat to a biotic element through habitat conversion—the primary cause of biodiversity decline. We use the term “stewardship” in place of “ownership” in recognition that legal ownership does not necessarily equate to the entity charged with management of the resource, and that the mix of ownership and managing entities is a complex and rapidly changing condition not suitably mapped by GAP. At the same time, it is necessary to distinguish between stewardship and management status in that a single category of land stewardship, such as a national forest, may contain several degrees of management for biodiversity.

The purpose of comparing biotic distribution with stewardship is to provide a method by which land stewards can assess their relative amount of responsibility for the management of a species or plant community and identify other stewards

sharing that responsibility. This information can reveal opportunities for cooperative management of that resource, which directly supports the primary mission of GAP to provide objective, scientific information to decisionmakers and managers to make informed decisions regarding biodiversity. It is likely that a steward that has previously borne the major responsibility for managing a species may, through such analyses, identify a more equitable distribution of that responsibility. We emphasize, however, that GAP only identifies private land as a homogeneous category and does not differentiate individual tracts or owners, unless the information was provided voluntarily to recognize a long-term commitment to biodiversity maintenance.

After comparison to stewardship, it is also necessary to compare biotic occurrence to categories of management status. The purpose of this comparison is to identify the need for change in management status of individual elements or areas containing high degrees of diversity. Such changes can be accomplished in many ways that do not affect the stewardship status. Although it will eventually be desirable to identify specific management practices for each tract and whether they are beneficial or harmful to each element, GAP currently uses a scale of 1 to 4 to denote relative degree of maintenance of biodiversity for each tract. A status of "1" denotes the highest, most permanent level of maintenance, and "4" represents the lowest level of biodiversity management, or unknown status. This is a highly subjective area, and we recognize several limitations in our approach, although we maintain certain principles in assigning the status level. Our first principle is that land ownership is not the primary determinant in assigning status. The second principle is that although data are imperfect and all land is subject to changes in ownership and management, we can use the intent of a land steward as evidenced by legal and institutional factors to assign status. In other words, if a land steward institutes a program backed by legal and institutional arrangements that are intended for permanent biodiversity maintenance, we use that as the guide for assigning status.

The characteristics used to determine status are as follows:

- Permanence of protection from conversion of natural land cover to unnatural (human-induced barren, exotic-dominated, arrested succession).
- Relative amount of the tract managed for natural cover.
- Inclusiveness of the management, i.e., single feature or species versus all biota.
- Type of management and degree that it is mandated through legal and institutional arrangements.

The four status categories can generally be defined as follows (after Crist et al. 1995, Edwards et al. 1995, Scott et al. 1993,):

Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, and intensity) are allowed to proceed without interference or are mimicked through management.

Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities.

Status 3: An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type or localized intense type. It also confers protection to federally listed endangered and threatened species throughout the area.

Status 4: Lack of irrevocable easement or mandate to prevent conversion of natural habitat types to anthropogenic habitat types. Allows for intensive use throughout the tract. Also includes those tracts for which the existence of such restrictions or sufficient information to establish a higher status is unknown.

Mapping Standards

The PRGAP land stewardship map is a 1:100,000-scale version of land ownership and management of Puerto Rico's protected areas, distinguishing local, state, and federal jurisdictions from private lands and delineating areas managed for the long-term maintenance of natural ecological processes and biodiversity. This layer therefore contains attributes for ownership, management, and for the level of biodiversity protection. We used the Lambert Conformal Conic projection, the North American 1983 Grid Coordinate System, and the North American Datum (NAD) 1983 State Plane Puerto Rico Virgin Islands Federal Information Processing Standard (FIPS) 5200 datum. The purpose of the PRGAP land stewardship is to provide a complete digital map of protected areas of Puerto Rico describing land ownership and land management. These data are intended to aid in state-level assessment of natural resources and are not intended for use at a scale greater than 1:100,000.

Stewardship Mapping Methods

Stewardship mapping—

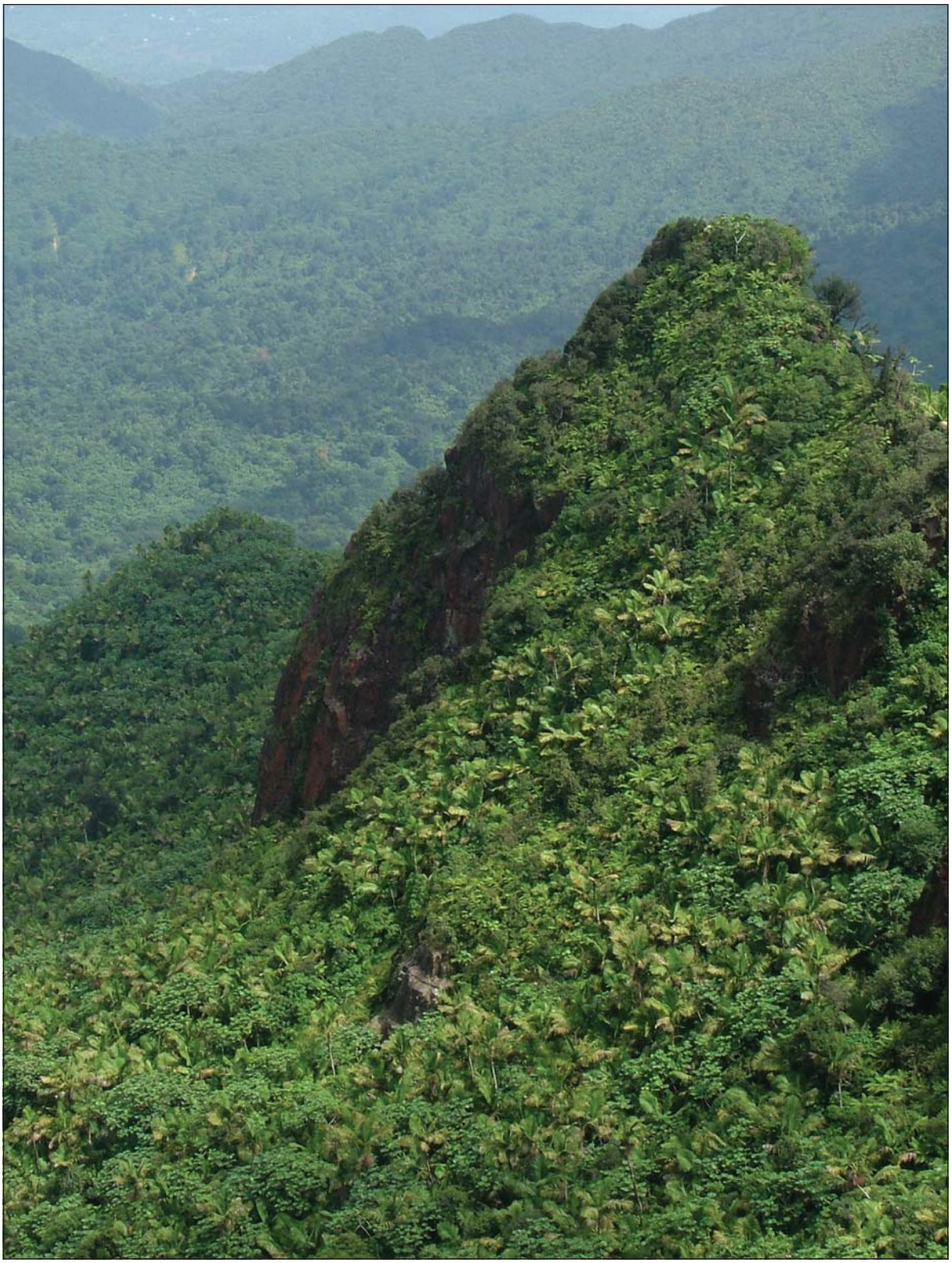
Protected area data sets were obtained from various GIS coordinators in government and nongovernmental agencies in Puerto Rico; the DNER, USFS, USFWS, the Conservation Trust of Puerto Rico, and the Puerto Rico Planning Board. These data sets were provided via disks, e-mail, downloaded from agency electronic bulletin boards, or as hard copy from management plans. Data sets were received in different formats: ArcView[1] shapefiles, ArcInfo coverages, and Arc export files. The data were brought into the land stewardship ArcGIS geodatabase of the PRGAP. After the data were converted to common projections, edge matching and editing were performed. Final mapping was done using ArcGIS 9.0.

Quality control was in the form of site interviews with all land managers, at which time a review of stewardship boundaries was conducted. Suggestions of boundary changes were incorporated when documentation was available from agencies to confirm the corrections.

Management status categorization—

Initially, we used information from the protected area's management plans in order to assign a GAP status code to each land unit. However, only 7 of the 77 protected areas have current management plans. The Puerto Rico Forest Bureau of the DNER is in the process of writing management plans for the state forests. Five additional plans were in development, and three were expired at the time of our interviews. Old management plans do not correctly describe current management practices. The Master Plan for the Commonwealth Forests of Puerto Rico (DRNA 1976) was developed for the state forests when they were being managed as multiple-use forests for timber production, resource management, and recreation. Today, the forests are not producing timber or wood products as in the past, although a small fraction of what was being produced in the 1970s and 1980s is still being used for craft products and fence posts for the state forests themselves. The forests are also seed sources for many of the DNER tree nurseries, which provide trees for reforestation projects on private lands and the forests. The forests are also being managed for biodiversity protection. As there were few active management plans to refer to for information, we conducted one-on-one interviews with land managers. The site visits made it possible to gather information on the land unit's boundaries, species

[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.



Mariano Solórzano

The Sierra palm *Prestoea montana* is abundant on the steep slopes of the Luquillo Mountains in northeastern Puerto Rico.

occurrence records, research areas, areas open to the public, threats (urban encroachment, invasive species, trespassing destruction of land, pollution, exotic species), and needs of the protected area managers to better reach their objectives.

Stewardship Mapping Results

We identified 90 stewardship areas for Puerto Rico. Seventy-seven stewardship areas have some management for conservation (table 8). Land ownership of these areas is shared among 20 organizations (table 9, fig. 32) with the DNER being the primary landowner. Management of land stewardship areas is primarily shared among 13 organizations (figs. 33 and 34, table 10) with the DNER, the USFS, and the USFWS being the primary governmental land managers and the Conservation Trust of Puerto Rico being the primary nongovernmental land manager.

Altogether, 7.6 percent of Puerto Rico has some management for conservation (GAP status 1, 2, or 3) and 7.4 percent of Puerto Rico has good management of conservation (GAP status 1 or 2) (fig. 35). Most of this management is under GAP status 2, management for natural resources, and this includes most of the commonwealth forests and reserves. Areas with a priority on biodiversity conservation (GAP status 1) include two management areas in the Luquillo Experimental Forest (Caribbean National Forest): The Baño del Oro and the El Toro Wilderness area (figs. 35 and 36). Fifty-nine percent of the stewardship areas are managed by commonwealth agencies, 30 percent by federal agencies, and 11 percent by nongovernmental or private agencies (fig. 37).

Stewardship Map Limitations

These data and maps are a compilation of ownership maps provided by a variety of sources that are individually responsible for their accuracy. They were created solely for the purpose of conducting the analyses described in this report and are not suitable for locating boundaries on the ground or determining precise area measurements of individual tracts. Land ownership, management, and land use are very dynamic. At the writing of this report, several areas were under consideration for either development, conservation, or some combination of these activities. This includes the former naval bases at Roosevelt Roads and Sabana Seca, public and private lands in the Northeast Ecological Corridor, the Piñones area, a potential ecological corridor linking the central mountain reserves with the northern karst and coastal plain, and the ecologically valuable northern karst region.

Table 8—Stewardship areas in Puerto Rico, area and percentage of total by management class

Area name	Class	Gap status 1		2		3		4		Total	
		Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%
Management for biodiversity conservation											
Area Natural Protegida Cañón de San Cristóbal	Nongovernmental			497	0.9					497	< 0.1
Area Natural Protegida Jorge Sotomayor del Toro	Nongovernmental			16	< 0.1					16	< 0.1
Area Natural Protegida Rio Encantado	Nongovernmental			284	0.5					284	< 0.1
Bosque de Pterocarpus de Dorado	Nongovernmental	12	0.1							12	< 0.1
Bosque del Pueblo de Adjuntas	Nongovernmental			418	0.8					418	< 0.1
Bosque Estatal de Aguirre	Commonwealth			432	0.8					432	< 0.1
Bosque Estatal de Boquerón	Commonwealth	623	5.7							623	< 0.1
Bosque Estatal de Cambalache	Commonwealth			649	1.2					649	< 0.1
Bosque Estatal de Carite	Commonwealth			2700	4.9					2700	0.3
Bosque Estatal de Ceiba	Commonwealth			119	0.2	118	5.5			237	< 0.1
Bosque Estatal de Cerrillos	Commonwealth			220	0.4					220	< 0.1
Bosque Estatal de Guajataca	Commonwealth			955	1.7					955	0.1
Bosque Estatal de Guánica	Commonwealth			3832	6.9					3832	0.4
Bosque Estatal de Maricao	Commonwealth			4168	7.6					4168	0.5
Bosque Estatal de Monte Guilarte	Commonwealth			1705	3.1					1705	0.2
Bosque Estatal de Piñones	Commonwealth			732	1.3					732	< 0.1
Bosque Estatal de Río Abajo	Commonwealth			2284	4.1					2284	0.3
Bosque Estatal de Susúa	Commonwealth			1298	2.4					1298	0.1
Bosque Estatal de Toro Negro	Commonwealth			2763	5.0					2763	0.3
Bosque Estatal de Tres Picachos	Commonwealth			2097	3.8					2097	0.2
Bosque Estatal de Vega	Commonwealth			482	0.9					482	< 0.1
Bosque La Olimpia	Nongovernmental			185	0.3					185	< 0.1
Bosque Urbano de San Patricio	Commonwealth			40	0.1					40	< 0.1
Bosque Urbano del Nuevo Milenio	Commonwealth			176	0.3					176	< 0.1
Bosque Urbano Doña Inez Mendoza	Nongovernmental					99	4.6			99	< 0.1
Cabo Rojo National Wildlife Refuge	Federal					758	35.1			758	< 0.1
Camp Santiago U.S. Military Reservation	Federal /nongovernmental			2916	5.3			2213	0.3	5129	0.6
Camuy Caves Park	Commonwealth					104	4.8			104	< 0.1
Corredor Ecologico de San Juan	Commonwealth					24	1.1			24	< 0.1
Culebra National Wildlife Refuge	Federal	603	5.5							603	< 0.1
Desecheo National Wildlife Refuge	Federal			131	0.2					131	< 0.1
El Yunque National Forest	Federal	7162	65.2	4267	7.7					11 429	1.3

Table 8—Stewardship areas in Puerto Rico, area and percentage of total by management class (continued)

Area name	Class	Gap status 1		2		3		4		Total	
		Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%
Estación Experimental Agrícola	Commonwealth	22	0.2							22	< 0.1
Finca Guillermeti	Nongovernmental			195	0.4					195	< 0.1
Jardín Botánico de la Universidad de Puerto Rico	Commonwealth					125	5.8			125	< 0.1
Laguna Cartagena National Wildlife Refuge	Federal			109	0.2	314	14.6			423	< 0.1
Parque Nacional Sun Bay	Commonwealth					23	1.1			23	< 0.1
Refugio de Vida Silvestre de Boquerón	Commonwealth			235	0.4					235	< 0.1
Refugio de Vida Silvestre Lago Guajataca	Commonwealth					272	12.6			272	< 0.1
Refugio de Vida Silvestre Lago La Plata	Commonwealth					188	8.7			188	< 0.1
Refugio de Vida Silvestre Lago Luchetti	Commonwealth					94	4.4			94	< 0.1
Reserva Nacional de Investigación Estuarina de Bahía de Jobos	Commonwealth	414	3.8	35	0.1					449	< 0.1
Reserva Natural Aguas Buenas	Commonwealth	709	6.5							709	< 0.1
Reserva Natural Arrecifes de la Cordillera	Commonwealth	21	0.2	63	0.1	4	0.2			88	< 0.1
Reserva Natural Bahía Ballena	Nongovernmental			97	0.2					97	< 0.1
Reserva Natural Bosque de Pterocarpus de Humacao	Nongovernmental	285	2.6							285	< 0.1
Reserva Natural Caja de Muertos	Commonwealth			188	0.3					188	< 0.1
Reserva Natural Caño La Boquilla	Commonwealth	70	0.6							70	< 0.1
Reserva Natural Caño Martin Peña	Commonwealth			107	0.2					107	< 0.1
Reserva Natural Caño Tiburones de Arecibo	Commonwealth			1933	3.5					1933	0.2
Reserva Natural Cerro El Buey	Nongovernmental			323	0.6					323	< 0.1
Reserva Natural Cueva del Indio	Commonwealth			6	0.0					6	< 0.1
Reserva Natural de Humacao	Commonwealth			898	1.6					898	0.1
Reserva Natural de Isla de Mona	Commonwealth	15	0.1	5671	10.3					5686	0.6
Reserva Natural de la Bahía Bioluminiscente de Vieques	Commonwealth			414	0.7					414	< 0.1
Reserva Natural de la Finca Seven Seas	Commonwealth	83	0.8							83	< 0.1
Reserva Natural de La Parguera	Nongovernmental	408	3.7							408	< 0.1
Reserva Natural de Laguna de Joyuda	Commonwealth			178	0.3					178	< 0.1
Reserva Natural de Punta Guaniquilla	Commonwealth			15	0.0					15	< 0.1
Reserva Natural del Río Espíritu Santo	Commonwealth			871	1.6					871	< 0.1
Reserva Natural Finca Belvedere	Commonwealth			162	0.3					162	< 0.1
Reserva Natural Hacienda Buena Vista	Nongovernmental			35	0.1					35	< 0.1
Reserva Natural Hacienda la Esperanza	Nongovernmental			924	1.7					924	0.1

Table 8—Stewardship areas in Puerto Rico, area and percentage of total by management class (continued)

Area name	Class	Gap status 1		2		3		4		Total	
		Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%
Reserva Natural Inés María Mendoza (Punta Yeguas)	Nongovernmental	130	1.2							130	< 0.1
Reserva Natural La Cienaga Las Cucharillas	Commonwealth			396	0.7					396	< 0.1
Reserva Natural La Parguera	Commonwealth			23	< 0.1					23	< 0.1
Reserva Natural Laguna Tortuguero	Commonwealth	273	2.5	992	1.8					1265	0.1
Reserva Natural Las Cabezas de San Juan	Nongovernmental			225	0.4					225	< 0.1
Reserva Natural Las Piedras del Collado	Commonwealth	8	0.1							8	< 0.1
Reserva Natural Mata de Platano Field Station	Nongovernmental	144	1.3							144	< 0.1
Reserva Natural Pantano de Cibuco	Commonwealth			267	0.5					267	< 0.1
Reserva Natural Punta Guaniquilla	Nongovernmental			166	0.3					166	< 0.1
Reserva Natural Punta Petrona	Commonwealth			175	0.3					175	< 0.1
Reserva Natural Punta Tuna	Commonwealth			52	0.1					52	< 0.1
San Juan National Historic Site	Federal					32	1.5			32	< 0.1
Servidumbre Escenica Río Portugues	Nongovernmental			14	< 0.1					14	< 0.1
Vieques National Wildlife Refuge	Federal			7070	12.8					7070	0.8
No management for biodiversity conservation											
Fort Allen Naval Radio Station	Federal							366	< 0.1	366	< 0.1
Fort Buchanan Military Reservation	Federal							276	< 0.1	276	< 0.1
Isla Grande Airport	Federal							102	< 0.1	102	< 0.1
Parque Nacional Punta Guilarte	Commonwealth							101	< 0.1	101	< 0.1
Ramey Air Force Base	Federal							1102	0.1	1102	0.1
Reserva Natural Torrecilla Alta (proposed)	Commonwealth							1599	0.2	1599	0.2
Roosevelt Roads Naval Reservation	Federal							3483	0.4	3483	0.4
Sabana Seca U.S. Naval Radio Station	Federal							920	0.1	920	0.1
Sierra Bermeja	Private							899	0.1	899	0.1
U.S. Military Reservation Aguadilla	Federal							459	< 0.1	459	< 0.1
U.S. Naval Radio Transmitter Facility Aguada	Federal							164	< 0.1	164	< 0.1
U.S. Naval Radio Transmitter Facility Aguadilla	Federal							156	< 0.1	156	< 0.1
Non-Stewardship Areas	Private/other							814 730	98.6	814 730	91.0
Total		10 983	100	55 205	100	2156	100	826 571	100	894 913	100

Note: Seventy-seven of the 90 stewardship areas have some management for biodiversity conservation (GAP status 1 through 3). Thirteen areas have no management for biodiversity conservation and are either proposed for future conservation management or have other civilian and military uses.

Table 9—Landowners of stewardship areas, area and percentage of total by management class

Owner	Class	Gap status 1		2		3		4		Total	
		Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%
ACT	Commonwealth			175	0.3					175	< 0.1
Citizens of the Karst Foundation	Nongovernmental	144	1.3	195	0.4					341	< 0.1
Commonwealth and other public or private entities	Commonwealth			861	1.6			23		886	< 0.1
Conservation Trust of Puerto Rico	Nongovernmental	835	7.6	2483	4.5					3330	0.4
Department of Natural and Environmental Resources	Commonwealth	1932	17.6	29 665	53.7	23	1.1			31 694	3.5
Department of Natural and Environmental Resources and the Conservation Trust of Puerto Rico	Commonwealth/ nongovernmental			97	0.2					97	< 0.1
Electrical Energy Authority	Commonwealth			173	0.3	555	26.0			754	< 0.1
Industrial Development Company	Commonwealth			63	0.1	4	0.2			67	< 0.1
Land Administration	Commonwealth	273	2.5	1993	3.6	340	15.9			2629	0.3
Land Authority	Commonwealth	22	0.2	4436	8.0	80	3.7	1700	0.2	6250	0.7
Luis Muñóz Marín Foundation						99	4.7			104	< 0.1
National Parks Company of Puerto Rico	Commonwealth			414	0.7					415	< 0.1
U.S. Army Corps of Engineers	Federal			220	0.4					220	< 0.1
U.S. Department of Defense	Federal			2916	5.3	118	5.5	5758	0.7	8802	1.0
U.S. Fish and Wildlife Service	Federal	575	5.2	7202	13.0	758	35.5			8588	1.0
U.S. Forest Service	Federal	7162	65.2	4267	7.7					11 502	1.3
U.S. National Park Service	Federal					32	1.5			34	< 0.1
U.S. Navy	Federal			45	< 0.1			3483	0.4	3528	0.4
University of Puerto Rico	Commonwealth	11	0.1			125	5.8			141	< 0.1
Private/other	Private	28	0.3					815 329	98.7	815 329	91.1
Total		10 983	100	55 204	100	2134	100	826 294	100	894 913	100

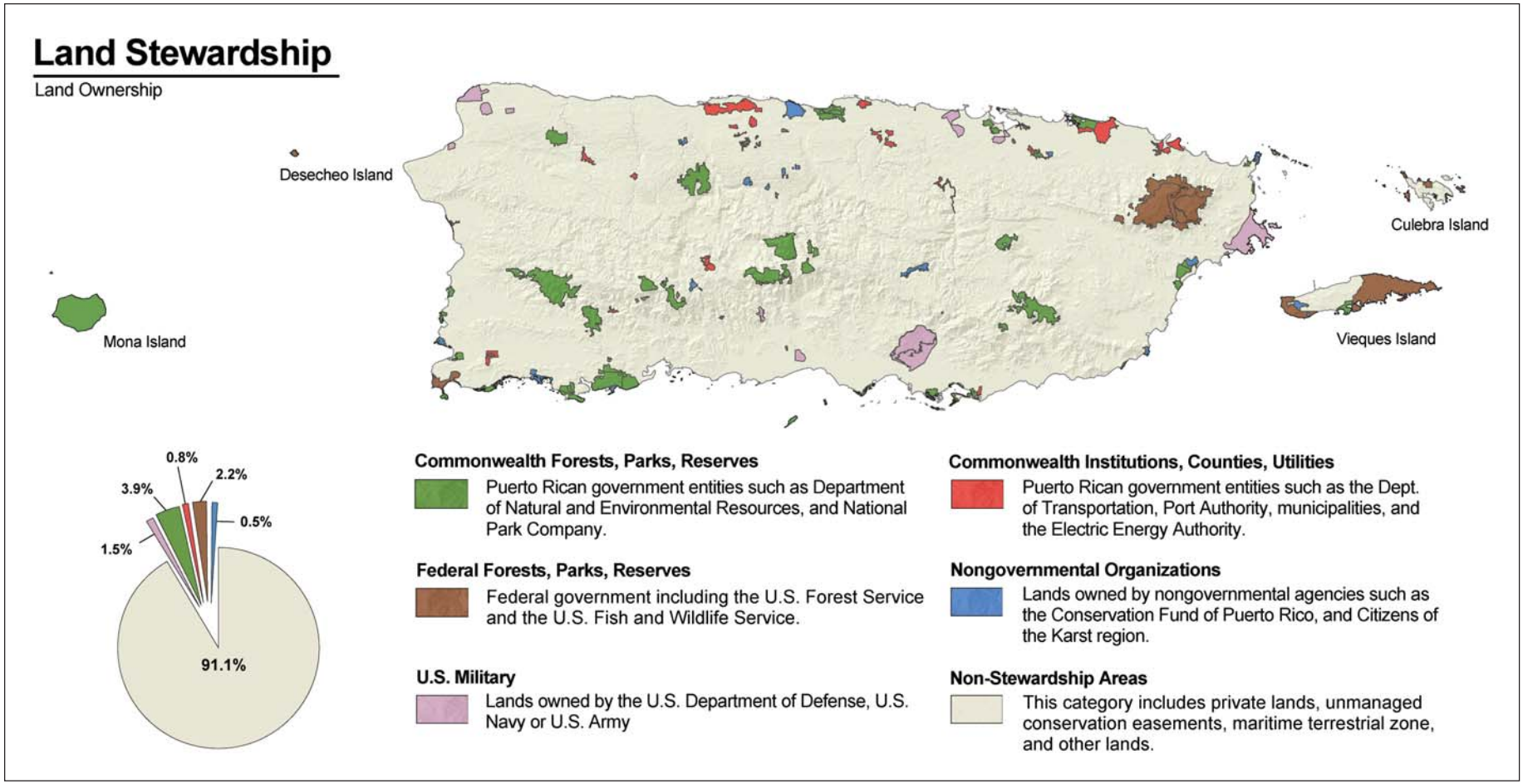


Figure 32—Landowners of stewardship areas in Puerto Rico (Gould et al. 2008e).

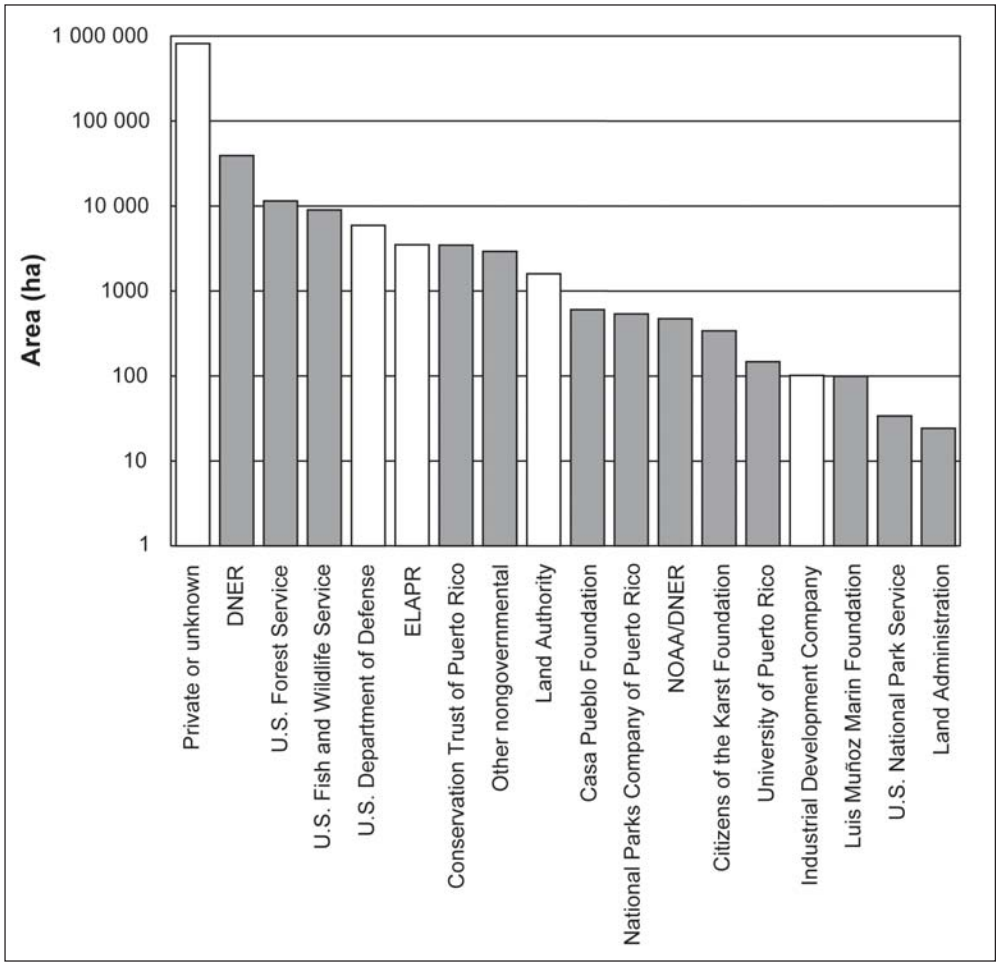


Figure 33—Primary land managers and the number of hectares managed in Puerto Rico under GAP management status 1, 2, 3, or 4. Entities with clear bars have no management for conservation (GAP status 4). Entities with dark bars are in part or all managed for conservation (GAP status 1 through 3). Note the scale is logarithmic. DNER = Puerto Rico Department of Natural and Environmental Resources, ELAPR = Estado Libre Associado de Puerto Rico (the commonwealth government), NOAA = the National Oceanic and Atmospheric Administration.

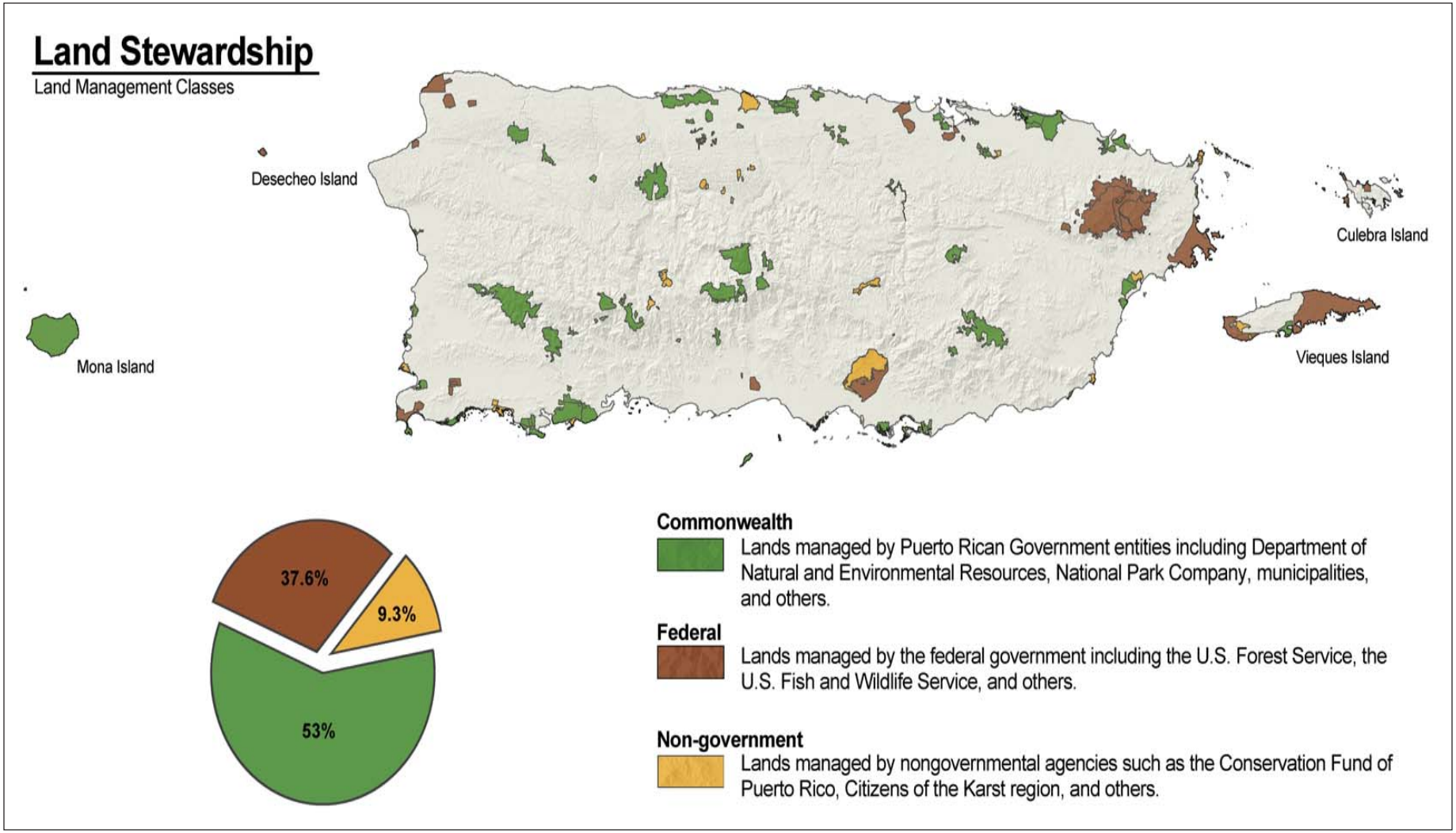


Figure 34—Land management of stewardship areas in Puerto Rico (Gould et al. 2008f).

Table 10—Land managers of stewardship areas, area and percentage of total

Manager	Gap status 1		2		3		4		Total	
	Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%
Citizens of the Karst Foundation	144	1.31	195	0.36					341	< 0.1
Industrial Development Company							101	< 0.1	101	< 0.1
Conservation Trust of Puerto Rico	705	6.42	2580	4.73					3296	0.37
Conservation Trust of Puerto Rico and Department of Natural and Environmental Resources	130	1.18							131	< 0.1
Department of Natural and Environmental Resources	1802	16.41	36 847	67.48	559	25.91			39 318	4.40
Department of Natural and Environmental Resources and NOAA	414	3.77	35	< 0.1					453	< 0.1
Commonwealth of Puerto Rico							3483	0.42	3483	0.39
Land Administration					24	1.12			25	< 0.1
Land Authority							1599	0.19	1599	0.18
Luis Muñóz Marín Foundation					99	4.61			104	< 0.1
National Parks Company of Puerto Rico			406	0.74	128	5.92			541	< 0.1
Other nongovernmental entities			2916	5.34					2921	0.33
Other private entities							899	0.11	899	0.10
University of Puerto Rico	22	0.20			125	5.77			153	< 0.1
U.S. Air Force							1102	0.13	1102	0.12
U.S. Army							2673	0.32	2673	0.30
U.S. Fish and Wildlife Service	603	5.49	7311	13.39	1072	49.72			9054	1.01
U.S. Forest Service	7162	65.21	4267	7.81					11 502	1.29
U.S. National Park Service					32	1.49			34	< 0.1
U.S. Navy			45	< 0.1	118	5.45	1983	0.24	2151	0.24
None or unknown							815 033	98.57	815 033	91.06
Total	10 983	100	54 601	100	2156	100	826 874	100	894 913	100

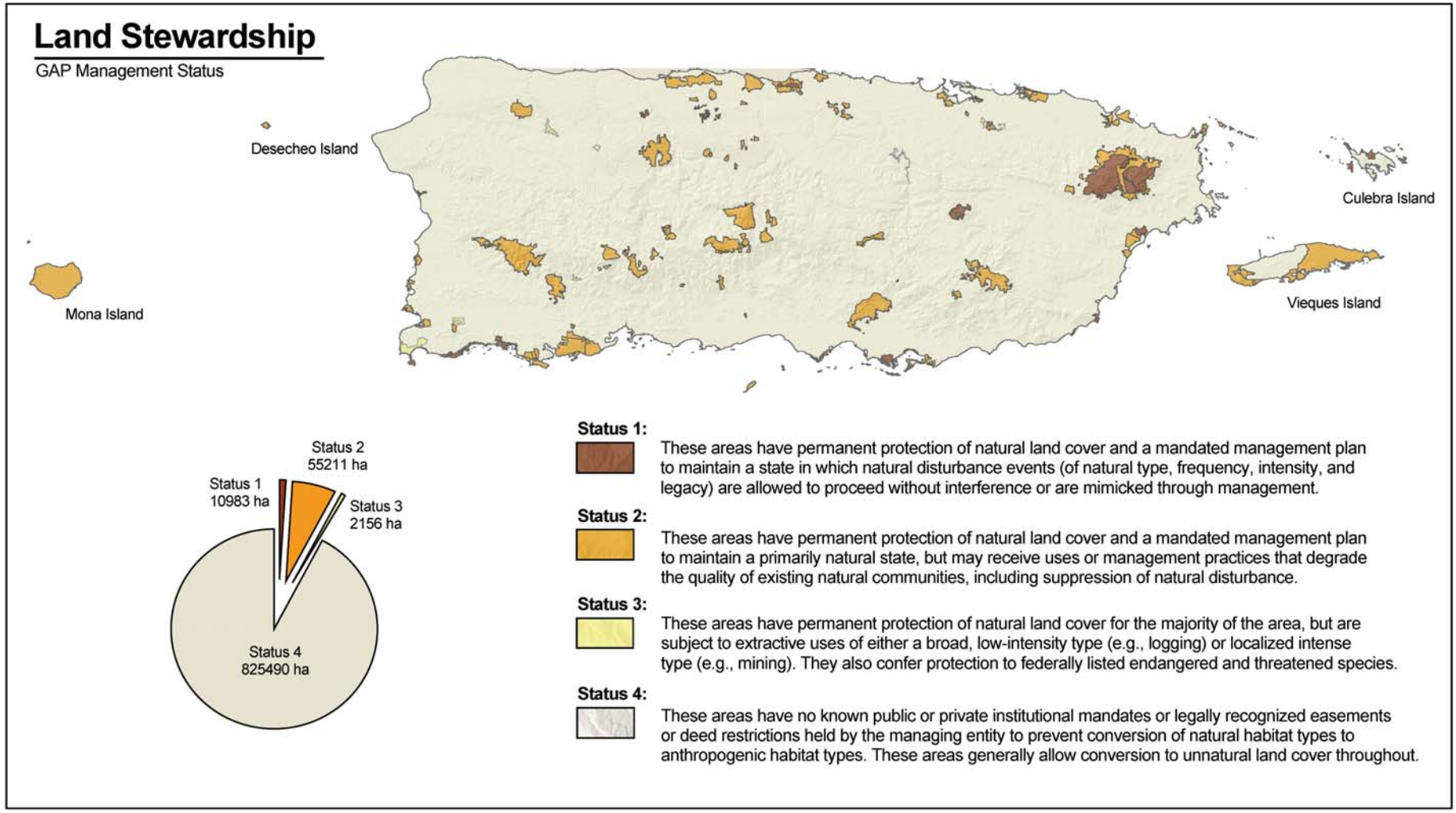


Figure 35—Priority given to conservation (GAP status levels 1 through 4) in stewardship areas in Puerto Rico (Gould et al. 2008g).

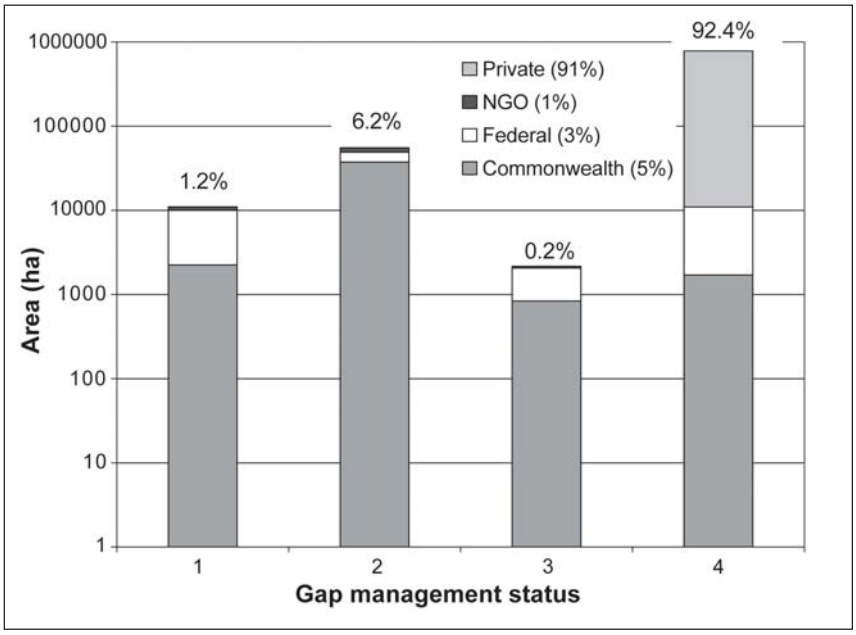


Figure 36—Number of hectares and managing agencies in GAP status 1, 2, 3, and 4 for Puerto Rico. Note scale is logarithmic. NGO = nongovernmental organization.

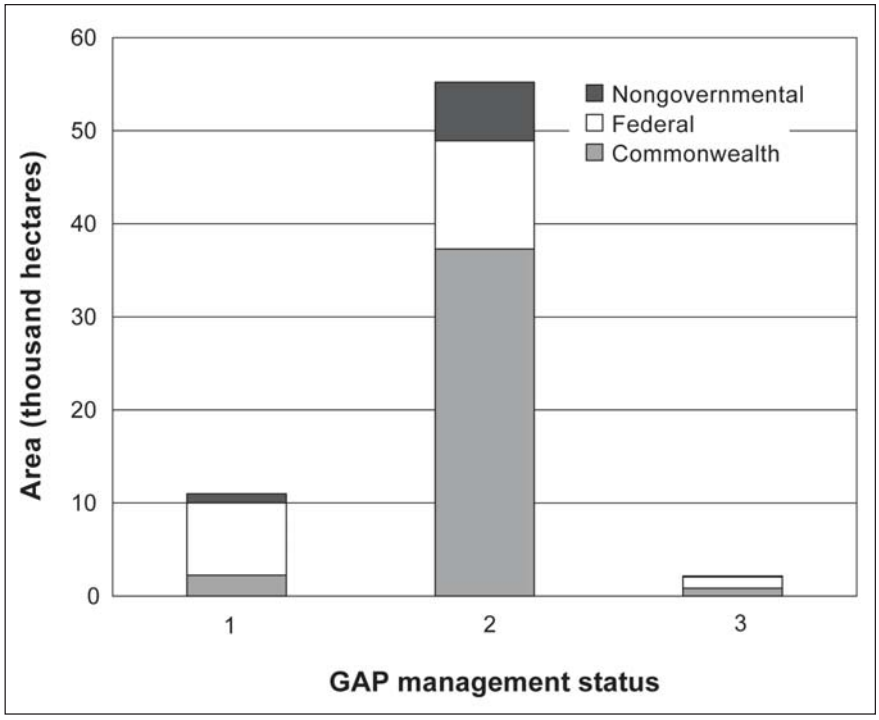


Figure 37—Number of hectares of areas with some management for biodiversity conservation (GAP status 1 through 3), by managing agency.

Analysis Based on Stewardship and Management Status

This section describes the method and results of the gap analysis as used by the Gap Analysis Program. The primary objective of GAP is to provide information on the distribution and status of elements of biological diversity. Although GAP seeks to identify habitat types and species not adequately represented in the current network of biodiversity management areas, a standard definition of "adequate representation" for land cover types or individual species is difficult (Noss et al. 1995). A practical solution to this problem is to report both percentages and absolute area of each element in protected areas and allow the user to determine which classes are adequately represented. There are many other factors that should be considered in such determinations:

- Loss or gain in historical distribution.
- Nature of the spatial distribution.
- Immediate versus long-term risk.
- Degree of local adaptation among populations of the biotic elements that are worthy of individual conservation consideration.

Such analyses are beyond the scope of this project, but we encourage their application coupled with field confirmation of the mapped distributions.

Currently, land cover types and terrestrial vertebrates are the primary focus of GAP's mapping efforts; however, other components of biodiversity, such as aquatic organisms or selected groups of invertebrates may be incorporated into GAP distributional data sets. Where appropriate, GAP data may also be analyzed to identify the location of a set of areas in which most or all land cover types or species are predicted to be represented. The use of "complementarity" analysis, that is, an approach that additively identifies a selection of locations that together may represent biodiversity rather than "hot spots of species richness" may prove most effective for guiding biodiversity maintenance efforts. Several approaches have been developed that facilitate this process (Csuti et al. 1997, Jennings 2000, Peterson and Klusa 2003, Pressey et al. 1993, Sowa et al. 2007, Williams et al. 1996, Vierling et al. 2007). These areas become candidates for field validation and may be incorporated into a system of areas managed for the long-term maintenance of biological diversity.

The network of Conservation Data Centers (CDCs) and Natural Heritage Programs established cooperatively by The Nature Conservancy and various state agencies maintain detailed databases on the locations of rare elements of

biodiversity. The GAP cooperatively uses these data to develop predicted distributions of potentially suitable habitat for these elements, which may be valuable for identifying research needs and preliminary considerations for restoration or reintroduction. Conservation of such elements, however, is best accomplished through the fine-filter approach of the above organizations as described in the introduction. It is not the role of GAP to duplicate or disseminate Heritage Program or CDC element occurrence records. Users interested in more specific information about the location, status, and ecology of populations of such species are directed to their state Heritage Program or CDC.

Analysis Methods

The gap analysis is accomplished by first producing maps of land cover (fig. 12), predicted distributions for selected animal species (fig. 15 and see volume 4), and land stewardship and management status (fig. 35). Intersecting the land stewardship and management map with the distribution of the elements results in tables that summarize the area and percentage of total mapped distribution of each element in different land stewardship and management categories. We created a raster image of the stewardship GAP status categories 1 through 4 using ERDAS Imagine 9.1 and intersected this with our land cover classes and with our individual species predicted habitat distributions. The resulting output includes the number of hectares of each species or land cover unit in each GAP status category.

Analysis Results

The data are provided in a format that allows users to carry out inquiries about the representation of each element in different land stewardship and management categories as appropriate to their own management objectives. This forms the basis of GAP's mission to provide landowners and managers with the information necessary to conduct informed policy development, planning, and management for biodiversity maintenance.

Land cover analysis—
Table 11 provides the area in hectares of each mapped cover type by status and the percentage of the total area in that cover type. For example, a typical entry indicates that freshwater *Pterocarpus* swamp covers 261 ha and that 172 ha is ranked status 1 or 2, which represents 66.1 percent of the 261 ha in that type.

Mariano Solórzano

Mangrove forests play an important role in harboring fish, crabs, and birds along Puerto Rico's coastlines.

As a coarse indicator of the status of the elements, we provide a breakdown along five levels of protection (0 to <1 percent, 1 to <10 percent, 10 to <20 percent, 20 to <50 percent, ≥50 percent). The <1 percent level indicates those elements with essentially none of their distribution in a protected status; while levels of 10, 20, and 50 percent have been recommended in the literature as necessary amounts of conservation (McNeely and Miller 1994, Noss and Cooperrider 1994, Odum and Odum 1972, Ride 1975). Summaries of the analysis according to the thresholds described above are shown in table 11.

Land cover with <1 percent in GAP status 1 or 2—
These eight land cover classes range from the smallest to largest in extent. They make up 43 percent of the island and are primarily subject to intensive human use such as agriculture, housing, and development. The class of moist grasslands and pastures covers nearly one-fourth of the island and is primarily abandoned agricultural land. Given the resilience of the natural vegetation in Puerto Rico, this land cover type has potential for management for reforestation or as natural grasslands. As a group, 0.7 percent is protected under GAP status 1 or 2.

Land cover with 1 to <10 percent in GAP status 1 or 2—
Twenty-seven land cover units fall in this category and they account for 44 percent of the island. They range from an extent of less than 1 to over 6 percent of the island. They contain a number of young secondary forest and woodland land cover classes, as well as artificial and natural barrens, active and abandoned shade coffee plantations, dry grasslands and pastures, riparian forests, and four mature secondary forest classes. As a group, 3.8 percent of these units are protected under GAP status 1 or 2.

Land cover with l0 to <20 percent in GAP status 1 or 2—
Four land unit classes fall in this category and they account for 1.7 percent of the island. They include two woodland or shrubland classes–which usually occur on abandoned agricultural land, a dryland riparian forest, and palm plantations. For the group, 16.2 percent is protected under GAP status 1 or 2.

Land cover with 20 to <50 percent in GAP status 1 or 2—
Fourteen land cover classes fall in this group, and they account for 6.1 percent of the island. They include a number of ecologically important areas including beaches and shorelines, mature forests, wetlands, mangrove complexes, and Sierra palm forest. For the group, 36.5 percent is protected under GAP status 1 or 2.

Nestor Pérez

The Mona Island rock iquana *Cyclura stejnegeri* is endemic to Mona Island

Table 11—Area in hectares, percentage of total, and protection category for each land cover type

Landcover type	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protection category
	Ha	*%*	*Ha*	*%*	*Ha*	*%*	*Ha*	*%*	*Ha*	*%*	*Ha*	*%*	
Puerto Rico	894 912	100	66 275	7.4	11 240	1.3	55 035	6.1	2253	0.3	826 385	92	4
Dry forest, woodland, and shrubland													
Mature secondary lowland dry alluvial semideciduous forest	1548	0.2	732	47.3	32	2.0	700	45.3	1	0.1	814	52.6	2
Young secondary lowland dry alluvial semideciduous forest	2881	0.3	62	2.2	5	0.2	57	2.0	14	0.5	2805	97.4	4
Lowland dry alluvial shrubland and woodland	4472	0.5	299	6.7	33	0.7	266	6.0	166	3.7	4007	89.6	4
Lowland dry riparian forest	806	0.1	120	14.9	6	0.8	114	14.1	0	0	686	85.1	3
Lowland dry riparian shrubland and woodland	423	0.5	15	3.5	1	0.3	14	3.2	0	0	408	96.5	4
Mature secondary lowland dry limestone evergreen forest	982	0.1	207	21.1	0	0	207	21.1	0	0	776	78.9	2
Mature secondary lowland dry limestone semideciduous forest	10 669	1.2	3871	36.3	33	0.3	3838	36.0	3	0	6795	63.7	2
Young secondary lowland dry limestone semideciduous forest	3922	0.4	163	4.2	23	0.6	140	3.6	13	0.3	3745	95.5	4
Lowland dry limestone woodland and shrubland	8181	0.9	3535	43.2	40	0.5	3495	42.7	0	0	4645	56.8	2
Lowland dry limestone shrubland	4694	0.5	1336	28.5	66	1.4	1270	27.1	64	1.4	3294	70.2	2
Lowland dry cactus shrubland	47	0	47	100	0	0	47	100	0	0	0	0.0	1
Coastal dwarf woodland and shrubland	103	0	103	100	0	0	103	100	0	0	0	0.0	1
Lowland dry limestone cliffside semideciduous forest	12	0	12	100	0	0	12	100	0	0	0	0.0	1
Lowland dry limestone cliffside shrubland and woodland	49	0	49	100	0	0	49	100	0	0	0	0.0	1
Abandoned dry forest plantation	81	0	81	100	0	0	81	100	0	0	0	0.0	1
Mature secondary lowland dry noncalcareous semideciduous forest	7062	0.8	3818	54.1	319	4.5	3499	49.5	0	0	3244	45.9	1
Young secondary lowland dry noncalcareous semideciduous forest	3644	0.4	285	7.8	4	0.1	281	7.7	1	0	3358	92.2	4
Lowland dry noncalcareous shrubland and woodland	13 307	1.5	2214	16.6	203	1.5	2011	15.1	6	0.1	11 086	83.3	3
Mature secondary dry and moist serpentine semideciduous forest	1839	0.2	379	20.6	0	0	379	20.6	0	0	1460	79.4	2
Young secondary dry and moist serpentine semideciduous forest	1960	0.2	1081	55.1	0	0	1081	55.1	0	0	879	44.9	1
Dry and moist serpentine woodland and shrubland	841	0.1	86	10.2	0	0	86	10.2	0	0	755	89.8	3

Table 11—Area in hectares, percentage of total, and protection category for each land cover type (continued)

Landcover type	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protection category
	Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Moist forest, woodland, and shrubland													
Mature secondary lowland moist alluvial evergreen forest	2256	0.3	165	7.3	8	0.4	157	7.0	1	0	2091	92.6	4
Young secondary lowland moist alluvial evergreen forest	6675	0.8	316	4.7	13	0.2	303	4.5	10	0.1	6350	95.1	4
Lowland moist alluvial shrubland and woodland	5141	0.6	128	2.5	7	0.1	121	2.4	6	0.1	5007	97.4	4
Lowland moist riparian forest	916	0.1	48	5.3	3	0.3	46	5.0	6	0.7	862	94.0	4
Lowland moist riparian shrubland and woodland	508	0.1	30	6.0	0	0	30	6.0	0	0	478	94.0	4
Mature secondary moist limestone evergreen and semideciduous forest	46 423	5.2	4370	9.4	121	0.3	4249	9.4	4	0	42 049	90.6	4
Young secondary moist limestone evergreen and semideciduous forest	15 494	1.7	169	1.1	5	0	164	1.1	94	0.6	15 231	98.3	4
Moist limestone shrubland and woodland	10 338	1.2	298	2.9	10	0.1	288	2.8	6	0.1	10 034	97.1	4
Mature secondary lowland moist noncalcareous evergreen forest	40 446	4.5	1305	3.2	255	0.6	1050	2.6	0	0	39 140	96.8	4
Young secondary lowland moist noncalcareous evergreen forest	52 980	5.9	438	0.8	161	0.3	277	0.5	110	0.2	52 432	99.0	5
Lowland moist noncalcareous shrubland and woodland	44 523	5.0	461	1.0	100	0.2	361	0.8	28	0.1	44 034	98.9	4
Lowland moist abandoned and active coffee plantations	11 068	1.2	121	1.1	23	0.2	98	0.9	0	0	10 947	98.9	4
Wet forest, woodland, and shrubland													
Mature secondary montane wet alluvial evergreen forest	613	0.1	139	22.7	10	1.6	130	21.1	0	0	474	77.3	2
Young secondary montane wet alluvial evergreen forest	988	0.1	17	1.7	1	0.1	16	1.6	0	0	971	98.3	4
Montane wet alluvial shrubland and woodland	900	0.1	6	0.7	0	0	6	0.7	0	0	894	99.3	5
Mature secondary montane wet noncalcareous evergreen forest	25 207	2.8	642	4.3	0	0	642	4.3	0	0	14 326	95.7	4
Montane wet evergreen abandoned and active coffee plantation	54 859	6.1	839	1.5	0	0	839	1.5	0	0	54 021	98.5	4
Mature primary and secondary montane wet noncalcareous evergreen tabonuco forest	8715	1.0	5114	57.8	2028	22.9	3086	34.9	0	0	3742	42.3	1
Mature primary and secondary montane wet noncalcareous evergreen palo colorado cloud forest	3712	0.4	7870	50.5	3401	21.8	4470	28.7	0	0	7713	49.5	1

Table 11—Area in hectares, percentage of total, and protection category for each land cover type (continued)

Landcover type	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protection category
	Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Mature primary and secondary montane wet noncalcareous evergreen sierra palm forest	11 953	1.3	3323	37.8	1388	15.8	1935	22.0	0	0	5458	62.2	2
Mature primary and secondary montane wet noncalcareous evergreen elfin woodland cloud forest	1537	0.2	1639	55.8	215	7.3	1424	48.5	0	0	1297	44.2	1
Young secondary montane wet noncalcareous evergreen forest	21 651	2.4	381	1.8	64	0.3	317	1.5	0	0	21 271	98.2	4
Montane wet evergreen noncalcareous shrubland and woodland	24 090	2.7	469	2.0	45	0.2	424	1.8	0	0	23 621	98.1	4
Mature secondary montane wet serpentine evergreen forest	3379	0.4	2889	85.5	0	0	2889	85.5	0	0	490	14.5	1
Young secondary montane wet serpentine evergreen forest	651	0.1	422	64.8	0	0	422	64.8	0	0	230	35.2	1
Wet serpentine shrubland and woodland	358	0	220	61.5	0	0	220	61.5	0	0	138	38.5	1
Flooded forest, woodland, and shrubland													
Mangrove forest and shrubland	8700	1.0	3999	46.0	890	10.2	3109	35.7	17	0.2	4683	53.8	2
Freshwater *Pterocarpus* swamp	261	0	172	66.1	75	28.9	97	37.2	88	33.9	0	0.0	1
Grasslands													
Dry grasslands and pastures	42 176	4.7	2851	6.8	209	0.5	2642	6.3	462	1.1	38 863	92.1	4
Dry cactus grassland and shrubland	213	0	202	94.9	0	0	202	94.9	0	0	11	5.1	1
Moist grasslands and pastures	218 945	24.5	1984	0.9	304	0.1	1679	0.8	81	0	216 880	99.1	5
Herbaceous wetlands													
Seasonally flooded herbaceous nonsaline wetlands	18 225	2.0	894	4.9	106	0.6	788	4.3	163	0.9	17 167	94.2	4
Seasonally flooded herbaceous saline wetlands	4865	0.5	1290	26.5	86	1.8	1204	24.8	1	0	3574	73.5	2
Emergent herbaceous nonsaline wetlands	1102	0.1	107	9.7	0	0	107	9.7	39	3.5	956	86.8	4
Emergent herbaceous saline wetlands	882	0.1	332	37.6	31	3.6	300	34.1	0	0	550	62.4	2
Agriculture													
Hay and row crops	25 764	3.0	179	0.7	25	0.1	154	0.6	9	0	25 576	99.3	5
Woody agriculture and plantations	492	0.1	76	15.4	1	0.2	75	15.2	0	0	417	84.6	3

Table 11—Area in hectares, percentage of total, and protection category for each land cover type (continued)

Landcover type	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protection category
	Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Natural barrens													
Rocky cliffs and shelves	397	0	215	54.1	59	14.7	157	39.4	2	0.5	180	45.4	1
Gravel beaches and stony shoreline	82	0	31	37.7	9	10.4	22	27.4	0	0	51	62.3	2
Fine to coarse sandy beaches, mixed sand and gravel beaches	1155	0.1	260	22.5	33	2.9	227	19.7	21	1.8	874	75.7	2
Riparian and other natural barrens	449	0.1	6	1.3	0	0	6	1.32	2	0.4	441	98.2	4
Salt and mudflats	1493	0.2	439	29.4	144	9.6	296	19.8	260	17.4	793	53.1	2
Developed areas													
Artificial barrens	8674	1.0	108	1.2	0	0	108	1.2	0	0	8566	98.8	4
Salt production	20	0	0	0	0	0	0	0	20	100	0	0.0	5
High-density urban development	52 335	5.9	58	0.1	0	0	58	0.1	23	0.04	52 254	99.8	5
Low-density urban development	37 237	4.2	225	0.6	30	0.1	194	0.5	33	0.1	36 979	99.3	5
Water													
Freshwater	4433	0.5	242	5.5	1	0	241	5.4	520	11.7	3671	82.8	4
Saline water	4005	0.5	2291	57.2	616	15.4	1675	41.8	64	1.6	1650	41.2	1
Aquaculture	101	0	0	0	0	0	0	0	0	0	101	100.0	5

Note: Protection category 1 = ≥50 percent protected, 2 = 20 to < 50 percent protected, 3 = 10 to < 20 percent protected, 4 = 1 to < 10 percent protected, 5 = < 1 percent protected.

Land cover with at least 50 percent in GAP status 1 or 2—
Seventeen land cover units are over 50 percent protected under GAP status 1 or 2 and they account for 5.1 percent of the island. They include important primary and mature secondary forest types in the Luquillo Mountains, freshwater *Pterocarpus* swamps, forests on serpentine substrates, and a number of dryland habitats unique to Mona Island and the Guánica Biosphere Reserve.

Land cover analysis limitations and discussion—
Assessing the conservation status of natural land cover is limited by several factors:

- GAP has typically found the accuracy of the mapped distributions of natural communities at the floristic (e.g., alliance) level to be substantially lower and more variable than that of animal distributions.
- Any aggregation of biotic units (e.g., above species) is a surrogate for species or lower levels of biotic organization and will underrepresent conservation needs (Pressey and Logan 1995).
- We do not distinguish the degree of natural condition or value of the mapped units because of management manipulation, exotic invasion, or spatial configuration. Considering an aggregation of species such as we have mapped to be sufficiently represented in existing conservation areas cannot be determined solely by the percentage of the community represented because the aggregation has unmapped variation in species composition that we could not measure. Until individual plant species distributions can be mapped, it is not possible to assure that the full range of plant biodiversity is represented, and surrogates must be used.

Predicted animal species distribution analysis—
Table 12 provides the area in hectares of each mapped species by status and the percentage of the total habitat area of that species. For example, a typical entry indicates the habitat area of the yellow-shouldered blackbird, *Agelaius xanthomus*, is 61,073 ha (6.8 percent of the island) and of that area 14,363 ha is ranked GAP status 1 or 2, which represents 23.5 percent of the habitat used by that species.

As a coarse indicator of the status of the elements, we provide a breakdown along five levels of protection (<1 percent, 1 to <10 percent, 10 to <20 percent, 20 to <50 percent, ≥50 percent). The <1-percent level indicates those elements with essentially none of their distribution in a protected status; levels of 10, 20, and 50 percent have been recommended in the literature as necessary amounts of conservation (McNeely and Miller 1994, Noss and Cooperrider 1994, Odum and Odum

1972, Ride 1975). Summaries of the analysis according to the thresholds described above are shown in table 12. Table 13 lists the locally or federally listed endangered, endemic, and vulnerable species.

Species with <1 percent in GAP status 1 or 2—
Four species have less than 1 percent of their habitat protected. Two species of gecko are common in urban areas and not in need of protection. One bird, *Carduelis cucullata,* is nonnative and has not been seen recently. *Eleutherodactylus cooki*, the guajón or rock coqui, has limited habitat and none of it is protected. This species and its habitat are strongly in need of protection. A fifth species, *Eleutherodactylus juanariveroii*, the coqui llanero, is a recently discovered species of coqui that has yet to be incorporated into the complete PRGAP database. It has a very limited known range and the area of sighting is unprotected. Plans are underway to protect the area but they conflict with ongoing development plans, so the outcome and survival of this species is not certain (fig. 38) (Ríos-López and Thomas 2007).

Species with 1 to <10 percent in GAP status 1 or 2—
Seventy-seven species have 1 to less than 10 percent of their habitat protected. Many are widespread and occur in disturbed habitats. A few, such as the blind snake *Typhlops platycephalus*, have limited habitat (15 percent of the island) and the majority of this is unprotected (98 percent of its habitat).

Species with l0 to <20 percent in GAP status 1 or 2—
Thirty-two species have 10 to less than 20 percent of their habitat protected. This includes the broad-winged hawk, *Buteo platypterus brunnescens*, an important competitor of the red-tailed hawk, *Buteo jamaicensis*, both of which prey on the endangered Puerto Rican parrot, *Amazona vittata*. These 32 species are an even mix of those with widespread and limited habitat extent.

Species with 20 to <50 percent in GAP status 1 or 2—
Forty-three species have 20 to less than 50 percent of their habitat protected. A number of these species are limited in the extent of their habitat. All but one, the wrinkled frog, *Eleutherodactylus wightmanae*, with a habitat extent covering 11 percent, are found on less than 10 percent of the island. A number of endangered species in this group would benefit from greater protection as well as habitat improvement and expansion. Many are limited to less extensive habitats such as saline and freshwater ponds and wetlands, or high mountain areas.

Table 12—Predicted distribution area and percentage of the total island for all resident, endemic, and endangered terrestrial vertebrate species in Puerto Rico

Species	Common name (English)	Common name (Spanish)	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protected category
			Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	
Puerto Rico			894 912	100	66 275	7.4	11 240	1.3	55 035	6.1	2253	0.3	826 385	92	4
Accipiter striatus venator	Puerto Rican sharp-shinned hawk	Halcón de sierra	84 589	9.5	20 647	24.4	6752	8.0	13 895	16.4	0	0	63 941	75.6	2
Agelaius xanthomus	Yellow-shouldered blackbird	Mariquita de Puerto Rico	61 073	6.8	14 363	23.5	1263	2.1	13 100	21.4	578	0.9	46 133	75.5	2
Alsophis portoricensis	Puerto Rican racer	Culebra corredora	826 049	92.4	60 162	7.3	9875	1.2	50 287	6.1	1581	0.2	764 306	92.5	4
Amazona ventralis	Hispaniolan parrot	Cotorra de la Española	1570	0.2	203	12.9	9	0.6	194	12.3	134	8.5	1233	78.5	3
Amazona vittata	Puerto Rican parrot	Cotorra Puertorriqueña	5648	0.6	5479	97.0	4788	84.8	691	12.2	0	0	169	3.0	1
Ameiva alboguttata	Puerto Rican ground lizard	Siguan de la Mona	4576	0.5	4576	100	0	0	4576	100	0	0	0	0	1
Ameiva desechensis	Puerto Rican ground lizard	Siguana de Desecheo	121	0	121	100	0	0	121	100	0	0	0	0	1
Ameiva exsul	Puerto Rican ground lizard	Siguana común	370 939	41.5	9042	2.4	943	0.3	8099	2.2	891	0.2	361 005	97.3	4
Ameiva wetmorei	Blue-tailed ground lizard	Siguana de rabo azul	23 550	2.6	5547	23.6	225	1.0	5322	22.6	220	0.9	17 783	75.5	2
Ammodramus savannarum	Grasshopper sparrow	Gorrión chicharra	110 886	12.4	5527	5.0	292	0.3	5235	4.7	559	0.5	104 799	94.5	4
Amphisbaena bakeri	Baker's legless lizard	Culebrita ciega de Baker	107 775	12.1	5725	5.3	3	0	5722	5.3	129	0.1	101 920	94.6	4
Amphisbaena caeca	Puerto Rican worm lizard	Culebrita ciega común	283 610	31.7	29 875	10.5	4207	1.5	25 668	9.1	257	0.1	253 477	89.4	3
Amphisbaena schmidti	Schmidt's worm lizard	Culebrita ciega de Schmidt	71 972	8.0	2339	3.3	82	0.1	2257	3.1	45	0.1	69 587	96.7	4
Amphisbaena xera	North American worm lizard	Culebrita ciega del seco	80 480	9.0	6441	8.0	226	0.3	6215	7.7	275	0.3	73 763	91.7	4
Anas bahamensis	White-cheeked pintail	Pato quijada colorada	4557	0.5	2770	60.8	563	12.3	2207	48.4	64	1.4	1722	37.8	1
Anolis cooki	Cook's anole	Lagartijo del seco	25 291	2.8	5546	21.9	1031	4.1	4514	17.8	963	3.8	18 783	74.3	2
Anolis cristatellus	Crested anole	Lagartijo común	876 825	98.0	55 661	6.3	10 535	1.2	45 127	5.1	1668	0.2	819 495	93.5	4
Anolis cuvieri	Puerto Rican giant anole	Lagarto verde	270 691	30.3	29 342	10.8	7645	2.8	21 697	8.0	178	0.1	241 171	89.1	3
Anolis desechensis	Anole	Lagartijo de Desecheo	121	0	121	100	0	0	121	100	0	0	0	0	1
Anolis evermanni	Emerald anole	Lagartijo verde	286 364	32.0	29 070	10.2	7630	2.7	21 440	7.5	130	0	257 164	89.8	3
Anolis gundlachi	Yellow-bearded anole	Lagartijo barba amarilla	266 628	29.8	28 556	10.7	7167	2.7	21 389	8.0	104	0	237 968	89.3	3

Table 12—Predicted distribution area and percentage of the total island for all resident, endemic, and endangered terrestrial vertebrate species in Puerto Rico (continued)

Species	Common name (English)	Common name (Spanish)	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protected category
			Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	
Anolis krugi	Upland grass anole	Lagartijo jardinero de montana	296 095	33.1	7358	2.5	846	0.3	6512	2.2	85	0	288 652	97.5	4
Anolis monensis	Mona anole	Lagartijo de la Mona	5571	0.6	5571	100	14	0.3	5557	99.7	0	0	0	0	1
Anolis occultus	Puerto Rican pygmy anole	Lagartijo pigmeo	297 730	33.3	30 376	10.2	7769	2.6	22 607	7.6	106	0	267 248	89.8	3
Anolis poncensis	Dryland grass anole	Lagartijo jardinero de Ponce	106 899	12.0	9040	8.5	396	0.4	8644	8.1	730	0.7	97 129	90.9	4
Anolis pulchellus	Common grass anole	Lagartijo jardinero	422 871	47.3	11 695	2.8	1150	0.3	10 545	2.5	994	0.2	410 182	97.0	4
Anolis roosevelti	Culebra Island giant anole	Chipojo de Culebra	14 893	1.7	7464	50.1	492	3.3	6972	46.8	18	0.1	7411	49.8	1
Anolis stratulus	Barred anole	Lagartijo manchado	403 298	45.1	40 885	10.1	8269	2.1	32 617	8.1	259	0.1	362 155	89.8	3
Anthracothorax dominicus	Antillean mango	Zumbador dorado	508 304	56.8	17 066	3.4	1586	0.3	15 480	3.0	808	0.2	490 430	96.5	4
Anthracothorax viridis	Green mango	Zumbador verde	419 555	46.9	32 052	7.6	7868	1.9	24 184	5.8	270	0.1	387 233	92.3	4
Aratinga canicularis	Orange-fronted parakeet	Periquito frentianaranjado	18 690	2.1	449	2.4	21	0.1	428	2.3	66	0.4	18 175	97.2	4
Aratinga chloroptera	Hispaniolan parakeet	Periquito de la Española	5437	0.6	5437	100	0	0	5437	100	0	0	0	0	1
Aratinga pertinax	Brown-throated parakeet	Periquito de curazao	4733	0.5	881	18.6	275	5.8	606	12.8	1	0	3851	81.4	3
Ardea alba	Great egret	Garzón blanco	84 803	9.5	8050	9.5	1519	1.8	6530	7.7	553	0.7	76 200	89.9	4
Arrhyton exiguum	Culebra garden snake	Culebra de jardín	510 750	57.1	49 657	9.7	9795	1.9	39 863	7.8	722	0.1	460 370	90.1	4
Artibeus jamaicensis	Jamaican fruit-eating bat	Muciérlago frutero	636 621	71.2	55 972	8.8	9832	1.5	46 140	7.2	638	0.1	580 011	91.1	4
Asio flammeus	Short-eared owl	Múcaro real	177 239	19.8	21 374	12.1	2771	1.6	18 603	10.5	510	0.3	155 356	87.7	3
Brachyphylla cavernarum	Antillean fruit-eating bat	Murciélago cavernícola	376 550	42.1	38 110	10.1	8547	2.3	29 563	7.9	498	0.1	337 942	89.7	3
Bubulcus ibis	Cattle egret	Garza del ganado	339 102	37.9	13 935	4.1	2197	0.6	11 738	3.5	1187	0.3	323 980	95.5	4
Bufo lemur	Puerto Rican crested toad	Sapo concho	241	0	75	31.2	0	0	75	31.1	0	0	166	68.8	2
Bufo marinus	Giant toad	Sapo común	525 164	58.7	17 367	3.3	2338	0.4	15 028	2.9	1194	0.2	506 604	96.5	4
Buteo jamaicensis	Red-tailed hawk	Guaraguao colirrojo	874 087	97.7	62 670	7.2	10 367	1.2	52 304	6.0	1363	0.2	810 054	92.7	4
Buteo platypterus brunnescens	Puerto Rican broad-winged hawk	Guaraguao de bosque	188 451	21.1	25 871	13.7	7071	3.8	18 800	10	95	0.1	162 485	86.2	3
Butorides virescens	Green heron	Martinete verde	41 920	4.7	8646	20.6	1686	4.0	6960	16.6	649	1.5	32 625	77.8	2

Table 12—Predicted distribution area and percentage of the total island for all resident, endemic, and endangered terrestrial vertebrate species in Puerto Rico (continued)

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			Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Caprimulgus noctitherus	Puerto Rican nightjar	Guabairo de Puerto Rico	15 411	1.7	3788	24.6	56	0.4	3733	24.2	24	0.2	11 599	75.3	2
Carduelis cucullata	Red siskin	Cardenalito	0	0	0	0	0	0	0	0	0	0	0	0	5
Cathartes aura	Turkey vulture	Aura tiñosa	282 785	31.6	18 440	6.5	1721	0.6	16 719	5.9	1382	0.5	262 964	93.0	4
Catoptrophorus semipalmatus	Willet	Playero aliblanco	3924	0.4	1468	37.4	292	7.4	1177	30	315	8.0	2140	54.5	2
Charadrius vociferus	Killdeer	Chorlo sabanero	100 307	11.2	4303	4.3	748	0.7	3556	3.5	901	0.9	95 102	94.8	4
Charadrius wilsonia	Wilson's plover	Chorlo marítimo	12 303	1.4	5686	46.2	1276	10.4	4409	35.8	355	2.9	6262	50.9	2
Chlorostilbon maugaeus	Puerto Rican emerald	Zumbadorcito de Puerto Rico	327 825	36.7	34 673	10.6	8570	2.6	26 103	8.0	133	0	293 019	89.4	3
Chordeiles gundlachii	Antillean nighthawk	Querequeqúe Antillano	172 738	19.3	16 805	9.7	664	0.4	16141	9.3	1280	0.7	154 654	89.5	4
Coccyzus americanus	Yellow-billed cuckoo	Pájaro bobo pechiblanco	29 348	3.3	11 758	40.1	918	3.1	10841	36.9	181	0.6	17 410	59.3	2
Coccyzus minor	Mangrove cuckoo	Pájaro bobo menor	247 501	27.7	28 646	11.6	1652	0.7	26 994	10.9	545	0.2	218 310	88.2	3
Coereba flaveola	Bananaquit	Reinita común	534 523	59.8	48 711	9.1	9357	1.8	39 353	7.4	605	0.1	485 208	90.8	4
Columbina passerina	Common ground-dove	Rolita	581 754	65.1	22 035	3.8	2213	0.4	19 822	3.4	1373	0.2	558 346	96.0	4
Contopus latirostris	Lesser Antillean pewee	Bobito Antíllano Menor	169 101	18.9	13 598	8.0	384	0.2	13 214	7.8	106	0.1	155 396	91.9	4
Crotophaga ani	Smooth-billed ani	Garrapatero	308 413	34.5	16 138	5.2	1553	0.5	14 586	4.7	998	0.3	291 277	94.4	4
Cyclura stejnegeri	Mona Island rock iguana	Iguana de la Mona	5483	0.6	5483	100	0	0	5483	100	0	0	0	0	1
Cypseloides niger	Black swift	Vencejo negro	64 818	7.2	16 944	26.1	7151	11.0	9793	15.1	0	0	47 874	73.9	2
Dendrocygna arborea	West Indian whistling-duck	Chiriría Caribeña	11 184	1.3	5421	48.5	1037	9.3	4384	39.2	97	0.9	5666	50.7	2
Dendrocygna bicolor	Fulvous whistling-duck	Chiriría bicolor	29 607	3.3	11 032	37.3	595	2.0	10 436	35.2	393	1.3	18 182	61.4	2
Dendroica adelaidae	Adelaide's warbler	Reinita mariposera	35 604	4.0	3335	9.4	162	0.5	3173	8.9	206	0.6	32 063	90.1	4
Dendroica angelae	Elfin-woods warbler	Reinita de bosque enaño	14 223	1.6	7177	50.5	2470	17.4	4707	33.1	0	0	7046	49.5	1
Dendroica petechia	Yellow warbler	Reinita amarilla	12 296	1.4	5471	44.5	1096	8.9	4376	35.6	41	0.3	6783	55.2	2
Diploglossus pleei	Puerto Rican galliwasp	Celestus	375 606	42.0	19 769	5.3	4591	1.2	15 178	4.0	575	0.2	355 263	94.6	4
Egretta caerulea	Little blue heron	Garza azul	34 002	3.8	8654	25.5	1645	4.8	7009	20.6	409	1.2	24 939	73.3	2
Egretta thula	Snowy egret	Garza blanca	32 069	3.6	8150	25.4	1645	5.1	6504	20.3	668	2.1	23 252	72.5	2

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			Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Egretta tricolor	Tricolored heron	Garza pechiblanca	8237	0.9	3982	48.3	713	8.7	3269	39.7	0	0	4255	51.7	2
Elaenia martinica	Caribbean elaenia	Juí blanco	29 912	3.3	11 047	36.9	247	0.8	10 800	36.1	106	0.4	18 758	62.7	2
Eleutherodactylus antillensis	Antillean frog	Churí	593 293	66.3	16 943	2.9	2102	0.4	14 840	2.5	696	0.1	575 654	97.0	4
Eleutherodactylus brittoni	Grass coqui	Coquí de las hierbas	294 705	33.0	6430	2.2	652	0.2	5778	2.0	131	0	288 145	97.8	4
Eleutherodactylus cochranae	Whistling frog	Coquí pitito	413 883	46.3	26 150	6.3	1996	0.5	24 154	5.8	369	0.1	387 363	93.6	4
Eleutherodactylus cooki	Rock coqui	Coquí guajón	3864	0.4	0	0	0	0	0	0	0	0	3864	100	5
Eleutherodactylus coqui	Common coqui	Coquí de las yerbas	1398	0.2	428	30.6	161	11.5	267	19.1	4	0.3	966	69.1	2
Eleutherodactylus eneidae	Eneida's coqui	Coquí de eneida	134 307	15.0	22 936	17.1	7544	5.6	15 392	11.5	0	0	111 371	82.9	3
Eleutherodactylus gryllus	Cricket coqui	Coquí grillo	44 987	5.0	3469	7.7	365	0.8	3105	6.9	2	0	41 517	92.3	4
Eleutherodactylus hedricki	Tree-hole frog	Coquí de Hedrick	10 764	1.2	8287	77.0	4993	46.4	3293	30.6	0	0	2477	23.0	1
Eleutherodactylus jasperi	Golden coqui	Coquí dorado	3332	0.4	1445	43.4	2	0	1444	43.3	0	0	1887	56.6	2
Eleutherodactylus locustus	Warty coqui	Coquí martillito	387	0	290	74.9	170	43.9	120	31.0	0	0	97	25.1	1
Eleutherodactylus monensis	Mona coqui	Coquí de la Mona	5557	0.6	5557	100	0	0	5557	100	0	0	0	0	1
Eleutherodactylus portoricensis	Puerto Rican coqui	Coquí de la montaña	73 158	8.2	17 912	24.5	5991	8.2	11 921	16.3	0	0	55 245	75.5	2
Eleutherodactylus richmondi	Ground coqui	Coquí caoba	179 182	20	27 435	15.3	7221	4.0	20 214	11.3	11	0	151 737	84.7	3
Eleutherodactylus unicolor	Burrowing coqui	Coquí duende	303	0	303	100	255	84.0	48	16.0	0	0	0	0	1
Eleutherodactylus wightmanae	Wrinkled frog	Coquí melodioso	98 708	11.0	24 311	24.6	7106	7.2	17 205	17.4	1	0	74 396	75.4	2
Epicrates inornatus	Puerto Rican boa	Culebrón	414 379	46.3	37 178	9.0	8827	2.1	28 351	6.8	286	0.1	376 916	91.0	4
Epicrates monensis granti	Virgin Islands tree boa	Culebrón de la Isla Virgin	2795	0.3	469	16.8	280	10	189	6.8	1	0	2325	83.2	3
Epicrates monensis monensis	Mona boa	Culebrón de la Mona	5436	0.6	5436	100	0	0	5436	100	0	0	0	0	1
Eptesicus fuscus	Big brown bat	Murciélago Marrón mayor	481 270	53.8	30 873	6.4	8252	1.7	22 621	4.7	668	0.1	449 730	93.4	4

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Erophylla sezekorni	Buffy flower bat	Murciélago las flores	582 629	65.2	39 759	6.8	8611	1.5	31 148	5.3	816	0.1	542 054	93.0	4
Estrilda melpoda	Orange-cheeked waxbill	Veterano	381 550	42.7	8714	2.3	789	0.2	7925	2.1	1028	0.3	371 807	97.4	4
Estrilda troglodytes	Black-rumped waxbill	Veterano orejicolorado	147 112	16.5	4820	3.3	487	0.3	4333	2.9	734	0.5	141 558	96.2	4
Eulampis holosericeus	Green-throated carib	Zumbador de pecho azul	71 073	7.9	6805	9.6	638	0.9	6167	8.7	495	0.7	63 773	89.7	4
Euphonia musica	Antillean euphonia	Jilguero	152 797	17.1	27 323	17.9	6948	4.5	20 376	13.3	0	0	125 473	82.1	3
Euplectes afer	Yellow-crowned bishop	Napoleon tejedor	7232	0.8	754	10.4	152	2.1	602	8.3	31	0.4	6447	89.1	3
Euplectes franciscanus	Orange bishop	Obispo colorado	98 783	11.0	3479	3.5	312	0.3	3167	3.2	712	0.7	94 591	95.8	4
Falco sparverius	American kestrel	Halcón común	159 196	17.8	11 658	7.3	690	0.4	10 968	6.9	995	0.6	146 543	92.1	4
Fulica caribaea	Caribbean coot	Gallinazo Caribeño	1130	0.1	233	20.6	0	0	233	20.6	265	23.4	632	55.9	2
Gallinula chloropus	Common moorhen	Gallareta común	6821	0.8	2599	38.1	591	8.7	2008	29.4	278	4.1	3944	57.8	2
Geotrygon chrysia	Key West quail-dove	Paloma perdíz aurea	214 244	24.0	20 868	9.7	393	0.2	20 475	9.6	117	0.1	193 259	90.2	4
Geotrygon montana	Ruddy quail-dove	Paloma perdíz rojiza	133 503	14.9	25 348	19.0	6736	5.0	18 612	13.9	0	0	108 155	81.0	3
Geotrygon mystacea	Bridled quail-dove	Paloma perdíz de Martinica	41 483	4.6	9293	22.4	311	0.8	8981	21.7	3	0	32 188	77.6	2
Hemidactylus brookii	Brook's house gecko	Salamanquesa	36 345	4.1	148	0.4	10	0	138	0.4	44	0.1	36 154	99.5	5
Hemidactylus mabouia	Cosmopolitan house gecko	Salamanquesa	45 264	5.1	105	0.2	4	0	101	0.2	7	0	45 151	99.8	5
Herpestes javanicus	Small Indian mongoose	Mangosta	775 094	86.7	55 684	7.2	9645	1.2	46 039	5.9	1302	0.2	718 108	92.6	4
Himantopus mexicanus	Black-necked stilt	Viuda Mexicana	33 746	3.8	8380	24.8	1596	4.7	6784	20.1	365	1.1	25 001	74.1	2
Hirundo rustica	Barn swallow	Golondrina horquilla	51 415	5.7	4274	8.3	429	0.8	3845	7.5	323	0.6	46 818	91.1	4
Icterus dominicensis	Greater Antillean oriole	Calandria	391 912	43.8	35 398	9.0	8006	2.0	27 392	7.0	543	0.1	355 970	90.8	4
Ixobrychus exilis	Least bittern	Martinetito	2830	0.3	871	30.8	113	4.0	758	26.8	50	1.8	1909	67.5	2
Lasiurus borealis	Eastern red bat	Murciélago rojo	74 097	8.3	14 842	20.0	6763	9.1	8079	10.9	207	0.3	59 048	79.7	2
Leptodactylus albilabris	White-lipped frog	Ranita de blanco	492 760	55.1	32 821	6.7	8004	1.6	24 817	5.0	499	0.1	459 440	93.2	4
Lonchura cucullata	Bronze mannikin	Diablito	196 080	21.9	5694	2.9	307	0.2	5387	2.7	682	0.3	189 704	96.7	4
Lonchura malabarica	Warbling silverbill	Gorrión picoplata	56 303	6.3	3859	6.9	156	0.3	3703	6.6	669	1.2	51 776	92.0	4
Lonchura malacca	Chestnut mannikin	Monjita tricolor	389 502	43.6	8582	2.2	710	0.2	7871	2.0	1054	0.3	379 866	97.5	4
Lonchura punctulata	Nutmeg mannikin	Gorrión canela	146 489	16.4	3830	2.6	453	0.3	3377	2.3	686	0.5	141 972	96.9	4
Loxigilla portoricensis	Puerto Rican bullfinch	Gallito	210 806	23.6	29 121	13.8	7298	3.5	21 823	10.4	5	0	181 680	86.2	3

Table 12—Predicted distribution area and percentage of the total island for all resident, endemic, and endangered terrestrial vertebrate species in Puerto Rico (continued)

Species	Common name (English)	Common name (Spanish)	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protected category
			Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Mabuya mabouya sloanei	Slippery-backed mabuya	Lucía	106 920	12.0	19 860	18.6	776	0.7	19 084	17.8	315	0.3	86 744	81.1	3
Margarops fuscatus	Pearly-eyed thrasher	Zorzal pardo	638 729	71.4	51 274	8.0	9696	1.5	41 578	6.5	873	0.1	586 582	91.8	4
Megascops nudipes	Puerto Rican screech-owl	Múcaro común	455 750	51.0	41 999	9.2	9504	2.1	32 495	7.1	549	0.1	413 202	90.7	4
Melanerpes portoricensis	Puerto Rican woodpecker	Carpintero	463 506	51.8	47 677	10.3	9080	2.0	38 597	8.3	552	0.1	415 278	89.6	3
Mimus polyglottos	Northern mockingbird	Ruisenor	546 630	61.1	9657	1.8	1352	0.2	8305	1.5	989	0.2	535 985	98.1	4
Molossus molossus	Velvety free-tailed bat	Murciélago casero	707 108	79.1	56 607	8.0	9966	1.4	46 640	6.6	915	0.1	649 586	91.9	4
Molothrus bonariensis	Shiny cowbird	Tordo lustrosso	395 788	44.3	9120	2.3	1131	0.3	7989	2.0	835	0.2	385 833	97.5	4
Monophyllus redmani portoricensis	Puerto Rican long-tongued bat	Murciélago	696 229	77.9	49 194	7.1	9259	1.3	39 935	5.7	1563	0.2	645 473	92.7	4
Mormoops blainvillii	Antillean ghost-faced bat	Murciélago barbicacho	350 556	39.2	23 391	6.7	619	0.2	22 772	6.5	298	0.1	326 867	93.2	4
Myiarchus antillarum	Puerto Rican flycatcher	Juí de Puerto Rico	409 729	45.8	44 959	11.0	9294	2.3	35 665	8.7	494	0.1	364 276	88.9	3
Nesospingus speculiferus	Puerto Rican tanager	Llorosa de Puerto Rico	161 567	18.1	24 184	15.0	7106	4.4	17 078	10.6	2	0	137 381	85.0	3
Noctilio leporinus	Greater bulldog bat	Murciélago pescador	12 125	1.4	3177	26.2	659	5.4	2518	20.8	629	5.2	8319	68.6	2
Nyctanassa violacea	Yellow-crowned night-heron	Yaboa comun	23 119	2.6	7631	33.0	1764	7.6	5867	25.4	914	4.0	14 573	63.0	2
Nycticorax nycticorax	Black-crowned night-heron	Yaboa real	14 627	1.6	4857	33.2	1091	7.5	3766	25.7	310	2.1	9461	64.7	2
Orthorhyncus cristatus	Antillean crested hummingbird	Zumbador crestado	94 472	10.6	16 441	17.4	1474	1.6	14 968	15.8	182	0.2	77 849	82.4	3
Oxyura jamaicensis	Ruddy duck	Pato chorizo	6841	0.8	3255	47.6	828	12.1	2427	35.5	367	5.4	3219	47.1	2
Patagioenas inornata	Puerto Rican plain pigeon	Paloma sabanera	306 755	34.3	4093	1.3	1170	0.4	2923	1.0	278	0.1	302 384	98.6	4
Patagioenas leucocephala	White-crowned pigeon	Paloma cabeciblanca	14 489	1.6	6649	45.9	1305	9.0	5344	36.9	157	1.1	7683	53.0	2
Patagioenas squamosa	Scaly-naped pigeon	Paloma turca	408 863	45.7	43 938	10.7	8594	2.1	35 343	8.6	256	0.1	364 670	89.2	3
Pelecanus occidentalis	Brown pelican	Pelícano pardo	32 200	3.6	9502	29.5	2160	6.7	7342	22.8	671	2.1	22 027	68.4	2
Petrochelidon fulva	Cave swallow	Golondrina de cuevas	553 717	61.9	23 443	4.2	2660	0.5	20 783	3.8	1932	0.3	528 343	95.4	4
Phyllodactylus wirshingi	Greater Antillean leaf-toed gecko	Salamanquesa bandeada	11 663	1.3	3968	34.0	295	2.5	3673	31.5	0	0	7695	66.0	2

Table 12—Predicted distribution area and percentage of the total island for all resident, endemic, and endangered terrestrial vertebrate species in Puerto Rico (continued)

Species	Common name (English)	Common name (Spanish)	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protected category
			Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Podilymbus podiceps	Pied-billed grebe	Zaramago	2696	0.3	1258	46.7	131	4.9	1127	41.8	0	0	1437	53.3	2
Porphyrio martinica	Purple gallinule	Gallareta azul	161	0	137	85.4	0	0	137	85.4	0	0	23	14.6	1
Porzana flaviventer	Yellow-breasted crake	Gallito amarillo	827	0.1	471	56.9	95	11.5	376	45.4	46	5.6	310	37.5	1
Progne dominicensis	Caribbean martin	Golondrina de iglesias	109 909	12.3	2736	2.5	277	0.3	2458	2.2	86	0.1	107 087	97.4	4
Pteronotus parnellii portoricensis	Parnell's mustached bat	Murciélago bigotudo mayor	451 275	50.5	32 586	7.2	9077	2.0	23 510	5.2	2100	0.5	416 589	92.3	4
Pteronotus quadridens	Sooty mustached bat	Murciélago bigotudo menor	291 484	32.6	29 257	10	7799	2.7	21 458	7.4	268	0.1	261 958	89.9	3
Quiscalus niger	Greater Antillean grackle	Mozambique	443 537	49.6	19 175	4.3	2418	0.5	16 757	3.8	1994	0.4	422 368	95.2	4
Rallus longirostris	Clapper rail	Pollo de mangle	11 117	1.2	5068	45.6	1313	11.8	3754	33.8	133	1.2	5916	53.2	2
Saurothera vieilloti	Puerto Rican lizard-cuckoo	Pájaro bobo mayor	349 779	39.1	31 973	9.1	7334	2.1	24 638	7.0	115	0	317 691	90.8	4
Sphaerodactylus gaigeae	Gaige's dwarf gecko	Salamanquita de Pandura	59 087	6.6	10 385	17.6	4489	7.6	5897	10	2	0	48 700	82.4	3
Sphaerodactylus klauberi	Klauber's dwarf gecko	Salamanquita negra	248 909	27.8	28 977	11.6	7292	2.9	21 685	8.7	104	0	219 828	88.3	3
Sphaerodactylus levinsi	Desecheo gecko	Salamanquita de Desecheo	15	0	15	100	0	0	15	100	0	0	0	0	1
Sphaerodactylus macrolepis	Common dwarf gekco	Salamanquita común	503 967	56.4	49 185	9.8	9609	1.9	39 576	7.9	585	0.1	454 197	90.1	4
Sphaerodactylus micropithecus	Monito gecko	Salamanquita de Monito	14	0	14	100	14	100	0	0	0	0	0	0	1
Sphaerodactylus monensis	Mona dwarf gekco	Salamanquita de la Mona	5531	0.6	5531	100	0	0	5531	100	0	0	0	0	1
Sphaerodactylus nicholsi	Nichol's dwarf gecko	Salamanquita pigmea	7566	0.8	2059	27.2	80	1.1	1979	26.2	31	0.4	5476	72.4	2
Sphaerodactylus roosevelti	Roosevelt's dwarf gecko	Salamanquita de Roosevelt	22 353	2.5	5584	25.0	187	0.8	5397	24.1	223	1.0	16 545	74.0	2
Sphaerodactylus townsendi	Townsend's dwarf gecko	Salamanquita del sureste	20 898	2.3	5787	27.7	68	0.3	5719	27.4	2	0	15 108	72.3	2
Spindalis portoricensis	Puerto Rican spindalis	Reina mora	433 764	48.5	37 416	8.6	8781	2.0	28 635	6.6	275	0.1	396 072	91.3	4
Stenoderma rufum	Desmarest's fig-eating bat	Murciélago rojo frutero	444 969	49.8	42 943	9.7	8132	1.8	34 811	7.8	379	0.1	401 648	90.3	4
Tachybaptus dominicus	Least grebe	Tigua	341	0	46	13.5	0	0	46	13.5	45	13.1	250	73.4	3

Table 12—Predicted distribution area and percentage of the total island for all resident, endemic, and endangered terrestrial vertebrate species in Puerto Rico (continued)

Species	Common name (English)	Common name (Spanish)	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protected category
			Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Tadarida brasiliensis	Brazilian free-tailed bat	Murciélago de cola libre	410 380	45.9	27 999	6.8	8331	2.0	19 668	4.8	1568	0.4	380 813	92.8	4
Tiaris bicolor	Black-faced grassquit	Gorrión negro	311 963	34.9	12 478	4.0	1483	0.5	10 995	3.5	1253	0.4	298 232	95.6	4
Tiaris olivacea	Yellow-faced grassquit	Gorrion barba amarilla	433 023	48.4	17 034	3.9	2184	0.5	14 850	3.4	1334	0.3	414 654	95.8	4
Todus mexicanus	Puerto Rican tody	San Pedrito	379 296	42.4	37 504	9.9	8638	2.3	28 866	7.6	158	0	341 634	90.1	4
Turdus plumbeus	Red-legged thrush	Zorzal de patas coloradas	380 984	42.6	38 371	10.1	8282	2.2	30 090	7.9	251	0.1	342 362	89.9	3
Typhlops granti	Grant's blind snake	Vibora de Grant	11 831	1.3	3891	32.9	206	1.7	3685	31.2	0	0	7939	67.1	2
Typhlops hypomethes	Blind snake	Vibora universitaria	5721	0.6	2747	48.0	204	3.6	2543	44.4	0	0	2974	52.0	2
Typhlops monensis	Mona blind snake	Vibora de la Mona	106	0	106	100	0	0	106	100	0	0	0	0	1
Typhlops platycephalus	Blind snake	Vibora de cabeza aplastada	9096	1.0	186	2.0	9	0.1	177	1.9	2	0	8909	97.9	4
Typhlops richardii	Richard's blind snake	Vibora común	2925	0.3	650	22.2	518	17.7	133	4.5	3	0.1	2272	77.7	2
Typhlops rostellatus	Puerto Rican wet-land blind snake	Vibora de pico	247 592	27.7	20 629	8.3	7314	3.0	13 315	5.4	364	0.1	226 599	91.5	4
Tyrannus caudifasciatus	Loggerhead kingbird	Clerigo	343 451	38.4	14 218	4.1	1103	0.3	13 116	3.8	292	0.1	328 942	95.8	4
Tyrannus dominicensis	Gray kingbird	Pitirre gris	725 432	81.1	27 482	3.8	3202	0.4	24 280	3.3	1515	0.2	696 435	96.0	4
Vireo altiloquus	Black-whiskered vireo	Julian chivi	541 744	60.6	40 513	7.5	9037	1.7	31 476	5.8	795	0.1	500 437	92.4	4
Vireo latimeri	Puerto Rican vireo	Bienteveo de Puerto Rico	151 020	16.9	15 704	10.4	588	0.4	15 116	10	106	0.1	135 210	89.5	3
Zenaida asiatica	White-winged dove	Tórtola aliblanca	487 655	54.5	44 150	9.1	6408	1.3	37 742	7.7	575	0.1	442 931	90.8	4
Zenaida aurita	Zenaida dove	Tórtola cardosantera	572 274	64.0	32 579	5.7	2798	0.5	29 781	5.2	1411	0.2	538 284	94.1	4
Zenaida macroura	Mourning dove	Tórtola rabilarga	267 912	30	25 008	9.3	1477	0.6	23 530	8.8	1208	0.5	241 696	90.2	4

Note: Protection category 1 = ≥50 percent protected, 2 = 20 to < 50 percent protected, 3 = 10 to < 20 percent protected, 4 = 1 to < 10 percent protected, 5 = < 1 percent protected.

Table 13—Federally listed endangered (LE), threatened (LT) and partial status (PS) species and those considered critically endangered (CE), endangered (EN), vulnerable (VU), or data deficient (DD) by the Puerto Rico Department of Natural and Environmental Resources indicating their area protected

Species	Common name (English)	Common name (Spanish)	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protected category
			Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Puerto Rico			894 912	100	66 275	7.4	11 240	1.3	55 035	6.1	2253	0.3	826 385	92	4
Accipiter striatus venator (LE, CR)	Puerto Rican sharp-shinned hawk	Halcón de sierra	84 589	9.5	20 647	24.4	6752	8.0	13 895	16.4	0	0.0	63 941	75.6	2
Agelaius xanthomus (LE, EN)	Yellow-shouldered blackbird	Mariquita de Puerto Rico	61 073	6.8	14 363	23.5	1263	2.1	13 100	21.4	578	0.9	46 133	75.5	2
Amazona vittata (LE, CR)	Puerto Rican parrot	Cotorra Puertorriqueña	5648	0.6	5479	97.0	4788	84.8	691	12.2	0	0.0	169	3.0	1
Ammodramus savannarum (PS, DD)	Grasshopper sparrow	Gorrión chicharra	110 886	12.4	5527	5.0	292	0.3	5235	4.7	559	0.5	104 799	94.5	4
Anas bahamensis (VU)	White-cheeked pintail	Pato quijada colorada	4557	0.5	2770	60.8	563	12.3	2207	48.4	64	1.4	1722	37.8	1
Anolis cooki (EN)	Cook's anole	Lagartijo del Seco	25 291	2.8	5546	21.9	1031	4.1	4514	17.8	963	3.8	18 783	74.3	2
Anolis poncensis (VU)	Dryland grass anole	Lagartijo jardinero de Ponce	106 899	12.0	9040	8.5	396	0.4	8644	8.1	730	0.7	97 129	90.9	4
Anolis roosevelti (LE, CR)	Culebra Island giant anole	Chipojo de Culebra	14 893	1.7	7464	50.1	492	3.3	6972	46.8	18	0.1	7411	49.8	1
Brachyphylla cavernarum (VU)	Antillean fruit-eating bat	Murciélago cavernícola	376 550	42.1	38 110	10.1	8547	2.3	29 563	7.9	498	0.1	337 942	89.7	3
Bufo lemur (LT, EN)	Puerto Rican crested toad	Sapo concho	241	0.0	75	31.2	0	0.0	75	31.1	0	0.0	166	68.8	2
Buteo platypterus brunnescens (LE, CR)	Puerto Rican broad-winged hawk	Guaraguao de bosque	188 451	21.1	25 871	13.7	7071	3.8	18 800	10.0	95	0.1	162 485	86.2	3
Caprimulgus noctitherus (LE, EN)	Puerto Rican nightjar	Guabairo de Puerto Rico	15 411	1.7	3788	24.6	56	0.4	3733	24.2	24	0.2	11 599	75.3	2
Carduelis cucullata (DD)	Red siskin	Cardenalito	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5
Coccyzus americanus (PS)	Yellow-billed cuckoo	Pájaro bobo pechiblanco	29 348	3.3	11 758	40.1	918	3.1	10 841	36.9	181	0.6	17 410	59.3	2
Cyclura stejnegeri (LT, EN)	Mona Island Rock Iguana	Iguana de la Mona	5483	0.6	5483	100.0	0	0.0	5483	100.0	0	0.0	0	0.0	1
Dendrocygna arborea (LE, CR)	West Indian whistling duck	Chiriría Caribeña	11 184	1.3	5421	48.5	1037	9.3	4384	39.2	97	0.9	5666	50.7	2
Dendroica angelae (VU)	Elfin-woods warbler	Reinita de bosque enaño	14 223	1.6	7177	50.5	2470	17.4	4707	33.1	0	0.0	7046	49.5	1
Eleutherodactylus cooki (LT, VU)	Rock coqui	Coquí guajón	3864	0.4	0	0.0	0	0.0	0	0.0	0	0.0	3864	100.0	5

Table 13—Federally listed endangered (LE), threatened (LT) and partial status (PS) species and those considered critically endangered (CE), endangered (EN), vulnerable (VU), or data deficient (DD) by the Puerto Rico Department of Natural and Environmental Resources indicating their area protected (continued)

Species	Common name (English)	Common name (Spanish)	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protected category
			Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Eleutherodactylus eneidae (CR)	Eneida's coqui	Coquí de Eneida	134 307	15.0	22 936	17.1	7544	5.6	15 392	11.5	0	0.0	111 371	82.9	3
Eleutherodactylus hedricki (DD)	Tree-hole frog	Coquí de Hedrick	10 764	1.2	8287	77.0	4993	46.4	3293	30.6	0	0.0	2477	23.0	1
Eleutherodactylus jasperi (LT, CR)	Golden coqui	Coquí dorado	3332	0.4	1445	43.4	2	0.0	1444	43.3	0	0.0	1887	56.6	2
Eleutherodactylus locustus (VU)	Warty coqui	Coquí martillito	387	0.0	290	74.9	170	43.9	120	31.0	0	0.0	97	25.1	1
Eleutherodactylus portoricensis (VU)	Puerto Rican coqui	Coquí de la montaña	73 158	8.2	17 912	24.5	5991	8.2	11 921	16.3	0	0.0	55 245	75.5	2
Eleutherodactylus richmondi (VU)	Ground coqui	Coquí caoba	179 182	20.0	27 435	15.3	7221	4.0	20 214	11.3	11	0.0	151 737	84.7	3
Epicrates inornatus (LE, VU)	Puerto Rican boa	Culebrón	414 379	46.3	37 178	9.0	8827	2.1	28 351	6.8	286	0.1	376 916	91.0	4
Epicrates monensis granti (LE, CR)	Virgin Islands tree boa	Culebrón de la Isla Virgin	2795	0.3	469	16.8	280	10.0	189	6.8	1	0.0	2325	83.2	3
Epicrates monensis monensis (LE, VU)	Mona boa	Culebrón de la Mona	5436	0.6	5436	100.0	0	0.0	5436	100.0	0	0.0	0	0.0	1
Erophylla sezekorni (VU)	Buffy flower bat	Murciélago las flores	582 629	65.2	39 759	6.8	8611	1.5	31 148	5.3	816	0.1	542 054	93.0	4
Fulica caribaea (VU)	Caribbean coot	Gallinazo Caribeño	1130	0.1	233	20.6	0	0.0	233	20.6	265	23.4	632	55.9	2
Gallinula chloropus (PS)	Common moorhen	Gallareta común	6821	0.8	2599	38.1	591	8.7	2008	29.4	278	4.1	3944	57.8	2
Geotrygon chrysia (DD)	Key West quail-dove	Paloma perdíz aurea	214 244	24.0	20 868	9.7	393	0.2	20 475	9.6	117	0.1	193 259	90.2	4
Geotrygon mystacea (DD)	Bridled quail-dove	Paloma perdíz de Martinica	41 483	4.6	9293	22.4	311	0.8	8981	21.7	3	0.0	32 188	77.6	2
Himantopus mexicanus (PS)	Black-necked stilt	Viuda Mexicana	33 746	3.8	8380	24.8	1596	4.7	6784	20.1	365	1.1	25 001	74.1	2
Icterus dominicensis (DD)	Greater Antillean oriole	Calandria	391 912	43.8	35 398	9.0	8006	2.0	27 392	7.0	543	0.1	355 970	90.8	4
Mabuya mabouya sloanei (VU)	Slippery-backed mabuya	Lucía	106 920	12.0	19 860	18.6	776	0.7	19 084	17.8	315	0.3	86 744	81.1	3
Monophyllus redmani portoricensis (VU)	Puerto Rican long-tongued bat	Murciélago	696 229	77.9	49 194	7.1	9259	1.3	39 935	5.7	1563	0.2	645 473	92.7	4

Table 13—Federally listed endangered (LE), threatened (LT) and partial status (PS) species and those considered critically endangered (CE), endangered (EN), vulnerable (VU), or data deficient (DD) by the Puerto Rico Department of Natural and Environmental Resources indicating their area protected (continued)

Species	Common name (English)	Common name (Spanish)	Total habitat		Status 1 or 2		Status 1		Status 2		Status 3		Status 4		Protected category
			Ha	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	*Ha*	%	
Oxyura jamaicensis (VU)	Ruddy duck	Pato chorizo	6841	0.8	3255	47.6	828	12.1	2427	35.5	367	5.4	3219	47.1	2
Patagioenas inornata (LE, EN)	Puerto Rican plain pigeon	Paloma sabanera	306 755	34.3	4093	1.3	1170	0.4	2923	1.0	278	0.1	302 384	98.6	4
Pelecanus occidentalis (LE, EN)	Brown pelican	Pelícano pardo	32 200	3.6	9502	29.5	2160	6.7	7342	22.8	671	2.1	22 027	68.4	2
Porzana flaviventer (DD)	Yellow-breasted crake	Gallito amarillo	827	0.1	471	56.9	95	11.5	376	45.4	46	5.6	310	37.5	2
Rallus longirostris (PS)	Clapper rail	Pollo de mangle	11 117	1.2	5068	45.6	1313	11.8	3754	33.8	133	1.2	5916	53.2	2
Sphaerodactylus gaigeae (DD)	Gaige's dwarf gecko	Salamanquita de Pandura	59 087	6.6	10 385	17.6	4489	7.6	5897	10.0	2	0.0	48 700	82.4	3
Sphaerodactylus levinsi (DD)	Desecheo gecko	Salamanquita de Desecheo	15	0.0	15	100.0	0	0.0	15	100.0	0	0.0	0	0.0	1
Sphaerodactylus micropithecus (LE, CR)	Monito gecko	Salamanquita de Monito	14	0.0	14	100.0	14	100.0	0	0.0	0	0.0	0	0.0	1
Tachybaptus dominicus (DD)	Least grebe	Tigua	341	0.0	46	13.5	0	0.0	46	13.5	45	13.1	250	73.4	3
Typhlops granti (DD)	Grant's blind snake	Vibora de Grant	11 831	1.3	3891	32.9	206	1.7	3685	31.2	0	0.0	7939	67.1	2
Typhlops monensis (DD)	Mona blind snake	Vibora de la Mona	106	0.0	106	100.0	0	0.0	106	100.0	0	0.0	0	0.0	1

Note: Protection category 1 = ≥50 percent protected, 2 = 20 to < 50 percent protected, 3 = 10 to < 20 percent protected, 4 = 1 to < 10 percent protected, 5 = < 1 percent protected.

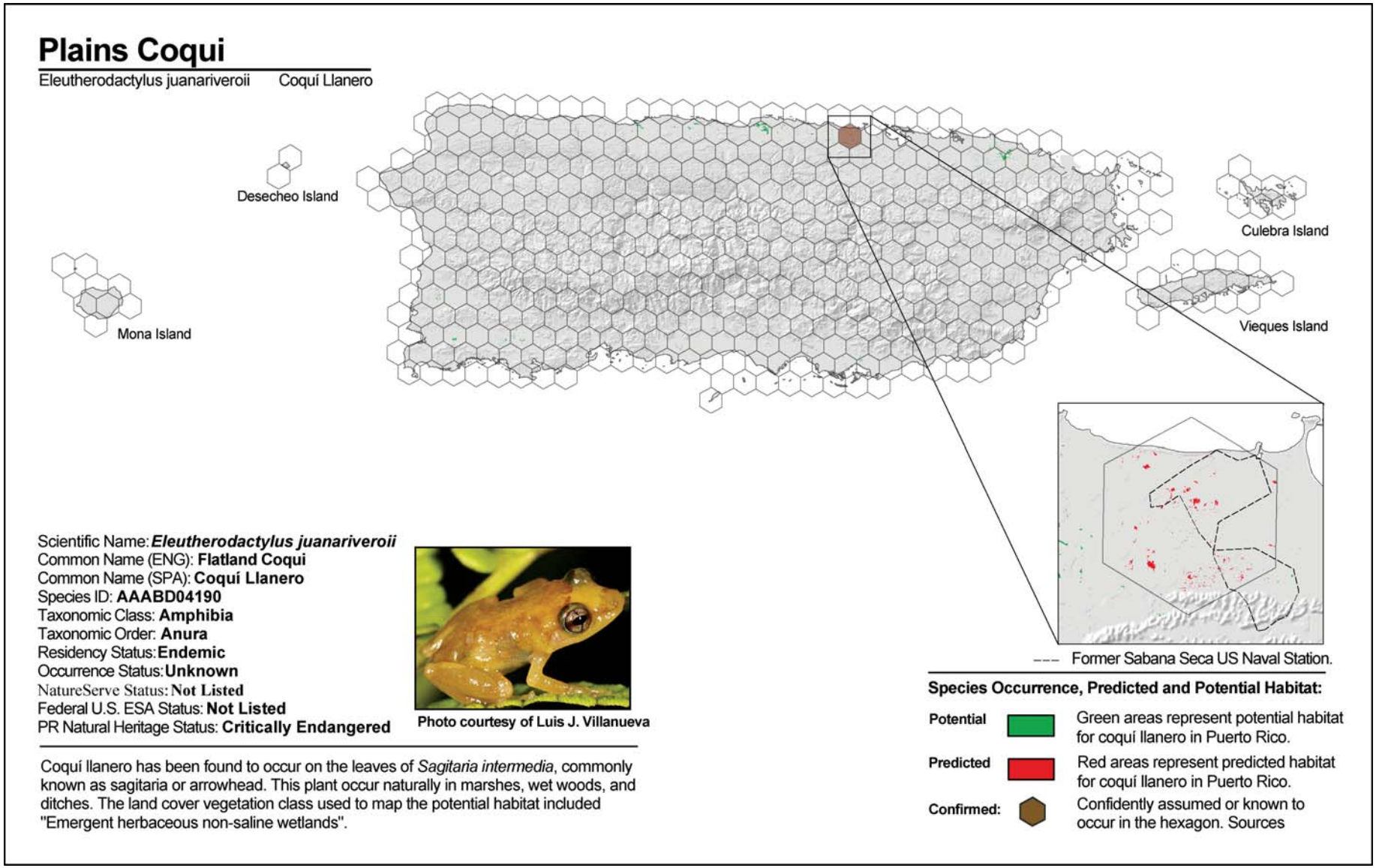

Figure 38—*Eleutherodactylus portoricensis* predicted distribution map (based on Río-López and Thomas 2007 and personal communication).

Species with at least 50 percent in GAP status 1 or 2—
Twenty-one species have at least 50 percent of their predicted habitat protected. These include a number of species found only on forest reserves or particular protected satellite islands (Mona and Desecheo). All of these species have very limited habitat and none exceed 2 percent of the island. Many of these species could benefit from management to extend their range to other suitable habitat, as is being done with the Puerto Rican parrot, *Amazona vittata*. Improving habitat inside and outside the current reserves, and increasing the number and extent of reserves would also benefit this group.

Endangered species representation in GAP status 1 and 2—
Forty-seven species are listed as either federally threatened or endangered or given partial status, or are locally listed by the DNER as vulnerable, endangered, critically endangered, or data deficient (table 13). The extent of habitat for 70 percent of these species is typically less than 5 percent of the island. Eighty-three percent of the species have a habitat extent less than 20 percent of the island. *Eleutherodactylus cooki*, the guajón or rock coqui, is the least protected, with no protected habitat. Ten species have less than 10 percent of their habitat protected and 18 species have less than 20 percent of their habitat protected. Five species are found only in reserves with 100 percent of their habitat protected.

Analysis Limitations

When applying the results of our analyses, it is critical that the following limitations are considered: (1) the limitations described for each of the component parts (land cover mapping, animal species mapping, stewardship mapping) of the analyses, (2) the spatial and thematic map accuracy of the components, and (3) the suitability of the results for the intended application.

Conclusions and Management Implications

Puerto Rico faces a number of problems that are common to much of the world. Population is increasing while land area is not, and there is an ongoing reassessment of land use policy and practice to accommodate growing populations, shifting economies, and changing public value systems. Puerto Rico shares similarities with the Eastern United States with its history of agricultural abandonment, relatively high population density, and abundance of “forested” suburban areas in the wildland-urban interface. Puerto Rico has affinities with other tropical regions with

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Melanerpes portoricensis, the Puerto Rican woodpecker, is endemic to the island.

high biodiversity and an abundance of rare species. Puerto Rico shares similarities with other islands in that land limitations are evident and abrupt at the terrestrial-marine interface and species diversity is controlled by the isolation of the island as well as climatic, evolutionary, and historical factors.

Puerto Rico is unique in its assemblage of species and characteristics that combine all of the above, as well as the character of its people, government, policies, and attitudes regarding conservation. There are a number of new initiatives within governmental and nongovernmental agencies and private citizens groups to develop better integrated, island-wide land use planning and policy. This is a very positive step. There are also a number of initiatives to consider regional planning for conservation efforts including Caribbean-wide assessments of biodiversity and the development of bird conservation efforts encompassing the Atlantic flyway. The PRGAP is a valuable resource for these efforts both in the information we are making available and as a model of data management and information development and transfer.

The PRGAP is a comprehensive assemblage of information on Puerto Rico's land cover, vertebrate occurrences, natural history information, and land stewardship. The results of this project are:

- An important body of information on current land cover attributes, terrestrial vertebrate species distributions, literature availability, and conservation priorities. This information can serve as an educational tool, a reference data set, as input for modeling, as a data set for analyses, and as a source of new hypotheses for research.
- A set of integrated geospatial information on land cover, land use, population dynamics, habitat use and dynamics, terrain characteristics, physiography, geology, climate, hydrology, land ownership and management, and species occurrences. This information is well documented as to its sources and carefully co-registered for integrated scientific analyses. It is designed to be used for analyses of PRGAP data, as well as to produce map products and datasets that will be useful for education and research.
- A set of databases that relate information on vertebrate occurrences, taxonomy, conservation status, habitat characteristics, scientific literature, life history traits, habitat distributions, and land management priorities. These data sets have complete information on the terrestrial resident, endemic, and endangered species in Puerto Rico, but also a framework and

initial taxonomic information on all of Puerto Rico and the U.S. Virgin Island's 490 terrestrial, freshwater, and marine species. The databases are designed to be maintained, updated, and expanded as long as institutional support is available.

- A network of public and private individuals and organizations that have provided input or will be future users of PRGAP products and information.

This report is a preliminary analysis of this comprehensive data set, and there is still much information to be derived from the PRGAP. Some of these initial findings indicate that the various physiographic regions of the island have distinct roles in the maintenance of biodiversity of different taxonomic groups. The bird species show highest diversity in the coastal plain and hills, with their mix of open forest, grasslands, wetlands, saline and freshwater ponds, and streams. This part of the island is under the greatest development pressure. The PRGAP information also indicates that a number of mature forest habitats are key to the survival of endangered and endemic species. The northern karst region is an important center of both mammal and reptile diversity. Reptile diversity and the presence of a number of endemic species is also high in the dryland habitats. The moist forested mountain peaks serve as reservoirs of amphibian diversity.

Protection of this landscape diversity is not uniform in Puerto Rico. The least protected areas are the former agricultural lands in the coastal plain, low hills, and the karst region, and these should be conservation priorities. Protection of diversity could be improved by (1) total protected area of at least 15 percent; (2) expanded reserves in the limestone hills and coastal plain, particularly the matrix of wetland and upland vegetation as found on the former Roosevelt Roads and Sabana Seca Naval Bases, the Northeast Ecological Corridor, Piñones, and other areas; (3) better regulation of development in the periphery of existing reserves to maintain the integrity of hydrologic systems in wetlands and to maintain viable corridors and buffer zones in the upland reserves; (4) development of ecological corridors, including riparian corridors to connect existing reserves with green space; (5) development of small and intermediate-sized parks and open space within urban areas that serve as habitat as well as recreational and educational resources for communities; (6) the protection of unique habitats such as mountain valleys that shelter *Eleutherodactylus cooki* (the guajón) and the freshwater nonforested wetlands that shelter *Eleutherodactylus juanariveroii* (the coqui llanero); and (7) the restoration of formerly extensive habitats such as the freshwater swamps or riparian forests of *Pterocarpus officinalis* Jacq. and the moist lowland ausubo (*Manilkara bidentata* (A. DC.) Chev.) forests.

Concluciones e Implicaciones de Manejo

Puerto Rico enfrenta una serie de problemas que son comunes al resto del mundo. La población aumenta, mientras no así el área, y hay una continua reevaluación de las políticas y las prácticas de uso del terreno para acomodar ese aumento. Además Puerto Rico experimenta el vaivén económico, y el cambio en los valores del sistema público. Puerto Rico comparte con el área este de los Estados Unidos una historia de abandono agrícola, densidad poblacional relativamente alta y en aumento, y abundancia de áreas suburbanas forestadas en la interfase urbano-silvestre. Puerto Rico tiene afinidades con otras regiones tropicales con gran biodiversidad y abundancia de especies raras. También comparte similitudes con otras islas en términos de las limitaciones de espacio, evidentes y abruptas en la franja marítimo-terrestre, y en que la diversidad de las especies está controlada por su aislamiento así como por factores climáticos, evolutivos e históricos.

Puerto Rico es único en su ensamblaje de especies y características que combinan todo lo anteriormente mencionado, así como el carácter de su gente, su gobierno, y sus actitudes con relación a la conservación. Existen en la isla un número de nuevas iniciativas dentro de agencias tanto gubernamentales como no-gubernamentales, y agrupaciones privadas con el fin de desarrollar políticas y planes de uso de terreno a nivel isla mejor integrados, lo cual es un paso muy positivo. También existen una serie de iniciativas para considerar planes regionales en los esfuerzos de conservación incluyendo avalúos de conservación a lo largo del Caribe y el desarrollo de esfuerzos de conservación de aves a lo largo de lo que se conoce como la ruta migratoria del Atlántico (conocida en inglés como Atlantic Flyway). El Proyecto Análisis Gap de Puerto Rico (PRGAP) es un recurso valioso para tales esfuerzos tanto en la información que se está haciendo disponible, y como modelo de manejo de datos y transferencia y desarrollo de información.

El PRGAP es una colección abarcadora de información de cobertura del terreno en la isla, las distribuciones e historia natural de especies vertebradas, así como el dominio de áreas de manejo con propósitos de conservación. Los resultados de este proyecto se podrían resumir como:

- Una colección comprensiva de información de atributos de cobertura terrestre actualizados, distribución de especies vertebradas terrestres, disponibilidad de literatura científica, y prioridades de conservación. Esta información representa una herramienta educacional, un conjunto de datos de referencia, una herramienta de datos para modelación, un conjunto de datos para análisis, y una fuente de hipótesis para la investigación.

- Un conjunto de información geo-espacial sobre la cobertura del terreno, el uso de suelos, dinámica de poblaciones, uso y dinámica del hábitat, características del terreno, fisiografía, geología, clima, hidrología, tenencia y manejo de tierras, y distribución geográfica de las especies de vertebrados. Las fuentes de información están bien documentadas, y cuidadosamente co-registradas para análisis científicos integrados. Está diseñada para ser usada en el análisis de la información de los datos de PRGAP, así como para la preparación de productos cartográficos y cubiertas digitales de utilidad educacional y en lo que a la investigación científica se refiere.
- Un conjunto de bases de datos que entrelazan datos de avistamientos de vertebrados, taxonomía, estatus de conservación, características de hábitat, literatura científica, rasgos de su historia natural, distribución de hábitat, y prioridades de conservación. Este conjunto de datos incluyen información completa sobre especies terrestres residentes, endémicas o amenazadas en Puerto Rico, pero también una estructura inicial de información taxonómica de todas las especies de vertebrados marinos, acuáticos de agua dulce, y terrestres de Puerto Rico y las Islas Vírgenes de Estados Unidos. Estas bases de datos están diseñadas para ser mantenidas, actualizadas, y expandidas mientras dure el apoyo institucional.
- Una red de agencias públicas, individuos privados y organizaciones que han proveído insumo y son o serán futuros usuarios de los productos y la información de PRGAP.

Este reporte representa un análisis preliminar de este abarcador conjunto de datos, y todavía existe el potencial de derivar nueva información del PRGAP. Algunos de los hallazgos iniciales indican que las distintas regiones fisiográficas de la isla tienen diferentes roles en mantener la biodiversidad de los diferentes grupos taxonómicos estudiados. Las aves muestran mayor diversidad en los llanos y lomas costeras, con su composición de bosques abiertos, pastizales, humedales, charcas y quebradas de agua dulce y salada. Esta porción de la isla está bajo la mayor presión de desarrollo urbano. La información del PRGAP también indica que un número de ambientes de bosque maduro son clave para la supervivencia de especies amenazadas y/o endémicas. La región del Carso es importante para la supervivencia de la diversidad de mamíferos y reptiles. La zona de vida seca muestra también una gran diversidad de reptiles y especies endémicas. Por otro lado, los bosques húmedos de los picos montañosos representan un santuario para la diversidad de anfibios.

La protección de esta diversidad de paisajes no es uniforme en Puerto Rico. Las áreas menos protegidas son aquellos terrenos de las llanuras costeras que otrora fuesen utilizados para la agricultura, las colinas bajas y la región del Carso, por lo que estas regiones deberían representar prioridades de conservación. La protección de la biodiversidad puede mejorarse, por ejemplo, (1) aumentando a 15% la superficie total de áreas protegidas; (2) expandiendo las reservas en las regiones del Carso y las planicies costeras, particularmente la matriz de humedales y vegetación de tierras elevadas como aquellas localizadas en las antigua bases navales de Roosevelt Roads y Sabana Seca, el Corredor Ecológico del Noreste, Piñones, y otras áreas; (3) mejorando la regulación del desarrollo urbano en la periferia de las reservas existentes para así mantener la integridad de los sistemas hidrológicos en humedales y mantener corredores viables y zonas de amortiguamiento en las reservas ubicadas a mayor elevación; (4) desarrollando corredores ecológicos, tales como corredores ribereños, para conectar reservas existentes con espacios verdes; (5) desarrollando parques medianos y pequeños y espacios abiertos entre áreas urbanas que sirvan como hábitat así como recursos educativos y recreacionales para las comunidades; (6) Protegiendo los hábitat únicos tales como los valles montañosos que sirven de santuario al Coquí Guajón (*Eleutherodactylus cooki*), y los humedales, ya sea los no boscosos de agua dulce, que cobijan a la recién descubierta especie de anfibio Coquí Llanero, provisionalmente *Eleutherodactylus juanariveroii*; y (7) restaurando hábitat antiguamente extensos, tales como los pantanos de agua dulce o bosques ribereños de *Pterocarpus officinalis* Jacq. y los bosques de ausubo (*Manilkara bidentata* (A. DC.) Chev.) de las planicies húmedas.

Product Use and Availability

How to Obtain Products

It is the goal of the Gap Analysis Program and the USGS Biological Resources Division (BRD) to make the data and associated information as widely available as possible. Use of the data requires specialized GIS software and substantial computing power. Additional information on how to use the data or obtain GIS services is provided below and on the GAP home page (URL below). While a CD-ROM or DVD of the data will be the most convenient way to obtain the data, it may also be downloaded via the Internet from the national GAP home page at http://www.gap.uidaho.edu/.

The home page will also provide, over the long term, the status of our state's project, future updates, data availability, and contacts. Within a few months of this project's completion, CD-ROMs or DVDs of the final report and data should be available at a nominal cost—the above home page will provide ordering information. To find information on this state GAP project's status and data, follow the links to "Current Projects" and then to the particular state of interest.

Disclaimer

Following is the official BRD disclaimer as of 29 January 1996, followed by additional disclaimers from GAP. Prior to using the data, you should consult the GAP home page for the current disclaimer.

Although these data have been processed successfully on a computer system at the BRD, no warranty expressed or implied is made regarding the accuracy or utility of the data on any other system or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data. It is strongly recommended that these data are directly acquired from a BRD server [see above for approved data providers] and not indirectly through other sources which may have changed the data in some way. It is also strongly recommended that careful attention be paid to the content of the metadata file associated with these data. The BRD shall not be held liable for improper or incorrect use of the data described or contained herein.

These data were compiled with regard to the following standards. Please be aware of the limitations of the data. These data are meant to be used at a scale of 1:100,000 or smaller (such as 1:250,000 or 1:500,000) for the purpose of assessing the conservation status of animals and vegetation types over large geographic

regions. The data may or may not have been assessed for statistical accuracy. Data evaluation and improvement may be ongoing. The BRD makes no claim as to the data's suitability for other purposes. This is writable data, which may have been altered from the original product if not obtained from a designated data distributor identified above.

Metadata

Proper documentation of information sources and processes used to assemble GAP data layers is central to the successful application of GAP data.

Metadata is a description of the content, quality, lineage, contact, condition, and other characteristics of data. It is a valuable tool that preserves the usefulness of data over time by detailing methods for data collection and data set creation. It greatly minimizes duplication of effort in the collection of expensive digital data and fosters sharing of digital data resources. Metadata supports local data asset management such as local inventory and data catalogs, and external user communities such as clearinghouses and Web sites. It provides adequate guidance for end-use application of data such as detailed lineage and context. Metadata makes it possible for data users to search, retrieve, and evaluate data set information by providing standardized terms for geospatial and biological data.

The Federal Geographic Data Committee approved the Content Standard for Digital Geospatial Metadata (FGDC-STD-001-1998) in June 1998, and the National Biological Information Infrastructure (NBII) (http://www.nbii.gov) developed the Biological Data Profile (approved in 1999) that adds fields for biological information such as taxonomy, analytical tools, and methodology to the FGDC standard core set of elements (http://www.nbii.gov/datainfo/metadata/standards/). Executive Order 12906 requires that any spatial data sets generated with federal dollars will have FGDC-compliant metadata.

Each PRGAP spatial data layer is accompanied by its metadata (*.xml or .sgml file) in the same directory. We also include an additional directory (called "meta_master'), which will include each metadata file in four forms (*.txt, *.xml, *.html, and *.sgml).

Appropriate Use of These Data

The PRGAP is an important source of island-wide biological GIS information. The data were created with the expectation that they would be used for other applications. Therefore, we list below both appropriate and inappropriate uses. This list is

in no way exhaustive but should serve as a guide to assess whether a proposed use can or cannot be supported by GAP data. For most uses, it is unlikely that GAP will provide the only data needed, and for uses with a regulatory outcome, field surveys should verify the result. In the end, it will be the responsibility of each data user to determine if GAP data can answer the question being asked, and if they are the best tool to answer that question.

Scale—

The data were produced with an intended application at the regional level, that is, geographic areas from tens of thousands to millions of hectares in size. The data provide a coarse-filter approach to analysis, meaning that not every occurrence of every plant community or animal species habitat is mapped–only larger, more generalized distributions. The data are based on the USGS 1:100,000 scale of mapping in both detail and precision. The PRGAP data can be used as a map for a particular geographic area, or to provide regional context for a particular area. The distinction can be made with the following example: You could use PRGAP land cover to determine the approximate amount of mangrove forest occurring in a municipality, or you could map mangrove with high-resolution aerial photography to determine a more precise amount. You could use PRGAP data to determine the approximate percentage of all mangrove forest in the region that occurs in a municipality, and thus gain a sense of how important the municipality's distribution is to maintaining that vegetation type.

Appropriate uses—

The above example illustrates two appropriate uses of the data: as a coarse map for a large area such as a municipality, and to provide context for fine-level maps. The following is a general list of applications:

- Island-wide biodiversity planning.
- Regional (Councils of Government) planning.
- Regional habitat conservation planning.
- Municipality or watershed comprehensive planning.
- Large-area resource management planning.
- Modeling future biodiversity or species distribution scenarios.
- Assessing habitat change.
- Coarse-filter evaluation of potential impacts or benefits of major projects or plan initiatives on biodiversity, such as utility or transportation corridors, wilderness proposals, or regional open space and recreation proposals.

- Determining relative amounts of management responsibility for specific biological resources among land stewards to facilitate cooperative management and planning.
- Basic research on regional distributions of plants and animals and to help target both specific species and geographic areas for needed research.
- Environmental impact assessment for large projects or military activities.
- Estimation of potential economic impacts from loss of biological resource-based activities.
- Education at all levels and for both students and citizens.

Inappropriate uses—

It is far easier to identify appropriate uses than inappropriate ones; however, there is a "fuzzy line" that is eventually crossed when the differences in resolution of the data, size of geographic area being analyzed, and precision of the answer required for the question are no longer compatible. Examples include:

- Using the data to map small areas (less than thousands of hectares), typically requiring mapping resolution at 1:24,000 scale and using aerial photographs or ground surveys.
- Combining GAP data with other data finer than 1:100,000 scale to produce new hybrid maps or answer queries.
- Generating specific overly precise areal measurements from the data (minimum mapping unit size and accuracy affect this precision).
- Establishing exact boundaries for regulation or acquisition.
- Establishing definite occurrence or nonoccurrence of any feature for an exact geographic area (for land cover, the percentage of accuracy will provide a measure of probability).
- Determining abundance, health, or condition of any feature.
- Establishing a measure of accuracy of any other data by comparison with GAP data.
- Altering the data in any way and redistributing them as a PRGAP data product.
- Using the data without acquiring and reviewing the metadata and this report.

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This work has been accomplished with the assistance and support of a great number of people. Their support and enthusiasm for conservation has in many cases been inspirational. First of all we thank Jaime Collazo and Eileen Helmer for bringing this project to Puerto Rico and the U.S. Forest Service International Institute of Tropical Forestry (IITF). The institutional support provided IITF and the Puerto Rico Department of Natural and Environmental Resources (DNER) was very important. Thanks to Ariel Lugo, José Berrios, and José Chabert. Kevin Gergley, program manager of the USGS Biological Resources Division, National Gap Program has supported this work. The staff at the National Gap office, Jocelyn Aycrigg, Jill Maxwell, Anne Davidson, and Nicole Coffey, have been a great help. Steve Williams and Alexa McKerrow, working with Jaime Collazo and the North Carolina and Southeast Gap projects have offered advice and experience since the project was initiated. Tom Brandeis assisted in developing the PRGAP hexagon layer.

This report draws on the GAP handbook template for final reports.

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Este reporte hace uso del texto del Manual GAP para los reportes finales.

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English Equivalents

When you know:	Multiply by:	To find:
Millimeters (mm)	0.0394	Inches
Meters (m)	3.28	Feet
Square meters (m^2)	10.76	Square feet
Kilometers (km)	0.621	Miles
Square kilometers (km^2)	0.386	Square miles
Degrees Celsius (°C)	1.8 °C + 32	Degrees Fahrenheit

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Appendix 1. Example GAP Applications

Businesses and Nongovernment Organizations

The following are some examples of applications of Gap Analysis Program (GAP) data by the private sector:

- The Wyoming Natural Heritage Program (a private nongovernment organization) transformed the endangered and sensitive species database into a spatially referenced digital geographic information system using the GAP digital base map and other GAP spatial data.
- Hughes Corp. is experimenting with the Utah and Nevada GAP digital base maps, simulating images to aid the development of new space-based remote-sensing devices.
- The Nature Conservancy used the Wyoming GAP data to develop a map of ecoregions of Wyoming.
- Weyerhaeuser Corp. is using the Arkansas GAP data in managing their lands in Arkansas.
- IBM Corp. is funding a project at the University of California-Santa Barbara that, in part, uses GAP data in the development of visualization software.
- The New Mexico GAP vegetation data is being used for an environmental assessment of a proposed spaceport, a state/private venture.
- The Conservation Trust of Puerto Rico and NatureServe are using Puerto Rico Gap data in their development of island-wide biodiversity conservation plans.

County and City Planning

Examples of the use of GAP by local governments:

- California GAP biological data were combined with the Southern California Association of Governments land ownership data to show which ownerships and jurisdictions were needed for joint conservation planning and management of a particular natural community or species, maximizing efficiency and minimizing the potential for yet another conservation crisis.
- In California, county and city planners of several jurisdictions, wildlife agencies, developers of the 4S Ranch property, and the state Natural Communities Conservation Planning program used the GAP regional data,

as well as more detailed information, to conserve 1,640 acres of habitat within a 2,900-acre planned development.

- Day-to-day county planning operations in Piute, Grande, and Washington counties, Utah.
- County planners in Piute County, Utah, used GAP data to optimize the siting of a proposed sawmill for aspen with respect to the distribution of aspen stands.
- Missoula County, Montana, used the GAP land cover map of the area as a base map for its comprehensive long-range plan.
- Snohomish County, Washington, used the GAP land cover map in meeting state requirements for a growth management plan.
- The City of Bainbridge Island, Washington, used GAP data to assist them in development of a watershed planning project.

State Uses

The following are some examples of uses of GAP data by state agencies:

- The GAP database of species habitats was used by the Tennessee Wildlife Resources Agency (TWRA) to update its book "Species in Need of Management."
- Images of land cover derived from GAP Landsat thematic mapper data are used by TWRA for locating particular habitat types. Information on the locations of these habitat types is provided by TWRA to the public for a wide variety of public service functions, from education to cooperative resource management.
- Early GAP data developed by TWRA were used to help identify an extremely important area of the state with high biodiversity that was subsequently purchased by the state for conservation.
- Preliminary findings from GAP were used by TWRA to develop three resource management initiatives.
- The Tennessee GAP project, which is being carried out primarily by TWRA, is the foundation of a multiagency, long-term biodiversity program for Tennessee.
- GAP data have been used by the Tennessee Forestry Stewardship Program to help develop a district program for nine conservation planning districts, outlining Best Management Practices (BMPs) for biological conservation on private lands.

- GAP data are being used extensively by TWRA in the preparation of project proposals to the North American Waterfowl Conservation Program. These proposals require that biodiversity issues are addressed in specific detail. The use of GAP data on occurrence of land cover types and terrestrial vertebrates has made this possible.
- The Wyoming Department of Fish and Game used GAP data to assist them in transforming the Wildlife Observation System database into a spatially referenced geographic information system.
- The Utah Division of Wildlife Resources and the Bear River Water Conservancy District used the Utah GAP land cover map in a resource management assessment for mitigating conflicts between a proposed groundwater withdrawal project and the maintenance of an elk calving area in the Uinta Mountains.
- The Utah Division of Wildlife Resources, the Rocky Mountain Elk Foundation, and Sheik Safari International used the Utah GAP land cover map to identify critical elk habitat. The environmental profile of these areas was then used to identify other similar areas for elk habitat enhancement.
- The Utah Division of Wildlife Resources used the Utah GAP land cover map for a rapid ecological assessment of the Echo Henefer Wildlife Management Area.
- The Washington Department of Fish and Wildlife used GAP data to develop a breeding bird atlas and an atlas of mammals of Washington State.
- The Washington Department of Fish and Wildlife uses GAP data to operate an integrated landscape management program.
- The Washington Department of Fish and Wildlife uses GAP data from eastern Washington to assist with an innovative program that brings the forest products industry, state agency biologists, nongovernment organizations, and tribal biologists together in the field to jointly determine the appropriate management practices for any particular site of concern (Timber, Fish & Wildlife Program).
- The Idaho Department of Fish and Game used GAP data to evaluate the impact from expanded military training activities on public lands in southern Idaho.
- The Idaho Department of Fish and Game uses GAP data for regional planning efforts on a regular basis.

- The Puerto Rico Department of Natural and Environmental Resources is incorporating Puerto Rico GAP data in publicly accessible, interactive mapping databases with land ownership and land use information.

Statewide Planning

Biodiversity planning programs or projects are now underway in Arizona, California, Colorado, Maine, Missouri, Nevada, Oregon, Puerto Rico, and Tennessee. It is likely that similar efforts will develop in other states. In some cases, these efforts grew out of the state GAP project; however, in most cases, the GAP data are being used to meet a previously defined need. In all cases, GAP data are central to their development and operations.

Federal Agency Applications

Examples of applications of GAP data by federal agencies:

- GAP data are being supplied to all military installations in the Great Basin ecoregion for integrated management of the natural resources. These installations constitute a very large amount of land area. Much of it is of high value for native species.
- The Ouachita National Forest used the Arkansas GAP data to help them develop an ecosystem management plan.
- The Wyoming GAP data were used by The National Aeronautics and Space Agency to calibrate a model that predicts vegetation types based on climate and soil variables.
- The potential contributions to biodiversity conservation of four options proposed for new wilderness designation in Idaho were quantified by the Idaho Cooperative Fish and Wildlife Research Unit in cooperation with the Park Studies Unit.
- The potential contributions to biodiversity conservation of four options proposed for new national park designation in Idaho were quantified by the Idaho Cooperative Park Studies Unit.
- The U.S. Forest Service in Booneville, Arkansas, used the Arkansas GAP data land cover maps in a 3-dimensional presentation to provide the public with a visual representation of the region and to enhance the public's involvement with the national forest planning process.
- The U.S. Fish and Wildlife Service regularly uses the GAP data for southern California for habitat evaluation and management.

- The U.S. Forest Service, Bureau of Land Management, and National Park Service are using GAP data for a wide variety of natural resource management operations in Utah. For example, the entire Utah GAP database is directly linked with existing National Park Service databases for use by national parks.
- The Bureau of Land Management uses the Wyoming GAP data for managing the Buffalo Resource Area.
- The U.S. Forest Service used the Utah GAP data to help assist them in evaluating human-induced impacts to forested lands surrounding ski resorts in central Utah.
- The U.S. Fish and Wildlife Service in Delaware used GAP data to help identify potential habitat for the federally endangered Delmarva fox squirrel (*Sciurus niger cinereus*). These maps were displayed and served as a catalyst for bringing together people with a stake in the issue.
- The U.S. Fish and Wildlife Service used the Indiana GAP data as part of a biological assessment for the base closure of the Jefferson Proving Grounds and its conversion to a National Wildlife Refuge. This 58,000-acre installation has restricted human access due to unexploded ordinance and contains some of the highest quality natural habitat in Indiana.
- The U.S. Fish and Wildlife Service in Louisiana used GAP data to avoid conflict over the designation of critical habitat of the federally endangered Louisiana black bear (*Ursus americanus luteolus*).
- The National Oceanic and Atmospheric Administration Coastal Marine Sanctuary in Washington State uses GAP data for an educational display.
- In Washington and New Mexico, digital land cover maps have been distributed to all national forests.
- The U.S. Natural Resources Conservation Service in New Mexico is using a GAP clustered imagery as a base for their land cover mapping activities.
- The Department of Defense (DoD) is funding the development of an electronic environmental information system for the Mojave ecoregion, which would use GAP data as a foundation or base layer of information. The system will link 29 DoD installations to a common source of environmental information.

Appendix 2. Terrestrial Vertebrate Species of Puerto Rico

This table includes the scientific name, English and Spanish common names, species identification code (species ID), class, order, family, and taxonomic authority for 436 terrestrial vertebrate species found in Puerto Rico. The 177 resident, endemic, or endangered terrestrial vertebrate species addressed in the Puerto Rico Gap Analysis Project are in **bold**.

Table 24—Terrestrial vertebrate species of Puerto Rico

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Birds (328 species)							
Accipiter striatus venator	**Puerto Rican sharp-shinned hawk**	**Halcón de sierra**	**ABNKC12021**	**Aves**	**Falconiformes**	**Accipitridae**	**Wetmore, 1914**
Actitis macularia	Spotted sandpiper	Playero coleador	ABNNF04020	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1766
Agelaius xanthomus	**Yellow-shouldered blackbird**	**Mariquita de Puerto Rico**	**ABPBXB0040**	**Aves**	**Passeriformes**	**Icteridae**	**Sclater, 1862**
Aix sponsa	Wood duck	Pato joyuyo	ABNJB09010	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Ajaia ajaja	Roseate spoonbill	Espátula rosada	ABNGE05010	Aves	Ciconiiformes	Threskiornithidae	Linnaeus, 1758
Amandava amandava	Red avadavat	Gorrión fresa	ABPCB03010	Aves	Passeriformes	Estrildidae	Linnaeus, 1758
Amazona amazonica	Orange-winged parrot	Cotorra alianaranjada	LANRA78220	Aves	Psittaciformes	Psittacidae	Linnaeus, 1766
Amazona ochrocephala	Yellow-headed parrot	Cotorra cabeciamarilla	ABNQA15120	Aves	Psittaciformes	Psittacidae	Ridgway, 1887
Amazona ventralis	**Hispaniolan parrot**	**Cotorra de La Española**	**ABNQA15050**	**Aves**	**Psittaciformes**	**Psittacidae**	**Muller, 1776**
Amazona viridigenalis	Red-crowned parrot	Cotorra coronirroja	ABNQA15080	Aves	Psittaciformes	Psittacidae	Cassin, 1853
Amazona vittata	**Puerto Rican parrot**	**Cotorra Puertorriqueña**	**ABNQA15060**	**Aves**	**Psittaciformes**	**Psittacidae**	**Boddaert, 1783**
Ammodramus savannarum	**Grasshopper sparrow**	**Gorrión chicharra**	**ABPBXA0020**	**Aves**	**Passeriformes**	**Emberizidae**	**Gmelin, 1789**
Anas acuta	Northern pintail	Pato pescuecilargo	ABNJB10110	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Anas americana	American wigeon	Pato cabeciblanco Americano	ABNJB10180	Aves	Anseriformes	Anatidae	Gmelin, 1789
Anas bahamensis	**White-cheeked pintail**	**Pato quijada colorada**	**ABNJB10100**	**Aves**	**Anseriformes**	**Anatidae**	**Linnaeus, 1758**
Anas clypeata	Northern shoveler	Pato cuchareta	ABNJB10150	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Anas crecca	Green-winged teal	Pato aliverde	ABNJB10010	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Anas cyanoptera	Cinnamon teal	Pato colorado	ABNJB10140	Aves	Anseriformes	Anatidae	Vieillot, 1816
Anas discors	Blue-winged teal	Pato zarcel	ABNJB10130	Aves	Anseriformes	Anatidae	Linnaeus, 1766
Anas penelope	Eurasian wigeon	Pato cabeciblanco Europeo	ABNJB10170	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Anas platyrhynchos	Mallard	Pato cabeciverde	ABNJB10060	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Anas querquedula	Garganey	Pato carretón	ABNJB10120	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Anas rubripes	American black duck	Pato oscuro	ABNJB10040	Aves	Anseriformes	Anatidae	Brewster, 1902
Anas strepera	Gadwall	Pato grís	ABNJB10160	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Anous minutus	Black noddy	Cervera negra	ABNNM11020	Aves	Charadriiformes	Laridae	Boie, 1844
Anous stolidus	Brown noddy	Cervera	ABNNM11010	Aves	Charadriiformes	Laridae	Linnaeus, 1758

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Anthracothorax dominicus	**Antillean mango**	**Zumbador dorado**	**ABNUC11040**	**Aves**	**Apodiformes**	**Trochilidae**	**Linnaeus, 1766**
Anthracothorax viridis	**Green mango**	**Zumbador verde**	**ABNUC11050**	**Aves**	**Apodiformes**	**Trochilidae**	**Audebert and Viellot, 1801**
Apus melba	Alpine swift	Vencejo real	ABNUA05030	Aves	Apodiformes	Apodidae	Linnaeus, 1758
Aramus guarauna	Limpkin	Carrao	ABNMJ01010	Aves	Gruiformes	Aramidae	Linnaeus, 1766
Aratinga canicularis	**Orange-fronted parakeet**	**Periquito frentianaranjado**	**ABNQA06070**	**Aves**	**Psittaciformes**	**Psittacidae**	**Linnaeus, 1758**
Aratinga chloroptera	**Hispaniolan parakeet**	**Periquito de la Española**	**ABNQA06040**	**Aves**	**Psittaciformes**	**Psittacidae**	**Souance, 1856**
Aratinga pertinax	**Brown-throated parakeet**	**Periquito de curazao**	**ABNQA06080**	**Aves**	**Psittaciformes**	**Psittacidae**	**Linnaeus, 1758**
Archilochus colubris	Ruby-throated hummingbird	Zumbadorcito gorgirrojo	ABNUC45010	Aves	Apodiformes	Trochilidae	Linnaeus, 1758
Ardea alba	**Great egret**	**Garzón blanco**	**ABNGA04040**	**Aves**	**Ciconiiformes**	**Ardeidae**	**Linnaeus, 1758**
Ardea herodias	Great blue heron	Garzón cenizo	ABNGA04010	Aves	Ciconiiformes	Ardeidae	Linnaeus, 1758
Arenaria interpres	Ruddy turnstone	Playero turco	ABNNF09010	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1758
Asio flammeus	**Short-eared owl**	**Múcaro real**	**ABNSB13040**	**Aves**	**Strigiformes**	**Strigidae**	**Pontoppidan, 1763**
Aythya affinis	Lesser scaup	Pato pechiblanco	ABNJB11070	Aves	Anseriformes	Anatidae	Eyton, 1838
Aythya collaris	Ring-necked duck	Pato acollarado	ABNJB11040	Aves	Anseriformes	Anatidae	Donovan, 1809
Aythya marila	Greater scaup	Pato boludo	ABNJB11060	Aves	Anseriformes	Anatidae	Linnaeus, 1761
Aythya valisineria	Canvasback	Pato lomiblanco	ABNJB11020	Aves	Anseriformes	Anatidae	Wilson, 1814
Bartramia longicauda	Upland sandpiper	Ganga	ABNNF06010	Aves	Charadriiformes	Scolopacidae	Bechstein, 1812
Bombycilla cedrorum	Cedar waxwing	Ampelis Americano	ABPBN01020	Aves	Passeriformes	Bombycillidae	Vieillot, 1808
Botaurus lentiginosus	American bittern	Yaboa Americana	ABNGA01020	Aves	Ciconiiformes	Ardeidae	Rackett, 1813
Branta bernicla	Brant goose	Ganso carinegra	ABNJB05010	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Branta canadensis	Canada goose	Ganso canadiense	ABNJB05030	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Brotogeris versicolurus	White-winged parakeet	Pequito aliamarillo	ABNQA11020	Aves	Psittaciformes	Psittacidae	Muller, 1776
Bubulcus ibis	**Cattle egret**	**Garza del ganado**	**ABNGA07010**	**Aves**	**Ciconiiformes**	**Ardeidae**	**Linnaeus, 1758**
Bucephala albeola	Bufflehead	Pato pínto	ABNJB18030	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Buteo jamaicensis	**Red-tailed hawk**	**Guaraguao colirrojo**	**ABNKC19110**	**Aves**	**Falconiformes**	**Accipitridae**	**Gmelin, 1788**
Buteo platypterus brunnescens	**Puerto Rican broad-winged hawk**	**Guaraguao de bosque**	**ABNKC19050**	**Aves**	**Falconiformes**	**Accipitridae**	**Vieillot, 1823**
Buteo ridgwayi	Ridgway's hawk	Guaraguaito de la Española	ABNKC19040	Aves	Falconiformes	Accipitridae	Cory, 1883
Buteogallus anthracinus	Common black-hawk	Guaraguano negro	ABNKC15010	Aves	Falconiformes	Accipitridae	Deppe, 1830
Butorides virescens	**Green heron**	**Martinete verde**	**ABNGA08010**	**Aves**	**Ciconiiformes**	**Ardeidae**	**Linnaeus, 1758**
Cairina moschata	Muscovy duck	Pato criollo	ABNJB07010	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Calidris alba	Sanderling	Playero arenero	ABNNF11030	Aves	Charadriiformes	Scolopacidae	Pallas, 1764
Calidris alpina	Dunlin	Playero espalda colorada	ABNNF11170	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1758
Calidris canutus	Red knot	Playero gordo	ABNNF11020	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1758

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Calidris ferruginea	Curlew sandpiper	Playero zarapatin	ABNNF11180	Aves	Charadriiformes	Scolopacidae	Pontoppidan, 1763
Calidris fuscicollis	White-rumped sandpiper	Playero de rabadilla blanca	ABNNF11110	Aves	Charadriiformes	Scolopacidae	Vieillot, 1819
Calidris himantopus	Stilt sandpiper	Playero patilargo	ABNNF11190	Aves	Charadriiformes	Scolopacidae	Bonaparte, 1826
Calidris mauri	Western sandpiper	Playero occidental	ABNNF11050	Aves	Charadriiformes	Scolopacidae	Cabanis, 1857
Calidris melanotos	Pectoral sandpiper	Playero pectoral	ABNNF11130	Aves	Charadriiformes	Scolopacidae	Vieillot, 1819
Calidris minutilla	Least sandpiper	Playerito menudillo	ABNNF11100	Aves	Charadriiformes	Scolopacidae	Vieillot, 1819
Calidris pusilla	Semipalmated sandpiper	Playero gracioso	ABNNF11040	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1766
Calonectris diomedea	Cory's shearwater	Pampero ceniciento	ABNDB06020	Aves	Procellariiformes	Procellariidae	Scopoli, 1769
Caprimulgus carolinensis	Chuck-will's-widow	Guabairo de la Carolina	ABNTA07010	Aves	Caprimulgiformes	Caprimulgidae	Gmelin, 1789
Caprimulgus cayennensis	White-tailed nightjar	Guabairo coliblanco	ABNTA07100	Aves	Caprimulgiformes	Caprimulgidae	J.F. Gmelin, 1789
Caprimulgus noctitherus	**Puerto Rican nightjar**	**Guabairo de Puerto Rico**	**ABNTA07080**	**Aves**	**Caprimulgiformes**	**Caprimulgidae**	**Wetmore, 1919**
Carduelis cucullata	**Red siskin**	**Cardenalito**	**ABPBY06070**	**Aves**	**Passeriformes**	**Fringillidae**	**Swainson, 1820**
Catharacta skua	Great skua	Págalo grande	ABNNM01040	Aves	Charadriiformes	Laridae	Brunnich, 1764
Cathartes aura	**Turkey vulture**	**Aura tiñosa**	**ABNKA02010**	**Aves**	**Ciconiiformes**	**Cathartidae**	**Linnaeus, 1758**
Catharus bicknelli	Bicknell's thrush	Zorzal de Bicknell	ABPBJ18120	Aves	Passeriformes	Turdidae	Ridgway, 1882
Catharus minimus	Gray-cheeked thrush	Zorzal carigris	ABPBJ18090	Aves	Passeriformes	Turdidae	Lafresnaye, 1848
Catoptrophorus semipalmatus	**Willet**	**Playero aliblanco**	**ABNNF02010**	**Aves**	**Charadriiformes**	**Scolopacidae**	**Gmelin, 1789**
Ceryle alcyon	Belted kingfisher	Martín pescador norteño	ABNXD01020	Aves	Coraciiformes	Alcedinidae	Linnaeus, 1758
Ceryle torquata	Ringed kingfisher	Martín pescador anillado	ABNXD01010	Aves	Coraciiformes	Alcedinidae	Linnaeus, 1776
Chaetura brachyura	Short-tailed swift	Vencejo pequeño	ABNUA03040	Aves	Apodiformes	Apodidae	Jardine, 1846
Charadrius alexandrinus	Snowy plover	Chorlo blanco	ABNNB03030	Aves	Charadriiformes	Charadriidae	Linnaeus, 1758
Charadrius melodus	Piping plover	Chorlo melódico	ABNNB03070	Aves	Charadriiformes	Charadriidae	Ord, 1824
Charadrius semipalmatus	Semipalmated plover	Chorlo acollarado	ABNNB03060	Aves	Charadriiformes	Charadriidae	Bonaparte, 1825
Charadrius vociferus	**Killdeer**	**Chorlo sabanero**	**ABNNB03090**	**Aves**	**Charadriiformes**	**Charadriidae**	**Linnaeus, 1758**
Charadrius wilsonia	**Wilson's plover**	**Chorlo marítimo**	**ABNNB03040**	**Aves**	**Charadriiformes**	**Charadriidae**	**Ord, 1814**
Chen caerulescens	Snow goose	Ganso blanco	ABNJB04010	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Chlidonias niger	Black tern	Gharrán ceniza	ABNNM10020	Aves	Charadriiformes	Laridae	Linnaeus, 1758
Chlorostilbon maugaeus	**Puerto Rican emerald**	**Zumbadorcito de Puerto Rico**	**ABNUC18050**	**Aves**	**Apodiformes**	**Trochilidae**	**Audebert and Vieillot, 1801**
Chordeiles gundlachii	**Antillean nighthawk**	**Querequeqúe Antillano**	**ABNTA02030**	**Aves**	**Caprimulgiformes**	**Caprimulgidae**	**Lawrence, 1857**
Chordeiles minor	Common nighthawk	Querequeqúe menor	ABNTA02020	Aves	Caprimulgiformes	Caprimulgidae	Forster, 1771
Circus cyaneus	Northern harrier	Gavilán de ciénaga	ABNKC11010	Aves	Falconiformes	Accipitridae	Linnaeus, 1758
Coccyzus americanus	**Yellow-billed cuckoo**	**Pájaro bobo pechiblanco**	**ABNRB02020**	**Aves**	**Cuculiformes**	**Cuculidae**	**Linnaeus, 1758**

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Coccyzus erythropthalmus	Black-billed cuckoo	Pájaro bobo piquinegro	ABNRB02010	Aves	Cuculiformes	Cuculidae	Wilson, 1811
Coccyzus minor	**Mangrove cuckoo**	**Pájaro bobo menor**	**ABNRB02030**	**Aves**	**Cuculiformes**	**Cuculidae**	**Gmelin, 1788**
Coereba flaveola	**Bananaquit**	**Reinita común**	**ABPBX28010**	**Aves**	**Passeriformes**	**Emberizidae**	**Linnaeus, 1758**
Colinus virginianus	Northern bobwhite	Codorniz de Virginia	ABNLC21020	Aves	Galliformes	Odontophoridae	Linnaeus, 1758
Columba livia	Rock dove	Paloma doméstica	ABNPB01010	Aves	Columbiformes	Columbidae	Gmelin, 1789
Columbina passerina	**Common ground-dove**	**Rolita**	**ABNPB06020**	**Aves**	**Columbiformes**	**Columbidae**	**Linnaeus, 1758**
Contopus hispaniolensis	Hispaniolan pewee	Bobito de la Española	LAP0946120	Aves	Passeriformes	Tyrannidae	Bryant, 1867
Contopus latirostris	**Lesser Antillean pewee**	**Bobito Antíllano Menor**	**ABPAE32090**	**Aves**	**Passeriformes**	**Tyrannidae**	**Verreaux, 1866**
Corvus leucognaphalus	White-necked crow	Cuervo pescueciblanco	ABPAV10050	Aves	Passeriformes	Corvidae	Daudin, 1800
Crotophaga ani	**Smooth-billed ani**	**Garrapatero**	**ABNRB11020**	**Aves**	**Cuculiformes**	**Cuculidae**	**Linnaeus, 1758**
Cygnus columbianus	Tundra swan	Cisne de tundra	ABNJB02010	Aves	Anseriformes	Anatidae	Ord, 1815
Cypseloides niger	**Black swift**	**Vencejo negro**	**ABNUA01010**	**Aves**	**Apodiformes**	**Apodidae**	**Gmelin, 1789**
Dendrocygna arborea	**West Indian whistling-duck**	**Chiriría caribeña**	**ABNJB01020**	**Aves**	**Anseriformes**	**Anatidae**	**Linnaeus, 1758**
Dendrocygna autumnalis	Black-bellied whistling-duck	Chiriría pinta	ABNJB01040	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Dendrocygna bicolor	**Fulvous whistling-duck**	**Chiriría bicolor**	**ABNJB01010**	**Aves**	**Anseriformes**	**Anatidae**	**Vieillot, 1816**
Dendroica adelaidae	**Adelaide's warbler**	**Reinita mariposera**	**ABPBX03150**	**Aves**	**Passeriformes**	**Parulidae**	**Baird, 1865**
Dendroica angelae	**Elfin-woods warbler**	**Reinita de bosque enaño**	**ABPBX03270**	**Aves**	**Passeriformes**	**Parulidae**	**Kepler and Parkes, 1972**
Dendroica caerulescens	Black-throated blue warbler	Reinita azul	ABPBX03050	Aves	Passeriformes	Parulidae	Gmelin, 1789
Dendroica castanea	Bay-breasted warbler	Reinita castaña	ABPBX03220	Aves	Passeriformes	Parulidae	Wilson, 1810
Dendroica cerulea	Cerulean warbler	Reinita cerúlea	ABPBX03240	Aves	Passeriformes	Parulidae	Wilson, 1810
Dendroica coronata	Yellow-rumped warbler	Reinita coronada	ABPBX03060	Aves	Passeriformes	Parulidae	Linnaeus, 1766
Dendroica discolor	Prairie warbler	Reinita galana	ABPBX03190	Aves	Passeriformes	Parulidae	Vieillot, 1809
Dendroica dominica	Yellow-throated warbler	Reinita gargantiamarilla	ABPBX03130	Aves	Passeriformes	Parulidae	Linnaeus, 1776
Dendroica fusca	Blackburnian warbler	Reinita de fuego	ABPBX03120	Aves	Passeriformes	Parulidae	Muller, 1776
Dendroica magnolia	Magnolia warbler	Reinita manchada	ABPBX03030	Aves	Passeriformes	Parulidae	Wilson, 1811
Dendroica palmarum	Palm warbler	Reinita palmera	ABPBX03210	Aves	Passeriformes	Parulidae	Gmelin, 1789
Dendroica pensylvanica	Chestnut-sided warbler	Reinita flanquicastaña	ABPBX03020	Aves	Passeriformes	Parulidae	Linnaeus, 1766
Dendroica petechia	**Yellow warbler**	**Reinita amarilla**	**ABPBX03010**	**Aves**	**Passeriformes**	**Parulidae**	**Linnaeus, 1766**
Dendroica pinus	Pine warbler	Reinita de pinos	ABPBX03170	Aves	Passeriformes	Parulidae	Wilson, 1811
Dendroica striata	Blackpoll warbler	Reinita rayada	ABPBX03230	Aves	Passeriformes	Parulidae	Forster, 1772
Dendroica tigrina	Cape May warbler	Reinita tigre	ABPBX03040	Aves	Passeriformes	Parulidae	Gmelin, 1789
Dendroica virens	Black-throated green warbler	Reinita verdosa	ABPBX03100	Aves	Passeriformes	Parulidae	Gmelin, 1789
Dolichonyx oryzivorus	Bobolink	Chambergo	ABPBXA9010	Aves	Passeriformes	Icteridae	Linnaeus, 1758
Dumetella carolinensis	Gray catbird	Mauyador gris	ABPBK01010	Aves	Passeriformes	Mimidae	Linnaeus, 1766
Egretta caerulea	**Little blue heron**	**Garza azul**	**ABNGA06040**	**Aves**	**Ciconiiformes**	**Ardeidae**	**Linnaeus, 1758**
Egretta garzetta	Little egret	Garza común	ABNGA06020	Aves	Ciconiiformes	Ardeidae	Linnaeus, 1766

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Egretta gularis	Western reef heron	Garza dimorfa	ABNGA06070	Aves	Ciconiiformes	Ardeidae	Bosc, 1792
Egretta rufescens	Reddish egret	Garza rojiza	ABNGA06060	Aves	Ciconiiformes	Ardeidae	Gmelin, 1789
Egretta thula	**Snowy egret**	**Garza blanca**	**ABNGA06030**	**Aves**	**Ciconiiformes**	**Ardeidae**	**Molina, 1782**
Egretta tricolor	**Tricolored heron**	**Garza pechiblanca**	**ABNGA06050**	**Aves**	**Ciconiiformes**	**Ardeidae**	**Muller, 1776**
Elaenia martinica	**Caribbean elaenia**	**Juí blanco**	**ABPAE09010**	**Aves**	**Passeriformes**	**Tyrannidae**	**Linnaeus, 1766**
Estrilda melpoda	**Orange-cheeked waxbill**	**Veterano**	**ABPCB02020**	**Aves**	**Passeriformes**	**Estrildidae**	**Vieillot, 1817**
Estrilda troglodytes	**Black-rumped waxbill**	**Veterano orejicolorado**	**ABPCB02030**	**Aves**	**Passeriformes**	**Estrildidae**	**Lichtenstein, 1823**
Eudocimus albus	White ibis	Ibis blanco	ABNGE01010	Aves	Ciconiiformes	Threskiornithidae	Linnaeus, 1758
Eulampis holosericeus	**Green-throated carib**	**Zumbador de pecho azul**	**ABNUC12020**	**Aves**	**Apodiformes**	**Trochilidae**	**Linnaeus, 1758**
Euphonia musica	**Antillean Euphonia**	**Jilguero**	**ABPBX35060**	**Aves**	**Passeriformes**	**Emberizidae**	**J. F. Gmelin, 1789**
Euplectes afer	**Yellow-crowned bishop**	**Napoleon tejedor**	**ABPCA02020**	**Aves**	**Passeriformes**	**Ploceidae**	**J.F. Gmelin, 1789**
Euplectes franciscanus	**Orange bishop**	**Obispo colorado**	**ABPCA02030**	**Aves**	**Passeriformes**	**Ploceidae**	**Isert, 1789**
Falco columbarius	Merlin	Halcón migratorio	ABNKD06030	Aves	Falconiformes	Falconidae	Linnaeus, 1758
Falco peregrinus anatum	American peregrine falcon	Halcón peregrino	ABNKD06071	Aves	Falconiformes	Falconidae	
Falco sparverius	**American kestrel**	**Halcón común**	**ABNKD06020**	**Aves**	**Falconiformes**	**Falconidae**	**Linnaeus, 1758**
Fregata magnificens	Magnificent frigatebird	Fragata magnifica, tijereta	ABNFF01010	Aves	Pelecaniformes	Fregatidae	Mathews, 1914
Fulica americana	American coot	Gallinazo Americano	ABNME14020	Aves	Gruiformes	Rallidae	Gmelin, 1789
Fulica caribaea	**Caribbean coot**	**Gallinazo Caribeño**	**ABNME14030**	**Aves**	**Gruiformes**	**Rallidae**	**Ridgway, 1884**
Fulmarus glacialis	Northern fulmar	Fulmar boreal	ABNDB01010	Aves	Procellariiformes	Procellariidae	Linnaeus, 1761
Gallinago gallinago	Common snipe	Becasina común	ABNNF18010	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1758
Gallinula chloropus	**Common moorhen**	**Gallareta común**	**ABNME13010**	**Aves**	**Gruiformes**	**Rallidae**	**Linnaeus, 1758**
Gallus gallus	Red junglefowl	Gallina, gallo	ABNLC06010	Aves	Galliformes	Phasianidae	Linnaeus, 1758
Geothlypis trichas	Common yellowthroat	Reinita pica tierra	ABPBX12010	Aves	Passeriformes	Parulidae	Linnaeus, 1766
Geotrygon chrysia	**Key West quail-dove**	**Paloma perdíz áurea**	**ABNPB09020**	**Aves**	**Columbiformes**	**Columbidae**	**Bonaparte, 1855**
Geotrygon montana	**Ruddy quail-dove**	**Paloma perdíz rojiza**	**ABNPB09110**	**Aves**	**Columbiformes**	**Columbidae**	**Linnaeus, 1758**
Geotrygon mystacea	**Bridled quail-dove**	**Paloma perdíz de Martinica**	**ABNPB09030**	**Aves**	**Columbiformes**	**Columbidae**	**Temminck, 1811**
Gracula religiosa	Hill myna	Maina de colinas	ABPBT03010	Aves	Passeriformes	Columbidae	Linnaeus, 1758
Haematopus palliatus	American oystercatcher	Ostrero Americano	ABNNC01010	Aves	Charadriiformes	Haematopodidae	Temminck, 1820
Helmitheros vermivorus	Worm-eating warbler	Reinita gusanera	ABPBX08010	Aves	Passeriformes	Parulidae	Gmelin, 1789
Himantopus mexicanus	**Black-necked stilt**	**Viuda Mexicana**	**ABNND01010**	**Aves**	**Charadriiformes**	**Recurvirostridae**	**Muller, 1776**
Hirundo rustica	**Barn swallow**	**Golondrina horquilla**	**ABPAU09030**	**Aves**	**Passeriformes**	**Hirundinidae**	**Linnaeus, 1758**
Hylocichla mustelina	Wood thrush	Zorzal pecho manchado	ABPBJ19010	Aves	Passeriformes	Turdidae	Gmelin, 1789
Icterus dominicensis	**Greater Antillean oriole**	**Calandria**	**ABPBXB9010**	**Aves**	**Passeriformes**	**Icteridae**	**Linnaeus, 1766**
Icterus galbula	Baltimore oriole	Calandria del norte	ABPBXB9190	Aves	Passeriformes	Icteridae	Linnaeus, 1758
Icterus icterus	Venezuelan troupial	Turpial	ABPBXB9120	Aves	Passeriformes	Icteridae	Linnaeus, 1766

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Ixobrychus exilis	**Least bittern**	**Martinetito**	**ABNGA02010**	**Aves**	**Ciconiiformes**	**Ardeidae**	**Gmelin, 1789**
Jacana spinosa	Northern jacana	Jacana Centroamericana	ABNNE01010	Aves	Charadriiformes	Jacanidae	Linnaeus, 1758
Junco hyemalis	Dark-eyed junco	Junco ojioscuro	ABPBXA5020	Aves	Passeriformes	Emberizidae	Linnaeus, 1758
Larus argentatus	Herring gull	Gaviota argéntea	ABNNM03120	Aves	Charadriiformes	Laridae	Pontoppidan, 1763
Larus atricilla	Laughing gull	Gaviota cabecinegra	ABNNM03010	Aves	Charadriiformes	Laridae	Linnaeus, 1758
Larus delawarensis	Ring-billed gull	Gaviota piquianillada	ABNNM03100	Aves	Charadriiformes	Laridae	Ord, 1815
Larus fuscus	Lesser Black-backed gull	Gaviota sombriá	ABNNM03150	Aves	Charadriiformes	Laridae	Linnaeus, 1758
Larus marinus	Great Black-backed gull	Gaviota marina	ABNNM03210	Aves	Charadriiformes	Laridae	Linnaeus, 1758
Larus philadelphia	Bonaparte's gull	Gaviota de Bonaparte	ABNNM03050	Aves	Charadriiformes	Laridae	Ord, 1815
Larus pipixcan	Franklin's gull	Gaviota de Franklin	ABNNM03020	Aves	Charadriiformes	Laridae	Wagler, 1831
Larus ridibundus	Black-headed gull	Gaviota cabecinegra forastera	ABNNM03040	Aves	Charadriiformes	Laridae	Linnaeus, 1766
Laterallus jamaicensis	Black rail	Gallito negro	ABNME03040	Aves	Gruiformes	Rallidae	Gmelin, 1789
Limnodromus griseus	Short-billed dowitcher	Agujeta pico corto	ABNNF16010	Aves	Charadriiformes	Scolopacidae	Gmelin, 1789
Limnodromus scolopaceus	Long-billed dowitcher	Agujeta pico largo	ABNNF16020	Aves	Charadriiformes	Scolopacidae	Say, 1823
Limnothlypis swainsonii	Swainson's warbler	Reinita de Swainson	ABPBX09010	Aves	Passeriformes	Parulidae	Audubon, 1834
Limosa fedoa	Marbled godwit	Barga canela	ABNNF08040	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1758
Limosa haemastica	Hudsonian godwit	Barga aliblanca	ABNNF08020	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1758
Lonchura cucullata	**Bronze mannikin**	**Diablito**	**L000000192**	**Aves**	**Passeriformes**	**Estrildidae**	**Swainson, 1837**
Lonchura malabarica	**Warbling silverbill**	**Gorrión picoplata**	**ABPCB04010**	**Aves**	**Passeriformes**	**Estrildidae**	**Linnaeus, 1758**
Lonchura malacca	**Chestnut mannikin**	**Monjita tricolor**	**ABPCB04040**	**Aves**	**Passeriformes**	**Estrildidae**	**Linnaeus, 1766**
Lonchura punctulata	**Nutmeg mannikin**	**Gorrión canela**	**ABPCB04030**	**Aves**	**Passeriformes**	**Estrildidae**	**Linnaeus, 1758**
Lophodytes cucullatus	Hooded merganser	Mergansa encapuchada	ABNJB20010	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Loxigilla noctis	Lesser Antillean bullfinch	Antillano menor	ABPBX82030	Aves	Passeriformes	Emberizidae	Linnaeus, 1766
Loxigilla portoricensis	**Puerto Rican bullfinch**	**Gallito**	**ABPBX82010**	**Aves**	**Passeriformes**	**Emberizidae**	**Daudin, 1800**
Margarops fuscatus	**Pearly-eyed thrasher**	**Zorzal pardo**	**ABPBK09020**	**Aves**	**Passeriformes**	**Mimidae**	**Vieillot, 1808**
Megascops nudipes	**Puerto Rican screech-owl**	**Múcaro común**	**ABNSB01120**	**Aves**	**Strigiformes**	**Strigidae**	**Daudin, 1800**
Melanerpes portoricensis	**Puerto Rican woodpecker**	**Carpintero**	**ABNYF04030**	**Aves**	**Piciformes**	**Picidae**	**Daudin, 1803**
Mellisuga minima	Vervain hummingbird	Zumbadorcito menor	ABNUC46010	Aves	Apodiformes	Trochilidae	Linnaeus, 1758
Melopsittacus undulatus	Budgerigar	Periquito Australiano	ABNQA01010	Aves	Psittaciformes	Psittacidae	Shaw, 1805
Melospiza lincolnii	Lincoln's sparrow	Gorrion de Linclon	ABPBXA3020	Aves	Passeriformes	Emberizidae	Audubon, 1834
Mergus serrator	Red-breasted merganser	Mergansa de pico largo	ABNJB21020	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Mimus polyglottos	**Northern mockingbird**	**Ruisenor**	**ABPBK03010**	**Aves**	**Passeriformes**	**Mimidae**	**Linnaeus, 1758**
Mniotilta varia	Black-and-white warbler	Reinita trepadora	ABPBX05010	Aves	Passeriformes	Parulidae	Linnaeus, 1766
Molothrus bonariensis	**Shiny cowbird**	**Tordo lustrosso**	**ABPBXB7010**	**Aves**	**Passeriformes**	**Icteridae**	**Gmelin, 1789**
Myiarchus antillarum	**Puerto Rican flycatcher**	**Juí de Puerto Rico**	**ABPAE43130**	**Aves**	**Passeriformes**	**Tyrannidae**	**Bryant, 1866**
Myiarchus crinitus	Great crested flycatcher	Juí crestado	ABPAE43070	Aves	Passeriformes	Tyrannidae	Linnaeus, 1758
Myiarchus stolidus	Stolid flycatcher	Manuelito	ABPAE43120	Aves	Passeriformes	Tyrannidae	Gosse, 1847

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Myiopsitta monachus	Monk parakeet	Perico monje	ABNQA04010	Aves	Psittaciformes	Psittacidea	Boddaert, 1783
Nandayus nenday	Black-hooded Parakeet	Periquito nanday	ABNQA15190	Aves	Psittaciformes	Psittacidea	Vieillot, 1823
Nesospingus speculiferus	**Puerto Rican tanager**	**Llorosa de Puerto Rico**	**ABPBX52010**	**Aves**	**Passeriformes**	**Emberizidae**	**Lawrene, 1875**
Nomonyx dominicus	Masked duck	Pato Dominico	ABNJB22020	Aves	Anseriformes	Anatidae	Linnaeus, 1758
Numenius americanus	Long-billed curlew	Playero Americano	ABNNF07070	Aves	Charadriiformes	Scolopacidae	Bechstein, 1812
Numenius borealis	Eskimo curlew	Playero picocorvo esquimal	ABNNF07010	Aves	Charadriiformes	Scolopacidae	Forster, 1772
Numenius phaeopus	Whimbrel	Playero trinador	ABNNF07020	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1758
Numida meleagris	Helmeted guineafowl	Guinea torcaz	ABNLC25010	Aves	Galliformes	Phasianidae	Linnaeus, 1758
Nyctanassa violacea	**Yellow-crowned night-heron**	**Yaboa común**	**ABNGA13010**	**Aves**	**Ciconiiformes**	**Ardeidae**	**Linnaeus, 1758**
Nyctibius jamaicensis	Northern potoo	Nictibio Jamaicano	LANUC01060	Aves	Caprimulgifores	Nyctibiidae	J.F. Gmelin, 1789
Nycticorax nycticorax	**Black-crowned night-heron**	**Yaboa real**	**ABNGA11010**	**Aves**	**Ciconiiformes**	**Ardeidae**	**Linnaeus, 1758**
Oceanites oceanicus	Wilson's storm-petrel	Petrel de Wilson	ABNDC01010	Aves	Procellariiformes	Hydrobatidae	Kuhl, 1820
Oceanodroma leucorhoa	Leach's storm-petrel	Pamperito rabo horquillado	ABNDC04020	Aves	Procellariiformes	Hydrobatidae	Vieillot, 1818
Oenanthe oenanthe	Northern wheatear	Zorzal gris	ABPBJ14010	Aves	Passeriformes	Turdidae	Linnaeus, 1758
Oporornis agilis	Connecticut warbler	Reinita de Connecticut	ABPBX11020	Aves	Passeriformes	Parulidae	Wilson, 1812
Oporornis formosus	Kentucky warbler	Reinita de Kentucky	ABPBX11010	Aves	Passeriformes	Parulidae	Wilson, 1811
Oporornis philadelphia	Mourning warbler	Reinita triste	ABPBX11030	Aves	Passeriformes	Parulidae	Wilson, 1810
Orthorhyncus cristatus	**Antillean crested hummingbird**	**Zumbador crestado**	**ABNUC13010**	**Aves**	**Apodiformes**	**Trochilidae**	**Linnaeus, 1758**
Oxyura jamaicensis	**Ruddy duck**	**Pato chorizo**	**ABNJB22010**	**Aves**	**Anseriformes**	**Anatidae**	**Gmelin, 1789**
Padda oryzivora	Java sparrow	Gorrión arrocero	ABPCB05010	Aves	Passeriformes	Estrildidae	Linnaeus, 1758
Pandion haliaetus	Osprey	Aguila pescadora	ABNKC01010	Aves	Falconiformes	Accipitridae	Linnaeus, 1758
Parula americana	Northern parula	Reinita pechidorada	ABPBX02010	Aves	Passeriformes	Parulidae	Linnaeus, 1758
Passer domesticus	House sparrow	Gorrión doméstico	ABPBZ01010	Aves	Passeriformes	Passeridae	Linnaeus, 1758
Passerina caerulea	Blue grosbeak	Picogrueso azul	ABPBX64010	Aves	Passeriformes	Cardinalidae	Linnaeus, 1758
Passerina ciris	Painted bunting	Mariposa	ABPBX64060	Aves	Passeriformes	Cardinalidae	Linnaeus, 1758
Passerina cyanea	Indigo bunting	Gorrión azul	ABPBX64030	Aves	Passeriformes	Cardinalidae	Linnaeus, 1766
Patagioenas inornata	**Puerto Rican plain pigeon**	**Paloma sabanera**	**ABNPB01071**	**Aves**	**Columbiformes**	**Columbidae**	**Vigors, 1827**
Patagioenas leucocephala	**White-crowned pigeon**	**Paloma cabeciblanca**	**ABNPB01050**	**Aves**	**Columbiformes**	**Columbidae**	**Linnaeus, 1758**
Patagioenas squamosa	**Scaly-naped pigeon**	**Paloma turca**	**ABNPB01040**	**Aves**	**Columbiformes**	**Columbidae**	**Bonnaterre, 1792**
Pelecanus erythrorhynchos	American White pelican	Pelícano blanco	ABNFC01010	Aves	Pelecaniformes	Pelecanidae	Gmelin, 1789
Pelecanus occidentalis	**Brown pelican**	**Pelícano pardo**	**ABNFC01020**	**Aves**	**Pelecaniformes**	**Pelecanidae**	**Linnaeus, 1766**
Petrochelidon fulva	**Cave swallow**	**Golondrina de cuevas**	**ABPAU09020**	**Aves**	**Passeriformes**	**Hirundinidae**	**Vieillot, 1808**
Petrochelidon pyrrhonota	Cliff swallow	Golondrina de Peñasco	ABPAU09010	Aves	Passeriformes	Hirundinidae	Vieillot, 1817
Phaethon aethereus	Red-billed tropicbird	Rabijunco piquirrojo	ABNFA01020	Aves	Pelecaniformes	Phaethontidae	Linnaeus, 1758
Phaethon lepturus	White-tailed tropicbird	Rabijunco coliblanco	ABNFA01010	Aves	Pelecaniformes	Phaethontidae	Daudin, 1802

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Phalacrocorax auritus	Double-crested cormorant	Cormorán crestado	ABNFD01020	Aves	Pelecaniformes	Phalacrocoracidae	Lesson, 1831
Phalacrocorax brasilianus	Neotropic cormorant	Cormorán neotropical	ABNFD01030	Aves	Pelecaniformes	Phalacrocoracidae	Gmelin, 1789
Phalaropus lobatus	Red-necked phalarope	Falaropo picofíno	ABNNF20020	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1758
Phalaropus tricolor	Wilson's phalarope	Falaropo tricolor	ABNNF20010	Aves	Charadriiformes	Scolopacidae	Vieillot, 1819
Pheucticus ludovicianus	Rose-breasted grosbeak	Piquegrueso pechirrojo	ABPBX61030	Aves	Passeriformes	Cardinalidae	Linnaeus, 1766
Philomachus pugnax	Ruff	Playero combatiente	ABNNF15010	Aves	Charadriiformes	Scolopacidae	Linnaeus, 1758
Phoenicopterus ruber	Greater flamingo	Flamenco	ABNHA01010	Aves	Phoenicopteriformes	Phoenicopteridae	Linnaeus, 1758
Picoides villosus	Hairy woodpecker	Carpintero velloso	ABNYF07040	Aves	Piciformes	Picidae	Linnaeus, 1766
Piranga olivacea	Scarlet tanager	Tangara escarlata	ABPBX45040	Aves	Passeriformes	Thraupidae	Gmelin, 1789
Plegadis falcinellus	Glossy ibis	Ibis lustroso	ABNGE02010	Aves	Ciconiiformes	Threskiornithidae	Linnaeus, 1766
Pluvialis dominica	American golden-plover	Chorlo dorado	ABNNB02030	Aves	Charadriiformes	Charadriidae	Muller, 1776
Pluvialis squatarola	Black-bellied plover	Chorlo cabezón	ABNNB02010	Aves	Charadriiformes	Charadriidae	Linnaeus, 1758
Podilymbus podiceps	**Pied-billed grebe**	**Zaramago**	**ABNCA02010**	**Aves**	**Podicipediformes**	**Podicipedidae**	**Linnaeus, 1758**
Porphyrio martinica	**Purple gallinule**	**Gallareta azul**	**ABNME12010**	**Aves**	**Gruiformes**	**Rallidae**	**Linnaeus, 1766**
Porzana carolina	Sora	Gallito sora	ABNME08020	Aves	Gruiformes	Rallidae	Linnaeus, 1758
Porzana flaviventer	**Yellow-breasted crake**	**Gallito amarillo**	**ABNME08030**	**Aves**	**Gruiformes**	**Rallidae**	**Boddaert, 1783**
Progne dominicensis	**Caribbean martin**	**Golondrina de iglesias**	**ABPAU01030**	**Aves**	**Passeriformes**	**Hirundinidae**	**J.F. Gmelin, 1789**
Progne subis	Purple martin	Golondrina azul Americana	ABPAU01010	Aves	Passeriformes	Hirundinidae	Linnaeus, 1758
Protonotaria citrea	Prothonotary warbler	Reinita protonotaria	ABPBX07010	Aves	Passeriformes	Parulidae	Boddaert, 1783
Pterodroma arminjoniana	Herald petrel	Petrel de la Trindade	ABNDB03080	Aves	Ciconiiformes	Procellariidae	Giglioli and Salvadori, 1869
Pterodroma hasitata	Black-capped petrel	Petrel Antíllano	ABNDB03010	Aves	Procellariiformes	Procellariidae	Kuhl, 1820
Puffinus assimilis	Little shearwater	Pampero chico	ABNDB07120	Aves	Ciconiiformes	Procellaridae	Gould, 1838
Puffinus gravis	Greater shearwater	Pampero capirotado	ABNDB07030	Aves	Procellariiformes	Procellariidae	O'Reilly, 1818
Puffinus griseus	Sooty shearwater	Pardela gris	ABNDB07060	Aves	Procellariiformes	Procellariidae	J.F. Gmelin, 1789
Puffinus iherminieri	Audubon's shearwater	Pampero de Audubon	ABNDB07130	Aves	Procellariiformes	Procellariidae	Lesson, 1839
Puffinus puffinus	Manx shearwater	Pampero pichoneta	ABNDB07090	Aves	Procellariiformes	Procellariidae	Brunnich, 1764
Quiscalus niger	**Greater Antillean grackle**	**Mozambique**	**ABPBXB6030**	**Aves**	**Passeriformes**	**Icteridae**	**Boddaert, 1783**
Rallus limicola	Virginia rail	Pollo de Virginia	ABNME05030	Aves	Gruiformes	Rallidae	Vieillot, 1819
Rallus longirostris	**Clapper rail**	**Pollo de mangle**	**ABNME05010**	**Aves**	**Gruiformes**	**Rallidae**	**Boddaert, 1783**
Recurvirostra americana	American avocet	Avoceta Americana	ABNND02010	Aves	Charadriiformes	Recurvirostridae	Gmelin, 1789
Riparia riparia	Bank swallow	Golondrina parda	ABPAU08010	Aves	Passeriformes	Hirundinidae	Linnaeus, 1758
Rynchops niger	Black skimmer	Rayador Americano	ABNNM14010	Aves	Charadriiformes	Laridae	Linnaeus, 1758
Saurothera vieilloti	**Puerto Rican lizard-cuckoo**	**Pájaro bobo mayor**	**ABNRB03020**	**Aves**	**Cuculiformes**	**Cuculidae**	**Bonaparte, 1850**
Seiurus aurocapillus	Ovenbird	Pizpita dorada	ABPBX10010	Aves	Passeriformes	Parulidae	Linnaeus, 1766
Seiurus motacilla	Louisiana waterthrush	Pizpita de río	ABPBX10030	Aves	Passeriformes	Parulidae	Vieillot, 1809
Seiurus noveboracensis	Northern waterthrush	Pizpita de mangle	ABPBX10020	Aves	Passeriformes	Parulidae	Gmelin, 1789

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Serinus mozambicus	Yellow-fronted canary	Canario cantador	ABPBY07010	Aves	Passeriformes	Fringillidae	Muller, 1776
Setophaga ruticilla	American redstart	Reinita candelita	ABPBX06010	Aves	Passeriformes	Parulidae	Linnaeus, 1758
Sicalis flaveola	Saffron finch	Pinzón azafrán	ABPBX89010	Aves	Passeriformes	Emberizidae	Linnaeus, 1766
Sphyrapicus varius	Yellow-bellied sapsucker	Carpintero de paso	ABNYF05010	Aves	Piciformes	Picidae	Linnaeus, 1766
Spindalis portoricensis	**Puerto Rican spindalis**	**Reina mora**	**L000000251**	**Aves**	**Passeriformes**	**Thraupidae**	**Bryant,H, 1866**
Spiza americana	Dickcissel	Sabanero Americano	ABPBX65010	Aves	Passeriformes	Cardinalidae	Gmelin, 1789
Stercorarius pomarinus	Pomarine jaeger	Págalo pomarino	ABNNM01010	Aves	Charadriiformes	Laridae	Temminck, 1815
Sterna anaethetus	Bridled tern	Gaviota monja	ABNNM08140	Aves	Charadriiformes	Laridae	Scopoli, 1786
Sterna antillarum	Least tern	Gaviota chica	ABNNM08100	Aves	Charadriiformes	Laridae	Lesson, 1847
Sterna caspia	Caspian tern	Gaviota de Caspia	ABNNM08020	Aves	Charadriiformes	Laridae	Pallas, 1770
Sterna dougallii	Roseate tern	Palometa	ABNNM08060	Aves	Charadriiformes	Laridae	Montagu, 1813
Sterna forsteri	Forster's tern	Gaviota de Forster	ABNNM08090	Aves	Charadriiformes	Laridae	Nuttall, 1834
Sterna fuscata	Sooty tern	Gaviota oscura	ABNNM08150	Aves	Charadriiformes	Laridae	Linnaeus, 1766
Sterna hirundo	Common tern	Gaviota común	ABNNM08070	Aves	Charadriiformes	Laridae	Linnaeus, 1758
Sterna maxima	Royal tern	Gaviota real	ABNNM08030	Aves	Charadriiformes	Laridae	Boddaert, 1783
Sterna nilotica	Gull-billed tern	Gaviota piquigorda	ABNNM08010	Aves	Charadriiformes	Laridae	Gmelin, 1789
Sterna paradisaea	Arctic tern	Gaviota del Artíco	ABNNM08080	Aves	Charadriiformes	Laridae	Pontoppidan, 1763
Sterna sandvicensis	Sandwich tern	Gaviota piquiaguda	ABNNM08050	Aves	Charadriiformes	Laridae	Latham, 1787
Streptopelia decaocto	Eurasian collared-dove	Tórtola turca	ABNPB02030	Aves	Columbiformes	Columbidae	Frivaldszky, 1838
Streptopelia risoria	Ringed turtle-dove	Tórtola	ABNPB02010	Aves	Columbiformes	Columbidae	Linnaeus, 1758
Streptoprocne zonaris	White-collared swift	Vencejo acollarado	ABNUA02010	Aves	Apodiformes	Apodidae	Shaw, 1796
Sturnus vulgaris	European starling	Estornino pinto	ABPBT01010	Aves	Passeriformes	Sturnidae	Linnaeus, 1758
Sula dactylatra	Masked booby	Boba enmascarada	ABNFB01010	Aves	Pelecaniformes	Sulidae	Lesson, 1831
Sula leucogaster	Brown booby	Boba parda	ABNFB01030	Aves	Pelecaniformes	Sulidae	Boddaert, 1783
Sula sula	Red-footed booby	Boba patirroja	ABNFB01040	Aves	Pelecaniformes	Sulidae	Linnaeus, 1766
Tachornis phoenicobia	Antillean palm swift	Vencejo Antíllano	ABNUA08010	Aves	Apodiformes	Apodidae	Gosse, 1847
Tachybaptus dominicus	**Least grebe**	**Tigua**	**ABNCA01010**	**Aves**	**Podicipediformes**	**Podicipedidae**	**Linnaeus, 1766**
Tachycineta bicolor	Tree swallow	Golondrina bicolor	ABPAU03010	Aves	Passeriformes	Hirundinidae	Vieillot, 1808
Tiaris bicolor	**Black-faced grassquit**	**Gorrión negro**	**ABPBX80030**	**Aves**	**Passeriformes**	**Emberizidae**	**Linnaeus, 1766**
Tiaris olivacea	**Yellow-faced grassquit**	**Gorrion barba amarilla**	**ABPBX80020**	**Aves**	**Passeriformes**	**Emberizidae**	**Linnaeus, 1766**
Todus mexicanus	**Puerto Rican tody**	**San Pedrito**	**ABNXB01050**	**Aves**	**Coraciiformes**	**Todidae**	**Lesson, 1838**
Tringa flavipes	Lesser yellowlegs	Playero guineilla pequeño	ABNNF01030	Aves	Charadriiformes	Scolopacidae	Gmelin, 1789
Tringa melanoleuca	Greater yellowlegs	Playero guineilla grande	ABNNF01020	Aves	Charadriiformes	Scolopacidae	Gmelin, 1789
Tringa nebularia	Common greenshank	Playero claro	ABNNF01010	Aves	Charadriiformes	Scolopacidae	Gunnerus, 1767
Tringa solitaria	Solitary sandpiper	Playero solitario	ABNNF01070	Aves	Charadriiformes	Scolopacidae	Wilson, 1813
Tryngites subruficollis	Buff-breasted sandpiper	Playero canela	ABNNF14010	Aves	Charadriiformes	Scolopacidae	Vieillot, 1819
Turdus migratorius	American robin	Zorzal petirrojo	ABPBJ20170	Aves	Passeriformes	Turdidae	Linnaeus, 1766

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Turdus plumbeus	**Red-legged thrush**	**Zorzal de patas coloradas**	**ABPBJ20210**	**Aves**	**Passeriformes**	**Turdidae**	**Linnaeus, 1758**
Tyrannus caudifasciatus	**Loggerhead kingbird**	**Clerigo**	**ABPAE52080**	**Aves**	**Passeriformes**	**Tyrannidae**	**d'Orbigny, 1839**
Tyrannus dominicensis	**Gray kingbird**	**Pitirre gris**	**ABPAE52070**	**Aves**	**Passeriformes**	**Tyrannidae**	**Gmelin, 1788**
Tyrannus forficatus	Scissor-tailed flycatcher	Pitirre rabotijera	ABPAE52100	Aves	Passeriformes	Tyrannidae	Gmelin, 1789
Tyrannus tyrannus	Eastern kingbird	Pitirre norteño	ABPAE52060	Aves	Passeriformes	Tyrannidae	Linnaeus, 1758
Tyto alba	Barn owl	Lechuza común	ABNSA01010	Aves	Strigiformes	Tytonidae	Scopoli, 1769
Vanellus vanellus	Northern lapwing	Avefría	ABNNB01010	Aves	Charadriiformes	Charadriidae	Linnaeus, 1758
Vermivora chrysoptera	Golden-winged warbler	Reinita alidorada	ABPBX01030	Aves	Passeriformes	Parulidae	Linnaeus, 1766
Vermivora ruficapilla	Nashville warbler	Chipe cachetigris	ABPBX01060	Aves	Passeriformes	Parulidae	Wilson, 1811
Vidua macroura	Pin-tailed whydah	Viuda colicinta	ABPCB06010	Aves	Passeriformes	Estrildidae	Pallas, 1764
Vireo altiloquus	**Black-whiskered vireo**	**Julian Chivi**	**ABPBW01250**	**Aves**	**Passeriformes**	**Vireonidae**	**Vieillot, 1808**
Vireo flavifrons	Yellow-throated vireo	Vireo gargantiamarillo	ABPBW01170	Aves	Passeriformes	Vireonidae	Vieillot, 1808
Vireo griseus	White-eyed vireo	Julian Chivi ojiblanco	ABPBW01020	Aves	Passeriformes	Vireonidae	Boddaert, 1783
Vireo latimeri	**Puerto Rican vireo**	**Bienteveo de Puerto Rico**	**ABPBW01090**	**Aves**	**Passeriformes**	**Vireonidae**	**Baird, 1866**
Vireo olivaceus	Red-eyed vireo	Vireo de ojo rojo	ABPBW01240	Aves	Passeriformes	Vireonidae	Linnaeus, 1766
Wilsonia canadensis	Canada warbler	Reinita de Canada	ABPBX16030	Aves	Passeriformes	Parulidae	Linnaeus, 1766
Wilsonia citrina	Hooded warbler	Reinita viuda	ABPBX16010	Aves	Passeriformes	Parulidae	Boddaert, 1783
Wilsonia pusilla	Wilson's warbler	Reinita gorrinegra	ABPBX16020	Aves	Passeriformes	Parulidae	Wilson, 1811
Zenaida asiatica	**White-winged dove**	**Tórtola aliblanca**	**ABNPB04010**	**Aves**	**Columbiformes**	**Columbidae**	**Linnaeus, 1758**
Zenaida aurita	**Zenaida dove**	**Tórtola cardosantera**	**ABNPB04020**	**Aves**	**Columbiformes**	**Columbidae**	**Linnaeus, 1758**
Zenaida macroura	**Mourning dove**	**Tórtola rabilarga**	**ABNPB04040**	**Aves**	**Columbiformes**	**Columbidae**	**Linnaeus, 1758**
Amphibians (24 species)							
Bufo lemur	**Puerto Rican crested toad**	**Sapo concho**	**AAABB02010**	**Amphibia**	**Anura**	**Bufonidae**	**Cope, 1869**
Bufo marinus	**Giant toad**	**Sapo común**	**AAABB01100**	**Amphibia**	**Anura**	**Bufonidae**	**Linnaeus, 1758**
Eleutherodactylus antillensis	**Antillean frog**	**Churí**	**AAABD04250**	**Amphibia**	**Anura**	**Leptodactylidae**	**Reinhardt and Lutken, 1863**
Eleutherodactylus brittoni	**Grass coqui**	**Coquí de las hierbas**	**AAABD04090**	**Amphibia**	**Anura**	**Leptodactylidae**	**Schmidt, 1920**
Eleutherodactylus cochranae	**Whistling frog**	**Coquí pitito**	**AAABD04180**	**Amphibia**	**Anura**	**Leptodactylidae**	**Grant, 1932**
Eleutherodactylus cooki	**Rock coqui**	**Coquí guajón**	**AAABD04010**	**Amphibia**	**Anura**	**Leptodactylidae**	**Grant, 1931**
Eleutherodactylus coqui	**Common coqui**	**Coquí de las yerbas**	**AAABD04100**	**Amphibia**	**Anura**	**Leptodactylidae**	**Thomas, 1966**
Eleutherodactylus eneidae	**Eneida's coqui**	**Coquí de Eneida**	**AAABD04060**	**Amphibia**	**Anura**	**Leptodactylidae**	**Rivero, 1959**
Eleutherodactylus gryllus	**Cricket coqui**	**Coquí grillo**	**AAABD04110**	**Amphibia**	**Anura**	**Leptodactylidae**	**Schmidt, 1920**
Eleutherodactylus hedricki	**Tree-hole frog**	**Coquí de Hedrick**	**AAABD04020**	**Amphibia**	**Anura**	**Leptodactylidae**	**Rivero, 1963**
Eleutherodactylus jasperi	**Golden coqui**	**Coquí dorado**	**AAABD04030**	**Amphibia**	**Anura**	**Leptodactylidae**	**Drewry and Jones, 1976**

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Eleutherodactylus karlschmidti	Web-footed coqui	Coquí palmeado	AAABD04040	Amphibia	Anura	Leptodactylidae	Grant, 1931
Eleutherodactylus locustus	**Warty coqui**	**Coquí martillito**	**AAABD04120**	**Amphibia**	**Anura**	**Leptodactylidae**	**Schmidt, 1920**
Eleutherodactylus monensis	**Mona coqui**	**Coquí de la Mona**	**AAABD04130**	**Amphibia**	**Anura**	**Leptodactylidae**	**Meerwarth, 1920**
Eleutherodactylus portoricensis	**Puerto Rican coqui**	**Coquí de la montaña**	**AAABD04140**	**Amphibia**	**Anura**	**Leptodactylidae**	**Schmidt, 1920**
Eleutherodactylus richmondi	**Ground coqui**	**Coquí caoba**	**AAABD04150**	**Amphibia**	**Anura**	**Leptodactylidae**	**Stejneger, 1904**
Eleutherodactylus unicolor	**Burrowing coqui**	**Coquí duende**	**AAABD04050**	**Amphibia**	**Anura**	**Leptodactylidae**	**Stejneger, 1904**
Eleutherodactylus wightmanae	**Wrinkled frog**	**Coquí melodioso**	**AAABD04160**	**Amphibia**	**Anura**	**Leptodactylidae**	**Schmidt, 1920**
Hyla cinerea	Green treefrog	Hila verde	AAABC02060	Amphibia	Anura	Hylidae	Schneider, 1799
Leptodactylus albilabris	**White-lipped frog**	**Ranita de blanco**	**AAABD02020**	**Amphibia**	**Anura**	**Leptodactylidae**	**Günther, 1859**
Osteopilus septentrionalis	Cuban treefrog	Hila platanera	AAABC04010	Amphibia	Anura	Hylidae	Duméril and Bibron, 1841
Rana catesbeiana	Bullfrog	Rana toro	AAABH01070	Amphibia	Anura	Ranidae	Shaw, 1802
Rana grylio	Pig frog	Rana	AAABH01110	Amphibia	Anura	Ranidae	Stejneger, 1901
Scinax rubra	Treefrog	Hila inquieta	AAABC08010	Amphibia	Anura	Hylidae	Laurenti, 1768
Mammals (27 species)							
Artibeus jamaicensis	**Jamaican fruit-eating bat**	**Muciérlago frutero**	**AMACB07010**	**Mammalia**	**Chiroptera**	**Phyllostomidae**	**Leach, 1821**
Brachyphylla cavernarum	**Antillean fruit-eating bat**	**Murciélago cavernícola**	**AMACB08010**	**Mammalia**	**Chiroptera**	**Phyllostomidae**	**Gray, 1834**
Capra hircus	Goat	Cabra	AMALE07010	Mammalia	Artiodactyla	Bovidae	Linnaeus, 1758
Eptesicus fuscus	**Big brown bat**	**Murciélago marrón mayor**	**AMACC04010**	**Mammalia**	**Chiroptera**	**Vespertilionidae**	**Palisot de Beauvois, 1796**
Erophylla sezekorni	**Buffy flower bat**	**Murciélago las flores**	**AMACB09010**	**Mammalia**	**Chiroptera**	**Phyllostomidae**	**Gundlach, 1860**
Felis catus	Feral cat	Gatto	AMAJH01070	Mammalia	Carnivora	Felidae	Linnaeus, 1775
Herpestes javanicus	**Small Indian mongoose**	**Mangosta**	**AMAJJ01010**	**Mammalia**	**Carnivora**	**Herpestidae**	**E. Geoffroy Saint-Hilaire, 1818**
Isolobodon portoricensis	Puerto Rican hutia	Jutía	AMAFL01010	Mammalia	Rodentia	Capromyidae	Allen, 1916
Lasiurus borealis	**Eastern red bat**	**Murciélago rojo**	**AMACC05010**	**Mammalia**	**Chiroptera**	**Vespertilionidae**	**Muller, 1776**
Macaca mulatta	Rhesus monkey	Macaco	AMAMB02010	Mammalia	Primates	Cercopithecidae	Zimmerman, 1780
Macrotus waterhousii	Waterhouse's leaf-nosed bat	Murciélago orejudo	LMGK025020	Mammalia	Chiroptera	Phyllostomidae	Gray, 1843
Molossus molossus	**Velvety free-tailed bat**	**Murciélago casero**	**AMACD03010**	**Mammalia**	**Chiroptera**	**Molossidae**	**Pallas, 1766**
Monachus tropicalis	West Indian monk seal		AMAJG04010	Mammalia	Carnivora	Phocidae	Gray, 1850
Monophyllus plethodon	Insular long-tongued bat	Murciélago lenguilargo	AMACB06010	Mammalia	Chiroptera	Phyllostomidae	Miller, 1900
Monophyllus redmani portoricensis	**Puerto Rican long-tongued bat**	**Murciélago**	**AMACB06021**	**Mammalia**	**Chiroptera**	**Phyllostomidae**	**Leach, 1821**
Mormoops blainvillii	**Antillean ghost-faced bat**	**Murciélago barbicacho**	**AMACA01020**	**Mammalia**	**Chiroptera**	**Mormoopidae**	**Leach, 1821**
Mus musculus	House mouse	Ratón casero	AMAFF22010	Mammalia	Rodentia	Muridae	Linnaeus, 1758
Noctilio leporinus	**Greater bulldog bat**	**Murciélago pescador**	**AMACE01010**	**Mammalia**	**Chiroptera**	**Noctilionidae**	**Linnaeus, 1758**
Odocoileus virginianus	White-tailed deer	Venado rabiblanco	AMALC02020	Mammalia	Artiodactyla	Cervidae	Zimmermann, 1780

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Pteronotus parnellii portoricensis	**Parnell's mustached bat**	**Murciélago bigotudo mayor**	**AMACA02011**	**Mammalia**	**Chiroptera**	**Mormoopidae**	**Miller, 1902**
Pteronotus quadridens	**Sooty mustached bat**	**Murciélago bigotudo menor**	**AMACA02020**	**Mammalia**	**Chiroptera**	**Mormoopidae**	**Gundlach, 1840**
Rattus norvegicus	Norway rat	Rata de Noruega	AMAFF21020	Mammalia	Rodentia	Muridae	Berkenhout, 1769
Rattus rattus	Black rat	Rata negra	AMAFF21010	Mammalia	Rodentia	Muridae	Linnaeus, 1758
Stenoderma rufum	**Desmarest's fig-eating bat**	**Murciélago rojo frutero**	**AMACB05010**	**Mammalia**	**Chiroptera**	**Phyllostomidae**	**Desmarest, 1820**
Sus scrofa	Feral hog	Cerdo	AMALA01010	Mammalia	Artiodactyla	Suidae	Linnaeus, 1758
Tadarida brasiliensis	**Brazilian free-tailed bat**	**Murciélago de cola libre**	**AMACD01010**	**Mammalia**	**Chiroptera**	**Molossidae**	**I. Geoffroy, 1824**
Trichechus manatus	West Indian manatee	Manati Antíllano	AMAKA01010	Mammalia	Sirenia	Trichechidae	Linnaeus, 1758
Reptiles (57 species)							
Alsophis portoricensis	**Puerto Rican racer**	**Culebra Corredora**	**ARADB40010**	**Reptilia**	**Squamata**	**Colubridae**	**Reinhardt and Lütken, 1862**
Ameiva alboguttata	**Mona ground lizard**	**Siguan de la Mona**	**ARACJ01042**	**Reptilia**	**Squamata**	**Teiidae**	**Boulenger, 1896**
Ameiva desechensis	**Desecheo ground lizard**	**Siguana de Desecheo**	**ARACJ01043**	**Reptilia**	**Squamata**	**Iguanidae**	**Heatwole and Torres, 1967**
Ameiva exsul	**Puerto Rican ground lizard**	**Siguana común**	**ARACJ01040**	**Reptilia**	**Squamata**	**Teiidae**	**Cope, 1862**
Ameiva wetmorei	**Blue-tailed ground lizard**	**Siguana de rabo azul**	**ARACJ01030**	**Reptilia**	**Squamata**	**Teiidae**	**Stejneger, 1913**
Amphisbaena bakeri	**Baker's legless lizard**	**Culebrita ciega de Baker**	**ARACA02010**	**Reptilia**	**Squamata**	**Amphisbaenidae**	**Stejneger, 1904**
Amphisbaena caeca	**Puerto Rican worm lizard**	**Culebrita ciega común**	**ARACA02020**	**Reptilia**	**Squamata**	**Amphisbaenidae**	**Cuvier, 1829**
Amphisbaena schmidti	**Schmidt's worm lizard**	**Culebrita ciega de Schmidt**	**ARACA02030**	**Reptilia**	**Squamata**	**Amphisbaenidae**	**Gans, 1964**
Amphisbaena xera	**North American worm lizard**	**Culebrita ciega del seco**	**ARACA02040**	**Reptilia**	**Squamata**	**Amphisbaenidae**	**Thomas, 1966**
Anolis cooki	**Cook's anole**	**Lagartijo del seco**	**ARACF01100**	**Reptilia**	**Squamata**	**Iguanidae**	**Grant, 1931**
Anolis cristatellus	**Crested anole**	**Lagartijo común**	**ARACF01020**	**Reptilia**	**Squamata**	**Iguanidae**	**Duméril and Bibron, 1837**
Anolis cuvieri	**Puerto Rican giant anole**	**Lagarto verde**	**ARACF01110**	**Reptilia**	**Squamata**	**Iguanidae**	**Merrem, 1820**
Anolis desechensis	**Desecheo anole**	**Lagartijo de Desecheo**	**ARACF01120**	**Reptilia**	**Squamata**	**Iguanidae**	**Heatwole, 1976**
Anolis evermanni	**Emerald anole**	**Lagartijo verde**	**ARACF01130**	**Reptilia**	**Squamata**	**Iguanidae**	**Stejneger, 1904**
Anolis gundlachi	**Yellow-bearded anole**	**Lagartijo barba amarilla**	**ARACF01140**	**Reptilia**	**Squamata**	**Iguanidae**	**Peters, 1876**
Anolis krugi	**Upland grass anole**	**Lagartijo jardinero de montana**	**ARACF01150**	**Reptilia**	**Squamata**	**Iguanidae**	**Peters, 1876**
Anolis monensis	**Mona anole**	**Lagartijo de la Mona**	**ARACF01160**	**Reptilia**	**Squamata**	**Iguanidae**	**Stejneger, 1904**
Anolis occultus	**Puerto Rican pygmy anole**	**Lagartijo pigmeo**	**ARACF01080**	**Reptilia**	**Squamata**	**Iguanidae**	**Williams and Rivero, 1965**
Anolis poncensis	**Dryland grass anole**	**Lagartijo jardinero de Ponce**	**ARACF01170**	**Reptilia**	**Squamata**	**Iguanidae**	**Stejneger, 1904**
Anolis pulchellus	**Common grass anole**	**Lagartijo jardinero**	**ARACF01210**	**Reptilia**	**Squamata**	**Iguanidae**	**Duméril and Bibron, 1837**

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Anolis roosevelti	**Culebra Island giant anole**	**Lagartijo gigante de Culebra**	**ARACF01070**	**Reptilia**	**Squamata**	**Iguanidae**	**Grant, 1931**
Anolis stratulus	**Barred anole**	**Lagartijo manchado**	**ARACF01200**	**Reptilia**	**Squamata**	**Iguanidae**	**Cope, 1861**
Arrhyton exiguum	**Culebra garden snake**	**Culebra de jardín**	**ARADB41010**	**Reptilia**	**Squamata**	**Colubridae**	**Cope, 1862**
Caiman crocodilus	Spectacled caiman	Baba	ARABA02010	Reptilia	Crocodila	Alligatoridae	Linnaeus, 1758
Caretta caretta	Loggerhead sea turtle	Cabezón	ARAAA01010	Reptilia	Testudines	Cheloniidae	Linnaeus, 1758
Chelonia mydas	Green sea turtle	Pejeblanco	ARAAA02010	Reptilia	Testudines	Cheloniidae	Linnaeus, 1758
Cyclura nubila	Cuban ground iguana	Iguana Cubana	ARACF18030	Reptilia	Squamata	Iguanidae	Gray, 1831
Cyclura stejnegeri	**Mona Island rock iguana**	**Iguana de la Mona**	**ARACF18010**	**Reptilia**	**Squamata**	**Iguanidae**	**Barbour and Noble, 1916**
Dermochelys coriacea	Leatherback sea turtle	Tinglar	ARAAC01010	Reptilia	Testudines	dermochelyidae	Vandelli, 1761
Diploglossus pleei	**Puerto Rican galliwasp**	**Celestus**	**ARACB03010**	**Reptilia**	**Squamata**	**Anguidae**	**Duméril and Bibron, 1839**
Epicrates inornatus	**Puerto Rican boa**	**Culebrón**	**ARADA03020**	**Reptilia**	**Squamata**	**Boidae**	**Reinhardt, 1843**
Epicrates monensis granti	**Virgin Islands tree boa**	**Culebrón de la Isla Virgin**	**ARADA03011**	**Reptilia**	**Squamata**	**Boidae**	
Epicrates monensis monensis	**Mona boa**	**Culebrón de la Mona**	**ARADA03012**	**Reptilia**	**Squamata**	**Boidae**	
Eretmochelys imbricata	Hawksbill	Carey	ARAAA03010	Reptilia	Testudines	Cheloniidae	Linnaeus, 1766
Hemidactylus brookii	**Brook's house gecko**	**Salamanquesa**	**ARACD03040**	**Reptilia**	**Squamata**	**Gekkonidae**	**Gray, 1845**
Hemidactylus mabouia	**Cosmopolitan house gecko**	**Salamanquesa**	**ARACD03050**	**Reptilia**	**Squamata**	**Gekkonidae**	**Moreau de Jonnés, 1818**
Iguana iguana	Green iguana	Iguana común	ARACF09010	Reptilia	Squamata	Iguanidae	Linnaeus, 1758
Lepidochelys olivacea	Olive Ridley sea turtle	Tortuga bastarda	ARAAA04020	Reptilia	Testudines	Cheloniidae	Eschscholtz, 1829
Mabuya mabouya sloanei	**Slippery-backed mabuya**	**Lucía**	**ARACH04011**	**Reptilia**	**Squamata**	**Scincidae**	**Daudin, 1803**
Phyllodactylus wirshingi	**Greater Antillean leaf-toed gecko**	**Salamanquesa bandeada**	**ARACD04020**	**Reptilia**	**Squamata**	**Gekkonidae**	**Kerster and Smith, 1955**
Sphaerodactylus gaigeae	**Gaige's dwarf gecko**	**Salamanquita de Pandura**	**ARACD05050**	**Reptilia**	**Squamata**	**Gekkonidae**	**Grant, 1932**
Sphaerodactylus klauberi	**Klauber's dwarf gecko**	**Salamanquita negra**	**ARACD05060**	**Reptilia**	**Squamata**	**Gekkonidae**	**Grant, 1931**
Sphaerodactylus levinsi	**Desecheo gecko**	**Salamanquita de Desecheo**	**ARACD05070**	**Reptilia**	**Squamata**	**Gekkonidae**	**Heatwole, 1968**
Sphaerodactylus macrolepis	**Common dwarf gecko**	**Salamanquita común**	**ARACD05110**	**Reptilia**	**Squamata**	**Gekkonidae**	**Gunther, 1859**
Sphaerodactylus micropithecus	**Monito gecko**	**Salamanquita de Monito**	**ARACD05040**	**Reptilia**	**Squamata**	**Gekkonidae**	**Schwartz, 1977**
Sphaerodactylus monensis	**Mona dwarf gecko**	**Salamanquita de la Mona**	**ARACD05080**	**Reptilia**	**Squamata**	**Gekkonidae**	**Meerwarth, 1901**
Sphaerodactylus nicholsi	**Nichol's dwarf gecko**	**Salamanquita pigmea**	**ARACD05090**	**Reptilia**	**Squamata**	**Gekkonidae**	**Grant, 1931**
Sphaerodactylus roosevelti	**Roosevelt's dwarf gecko**	**Salamanquita de Roosevelt**	**ARACD05010**	**Reptilia**	**Squamata**	**Gekkonidae**	**Grant, 1931**
Sphaerodactylus townsendi	**Townsend's dwarf gecko**	**Salamanquita del sureste**	**ARACD05120**	**Reptilia**	**Squamata**	**Gekkonidae**	**Grant, 1931**
Thamnophis sirtalis	Common garter snake	Culebra listonada común	ARADB36130	Reptilia	Squamata	Colubridae	Linnaeus, 1758

Table 24—Terrestrial vertebrate species of Puerto Rico (continued)

Scientific name	English common name	Spanish common name	Species ID	Class	Order	Family	Authority
Trachemys stejnegeri stejnegeri	Puerto Rican slider	Hicotea	ARAAD09030	Reptilia	Testudines	Emydidae	Schmidt, 1928
Typhlops granti	**Grant's blind snake**	**Vibora de Grant**	**ARADG02010**	**Reptilia**	**Squamata**	**Typhlopidae**	**Ruthven and Gaige, 1935**
Typhlops hypomethes	**Blind snake**	**Vibora Universitaria**	**ARADG02060**	**Reptilia**	**Squamata**	**Typhlopidae**	**Hedges and Thomas, 1991**
Typhlops monensis	**Mona blind snake**	**Vibora de la Mona**	**ARADG02020**	**Reptilia**	**Squamata**	**Typhlopidae**	**Schmidt, 1926**
Typhlops platycephalus	**Blind snake**	**Vibora de cabeza aplastada**	**ARADG02050**	**Reptilia**	**Squamata**	**Typhlopidae**	**Duméril and Bibron, 1844**
Typhlops richardii	**Richard's blind snake**	**Vibora común**	**ARADG02030**	**Reptilia**	**Squamata**	**Typhlopidae**	**Duméril and Bibron, 1844**
Typhlops rostellatus	**Puerto Rican wetland blind snake**	**Vibora de pico**	**ARADG02040**	**Reptilia**	**Squamata**	**Typhlopidae**	**Stejneger, 1904**

Appendix 3. Land Cover Vegetation Classification

Identification codes (values) from the raster image land cover map, unit name, physiography, moisture class, substrate, forest age if applicable, land forms on which class typically occurs, formation of vegetation type (from Dansereau 1966 or Borhidi 1996 when noted; otherwise from Ahern et al. 1999, and Areces-Mallea et al. 1999), area in hectares (ha) and percentage of Puerto Rico for 70 land cover units in the PRGAP land cover map and database.

Table 25—Puerto Rico land cover type site features

Value	Class name	Physiognomy	Moisture	Substrate	Age	Land form	Formation	Area	Percentage
					Years			*Hectares*	
1	Mature secondary lowland dry alluvial semideciduous forest	Closed forest	Dry	Alluvial	> 25	Plains and valleys	Closed, broadleaf mixed, lowland subtropical semi-deciduous forest.	1548	0.2
2	Young secondary lowland dry alluvial semideciduous forest	Closed forest	Dry	Alluvial	< 25	Plains and valleys	Closed, broadleaf mixed, lowland subtropical semi-deciduous forest.	2881	0.3
3	Lowland dry alluvial shrubland and woodland	Open forest, woodland, or shrubland	Dry	Alluvial	NA	Plains and valleys	Open, broadleaf, lowland subtropical semideciduous woodland and shrubland.	4472	0.5
46	Lowland dry riparian forest	Closed forest	Dry	Alluvial	NA	Valleys	Closed, broadleaf, lowland subtropical seasonal ever-green forest.	806	0.1
47	Lowland dry riparian shrubland and woodland	Open forest, woodland or shrubland	Dry	Alluvial	NA	Valleys	Open, broadleaf, lowland subtropical semideciduous woodland and shrubland.	423	0.1
4	Mature secondary lowland dry limestone evergreen forest	Closed forest	Dry	Calcareous, limestone	> 25	Ridges, slopes, valleys, and plains	Closed, broadleaf, lowland subtropical seasonal evergreen forest.	982	0.1
5	Mature secondary lowland dry limestone semideciduous forest	Closed forest	Dry	Calcareous, limestone	> 25	Ridges, slopes, valleys, and plains	Closed, broadleaf, mixed lowland subtropical semi-deciduous forest.	10 669	1.2
6	Young secondary lowland dry limestone semideciduous forest	Closed forest	Dry	Calcareous, limestone	< 25	Ridges, slopes, valleys, and plains	Closed, broadleaf, mixed lowland subtropical semi-deciduous forest	3922	0.4
7	Lowland dry limestone woodland and shrubland	Open forest, woodland, or shrubland	Dry	Calcareous, limestone	NA	Ridges, slopes, valleys, and plains	Open, broadleaf, lowland subtropical semideciduous woodland and shrubland.	8181	0.9

Table 25—Puerto Rico land cover type site features (continued)

Value	Class name	Physiognomy	Moisture	Substrate	Age	Land form	Formation	Area	Percentage
					Years			*Hectares*	
8	Lowland dry limestone shrubland	Shrubland	Dry	Calcareous, limestone	NA	Ridges, slopes, valleys, and plains	Closed, broadleaf, lowland subtropical semideciduous shrubland.	4694	0.5
9	Lowland dry cactus shrubland	Shrubland	Dry	Calcareous, limestone	> 25	Ridges, slopes, valleys, and plains	Semidesert scrubs with columnar cacti (Borhidi 1996).	47	0.0
10	Coastal dwarf woodland and shrubland	Shrubland	Dry	Calcareous, limestone	> 25	Ridges, slopes, valleys, and plains	Open, broadleaf lowland subtropical semideciduous woodland and shrubland.	103	0.0
11	Lowland dry limestone cliffside semideciduous forest	Closed forest	Dry	Calcareous, limestone	> 25	Steep slopes	Closed, broadleaf, mixed lowland subtropical semi-deciduous forest.	12	0.0
12	Lowland dry limestone cliffside shrubland and woodland	Open forest, woodland, or shrubland	Dry	Calcareous, limestone	> 25	Steep slopes	Open, broadleaf, lowland subtropical semideciduous woodland and shrubland.	49	0.0
19	Abandoned dry forest plantation	Closed forest	Dry	Calcareous, limestone	> 25	Ridges, slopes, valleys, and plains	Closed, broadleaf, lowland subtropical seasonal evergreen forest.	81	0.0
13	Mature secondary lowland dry noncalcareous semideciduous forest	Closed forest	Dry	Noncalcar-eous, volcanic	> 25	Ridges, slopes, valleys, and plains	Closed, broadleaf mixed, lowland subtropical semi-deciduous forest.	7062	0.8
14	Young secondary lowland dry noncalcareous semideciduous forest	Closed forest	Dry	Noncalcar-eous, volcanic	< 25	Ridges, slopes, valleys, and plains	Closed, broadleaf mixed, lowland subtropical semi-deciduous forest.	3645	0.4
15	Lowland dry noncalcareous shrubland and woodland	Open forest, woodland, or shrubland	Dry	Noncalcar-eous, volcanic	NA	Ridges, slopes, valleys, and plains	Open, broadleaf, lowland subtropical semideciduous woodland and shrubland.	13 307	1.5
16	Mature secondary dry and moist serpentine semideciduous forest	Closed forest	Dry	Ultramafic, serpentine	> 25	Ridges, slopes, valleys, and plains	Closed, broadleaf mixed, lowland subtropical semi-deciduous forest.	1839	0.2
17	Young secondary dry and moist serpentine semideciduous forest	Closed forest	Dry	Ultramafic, serpentine	< 25	Ridges, slopes, valleys, and plains	Closed, broadleaf mixed, lowland subtropical semi-deciduous forest.	1960	0.2
18	Dry and moist serpentine woodland and shrubland	Open forest, woodland, or shrubland	Dry	Ultramafic, serpentine	NA	Ridges, slopes, valleys, and plains	Arid lowland serpentine shrubwoods (Borhidi 1996).	841	0.1
20	Mature secondary lowland moist alluvial evergreen forest	Closed forest	Moist	Alluvial	> 25	Plains and valleys	Closed, broadleaf evergreen, lowland subtropical seasonal evergreen forest. Lowland rain forest (Dansereau 1996).	2256	0.3

Table 25—Puerto Rico land cover type site features (continued)

Value	Class name	Physiognomy	Moisture	Substrate	Age	Land form	Formation	Area	Percentage
					Years			*Hectares*	
21	Young secondary lowland moist alluvial evergreen forest	Closed forest	Moist	Alluvial	< 25	Plains and valleys	Closed, broadleaf evergreen, lowland subtropical seasonal evergreen forest.	6675	0.8
22	Lowland moist alluvial shrubland and woodland	Open forest, woodland, or shrubland	Moist	Alluvial	NA	Plains and valleys	Open, broadleaf evergreen, lowland subtropical seasonal evergreen woodland and shrubland.	5141	0.6
68	Lowland moist riparian forest	Closed forest	Moist	Alluvial	> 25	Valleys	Closed, broadleaf evergreen, lowland subtropical seasonal evergreen forest. Lowland rainforest (Dansereau 1996).	916	0.1
69	Lowland moist riparian shrubland and woodland	Open forest, woodland, or shrubland	Moist	Alluvial	NA	Valleys	Open, broadleaf evergreen, lowland subtropical seasonal evergreen woodland and shrubland.	508	0.1
23	Mature secondary moist limestone evergreen and semideciduous forest	Closed forest	Moist	Calcareous, limestone	> 25	Ridges, slopes, and valleys	Closed, broadleaf mixed, lowland subtropical semideciduous forests. Karstic forests (Borhidi 1996).	46 423	5.2
24	Young secondary moist limestone evergreen and semideciduous forest	Closed forest	Moist	Calcareous, limestone	< 25	Ridges, slopes, and valleys	Closed, broadleaf mixed, lowland subtropical semideciduous forests. Karstic forests (Borhidi 1996).	15 494	1.7
25	Moist limestone shrubland and woodland	Open forest, woodland, or shrubland	Moist	Calcareous, limestone	NA	Ridges, slopes, and valleys	Open, broadleaf mixed, lowland subtropical semideciduous forests.	10 338	1.2
26	Mature secondary lowland moist noncalcareous evergreen forest	Closed forest	Moist	Noncalcareous, volcanic	> 25	Ridges, slopes, valleys, and plains	Closed, broadleaf evergreen, lowland subtropical seasonal evergreen forest. Lowland rain forest (Dansereau 1996).	40 446	4.5
27	Young secondary lowland moist noncalcareous evergreen forest	Closed forest	Moist	Noncalcareous, volcanic	< 25	Ridges, slopes, valleys, and plains	Closed, broadleaf evergreen, lowland subtropical seasonal evergreen forest.	52 981	5.9
28	Lowland moist noncalcareous shrubland and woodland	Open forest, woodland, or shrubland	Moist	Noncalcareous, volcanic	NA	Ridges, slopes, valleys, and plains	Open, broadleaf evergreen, lowland subtropical seasonal evergreen woodland and shrubland.	44 523	5.0

Table 25—Puerto Rico land cover type site features (continued)

Value	Class name	Physiognomy	Moisture	Substrate	Age	Land form	Formation	Area	Percentage
					Years			*Hectares*	
29	Lowland moist abandoned and active coffee plantations	Closed forest	Moist	Noncalcareous, volcanic	> 25	Ridges, slopes, valleys, and plains	Closed, broadleaf evergreen, lowland subtropical seasonal evergreen forest.	11 068	1.2
30	Mature secondary montane wet alluvial evergreen alluvial forest	Closed forest	Wet	Alluvial	> 25	Plains and valleys	Closed, broadleaf evergreen, montane subtropical rain forest. Montane rain forests (Borhidi 1966).	613	0.1
31	Young secondary montane wet alluvial evergreen forest	Closed forest	Wet	Alluvial	< 25	Plains and valleys	Closed, broadleaf evergreen, montane subtropical rain forest. Montane rain forests (Borhidi 1966).	988	0.1
32	Montane wet alluvial shrubland and woodland	Open forest, woodland, or shrubland	Wet	Alluvial	NA	Plains and valleys	Open, broadleaf evergreen, montane subtropical woodland and shrubland.	900	0.1
33	Mature secondary montane wet noncalcareous evergreen forest	Closed forest	Wet	Noncalcareous, volcanic	> 25	Ridges, slopes, and valleys	Closed, broadleaf evergreen, montane subtropical rain forest. Montane rain forests (Borhidi 1966).	14 968	1.7
43	Montane wet evergreen abandoned and active coffee plantation	Closed forest	Wet	Noncalcareous, volcanic	> 25	Ridges, slopes, and valleys	Closed, broadleaf evergreen, montane subtropical rain forest.	54 859	6.1
34	Mature primary and secondary montane wet noncalcareous evergreen tabonuco forest	Closed forest	Wet	Noncalcareous, volcanic	> 25	Ridges, slopes, and valleys	Closed, broadleaf evergreen, montane subtropical rain forest. Montane rain forests of the Caribbean (Borhidi 1966).	8856	1.0
35	Mature primary and secondary montane wet noncalcareous evergreen palo colorado cloud forest	Closed forest	Wet	Noncalcareous, volcanic	> 25	Ridges, slopes, and valleys	Closed, broadleaf evergreen, montane subtropical cloud forest. Cloud forests of the Antillean high mountains (Borhidi 1966).	15 583	1.7
36	Mature primary and secondary montane wet noncalcareous evergreen sierra palm forest	Closed forest	Wet	Noncalcareous, volcanic	> 25	Ridges, slopes, and valleys	Closed, broadleaf evergreen, montane subtropical rain forest. Montane rain forests of the Caribbean (Borhidi 1966).	8781	1.0
37	Mature primary and secondary montane wet noncalcareous evergreen elfin woodland cloud forest	Closed forest	Wet	Noncalcareous, volcanic	> 25	Ridges and slopes	Closed, broadleaf evergreen, montane subtropical cloud forest. Cloud forests of the Antillean high mountains (Borhidi 1966).	2936	0.3

Table 25—Puerto Rico land cover type site features (continued)

Value	Class name	Physiognomy	Moisture	Substrate	Age	Land form	Formation	Area	Percentage
					Years			*Hectares*	
38	Young secondary montane wet noncalcareous evergreen forest	Closed forest	Wet	Noncalcareous, volcanic	< 25	Ridges, slopes, and valleys	Closed, broadleaf evergreen, montane subtropical rain forest. Montane rain forests of the Caribbean (Borhidi 1966).	21 651	2.4
39	Montane wet noncalcareous evergreen shrubland and woodland	Open forest, woodland, or shrubland	Wet	Noncalcareous, volcanic	NA	Ridges, slopes, and valleys	Open, broadleaf evergreen, montane subtropical woodland and shrubland. Moist, high montane shrubwoods (Borhidi 1996).	24 090	2.7
40	Mature secondary montane wet serpentine evergreen forest	Closed forest	Wet	Ultramafic, serpentine	> 25	Ridges, slopes, and valleys	Closed, broadleaf evergreen, montane subtropical rain forest.	3379	0.4
41	Young secondary montane wet serpentine evergreen forest	Closed forest	Wet	Ultramafic, serpentine	< 25	Ridges, slopes, and valleys	Closed, broadleaf evergreen, montane subtropical rain forest.	651	0.1
42	Wet serpentine shrubland and woodland	Open forest, woodland, or shrubland	Wet	Ultramafic, serpentine	NA	Ridges, slopes, and valleys	Open, broadleaf evergreen, montane subtropical woodland and shrubland.	358	0.0
44	Mangrove forest and shrubland forest	Mixed closed and open	Flooded	Marine sediments	> 25	Plains	Mixed closed and open, flooded, tidally flooded evergreen sclerophyllus forest. Mangrove (Dansereau 1966, Borhidi 1996)	8699	1.0
45	Freshwater *Pterocarpus* swamp	Closed forest	Flooded	Alluvial deposits	> 25	Plains and valleys	Closed, flooded, subtropical seasonally flooded rain forest.	261	0.0
48	Dry grasslands and pastures	Grassland	Dry		NA	Plains, slopes, and valleys	Subtropical grassland with a shrub layer.	42 176	4.7
49	Dry cactus grassland and shrubland	Grassland	Dry		NA	Plains, slopes, and valleys	Subtropical grassland with a shrub layer.	213	0.0
50	Moist grasslands and pastures	Grassland	Moist		NA	Plains, slopes, and valleys	Subtropical grassland with a shrub layer.	218 945	24.5
53	Seasonally flooded herbaceous nonsaline wetlands	Grassland	Seasonally flooded	Nonsaline alluvial deposits	NA	Plains, depressions, and valleys	Seasonally or temporarily flooded nonsaline subtropical grassland with a shrub layer.	18 225	2.0

Table 25—Puerto Rico land cover type site features (continued)

Value	Class name	Physiognomy	Moisture	Substrate	Age	Land form	Formation	Area	Percentage
					Years			*Hectares*	
54	Seasonally flooded herbaceous saline wetlands	Grassland	Seasonally flooded	Saline alluvial deposits and marine sediments	NA	Plains, depressions, and valleys	Seasonally or temporarily flooded saline subtropical grassland with a shrub layer.	4865	0.5
51	Emergent herbaceous nonsaline wetlands	Herbaceous	Flooded	Nonsaline alluvial deposits	NA	Plains, depressions, and valleys	Perennially flooded nonsaline aquatic herbaceous vegetation.	1102	0.1
52	Emergent herbaceous saline wetlands	Herbaceous	Flooded	Saline alluvial deposits and marine sediments	NA	Plains, depressions, and valleys	Perennially flooded nonsaline aquatic herbaceous vegetation.	882	0.1
55	Hay and row crops	Herbaceous	Dry and moist	Alluvial deposits	NA	Plains, slopes, and valleys	Herbaceous agriculture.	25 764	2.9
56	Woody agriculture and plantations	Closed forest moist	Dry and deposits	Alluvial	NA	Plains	Orchards.	492	0.1
57	Rocky cliffs and shelves		Barrens	NA	NA	Steep slopes and plains	NA	397	0.0
58	Gravel beaches and stony shoreline		Barrens	NA	NA	Plains, depressions, and valleys	NA	82	0.0
59	Fine to coarse sandy beaches, mixed sand and gravel beaches		Barrens	NA	NA	Plains, depressions, and valleys	NA	1155	0.1
60	Riparian and other natural barrens		Barrens	NA	NA	Plains, depressions, and valleys	NA	449	0.1
61	Salt and mudflats		Barrens	NA	NA	Plains, depressions, and valleys	NA	1493	0.2
65	Artificial barrens		Barrens	NA	NA	Ridges, slopes, valleys, and plains	NA	8674	1.0

Table 25—Puerto Rico land cover type site features (continued)

Value	Class name	Physiognomy	Moisture	Substrate	Age	Land form	Formation	Area	Percentage
					Years			*Hectares*	
62	Salt production		Barrens	NA	NA	Plains, depressions, and valleys	NA	20	0.0
63	High-density urban development		Developed	NA	NA	Ridges, slopes, valleys, and plains	NA	52 335	5.9
64	Low-density urban development		Developed	NA	NA	Ridges, slopes, valleys, and plains	NA	37 237	4.2
66	Freshwater		Water	NA	NA	Plains, depressions, and valleys	NA	4434	0.5
67	Saline water		Water	NA	NA	Plains and depressions	NA	4005	0.5
70	Aquaculture		Water	NA	NA	Plains	NA	101	0.0

Appendix 4. Puerto Rico Land Cover Descriptions

Identification codes (values) from the raster image land cover map, unit name, and general description for 70 land cover units in the PRGAP land cover map and database.

Table 26—Descriptions of land cover types in Puerto Rico

Value	Land cover type	General description
1	Mature secondary lowland dry alluvial semideciduous forest	Mature dry forest on alluvial material of the coastal plain on the northeast and south coast of the main island and on Vieques, Culebra, and Mona. These remnants are in relatively undisturbed areas, often along riparian corridors. Much of this extensive substrate has been converted to agriculture and pasture. Conditions are somewhat more moist than surroundings because of the riparian location.
2	Young secondary lowland dry alluvial semideciduous forest	Young secondary dry forest on alluvial material of the coastal plain on the northeast and south coast of the main island. This is often disturbed by fire and grazing and developed on abandoned agricultural lands.
3	Lowland dry alluvial shrubland and woodland	Open forest and shrubland developing on abandoned pasture of the southern coastal plain. This is often disturbed by fire and grazing.
46	Lowland dry riparian forest	Semideciduous and evergreen forests along the riparian corridors in the southwestern part of the island. Often remnants of formerly extensive southern coastal plain forests on alluvial material. More evergreen species because of greater available moisture along the riparian corridor.
47	Lowland dry riparian shrubland and woodland	Open forest and shrubland along riparian corridors of the southern coastal plain. This is often disturbed by fire and grazing.
4	Mature secondary lowland dry limestone evergreen forest	Evergreen forests in arroyos, sinkholes, and narrow valleys on limestone substrates in the southwestern part of the main island and in the bajuras (sinkholes) of Mona Island.
5	Mature secondary lowland dry limestone semideciduous forest	Mature semideciduous forests on mid and upper slopes of limestone hills on the southwestern part of the main island and Caja de Muertos and on the limestone plateau of Mona Island.
6	Young secondary lowland dry limestone semideciduous forest	Young secondary semideciduous forests on mid and upper slopes of limestone hills on the southwestern part of the main island. These often on abandoned agricultural land.
7	Lowland dry limestone woodland and shrubland	Open semideciduous forests and shrublands on limestone hills in the southwestern part of the main island, Caja de Muertos, and Mona Island. These often on abandoned agricultural land or semi-active pastures.
8	Lowland dry limestone shrubland	Dense thorny shrublands on limestone substrates in the southwestern part of the island, primarily abandoned pasture, and on the eastern edge of Mona Island, strongly influenced by salt-laden winds restricting tree growth.
9	Lowland dry cactus shrubland	Open shrubland with cactus on limestone substrates, often with poor soil development and much exposed bedrock.
10	Coastal dwarf woodland and shrubland	Open forest of dwarfed trees in wind-exposed coastal sites on the southwest side of the island, somewhat easterly exposure. Very old but gnarled and twisted trees with horizontal stem growth on leeward side. Little soil development and much exposed bedrock.
11	Lowland dry limestone cliffside semideciduous forest	Narrow bands of closed semideciduous forest on limestone cliff edges and along the base, primarily on Mona Island.

Table 26—Descriptions of landcover types in Puerto Rico (continued)

Value	Land cover type	General description
12	Lowland dry limestone cliffside shrubland and woodland	Narrow bands of open semideciduous forest or woodland on limestone cliff edges and along the base, primarily on Mona Island.
19	Abandoned dry forest plantation	Abandoned plantations of *Casuarina* and *Swietenia* on limestone substrates on Mona Island, primarily on the coastal plain.
13	Mature secondary lowland dry noncalcareous semideciduous forest	Mature dry forest on substrates derived from volcanic bedrock. These are found on coastal hills in northeastern Puerto Rico and in the Sierra Bermeja range in southwestern Puerto Rico. It occurs on noncalcareous substrates in the lowland subtropical dry Holdridge life zone (Ewel and Whitmore 1973).
14	Young secondary lowland dry noncalcareous semideciduous forest	Young secondary dry forest on substrates derived from volcanic bedrock. These are found on coastal hills in northeastern Puerto Rico and in the Sierra Bermeja range in southwestern Puerto Rico. They are typically pastures abandoned in the last 10 to 25 years.
15	Lowland dry noncalcareous shrubland and woodland	Open dry forest (woodland) and shrubland on substrates derived from volcanic bedrock. These are found on coastal hills in northeastern Puerto Rico and in the Sierra Bermeja range in southwestern Puerto Rico. They are typically recently abandoned or marginally active pastures.
16	Mature secondary dry and moist serpentine semideciduous forest	Mature forests on ultramafic (high pH) serpentine soils in the wetter Maricao and drier Susua areas of Puerto Rico.
17	Young secondary dry and moist serpentine semideciduous forest	Young secondary forests on ultramafic (high pH) serpentine soils in the wetter Maricao and drier Susua areas of Puerto Rico.
18	Dry and moist serpentine woodland and shrubland	Open forests (woodland) on ultramafic (high pH) serpentine soils in the wetter Maricao and drier Susua areas of Puerto Rico.
20	Mature secondary lowland moist alluvial evergreen forest	Mature lowland moist forests on alluvial material in the northern and eastern coastal plains and lower valleys, often associated with riparian corridors.
21	Young secondary lowland moist alluvial evergreen forest	Young secondary lowland moist forests on alluvial material in the northern and eastern coastal plains and lower valleys, often developed on abandoned pasture or former sugar cane fields.
22	Lowland moist alluvial shrubland and woodland	Lowland moist woodland and shrubland on alluvial material in the northern and eastern coastal plains and lower valleys, often developed on abandoned or semi-active pasture.
68	Lowland moist riparian forest	Riparian forests along rivers in the northern and eastern coastal plains, either relicts of formerly extensive forests or, more commonly, regenerating forests on abandoned agricultural land.
69	Lowland moist riparian shrubland and woodland	Riparian woodland and shrubland along rivers in the northern and eastern coastal plains on abandoned or semi-active pastures. Often disturbed by grazing and flooding.
23	Mature secondary moist limestone evergreen and semideciduous forest	A matrix of mature forest types occurring along a topographic sequence in the haystack hills or "mogotes" of the northern karst region of Puerto Rico. These are mature forest types with drier conditions on the ridges and steep slopes and more mesic conditions on lower slopes and valley bottoms. Much have regenerated on long-abandoned (> 25 years) agricultural fields, either sugar cane, shade coffee, or pasture.

Table 26—Descriptions of landcover types in Puerto Rico (continued)

Value	Land cover type	General description
24	Young secondary moist limestone evergreen and semideciduous forest	A matrix of young secondary forest types occurring along a topographic sequence in the haystack hills or "mogotes" of the northern karst region of Puerto Rico. These are early successional forest types with drier conditions on the ridges and steep slopes and more mesic conditions on lower slopes and valley bottoms. Much have regenerated on recently abandoned (10 to 25 years) agricultural fields, either sugar cane, shade coffee, or pasture.
25	Moist limestone shrubland and woodland	Shrubland and woodland in the haystack hills or "mogotes" of the northern karst region of Puerto Rico. Most are abandoned or semi-active pasture.
26	Mature secondary lowland moist noncalcareous evergreen forest	Mature lowland moist forest on substrates primarily derived from volcanic material on the northern coastal plain, lower elevations of the central and Luquillo Mountains, the Caguas Valley, and southeastern Puerto Rico. These occur primarily on long-abandoned (> 25 years) sugar cane, shade coffee, and pasture lands but contain remnants of older lowland moist forests and harbor a majority of native tree species. It is likely similar to formerly extensive moist lowland forests converted to agriculture in the preceding century. It occurs in the lowland subtropical moist Holdridge life zone (Ewel and Whitmore).
27	Young secondary lowland moist noncalcareous evergreen forest	Young secondary lowland moist forest on substrates primarily derived from volcanic material on the northern coastal plain, lower elevations of the central and Luquillo Mountains, the Caguas Valley, and southeastern Puerto Rico. These occur primarily on recently abandoned (10 to 25 years) pasture lands and have a number of established exotic species.
28	Lowland moist noncalcareous shrubland and woodland	Young secondary lowland moist forest on substrates primarily derived from volcanic material on the northern coastal plain, lower elevations of the central and Luquillo Mountains, the Caguas Valley, and southeastern Puerto Rico. These occur primarily on recently abandoned or semi-active pasture lands.
29	Lowland moist abandoned and active coffee plantations	A mix of active sun coffee plantations and abandoned shade coffee plantations in the lower elevations of the central mountains.
30	Mature secondary montane wet alluvial evergreen forest	Mature secondary wet evergreen forests on small patches of alluvial material in the upper central and Luquillo Mountains. These are areas with less steep terrain and better soil development, and deeper soils than surrounding volcanic substrates.
31	Young secondary montane wet alluvial evergreen forest	Young secondary wet evergreen forests on small patches of alluvial material in the upper central and Luquillo Mountains. These are areas with less steep terrain and better soil development, and deeper soils than surrounding volcanic substrates. Forests have developed on recently abandoned agricultural lands.
32	Montane wet alluvial shrubland and woodland	Montane wet shrublands and open forests (woodland) on small patches of alluvial material in the upper central and Luquillo Mountains. Developing on very recently abandoned agricultural lands.
33	Mature secondary montane wet noncalcareous evergreen forest	Mature secondary wet evergreen forests on volcanic substrates in the upper central and Cayey Mountains. These are on areas that were not likely shade coffee but may have had been cleared for other reasons.
43	Montane wet evergreen abandoned and active coffee plantation	A mix of active sun coffee plantations and abandoned shade coffee plantations in the upper elevations of the central mountains.

Table 26—Descriptions of landcover types in Puerto Rico (continued)

Value	Land cover type	General description
34	Mature primary and secondary montane wet noncalcareous evergreen tabonuco forest	Mature primary tabonuco forests in the Luquillo Mountains and other mature secondary forests in the central mountains. This is a closed broad-leaved forest occurring in the subtropical wet Holdridge life zone (Ewel & Whitmore 1973.
35	Mature primary and secondary montane wet noncalcareous evergreen palo colorado cloud forest	Mature primary palo colorado tall cloud forests in the Luquillo Mountains and other mature cloud secondary forests in the central mountains. Occurs in the lower montane wet Holdridge life zone and is considered the zonal vegetation of this life zone (Ewel and Whitmore 1973).
36	Mature primary and secondary montane wet noncalcareous evergreen sierra palm forest	Mature primary sierra palm forests in the Luquillo Mountains and other mature secondary forests in the central mountains. This is a closed broad-leaved evergreen forest (Weaver 1991, 1994) and classified within the montane subtropical rain forest formation. The Sierra palm forest type is found in the lower montane wet and subtropical rain Holdridge life zones (Ewel & Whitmore 1973) on azonal (although common) steeply sloping sites.
37	Mature primary and secondary montane wet noncalcareous evergreen elfin woodland cloud forest	Mature primary elfin woodland in the Luquillo Mountains and other mature secondary cloud forests in the central mountains. This is a closed broad-leaved evergreen forest (Ahern et al. 1999) classified in the elfin woodland forest type or alliance (Weaver 1994). The community is found within both the lower montane wet and rain Holdridge life zones (Ewel & Whitmore 1973) on azonal sites including exposed slopes and ridges (Weaver 1990, 1991,1994; Weaver et al. 1986).
38	Young secondary montane wet noncalcareous evergreen forest	Young secondary wet evergreen forests on volcanic substrates in the upper Luquillo, central, and Cayey mountains. Regenerating on recently (10 to 25 years) abandoned pastures.
39	Montane wet noncalcareous evergreen shrubland and woodland	Montane wet shrubland and open woodland on volcanic substrates in the upper Luquillo, central, and Cayey mountains. Regenerating on abandoned or semi-active pastures or disturbed areas (landslides, hurricane, forest clearing).
40	Mature secondary montane wet serpentine evergreen forest	Mature secondary wet evergreen forests and some forest plantations on ultramafic (high pH) serpentine substrates in the Maricao area of the central mountains.
41	Young secondary montane wet serpentine evergreen forest	Young secondary wet evergreen forests on ultramafic (high pH) serpentine substrates in the Maricao area of the central mountains. Regenerating on recently abandoned (10 to 25 years) agricultural land.
42	Wet serpentine shrubland and woodland	Montane wet shrubland and open woodland on ultramafic (high pH) serpentine substrates in the Maricao area of the central mountains. Regenerating on abandoned or semi-active pastures or disturbed areas (landslides, hurricane, forest clearing).
44	Mangrove forest and shrubland	Flooded forest and shrublands in coastal areas periodically inundated with saline tide waters of the Caribbean and Atlantic oceans. Mangroves may be riparian, estuarine, or littoral, typically with some freshwater inputs as well as connectivity with the ocean. May be very old and stable communities (up to 4,000 years), or relatively young communities invading land formerly drained for agriculture.

Table 26—Descriptions of landcover types in Puerto Rico (continued)

Value	Land cover type	General description
45	Freshwater *Pterocarpus* swamp	Flooded freshwater swamps on the coastal plain and along riparian areas. It occurs in relict patches within the Lowland subtropical moist Holdridge life zone (Ewel and Whitmore 1973) and was likely much more extensive on the coastal plain and riparian corridors prior to deforestation for agriculture (Alvárez 1982, Eusse and Aide 1999). It is found on undisturbed freshwater seasonally flooded noncalcareous alluvial substrates.
48	Dry grasslands and pastures	Active and abandoned pastures in the subtropical dry Holdridge life zone on the southwestern side of Puerto Rico and the smaller islands. Maintained as grassland by fire and grazing.
49	Dry cactus grassland and shrubland	Rocky, often calcareous, slopes on the southwest side of the island and the Mona plateau.
50	Moist grasslands and pastures	Active and abandoned pastures in the moist and wet Holdridge life zones on the north and central areas of Puerto Rico. Maintained as grassland by fire, grazing, or other disturbances.
53	Seasonally flooded herbaceous nonsaline wetlands	Grasslands in lowland areas of the coastal plain frequently flooded by winter and spring rains and overflowing rivers. Often used for pasture or hay when not flooded.
54	Seasonally flooded herbaceous saline wetlands	Grasslands in lowland areas of the coastal plain frequently flooded by saline and brackish water during storms. Often adjacent to mudflats and mangroves but with some drainage and often drying out.
51	Emergent herbaceous nonsaline wetlands	Mixed herbs or grasses emerging from brackish water in perennially flooded swamp lands. May included floating mats of herbaceous vegetation.
52	Emergent herbaceous saline wetlands	Mixed herbs or grasses emerging from freshwater in perennially flooded swamp lands. Often adjacent to mudflats and mangroves or developing on disturbed saline swamp lands.
55	Hay and row crops	Hay crops, pineapple, bananas, plantains, or other herbaceous row crops.
56	Woody agriculture and plantations	Primarily coconut plantations but may include citrus, mango, pine, and mahogany plantations.
57	Rocky cliffs and shelves	Coastal cliffs and rocky shelves and shorelines in the intertidal and supratidal zones. Typically < 20 percent vegetation cover, vegetation halophytic. Often periodically flooded with storm surge.
58	Gravel beaches and stony shoreline	Stoney and gravelly shorelines in the intertidal and supratidal zones along the coast. Typically < 20 percent vegetation cover, vegetation halophytic. Often periodically flooded with storm surge.
59	Fine to coarse sandy beaches, mixed sand and gravel beaches	Fine to coarse sandy beaches, mixed sand and gravel beaches in the intertidal and supratidal zones along the coast. Typically < 20 percent vegetation cover, vegetation halophytic. Often periodically flooded with storm surge. Some beaches subject to artificial maintenance.
60	Riparian and other natural barrens	Typically < 20 percent vegetation cover, often periodically flooded if riparian.
61	Salt and mudflats	Typically < 20 percent vegetation cover, often periodically flooded. Salt flats in low-lying coastal areas seasonally flooded with brackish water, part of a mangrove habitat complex when associated with mangrove trees.
65	Artificial barrens	Recent developments cleared for construction (ephemeral, likely to have changed within recent years), landfills, and quarries.

Table 26—Descriptions of landcover types in Puerto Rico (continued)

Value	Land cover type	General description
62	Salt production	Commercial salt production.
63	High-density urban development	Developed pixels that exist within a matrix of > 20 percent developed pixels (< 80 percent vegetated, water or natural barrens) within a 1-km^2 area surrounding each pixel (Martinuzzi et al. 2007).
64	Low-density urban development	Developed pixels that exist within a matrix of < 20 percent developed pixels (> 80 percent vegetated, water or natural barrens) within a 1-km^2 area surrounding each pixel (Martinuzzi et al. 2007).
66	Freshwater	Lakes, ponds and rivers that are detectable in Landsat imagery. A number of small streams, small ponds, and ephemeral ponds and streams are not included.
67	Saline water	Coastal lagoons, brackish canals, and estuaries. Often bordered by mangrove and mudflats. These form part of the mangrove habitat complex when adjacent to mangroves.
70	Aquaculture	Shrimp farms.

Glossary

algorithm—A procedure to solve a problem or model a solution. In the gap analysis program (GAP) this typically refers to a geographic information system (GIS) procedure used to model animal distributions.

alliance level—A land unit made up of a group of natural communities that have the same dominant or co-dominant plant species or, in the absence of vegetation, by the dominant land cover typically described according to the Anderson land cover classification (Grossman et al. 1994).

alpha diversity—A single within-habitat measure of species diversity regardless of internal pattern, generally over an area of 0.1 to 1000 ha (Whittaker 1960, 1977).

anthropogenic—Caused by humans.

assemblages—A group of ecologically interrelated plant and animal species.

band, spectral—A segment of the electromagnetic spectrum defined by a range of wavelengths (e.g., blue, green, red, near infrared, far infrared) that compose the satellite imagery (e.g., Landsat ETM+ imagery).

beta diversity—The change in species diversity among different natural communities of a landscape; an index of between-habitat diversity (Whittaker 1960, 1977).

biodiversity—Generally, the variety of life and its interrelated processes.

biogeographic—Relating to the geographical distribution of plants and animals

biological diversity—See biodiversity.

cartographic—Pertaining to the art or technique of making maps or charts.

coarse filter—The general conservation activities that conserve the common elements of the landscape matrix, as opposed to the "fine filter" conservation activities that are aimed at special cases such as rare elements (Jenkins 1985).

community—A group of coexisting plants and animals.

cover type—A nontechnical high-level floristic and structural description of vegetation cover.

cross-walking—Matching equivalent land cover categories between two or more classification systems.

delineate—Identifying the boundaries between more or less homogenous areas; for remotely sensed images it is based on detectable differences in tone and texture.

delta diversity—The change in species diversity between landscapes along major climatic or physiographic gradients (Whittaker 1977).

digitization—Entering spatial data digitally into a geographic information system.

ecoregion—A large region, usually spanning several million hectares, characterized by having similar biota, climate, and physiography (topography, hydrology, relief).

ecosystem—A biological community, its physical environment, and the processes through which matter and energy are transferred among the components.

edge-matching—The process of connecting polygons at the boundary between two independently created maps, either between thematic mapper scenes or between state GAP data sets.

element—A plant community or animal species mapped by GAP. May also be referred to as "element of biodiversity."

error of commission—The occurrence of a species (or other map category) is erroneously predicted in an area where it is, in fact, absent.

error of omission—Failure of a model to predict the occurrence of a species that is actually present in an area.

extinction—Disappearance of a species throughout its entire range.

extirpation—Disappearance of a species from part of its range.

fine filter—See "coarse filter."

floristic—Pertaining to the plant species that make up the vegetation of a given area.

formation level—The level of land cover categorization between "group" and "alliance" describing the structural attributes of a land unit, for example, "evergreen coniferous woodlands with rounded crowns" (Jennings 1993).

gamma diversity—The species diversity of a landscape, generally covering 1000 to 1 000 000 ha, made up of more than one kind of natural community (Whittaker 1977).

gap analysis—A comparison of the distribution of elements of biodiversity with that of areas managed for their long-term viability to identify elements with inadequate representation.

geographic information systems (GIS)—Computer hardware and software for storing, retrieving, manipulating, and analyzing spatial data.

global positioning system (GPS)—An instrument that uses satellite signals to pinpoint its location on the Earth's surface.

ground truthing—Verifying maps by checking the actual occurrence of plant and animal species in the field at representative sample locations.

habitat—The physical structure, vegetation composition, and physiognomy of an area, the characteristics of which determine its suitability for particular animal or plant species.

hectare—A metric unit of area of 10 000 m^2 and equal to 2.47 acres.

metadata—Information about data, e.g., their source, lineage, content, structure, and availability.

minimum mapping unit—The smallest area that is depicted on a map.

Neotropics—The biogeographic region stretching southward from the tropic of Cancer and including southern Mexico, Central and South America, and the West Indies.

phenology—The study of periodic biological phenomena, such as flowering, breeding, and migration, especially as related to climate.

phenotype—The environmentally and genetically determined observable appearance of an organism, especially as considered with respect to all possible genetically influenced expressions of one specific character.

physiognomic—Based on physical features.

physiographic province—A region having a pattern of relief features or land forms that differ significantly from that of adjacent regions.

pixel—The smallest spatial unit in a raster data structure.

polygon—An area enclosed by lines in a vector-based GIS data layer or a region of contiguous homogeneous pixels in a raster system.

preprocessing—Those operations that prepare data for subsequent analysis, usually by attempts to correct or compensate for systematic, radiometric, and geometric errors.

range—The geographic limit of the species.

range unit—A spatial, geographic unit to record and display species geographic range.

reach—A stream or river segment between inflowing tributaries.

registration, spatial—Matching different images to each other by finding points on the images that can be matched to known points on the ground.

remote sensing—Deriving information about the Earth's surface from images acquired at a distance, usually relying on measurement of electromagnetic radiation reflected or emitted from the feature of interest.

resolution, spatial—The ability of a remote sensing system to record and display fine detail in a distinguishable manner or the smallest feature that can be distinguished or resolved on a map or image, such as a thematic mapper pixel.

scale, map—The ratio of distance on a map to distance in the real word, expressed as a fraction; the smaller the denominator, the larger the scale, e.g. 1:24,000 is larger than 1:100,000.

species richness—The number of species of a particular interest group found in a given area.

supervised classification—The process of classifying thematic mapper pixels of unknown identity by using samples of known identity (i.e., pixels already assigned to informational classes by ground truthing or registration with known land cover) as training data.

synoptic—Constituting a brief statement or outline of a subject; presenting a summary.

tessellation—The division of a map into areas of equal and uniform shape such as the EPA-EMAP hexagon.

Thematic Mapper—A sensor on LANDSAT 4 and 5 satellites that records information in seven spectral bands, has a spatial resolution of about 30 by 30 m, and represents digital values in 256 levels of brightness per band.

universal transverse mercator—One of several map projections or systems of transformations that enables locations on the spherical Earth to be represented systematically on a flat map.

universal transverse mercator grid—A geographic reference system used as the basis for worldwide locational coding of information in a GIS or on a map.

unsupervised classification—The definition, identification, labeling, and mapping of natural groups, or classes, of spectral values within a scene. These spectral classes are reasonably uniform in brightness in several spectral channels.

vector format—A data structure that uses polygons, arcs (lines), and points as fundamental units for analysis and manipulation in a GIS.

wildlife habitat relationship model—A method of linking patterns of known habitat use by animal species with maps of existing vegetation, thereby identifying the spatial extent of important habitat features for use in conservation and management

Glossary of Acronyms

ACSM	American Congress on Surveying and Mapping
ADAMAS	Aquatic Database Management System
ADEM	Alabama Department of Environmental Management
AML ARC/INFO	Macro Language
ASPRS	American Society for Photogrammetry & Remote Sensing
AVHRR	Advanced Very High Resolution Radiometer (satellite system)
BBS	Breeding Bird Survey
BEST	Biomonitoring of Environmental Status and Trends
BLM	Bureau of Land Management
BRD	Biological Resources Division of the USGS
CAFF	Conservation of Arctic Flora and Fauna
C-CAP	Coastwatch Change Analysis Program (NOAA)
CDC	Conservation Data Center
CEC	Council on Environmental Cooperation
CENR	Committee on Environment and Natural Resources
CERES	California Environmental Resources Evaluation System
CIESIN	Consortium for International Earth Science Information Network
CODA	Conservation Options and Decision Analysis (software)
CRMP	Coordinated Resource Management Plan
CRUC	Cooperative Research Unit Center
DLG-E	Digital line graph–enhanced
DNER	Department of Natural and Environmental Resources
DOI	Department of the Interior
EDC	EROS Data Center

ECOMAP	The National Hierarchical Framework of Ecological Units mapping project of the USDA Forest Service
EMAP	Environmental Monitoring & Assessment Program
EMAP-LC	EMAP-Landscape Characterization (USEPA)
EMSL	Environmental Monitoring & Systems Laboratory (USEPA)
EMTC	Environmental Management Technical Center (NBS)
EOS	Earth Observing System
EOSAT	Earth Observation Satellite Company (the commercial operator of the Landsat satellite system)
EOSDIS	EOS Data and Information System
ERDAS	Imagery processing software
ERL	Environmental Research Laboratory, Corvallis (USEPA)
EROS	Earth Resources Observation Systems (USGS)
ESRI	Environmental Systems Research Institute
ETM+	Enhanced Thematic Mapper plus
FGDC	Federal Geographic Data Committee
FIA	Forest Inventory and Analysis
FIPS	Federal Information Processing Standard
FTP	file transfer protocol
FY	Fiscal Year
GAO	General Accounting Office (Congress)
GAP	Gap Analysis Program
GCDIS	Global Change Data and Information System
GIS	Geographic information system
GLIS	Global Land Information System (USGS)

GLOBE	Global Learning and Observations to Benefit the Environment
GPS	Global positioning system
GRASS	Geographic Resources Analysis Support System
GRIS	Geographic Resource Information Systems
HRMSI	High-Resolution Multispectral Stereo Imager
IALE	International Association of Landscape Ecology
IDRISI	GIS developed by Clark University
IITF	International Institute of Tropical Forestry
IKONOS	Commercial Earth observation satellite
LAPS	Land Acquisition Priority System
LC/LU	Land cover/land use (USGS)
MIPS	Map and Image Processing System
MOU	Memorandum of understanding
MMU	Minimum mapping unit
MRLC	Multi-Resolution Land Characteristics Consortium
MSS	Multi-spectral scanner
MTPE	Mission to Planet Earth
NAD	North American Datum
NAFTA	North American Free Trade Agreement
NALC	North American Landscape Characterization (USEPA, USGS)
NAWQA	National Water Quality Assessment (USGS)
NBII	National Biological Information Infrastructure
NBS	National Biological Service
NCCP	Natural Communities Conservation Planning program (in CA)

NDCDB	National Digital Cartographic Data Base
NDVI	Normalized Difference of Vegetation Index
NERC	National Ecology Research Center (Fort Collins, CO)
NMD	National Mapping Division
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NSDI	National Spatial Data Infrastructure
NSTC	National Science and Technology Council
NVCS	National Vegetation Classification System
NWI	National Wetlands Inventory (USFWS)
OMB	Office of Management and Budget (Administration)
OSIS	Oregon Species Information System
PA	Protected area
PARC	Public Access Resource Center
PI	Principal investigator
PRGAP	Puerto Rico Gap Analysis Project
PRUSVIGAP	Puerto Rico and the United States Virgin Islands Gap Analysis Project
SAB	Science Advisory Board (USEPA)
SCICOLL	Scientific Collections Permit Database
SDTS	Spatial data transfer standard
SGID	State Geographic Information Database
SMMR	Scanning Multichannel Microwave Radiometer
SNEP	Sierra Nevada Ecosystem Project
SOPI	Sociedad Ornitológica Puertorriqueña
SOFIA	Southern Forest Inventory and Analysis

SPOT	Systáme Pour l'Observation de la Terre
RMSE	Root mean square error
TIGER	Topologically Integrated Geographic Encoding and Referencing system (used for U.S. census)
TM	Thematic Mapper
TNC	The Nature Conservancy
UA	Urban area
UNESCO	United Nations Educational, Scientific, and Cultural Organization
URISA	Urban and Regional Information Systems Association.
URL	Universal resource locator
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Service
USFS	U.S. Forest Service
USFWS	U.S. Fish & Wildlife Service
UTM	Universal Transverse Mercator
WHRM	Wildlife/habitat relationship model

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