

Conservation status of plants in the Caribbean Island Biodiversity Hotspot

Christian W. Torres-Santana¹, Eugenio Santiago-Valentín^{2,3}, Ángela T. Leiva Sánchez⁴, Brígido Peguero⁵, Colin Clubbe⁶

¹Department of Botany, University of Hawai'i at Mānoa, 3190 Maile Way, St. John 101, Honolulu, Hawai'i 96822, United States

²Departamento de Biología, Universidad de Puerto Rico, Recinto de Río Piedras, Apartado 23360, San Juan, Puerto Rico 00931-3360

³Herbario, Jardín Botánico, Universidad de Puerto Rico, 1187 Calle Flamboyán, San Juan, Puerto Rico 00926-1117

⁴Jardín Botánico Nacional, Universidad de La Habana. Carretera del Rocío km. 3½, Calabazar, Boyeros, Ciudad de La Habana, CP 19230, Cuba

⁵Jardín Botánico Nacional Dr. Rafael Ma. Moscoso, Apartado Postal 21-9, Santo Domingo, Dominican Republic

⁶Herbarium, Library, Art and Archives, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, United Kingdom

Abstract

We present an overview of the conservation status of plants in the Caribbean Islands. We discuss the major accomplishments, gaps and limitations towards the 2010 Global Strategy for Plant Conservation (GSPC). A questionnaire on plant conservation nationally was distributed among the authors of this paper to be completed for their respective island(s). Additionally, we reviewed the accomplishments towards the 2010 GSPC for each independent country including the latest National Reports to the United Nation's Convention on Biological Diversity and additional literature. Because all the targets rely primarily on Targets 1 and 2, this study is particularly focused on reviewing the achievements related to them. To study progress towards Target 4, the ecoregions and the world protect areas databases were mapped using ArcGIS. Success for the implementation of the Targets of the 2010 GSPC has been extremely variable across the Caribbean. Whereas substantial progress has been made for many targets in Cuba, the Cayman Islands, Guadeloupe and Martinique, accomplishments in other islands, including Jamaica, The Bahamas, and some of the Lesser Antilles are limited. Some of the priority needs and knowledge gaps for the region include limited financial resources, understaffing, lack of local training and appropriate equipment, important plant areas lacking of adequate protection, ineffective enforcement of environmental laws, limited flow of information, including difficult Internet access, and lack of environmental awareness in the public. Although there has been considerable activity in the Caribbean, there is relatively little collaboration among island plant conservationists. We therefore advocate that a regional and global oceanic island plant conservation network should be initiated to strengthen current efforts in island conservation, to share experiences and best practices and to provide a forum for a wider discussion and support.

Keywords

Bahamas Archipelago, ecoregions, endemism, Global Strategy for Plant Conservation (GSPC), Greater Antilles, IUCN Red List, Lesser Antilles, West Indies

Introduction

Oceanic island floras are known to possess larger numbers of endemics when compared to continental floras. As a result of high level of localized endemism and increasing threats to their

biodiversity, it is likely that a substantial portion of their flora are vulnerable to extinction (Caujapé-Castells *et al.*, 2010). Some of the most diverse and threatened hotspots on Earth are located in insular systems, including the Caribbean Island Biodiversity Hotspot (henceforth, Caribbean) (Mittermeier *et al.*, 2005). This region is comprised of 124 main islands and over 3,500 cays and rocky islets in a land area of 229,550 km² (Figure 1). The islands are grouped in three archipelagos (the Greater Antilles, the Lesser Antilles, and the Bahamas) and a few islands off Venezuela and Honduras. Their geological origin is complex, but overall, they were formed by volcanic activity and joined by landblocks that arose since the middle Eocene (49 Ma) (Graham, 2003). Limestone is also widespread. Altitude ranges from -40m to over 3,100m, both in Hispaniola. Mean annual temperature and precipitation ranges from 28°C and 390mm at sea level to 12.5°C and 2,674mm at the montane extreme (Lugo *et al.*, 2000). Volcanoes are still active in some of the Lesser Antilles. The entire region is prone to hurricanes.

Habitat diversity in the Caribbean comprises 28 of the World Wildlife Fund (WWF)-defined terrestrial ecoregions, covering six Neotropical biomes. Apart from one that is shared with Venezuela they are all endemic to the Caribbean. Subtropical dry broadleaf forests (coastal and lowlands) are the most extensive (40%; see Figure 1) and most endangered (WWF, 2010).

The spermatophyte flora comprises 205 families and 1,447 genera; 191 of the latter are endemic (of which 95 are monotypic) (Acevedo-Rodríguez & Strong, 2008) (Table 1). The region comprises c.13,000 native vascular plant taxa (Adams, 1997), forming c.2.3% of Earth's flora (Myers *et al.*, 2000). About 7,868 spermatophyte taxa are endemic to the Caribbean (61%) (Acevedo-Rodríguez & Strong, 2008). Pteridophytes have not been widely included in these estimates due to the lack of information, but in addition to the estimate above, there are at least 156 further single island endemics (Proctor, 1977, 1985, 1989; Adams, 1997). All pteridophyte endemism is infrageneric.

The Caribbean was first settled 6,000-7,000 years ago (Fitzpatrick & Keegan, 2007) and later colonized by Europeans from 1492. Today, many landscapes are considerably altered. Politically, the Caribbean is very complex, consisting of 12 independent nations and 15 territories under diverse status. The population in 2009 was estimated to be 40 million, with densities ranging from 50 inhabitants/km² (Bahamas) to 800 (St. Maarten) (Central Intelligence Agency [CIA], 2010). The main economic drivers include tourism, agriculture, and offshore banking (CIA, 2010). The political, socio-economical and cultural heterogeneity translates into a wide spectrum of realities that limits effective implementation of conservation policies as a region (Mauder *et al.*, 2008).

The main threat to the flora is habitat destruction and deforestation (for tourism, mining, agriculture and urban development). For instance, 46% of Cayman Islands' flora is threatened by development (Burton 2008). In 2007, only 26% of forest cover remained, ranging from 3% in Haiti to 92% in St. John, US Virgin Islands (Brandeis & Oswalt, 2007; Food and Agriculture Organization, 2010). Other major influences on plant diversity include invasive alien species (*e.g.* *Dichrostachys cinerea* (marabú) invades large areas in Cuba), pests and diseases (*e.g.* pine scales in Turks & Caicos Islands), fires, unsustainable harvesting of native species, and climate change that is predicted to cause severe drought, increase in hurricane intensity and frequency, and reduction of coastal habitats. Inadequate management of ecosystems and enforcement of conservation laws continues to be a challenge in the Caribbean.

In this paper, we present an overview of the conservation status of plants in the Caribbean Islands. We discuss the major accomplishments, gaps and limitations towards the 2010 Global Strategy for Plant Conservation [GSPC] (<http://www.cbd.int/gspc/>).

Methods

A questionnaire on plant conservation nationally was distributed among the authors of this paper to be completed for their respective island(s). Additionally, we reviewed the accomplishments towards the 2010 GSPC for each independent country included in the latest National Reports to the United Nation's Convention on Biological Diversity (CBD). For the United Kingdom Overseas Territories (UKOTs), we consulted the UKOTs Online Herbarium (<http://dps.plants.ox.ac.uk/bol/UKOT/Home/Index>). For the French Overseas Departments, Dutch Overseas Territories, United States Territories, and all other islands, additional literature was reviewed (cited throughout the work). Information for the Swan Islands (Honduras) and the Federal Dependencies of Venezuela were not available, however, these small low-lying islands are currently under protection. The Caribbean Islands Ecosystem Profile was also reviewed as it represents the most up-to-date conservation assessment for the region conducted using a multi-agency approach (BirdLife International *et al.*, 2009). Because all the targets rely primarily on Targets 1 and 2, this study is particularly focused on reviewing the achievements related to them. Of particular interest was also Target 4, because in the case of the Caribbean all ecoregions except one are endemic and achieving the target will have an important impact towards achieving this Target globally. To study Target 4, the dataset of the WWF Ecoregions (http://www.worldwildlife.org/wildworld/profiles/terrestrial_nt.html) and from the World Database on Protect Areas (www.wdpa.org) were mapped using ArcGIS 9.3 (ESRI 2010).

Results

Success for the implementation of the Targets of the 2010 GSPC has been extremely variable across the Caribbean. Whereas substantial progress has been made for many Targets in Cuba, the Cayman Islands, Guadeloupe and Martinique, accomplishments in other islands, including Jamaica, The Bahamas, and some of the Lesser Antilles are limited (Table 2).

Target 1 (“A widely accessible working list of known plant species”). Floras for many Caribbean islands have been substantially completed or completed, reflecting significant progress towards Target 1. Although some floras are over 30 years old, they still provided the framework to develop a widely available Online Catalogue of Seed Plants of the West Indies (Acevedo-Rodríguez & Strong, 2007). Other online checklists are available for the Netherlands Antilles and Aruba (Mori *et al.*, 2007 onward; Caribbean Research and Management of Biodiversity, 2009), the Lesser Antilles (Carrington, 2007), St. Lucia (Graveson, 2010) and for Cuba (Greuter & Rankin Rodríguez, 2010). The revised edition flora of the Cayman Islands (Proctor, in review) is currently in review at Royal Botanic Garden, Kew (Kew). A supplement to the Flora of Hispaniola was recently published by Liogier (2010). The modern Flora of Cuba, a work in progress since 1992, comprises 16 published fascicles covering 64 families (less than 35% of the families) (Greuter & Rankin Rodríguez, 2010). Working lists are available for Montserrat, British Virgin Islands, and Turks & Caicos Islands (UKOTs Online Herbarium, 2010). The major taxonomic gaps include a flora for pteridophytes, monocots, and Cactaceae for Hispaniola, and a widely accessible working list of the Pteridophytes of the Caribbean. The completion of a treatment for the Poaceae of Puerto Rico (in progress), and a publication of a new synopsis of the Puerto Rican flora (Axelrod, in press) will bring the island close to fully achieving Target 1.

Target 2 (“A preliminary assessment of the conservation status of all known plant species”). The conservation status of plants has been primarily evaluated using the IUCN Red List Criteria (IUCN, 2001). Puerto Rico and US Virgin Islands mostly rely on the conservation assessments of the Endangered Species Act (US Congress, 1973). The Red Listing of Caribbean plants has been previously compiled by the World Conservation Monitoring Centre (IUCN, 1997) and IUCN-SSC Action Plants have been developed for some plant groups, including cycads, palms, orchids, conifers and cacti & other succulents plants (IUCN-SSC, 2010). A total of 604 taxa have been globally assessed of which 477 are considered threatened (IUCN, 2010). Thus, less than 7% of the Caribbean Islands endemic plants were evaluated. A few islands have made substantial progress towards implementing Target 2 nationally, while only palms have been evaluated regionally (Zona *et al.*, 2007). The Cayman Islands, in collaboration with Kew, published a Red List of their entire flora in 2008, fully accomplishing Target 2 (Burton, 2008). Cuba and Antigua & Barbuda have progressed significantly by using rapid assessments to evaluate over 70% of their flora (Pratt & Lindsay, 2008; Leiva & González-Torres, 2010). Cuba has published several Red List assessments (see www.uh.cu/centros/jbn/textos/16.html), the most recent being a Red List for the plants in Pinar del Río Province (Novo Carbó *et al.*, 2010). Other islands in the Caribbean have taken similar approaches to evaluate their flora, like Guadeloupe and Martinique (Sastre, 1978; Gargominy, 2003; Ministère de l'Écologie et du Développement Durable, 2006), the British Virgin Islands (Pollard & Clubbe, 2003), Jamaica (Kelly, 1988, 1991), Puerto Rico and the US Virgin Islands (US Fish and Wildlife Service, 2010). The Dominican Republic is now beginning to develop a national Red List (Peguero & Jiménez, 2008), but due to their high floristic richness they will probably need further international assistance. The New York Botanical Garden in collaboration with the Smithsonian Institution, and the University of Puerto Rico are currently assessing the entire flora of Puerto Rico using herbarium vouchers from their collections.

A confident estimate of threatened plants in the Caribbean is not yet possible because the available assessments were conducted nationally, including species shared with other islands, which makes computation difficult. However, we estimate that over 1,553 (22%) single island endemic plants from the Caribbean are threatened with extinction (IUCN categories VU, EN, CR) and that at least 445 (6%) of them are critically endangered (CR).

Target 3 (“Development of models with protocols for plant conservation and sustainable use”). The Caribbean has recently convened a biodiversity hotspot profile where key biodiversity areas (KBA) were identified, including areas with high plant diversity. A strategy for investment and prioritization in KBA was outlined particularly for biological corridors (BirdLife International *et al.*, 2009). The Conservation Action Plan for Botanic Gardens in the Caribbean was developed in 1998, which contains a framework for conservation activities to implement the CBD (Burbidge & Wyse Jackson, 1998). Cuba is developing the Cuban Strategy for Plant Conservation using the 2020 GSPC Targets and also operates a botanic gardens national network. The Cayman Islands produced a Biodiversity Action Plan including Species Action Plans for threatened plants (UKOTs Online Herbarium, 2010). Other islands have adopted an ecosystem approach. For example, the identification of important plant areas in the Cockpit Country (Jamaica), the Jaragua-Bahoruco-Enriquillo Biosphere Reserve (Dominican Republic), and the Centre Hills and Silver Hills (Montserrat). In other instances, conservation strategies implemented are based on a species approach. Kew has developed propagation protocols for some UKOTs plants (Hamilton *et al.*, 2007; Corcoran *et al.*, 2008); an epiphytic orchid was transplanted after a hurricane in Puerto Rico (Tremblay, 2008); actions plans for 10 Cuban plant species have been developed (Leiva *et al.*, 2008); recovery plans exist for 48 species of

Puerto Rico and US Virgin Islands (US Fish and Wildlife Service, 2010); and a fire management plan for the endemic *Pinus caribaea* var. *bahamensis* (Bahamian pine) has been written (Myers *et al.*, 2004).

Target 4 (“At least 10 per cent of each of the world’s ecological regions effectively conserved”). Less than 25 percent of the Caribbean (terrestrial) is under some sort of legal protection (see Figure 1; Estrada *et al.*, 2008; WDPA 2010). For instance, Martinique has 69% of habitat protected, St. John (US Virgin Islands) has 62%, and Dominican Republic has 25%. Progress has been good for some islands, but the effectiveness of their protection remains an issue for many islands. A comprehensive estimate of the percent of each ecoregion protected remains to be analyzed, but it was out of the scope for this work.

Target 5 (“Protection of 50 per cent of the most important areas for plant diversity assured”). Progress has been patchy and remains a long way short of protection of 50% of the most important areas of plant diversity. However, several islands including Cuba, Puerto Rico, Turks & Caicos Islands, Cayman Islands, and Montserrat have identified Important Plant Areas (IPA) (Figueroa Colón, 1996; Areces *et al.*, 2000; Hamilton *et al.*, 2008; Williams, 2009; UKOTs Online Herbarium, 2010).

Target 6 (“At least 30 per cent of production lands managed consistent with the conservation of plant diversity”) has neither progressed nor has it been effectively quantified.

Target 7 (“60 per cent of the world’s threatened species conserved *in situ*”) has been fully accomplished by Cuba under the current protected areas network (Leiva, 2009). In islands with relatively low numbers of threatened plants work is in progress, but the actual conservation status of most of their flora has not been evaluated.

Target 8 (“60 per cent of threatened plant species in accessible *ex situ* collections, [...] and 10% of them included in recovery and restoration programmes”) has been accomplished for more than 60% of the 48 species listed as endangered in Puerto Rico and US Virgin Islands. Seeds from most threatened species of the Caribbean UKOTs are stored in the Millennium Seed Bank and they are also in cultivation locally. Cuba houses 16% of the threatened plants in *ex situ* cultivation and has reintroduced 75 species through several multi-agency projects (Leiva, 2009).

Target 9 (“70% of the genetic diversity of crops and other major socioeconomically valuable plant species conserved, and associated indigenous and local knowledge maintained”) has not been achieved, but perhaps it has not been effectively quantified. For islands where agriculture has been historically important, local universities often maintain a living collection of important crops, and in Puerto Rico, the US Department of Agriculture also houses such collections.

Target 10 (“Management plans in place for at least 100 major alien species that threaten plants [...]”). The management of invasive alien species (IAS) in the Caribbean primarily focuses on animal conservation. There has been considerable work to quantify IAS in the Caribbean (Kairo *et al.*, 2003), UKOTs (Varnham, 2005), Dominican Republic, Jamaica, and Bahamas (IABIN Invasives Information Network I3N, 2008), Puerto Rico (Torres-Santana, 2007), and a more recent study of pathways of invasive plants (Meissner *et al.*, 2009). Control of *Casuarina equisetifolia* (ironwood) has been successfully achieved on some offshore keys in Cuba (Matos Mederos & Ballate Denis, 2006) and several alien plant species were controlled in

the Virgin Islands National Park (Stocker *et al.*, 2006). A large island-wide project for mammal eradication is being conducted in the Desecheo National Wildlife Refuge in Puerto Rico (J. Schwagerl, US Fish and Wildlife Service, pers. comm.).

Target 11 (“No species of wild flora endangered by international trade”) can be considered to be achieved by all islands. CITES has been adopted by most islands and there is little or no international trade in plant species.

Target 12 (“30 per cent of plant-based products derived from sources that are sustainably managed”) and **Target 13 (“The decline of plant resources and associated indigenous and local knowledge, innovations and practices that support sustainable livelihoods [...] halted”)** have neither progressed nor have they been effectively quantified. Dominica is the only island where indigenous populations (Caribs) remain and a forest reserve has been set aside to preserve some of their living conditions and culture (Petersen, 1997).

Target 14 (“The importance of plant diversity and the need for its conservation incorporated into communication, educational and public –awareness programmes”). The amount of work in many local botanic gardens across the region to raise public awareness is noteworthy. Successful efforts are those of Cuba’s and Dominican Republic’s National Botanic Gardens, and The Queen Elizabeth II Botanic Garden on Cayman Islands.

Target 15 (“The number of trained people working [...] in plant conservation increased [...]”) has progressed considerably in the Caribbean and there are more trained people, but the Plant Conservation Report notes the need for the number of trained plant conservationist to double in the next 10 years (CBD, 2009). The Universities of Havana and Puerto Rico are the only institutions offering doctoral degrees in plant conservation. Cuba has greatly increased the number of trained people in plant conservation. Other local universities offer M.Sc. degrees and more commonly B.S. in biological science, which include botany. Kew has been developing capacity, and building botanical infrastructure in the British Virgin Islands (Clubbe, 2005), as well as in other Caribbean Islands. Red Listing workshops have been offered in Cuba, UKOTs, and Puerto Rico. Additionally, botanists from Jamaica, Cuba, British Virgin Islands, Turks & Caicos Islands, Cayman Islands, Anguilla, Barbados, St. Lucia, and more recently, from Haiti have successfully completed International Diplomas courses in plant conservation offered by Kew.

Target 16 (“Networks for plant conservation activities established or strengthened at national, regional and international levels.”). The Caribbean has several regional networks that hold meetings occasionally and discuss topics on plant conservation. These groups include the Caribbean Botanic Gardens for Conservation, Red Mesoamericana de Herbarios, and Asociación Latinoamericana de Botánica. Some botanical gardens are member of Botanic Gardens Conservation International (BGCI) and the Center for Plant Conservation. The UKOTs have established a strong international partnership with Kew. Most islands in the Greater Antilles have also established collaborations with Fairchild Tropical Botanic Garden and the New York Botanical Garden. Other relevant national networks include the Cuban Network of Botanic Gardens and Le Conservatoire Botanique des Antilles Françaises.

Additionally, priority needs and knowledge gaps were identified for some of the Caribbean Islands. They include limited financial resources, understaffing, lack of training and appropriate equipment, important plant areas lacking of adequate protection, ineffective enforcement of environmental laws, limited flow of information, including difficult Internet access, and lack of

environmental awareness in the general public. Although there has been a great deal of work conducted in the Caribbean, there is relatively little collaboration among island plant conservationists. We therefore advocate that a regional and global oceanic island plant conservation network should be initiated to strengthen current efforts in island conservation, to share experiences and best practices and to provide a forum for a wider discussion and support.

Acknowledgements

We thank Christoph Kueffer, Juli Caujapé-Castells, and Noeleen Smyth for organizing and inviting us to present this work at the Conservation of Oceanic Island Floras Symposium. CWT-S thanks the University of Hawai'i at Mānoa for time to lead this project and for travel support. ES-V thanks the Biology Department of the University of Puerto Rico-Río Piedras (UPR-RP) for a sabbatical leave, and the Center for Applied Tropical Ecology and Conservation (CATEC-UPR-RP) for support via National Science Foundation grant HRD-0734826. This is contribution number 004 of the Herbarium of the UPR Botanical Garden. We also thank Tim Gallaher who helped with the map, Luis González Torres for providing numbers of threatened plants for Cuba, and to James Ackerman and Christoph Kueffer who reviewed and provided insights to the manuscript.

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Archipelago	Area (km ²) ^a	No of WWF Ecoregions ^b	Spermatophyte genera (G End) ^c	Native vascular plant taxa	SIE taxa (%)
Greater Antilles	208,062	16	-----	-----	-----
Cuba	110,992	6	1,210 (65)	7020 ^e	3,474 (49)
Hispaniola	76,420	5	1,103 (33)	6000 ^f	2,050 (34)
Jamaica	10,991	3	810 (6)	3304 ^g	923 (28)
Puerto Rico & Virgin	9,397	6	793 (1)	2585 ^{c,g}	332 (13)
Cayman Islands	264	3	-- (0)	415 ^h	29 (7)
Lesser Antilles	6,477	7	765 (1)	2406^{c,i}	358 (15)
Bahamas & TCI	13,880	3	507 (0)	1145^j	130 (11)
Aruba-Bonaire-	1,067	2	-- (0)^d	~ 468^g	25 (5)
Caribbean Islands Total	229,550 km²	28 Ecoregions	1,447 (191)	13,000^g	6,984 (54%) SIE 7,868 (61%) RE

Table 1. Floristic composition and habitat diversity in the Caribbean Island Biodiversity Hotspot. Pteridophytes have not been included in some of these estimates due to the lack of reliable information for several islands. Acronyms in table, G End = generic endemism, TCI= Turks & Caicos Islands, WWF = World Wildlife Fund, SIE = Single Island Endemics (vascular plants), RE = Regionally (Caribbean) endemics. Legend to the superscripts: ^aCIA (2010); ^bWWF (2010), ^cAcevedo-Rodríguez & Strong (2008); ^dvan Proosdij *et al.* 2001; ^eGreuter & Rankin Rodríguez (2010); ^fPeguero & Jiménez (in prep); ^gAdams (1997); ^hProctor (in review); ⁱHoward (1974–1989); ^jCorrell & Correll (1982).

Island(s) [Sovereignty]	Documenting plant diversity			Conserving plant diversity							Using plant diversity sustainably			Education/awareness	Building capacity	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Anguilla [UK]	2	2	2	2	2	1	2	2	2	2	5	1	1	2	3	2
Antigua & Barbuda	4	4	1	3	2	2	2	2	2	2	2	2	2	4	2	3
Aruba [Netherlands]	5	1	1	2	1	1	1	1	1	1	1	1	1	3	3	3
Bahamas	4	2	2	2	2	2	2	2	2	4	4	2	2	2	2	3
British Virgin Islands [UK]	4	4	3	3	3	1	3	3	3	3	5	1	1	4	4	4
Barbados	4	2	3	2	2	2	2	2	3	2	3	2	2	3	3	2
Cayman Islands [UK]	5	5	4	4	3	1	4	3	1	4	5	1	1	4	4	4
Cuba	4	4	4	4	3	3	5	3	3	4	5	3	3	4	4	4
Dominica	4	3	3	4	3	1	3	3	1	1	1	1	4	4	3	3
Dominican Republic	4	3	3	4	3	2	3	3	1	3	3	1	3	3	3	3
Granada	3	2	3	3	3	1	3	1	1	1	1	1	1	3	3	3
Guadeloupe [France]	5	4	4	4	3	1	3	3	1	3	5	1	3	4	4	4
Haiti	3	2	1	2	1	2	1	1	1	1	1	2	2	3	3	3
Jamaica	4	3	3	3	3	2	3	3	2	4	3	2	3	3	2	3
Martinique [France]	5	4	4	5	4	1	3	3	1	3	5	1	3	4	4	4
Montserrat [UK]	5	4	3	3	3	1	3	3	1	4	5	1	1	4	4	4
Netherland Antilles [Netherlands]	5	1	3	4	4	1	1	1	1	1	1	1	1	4	3	3
Puerto Rico	4	4	4	4	3	3	3	4	3	4	5	3	3	3	3	4
St. Barthélemy [France]	5	4	3	2	2	1	1	1	1	1	5	1	3	3	4	4
St. Kitts & Nevis	4	3	3	3	3	1	1	1	1	3	1	1	3	3	3	3
St. Lucia	5	2	2	4	3	2	2	3	3	2	5	3	3	3	3	3
St. Martin [Netherlands/France]	5	4	3	2	2	1	1	1	1	1	5	1	3	3	4	4
St. Vincent & The Grenadines	3	1	3	3	2	1	1	3	3	3	1	2	3	3	1	3
Turks & Caicos Islands [UK]	5	4	3	4	3	1	3	4	1	4	5	1	1	4	4	4
US Virgin Islands [US]	4	3	3	5	3	3	4	4	1	4	5	1	3	4	3	3

Table 2. Summary of Caribbean Islands' accomplishments towards the 2010 Global Strategy for Plant Conservation (GSPC). Category numbers (1 to 5) indicate the degree of progress towards the GSPC, being 5 (light green shading) for Target completed; 4 (light yellow) for good progress made; 3 (tan) for target initiated / some progress; 2 (red) for no progress; and 1 (no color) for data not available. Category numbers for St. Martin include only the French part.

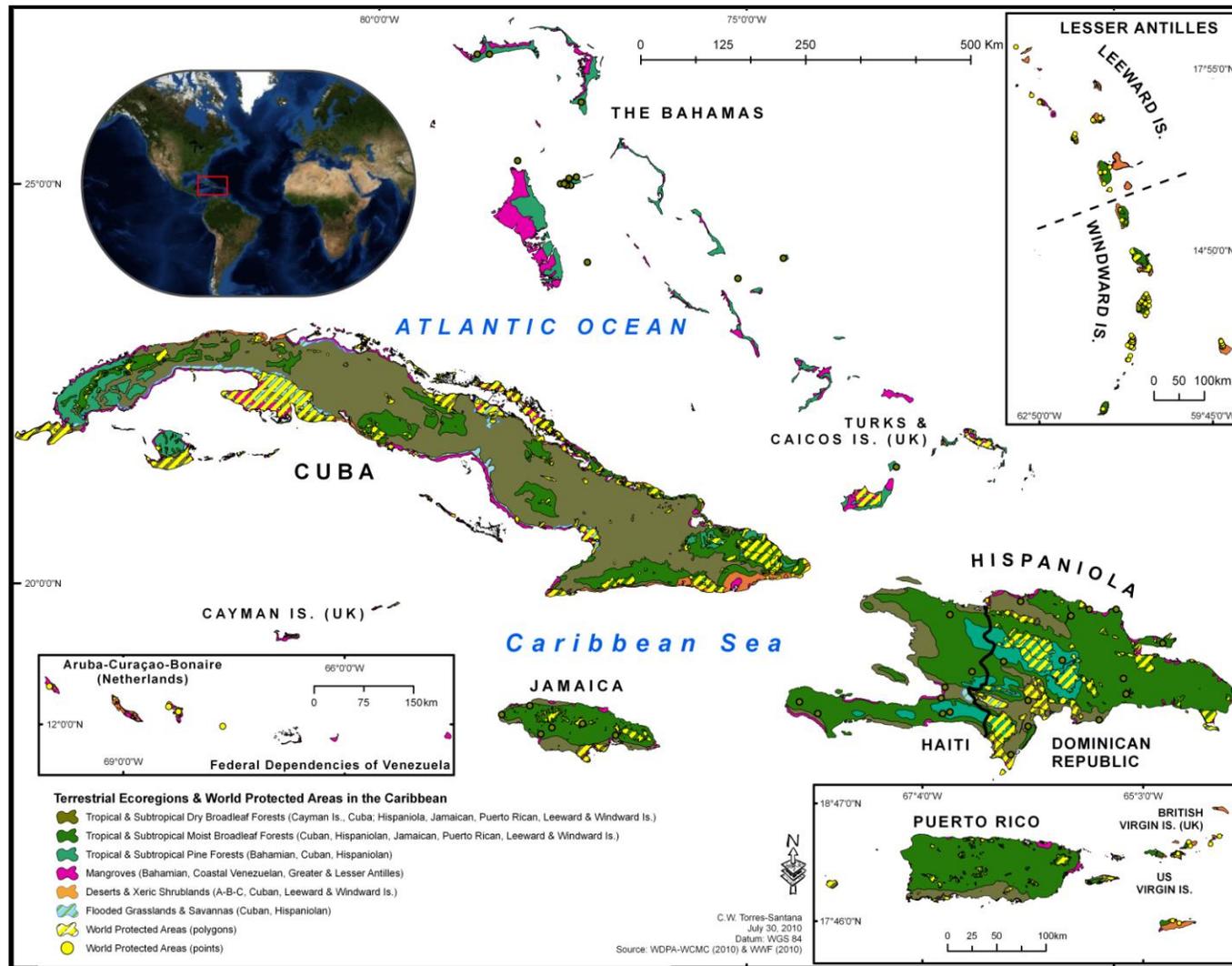


Figure 1. Caribbean Islands' terrestrial ecoregions with the protected areas. The legend represents six Neotropical biomes and each ecoregion is considered to be endemic to each island or island group (except the Coastal Venezuelan mangroves). The Greater Antilles include the Cayman Islands, Cuba, Jamaica, Hispaniola, Puerto Rico and the Virgin Islands. From the legend, A-B-C = Aruba-Bonaire-Curaçao (Netherlands).