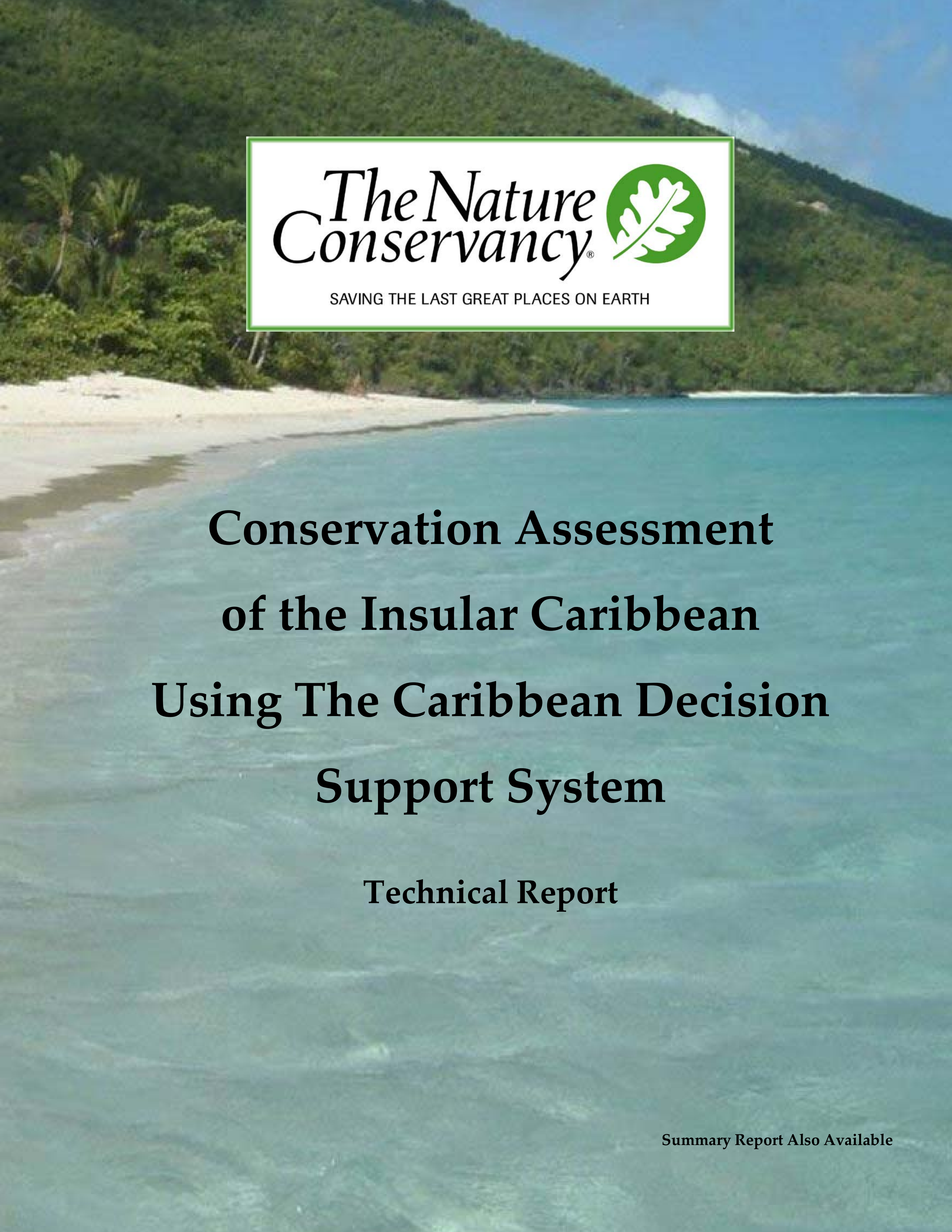

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Conservation Assessment of the Insular Caribbean Using The Caribbean Decision Support System

Technical Report

Summary Report Also Available

Principal Author: **Annette Huggins**

Co - Authors: **Anthony Chatwin**
Richard Jeo
Shirley Keel
Phillip Kramer
Francisco Núñez
Steve Schill

Contributors: **Matthew McPherson**
Kim Thurlow
Michelle Libby
Rick Tingey
Michael Palmer
Raquel Seybert

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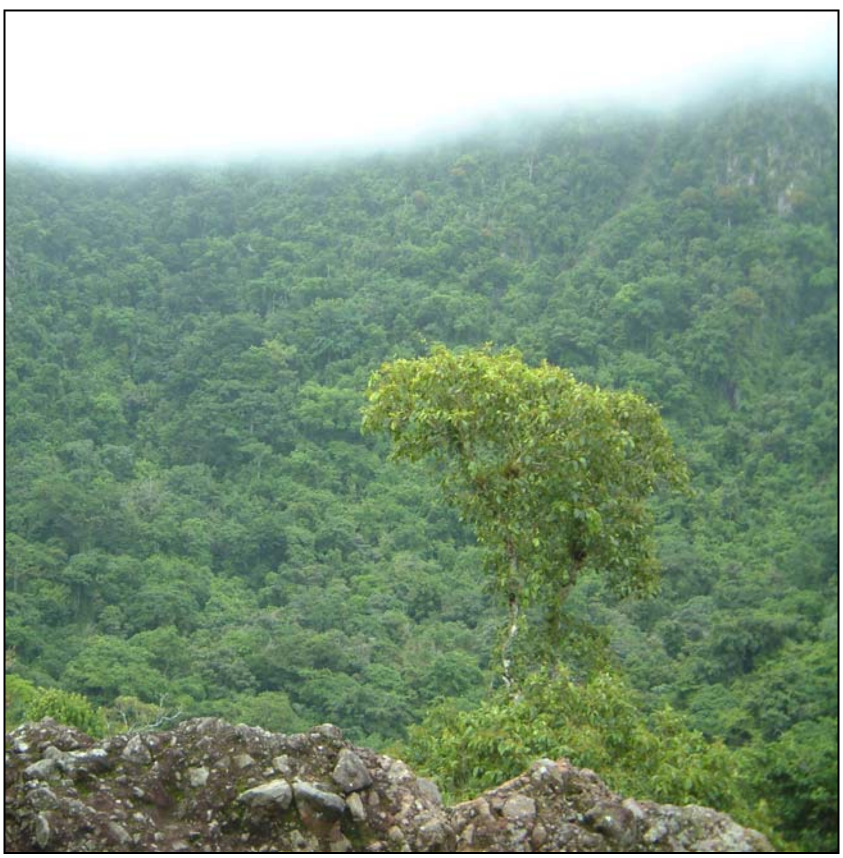

EXECUTIVE SUMMARY

Stretching across three million square kilometers of shimmering turquoise seas, and including more than five thousand islands and cays, the Caribbean is home to some of the world's biologically richest freshwater, land and marine environments, which are home to thousands of plants and animals, hundreds of which are unique endemics found nowhere else on Earth. These ecosystems are closely interlinked with the communities of twenty three culturally diverse nations and territories. It is also, however, one of the World's most imperiled regions. Human activities in the region are often intense, which can have disastrous effects on the region's species and habitats. Conservation is consequentially challenging in this threatened, diverse, and globally important area. The Nature Conservancy is addressing this challenge through country programs that employ science-based conservation strategies with local partners.

To facilitate this approach, a regional biodiversity assessment was initiated that built a framework of data and tools to aid systematic conservation planning and decision making and to guide conservation strategy development. This framework has been developed into the Caribbean Decision Support System (CDSS). The CDSS encompasses two primary components: the first is a detailed database housing vast geospatial information layers about a) habitats (e.g. turtle breeding grounds, mangroves, and coral reefs); b) threats to habitats (e.g. tourism, pollution and road construction); and c) protected areas; and the second component is a suite of tools designed to a) create "environmental risk surfaces" that indicate the level of threat to a particular habitat or species and are used to identify and assess protected area networks and conservation measures; b) identify critical areas of rare habitats across a landscape, and; c) facilitate the use of the software MARXAN (Ball & Possingham, 2000; www.ecology.uq.edu.au/marxan) to create optimal protected area scenarios based on quantitative conservation goals while minimizing impending threats to habitats.

Using the CDSS and working with local experts, the Caribbean assessment identified a portfolio of priority areas that represent the region's biodiversity to achieve regional goals and objectives. The process involved steps to; identify and map biodiversity elements known as targets; identify quantitative goals for the amount of each target to be represented; identify and map factors, such as threats, that may affect the suitability of candidate sites for inclusion in the portfolio of conservation areas; and analyze these data to identify a portfolio of priority conservation areas.

Ecosystem, landscape and species level biodiversity elements, known as targets, that represent a full spectrum of terrestrial, freshwater and marine biodiversity were identified and mapped using combinations of biophysical factors such as climate, geology, land elevation and ocean depth. Satellite imagery was used to create and validate habitat maps that were reviewed by local experts. Human activities were mapped and validated to provide a set of environmental risk maps that were used as conservation area suitability maps. Appropriate models were used for the three sets of biodiversity in the freshwater, terrestrial and marine environments. The CDSS was used to facilitate the use of the software MARXAN to identify a portfolio of priority conservation areas using the mapped targets and suitability or threat factors. The results were reviewed and developed into a portfolio of conservation areas that met the conservation objectives.

Optimal conservation portfolios identified for the marine environment consisted of 141 areas covering 775,8894 hectares that encompassed 20.2% of the region. The terrestrial portfolio consisted of 64 conservation areas covering 749,3888 Hectares or 3533,786 hectares of target, and the freshwater of 15 groups of areas covering 6679,131 hectares. These conservation portfolios, however, are not intended to be prescriptive. Users are encouraged to utilize the CDSS to facilitate strategic conservation planning that is directly linked to decision making and natural resource management at a more local level. It is also hoped that collaborative partnerships and further research and monitoring efforts will be encouraged by this framework that, in time, will facilitate new and strengthen existing conservation efforts in the region.

INTRODUCTION

In the face of limited conservation resources, the need for biodiversity conservation approaches that are linked to systematic and strategic planning has long been recognized (Margules *et al.,* 1988; Margules & Pressey, 2000; Possingham *et al.,* 2000; Beck, & Odaya, 2001; Leslie *et al.,* 2003; Ferdaña, 2005; Jeo *et al.,* 2005 etc). Human well-being in the Caribbean is strongly connected to ecological health and ecosystem services, so decisions concerning the location and size of protected areas and other conservation strategies must consider both biological and socio–economic factors and be supported by systematic decision support tools.

A lack of easily accessible spatial data and tools to map ecological processes and human activities at this broad scale has previously made strategic, data-driven conservation decisions difficult, time-consuming and expensive (Jeo *et al.,* 2005). It has also contributed to difficulties in establishing a basis for cooperative, cross-border actions. Recognizing this, there is increasing interest amongst governments, environmental organizations and funding agencies to move towards technical methods that better manage the region's complex ecosystems and human societies (Jeo *et al.,* 2005). The Caribbean Decision Support System (CDSS) was created with the aim of meeting these needs. It provides the latest and most comprehensive biodiversity and socio-economic data and analytical tools to natural resource managers and decision makers striving to implement national or local conservation strategies across the region.

THE CARIBBEAN DECISION SUPPORT SYSTEM

The CDSS encompasses three components designed to meet the needs of natural resource managers across the region and support the complex decisions they make to protect the region's natural resources. The first component is a detailed geospatial database housing vast information layers about habitats (e.g. turtle breeding grounds, mangroves, and coral reefs), threats (e.g. tourism, pollution and road construction), and protected areas; the second component is a suite of tools designed to create "environmental risk surfaces" that indicate the level of threat to a particular habitat or species; and the third component is a suite of tools to assess habitat uniqueness across a landscape and facilitate the use of the software MARXAN to create optimal conservation plans based on several threat factors and sustainable development scenarios. The CDSS aided the large-scale biodiversity assessment of the region carried out by The Nature Conservancy that identified a portfolio of conservation areas to concentrate detailed planning and conservation strategies and so sustain the biological diversity of the region. The portfolio represents target biodiversity to quantitative goals in areas least threatened by human impacts that can support populations, ecosystems and ecological processes into the future.

Users are encouraged to utilize the CDSS across the region, taking advantage of the flexibility designed into the system to customize the decision-making process by incorporating local knowledge and accommodating local concerns towards natural resource management. It hoped that collaborative partnerships and further research and monitoring efforts will also be encouraged by the CDSS framework that, in time, will facilitate new and strengthen existing conservation efforts in the region.

The Caribbean Decision Support System with user guide and presentation are available on the accompanying DVD, in addition to MARXAN tutorials and information, ArcReader and a summary version of this report on the Insular Caribbean Conservation Assessment. Full details of the database are available in the CDSS are provided in Appendix H.

THE CARIBBEAN REGION

The Caribbean basin comprises over 20 nations and territories, each characterized by unique and wide ranging biodiversity and culture. It is one of the world's greatest centers of biodiversity and endemism, arising from the region's geography and climate: an archipelago of habitat-rich tropical and semi-tropical islands tenuously connected to surrounding continents. Plants and animals arrived from the neighboring continents and islands, and as their descendants spread into new environments they evolved as a result of new ecological opportunities. The region harbors a staggering 12,000 plant species, 1,518 vertebrate species and 3,000 shallow marine species. Of this diverse flora and fauna, many are endemics found nowhere else on Earth, some unique to individual islands, or to isolated places within specific islands.

Marine

The Caribbean forms the heart of Atlantic marine diversity. Roughly 8 to 35% of species within the major marine taxa are endemic to this area. The shallow marine environment contains 25 coral genera (62 species scleractinian coral), 4 mangroves, 7 seagrasses, 117 sponges, 633 mulluscs, 378 bivalves, 77 stomatopods, 148 echinoderms, over 1400 fishes, 76 sharks, 45 shrimp, 30 cetaceans, 1 sirenia, and 23 seabirds. Only one marine species has gone extinct, the Caribbean Monk Sea, which was last seen in the mid 1950's.

The Caribbean contains approximately 10,000 square kilometers of reef (Spalding, *et al.,* 2001; Andréfouët *et al.,* 2005); 22,000 square kilometers of mangrove (amended from Spalding *et al.,* 1997); and as much as 33,000 square kilometers of seagrass beds (Spalding *et al.,* 2003). Other unique and interesting carbonate structures found in the insular Caribbean include stromatolites, algal ridges, ooid shoals, and blue holes.

There is surprisingly little variation in marine species diversity within the Caribbean province in large part because of the high degree of connectivity. The strong and predictable Caribbean Current that meanders through the basin year round transporting larvae between islands and regions. As a result, marine habitats share many of the same marine species and show remarkably low degree of endemism (between marine ecoregions) in stark contrast to the regions highly endemic terrestrial island biodiversity. Large ranging and highly migratory species such as turtles, whales, sea birds and pelagic fishes, inhabit different portions of the Caribbean basin during different stages of life. Despite this high degree of mixing, there are significant differences in geology, climate, productivity, and island size all of which influence the relative abundance, extent, intactness, and vulnerability of marine biodiversity in the Caribbean. Three distinct ecosystems are identified as follows;

The Bahamian marine ecoregion encompasses the large shallow bank systems of the Bahamas and Turks and Caicos as well as several smaller banks at the southern terminus owned by the Dominican Republic. This region of the Caribbean is tectonically very stable creating massive build-up of carbonate sediments that make up the banks. The sediments are almost entirely composed of carbonate grains derived from the shells of living organism that thrive in the warm shallow waters. Islands and small islets number into the thousands and are all generally low-lying with very limited freshwater river outflows that occur as groundwater discharge. Tides are larger than in other parts of the Caribbean and have shaped complex coastal landforms of tidal creeks, mud flats, and ooid sand shoals. Habitat diversity (beta diversity) is similarly different than other parts of the Caribbean. Reefs tend to be narrow fringing barriers (bank margin reefs) and Holocene biogenic reef islands are virtually absent. Soft-bottom communities such as seagrass beds are generally sparser than other parts of the Caribbean while macroalgal biomass on deeper fore reefs is significantly higher. Coral reefs vary in form mainly with respect to exposure to wave energy and generally occur along all of the windward margins of the banks. A number of distinct carbonate structures unique to this part of the Caribbean include an extraordinary number of blue holes, modern stromatolites actively growing in tidal channels, and active ooid sand shoals.

Species diversity in the Bahamian ecoregion is different to other parts of the Caribbean such as along the coasts of south and central America. Absent are manatees, saltwater crocodiles, and many of the species associated with large fluvial estuaries. Acroporid corals (*Acropora palmate*) is particularly abundant on shallow fringing reef structures and *Montastraea annularis* is the major reef builder on the deeper fore reefs. Extensive hardbottom algal communities characterize large areas of the exposed southern banks whereas soft bottom communities occur in the island sheltered banks. Reef fish communities in much of the region contain largely intact predator assemblages, including large numbers of Nassau groupers (*Epinephelous striates*) with a very high number of intact spawning aggregation sites. A recent rapid ecological assessment of this area found that it harbors some of the largest populations of bonefish in the world.

Sea turtles (mainly greens and loggerheads) forage over much of this area during juvenile life stages with some of the highest densities ever observed. Seabirds occupy many of the uninhabited offshore cays particularly in areas of higher productivity such as Cay Sal Bank. The largest breeding ground for Atlantic humpback whales occur on the banks at the southern end of this ecoregion. Pressure on the marine resources continues to be comparatively light due to the fairly low population densities and opportunities in the growing tourism industries.

The Greater Antilles are the large, tectonically active and mountainous islands of Cuba, Jamaica, Hispaniola, and Puerto Rico. The sheer size and height of these island masses are enough to create localized daily adiabatic winds that can override the regional easterly trade winds and produce localized climate and rainfall. Watersheds are small to moderate in size producing substantial fluvial discharge and nutrients into the coastal zones. Tectonic activity in this area of the Caribbean remains high because of the underlying plate boundary and tectonic uplift continues today. Estuaries tend to occur as large tectonic shaped inlets (perpendicular to the coastline) that may be highly stratified and deep depending on the amount of fluvial discharge. Except for the north coasts of Cuba and Puerto Rico, tides are typically quite low (~25 cm) for much of the rest of the ecoregion. The marine habitat beta diversity in the Greater Antilles is higher than in the eastern Caribbean or Bahamian ecoregions because of the substantial gradients around the islands with respect to exposure and productivity. Fringing reefs are most common with larger barriers forming along the wider shelf areas south as found along the south coast of Cuba. There are several banks within this ecoregion including Pedro Bank and several off the south coast of Cuba but the water depths are greater than for banks in the Bahamian ecoregion.

Marine species diversity is high but larger megafauna have been severely impacted by human activity over the past several hundreds of years. Small populations of manatees and saltwater crocodiles still occur on all of the Antilles but are restricted to a very small portion of their original distribution. Similarly, sea turtle populations and nesting occurrences have also been dramatically reduced from what was observed several hundreds of years ago but still occurs on all of the islands in small numbers. Coral reef species include all of the known scleractinian corals that exist in the western tropical Atlantic. With a combined population of over 25 million on these islands, the density of people living on the Greater Antillean islands is some of the highest in the world. Severe overfishing has depleted reef fish stocks and altered the trophic structure of the entire coastal zone.

The Lesser Antilles or Eastern Caribbean is a half-moon shaped string of over 60 islands stretching 600 miles from the U.S. and British Virgin Islands to Grenada. This region of the Caribbean is a back-arc basin and characterized by small island sizes many of volcanic origins associated with the adjacent plate boundary. The Virgin islands (U.S. and British) found at the northern boundary of this ecoregion are geologically more similar to the Greater Antilles but have been grouped into the Eastern Caribbean because of their small island size and easterly exposure to the Atlantic swells. The small size of the islands minimized localized climate and rainfall effects and produces very few large freshwater rivers or estuaries.

Coastal salt ponds are quite common that are orientated parallel to the coastline but are often not hydraulically connected to the sea in part because of the lower tidal amplitudes (~25 cm) in this portion of the Caribbean. Much of the eastern Caribbean is influenced by the discharge of massive amounts of freshwater from several large South American rivers such as the Orinoco. This produces salinities well below oceanic conditions for several months each year. Coral reefs tend to occur as fringing forms around the islands and the northern more exposed portions of the eastern Caribbean also has unique coral algal ridges which form in response to high wave energy.

Marine species in the eastern Caribbean are similar to elsewhere in the Caribbean but is somewhat lower diversity than found along the larger islands or continental coasts. Species such as manatees and saltwater crocodiles are rare (although historically Manatees were found in Guadeloupe) as are species associated with larger estuaries. Sea turtle nesting for both Leatherback and Hawksbills is common on many of the islands and the area is important for Green turtle foraging. Seabirds are also very abundant in this area of the Caribbean possibly because of easy access to deeper water productive fishing grounds. Whales, including Humpback and Sperm, frequently use this area during the winter possibly because the easy access through numerous deep water channels that bisect the islands. This ecoregion spans more than 17 distinct political units, with a population of just 2.5 million inhabitants. The small island size and developing economies and their isolation make these islands more vulnerable to environmental degradation and more dependent on tourism than the other regions.

Terrestrial

The large geographic expanse of the Caribbean contains at least fourteen Holdridge Life Zones and a complex geology (Lugo *et al*., 2000). The Greater Antilles (Cuba, Hispaniola, Jamaica, Puerto Rico and the Virgin Islands) are located on a partially elevated platform that supports a mature volcanic range. The Lesser Antilles (the islands from Anguilla to Grenada), are of more recent origin, consisting of an outer chain of islands composed of low coral and limestone and an inner chain of steep volcanic islands. The Bahamas bank assemblage (including Turks and Caicos), located southeast of the Florida peninsula, rises from a rock submarine plateau (Lugo *et al*., 2000; Areces-Mallea *et al*., 1999).

The Caribbean is one of the world's centers of terrestrial biodiversity and endemism. It harbors about 12,000 plant species and 1,518 vertebrate species (668 bird, 164 mammal, 497 reptile, and 189 amphibian species). Of this diverse flora and fauna, 7,000 vascular plant species and 779 vertebrate species (148 bird, 49 mammal, 418 reptile, and 164 amphibian species) are endemic to the Caribbean. This accounts for 2.3% of the world's 300,000 plant species, and 2.9 % of the world's 27,298 vertebrate species. Total land surface of the Caribbean islands is only 263,500 km^2 with only 11.3% of the original primary vegetation remaining, an aggregated area of only 29,840 km^2. Many species are endemic not only to the region, but to individual islands, or to isolated places within specific islands. Among the faunal groups, very high endemism is found in fish, amphibians, reptiles, and mammals (Myers, *et al*., 2000; Davis *et al*., 1997; Woods & Sergile, 2001; Global Amphibian Assessment, 2004; Raffaele *et al*., 1998; Nowak, 1994; Nature Serve).

Caribbean species richness is supported by diverse habitats; there are 4 major habitat types, 16 WWF ecoregions**,** and 14 Holdridge life zones. The distribution and biodiversity characteristics of the major habitat types (Adams 1972; Areces-Mallea et al., 1999; Borhidi 1991; Correll and Correll, 1982; Howard 1973; Lugo et al., 2000; Neotropical Ecosystems Integrity Assessment 2001) are described below:

Tropical/ Subtropical Moist Broadleaf Forests are characterized by the large number of tree species occurring together with a closed canopy. Gregarious dominants are uncommon. The forest in general has smooth, wind-sculptured canopies without emergent trees. Understory vegetation, especially herbaceous plants, is often sparse. Cylindrical bole, pinnate leaf, large leaf blade, buttress, liana, and cauliflory are common. It occurs in a climate where water stress is absent with no regular annual dry season and an average of monthly rainfall of 100 mm or more, or where water stress is intermittent with short dry season of monthly rainfall of 60 mm or more or with particular soil conditions. This factor is coupled with high temperature (mean temperature 18^0C or more in the coldest month of the year) and a strong evapo-transpiration. The high net primary productivity of successional forests supports a large animal population, but not the same species as a mature forest. Dominant species groups include Leguminosae, Moraceae, Meliaceae, Palmae, and Lauraceae. Diagnostic species groups are Bromeliaceae and tree ferns. In the Caribbean, moist forests occur mainly in lowland areas influenced by north-easterly or north-westerly winds, and windward mountain slopes, e.g., northern part of eastern Cuba, northern Jamaica, eastern Hispañola, northern Puerto Rico, and small patches in the Lesser Antilles, Trinidad and Tobago.

Tropical / Subtropical Dry Broadleaf Forests are found in areas with high temperatures throughout the year, an annual precipitation of less than 1,600 mm with one or two long and pronounced dry seasons. The duration and intensity of drought govern the distribution of dry forests. Dry forests during the rainy season are often similar physiognomically to tropical humid forests but are generally smaller in stature and biomass, lower in biodiversity, and more seasonally pulsed in tree growth, reproductive cycles, and organic matter turnover than forests with higher and less seasonal rainfall. The structure and composition of dry forest vary greatly relative to climate, soil, and other environmental factors. Factors that are largely governed by latitudinal position such as timing, frequency, and duration of dry periods, are also important determinants of dry forest characteristics. Dry forests usually have a high level of endemism. Most woody plants and succulents are diecious or hermaphrodites but self incompatible. Their reproduction relies on pollinators, particularly bees. Dominant species groups include Capparidaceae, Cactaceae, Erythroxylaceae, Zygophyllaceae, Anacardiaceae, Asteraceae, Malvaceae, Lamiaceae, and Leguminosae. Common genera include *Acacia, Caesalpinia, Cassia, Mimosa, Tabebuia, Capparis, Byrsonima, Lysiloma, Ceiba, Aspidosperma, Erythroxylon*, *Brya, Pictetia, Plumeria,* and *Bursera.* Diagnostic species are *Melocactus spp., Cephalocereus royenii, Leptocerreus quadricostatus*, and *Thrinax morrisii.* In the Caribbean dry forests are found in The Bahamas, Caymen Islands, Cuba, Hispaniola, Jamaica, Leeward Islands, Puerto Rico, Trinidad and Tobago, and Windward Islands. The dry forest life zone tends to be favored for human habitation, largely because of relatively productive soils and reasonably comfortable climate. For this reason, few dry forests remain undisturbed.

Tropical / Subtropical Coniferous Forests belong to a fire-maintained, single–species dominant system. They occur on nutrient-poor acidic soils, either on quartz sands, slates and sandstones as subclimax communities, or as paraclimax communities on ferritic soils. In addition to fires, hurricanes and landslides are the major natural disturbance affecting the distribution, composition and structure of the pine forests. In the Caribbean pine forests are found in The Bahamas, Turks, Caicos, Cuba, and Hispaniola. In Cuba, coniferous forests occur in the eastern and western ends of the island. The lowland pine forests on the ferritic soils or slately sandstone are dominated by *Pinus caribaea* var. *caribaea*; while pine forests on deep, acidic ferritic soils are dominated by *P. cubensis*. They are rich in endemics. Low-altitude pine forests of Isla de La Juventud are dominated by *P. tropicalis.* Montane pine forests on acidic soils derived from sandstone and andesitic tuffs in south eastern Cuba are dominated by *P. maestrensis*. On the island of Hispaniola, montane pine forests are found in the Cordillera Central with *P. occidentalis.* Pine barrens or open pine woodlands on limestone with monospecific canopy of *P.caribaea var. bahamensis* occur in The Bahamas. The major threats to pine forests include irrational timber extraction and frequent man-made fires which change the age structure and density of the pine forests, and **e**xotic species which displace native species in the understory modifying the fire regime, water and nutrient availability.

Shrublands and Xeric Scrub occur in areas of rain shadows created by mountains in areas of extreme temperatures. Xeric areas generally have low and highly seasonal precipitation, with great interannual variation. Xeric shrublands are open vegetation with small trees and shrubs, cacti are dominant or co-dominant in both shrub and canopy layers. Vegetation cover by annual plants varies due to large quantitative and seasonal rain fluctuations. During the dry season the landscape is barren. A large proportion of xeric vegetation consists of annual plants. Microphyllous shrubs, small succulent trees, plants in rosettes (such as agaves and terrestrial bromeliads) or perennial and semi-deciduous shrubs can also be present. Xeric vegetation has high levels of endemism at the species and genus level. Flowering and faunal reproduction processes are adapted to rainy seasons. Ants and rodents are fundamentally important species. Habitat diversity in the hot xeric system is spatially very heterogeneous and patchy. Dominant species include *Rittereocereus hystrix, Opuntia spp., Cylindropuntia histrix, Rhodocactus cubensis, Caesalpinia spp., Capparis spp., Gaujacum officinale, Consolea macracantha, Dendrocereus nudiflorus, Pilosocereus brooksianus, Harrisia fernowii, Agave albescens,* and *Melocactus acunae.* Diagnostic species group are *Jacquinia, Gochnatia, Cordia, Guettarda, Lantana and Coccothrinax* palms. In the Caribbean xeric shrublands and cactus scrubs are found on the Leeward Islands, Windward Islands, and Cuba.

The biological diversity of Caribbean islands is very spatially compact. It was recently noted (Lugo *et al*., 2000) that major environmental gradients and vegetation change occur over short distances of less than 100 km. Natural disturbances, such as earthquakes, volcanic eruptions and hurricanes, in combination with human interference such as mining/quarrying, air/water pollution, forest fires, agriculture development, urban sprawl, tourism, introduced animals, and invasive exotics have modified vegetation and the landscape of the Caribbean. Strategies must be developed to prioritize conservation actions to prevent the remaining endemic species habitats becoming severely fragmented.

Freshwater

The Caribbean's freshwater biodiversity is found in a variety of habitats including large lowland rivers, montane rivers and streams, lakes, wetlands and underground karst networks. In addition to being habitats for many important, unique and migratory animals and plants, these freshwater habitats provide clean water, food and many services to local communities. These services are especially important as the small islands of the insular Caribbean are completely surrounded by salt water, and rely greatly on limited, land-based freshwater from functional ecosystems.

Information on the distribution of many Caribbean freshwater species is scarce, distribution is not known for most freshwater taxa, even for fish that are otherwise well studied. 167 freshwater fish species have been identified (Neodat, 2007; Lee *et al*., 1983; Reis *et al*., 2003), although there have been a large number of introduced species from aquaculture and aquarium collections. Fifty of these species are endemic to the Caribbean, with the genera Limia and Gambusia being predominant.

Reptiles are represented by several species that are included in the IUCN Red List such as the American and Cuban Crocodiles (*Crocodylus acutus* and *C. rhombifer*) and the Hispaniolan Slider (*Trachemys decorata*). Amphibians are primarily terrestrial in the Caribbean represented by the Genus Eleutherodactylus but some truly aquatic species exist within the Genera *Bufo*, *Hyla* and *Osteopilus* (e.g. *Bufo fluviaticus, B. guentheri, Hyla heilprini*, *H. vasta* and *Osteopilus dominicensis*) with a tendency to be locally endemic.

Macroinvertebrates are important to Caribbean freshwater biodiversity due to their disproportionate influence on ecosystem functioning. *Macrobrachium* is a widespread genus indicated in the ecological literature as a keystone species in insular Caribbean freshwater environments (Pringle *et al.*, 1993; Ramírez & Pringle 1998; March *et al*., 2001). At least six species of Macrobrachium shrimp (*M. acanthurus, M. carcinus, M. crenulatum, M. faustinum, M. heterochirus,* and *M. olfersii*) are known to occur in freshwater habitats on Caribbean islands (Holthuis, 1952; Chace & Hobbs, 1969; Hunte, 1976; Covich & McDowell, 1996; Bowles *et al*., 2000). Widespread freshwater prawns found in the Caribbean belong to the genus *Atya* that has at least three known species (*A. innocuous, A. lanipes,* and *A. scabra*). Aquatic insects have representatives in the taxonomic groups Tricoptera, Ephemeroptera, Diptera and Odonata, with some being included in the IUCN Red List (*Ortholestes clara, O. trinitatis*, and *Phylolestes ethelae*).

The Bahamas Archipelago Ecoregion: The entire region was shaped by sea level changes during the Pleistocene Ice Age, encouraging karst and cave development. The numerous caves and sinkholes in the Bahamas can reach depths of 100 metres, representing the lowest sea level from Pleistocene times. Today, the groundwater on many islands consists of a freshwater lens floating on underlying sea water. Most of these islands contain much shallow water and swamps, some of them connected to freshwater streams. Southern islands lack well-developed groundwater resources, although localized freshwater lenses do occur. Caicos island has the only standing freshwater ponds, of which there are seven. Literature from the eighteenth century report a large lagoon that fragmented as consequence of increased aridity from land clearance (Keegan, 1993).

The inland blue holes found in the Bahamas are a unique type of cave ecosystem, with a layer of freshwater lying above a layer of salt water below. They were created during the ice ages, when sea levels were 400 feet lower and the Bahamas was a great exposed limestone platform. Stalactites and flowstone present within the caves were formed at these times when the caves were dry or above sea-level. Blue holes are particularly abundant in the north of Andros Island, with other concentrations of blue holes occuring on Grand Bahama, Eleuthera and Mayaguana islands. Fauna found in Blue Holes include Typhlatya shrimps, Cyprinodon variegats baconi, Lophogobius cyprinoids and Gambusia hubbi. Isopods of the genus Bahalana are endemic to the Bahamas with five species, originally described from Mount Misery Cave, Little Bay, Mayaguana Island, and later found in Duncan Pond Cave on Acklins Island.

The Cuba Archipelago Ecoregion: includes the island of Cuba, the Isla de la Juventud and 1,600 islets and cays. The island of Cuba is mostly flat land rolling plains with mountain systems, such as the Sierra del Escambray, the western Sierra de los Organos and the rugged easterly Sierra Maestra. Much of the southern coast is low and marshy with wetland ecosystems. Cuba has over 200 rivers as well as small streams that are dry in summer. The country's longest river is the Cauto. The highest point is the Pico Real del Turquino at 2,005 meters in the Sierra Maestra.

The Sierra del Escambray mountain range in south central Cuba is characterized by rivers, waterfalls and caves. Sierra de los Organoscontains many cave systems and underground rivers. Sierra del Rosario mountain range has high pluviometry and many waterfalls. Sierra Maestra is home to the headwaters of the area’s most important rivers, including El Cauto, Cautillo, Contramaestre, Bayamo, Guisa and Guamá, forming part of the extensive Cauto basin. In the southern part of the Sierra, are the deltas of Mota and Macío. The Delta of the Cauto River is a biodiversity refuge and is a Ramsar site covering 61,700 hectares with extensive mangroves. It includes the Turquino Nacional Park and the Alejandro de Humboldt National Park. Wetlands can be found throughout Cuba. They harbour a wide diversity of species including ducks, herons, gallinules and rails, many of which are endemic to the island. The southern Zapata Peninsula and its surrounding areas contain extensive wetlands. The Cauto river flows into the Gulf of Guacanayabo in the east of the island. The 48,000 hectares of the Cauto delta with its complex of estuaries and lagoons has been proposed as a Ramsar site. Cienaga de Lanieron the Isle of Youth consists of approximately 88,000 hectares of wetlands. The area also includes other habitats including semi-deciduous forest, freshwater coastal lagoons, mangroves, swamp grasses and small rivers. Humedal Río Máximo-Cagüey is an extremely fragile marine-coastal ecosystem undergoing salinization. Located at the mouth of the rivers Máximo and Cagüey, with a number of keys in the shallow waters, this area is the largest nesting site for flamingos in the Caribbean and is also a refuge for other migratory birds from across the Americas. Large populations of American crocodile and Caribbean manatee, both vulnerable species, inhabit the Humedal Río Máximo-Cagüey.

The Jamaican Ecoregion: The island is made up of coastal lowlands, a limestone plateau, and several mountain ranges; the Blue Mountains, a group of volcanic hills, in the east, the Central Range in the north and the Port Royal Mountains that rise above the Liguanea Plain just north of Kingston. The highest point is Blue Mountain Peak, at an elevation of over 2,255 meters. The John Crow Mountains are the largest limestone range in the country. The mountains create a network of 160 rivers and waterfalls. The eastern face of the Blue Mountains receives more than 300 inches of rain each year, providing water for nearly half of Jamaica's population. The largest river on the island is the Black River. Other significant rivers include the Rio Cobre, the White River, the Rio Grande, and the Lethe.

The limestone substrate accounts for the great number of caves found in Jamaica. Karst habitat is found near the Cockpit Country which is a rugged area of inland Jamaica that has been proposed as a World Heritage Site. It includes the upper parts of three important watersheds of the Great River, Black River and Martha Brae, and is next to the Montego River and St. Ann watersheds, recharging aquifers in St Elizabeth, St. James and Trelawny. The porous nature of karst landscapes means that relatively little exploitable surface water runoff is present. Karst springs well-up from the limestone aquifer in the northern, lower elevation areas. Drainage is mostly vertical and feeds underground rivers more than 100m below ground level. These rivers may re-emerge more than 8 km from their source. Small rivers can emerge from blue holes and run short distances before disappearing underground, but generally the areas are dry or, in the case of low elevation regions, contain ponds only during the wet season. The limestone aquifer, however, has the capacity to contribute over 40% of the island's exploitable ground water. Negril Great morass is the second largest stand of freshwater wetlands in Jamaica. This forest covers an area of 6,000 hectares, and acts as a filter of freshwater from the Fish River Hills to the east, flowing into the Negril marine park in the West.

The Black River Lower Morass is a diverse set of habitats, where five rivers meet, including wetlands, mangroves, and marshland containing the largest crocodile population in Jamaica and birds such as egrets, herons, ducks and the blue-winged teal, and savannas with plants such as butterfly ginger, bull thatch, saw grass, water hyacinths and pancake lilies. Portland Bight is a body of water between the Hellshire Hills to the west of Kingston and Portland Ridge. The Portland Bight Protected Area is rich in wildlife with the dry limestone forests of Hellshire, Portland Ridge and Braziletto Mountain, and the largest almost continuous mangrove stands remaining in Jamaica. The wetlands support many waterfowl and crocodile, which, together with the extensive sea-grass beds in the waters of the Bight provide probably the largest nursery area for fish, crustaceans and molluscs on the island. This supports 4,000 of Jamaica's 16,000 fishers and their families.

The Hispaniola Island Ecoregion: Hispaniola, the second largest island in the Greater Antiles, is formed from continental rock and and has five major mountain ranges, the Cordillera Central, the Cordillera Septentrional, Cordillera Septentrional, Cordillera Oriental, and the Sierra de Neiba. Pico Duarte in the Cordillera Central is the highest peak in the Antilles at 3,087meters and Pic de la Selle in the southern range is the highest point in Haiti, at 2,680 meters.

The Dominican Republic has seven major drainage basins. Five of these rise in the Cordillera Central and a sixth, in the Sierra de Yamasá. The seventh flows into Lago Enriquillo from the Sierra de Neiba to the north and from the Sierra de Baoruco to the south. The Yaque del Norte is the most significant river in the country at 96 km long, with a basin area of 7,044 square kilometres. Its headwaters are near Pico Duarte at 2,580 meters and it flows into the Bahía de Monte Cristi on the northwest coast, where it forms a delta. The Yaque del Sur is the most important river on the southern coast. The headwaters are at an altitude of 2,707 meters in the southern slopes of the Cordillera Central. Three quarters of its 183 km length is through the mountains, and has a basin area of 4,972 square kilometers. The river forms a delta near its mouth in the Bahía de Neiba. The Artibonite river flows from the western Dominican Republic across central Haiti to the Caribbean Sea. The watershed of 9,530 square kilometres is critical to the sustained development of the

Western San Juan valley and border area within the Dominican Republic, and is the prime source of water for the Peligre Dam, whose irrigation, domestic water, and hydro-electric services are essential to the economic development and food security of Haiti.

The Lago Enriquillo lies in the western part of the Hoya de Enriquillo. Its drainage basin includes ten minor river systems and covers an area of over 3,000 square kilometers. The northern rivers of the system rise in the Sierra de Neiba and are perennial, while the southern rivers rise in the Sierra de Baoruco but only flow after heavy rainfall. Most of the wetlands are found in the north-central part of the island; Laguna Limón, Laguna Redonda and floodplains of the Río Yuna and Río Barracote and also in the southeast; Lago Enriquillo, Laguna Limón, Laguna Cabral, Laguna de Oviedo and Laguna Salada.

The Puerto Rico Island Ecoregion: The Freshwater System in Puerto Rico is composed of surface running water, ground water, wetlands, coastal lagoons, a few natural ponds and geothermal springs. There are also artificial reservoirs, channels for agricultural irrigation and cattle ponds. Most of the wetlands are in the lower watersheds and the one lake, Cartagena, suffers from high sedimentation rates. All headwaters are below 1,350 meters elevation. Despite low elevations, Puerto Rico has a highly diversified and complex aquatic ecological system. As usual for the Caribbean, stream flows in Puerto Rico vary widely because the rainfall pattern is influenced by windward / leeward orographic effects, as well as the impact of seasonal storms and hurricanes.

There are 17 major watersheds on the island with chemical composition of stream water reflecting the island's geology (Bogart *et al*., 1964). These are divided into 33 watersheds and sub-watersheds. The largest by drainage area are: Grande de Loiza, La Plata, Grande de Arecibo, Grande de Añasco, Caliza de Arecibo, Guayanilla and Guajataca. The watersheds were grouped based on a potential historical connectivity, common geology, physiographic and climatic characteristics. In the Northeast there is a complex of small watersheds where the Loiza is the only relatively large river. Topography in the south is flat and the climate is drier than the rest of the island. Its watersheds are very small, with low flow rate and drainage density but are subject to flash flooding. Rivers in this part of the island include: Guamaní, Seco, Salinas, Coamo, Jacaguas, Tallaboa, Guayanilla, and Yauco. There is also a large wetland system, which has been impacted by intensive agriculture and irrigation channels. Water temperature has no significant variation, ranging from 70°F to 90°F, in contrast to islands such as Hispaniola and Cuba and is a consequence of the island's low elevation. There is turbidity due to sedimentation because of steep topography, heavy rainfall and erodable soils. Turbidity has also been accentuated by human activities, such as urban development and agriculture. The west of the island has few relatively large watersheds with a high precipitation rate. Although climatic conditions are similar to the northeast, the drainage density is not and catchments surface is larger in the main rivers including Grande de Añasco, Guanajibo and Culebrinas. In the northwest, there is a karstic system with low drainage density and few large rivers. Many of the rivers run underground, hindering efforts to accurately map their distribution. They include the Guajataca, Camuy, Grande de Arecibo, Grande de Manatí, Cibuco, La Plata, and Bayamón.

Lesser Antilles Complex Ecoregion: The Lesser Antilles are a chain of islands from the Virgin Islands in the North to Grenada in the south. As small islands, many areas do not have representatives of freshwater biodiversity.

The Guadeloupe Archipelago consists of five islands including St Barthelemy and St Martin. The Soufriere Mountain is the highest point in the Lesser Antilles at 1,484meters and is located in the Parc National de la Guadeloupe on Basse-Terre. There are two main rivers, the Bras-David and Corossol. *Donimica* is mostly covered by rainforest and has many waterfalls, springs and rivers including the Layou, L'Or, Macoucherie, White river and Indian river. Cabrits National Park contains tropical forest and the largest wetland of the island. Morne Trois Pitons contains several crater lakes and waterfalls. The highest point is Morne Diablotin at 1,438m. *Martinique* is mountainous with three principal volcanoes; Mount

Pelée which is an active volcano of 1,397metres, Lacroix Peak at 1188 meters and Mount Vauclin at 501 meters. The relief of the island has led to a complex drainage pattern, characterized by short watercourses, with some mangroves and estuaries. In the south, the Salée and the Pilote rivers flow from Mount Vauclin. In the center, the rivers flow outwards from the Carbet Mountains, including the Lorrain, Galion, Capot, and Lézarde rivers. In the north, the Grande River, the Céron, the Roxelane, the Pères, and the Sèche irregular torrents. *St Lucia* is the most mountainous Caribbean island, with the highest peak being Mount Gimie, at 950 meters. Rivers include the Rosseau, Cul de Sac and Troumasse. *St. Vincent* is a rugged volcanic island. La Soufriere is the highest peak at 1178 meters, and dominates the northern third of the island. Very little of the island is flat, the Central and Southern sections of the island fall sharply from the 300 to 600 meter mountains to the sea. *Grenada* is a rolling, mountainous and volcano island with several small rivers and waterfalls, rainforests including Mount St. Catherine at 835 meters, a wetland system and the volcanic lakes of Levera Pond and Antoine Lake.

The diverse marine, terrestrial and freshwater habitats and species of the region are closely linked to the local human communities. Human well being relies upon diverse ecosystem services, such as buffering coastal communities from the effects of storms, freshwater, growing and harvesting food, providing a basis for recreational and tourism industries in addition to providing habitat for commercial species.

VULNERABILITY AND THREATS

Heightening human pressures in the region are thought to be putting the biodiversity of the region under unprecedented stress. Activities include cruise ship tourism, terrestrial and marine tourism and their associated infrastructures, hydropower dams and reservoirs, canalization, freshwater withdrawals, road building, agriculture, over-fishing, introduction of alien species, sand and bedrock mining, discharge of untreated sewage and industrial waters, intensive agrochemicals use, aquaculture, overharvesting, population growth, urban sprawl and resource extraction. These activities can lead to changes in ecological systems such as habitat fragmentation, degradation and loss, invasive species, hyrdrological regime change, degraded water quality, pollutant release, sedimentation, ecosystem service degradation and the resulting effects on local human communities. The cumulative impacts of all these influences on biodiversity are largely unknown.

The complex mix of political and social factors exacerbates these problems and results in the Caribbean being one of the world's most threatened places. The strategies necessary to balance sustaining the livelihoods of people and the growth of economies with the need to reduce threats and protect remaining biodiversity are complex and interrelated. Deciding how and where to act in the face of multiple, imminent threats is an increasing challenge. It is hoped the data on many of these threats in addition to conservation targets and tools contained within the Caribbean decision support system (Appendix H) will greatly facilitate actions to meet these challenges.

CONSERVATION TARGETS and DATA SOURCES

One of the principle goals of the assessment was to identify important areas of biodiversity; those areas that contain multiple and viable (or feasibly restorable) examples of native plants, animals, and ecological communities and systems across key environmental gradients. These biodiversity features are often termed conservation targets and serve to focus The Nature Conservancy's conservation planning and action.

A suite of conservation targets were selected and mapped to represent as full a range of biodiversity as possible across the region. Inevitably, a range of surrogates were used, as the representation of all biodiversity elements of the region is not possible. These surrogates are often in the form of habitats or geoclimatic types thought to influence and reflect the communities of species and ecological systems inhabiting them. Emphasis was placed on habitat targets as they offer several advantages including increasing the feasibility of the assessment because their delineation is less time intensive and resources and can be incorporated from remote sensing data (Jeo *et al.,* 2005; Huggins, 2002). They can also encompass major ecological processes that do not operate at the scale of species and small natural communities.

A key component of the selection of targets and the target mapping process was contributions from experts who are familiar with the different species, ecological communities, habitat types and ecological systems present in the region. The three habitat realms of freshwater, terrestrial and marine implemented different appropriate methodologies for spatial representation of targets according the availability of data across the region. All data are available in the CDSS on the accompanying DVD and online as detailed in Appendix H.

Marine Targets

Long-known as a center of biodiversity for shallow coastal communities, notably coral reefs, seagrasses and mangroves, the Caribbean region encompasses the heart of Atlantic species biodiversity. Data were assembled for a range of marine biodiversity features, including both habitat and species targets. Existing data sets and models were utilized in addition to developing both bathymetry-based and satellite image analysis-based distribution models. Full details can be found in Appendix A.

Coastal Strand Complex or beach habitat represents the lands bordering the sea. It is a home to a very specialized community of associated fauna that has adapted to live in this harsh environment. The main zones include: upper beach, intertidal zone, low tide line, and sub-tidal zone. Sandy beaches were mapped across the Caribbean basin using the program Feature Analyst with Landsat remote sensing images.

Coastal Wetland Complex including Mangroves Forests are some of the most productive ecosystems in the world. Their high primary productivity and nutrient profusion make them essential to the breeding, foraging, and roosting of many species, including aquatic plants, fish, shellfish, insects, amphibians, birds, and mammals. They generally consist of four principal mangrove species: *Rhizophorae mangle*, *Avicennia germinans*, *Laguncularia racemosa*, and *Conocarpus erecta.* Mangrove forests and associated wetland vegetation habitats were mapped using GeoCover land cover (CY 2000) global Landsat land cover (Tucker *et al.*, 2004). Mangrove areas from the Bahamas that were poorly represented by the GeoCover datasets were supplemented with mangrove data from the World Conservation Monitoring Centre which was compiled from various sources.

Estuaries are semi-enclosed, coastal areas in which the seawater is significantly diluted by freshwater coming from streams and rivers and groundwater that are feeding the estuary. Estuaries are considered as some of the most productive habitats on earth and also serve as important breeding and nursery areas for many marine species, including: sea and shore birds, marine mammals, fish, crustaceans, and reptiles. Estuaries were mapped by identifying the discharge points of all streams of order 3 and higher. In the Bahamas where there are no known rivers due to the porous limestone geology, groundwater maps were used with GIS buffering methodologies to identify small bays and estuaries, and centroid methods were used to identify larger bays and estuaries.

Lacustrian Features or lagoons are usually semi-enclosed by land but have some degree of access to the open ocean. They are influenced by oceanic tides, precipitation, and freshwater runoff from land areas, evaporation, and wind, therefore their salinities can range from hyperhaline to oligohaline. Salt ponds fall under the category of hyperhaline lagoons. Anchialine ponds are landlocked saline bodies of water with permanent connections to the open ocean. Blue holes are anchialine ponds with the thin freshwater lens. Structurally classed as cave systems, they support endemic fauna and microbial communities. The highest number of blue holes has been accounted for on Andros Island; over 100 of them have been identified on land and in the sea, with depths exceeding 121 meters in some cases. These features are widespread in the Caribbean region. The coastal lagoons were mapped by using Landsat remotely sensed imagery within 1 km of the coast. Blue holes were mapped by using Landsat imagery and a variety of digital topographic maps. They were identified on Andros, Great Exuma, Cat, Long, Crooked, New Providence, Eleutera, and San Salvador Islands.

Rocky Shore Complex dominates much of the Caribbean coastline. Rocky shores are colonized by a wide variety of marine algae and animals that are adapted to very stressful environments, which is evident in the distinct vertical zonation of rocky intertidal communities. These zones are home to a diverse assemblage of invertebrate grazers and predators unique to these communities. Rocky shores are important feeding grounds for puffer and trigger fish, as well as generalist wrasse feeders and herbivorous fish. Rocky shores were mapped using slope maps from 90m Shuttle Radar Topography Mission elevation data. Rocky shores were delineated where slope was over 10% at the shoreline. Rocky shores co-exist with sandy beaches in some areas.

Seagrass Communities are common throughout the waters of the Caribbean. They serve a variety of functions, including: trophic support, refuge from predation, recruitment, provision of nursery areas, environmental filter, and waterfowl habitat. Seagrass beds in the Caribbean are characterized by the habitat-forming turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme)*, shoalgrass (*Halodule spp.*), and calcareous green algae (*Halimeda spp.* and *Penicillus spp.*). Perhaps, most important of all, seagrasses act as “foundation species”, meaning that the persistence of the entire community rests on the persistence of seagrasses. Seagrass of medium to dense communities were mapped from a combination of data sources including Landsat ETM images, NOAA habitat maps, WWF and WCMC maps.

Sea Bird Nesting and Roosting Areas. Seabirds, shorebirds, herons, and numerous land birds flock seasonally to winter foraging and nesting grounds of the Caribbean. Secluded cays and islets, rocky shores and cliffs, estuaries, lagoons and mudflats are some of the key areas that provide attractive habitat for roosting and nesting in close proximity to the sea. Most seabirds, attracted by the absence of alien predators, such as cats, rats and raccoons, take advantage of small isolated islands to nest in high densities.

The data used to represent seabird and shorebird nesting and roosting areas was from The Society for the Study and Conservation of Caribbean Birds and other published studies. A total of 735 nesting and roosting point locations were identified and checked for spatial accuracy using Landsat ETM images or national topographic maps from each country. Species number, year of observation, and overall importance were attributed to each site. Conservation goals were set based on the ranked importance of each site.

Sea Turtle Nesting Areas. Although found in a number of ecosystems that are conservation targets in this assessment, sea turtles were treated as a separate conservation target due to their precarious state; all four species of marine turtles in the Caribbean are considered as either threatened or endangered by the World Conservation Union (IUCN). The target species include: Green turtles (*Chelonia mydas*), Hawksbill turtles (*Eretmochelys imbricate*), Loggerhead turtles (*Caretta caretta*), and Leatherback turtles (*Dermochelys coriace*). Today some of the largest breeding populations the world has ever known have all but disappeared due to a combination of factors operating at local and regional scales. The distribution of this conservation target is based solely on turtle nesting sites; the foraging habitats and migration patterns were not included in this assessment.

Sea turtle nesting beach distribution was mapped in collaboration with Wider Caribbean Sea Turtle Conservation Network. A total of 470 nesting locations were mapped for four species. Goals were set based on confidence in the nesting location data, ranked according to the data source, rather than by species or number of nests or crawls.

Channel Complexes were defined as narrow depressions or valleys that occur on top of the shelf areas (0-30 meters). They act as important conduits for water between deep and bank water, influenced by tidal movements and associated with bottom types such as: sand, sea grass, hard-bottom, or coral reef. Coral reef channels are dominated by massive coral species and are often important for migrating or spawning fishes.

Channels and pass maps were extracted from the Millennium Reef Mapping Project geomorphic reef maps (Andréfouët *et al.,* 2006). Channels were identified from Landsat ETM satellite images based on differences in water depth. Approximately 200 channels and passes were identified in the Caribbean. Near-shore tidal channels around islands in the Bahamas were also mapped using Landsat ETM image analysis. The data were checked against expert opinion and selected field investigations in Jamaica, Grenada, Bahamas, and Mexico but a quantitative accuracy assessment was not undertaken.

Coral Reef Complexes are the most famous hard bottom habitats in the Caribbean. Other types of hard bottom habitats were not included as their remote identification is difficult and very little attention has been invested in mapping them in the past. Coral reefs create three dimensional structures that provide home to a large array of organisms (Castro & Huber, 2000). The coral reefs were divided into: shallow reef (zero to five meters), fore reef (five to thirty meters), and biogenic reef formed islands.

The coral reefs were mapped as part of the Millennium Reef Mapping Project (Andréfouët *et al.,* 2006). The shelf areas of all Caribbean islands were classified from Landsat ETM images, based on geomorphology not biotic cover. The data were checked against expert opinion and selected field investigations in Jamaica, Grenada, Bahamas, and Mexico but a quantitative accuracy assessment was not undertaken.

Deep Slopes/Walls Coral reefs also thrive in deeper and cooler waters of the tropics, living along or at the edge of the continental shelf. These vertical walls or drop-offs that are 55-65 m in depth, may be interspersed with caves, ledges, overhangs, vertical chutes and gullies, providing ideal habitat for gorgonian corals, sponges, encrusting algae and numerous fish and invertebrates. They provide linkages to surrounding marine communities, and often provide corridors within which large schools of fish travel.

The probable occurrence of coral reef walls was mapped using slope and depth to delineate places where conditions predict their existence. Steep slopes (over 15 degrees) that occur between 30 and 300 meters were mapped using 1 km regional digital bathymetry datasets for the Caribbean.

Marine Mammal Complex Marine mammals are an integral part of marine and coastal ecosystems and use the waters of the Caribbean Sea for critical functions such as feeding, mating and calving. Seven of the species found in the Caribbean are considered endangered. Critical manatee areas were mapped by integrating datasets from a variety of local sources including national monitoring datasets, expert knowledge, aerial surveys and on-line sources. A total of 118 locations were identified. The Ocean Biogeographic Information database information on 15 cetacean species was associated with shelf areas to identify critical areas for other marine mammals and ranked according to the number of sightings observed in each area.

Reef Fish Spawning Aggregations In a spawning aggregation, non-specific individuals group together in densities three times higher than those found in non-reproductive periods. 'Resident' and 'transient' spawning aggregations have been identified. Many sites serve as spawning aggregation sites for multiple species, and are at predictable times and locations, making them very vulnerable to over-fishing.

The locations of reef fish spawning aggregations were compiled from a variety of sources including local fishermen in each country, published literature, and expert knowledge including from the Society for the Conservation of Reef Fish Spawning Aggregations. A total of 100 transient spawning areas representing twelve species were mapped. These were ranked according to the source of the data and confidence in the reported location. In addition to known aggregation sites, a predictive model was created to identify areas along the shelf with suitable geomorphic characteristics that represent potential historic aggregation sites which are no longer active today. A total of 750 ten km shelf segments were identified based on shelf morphology. Goals were established based on the confidence of the data sets.

Full target and mapping details are available in Appendix A and target quantities are listed in Appendix B.

Terrestrial Targets

Climate, geology and the soils they support are the dominant environmental variables controlling the distribution of vegetation and its associated biodiversity, so terrestrial coarse-filter targets were created by combining ecoregions, geology and natural areas from land cover. The ecoregions used were those delineated by The World Wide Fund for Nature (Dinerstein *et al*., 1995), and serves to represent climate. The geology map was provided by simplifying the US Geological Survey surficial map (French & Schenk, 2004). Generic geological parent rocks were grouped by virtue of their soil-producing characteristics from 72 classes to 3 classes: limestone, ultramafic and all 'others'. The land cover map was derived from the GeoCover LC (CY 2000) global Landsat land cover product (Tucker *et al*., 2004) which had been classified to identify areas of remaining natural vegetation in the following classes: forests, scrub/shrub, grassland and wetlands.

The overlay of these three maps resulted in a distribution map of 55 terrestrial conservation targets representing the remaining vegetation and their nested ecological communities. Within the Bahamas, only one target was identified using this method. TNC country program staff suggested refinements to the ecosystem layer so that 3 ecoregions be considered using topography and several island vegetation maps (Boucher *et al*., 1999; International Institute of Tropical Forestry (Helmer, E.M. *et al*., 2005)). Three vegetation types on limestone substrate were thus identified in the Bahamas Archipelago. Further details of targets are provided in Appendix A .

The vegetation targets, by ecoregion, are described below.

Puerto Rican Dry Forest Ecoregion on volcanic, sedimentary and alluvial substrates*:* vegetation tends to form a complete ground cover, and almost entirely deciduous on most soils. Tree heights usually do not exceed 15 meters. The crowns are broad, spreading, and flattened, with sparse foliage. Succulent or coriaceous leaves, thorns and spines are common. Vegetation is dominated by *Bursera simaruba, Pilosocereus royenii, Bucida bucera, Savia sessiliflora, Krugiodendron ferreum*. Indicator tree species include *Bursera simaruba, Prosopis juliflora, Cephalocereus royenii, Pictetia aculeata, Bucida buceras, Guaiacum officinale, G. sanctum,Tamarindus indica, Acacia macracantha, A. farnesiana, Melicoccus bijugatus,* and *Capparis spp.* In low alluvial areas with saline soils, the vegetation is dominated by *Prosopis juliflora.* In areas with imperfect drainage, pure stands of *Parkinsonia aculeata* are found. Both *Prosopis juliflora* and *Parkinsonia aculeata* are introduced species. Much of the land on better soils has been heavily grazed in the past.

Puerto Rican Dry Forests on limestone substrate*:* karstic vegetation is characterized by drought-tolerant deciduous trees with small diameter, scleromorphous leaf, and high numbers of individuals. Dry forest on limestone has a canopy height of 5-15 meters with some emergents. A lower layer may or may not present, and ground vegetation is sparse. Soil is often only represented by accumulations of humus in the grykes of the limestone karst. Trees of the dry limestone forest include: *Pisonia albida, Capparis cynophallophora, Pictetia aculeata, Guaiacum sanctum, Amyris elemifera, Bursera simaruba, Gymnanthes lucida, Thouinia portoricensis, Colubrina arborescens, Sarcomphalus reticulatus, Cephalocereus royenii, Opuntia rubescens, Bucida buceras, Dipholis salicifolia,* and *Plumeria alba*.

Puerto Rican Dry Forests on ultramafic substrate: Xeromorphic vegetation grows on soils with high concentrations of heavy metals (e.g., iron, chromium, nickel and cobalt), low levels of essential nutrients (e.g., nitrogen, phosphorus, potassium, and calcium), and a high magnesium-calcium ratio. High levels of specialization and adaptation to the physical and chemical composition of serpentine soils results in high levels of endemism of serpentine flora (Cedeño-Maldonado & Breckon, 1996).

Puerto Rican Moist Forests on volcanic, sedimentary and alluvial substrates: in lowland forests, canopy height ranges between 20 and 30 m high with vegetation including Tabonuco forest dominated by *Dacryodes excelsa, Sloanea berteriana,* and *Manilkara bidentata ssp. surinamensis* and Colorado forest dominated by *Cyrilla racemiflora, Micropholis guyanensis, Micropholis garciniifolia,Ocotea spathulata* and *Magnolia splendens.* Common species are *Roystonea borinquena* (endemic to Puerto Rico), *Tabebuia heterophylla*, *Nectandra* and *Ocotea spp., Erythrina poeppigiana, Inga vera,* and *I. laurina.* In disturbed successional forest at 0-250 meters elevation there is trumpet-wood forest, with *Cecropia peltata, Andira inermis,* and *Didymopanax morototoni* as major components; on lower slopes with better drained topography and less mature soils there is Bucaro forest dominated by *Bucida buceras* develops, and endemic monospecific *Thespesia (=Montezuma) grandiflora* forest is prevalent on hill slopes.

Montane forests, between 700 and 1000 meters, are characterized by open-crowned trees with greater abundance of epiphytes, palms, and tree ferns. Leaves tend to be coriaceous and grouped toward the ends of the branches. The cloud forest, variously called elfin woodland, mossy forest, montane thicket, or dwarf forest, is characterized by gnarled trees less than 7 m tall, high basal area, small diameters, slow growth rates. Dwarf stature of trees may be attributed to strong winds and water-saturated soils. Tree roots form a tight, complete mat on the surface. Tree-fern forest is dominated by *Cyathea arborea, Cnemedaria horrida, Dicranopteris nervosa* and *Sticherus bifidus;* while cloud forest is dominated by *Tabebuia rigida, Ocotea spathulata, Eugenia borinquensis,* and *Calyptranthes krugii* in north eastern Puerto Rico at 900-1000 meters elevation of the Luquillo Mountains. Sierra palm forest of *Prestoea* *montana, Cordia borinquensis, Miconia sintenisii* occurs on steep slopes and wet soils at elevations of 500-1100 meters.

Puerto Rican Moist Forests on limestone substrate**:** Puerto Rican karst forests, regardless of rainfall conditions, share common characteristics including physiognomy and leaf characteristics. Tree height of karstic forest increases along moisture gradient from less than ten meters to over 25 meters. Forests on the base of mogotes has a height of 25 meters to 30 meters, a close canopy, shrubby, and herbaceous understories. Common species are *Dendropanax arboreus* and *Quararibea turbinate.* (Lugo *et al*., 2001). On mogotes—tower-like karstic hills, up to 300-400 m, with steep slopes and plateaus, bare karstic rock and more or less eroded skeletal soils—depending on the position and substrate, the vegetation varies. The forest has a 5-10 m high open canopy with terrestrial bromeliads or diverse shrubs. Vegetation communities include Gateado forest dominated by *Coccoloba diversifolia, Bursera simaruba, Bucida buceras, and Zanthoxylum martinicense* on magote sides and tops**;** *Leucaena leucocephala* shrubland; *Axonopus compressus* or *Stenotaphrum secundatum* grasslands. Little and Wadsworth (1964) list the following tree species as common members of the moist limestone hill forests: *Aiphanes acanthophylla, G. attenuata, Coccoloba diversifolia, C. pubescens, Licaria salicifolia, Zanthoxylum martinicense, Bursera simaruba, Cedrela odorata, Hyeronima clusioides, Sapium laurocerasus, Thouinia striata, Montezuma speciosissima, Ochroma pyramidale, Clusia rosea, Bucida buceras, Tetrazygia eleagnoides, Dipholis salicifolia, Sideroxylon foetidissimum, Guettarda scabra, Terebraria resinosa, Randia aculeata*.

Puerto Rican Moist Forests on ultramafic substrate**:** Gumbolimbo savanna dominated by *Bursera simaruba* occurs on serpentine-derived soils (Nipe and Rosario series). Trees are slender, open-crowned, and usually less than twelve meters tall. The forest floor is open, for the excessively drained soil supports little herbaceous growth. Most of the species are sclerophyllous and the vegetation is almost completely evergreen. Rich in woody flora. Common shrubs include *Pilosocereus royenii, Thouinia striata var. portoricensis, Plumeria alba, Croton lucidus, Pictetia aculeata,* and *Comocladia dodonaea.* The serpentine vegetation in wetter climate is denser, lusher with more epiphytes. In disturbed areas, fern savanna dominated by *Cyathea arborea, Cnemedaria horrida, Dicranopteris nervosa,* and *Sticherus bifidus* occur. Serpentine-restricted plant species endemic to Puerto Rico include *Mikania stevensiana, Calyptranthes triflorum, Myrcia maricaensis, Brunfelsia densifolia, Thelypteris namaphila, Cranichis ricartii, Calliandra locoensis, Gesneria portoricensis, Calyptranthes peduncularis, Xylosma pachyphyllum, Scolosanthus portoricencis* (Cedeño-Maldonado & Breckon, 1996).

Jamaican Dry Forests on volcanic, sedimentary and alluvial substrates: Vegetation dominated by thorny legumes three to ten meters tall. Common tree species are *Prosopis juliflora, Acacia tortuosa, A. macrantha, Haematoxylum campechianum, Caesalpinia vesicaria* and *Guaiacum officinale.* Shrubs include *Capparis ferruginea, Cassia emarginata,* and *Brya ebenus.* There are many xerophytic epiphytes and climbing cacti. Disturbed thorn thicket with impeded drainage may be dominated by *Mimosa pigra* or introduced *Callistemon spp.*

Jamaican Dry Forests on limestone substrate**:** Canopy height of eight to fifteen meters with some emergents. Ground vegetation is sparse. Common trees are *Ateramnus lucidus, Bumelia salicifolia, Bursera simaruba, Diospyros tetrasperma, Drypetes laterifolia,* and *Metopium brownei. Bursera simaruba* is a conspicuous emergent. Small trees and shrubs; *Guettarda elliptica, Capparis flexuosa, C. ferruginea, Portlandia grandiflora*, *Oplonia armata* and climbers *Hylocereus hystrix* and *Selenicereus grandiflorus* are frequent. In secondary forest, thorny legumes become abundant.

***Jamaica Moist Forests on volcanic, sedimentary and alluvial substrates*:** Submontane forest above 600 meters elevation, dominated by *Laplacea haematoxylon, Solanum punctulatu,* and *Turpinia occidentalis.* Tree ferns are frequent, particularly *Cyathea pubescens.* Diagnostic species is *Boehmeria caudate*. In disturbed forests, co-dominants change to *Clethra ocidentalis and Calophyllum calaba.* In upper montane areas, constant tree species are *Alchornea latifolia, Clethra occidentalis, Clusia havetioides, Cyrilla racemiflora, Ilex macfadyenii* and *Podocarpus urbanii.* In higher elevation, *Clethra occidentalis* is replaced by *C. alexandri. Alchornea latifolia is absent and Eugenia alpine, Ilex obcordata and Myrsine coriacea* are abundant.

Jamaica Moist Forests on limestone substrate: Includes montane wet limestone forest and lowland moist limestone forest. Canopy height ranges from eight to 28 meters depending on soil depth. In montane forests, epiphytes and ground herbs are abundant. Diagnostic species include: *Ardisia brittonii*, *Calophyllum calaba, Calyptronoma occidentalis, Cordia elliptica, Cyathea grevilleana, Drypetes alba, Heliconia caribaea, Solanum acropterum.* Ground layer may be dominated by *Diplazium costal or Pilea spp.* In less humid area, *Bumelia nigra, Cedrela ordorata, Cinnamomum montanum, Coccoloba swartzii, Guapira fragrans, Nectandra patens,* and *Pisonia subcordata* are frequent. In disturbed forests, *Piper spp.* and melastomaceous shrubs are abundant. In more open places, *Rhytidiadelphus squarrosus* and *Themeda arguens* are frequent. Ferns may be dominant in the ground layer. In disturbed forests, *Cecropia peltata* and *Bocconia frutescens* occur.

***Hispaniola Dry Forests on volcanic, sedimentary and alluvial substrates*:** Most dry forests in Dominican Republic are secondary and in the process of regeneration. Canopy height ranges from five to twelve meters high. Trees are deciduous during dry seasons that can last eight to ten months. In the tree strata, dominant species include *Bursera simaru, Acacia sckeroxyla, Phyllostillon brasiliensis, Guaiacum sanctum, Guaiacum officinale, Acacia macracantha, Krugiodendron ferreum, Prosopis juliflora, Senna atomaria and Metopium sp.* **S**hrubs *Eugenia rhombea, E. axillares, E. foetida, Calliandra haematomma, Croton spp., Capparis flexuosa* and *C. ferruginea* are common. In the herbaceous strata, *Commelina sp*. and *Agave antillarum* are frequent.

***Hispaniola Dry Forests on limestone substrate*:** Open forests with the upper canopy five to twelve meters high. Percentage of vegetation cover and canopy height diminishes from east to west, and rich in endemic species. Characteristic species include**:** *Metopium brownei, M. toxiferum, Acacia skleroxyla,Guaiacum sanctum, Bursera simaruba, Plumeria obtusa, Haitiella ekmanii, Thouinidium inaequilaterum, Cameraria linearifolia, Tabebuia ostenfeldi,* and *Lonchocarpus pycnophyllus.* In the driest areas, the vegetation on limestone rocks is dominated by cacti *Pilosocereus polygonus, Lemaireocereus hystrix,* and *Opuntia moniliformis.* In disturbed areas, forests are dominated by *Prosopis juliflora, Acacia macracantha.*

***Hispaniola Moist Forests on volcanic, sedimentary and alluvial substrates*:** Moist forests in Hispaniola include parts of the lowland semi-humid broadleaf forest, montane humid broadleaf forest and cloud forest. Trees *Cyrilla racemiflora, Mora abbottii, Sloanea berteriana, Ormosia krugii, Calyptromona dulcis, Buchenavia capitata, Cyathea arborea* and *Prestoea Montana* are common in the montane humid broadleaf forests. Cloud forests ocur mostly in the windward slopes of Cordilleras Central, Cordilleras Septentrional and Sierras de Neiba. The tree strata are frequented by *Didymopanax tremulus,Brunellia comocladifolia, Garrya fadyenii, Oreopanax capitatus, Podocarpus aristulatus, Cocothrinax spp., Magnolia pallescens, M .hamori, Clusia clusioides, Cyathea arborea* and *Prestoea Montana.* Epiphytes and tree ferns are abundant.

***Hispaniola Moist Forests on limestone substrate*:** Forests canopy height ranges from 5 to 20 m. On the mogotes of Los Haitises, *Coccothrinax argentea, C. gracilis, Leptogonum molle, Clusia abbottii, C. minor, C. rosea, Alchornea latifolia, Drypetes alba, Sapium jamaicense, Thouinia domingensis,* and

Maytenus domingensis are common. Between mongotes principal tree species include *Oxandra laurifolia*, *Tetragastris balsmifera, Dendropanax arborea, Ocotea spp., Sideroxylon domingense,* and *Hyeronima domingensis*. In other areas, moist limestone forests are dominated by *Clusia rosea, Bucida buceras, Ottoschulzia rhodoxylon, Sideroxylon foetidissimun, S. salicifolium,* and *Bursera simaruba.*

***Hispaniola pine forests on volcanic, sedimentary and alluvial substrates*:** Distribution is highly modified by disturbance regime, growing under a wide range of physical parameters. Most pine forests are found above 2200 meters in the Cordillera Central of Hispaniola. Forests are characterized by fairly open and monospecific canopy of *Pinus occidentalis*, with many endemic shrubs and ferns in the understorey. Shrub species are diverse: *Garrya fadyenii, Rubus sp., Eupatorium illitium,Ilex tuerckheimii, Fuchsia sp., Ambrosia sp.,* and *Senecio picadae.* Herbaceous plants include *Pilea sp., Verbascum thapsus, Ranunculus sp., Agave brevispina,* and *Danthonia domingensis.*

Hispaniola pine forests on limestone substrate :Open pine forests develop on limestone substrate and dominated by *Pinus occidentalis*.

***Hispaniola pine forests on ultramafic substrate*:** Open pine forests develop on ultramafic substrate and dominated by *Pinus occidentalis*.

Cuban Dry Forests on volcanic, sedimentary and alluvial substrates: Lowland semi-deciduous forests occur in areas with dry season of three to six months, two canopy layers with the upper canopy eighteen to 25 meters and about 75% deciduous species. Woody understorey, six to twelve meters, is mostly evergreen. Herb layer is poorly developed or completely lacking. The prevailing conditions determine if this forest type is deciduous or semi-deciduous. In sandy or rocky areas with nutrient poor soils, forests are lower in height and include a spiny sclerophllous shrub layer. Characteristic tree are *Bursera simaruba, Cordia spp. Tabebuia spp., Copernicia spp., Swietenia mahagoni, Metopium brownie, Krugiodendron ferreum.*

Cuban Dry Forests on limestone substrates: These are species-poor karstic forests with a canopy height of five to six meters, occurring in a seasonal climate of one to four dry months and 1200-1600 mm rainfall per year. *Thrinax morrisi, Bombacopsis cubensis* and *Agave tubulata* are characteristic elements. In Pinar del Rio and Isla de Pinos, semi-deciduous forests with two canopy layers occur, with the upper canopy 18-25 m and about 75% deciduous species. Woody understorey, six to twelve meters, is mostly evergreen. The herb layer is poorly developed or completely lacking. Characteristic elements of the upper canopy layer are *Cedrela mexicana, Andira inermis, Bursera simaruba,* and *Catalpa punctata.*

Cuban Dry Forests on ultramafic substrate: Occuring in areas with a single dry season with one to six dry months and annual precipitation averaging 1000-1600 mm a year, the woodlands are characterized by a dense shrub layer and four to six meters high microphyllous evergreen trees. Common characteristic species are *Neobracea valenzuelana, Phyllanthus orbicularis, Annona bullata,* and *Rondeletia camarioca.*

***Cuban Moist Forests on volcanic, sedimentary and alluvial substrates**:* Forests with three canopy layers occurring in areas with annual precipitation more than 2500 mm and evenly distributed over the year. The upper canopy is closed, 30-35 meters high. The middle layer is 20-25 meters high with numerous tree species. The third canopy layer is 6-15 meters high, very rich in species.

Cuban Moist Forests on limestone substrate: Tower-like karstic hills (mogotes), up to 300-400 meters, with steep slopes and plateaus, bare karstic rock and more or less eroded skeletal soils. Depending on the position and substrate, the vegetation can be similar to a deciduous forest with terrestrial bromeliads or diverse shrubs. The forest has a 5-10 meters high open canopy. In western Cuba, forests are open, 5-8 meters high, mostly deciduous trees on the steep slopes and the top of the karstic mountains. Characteristic species include *Bombacopsis cubensi* and *Gaussia princes* with barrel-like trunks, *Spathelia brittonii, Thrinax punctulat.* Surveys of plant communities in limestone formations of Cuba show that the karstic forests in the west are the richest in endemics.

Cuban Moist Forests on ultramafic substrate**:** Occurs on ferritic soils derived from serpentine bedrock, with ann toual precipitation 1800-3200 mm and mean annual temperature of 18-24^{0}C. Two canopy layers, mostly sclerophyllous and lauraceous trees and shrubs, abundant lianas, poor in epiphytes.

Cuban Pine Forests on volcanic, sedimentary and alluvial substrates: Found in the sandstone belt of western Cuba, on yellow soils derived from sandstone rocks. The canopy is rather closed with pines, palms and evergreen trees. With open canopy, growing on low nutrient, light gray quartz sand. Shrub layer are rich in species. Characteristic species include; *Acoelorraphe wrightii, Coccothrinax miraguama, Colpothrinax wrightii and Pinus caribaea - Pachyanthus poiretii.*

Cuban Pine Forests on limestone substrate: In the northwest, the target sites may represent transitional zones from *Pinus tropicalis-Pinus caribaea* woodland on slate to karstic forests. In the south east it may represent east Cuban karstic forest.

Cuban Pine Forests on ultramafic substrate: On ferritic soils of lowlands and hilly serpentine areas of the Sagua-Baracoa range in eastern Cuba. The canopy of forests growing on deep soils is high and relatively open with a well-developed shrub layer. Very high endemism exists among the coniferous forest communities in Cuba. On cliffs or submontane rocky substrate, the canopy cover is only 30 to 50%. Characteristic species are *Pinus cubensis*, *Anemia coriacea, A. nipensis, Coccothrinax orientalis, Casearia crassinervis*.

Cuban Cactus Scrub on volcanic, sedimentary and alluvial substrates: The cactus scrubs are open vegetation with small trees and shrubs. Succulents, mainly cacti, are co-dominant or dominant in both shrub and canopy layers. Geographically separated associations occur depending on whether the soil is rocky or sandy and on the duration of dry periods. On sandy soils *Rittereocereus hystrix, Opuntia dillenii, O. militaris, Cylindeopuntia histrix* and *Rhodocactus cubensis* are dominant trees and shrubs are members of Caesalpiniaceae and Capparidaceae.

Cuban Cactus Scrub on limestone substrate: Occurs on bare rock of limestone terraces and on lowland karstic 'dogtooth' terrain. Dominant species include *Consolea macracantha, Dendrocereus nudifloras, Pilosocereus brooksianus, Harrisia fernowii, Agave albescens, and Melocactus acunae.* The shrub flora is rich in species diversity.

Caribbean Shrublands on volcanic, sedimentary, and alluvial substrates: Distribution is highly modified by disturbance regime, growing under a wide range of physical parameters. In the dry life zone on alluvial soils, the vegetation includes *Coccoloba uvifera Thespesia populnea* hemisclerophyllous evergreen shrubland, an oceanwards berm community; *Pilosocereus royenii - Agave karatto s*ucculent evergreen shrubland; *Acacia macracantha - Acacia farnesiana* drought-deciduous shrubland; *Chamaesyce mesembrianthemifolia* dwarf-shrubland; *Ipomoea pes-caprae* vine-shrubland; *Sesuvium portulacastrum* forb vegetation. Secondary vegetation includes *Leucaena* *leucocephala* shrubland and bunch grasslands dominated by *Leptochloopsis virgata, Leptocoryphium lanatum - Aristida portoricensis,* and *Sporobolus indicus.* In the moist life zone on volcanic substrates, the vegetation includes shrublands dominated by *Croton lucidus* or *Leucaena leucocephala; and* grasslands dominated *by Schizachyrium gracile or Sporobolus indicus.*

Caribbean Shrublands on limestone substrate: Caribbean shrublands or cactus scrubs grow on coastal rock pavements or limestone terraces, coastal cliffs, rocky outcrops, dogtooth limestone, and boulder fields exposed to winds and salt-spray. Common woody species include *Cassia lineate, Strumpfia maritime,* and *Rachicallis americana.*

Caribbean Shrublands on ultramafic substrate: Xeromorphic vegetation with high levels of endemism and diversity are characteristic of serpentine floras (Cedeño-Maldonado & Breckon, 1996).

Bahamian Pine Forests/ Woodlands on volcanic, sedimentary, and alluvial substrates: Open pine woodlands on limestone with essentially monospecific canopy of *Pinus caribaea var. bahamensis* with substantial grass coverage. These woodlands occur on the boundaries between wetlands and uplands (Areces-Mallea *et al*., 1999).

Winward Islands Moist Forests on volcanic, sedimentary and alluvial substrates**:** The moist forests of St Lucia and Grenada are dominated by *Dacryodes excelsa, Sloanea massonii,Talauma dodecapetala* and *Licania ternatensis.* Except for *Dacryodes excelsa,* the floristic composition is dominated by species endemic to the Lesser Antilles. Depending on the island, the very diverse canopy layers may include different species, e.g. *Sterculia caribaea, Tovomita plumieri, Endlicheria sericea, Chimarrhis cymosa* in St. Lucia, and *Byrsonima trinitensis in* Grenada.

Leeward Islands Moist Forests on volcanic, sedimentary and alluvial substrates: Lowland but mostly submontane rain forest, dominated by *Dacryodes excelsa, Sloanea massonii, Talauma dodecapetala Licania ternatensis* and a few other species*, Dacryodes excelsa* and other tree species are found in the upper canopy. The middle story of trees is usually dominated by members of the Lauraceae, especially species of the genera *Nectandra* and *Ocotea. Dacryodes excelsa* is fairly widespread in the Lesser Antilles; *Sloanea massonii, Talauma dodecapetala* and *Licania ternatensis* are endemic to the Lesser Antilles (Areces-Mallea *et al*., 1999)**.**

Lesser Antillean Dry Forests on volcanic, sedimentary and alluvial substrates: The available information is from St. Lucia. The tropical dry forest of St. Lucia covers about 34% of the island with mean annual temperature 26^{0}C, annual rainfall 1000~2000 mm. The majority of dry forest is dominated by a secondary forest that has been harvested for fuel wood or charcoal production. Dominant overstory species *Inga laurina* and *Ocotea membranaceae* occur in the relatively undisturbed area. The dry forest life zone of St. Lucia is largely covered by scrub forest characterized by a short canopy and a large number of small-diameter trees due to repeated disturbance. Dominant tree species include *Guettarda scabra, Croton spp., Erithalis fruticosa, Erithalis odorifera, Coccoloba pubescens, Myrica spp., Tabebuia pallida,* and *Wedelia calycina* (Gonzalez & Zak, 1996).

Lesser Antillean Dry Forests on limestone substrate**:** The available information is from Antigua: The floristic composition of Antigua and Barbuda is similar due to their proximity. The limestone vegetation of Antigua occurs in the driest part of the island with a mean annual rainfall fewer than 89 cm. The soil is extremely shallow and highly alkaline. The vegetation consists of a dense shrub layer about 2-4 m high, over-topped by scattered but more or less uniformly distributed trees reaching a height of 7-8 m. Tall trees are *Bumelia cuneata, Bursera simaruba, Canella winterana, Krugiodendron ferreum, Pisonia fragrans, P. subcordata, Tabebuia pallida. Fagara flava* and *Guaiacum officinale* were elements of the original formation but, due to exploitation, are no longer present. Succulents are represented in the shrub layer by *Agave karatto*, *Cephalocereus royeni*, and *Opuntia spp.* Climbers and epiphytes are common. Ground vegetation is sparse (Loveless, 1960).

Full target and mapping details are available in Appendix A and target quantities are listed in Appendix B.

Freshwater Targets

The Freshwater biodiversity of the Caribbean is characterized by the existence of deep slope rivers in highlands over 10,000 feet tall, small floodplain rivers, ground water rivers, wetlands, coastal lagoons, lakes, natural ponds and geothermal springs. Other water features such as artificial reservoirs, channels for agricultural irrigation and cattle ponds are present but were not considered conservation targets as they do not represent natural systems. When country-scale topographic information was unavailable, elevation derived linear targets, such as streams and rivers were modeled from Shuttle Radar Topography Mission (SRTM) terrain data. Freshwater polygon targets were delineated primarily from Geocover LC (CY 2000) global Landsat land cover (Tucker *et al.*, 2004) with the help of experts from the region.

Stream channels are areas that reflect where water would flow over the surface**.** The hydrology software RiverTools (www.rivix.com) was used to process and delineate streams based on SRTM digital terrain data. These streams were classified using the Horton-Strahler stream order system which produced stream orders from one to nine. Stream orders were grouped into: s*mall rivers* that are represented by stream orders one to three; *medium rivers* that are represented by stream order four to six; and *large rivers* that are represented by river segments greater than stream order six.

Small Rivers are all head water streams with a characteristic mixture of flows and depths that create a variety of habitats to support fish and invertebrate biodiversity. Presence of pools, riffles and runs with annual media river flow varying from 0.2 to 1.5 cubic meters per second and a substrate composition of; sand (up to 0.1 inch), small gravel particles (0.1-2 inches) and cobbles (2-10 inches). Deposits of organic materials from falling leaves or aquatic grasses can often be found inside the stream bed.

Medium Rivers are generally at mid elevation and water flows range from 1.5 to 10 cubic meters per second. Still pools, riffles and runs are present but habitats are distinct from small rivers by the distinct presence of river banks and dense vegetation coverage in some places. There is an increased presence of logs and woody debris and an increased amount of clay and mud in the substrate between order four to six river segments.

Large Rivers are at low elevation and have an annual flow ranging from 10 to 96 cubic meters per second. Few rivers in the Caribbean region acquire such a flow and they are usually only found on the largest islands. This aquatic system represents the highest sedimentation deposition and water turbidity with no pools, riffles or runs. Accumulation of organic materials in the substrate will predominately be clay and mud. The presence of large species and aquatic vegetation in bank margins is common.

Coastal lagoons are all water bodies from the land cover map that are within five kilometers of the coast. These were screened by experts to ensure only true lagoons were mapped.

Wetlands are vegetated wetlands that consist of herbaceous species from the land cover map and are located at least five kilometers beyond the coast and major river outlets. These areas are where the water table is at or near the surface for a substantial portion of the growing season. In Hispaniola this target can also befound in high elevations above 3,000 feet up to approximately 8,000 feet.

Estuaries with mangroves and estuaries without mangroves are vegetated herbaceous wetlands areas from the land cover map within five kilometers of both the coast and a major river outlet. These areas may include salt flats and non-tidal mud flats with salinity below five ppm.

Estuaries are the river and coast systems interface, a semi-enclosed coastal body of water which has free connection to the open sea and within which sea water is measurably diluted with fresh water derived from land drainage to maintain salinity below five parts per thousand. The *Thalweg profile* of estuaries are both deep and shallow extending from the river to the sea. Estuaries with and without mangroves were determined, with the help of experts in the region, based on the presence of stream order 5 or above (some areas also included stream order 3 or 4 where in close proximity to the coast).

Lakes are all water bodies within the land cover map greater than 0.08 ha (1 pixel of the map) in size and further than 5 kilometers from the coast. These targets were screened by experts to separate natural lakes from dammed lakes.

Full details are available in Appendix A.

CONSERVATION GOALS

Quantitative representation goals were defined for each target in order that a robust set of priority conservation areas could be selected to represent the full spectrum of biodiversity and ecosystem processes within the region. The goals are proportions of the distributions or of each biodiversity target sufficient to allow the possibility of sustaining viable populations and ecosystem processes over time. Accepted methods to determine conservation goals focus on measures of abundance and distribution (Groves *et al.*, 2002; Groves, 2003), although there are no rules to determine exact quantities necessary to capture enough biodiversity to maintain ecosystem processes and habitats into the future. For some Caribbean biodiversity there are uncertainties as many gaps exist in the knowledge of species and populations, due to the very low numbers of research carried out within some areas, and especially within the freshwater environment. Ecological and evolutionary processes are also poorly understood.

Marine

Marine target goals were calculated by the marine planning team using the following criteria; landscape context, degree of endemism and rarity, current status compared to historic, vulnerability and whether the habitat was a source area. These criteria were used previously by local biodiversity assessments such as Puerto Rico (Chatwin, 2004), Jamaica (Zenny, 2006) and Andros Island, Bahamas (Thurlow *et al.*, 2005). The goals ranged from 5% of the distribution of wide ranging species up to 40% for other targets and are listed in Appendix B.

Terrestrial

The representation goal of terrestrial targets was ten percent of the original extent of each target. The original extent refers to the theoretical or hypothetical vegetation area derived from the full potential extent of each type created from the intercept of ecoregions with geology. For the targets whose current extent is insufficient to meet the goal, such as Puerto Rican dry forests on ultramafic substrate and the targets with data insufficient to predict the historic extent, such as in the Bahamas, the goal was thirty per cent of the current extent. This is based on inferences from species-area relationship studies that suggest for islands, conserving 30-50% of the area of a given terrestrial community is likely to save 70-80% of the species that occur in them (Groves, 2003). Unfortunately 30% is unattainable and not practical, 10% is a more realistic and practical goal. Full goals are available in Appendix B.

Freshwater

Several criteria for each target was evaluated and a goal assigned accordingly. The criteria were; the number of occurrences or target abundance; the biodiversity relevance or the level of endemism and rarity in the ecoregion; the systems vulnerability or how susceptible it is to diverse threats and intensity; and whether there was a potential for extinction. The goals ranged from 25 – 99% of targets' current extent and are shown in full in Appendix B.

STRATIFICATION of TARGETS and CANDIDATE PLANNING UNITS

Through evolutionary history, as a result of differing environmental conditions, there are now areas in the Caribbean that are distinct from each other in the ecosystems, communities, populations and occurrences of biodiversity, associated ecological processes that they contain. These differences exist in the marine environment despite a high degree of mixing. These distinct areas, or ecoregions, were used to stratify the conservation targets. The stratification enabled representation of all conservation targets across the region as the goals were met overall and also within each ecoregion where the target existed.

Marine targets were stratified by marine ecoregions created using biogeographic information (Smith *et al.*, 2002; Briggs, 2005) and biophysical factors within shelf areas (less than 200 meters), and further subdivided by coastal shelf units (Sullivan & Bustemante, 1999) based on island size, geology, height and shelf structures. In addition, other features such as estuary type, watershed area, coastal features, and reef geomorphology were examined. The stratification units are illustrated in Appendix C, figure 8.

Terrestrial targets were stratified within their definition by terrestrial ecoregions, and are illustrated in Appendix C, figure 9.

Unfortunately, Caribbean freshwater ecoregions lack a comprehensive biogeographic study that permits target stratification based on the phylogenetic relationships of the major aquatic taxa. The region's targets were therefore classified into six ecoregions. These ecoregions were further stratified by ecological drainage units (EDU) which reflect the pattern of dispersal and distribution of the freshwater biodiversity. The ecological drainage units are watersheds grouped according to potential historical connectivity, physiographic and climatic characteristics and common geology. The Caribbean region consists of twenty one ecological drainage units. The stratification units are illustrated in Appendix C, figure 10.

The region as a whole was sub-divided into smaller arbitrary hexagonal 'planning units' across the realms to be able to assess different candidate areas with regard to their contribution to conservation goals and their suitability for inclusion in a conservation area. The unit size (1039 Ha) and shape was designed to best reflect the target data and facilitate conservation efforts in the conservation areas selected. The size is chosen to reflect differences between fragmented and non-fragmented targets and to reflect the quantitative differences between units. Target distributions within very small units becomes presence / absence information and does not reflect differences regarding the size of target patches or the co-existence of targets within the units. Uniformly sized and shaped planning units ensure consistency across terrestrial and marine realms and avoids area and boundary related bias that can occur when irregular units, such as watersheds, are used. The planning units are clustered into larger conservation areas.

SUITABILITY MAPS

To enhance the decision support system, suitability maps were used to identify and spatially represent factors that may favorably or adversely influence an area's suitability as a candidate for a conservation area. These factors can affect both the likelihood of conservation success and the probability of robust ecological integrity of biodiversity targets. Ecological integrity or the ability of an ecological system to support and maintain an adaptive community of organisms is of utmost importance when considering candidate areas for a representative portfolio of conservation areas (Jeo *et al.*, 2005). Although it has been well established, through experimental and correlative studies, that ecological systems are adversely affected by human impacts, there is still a lack of information about the actual relationship at the landscape and watershed-scale (Jungwirth *et al*., 2002).

A relative measure of human impacts, however, can provide a means to compare the likely suitability of candidate areas relative to each other. An area that has extensive development and sources of pollution may be less suitable as a conservation site, both because the ecological integrity of the biodiversity may be impacted and because the cost of conservation strategies may be higher, and the likelihood of their success lower. An area that has previously received a protective designation may provide a higher probability of conservation effectiveness and success. Maps of these factors or environmetal risk were used to indicate the likely suitability of candidate areas.

A set of three methodologies for creating environmental risk maps, that were used as suitability maps, was utilized for the three environments. The freshwater assessment utilized standard flow accumulation methods that measured both proximal and downstream influence of human activities, the marine assessment utilized human impact models created by the World Resource Institute Reefs at Risk Program (Burke & Maidens, 2004) and the terrestrial assessment utilized an environmental risk distance decay methodology that combined proximal distance and intensity (Huggins, 2004) using the Caribbean Decision Support System. Human activities used in the creation of these maps included urban areas, roads, tourism and agricultural areas. Protected area status was identified as a factor likely to increase an area's suitability as a candidate conservation area, both due to the likely decrease of environmental risk and the increased likelihood of conservation success, so all suitability maps incorporated an increased suitability in areas already designated under a protected designation.

Marine Environmental Risk Surface used as Suitability Map

Models of marine human impacts were created by the World Resource Institute Reefs-at-Risk in the Caribbean program (Burke & Maidens, 2004). The modeled risk elements included coastal development, sediment and pollution from inland sources, marine based pollution and fishing pressure. Distance decay was used in their creation. Substantial input from scientists in the region contributed to the selection of the activities and thresholds developed, while the impact indicators were further calibrated against available information on observed impacts on coral reefs. The models were also calibrated and validated. These were combined into a cumulative environmental risk surface that was used as a suitability map in the analysis. Suitability scores of areas within protected areas reflected higher suitability as a conservation area. Further information can be found in Appendix D and shown in Figure 1.

Terrestrial Environmental Risk Surface used as Suitability Map

An environmental risk surface was used to indicate suitability of candidate conservation areas was created by delineating human activity intensity and applying a distance decay and distance threshold methodology (Huggins, 2004) using the Caribbean Decision Support System. Terrestrial human impact activities that increased environmental risk and so reduced suitability included tourism, agriculture, urban areas and roads. Intensity classes were assigned according to a logistical function that assumed upper and lower thresholds and a non linear relationship between activity intensity and impact on biodiversity. The CDSS ‘environmental risk surface’ module used raster GIS layers that measured distance away from each activity up to a threshold influence distance. Combined with intensity, individual layers for each activity were standardized across the region and further combined with each other by calculating the maximum risk (or lowest suitability) for each area. The maximum value method is used to prevent a build up of risk in areas where two parts of the same activity that had different influence distances overlap. For example, shipping lanes and harbours; the risk is provided by the same type of activity, but the influence distance is different for the two parts. The maximum value method also prevents the build up of risk in an area outside an activity to a risk level higher than inside an activity, that may be caused by the overlap of two circles of influence distance. Risk scores within protected areas were reduced to reflect higher suitability as a conservation area. A baseline score was applied to aid spatial efficiency and reflect potential costs of additional areas when building the portfolio of conservation areas. Further details are available in Appendix D and shown in Figure 2.

Freshwater Environmental Risk Surface used as Suitability Map

Freshwater ecosystem are impacted by many diverse threats in the Caribbean region. Many of the diverse set of factors which can cause impact have limited or no spatial information available across the whole region. A set of factors that were available were mapped and used in a GIS flow accumulation model to provide a measure of the environmental risk of inland terrestrial activities on freshwater biodiversity and so suitability for conservation areas. The model calculates the path water is predicted to flow from the higher elevations and ridges to the lower elevations. The amount of urban and agriculture areas passed through on the way downstream are calculated and attributed to each section of the stream and river. GeoCover LC 2000 was used to define agriculture and urban areas in the Insular Caribbean. Full details are available in Appendix D and shown in Figure 3.

Protected Areas Map

Protected areas are a key component of conservation and natural resource management strategies throughout the region. Protected area maps were used to deacreas the risk score (therefore increasing its suitability as a candidate) where an area has existing designation. The extent and management of protected areas throughout the region was mapped by gathering and improving available marine and terrestrial protected area attribute and boundary data, primarily from the WDPA Consortium 2003 World Database on Protected Areas, with additional local information. Management effectiveness was an important component of this database in order to ensure its usefulness to the region’s practitioners as part of the CDSS, as the precise purposes for which protected areas are managed differ greatly. IUCN management category definitions were maintained or attributed to the database where existing or possible. The protected area network is shown within Figure 5.

SELECTING CONSERVATION AREAS

The biodiversity assessment of the Insular Caribbean aimed to develop the Caribbean Decision Support System to provide a decision support framework for biodiversity conservation and to promote sound natural resource management. The wider framework includes systems to determine and justify conservation goals, targets and suitability factors. It has a flexible approach that allows assessment of how changes in these factors might alter decisions, and can offer alternatives for conservation practitioners. These systems can be implemented across regions and repeated in the future should it become necessary as situations change or other data become available and are incorporated into the CDSS.

Part of the CDSS provides a system to facilitate the use of software to select a comprehensive network of conservation areas to concentrate detailed planning and conservation strategies and so sustain the biological diversity of the region. The network of conservation areas or ‘portfolio’ should be the most suitable suite of areas that meet the conservation goals for representation of all biodiversity targets in an efficient way that minimizes total area and a measure of risk from threats. Users are encouraged to critically evaluate the CDSS framework and data, and to utilize them to facilitate strategic conservation planning that is directly linked to decision-making and natural resource management at appropriate scales.

The CDSS facilitated the use of the conservation area selection software MARXAN (Ball & Possingham, 2000) to evaluate biodiversity targets, goals and suitability factors in a spatial context under different alternative scenarios to identify portfolios of conservation areas for consideration by the planning team. MARXAN was used to implement a 'simulated annealing' optimization algorithm. Many potential portfolios are assessed according to how efficiently they meet representation, suitability and spatial goals such as connectivity and management practicality. This flexibility allows expert knowledge to be utilized in a planning exercise where a suite of efficient portfolios that attain all goals are possible. Full details of the software are available in Appendix E. Tutorials and guidelines on running MARXAN are available for GIS beginners and for those with GIS experience (Huggins, 2005), on the accompanying DVD and online at http://www.conserveonline.org/workspaces/Caribbean.conservation, to enable users to explore its use and capabilities.

Inputs to MARXAN are created from GIS data by the CDSS and are in the form of the area or number of occurrences of biodiversity targets within each planning unit, the quantitative conservation goal (area, length or number of occurrences) for each target, the suitability of each planning unit and the planning unit boundary lengths. The boundary lengths are used to allow the selection of planning units clustered into conservation areas. Planning units with a higher suitability would be favored for selection when biodiversity target values and clustering implications are similar.

Other user inputs to the analysis include the number of iterations or portfolio configurations assessed during each run of the algorithm, the number of independent runs of the algorithm, penalties when a target does not meet its quantitative representation goal and a factor known as the 'boundary length modifier' (BLM) that determines the level of clustering of planning units into conservation areas to improve spatial cohesion of the portfolio. A low value of BLM will result in widely dispersed and fragmented planning units within the portfolio and a higher value of BLM will increase the clustering of the planning units into larger conservation areas but may result in a higher number of planning units required to meet the goals. The management efficiency, ecological cohesion and connectivity of the portfolio may, however, be greatly increased.

A high penalty for meeting representation goals was levied to ensure so that all carefully considered and agreed biodiversity representation goals were met. This also allowed conservation scenarios to be compared by the planning teams. The analyses were based on many independent runs of the algorithm, each of one million iterations. Many levels of BLM were evaluated by the planning teams and the final value that offered an appropriate balance between ecological coherence and efficiency was carried forward to further analysis. The value varied across the marine, terrestrial and freshwater analyses.

RESULTS

DELINEATION OF CONSERVATION AREAS

The development of the conservation areas portfolio can be supported by two outputs of the site selection program MARXAN called 'best portfolio' and 'summed solution'. The best portfolio is the portfolio that meets the goals and objectives in the most efficient manner and the summed solution is the number of times each planning unit was selected within a portfolio in the repeated independent runs.

There are often many portfolios that are very efficient, the best may be only marginally more efficient that the next best. The summed solution (often termed irreplaceability), therefore, gives a measure of the flexibility of including each planning unit in an efficient portfolio. It measures the priority of a planning unit to achieving goals efficiently and is the flexibility available in including that unit in a portfolio or swapping it with one that provides similar biodiversity distribution in an area that fits with the other selected units more easily. If a planning unit is selected in all or many runs (low flexibility), it may include biologically rich areas or areas that contain a large proportion of one or several biodiversity targets or could contain reasonable amounts of biodiversity targets in a planning unit with a high suitability score. The flexibility of the unit can, therefore, be used to identify core areas that are more likely to be necessary for inclusion in final conservation areas and also to guide the iterative process of portfolio selection by MARXAN and the planning team. Areas with higher flexibility are often interpreted as low importance. These areas are not less important, as the inclusion of many of these areas in the portfolio may be necessary to meet representation goals, it is the choice of which of these to choose to make the representation that is more flexible. These areas can be seen as lower in priority as long as those of them that are necessary to meet the set goals are eventually represented in the protected portfolio.

Several cluster levels were tested and one that produced an ideal level that met the planning team's criteria was identified. Several scenarios were analysed. These scenarios included constraining the portfolio to include the current protected areas, using the environmental risk surface as a measure of suitability and analyzing without these constraints. These conservation portfolios were reviewed by the planning teams with experts to determine the most appropriate scenario and create a final optimal portfolio.

Marine Portfolio Selection

The team considered that the scenario that included the suitability surface but without locking protected areas into the portfolio to be the most appropriate. Special areas were locked into the second iteration of portfolio selection. These areas were those that were chosen over 50% of the runs of the algorithm. Some slight alterations were made by the planning team to improve spatial cohesion and to remove some isolated units and highly flexible units to improve the realistic acceptance of the portfolio. Locking in special areas and the manipulation of the portfolio caused a reduction in efficiency and the number of targets that are represented to their goal but increased the likelihood of utilization. The optimal portfolio was over 1039,000 Ha smaller than the portfolios identified when protected areas were locked into the portfolio. The final optimal portfolio consisted of 7,466 planning units in 141 areas covering 7,758,894 hectares (20.2% of the region) and representing 53 (75%) ecosystem targets to their goals.

When protected areas (4254 planning units) were locked into the portfolio, a total of 8,890 units or 9,238,754 hectares were necessary to meet all representation goals. The conservation areas are listed in Appendix G and shown in Figure 4.

Terrestrial Portfolio Selection

The planning team identified the most practical portfolio to be the scenario that locked in the official current protected area system and included the environmental risk map as a suitability map. This optimal portfolio consists of 64 conservation areas with 7211 planning units or 7493,888 hectares which comprises 3533,786 hectares of targets. 5246 planning units were chosen as part of a portfolio in more than 82% of the runs. The conservation areas are listed in Appendix G and shown in Figure 5.

Freshwater Portfolio Selection

The four scenarios were run for the freshwater analysis with natural lakes and freshwater coastal lagoon areas locked into the portfolio as they were considered in need of full 100% representation. Analysis of the portfolios showed that they did not fully represent relevant known important freshwater sites in the region. This may be due to the nature of the data describing the targets, as those parts of targets in areas known to be important were not distinguished from other parts of the target. In each scenario some important areas were present but others were missing and the portfolio sites represented either unrealistic target bias by locking in the protected areas or were disseminated across the landscape in a diffuse pattern. The analysis does not consider the linear nature of freshwater targets and the necessity of connectivity through each individual system. Modifications could be made to encourage clustering of PU's through each freshwater system, but it would be necessary to accomplish this target by target rather than PU by PU.

Considering the high number of occurrences of some targets in the portfolio, an evaluation of target aggregation and regional importance was conducted in order to reduce the number of sites and prioritize areas to focus on conservation strategies. Those sites that were removed were isolated occurrences or areas with a size and potential threat that would affect their viability in the long term. Modifications were therefore made by the planning team to the portfolio created using the suitability map, but not locking the protected areas, to create a more realistic and acceptable portfolio. After modifications were made, a regional portfolio of sites was obtained that contained the most important freshwater conservation areas in the region, although some targets no longer met their goals. The conservation priority areas are listed in Appendix G and shown in Figure 6.

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DISCUSSION

Marine

While coral reefs have declined over the past three decades, there are encouraging signs that recovery is occurring at local scales for sea turtles, whales, and sea birds. In comparison to many other tropical regions, the Caribbean region has a high literacy rate, rising per capita income, and decreasing birth rates. Over the last decade rising environmental awareness and a stewardship ethic has been spreading throughout the region. The capacity in marine sciences and coastal management is moderate and there are already well established networks of marine scientists and international agreements. The Caribbean marine ecroregions therefore represent places where conservation actions are likely to have a lasting impact on protecting tropical Atlantic biodiversity.

The portfolio of sites established during the insular Caribbean planning process provides a starting point to help guide conservation efforts at both national and regional scales. Representing at least 20% of the known marine biodiversity, this portfolio can help set conservation priorities at different scales and link sites together into larger regional networks. Many of the portfolio sites are already designated managed areas but lacking management plans and effective enforcement while others represent areas to look towards for expanding or redesigning marine managed areas to make them more resilient to human and natural impacts. The marine strategies presented below are preliminary large-scale cross cutting strategies developed for all three marine ecoregions of the insular Caribbean. They focus on the need to combat unsustainable and destructive fishing, coastal habitat loss, changes in coastal water quality and freshwater inflows, climate change and other emerging threats in the insular Caribbean. Implementation of these strategies within each geography varies considerably and will be refined in future editions of this plan.

Marine conservation strategies:

Establish and strengthen networks of marine protected areas that provide tangible economic, social and environmental benefits to coastal communities by improving management effectiveness of current sites and creating new ones;

Improve the leadership, technical and financial capacity of local organizations to deliver benefits to civil society through the conservation and sustainable use of marine and coastal resources;

Foster political will to enforce environmental laws, reduce perverse fishing subsidies and generate sustainable funding from multi-lateral and government agencies for marine and coastal conservation across 19 coastal and island political units;.

Engage the private sector, including tourism, fishing, real-estate and energy industries, to adopt sustainable patterns of production, certify products and promote social entrepreneurship;

Establish a comprehensive monitoring and evaluation protocol for triple bottom line approaches to marine and coastal conservation through the development of a score card system and other evaluation tools to establish base line data, improve adaptive management, share best practices, replicate projects and develop exit strategies;

Develop comprehensive regional strategies and policy alternatives that address current and emerging threats to island and coastal resources and communities including: climate change; over-fishing;

unsustainable tourism; coastal development; oil and gas development; uncertified aquaculture and invasive species;

Significantly decrease the pollution and damage to downstream coastal areas caused by upstream development, habitation, agricultural and industrial activities.

Use and share the best available technology to plan for future development by creating comprehensive geospatial databases, developing innovative science tools, and providing training that helps facilitate cooperation among communities and key stakeholders.

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Summary of Marine Strategies by Ecoregion

	Bahmian		Eastern Caribbean		Greater Antillian	
Aggregation of Strategic Themes	Shelf	Nearshore	Shelf	Nearshore	Shelf	Nearshore
Land/Water Protection						
Consolidation of existing Protected Areas		x	x	x	x	x
Establishment of new protected Areas	x	x	x			
Private Lands Conservation		x				
Site/Ecosystem Management						
Ecosystem management and restoration		x		x		x
Fisheries	x	x	x	x	x	x
Pollution			x			x
Tourism		x		x		x
Partnerships and Conservation Capacity						
Institutional/Professional Capacity	x	x	x	x	x	x
Corporate Conservation						
Corporate funding for conservation		x				x
Corporate Behavior and practices		x		x		x
Environmental Services						
User fees	x	x	x	x		
Vulnerability/natural disaster mitigation				x		x
Conservation Finance & Policy						
Public funding (national budgets, bi-multilaterals, public fin. mechanisms)			x	x		x
International Agreements, national laws and regulatory framework	x		x		x	
Public Institutions		x		x		x
Science and information						
Data & knowledge management	x	x	x	x	x	x

Terrestrial

The selection of a portfolio of conservation areas relies on the quality and scale of input data. The terrestrial portfolios represent a first approximation under a given set of constraints. There may still be areas important to biodiversity that are not included in any of the portfolios. This is likely to have been a result of the target data. The data should be refined to include measures that differentiate known quality indicators such as patch size. We therefore encourage the participation of experts and stakeholders to review the data and portfolios in order to achieve the goal of protecting all Caribbean biodiversity.

Terrestrial conservation strategies are based on the preliminary region-wide threat analysis and protected areas gap analysis with an emphasis on preventing habitat loss and reducing the impact of invasive species and climate change on biodiversity:

Establish new conservation areas via public or private land acquisition and strengthen the current national protected areas system. The terrestrial portfolios presented in this report can serve as reference points for site selection.

Facilitate The Nature Conservancy's field programs and partners *build local capacities for ecosystem management* to maintain or restore the ecological integrity of landscape-scale conservation areas.
Create an information system that allows sharing best management practices and monitoring conservation results.

Develop land conservation strategies that produce benefits to freshwater and marine ecosystems, such as forest certification programs or carbon sequestration projects that protect watersheds.

Demonstrate the economic benefits of environmental services (e.g. watershed protection and drinking water) as a vehicle to encourage the participation of the general public and government agencies in protecting the environment.

Engage regional stakeholders in addressing large-scale threats to islands: invasive species and sea-level rise.

Influence policy changes at the regional level by enhancing laws and regulatory systems to strengthen biodiversity conservation and maintain a clean environment.

Freshwater

Selection of regional conservation areas that have a biological significance was conducted using the criteria of coarse-scale focus, representativeness, efficiency, integration, functionality, and completeness outlined in *Geography of Hope* (The Nature Conservancy, 2000) and guided by TNC's Freshwater Classification Approach for Biodiversity Conservation Planning (Higgings *et al.,* 2005).

Regional freshwater selected sites were the results of an iteration of MARXAN after a critical analysis that collected expert opinion on the portfolio sites. This analysis, however, has resulted in portfolios which were assembled with little consideration about the need for linkages, connections or juxtapositions among sites with respect to the ecology of the conservation targets. This is a limitation in the methodology that should be clearly stated for those using the results achieved in this regional assessment.

Freshwater conservation strategies:

Work with governments to identify rivers that still have relatively intact surface and groundwater hydrologic regimes, freshwater biodiversity and ecosystem functions in order to timely prevent alterations and use them as models for ecosystem restoration.

Promote policies and regulations that financially support ecosystem functioning and freshwater biodiversity conservation thru payment for environmental services.

Increase effective management of protected areas associated to freshwater conservation targets.

Work with infrastructure development agencies to reduce impacts of housing projects, highways, secondary roads and rural roads constructions and maintenance.

Produce incentives for clean energy production through small hydropower plants managed by indigenous / local community organizations.

Promote regulations of water withdrawals in order to maintain ecologically sustainable river flow.

Promote efficiency of crop and animal production through best practices that reduce water and agrochemical uses to lower the impact of agriculture and husbandry on water quality.

Develop educational programs in agricultural communities to link human health with aquatic ecosystem health originated by preservation of good water quality in streams.

Establish platform projects that showcase results and serves as training centers of applied best management practices to improve water quality and biodiversity conservation.

Influence multilateral and bilateral agencies to request countries planning to build new dams to have infrastructure design considering sustainable river flow and conservation of river biodiversity.

Influence government offices to set dam standard operation procedures that sustain ecologically needed river flows.

Encourage mapping of principal contributing subwatersheds to identify major contamination sources to focus watershed management on priority sites.

Work with governments to create institutional mechanisms for an *integrated watershed-coastal management* committee.

Identify freshwater systems with no presence of invasive species and work with GO Offices, NGOs and communities to prevent introductions, as well as establish early warning surveillance systems and rapid response plans to eradicate or control incipient invasions.

Maps

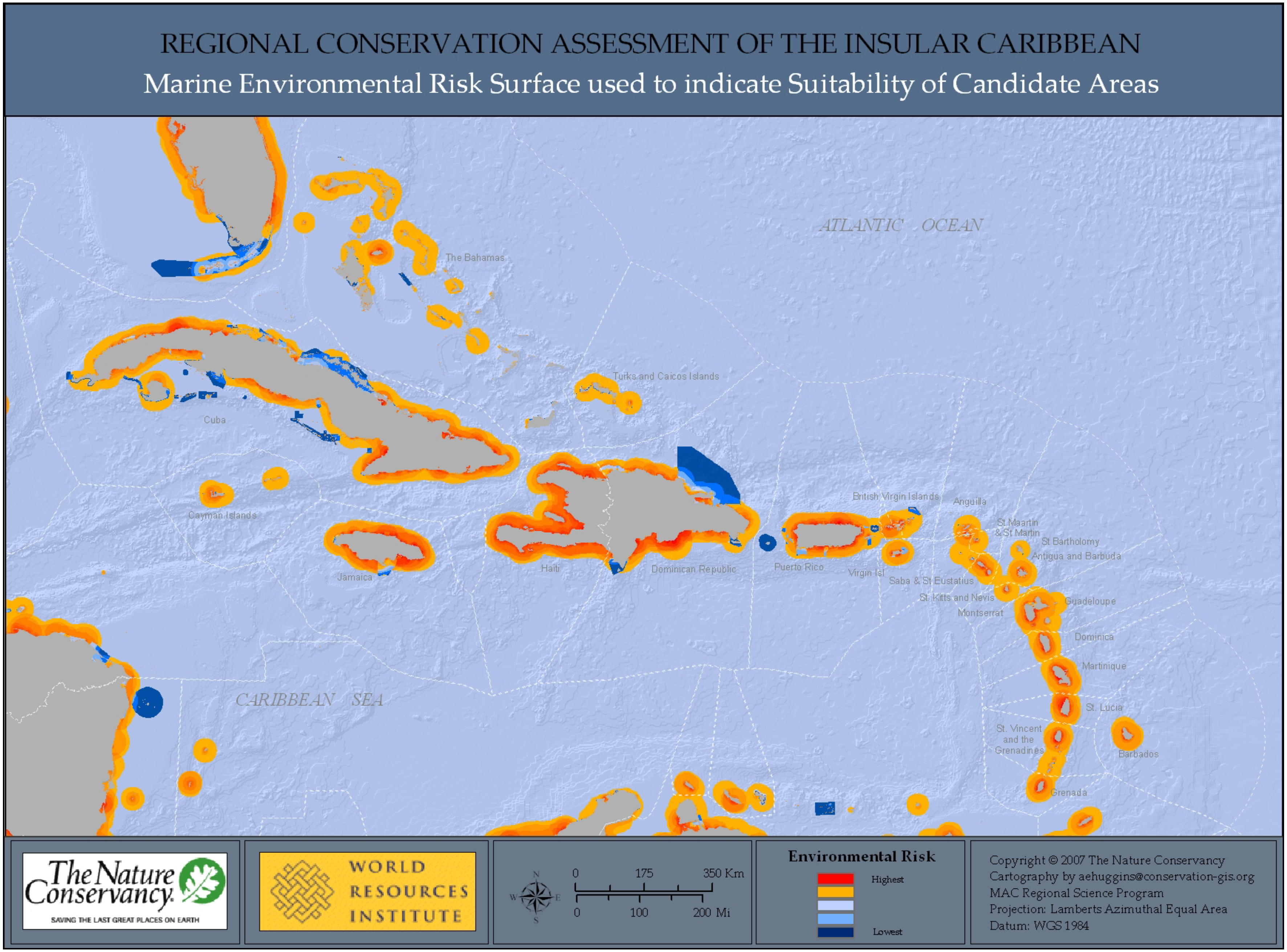

Figure 1; Marine Environmental Risk Map used as a Suitability map for the Insular Caribbean

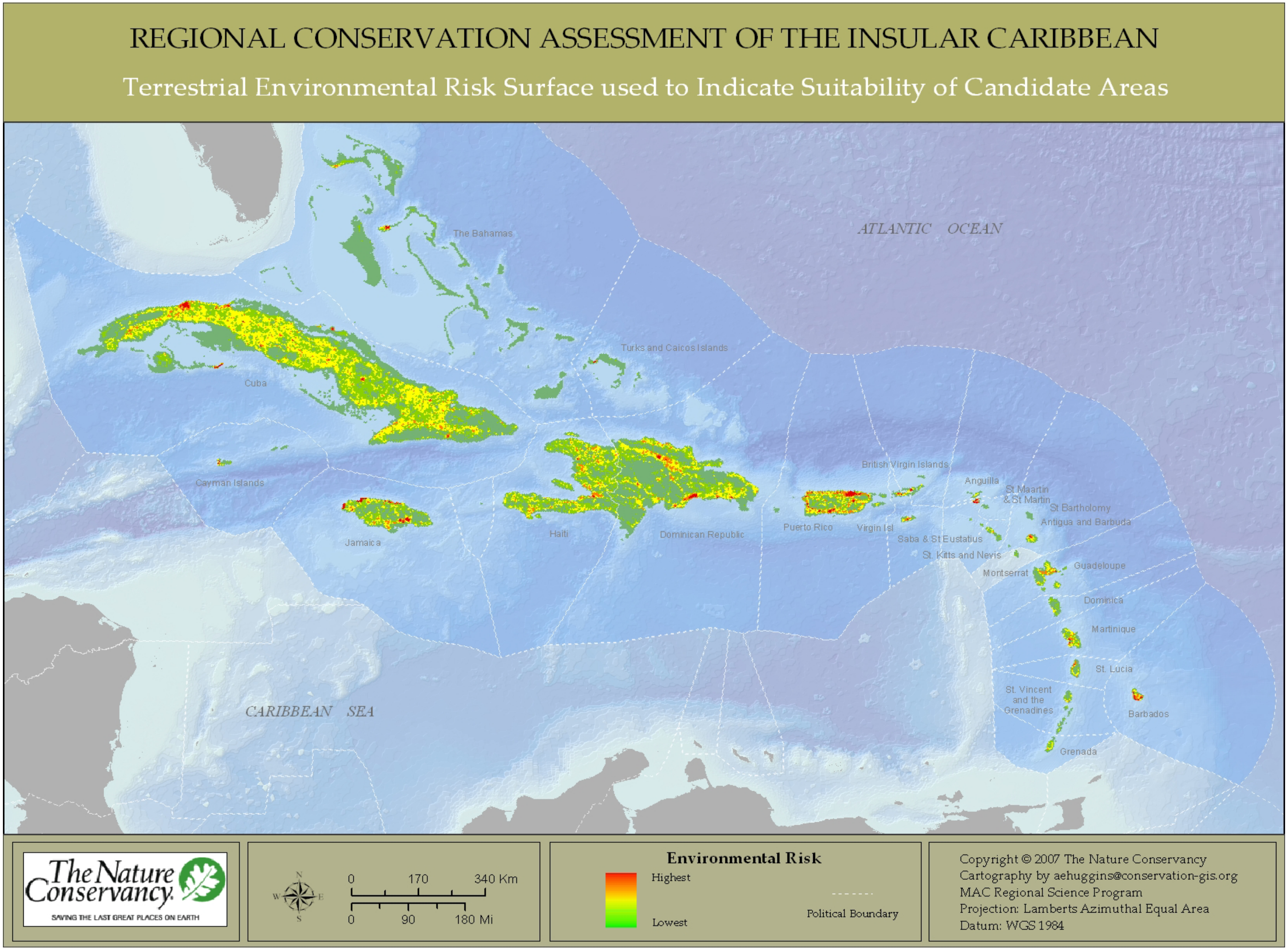

Figure 2; Terrestrial Environmental Risk Surface used as a Suitability Map for the Insular Caribbean

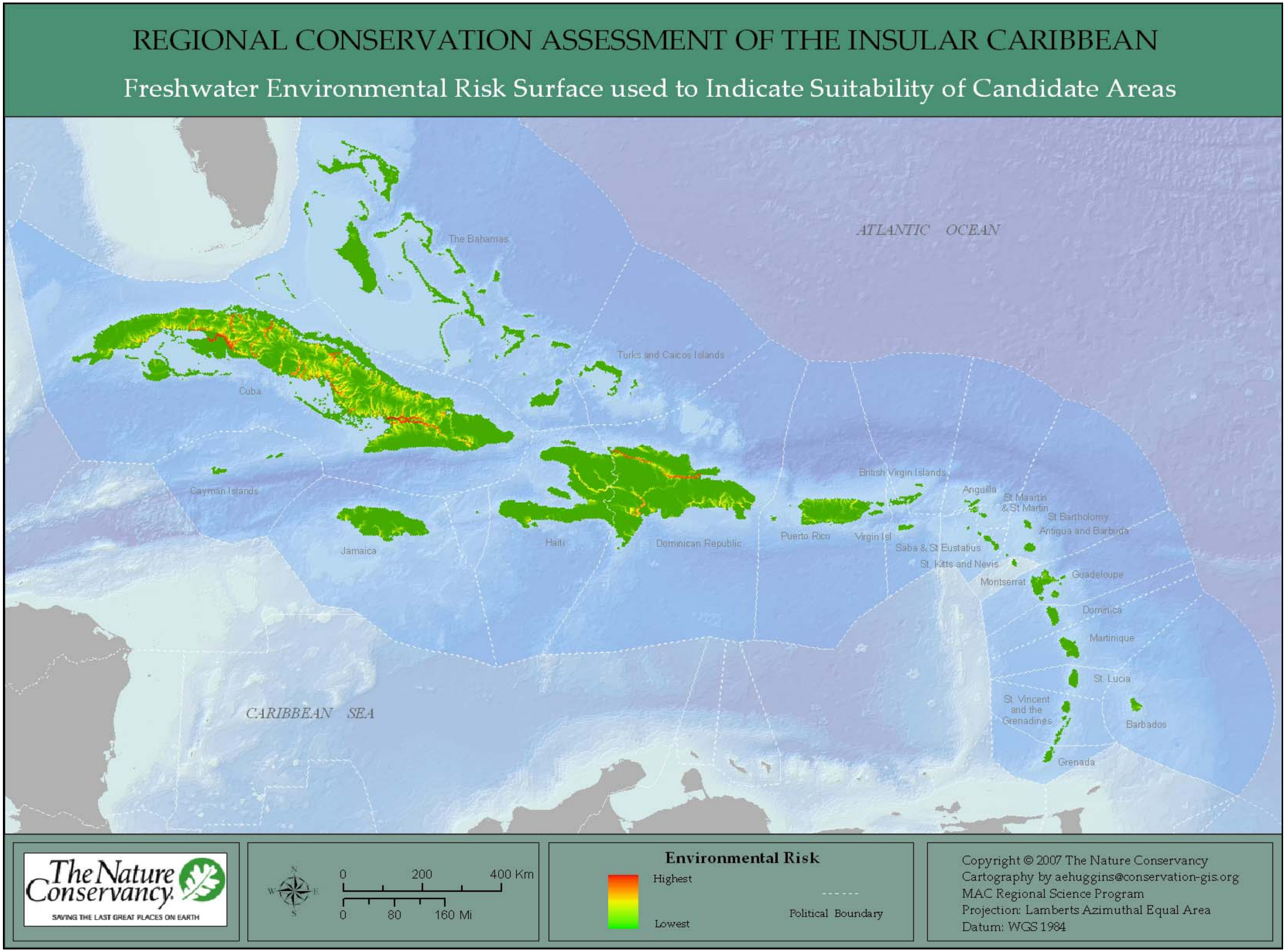

Figure 3; Freshwater Environmental Risk Surface used as a Suitability Map for the Insular Caribbean

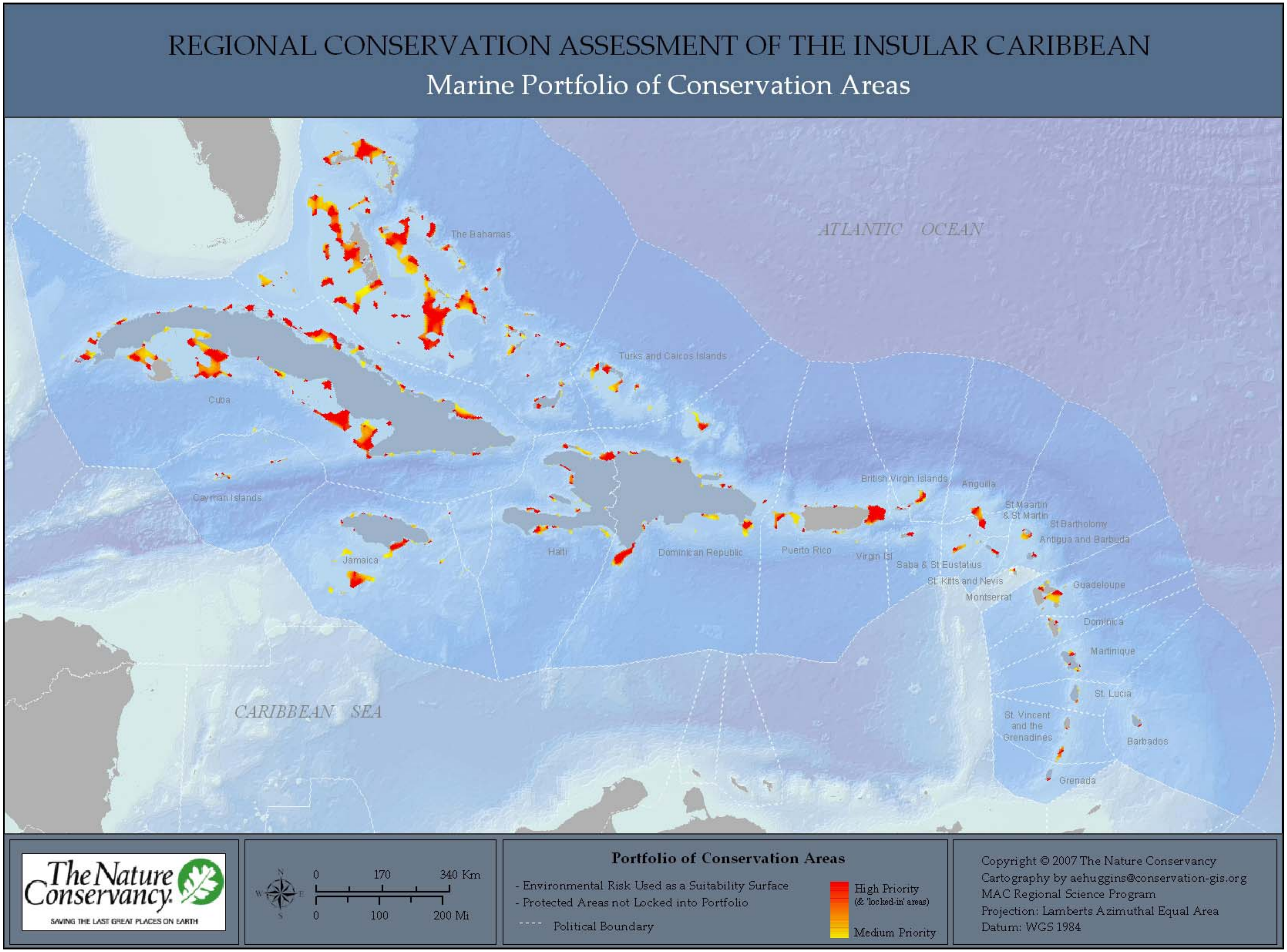

Figure 4; Optimal Marine Portfolio

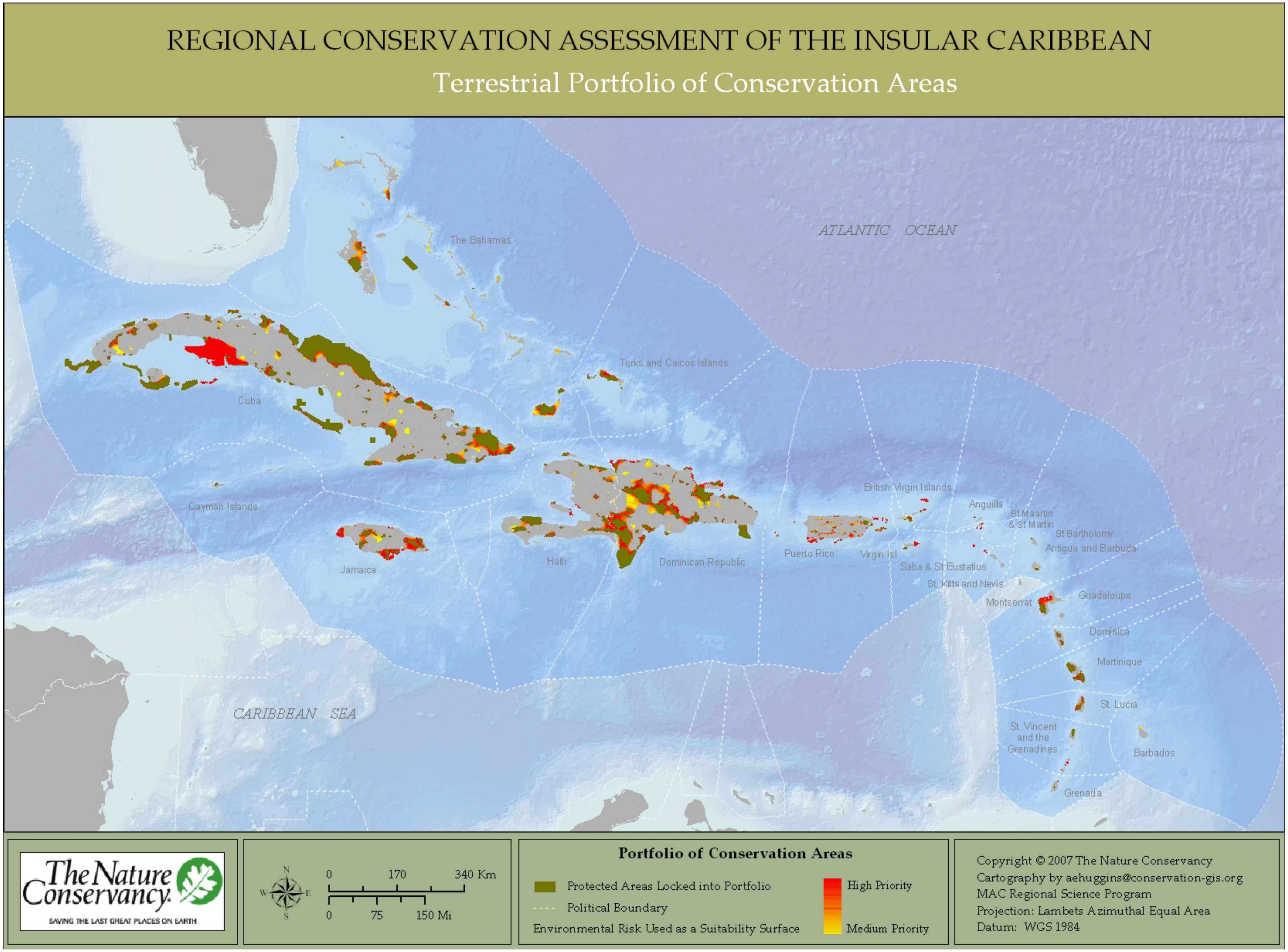

Figure 5; Optimal Terrestrial Portfolio

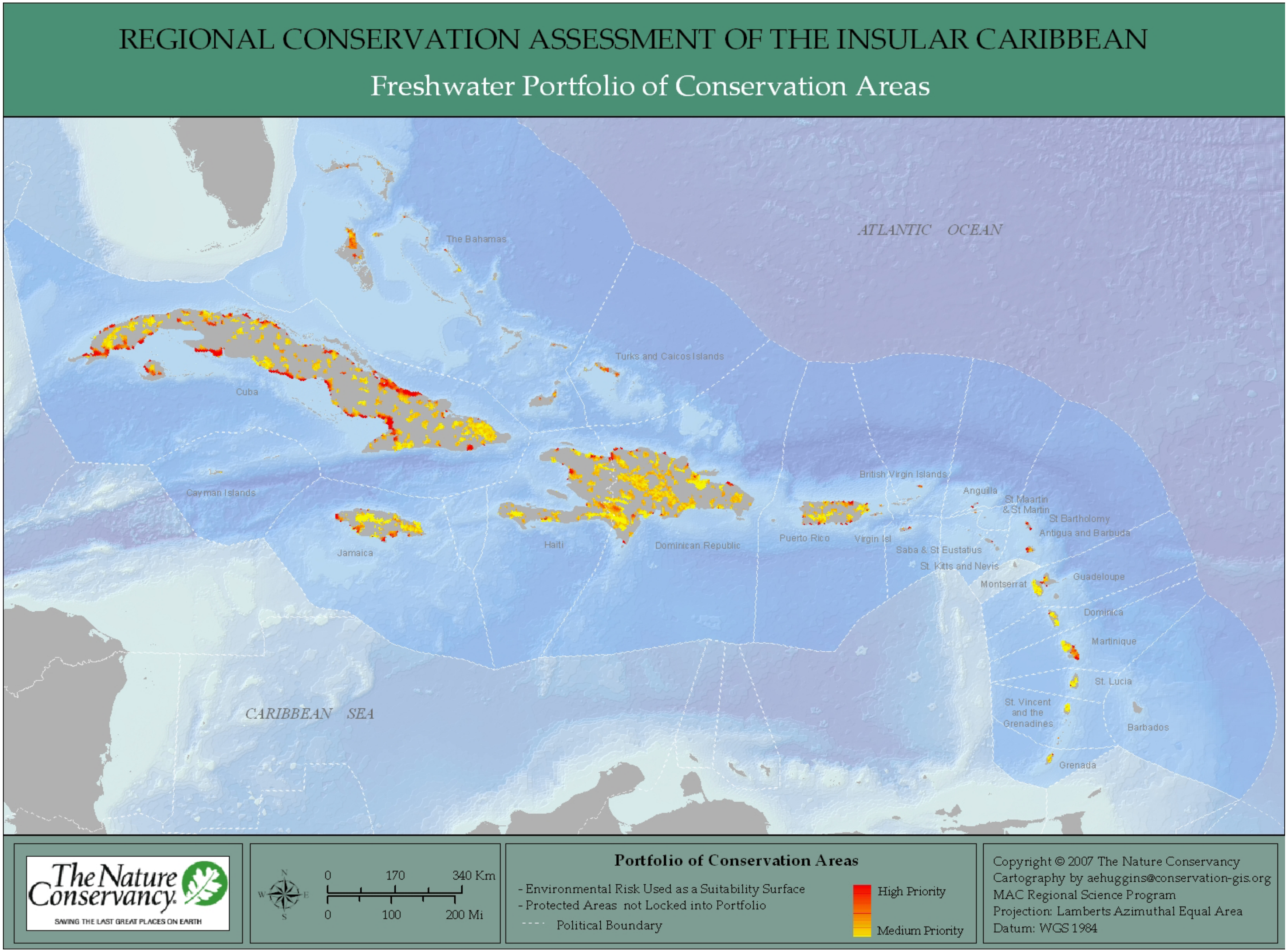

Figure 6; Optimal Freshwater Portfolio

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Appendix A

TARGET and TARGET MAPPING DETAILS

Marine

Channel Complexes: Channels are defined as narrow depressions or valleys that occur on top of the shelf areas (0-30 m). Channels act as important conduits for water between deep and bank water; tidal movements are often concentrated there. Most channels were formed many thousands of years ago and represent drowned river valleys or other such geomorphic features. Some paleo-channels have been completely in-filled by Holocene sediments where sedimentation rates have been very high or tidal flows—low. A variety of bottom types can be associated with channels including: sand, sea grass, hard-bottom, or coral reef. Channels containing coral reefs generally occur near the shelf edge where they bisect shallow barrier or fringing reefs. They are dominated by massive coral species and are often important conduits for migrating or spawning fishes. Parrotfish and many other reef fish are known to use channels for daily spawning activity. Other channels include deep tidal channels around islands that funnel inimical water between shallower embayments or banks out to open water. These tidal channels are generally lined with seagrass beds or hard-bottom substrates, and serve as important foraging areas for sharks along with loggerhead and green sea turtles.

Mapping Regional Distribution Channels and passes were extracted from the Millennium Reef Mapping Project geomorphic reef maps as part of collaboration with Dr. Serge Andréfouët (University of South Florida). Channels were identified from Landsat ETM satellite images based on (differences in water depth). Approximately 200 channels and passes were identified in the Caribbean. Near-shore tidal channels around islands in the Bahamas were also mapped using Landsat ETM image analysis and included as part of the target dataset. The data were checked against expert opinion and selected field investigations in Jamaica, Grenada, Bahamas, and Mexico but a quantitative accuracy assessment was not undertaken.

Key Attributes 1) High productivity is partly driven by tidal flow, and depends on the length, width, and depth of the channel; 2) Channels are important migration corridors and spawning grounds for a multitude of species; 3) Channels serve as important foraging areas for sharks and sea turtles.

Key Threats 1) Channel modification/shipping lanes; 2) Coastal development; 3) Industrial spills, nutrient loads.

Coastal Strand Complexes: Commonly referred to as beaches, the coastal strand complex represents the lands bordering the sea. The beach is a place of natural beauty which humans use for recreation, inspiration, and commercial activities, ranging from tourism to sand mining. The beaches of the Caribbean receive millions of tourists from the northern hemisphere, often looking for a temporary get away from the rigorous winter of the higher latitudes. It is also home to a very specialized community of creatures that have adapted to live in this harsh environment. A transition zone between terrestrial and marine environments, the beach is a tough place to live because of ever-changing conditions. Submerged by seawater for part of the day and exposed to air for the other, often covered by sediments that may be moved to and from the beach at every breaking wave, the beach is a very dynamic habitat.

The strand line marks the highest place where the ocean washes the beach (Lerman, 1986). The strand line is often marked by accumulated debris washed ashore by the ocean waves. This is an area rich with biological activity of the associated fauna. The strand line also marks a transition between the upper beach and the area of the beach that is within the range of tide. Different communities of organisms have adapted to different conditions of these zones. The upper beach is an area with primarily terrestrial characteristics, with species that use the ocean for part of their life cycles. Plant species such as the coconut palm (*Cocos nucifera*), the sea grape (*Coccoloba uvifera*), the beach morning glory (*Ipomea pes-caprae*) and the sea purslane (*Sesuvium portulacastrum*) provide cover for a number of animal species in the upper beach, such as the soldier crab (*Coenobita clypeatus*) and the willet (*Catoptrophorus semipalmatus*). During the summer through autumn months it is not unusual to find turtle hatchlings making their way from the nest, crafted by their mothers in the upper areas of many Caribbean beaches.

The inhabitants of the Intertidal zone, including crustaceans, such as the ghost crab (*Ocypode quadrata*), as well as mollusks and annelids that are preyed upon by wading birds like the least tern (*Sterna antillarum*) and the American oystercatcher (*Haematopus palliatus*), are adapted to part-time marine and part-time terrestrial living.

The seaward limit of land, which is exposed to air due to ebbing tidal flow, is referred to the low tide line mark. Below this line the land is continuously submerged in seawater, and is referred to as the sub-tidal zone. The community that inhabits this area includes fish species, such as the African pompano (*Alectis crinitus*), the permit (*Trachinotus falcatus*) and the yellowtail snapper (*Ocyurus chrysurus*), which are adapted to living in the marine environment full-time, by being well-suited to the shallow water, often crushed with strong wave action and coastal circulation.

Mapping Regional Distribution: Sandy beaches were mapped across the Caribbean basin using Landsat 7 Enhanced Thematic Mapper Plus (ETM+) images. Images dated from 1999-2002 were downloaded from the University of Maryland's Earth Science Data Interface at the Global Land Cover Facility (http://glcf.umiacs.umd.edu). Approximately 93 ETM+ scenes were used throughout the Caribbean Basin. The program Feature Analyst was used to classify image pixels using both spectral and contextual properties. After several trials using different combination of panchromatic, multi-spectral, and the thermal bands, it was determined that the 30m multi-spectral data was best suited for beach mapping. Beaches were often grouped in the same class as urban or barren due to the high reflectance properties of the feature. To separate beaches from other inland areas of high reflectance, we used the presence of water on one side to define a beach. An accuracy assessment was conducted using 1:25,000 topographic maps from Jamaica and St Vincent & the Grenadines. A total of 144 random points were used for beaches with buffer distances ranging from 100 to 500 m. For beaches, a maximum accuracy of 61.81% (89 out of 141) occurred at a buffer distance of 500m. At a 100m buffer distance, only 13 out of 141 were correctly classified (9.03%).

Key Attributes 1) Sediment transport – beach size resulting from accretion and erosion, and influenced by proximity to rivers; 2) Natural disturbance – beach slope resulting from tidal action, coastal circulation, wave energy and wind.

Key Threats:1) Coastal development that affects and impacts ability of species to colonize the upper beaches, as well as coastal circulation and sediment transport (Cambers, 1998); 2) Beach nourishment that alters the zonation of the beach with sediment from other areas; 3) Sand mining for construction that removes habitat; 4) Climate change that leads to altered circulation and sea level rise which could submerge the beach or affect sediment transport.

Coastal Mangroves/ Wetlands: Coastal wetlands including mangrove forests are some of the most productive ecosystems in the world. Their high primary productivity and nutrient profusion make them essential to the breeding, foraging, and roosting of many species, including aquatic plants, fish, shellfish, insects, amphibians, birds, and mammals. By providing food, shelter, and protection from predators they serve their role of biological nurseries well. In addition, they reduce the amount of pollution flowing into the bays and ocean.

Mangroves occur across the entire Caribbean basin and generally consist of four principal mangrove species: *Rhizophorae mangle*, *Avicennia germinans*, *Laguncularia racemosa*, and *Conocarpus erecta.* Mangroves play an important functional role for many fish fauna, many of which spend their early juvenile life stages within this habitat. Mangrove leaf litter represents a major source of organic matter and nutrients to adjacent estuarine waters and is essential in supporting high productivity of many near shore waters.

Mangroves grow on a wide range of soil types, including heavy consolidated clays, unconsolidated silts, calcareous and mineral sands, coral rubble, and organic peats, with salinity concentration close to 35%o. The development of mangrove swamps is the result of: topography, substrate, freshwater hydrology, and tidal action. The hydrologic energy of riverine mangroves is high since it is dominated by river flow and tidal inundation. Fringe mangroves, on the other hand, are influenced mainly by frequent tidal inundation. Basin mangroves have even less hydrologic energy, because they are located inland of fringe or riverine communities, and as a result, are less frequently inundated by either tides or river floods.

Fish species composition and richness in any tropical mangrove system primarily depends upon: (a) its size and diversity of habitats together with its flood and tidal regimes; (b) its proximity to other mangrove systems, and (c) the nature of the offshore environment, particularly depth and current patterns (Ball, 1980). Proximity to other mangrove systems ensures colonization through movements of adults and juveniles, even by those species that have nonexistent or short larval duration. A corollary of this is that proximity to non-mangrove areas, such as coral reefs may influence fish species composition in the mangrove (Parrish, 1987).

Mapping Regional Distribution: Mangrove and associated wetland vegetation layers were extracted from the 1990 and 2000 Earthsat GeoCover LC data layer (Tucker et al., 2004), which applies a uniform land cover classification over the entire Caribbean. A majority 4x4 filter was passed across the GeoCover LC data to generalize the classification of the classes and reduce single pixel "noise". Mangrove areas from the Bahamas that were poorly represented by the GeoCover datasets were supplemented with mangrove data of the World Conservation Monitoring Center (WCMC) which was compiled from various sources. The final mangrove and wetlands data layer represents a merger between these two sources and is in the form of polygons. A total of 21,108 mangrove polygon occurrences were identified within the three insular Caribbean marine ecoregions.

Key Attributes: 1) Vegetation type – area and percent cover of Mangrove forest species; 2) Community structure –population density of juvenile reef fish; 3) Seascape pattern and structure – combination of slope, elevation, and wave energy that characterize sheltered and low relief coastline that prevents uprooting; 4) Hydrological regime influenced by watershed dynamics – affecting sedimentation rates, freshwater flow, salinity, and nutrient loadings.

Key Threats: 1) Coastal development (dredging, filling) leads to habitat destruction, conversion, fragmentation, and increased erosion/sedimentation; 2) Logging/extraction of material from mangroves which leads to losses of key species of the ecosystem; 3) Incompatible operation of drainage or diversion systems/irrigation/flood control that modifies water levels and natural flow factors (freshwater inflow, saltwater flow); 4) Eutrophication, which lead to low oxygen conditions and increased algal blooms.

Deep Slopes / Walls : Coral reefs are commonly associated with warm and clear shallow waters, yet they also thrive in deeper and cooler waters of the tropics. These corals are deepwater organisms, living along or at the edge of the continental shelf (the shallow underwater extension of the world's continental landmasses ranging from 100 to 200 meters below the ocean's surface). Where the insular or continental shelf ends, the reefs follow the contour of the seafloor, and thus vertical walls or drop-offs are created along the shelf edge (at average between 55 to 65 meters). These walls can be incredibly beautiful and dramatic, plunging into seemingly endless blue ocean. The walls may be interspersed with caves, ledges, overhangs, vertical chutes and gullies, providing ideal habitat for gorgonian corals, sponges, encrusting algae and numerous fish and invertebrates. A 'biological zone' present on many reefs in the Caribbean region is the blackcap basslet (*Gramma melacara*) 'zone' where the basslet is the most common fish at depths between 50 and 100 meters. Such areas are also prime locations for sighting nurse (*Ginglymostoma cirratum*) and whale sharks (*Rhincodon typus*) and other large open water fish such as grouper (*Epinephelus*) or ocean triggerfish (*Canthidermis sufflamen*). Black corals (*Antipatharia*), known to many in the Caribbean for jewelry production, also thrive here, extending to the depths of 100 meters or more.

Shelf edge communities, also known as coral walls or deep reef, are characterized by sudden and steep increases in depth from shallower reef communities. Most simply put, these are vertical coral reefs without the significant reef structure. At these depths, reef-building corals are replaced by substantial sponge and gorgonian communities. The substrate is typically less complex, and energy regime is moderate.

Although the structural heterogeneity that supports reef biodiversity is less pronounced, these areas do provide food, refuge, and much sought after space to numerous invertebrates and fishes. These communities provide linkages to surrounding marine communities, and often provide corridors within which large schools of fish travel. In addition to schooling fish, many large pelagic species, such as the bull shark and hammerhead shark, use these areas as feeding grounds. This habitat represents boundary where the deep ocean meets the coastal waters, and is heavily influenced by current, temperature, and light regimes. Although most of Puerto Rico and the Virgin Islands are surrounded by shallow coastal waters, some of the deepest trenches in the Atlantic Ocean can be found to the north of these islands.

Mapping Regional Distribution: The actual distribution of coral reef walls has not been accurately mapped for the insular Caribbean region. The probable occurrence of deep slopes and coral reef walls was mapped using slope and depth to predict places where coral reef walls are known to occur. Steep slopes (>15 degrees) that occur between 30 and 300 meters were mapped using 1 km regional digital bathymetry datasets for the Caribbean.

Key Attributes: 1) Shelf-edge communities: vertical gradient in seafloor topography, wave energy, water quality, presence of sclerosponges as they are thought to play an important role in maintaining the structure of the drop-off – serve as sediment traps, connectivity to reef crest and fore-reef, temperature gradient, trophic structure, relief (presence of ledges, caves, etc); 2) Deep reef resources, deepwater corals: bathymetry, bottom substrate, deep-sea currents, trophic structure.

Key Threats: 1) Shelf-edge communities: habitat destruction via dynamiting, net and pot fishing, trawling, irresponsible diving and boating; harvesting of some black coral species threatening long-term species survival. Over-fishing and dynamiting also create resource depletion leading to disruption of trophic structure and food chains; industrial discharge and pollution lead to eutrophication, changes in composition of benthic faunal community, diminished populations, excessive algal growth, and increased temperature. 2) Deep reef resources, deepwater corals: massive habitat destruction and resource depletion due to: bottom trawling, long-lining (hooks, nets, pots); gillnet fishing, oil and gas exploration and drilling.

Estuaries: Estuaries are semi-enclosed, coastal areas in which the seawater is significantly diluted by freshwater coming from streams and rivers and groundwater that are feeding the estuary (Dando et al, 1996). The estuarine environment is a transition zone between the fresh water and seawater worlds. As such, the salinity within estuaries fluctuates frequently, creating stress on the organisms that inhabit these areas. Estuaries are considered as some of the most productive habitats on earth and also serve as important breeding and nursery areas for many marine species. Estuaries in the insular Caribbean can be classified into three broad groups based on their geomorphology: drowned river, tectonic, and lagoonal.

Drowned River Estuaries are generally fairly shallow (<5m) often associated with strong tidal flows and stable tectonic geology which characterize much of the Bahamian ecoregion. They consist of ancient tidal channels that generally run perpendicular to the islands or shelf edges and can completely bisect limestone islands. Bahamian estuaries are typically fed by groundwater that accumulates beneath the highest and widest portions of the islands. There is also some limited surface water flow on the larger islands such as Andros Island during the wet seasons.

Tectonic Estuaries are more similar to deep fjords, and occur where geological uplift and thrust faulting create steep inlets or embayments surrounded by land. Tectonic estuaries can be quite deep, often exceeding 10 m in depth, and are often quite large in size. Large watersheds and high rainfall amounts are necessary to create low salinity conditions, which are often restricted to the uppermost areas of the estuary. Tectonic estuaries are found across much of the Greater Antillean ecoregion, particularly along the north and south coasts of Hispaniola, southeastern coasts of Cuba, and southern coast of Jamaica.

Lagoonal Estuaries are fed intermittently by small streams; they typically occur in depressions that run parallel to the coastline. They tend to fluctuate greatly between wet and dry seasons, and may even become disconnected from the sea following hurricanes which shift sediments around. Lagoonal estuaries are typical of the small, steep islands of the eastern Caribbean ecoregion. The southeastern Caribbean is also influenced to some degree by the discharges from the Amazon and the Orinoco rivers which together account for 25% of the total riverine input to the Atlantic and can be measured all the way near Puerto Rico (Morrel and Corredor, 2001).

Estuaries are fascinating and beautiful ecosystems distinct from all other places on earth. The productivity and variety of estuarine habitats foster a wonderful abundance and diversity of wildlife. Many different habitat types are found in and around estuaries, including shallow open waters, freshwater and salt marshes, sandy beaches, mud and sand flats, rocky shores, oyster reefs, mangrove forests, river deltas, tidal pools, sea grass and kelp beds, and wooded swamps. The tidal, sheltered waters of estuaries support unique communities specially adapted for life at the margin of the sea, including: shore birds; fish, such as anchovies, bull sharks, sawfish, croaker, and lane snapper; crabs, and lobsters; marine mammals; clams, shrimp, and other shellfish; marine worms; sea birds; and reptiles. These animals are linked to one another and to an assortment of specialized plants and microscopic organisms through complex food webs and other interactions.

Mapping Regional Distribution: Estuaries were mapped by identifying the discharge points of all streams of order 3 and higher that were modeled as part of the Caribbean freshwater ecoregional planning. In the Bahamas where there are no known rivers due to the porous limestone geology, groundwater maps were used from the Bahamas Water and Sewage Department and a 2 km buffer was applied. A seaward buffer of 2 km was then applied to both of these features and the resulting area was clipped with land to capture smaller bays and estuaries. For larger bays and estuaries, a centroid, or center of the 2 km buffer polygons was determined and radial lines were generating every 45 degrees from this point out to 10 km. Centroids with lines that intersected land were then identified and their buffer was extended an additional 5km to include more of these larger embayments. A total of 1,577 estuarine areas were mapped within the three insular Caribbean marine ecoregions.

Key Attributes : Freshwater flow (base flow), seasonal freshwater pulsing (water levels), estuarine salinity – mixing of freshwater and sea water, tidal flushing, coastal geomorphology (embayments), depositional area for sediments, and nutrient input, water quality (visibility) are the main factors that characterize estuaries.

Key Threats: Estuaries are used, abused, and managed heavily for resource extraction, habitation and recreation (coastal development). The pressures on estuarine resources from population redistribution and growth are predicted to increase significantly in the next few decades. The resulting changes in nutrient loading (pollution) and hydrology (river dams affecting flow and volume) at the regional scale, as well as accelerated sea-level rise and climate change at a global scale, will lead to significant alterations of estuarine habitats. (Geyer *et al*, 2000).

Lacustrian Features: Lagoons are one of the types of the Estuarine System (estuaries are the other). They are usually semi-enclosed by land but have some degree of access to the open ocean. They are influenced by oceanic tides, precipitation, and freshwater runoff from land areas, evaporation, and wind. Their salinities can range from hyperhaline to oligohaline. Salt ponds fall under the category of hyperhaline lagoons. Anchialine ponds are landlocked saline bodies of water with permanent connections to the open ocean. The salinity in ponds may vary, ranging from polyhaline to euhaline; therefore do not fit the tradition definition of lacustrine (lakes) and palustrine (ponds) systems.
Blue holes are anchialine ponds which include caves and crevices. They formed in islands' limestone skeleton when subterranean caverns collapsed, dating back to the Pleistocene. At first the holes were flooded with seawater; but after countless seasons of storms, fresh water collected, settling atop the heavier salt water. Blue holes are unique cave systems that support endemic fauna and microbial communities. They fall into the category of wetland areas which do not support hydrophytes ("water-loving or wetland plants) but where the geomorphology of an island includes a solution hole, depression, pond or swale, and where drastic fluctuation in water level, turbidity, or high concentration of salts may prevent the growth of hydrophytes. Living in the thin freshwater lens are hundreds of species unique to each blue hole. Blue holes, therefore, present a unique component of lacustrine systems. The highest number of blue holes has been accounted for on Andros Island; over 100 of them have been identified on land and in the sea, with depths exceeding 121.9 meters in some cases.

Mapping Regional Distribution: **Lagoons and salt ponds** are widespread feature in the Caribbean region. The regional maps were derived by using "Landsat 7 ETM+" imagery and producing GeoCover TM Mosaic Data inland water within 1 km buffer of the coast. **Blue Holes:** The regional maps were derived by using "Landsat 7 ETM+" imagery (in 2000) and from variety of digital topographic maps (1970s). Blue holes systems were identified on the following islands: Andros, Great Exuma, Cat, Long, Crooked, New Providence, Eleutera, and San Salvador Islands.

Key Attributes: **Lagoons:** Salinity – mixing of freshwater and sea water, tidal flushing, coastal geomorphology (embayments), depositional area for sediments, and nutrient input; salinity ranges between 30 and 5 ppt. **Blue Holes:** The carbonate geology of the Bahamian archipelago allows salt water to penetrate under all the islands, which results in a freshwater being layered over seawater;
salinity due to ocean-derived salts is always below 5 ppt; endemic fauna and flora.

Key Threats : **Lagoons:** Similarly to estuaries, lagoons are used, abused, and managed heavily for resource extraction, habitation and recreation (coastal development). The pressures on estuarine resources from population redistribution and growth will increase significantly in the next few decades. **Blue Holes**: Incompatible recreational activities; potential fresh water depletion (Six million gallons of fresh water are daily exported to Nassau, posing a severe threat to Andros' ecosystems.); pollution due to incompatible resource extraction-mining/drilling. The resulting changes in nutrient loading (nutrification) and altered hydrology (river dams affecting flow and volume) effect lagoons at the regional scale. In addition, accelerated sea-level rise and climate change at the global scale, will lead to significant alterations of lagoons and salt pond habitats.

Seagrass Communities: Seagrass communities are common throughout the waters of the Caribbean. They are home to a myriad of fish and invertebrates. Green sea turtles are regular inhabitants of these sunny expanses, using the areas to feed primarily on the aptly named "turtle grass". Seagrass beds are primarily subtidal, with some extending into the intertidal zone. They are distributed throughout much of the near-shore areas, forming linkages to other marine communities through movement of animals and export of large quantities of slowly decaying organic matter. The seagrass beds provide habitat for diverse populations of macroalgae, epiphytic diatoms, invertebrates, and juvenile fish. Seagrass habitats serve a variety of functions, including: trophic support, refuge from predation, recruitment, provision of nursery areas, environmental filter, and waterfowl habitat.

These grass-dominated habitats are found in relatively clear, shallow water (~.5-10m). The substrate of these communities is comprised of carbonate sand and fine organic matter, which is a product of both autogenic (*in situ* production) and allogenic (trapping of suspended particles) processes. Seagrass beds in the Caribbean are characterized by the habitat-forming turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme)*, shoalgrass (*Halodule spp.*), and calcareous green algae (*Halimeda spp.* and *Penicillus spp.*). Perhaps, most important of all, seagrasses act as "foundation species", meaning that the persistence of the entire community rests on the persistence of seagrasses. Their loss from areas is associated with rapid declines of commercially and ecologically valuable species and overall community function. Essentially seagrasses, via their biogenic structure, ameliorate environmental stresses (e.g., biotic – predation; and abiotic – wave disturbance), that would otherwise lead to the local extinction of the great majority of associated flora and fauna.

Mapping Distribution: The regional maps were derived from a combination of data sources. Seagrass data from the Bahamas was mapped by the University of South Florida (Damaris Torres) using remote sensing analysis of 14 Landsat ETM images. Seagrass data from Puerto Rico and the Virgin Islands was extracted from NOAA habitat maps. Seagrass data from Cuba was digitized from maps produced as part of the National Marine Ecoregional Planning effort undertaken by WWF and colleagues from Cuba. Data from the remainder of the Caribbean was taken from World Conservation Monitoring Center seagrass dataset which was compiled from various sources. The final data represented medium to dense seagrass areas and was a combination of lines and polygons.

Key Attributes: 1) Community structure: species composition (i.e. Mollusks, crustaceans, echinoderms) and patch size; 2) Trophic structure (herbivore and predator densities); 3) Seascape pattern and structure: combination of substrate type (soft limestone rock or hard igneous rock communities), slope at the coastline and wave energy intensity; water clarity, nutrient dynamics, complex, temperature, sediment regime.

Key Threats: Habitat disturbance or destruction from boating and shipping activities, nutrient loading from sewage discharge and agricultural run-off, sedimentation from poor land development practices, industrial activities/discharge, and incompatible fishing.

Seabird Nesting and Roosting Sites: Seabirds, shorebirds, herons, and numerous landbirds flock seasonally on winter foraging and nesting grounds of the Caribbean. Secluded cays and islets, rocky shores and cliffs, estuaries, lagoons and mudflats are some of the key habitats that provide attractive habitat for roosting and nesting in close proximity to the sea. Sooty terns (*Sterna fuscata*) nest in their hundreds of thousands on tiny off shore islands, traveling hundreds of miles to provision their chicks, and follow the ocean currents across the tropical Atlantic, as far as Africa for the rest of the year. Brown pelicans (*Pelicanus occidentalis*) and magnificent frigatebirds (*Fregata magnificens*) stay close to shore year round.

Most seabirds take advantage of small, isolated islands to nest in high densities. Absence of alien predators such as cats, rats and raccoons, suitable vegetation (or the lack of it) and proximity to feeding grounds, are some of the factors that contribute to suitable habitat for seabirds. A few ones, like the rare and endangered Black-capped Petrel (*Pterodroma hasitata)* travel further inland to nest in deep, forested cliffs of the interior of larger islands.

Herons and egrets prefer to nest in large mixed colonies close to water in the mangroves, while shorebirds are more likely to be found nesting on salinas and mudflats. Deep in the canopy of mangroves and coastal woodland Yellow Warblers (*Dendroica petechia*) and hummingbirds are joined by seasonal migrants—North American warblers like American redstarts (*Setophaga ruticilla*), on their way north to breed in the summer, followed by austral migrants, migrating from central and South America to breed in the Caribbean. Whatever the destination, the coastal wetlands of the Caribbean provide abundant food and shelter for birds on their wintering grounds or the ones just passing through.

Mapping Regional Distribution: Birds are probably one of the best studied groups of animals in the Caribbean, but with thousands of islands and many miles of inaccessible and remote beaches there are huge gaps in our knowledge of the distribution of species and habitats. The data used to represent seabird and shorebird nesting and roosting areas comes from an access database compiled over a 10 year period by William Mackin of The Society for the Study and Conservation of Caribbean Birds (SSCCB). Locations were taken from published chapters in an upcoming book on Caribbean Sea birds, monitoring studies, and from local expert knowledge from SSCCB members. A total of 735 nesting and roosting point locations were identified and checked for spatial accuracy using Landsat ETM images or national topographic maps from each country. Species number, year of observation, and overall importance (ranked 0-2) were attributed to each point for use in the Caribbean ecoregional plan. Conservation goals were set based on the ranked importance of each site.

*Key Attribut*es: 1) Trophic structure: primary productivity (abundant food resources), and predator density (lower densities are better); 2) Vegetation type: species composition, vegetation height, density and structure or substrate type and exposure; 3) Connectivity among ecosystems: nesting site fidelity, proximity to feeding grounds.

Key Threats: Throughout the region, many of the nesting sites are threatened or are no longer suitable for nesting because of the presence of cats, rats, mongooses and raccoons. A few of these insatiable predators can extirpate a huge nesting colony. Meanwhile food resources are being reduced as pollution from coastal developments coupled with agricultural runoff affect coastal productivity. Pesticides and heavy metals accumulate in food chains. Over-hunting has become another threat to some of the once widespread bird species, such as flamingos or white-crowned pigeons. These factors combined place the shorelines and other coastal environments of the Caribbean among the most significant for wildlife as well as among the most threatened in the region.

Sea Turtles: Although found in a number of ecosystems that are conservation targets in this planning effort, Sea Turtles are treated here as a separate conservation target due to their precarious state—all four species of marine turtles in the Caribbean are considered as either threatened or endangered by the World Conservation Union (IUCN). The Caribbean region once supported populations of sea turtles that numbered in the tens of millions. Seventeenth and eighteenth century mariner records document flotillas of turtles so dense and vast that net fishing was impossible, even the movement of ships was curtailed. Today some of the largest breeding populations the world has ever known have all but disappeared due to a combination of factors operating at local and regional scales.

All over the Caribbean people enjoy relaxing on beautiful sandy beaches, most of them without ever realizing that they could be on the nesting grounds for some of the oldest residents in the ocean: Sea turtles. Two of the turtle species alive today belong to genera, *Chelonia* which includes the green turtles (Chelonia mydas) and *Caretta*, which includes the loggerhead turtles (Caretta caretta), have been found in the fossil record dating back to the cretaceous period (Waller et al, 1996) between 75 and 135 million years ago. These animals have ancestors that lived through the mass extinction of dinosaurs and other giant reptiles and the advent of modern insects, as well as the entire history of the human species. The life history of turtles is of great interest due to their extensive migrations in the ocean and to the fidelity they demonstrate toward their nesting beaches, illustrating incredible navigation abilities that allow them to return every two to four years to their ancestral nesting places (Lerman, 1986). Sea turtles are remarkably adapted to life in the ocean, with powerful paddle-shaped front flippers coupled with a stream lined body that enable them to swim fast and over long distances. In addition, they have evolved to exploit a variety of food sources available in the ocean.

Green turtles (*Chelonia mydas*) feed and nest throughout the tropics and into subtropical oceans. They are the only sea turtles that eat large amounts of plants. They consume a variety of seagrasses such as Thalassia (turtle grass), Syringodium, Halophila, Posidonia, Halodule, and Zostera, and algae such as Chaetomorpha, Sargassum, and Hypnea. They also eat other green and red algae and some jellyfish, salps, and sponges. It takes a long time for a green turtle to reach maturity than any other turtle; in the Caribbean females mature at 26 or 27 years of age. They rarely re-nest the following year, waiting as long as four to six years. Green turtles are known to exhibit a "basking" behavior, coming out of the water during the day and laying on the sand. They avoid cold temperatures to stay alive. One of the actions they take is burrowing into the mud of subtropical lagoons and hibernating through the winter. (Spotila, 2004)

Hawksbill turtles (*Eretmochelys imbricate*) once nested in colonies, but since its populations diminished greatly—they are often lone nesters. Like green turtles, they forage mostly in small areas over coral reef, rock outcropping, and sea grass beds in mangrove bays and estuaries. These carnivorous marine turtles are equipped with a unique hooked beak, probably used to pry mussels and barnacles from submerged rocks; but also eat clams, jellyfish, and marine algae. The unique ecological role of this animal is the result of its diet, often rich in sponges. Caribbean hawksbills feed exclusively on only a few kinds of sponges in the genera Chondrilla, Ancorina, Geodia, Placospongia, and Suberites. They appear to avoid sponges with skeletons made of the protein sponging or of calcium carbonate. They can be defined as the architects of the coral reefs but regulating the sponges' competition for space on a reef with the coral by outgrowing it. It is suspected that hawksbills come to maturity at the age 20-25 years. (Spotila, 2004)

Loggerhead turtles (*Caretta caretta*) are keystone species of the world's oceans. As a carnivore, it plays a central role in the food chain, feeding on large numbers of invertebrate prey. Because of their large heard and crushing jaws are able to feed on large shellfish, such as: horseshoe, spider, rock, hermit, and lady crabs; mussels, shells, and conches. They are generalized ecologically because they have broad ecological requirements in ocean ecosystems. They return to nest every 2-4 years, traveling over the greatest geographic range of any sea turtle, from the tropics to the temperate zone, living and foraging in both open waters and the near-shore regions of all tropical and temperate ocean basins. They serve as mobile islands by providing home on their carapaces for organisms such as: barnacles, skeleton shrimp, and algae. (Spotila, 2004)

Leatherback turtle (*Dermochelys coriace*) is the largest turtle in the world and also one of the largest living reptiles. It is the deepest diving reptile, with ability to descend to as deep as a whale—4,000 feet (1230m) and deeper. Its fatty insulation allows it to control its body temperature. It is also the fastest of all sea turtles thanks to its streamlined shell. These characteristics allow this turtle's distribution around the globe through the tropical, temperate, and even sub-arctic waters. They are primarily pelagic animals and migrate great distance form their nesting beaches to their feeding grounds. For example, leatherbacks from St. Croix are known to feed in the north Atlantic and the Gulf of Mexico. Females return to nesting place every 2-7 years. They are the fastest growing reptile—reaching the adult size in 7-13 years. They forage for food from the surface down to great depths, preying on jellyfish, colonial siphonophores (i.e. Portuguese man-of-war), tunicates, and other soft-bodied animals. The leatherback turtle feeds on jellyfish, far from shore in the open ocean, often growing up to 1200lbs. (Spotila, 2004)

Mapping Distributions: A database of sea turtle nesting beaches was created in cooperation with the Wider Caribbean Sea Turtle Conservation Network (WIDECAST). Effort was placed on compiling all existing data for nesting beaches on a country level scale throughout the Caribbean region. These records were updated with on-going monitoring project data and attributed as fully as possible with species, crawl numbers and geographic coordinates.
A total of 470 nesting locations were mapped for the insular Caribbean for four species. Nesting locations were ranked in terms of "confidence" from 1-3 based on the sources of data. Goals were set based on confidence in the data rather than by species or number of nests/crawls.

Key Attributes: 1) Population structure and recruitment: nesting density, reproductive success (number of hatched eggs); 2) Seascape pattern and structure: combination of coastal geomorphology, access to open water, oceanographic dynamics and sediment composition of beaches; 3) Connectivity among ecosystems: nesting site fidelity, long distance migrations.

Key Threats: 1) Fishing: especially commercial fisheries through many different fishing practices, from long-lining to shrimp-trawling that cause injuries and mortality from both—targeted catch and incidental capture (bycatch); 2) Coastal development: degrades quality of nesting habitat hindering the ability of safe nesting and of hatchlings to reach the water; scarring of seagrass beds from anchoring or propellers reduce the productivity of seagrasses; silt deposition on coral reefs and sea grass beds reduces foraging habitat as well; 3) Industrial discharge: degrades water quality and causes disease and mortality 4) Debris (i.e. plastics, synthetic fibers, tar) ingestion by young pelagic stage turtles.

Marine Mammal Complex: Marine mammals are an integral part of marine and coastal ecosystems and use the waters of the Caribbean Sea for critical functions such as feeding, mating and calving. The mosaic of deep-water basins, oceanic islands, steep drop-offs, and varied topography of the ocean floor that is characteristic of the Caribbean (Earle, 2001), provides a diverse range of conditions and habitats that suit a variety of marine mammals, including species that prefer deep oceanic conditions and are usually found far offshore (Ward et al. 2001).

From the 34 species (31 cetaceans, 1 pinniped and 1 sirenian) of marine mammals—7 are considered endangered. The pinniped species, the Caribbean Monk seal, is considered extinct (Wurtzig et al. 2000). The distribution of the various species of marine mammals may vary according to the following factors: water temperature, salinity, tidal flow and currents, areas of upwelling, prey movements or concentrations, and seafloor topography (Ward et al., 2001). Additional factors may influence distribution patterns including demographics such as: reproductive status, age, sex, and population size; species adaptations including physiological and behavioral factors; and human effects, including pollutants and habitat disturbance. The principal calving area for the Atlantic Humpback whale population is the Silver Banks area north of the Dominican Republic. Recent surveys estimate that over 17,000 animals now use the area, and the trend has been increasing over the past decade. Other important areas for dolphins include: the western margins of the little Bahamas and the Great Bahama Bank

The West Indian Manatee occurs mainly around the Greater Antillean islands of Puerto Rico, Cuba, and to a lesser extent—Jamaica and Hispaniola. Centuries of hunting and alteration of habitat have greatly reduced their numbers. Although the Manatee historically occurred in the eastern Caribbean (Guadeloupe), it is no longer found there. Occasionally, Manatees are sighted in the Bahamas, but these are thought to come from Florida, and at present there is not a year round resident population in the Bahamas.

Mapping Regional Distribution: Critical manatee areas were mapped as point data through merging datasets from a variety of sources. These include National monitoring datasets from Jamaica (NEPA) and the Dominican Republic (expert input), Puerto Rico (USFWS sightings data based on aerial surveys), Manatee data for other areas was compiled from on-line sources. A total of 118 point locations were identified as critical manatee areas for the three marine ecoregions. To identify shelf areas (0-200 m) that were of more or less importance to other marine mammals, we used 123 sightings representing 15 cetacean species from the Ocean Biogeographic Information (OBIS) database for the insular Caribbean. Individual sights were attributed to the nearest coastal shelf unit (total of 63 for the Caribbean). Coastal shelf units were then ranked from 1-3 (1=low; 2=medium; 3= important) based on the number of sightings. Fifteen shelf units were classified as important, 14 as medium and 34 as low.

Key Attributes: 1) Population structure and recruitment: abundance and age distribution of animals, their reproductive success; 2) Water acoustic regimen, as measured by noise levels;3) Connectivity among ecosystems: oceanographic processes that reflect the notorious long distance migration patterns (can be monitored by visitation densities at known calving and feeding grounds);4) Seascape pattern and structure: combination of coastal geomorphology, narrow continental shelves, oceanographic dynamics.

Key Threats: 1) Shipping activities: collisions can cause injury and mortality; 2) Fishing (gear, incidental take): causes injuries and mortality; 3) Acoustic disturbances; 4) Industrial discharge that degrades habitat.

Reef Fish Spawning Aggregations: Reef fish generally live in solitary or small groups, although some species exhibit schooling behavior. When larger numbers of reef fish are observed, these aggregations usually form for feeding, shelter or spawning. By definition, a spawning aggregation is a group of non-specific individuals grouped together in densities three times higher than those found in non-reproductive periods (Domeier and Colin 1997). Aggregations can also be recognized by indirect evidence such as swollen abdomens, spawning colorations or behaviors, and by direct evidence, such as observation of hydrated eggs or actual spawning activities (Colin *et al*. 2003; www.scrfa.org). Reef fish spawning aggregations occur in tightly defined locations and at predictable times, making them very vulnerable to overfishing. Reef fish spawning aggregations are one of the most dramatic and important events in the life history of reefs. At times, tens of thousands of individuals aggregate and spawn en masse, releasing gamete clouds so dense that they obscure all vision within Caribbean waters, famous for their turquoise translucence. The density of the spawning adults attracts predators, such as sharks and dolphins, while the high density egg release attracts planctivorous organisms including whale sharks (Heyman *et al*., 2001).

Two different types of spawning aggregations have been defined, "resident" and "transient", using the following three criteria: the frequency of aggregations, the longevity of aggregations, and the distance traveled by fish to the aggregation. Spawning in resident aggregations is common to most rabbitfish (iguanids), wrasses (labroids) and angelfish (canthারides). Resident spawning aggregations are brief (1-2 hours) and frequent (often daily), and involve short travel distances. By contrast, most grouper (errands), snapper (litanies), jacks (carangids), along with several other families, form transient spawning aggregations. Transient aggregations generally exhibit the following characteristics: a) fish frequently migrate long distances (can be > 100 km) to the aggregation site, sometimes using specific routes; b) aggregations typically form for only a few months of the year; c) the formation of aggregations is entrained to the lunar cycle; d) the duration of the aggregation is from a few days to a few weeks each lunar cycle; e) aggregations occur during a limited period or season of the year, possibly in relation to day length or seawater temperature. For the species that use this strategy, it appears that all reproductive activity for the year takes place within these aggregations, as there is no evidence of spawning in these species outside the aggregation.

Many sites that serve as spawning aggregation sites for one transient spawning species appear to serve as multi-species spawning aggregation sites, at predictable times and locations (Heyman and Requena 2002; Heyman and Boucher, in prep.). These sites are all windward, facing reef promontories that jut into deep oceanic waters. Reef promontories have been shown to harbor multi-species reef fish spawning aggregations in Belize, the Cayman Islands, Cuba, and Mexico (Whaylen et al., 2002; Claro and Lindemen, 2003, Sosa et al., 2002), and the pattern may be more wide spread.

Reef fish spawning aggregations are highly vulnerable to fishing. For example, Nassau grouper, *E. striatus*' aggregations, have been extirpated in: Belize, the Bahamas, Honduras, Mexico, Virgin Islands, Bermuda, Puerto Rico, Dominican Republic, and Florida. In part, a result of this overfishing at their spawning sites, they are listed as “endangered” by the IUCN. Other grouper species appear to be showing similar declines. These trends are common throughout the Caribbean, where many known grouper spawning aggregations have been fished to near extinction.

Mapping Regional Distribution: The locations of reef fish spawning aggregations were compiled from a variety of sources including local fishermen in each country, published literature, and expert input from the Society for the Conservation of Reef Fish Spawning Aggregations (SCRFA) and Dr. Brian Luckhurst. All known spawning areas were associated with species and approximate number (if known) and geo-referenced. A total of 100 transient spawning areas representing twelve species were mapped within the insular Caribbean ecoregions. These were ranked from 1 to 3 based on the source of the data and confidence in the reported location. In addition to known aggregation sites, a predictive model was created to identify areas along the shelf with suitable geomorphic characteristics (promontories, large adjacent reef area). These areas were used to represent potential historic aggregation sites which are no longer active today. A total of 750 10 km shelf segments (30 meter bathymetric contour) were identified based on shelf morphology. Goals were established based on the confidence of the data sets with predicted locations having the lowest goal (10%) and the fully validated aggregations having the highest goal (40%)

Key Attributes: 1) Population structure and recruitment: SPGS play a crucial role in the life cycle of fish populations. The health of the population is a function of the densities and structure of key species at different life stages (adult and eggs and larvae). This key attribute can be monitored from fish length (median size vs. minimum size at reproduction) or from size frequency distribution of each of several key species, e.g. Nassau, Black Groupers, Mutton snappers, Cubera snappers, with the minimum size at their reproductive maturity; 2) Seascape pattern and structure: combination of reef geomorphology (shape, slope), water temperature, current speed and direction at surface and aggregation depth (25 - 35 m), and tide state; 3) Connectivity among ecosystems: connectivity with migration routes, larval dispersal and nursery areas measured by species densities.

Key Threats: Overfishing is the clearest and the largest threat to reef fish spawning aggregations as it alters population structure and recruitment, a key attribute of this target. These aggregations form during predictable times, in known locations, and can be very vulnerable, particularly to net or trap fishing. Handline fishing, though lighter in pressure, has been known to extirpate spawning aggregation sites for Nassau grouper. The Live Reef fish Food Trade, largely feeding the high demand in Hong Kong has created extreme pressures on spawning aggregations throughout the Indo-Western Pacific and appears to be spreading into Caribbean Waters. This threat accelerates the existing threat of overfishing from local subsistence or small-scale commercial fishers within the region. Spawning aggregation sites can also be threatened by decreasing water quality with inputs from riverine sediments, pollutants, and/or fresh water.

Coral Reef Complexes: Coral Reefs are the most famous hard bottom habitats in the Caribbean. The hard bottom habitats are usually found in areas where there is a strong circulation that carries away finer sediment. The organisms that inhabit this environment have special adaptations to anchor themselves to the bottom of the ocean to avoid being carried away. We decided not to focus on other types of hard bottom habitats other than coral reefs since their remote identification is difficult, and mapping these complexes has had very little attention in the past.

Coral reefs are an extremely important member of the Caribbean marine ecosystem because they create three-dimensional structures that provide home to a large array of organisms (Castro and Huber, 2000). Coral species are remarkably evenly distributed around the Caribbean. In almost all reefs six scleractinian genera (Acropora, Montastrea, Porites, Diploria, Siderastrea, and Agaricia) and one hydrozoan (Millepora) constitute over 90% of the total coral biomass. However, studies suggest that relative species dominance does vary geographically within the Caribbean (Kramer, 2003). Coral reefs occur in many shapes and forms, and have been divided into three basic types: fringing reefs that form barriers along the shore; barrier reefs that are separated from the coast by a large lagoon or a channel; and atolls, which resemble a chain of corals surrounding an island (Lerman, 1986). For our mapping purposes, we have divided corals reefs into: shallow reef (0 to 5 meters), fore reef (5 to 30 meters), and biogenic reef formed islands.

Shallow Reef: This class consists of: patch reefs, reef crests, and back reefs with large amounts of the branching acroporid coral (*Acropora palmata*). The reef crest, or algal ridge, in much of the Eastern Caribbean, is the highest point of the reef, and is exposed at low tide. Because this area is so shallow, it experiences the wide variation in temperature and salinity, and frequent exposure to the full force of breaking waves. The factors, such as: reduced water circulation, accumulation of sediments, and periods of tidal immersions—when the reef is exposed during low tide, combine to limit coral growth. Although living corals may be scarce except near the seaward section of this zone, its many microhabitats support the greatest number of species in the reef ecosystem, with mollusks, worms and decapod crustaceans often dominating the visible macrofauna (Barnes, R.D., 1987; Lalli and Parsons, 1995; Sumich, 1996).

Fore Reef: The fore reef, as represented in our mapping, consists of the outer seaward slope of most coral reefs and contains rugged zones of spurs or buttresses, radiating out from the reef. Deep channels that slope down the reef face are interspersed between the buttresses. These alternating spurs and channels may be several meters wide and up to 300 m long. Continuing down the seaward slope to about 20 m, optimal light intensity decreases, but wave action decreases as well, allowing the maximum number of coral species to develop. Beginning at approximately 30 m, sediments accumulate on the gentle slope, and corals become patchy in distribution. Sponges, sea whips, sea fans, and ahermatypic (non-reef-building) corals become increasingly abundant and gradually replace hermatypic corals in deeper, darker water (Barnes, R.D., 1987; Lalli and Parsons, 1995; Sumich, 1996).

Biogenic Reef Island: Where scleractinian corals grow unusually well, the calcium carbonate debris (dead coral skeletons) is shed from the reef, and can accumulate to form small islands. These islands may be fairly short-lived as hurricanes and storms can wipe them out from time to time; however, over longer periods of time (centuries) they do generally reform. These small isolated islands provide critical nesting areas for seabirds and sea turtles, and represent a unique feature of coral reef systems.

Mapping regional distribution: The coral reefs were mapped as part of the Millennium Reef Mapping Project led by Dr. Serge Andréfouët from the University of South Florida. The shelf areas of all Caribbean islands were classified from Landsat ETM images using a global 4-tiered classification scheme. Reef and shelves were classified based on geomorphology not biotic cover. A total of 126 classes were identified for the three Caribbean marine ecoregions. These classes were then simplified into a shallow and fore reef classes by lumping together selected classes that represented true coral reef structures (as opposed to hard-bottom, sand, or seagrasses). The data were checked against expert opinion and selected field investigations in Jamaica, Grenada, Bahamas, and Mexico but a quantitative accuracy assessment was not undertaken.

Key Attributes: 1) Population structure and recruitment, measured by percent cover of live coral on reef; 2) Herbivory, an important process to prevent algae taking over the reef, measured through the population density of herbivores; 3) Water quality and clarity, measured by nutrient loading and turbidity respectively; 4) Climatic processes which affect sea level rise, temperature and wave energy.

Key Threats 1) Fishing & harvesting aquatic resources which leads to resource depletion and disruption of trophic structure (reduced species diversity, specifically loss of herbivory); 2) Destructive fishing (trawls, nets, traps) which causes habitat loss; 3) Climate change which induces bleaching-mortality and diseases and leads to a loss of live cover on reef; 4) Coastal development (shoreline stabilization, land reclamation and sewage discharge) which leads to habitat destruction, increased erosion/sedimentation, nutrient loading and discharges of toxins/contaminants.

Rocky Shore Complexes: Rocky shores dominate much of the Caribbean coastline and are colonized by a wide variety of marine algae and animals that are adapted to very stressful environments. These organisms have to tolerate wide variations in: desiccation, temperature, salinity, wave activity, food availability, and predation pressure, in order to survive and reproduce. The adaptations of these organisms are evident in the distinct vertical zonation of rocky intertidal communities. Rocky intertidal communities are found on both— limestone and volcanic rock hard-substrate shorelines region-wide.

The upper and lower boundaries of these communities are set by the low and high tide lines, which in the Caribbean range from 6 to 15 inches in vertical elevation. Tropical rocky intertidal systems are characterized by three distinct elevation zones: a white/upper intertidal zone, a black/mid-intertidal zone, and a yellow/lower intertidal zone. The upper, white zone is flooded only once a month on spring high tides and is barren of most plant life. The mid-zone, black intertidal area, is flooded approximately 50% of the time over a lunar cycle (~28 days) and gains its characteristic dark coloration from encrusting, desiccant resistant marine algae. The lower, yellow zone is flooded daily and again gains its coloration from marine algae, which blanket the entire rock surface. The algal community in this area is much more diverse and foliose in structure, with representative species from subtidal algal assemblages and alga which are strictly intertidal.

Intertidal zones are home to a diverse assemblage of invertebrate grazers and predators unique to these communities. Nerite and periwinkle snails, that are highly tolerant to extreme conditions, inhabit the upper-white and mid-black zone, while a much more diverse assemblage of gastropod grazers (Nerites – 6 species, Turbans – 3 species), gastropod predators (Muricids – 4 species), urchins, chitons, mussels, barnacles, annelids, sea cucumbers, tunicates, sponges, crabs, and amphipods occupy the lower yellow zone. Rocky shores are important feeding grounds for puffer and trigger fish, as well as generalist wrasse feeders and herbivorous fish (e.g. princess parrot fish).

Mapping Regional Distribution: Rocky shores were derived from 90m SRTM (Shuttle Radar Topography Mission) elevation data. The raw SRTM data was downloaded from the NASA JPL site and post processed for filling of sinks and no-data gaps. Once post-processing was completed, a slope calculation was performed in ArcView. All areas were classified into slope classes a) < 10% (No Data); b) > 10 %;c) > 15%; and d) > 20%. These classes were examined for correlation with rocky shores based on available topographic maps where rocky shores were previously delineated. It was determined that all areas greater than 10% slope were a good candidate for surrogate modeling of rocky shores. A shoreline buffer was then created to clip out the coastal rocky shores. A land mask was created from the SRTM data (all land area was recoded to 1) and a 250 meter inside buffer was used to clip out the coastal rocky shores. These areas were then converted to polygons using the GRIDPOLY command in ArcInfo Workstation. It is important to note that the layer is ONLY derived from elevation data, and is technically steep slopes, not rocky shores. However, this seemed to be the best way to get a remotely sensed model of rocky shorelines in the Caribbean, as there is currently no regional data for this layer. Once the rocky shores were completed, a decision had to be made about the overlap between beaches and rocky shores. It was determined that beaches should have precedence over the rocky shores, so in all areas where there was co-occurrence, beaches became the overriding class. In some instances, the beaches were mapped behind rocky shores; the rocky shores became the overriding class.

Key Attributes: Community structure: 1) Species composition (i.e. Mollusks, crustaceans, echinoderms); 2) Trophic structure – herbivore and predator densities; 3) Seascape pattern and structure: combination of substrate type (soft limestone rock or hard igneous rock communities) and substrate availability slope at the coastline and wave energy intensity.

Key Threats: 1) Fishing: resource depletion and alteration in predation regime reduce species diversity;
2) Coastal development, including shoreline stabilization, land reclamation, habitat destruction, and sewage discharge, cause nutrient loading and reduce species diversity.

Terrestrial

GeoCover LC represents the world's most consistently prepared, moderate-resolution land cover (LC) database (30 x 30m) with plans for long-term updates based on a standardized methodology. Geocover LC was derived from spectral analysis of orthorectified Landsat Thematic Mapper (TM) imagery, and features a standard 13-class land cover based on Landsat TM imagery from CY 2000 GeoCover. The map was prepared for use to delineate terrestrial targets by passing a majority 4x4 filter across the data to generalize the classification and remove single pixel "noise". Non-natural areas classed as; barren, urban/built-up, agriculture (general), and agriculture (rice paddy) were removed. This approach provides a consistently modeled terrestrial ecosystem map for the entire region. The USGS Surface Geology map portion of the terrestrial targets also provides a consistent mapping methodology and a spatially accurate product across the assessment area.

<u>Nested Vegetation and Faunal Targets within Ecoregional Targets</u>

Puerto Rican Dry Forest Ecoregion on volcanic, sedimentary and alluvial substrates
Nested vegetation communities (International Institute of Tropical Forestry (IITF) Map (Helmer, 2005):

- Lowland dry semideciduous forest

- Lowland dry semideciduous woodland/shrubland
- Lowland dry mixed evergreen drought-deciduous shrubland with succulents

Nested faunal targets (DNER database):
- *Dermochelys coriacea(*G3)
- *Eretmochelys imbricata*(G3)
- *Caprimulgus noctitherus* (G1)

Puerto Rican Dry Forests on limestone substrate
Nested vegetation communities (IITF Map):
- Lowland dry semideciduous forest;
- Lowland dry semideciduous woodland/shrubland;
- Lowland dry mixed evergreen drought-deciduous shrubland with succulents

Nested faunal targets (DNER database):
- *Caprimulgus noctitherus* (G1)
- *Agelaius xanthomus* (G1)
- *Peltophryne lemur* (G1)
- *Anolis cooki* (G2)
- *Eretmochelys imbricata* (G3).

Puerto Rican Dry Forests on ultramafic substrate
Nested vegetation communities (IITF Map):
- Lowland dry and moist, mixed seasonal evergreen sclerophyllous forest

Puerto Rican Moist Forests on volcanic, sedimentary and alluvial substrates
Nested vegetation communities (IITF Map):
- Lowland moist seasonal evergreen forest
- Lowland moist seasonal evergreen forest/shrub
- Lowland moist semi-deciduous forest
- Submontane wet evergreen forest
- Submontane and lower montane wet evergreen sclerophyllous forest
- Submontane and lower montane wet evergreen sclerophyllous forest/shrub
- Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee
- Lower montane wet evergreen forest - tall cloud forest
- Lower montane wet evergreen forest - mixed palm and elfin cloud forest
- Lower montane wet evergreen forest - elfin cloud forest

Nested faunal targets (DNER database):

Accipiter straiatus venator (G3T2), *Amazona vittata vittata* (G1), *Amphisbaena bakeri* (G2G3), *Anolis occultus*(G2), *Anthrqacothorax viridis* (G3), *Buteo platypterus brunnescens* (G3T2), *Chlorostilbon maugaeus* (G3), *Columba inornata wetmorei* (G1), *Columba leucocephala* (G3), *Dendroica angelae* (G1G2), *Dermochelys coriacea*(G3), *Dendrocygna arborea*(G3), *Diploglossus pleei* (G2G3),*Eleutherodactylus eneidae*(G1G2), *E. hedricki*(G2), *E. jasperi*(G1), *E. karlschmidti* (G1), *E. locustus*(G1). *E. unicolor*(G1), *E. gryllus*(G2G3) *E. richmondi* (G2), *E. wrightmanae* (G3N3) ,*Epicrates inornatus* (G1G2), *E. monensis* (G2), *E. portoricensis* (G3), *Eretmochelys imbricata*(G3), *Falco peregrinus anatum* (G3), *Melanerpes portoricensis* (G3), *Mormoops blainvillii cinnamomeum* (G3T2), *Myiarchus antillarum* (G3), *Saurothera vieilloti* (G3), *Stenoderma rufum dariori* (G2G3)

Puerto Rican Moist Forests on limestone substrate:
Nested vegetation communities (IITF Map):
- Lowland moist semi-deciduous forest
- Lowland moist semi-deciduous forest/shrub
- Lowland moist seasonal evergreen forest
- Lowland moist seasonal evergreen forest/shrub

Nested faunal targets (DNER database):
Diploglossus pleei (G2G3), *Accipiter striatus venator* (G3T2), *Mormoops blainvillii cinnamomeum* (G3T2), *Epicrates inornatus* (G1G2), *Caprimulgus noctitherus*(G1), *Anolis occultus*(G2), *Pteronotus parnellii portoricensis* (G3T1), *Stenoderma rufum* (G2G3), *Melanerpes portoricensis* (G3), *Buteo platypterus brunnescens* (G3T2), *Myiarchus antillarum*(G3).

Puerto Rican Moist Forests on ultramafic substrate
Nested vegetation communities (IITF Map):
- Lowland dry and moist, mixed seasonal evergreen sclerophyllous forest
- Submontane and lower montane wet evergreen forest/shrub and active/abandoned shade coffee.

Nested faunal targets (DNER database):
Caprimulgus noctitherus (G1), *Stenoderma rufum darioi* (G2G3), *Eleutherodactylus eneidae*(G1G2), *Amphisbaena bakeri*(G2G3), *Diploglossus pleei* (G2G3), *Diploglossus pleei* (G2G3), *Accipiter striatus venator* (G3T2), *Anolis occultus* (G2), *Amphisbaena bakeri* (G2G3), *Eleutherodactylus eneidae*(G1G2).

Jamaican Dry Forests on volcanic, sedimentary and alluvial substrates
Nested vegetation communities (TNC Land Cover Map, 1998):
- Lowland semi-deciduous forest
- Lowland semi-deciduous forest with admixture of lowland drought deciduous shrubland
- Mixed seasonal evergreen & semi-deciduous forest
- Disturbed lowland/submontane semi-deciduous forest

Jamaican Dry Forests on limestone substrate
Nested vegetation communities (TNC Land Cover Map, 1998):
- Lowland semi-deciduous forest
- Lowland semi-deciduous forest with admixture of lowland drought deciduous shrubland
- Lowland semi-deciduous forest with admixture of mixed evergreen-drought deciduous shrubland with succulents
- Mixed evergreen-drought deciduous shrubland with succulents
- Mixed seasonal evergreen and semi-deciduous forest

Jamaica Moist Forests on volcanic, sedimentary and alluvial substrates
Nested vegetation communities (TNC Land Cover Map, 1998):
- Lowland/submontane seasonal evergreen forest
- Mixed seasonal evergreen and semi-deciduous forest
- Submontane rain forest on shale/volcanic rock
- Montane rain forest on shale/volcanic rock

Jamaica Moist Forests on limestone substrate

Nested vegetation communities (TNC Land Cover Map, 1998):

- Lowland semi-deciduous forest
- Lowland semi-deciduous forest with admixture of lowland drought deciduous shrubland
- Lowland/submontane seasonal evergreen forest
- Mixed seasonal evergreen and semi-deciduous forest
- Submontane rain forest on limestone
- Montane rain forest on limestone

Jamaica Moist Forests on ultramafic substrate

Nested vegetation communities (TNC Land Cover Map, 1998):

- Disturbed submontane rain forest on limestone
- Giant bunch bamboo forest/shrubland mixed areas of herbaceous/shrub/tree cultivars
- Submontane rain forest on shale/volcanic rock

Hispaniola Dry Forests on volcanic, sedimentary and alluvial substrates

Nested vegetation communities (DIRENA Map, 1996):

- Dry forest

Hispaniola Dry Forests on limestone substrate:

Nested vegetation communities (Hager & Zanoni, 1993):

- Dry forest of Peninsula of Barahona.

Hispaniola Moist Forests on volcanic, sedimentary and alluvial substrates

Nested vegetation communities (DIRENA Map, 1996):

- Montane rain forest and cloud forest, submontane rain and seasonal evergreen forests and lowland semi-decidous forest.

Hispaniola Moist Forests on limestone substrate

Nested vegetation communities:

- Bosque de Los Haitises (Hager & Zanoni, 1993); montane rain forest and cloud forest, submontane rain and seasonal evergreen forests and lowland semi-decidous forest.

Hispaniola Moist Forests on ultramafic substrate

Nested vegetation communities:

- Montane rain forest and cloud forest, submontane rain and seasonal evergreen forests.

Hispaniola pine forests on volcanic, sedimentary and alluvial substrates

Nested vegetation communities: (Areces-Mallea et al., 1999):

- Montane pine forest and mixed pine-broad-leaved forest and pine woodland.

Hispaniola pine forests on limestone substrate

Nested vegetation communities (Areces-Mallea et al., 1999):

- Montane pine forest and mixed pine-broad-leaved forest and pine woodland.

Hispaniola pine forests on ultramafic substrate

Nested vegetation communities (Areces-Mallea et al., 1999):

- Montane pine forest and mixed pine-broad-leaved forest and pine woodland.

Cuban Dry Forests on volcanic, sedimentary and alluvial substrates
Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba:* Semi-deciduous forest, Dry evergreen forest: *Swietenia mahagoni-Metopietum brownie* forests, *Lysiloma latisiliqua - Swietenia mahagoni - Peltophorum adnatum - Bucida spinosa - Pseudosamanea cubana / Tillandsia usneoides* forests., *Phyllostylon brasiliensis - Maytenus buxifolia - Pilososereus brooksianus - Amyris elemifera* forests, and *Phyllostylon brasiliensis - Senna insularis - Stenocereus peruvianus - Dendrocereus nudiflorus* forests.
- TNC Land Cover Map, 1998: Lowland semi-deciduous forest, Mixed pine-broad-leaved forest, Succulent evergreen woodland, xeromorphic mixed evergreen-deciduous forest.

Cuban Dry Forests on limestone substrates
Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba:* Dry evergreen forest, Xerophytic semi-deciduous forest: *Bombacopsis cubensis-Catalpa punctata* forests, *Coccoloba diversifolia-Bursera simaruba* forests and *Zanthoxylum elephantiasis-Bursera simaruba* forests
- TNC Land Cover Map, 1998: Haystack mountain (Mogote) complex, lowland semi-deciduous forest, Lowland/submontane evergreen sclerophllous forest, seasonally flooded/saturated semi-deciduous forest and xeromorphic mixed evergreen-deciduous forest.

Cuban Dry Forests on ultramafic substrate
Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba:* Dry thorny serpentine shrubwoods: *Coccothrinax miraguana.- Tabebuia lepidota, Guettarda sp. Jacaranda cowellii, Rondeletio sp.-Guettarda clarensis, Copernicia sp.-Tabebuia trachycarpa, Acacia belairiodi-Spirotecoma holguinensis* communities
- TNC Land Cover Map, 1998: Lowland semi-deciduous forest and montane evergreen extremely xeromorphic serpentine woodland.

Cuban Moist Forests on volcanic, sedimentary and alluvial substrate
Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba:* Submontane rain forest, wet montane rain forest, elfin forest: *Carapa guianensis - Calophyllum utile* forest, *Hyeronima nipensis - Sloanea curatellifolia - Byrsonima coriacea* Forest, *Prestoea montana / Cordia borinquensis - Miconia sintenisii* forest (palm brake/ forest), *Bonnetia cubensis - Pera ekmanii - Podocarpus ekmanii* Forest, *Magnolia cubensis ssp. acunae - Cyrilla racemiflora* forest, *Magnolia cubensis ssp. cubensis - Laplacea angustifolia - Ocotea ekmanii* forest, *Ocotea ekmani - Cyrilla racemiflora* forest and *Weinmannia pinnata-Cyrilla racemiflora.*
- TNC Land Cover Map, 1998: Cloud forest, lowland rain forest, lowland seasonal evergreen forest, montane rain forest, seasonally flooded/saturated semi-deciduous forest, submontane rain forest and submontane seasonal evergreen forest.

Cuban Moist Forests on limestone substrate
Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba*: West-Cuban species rich karstic forest, *Spathelio brittonii-Gaussion princes* forest, *Tabebuia albicans-Coccothrinax elegans* forests, and *Tabebuia sauvallei-Garrya fadyenii* forests.
- TNC Land Cover Map, 1998: Haystack mountain (Mogote) complex, lowland seasonal evergreen forest, seasonally flooded/saturated semi-deciduous forest, submontane rain forest, submontane seasonal evergreen forest.

Cuban Moist Forests on ultramafic substrate

Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba*: Semi-dry, sclerophyllous montane rain forest on serpentine, *Pinus cubensis* forest on serpentine: *Podocarpus ekmanii- Hyeronima nipensis, Sloanetum curatellifolia, Clusia spp. - Ilex spp.* shrublands *, Ilex spp. - Laplacea moaensis*, *Myrcia retivenia - Bourreria pauciflora.*
- TNC Land Cover Map, 1998: Cloud forest, Lowland rain forest, Lowland seasonal evergreen forest, Montain rain forest, Submontane rain forest, Submontane seasonal evergreen forest.

Cuban Pine Forests on volcanic, sedimentary and alluvial substrates

Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba*: *Pinus tropicalis-Pinus caribaea* woodland on slate: *Pinus tropicalis - Pinus caribaea var. caribaea* Forest , *Pinus tropicalis / -Byrsonima crassifolia - Tabebuia lepidophylla* woodland, *Pinus tropicalis / Eragrostis cubensis* woodland, *Pinus tropicalis / Paepalanthus seslerioides - Syngonanthus insularis* woodland.
- TNC Land Cover Map, 1998: Pine woodland, tropical or subtropical needle-leaved evergreen woodland.

Cuban Pine Forests on limestone substrate

Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba*: In the northwest, a mix of West-Cuban species rich karstic forest, and Pinus tropicalis-Pinus caribaea woodland; in the south east, parts of middle and east Cuban Karstic forest.
- TNC Land Cover Map, 1998: Pine woodland.

Cuban Pine Forests on ultramafic substrate

Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba*: Pinus cubensis forest on serpentine: *Pinus cubensis - Dracaena cubensis* forest, *Pinus cubensis / Agave shaferi - Ariadne shaferi* woodland, *Pinus cubensis / Anemia coriacea - Anemia nipensis - Clerodendron nipense w*oodland, *Pinus cubensis / Bactris cubensis - Shafera platyphylla* forest, Pinus cubensis / Euphorbia helenae woodland, *Pinus cubensis / Rhynchospora tenuis - Baccharis scoparioides - Vernonia urbaniana* forest.
- TNC Land Cover Map, 1998: Tropical or subtropical needle-leaved evergreen woodland, pine woodland

Cuban Cactus Scrub on volcanic, sedimentary and alluvial substrates

Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba*: Semi-desert cactus scrubs (on sandy soils).
- TNC Land Cover Map, 1998: Secondary or succesional herbaceous and woody vegetation.

Cuban Cactus Scrub on limestone substrate

Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba*: Semi-desert cactus scrubs (on rock).
- TNC Land Cover Map, 1998: Succulent extremely xeromorphic evergreen shrubland.

Cuban Cactus Scrub on ultramafic substrate

Nested vegetation communities:

- Borhidi, 1991. *Phytogeography of Cuba*: Semi-desert cactus scrubs (on rock).

- TNC Land Cover Map, 1998: Lowland/submontane evergreen serpentine shrubland.

Nested vegetation communities

- Areces-Mallea *et al*., 1999**:** Pine woodland, Dry Pine Barren: *Pinus caribaea* var. *bahamensis* - *Coccothrinax argentea - Vernonia bahamense- Tabebuia bahamensis* woodland; Saturated pine woodland**,** Wet Pine Barren: *Pinus caribaea*var. *Bahamensis - Metopium toxiferum - Byrsonima lucida*woodland, pine woodland; saturated pine woodland.

Winward Islands Moist Forests on volcanic, sedimentary and alluvial substrates

Nested vegetation communities (Areces-Mallea et al., 1999):

- Submontane rain forest : *Dacryodes excelsa - Sloanea massonii - Talauma dodecapetala - Licania ternatensis* forest.

Winward Islands Moist Forests on limestone

Nested vegetation communities (Areces-Mallea et al. 1999):

- Submontane rain forest : *Dacryodes excelsa - Sloanea massonii - Talauma dodecapetala - Licania ternatensis*.

Leeward Islands Moist Forests on volcanic, sedimentary and alluvial substrates

Nested vegetation communities (Areces-Mallea et al., 1999):

- Submontane rain forest : *Dacryodes excelsa - Sloanea massonii - Talauma dodecapetala - Licania ternatensis* forest.

Leeward Islands Moist Forests on limestone substrate

Nested vegetation communities (Areces-Mallea et al., 1999):

- Submontane rain forest : *Dacryodes excelsa - Sloanea massonii - Talauma dodecapetala - Licania ternatensis* forest.

Lesser Antillean Dry Forests on volcanic, sedimentary and alluvial substrates

Nested vegetation communities: Evergreen woodland.

Lesser Antillean Dry Forests on limestone substrate

Nested vegetation communities (Areces-Mallea et al., 1999):

- Succulent evergreen shrubland, seasonally flooded/saturated semi-deciduous forest, lowland seasonal evergreen forest, lowland semi-deciduous forests and evergreen woodland.

Agricultural areas were derived from GeoCover LC, which represents a consistently prepared, moderate-resolution land cover (LC) database (30 x 30m). It is derived from spectral analysis of orthorectified Landsat Thematic Mapper (TM) imagery, and features a standard 13-class land cover based on Landsat TM imagery from CY 1990 and CY 2000.

Freshwater

Watersheds and stream channels were modeled on SRTM level 1.1 data with the insular Caribbean at a cell size of 90m, which is based on data points located every 1-arc second (approximately 30 meters) on a latitude/longitude grid. The absolute vertical accuracy of the elevation data is 16 meters (at 90% confidence). Data voids were filled using a focal mean 4x4 interpolation technique.

Appendix B

GOALS

Freshwater

Target	Goal %	Selection Criteria & Comments
Large Rivers	25	Abundant number of occurrences, most species present in other targets, capacity to maintain its natural variation range
Medium Rivers	25	Abundant number of occurrences, most species present in other targets, capacity to maintain its natural variation range
Small Rivers	25	Abundant number of occurrences, many species present only in the target, capacity to maintain its natural variation range
Estuaries	25	Abundant number of occurrences, most species present in other targets, capacity to maintain its natural variation range
Coastal Lagoons	99	Rare, some species present only in the target, subject to many potential factors that alter its natural range of variation. For the Bahamas we lower the goal to 50% as the number of occurrences was much higher than in the island system
Coastal Springs	25 – 75	Abundant number of occurrences, many species present only in the target, capacity to maintain its natural variation range. Lower goal applies to Greater Antilles Ecoregions as target is less abundant in other ecoregions.
Freshwater Wetlands	50 -75	Abundant number of occurrences, some species present only in the target, capacity to maintain its natural variation range is subject to many different factors, Potential for extinction with biodiversity implications. Lower goal applies to Greater Antilles Ecoregions as target is less abundant in others.
Natural Lakes	99	Rare, some species present only in the target, subject to many potential factors that alter its natural range of variation. Potential for extinction with biodiversity implications. For the continent we lower the goal to 50% as the number of occurrences was much higher than in the island system

Marine

Target	Goal %	Selection Criteria & Comments
SPAGS	20	Determined using the following criteria; landscape context, degree of endemism and rarity, current status compared to historic, vulnerability and whether the habitat was a source area
Sea turtle nesting beach	20	
Seagrass	20	
Birds low	30	
Birds medium	30	
Birds high	40	
Cetacians high	15	
Cetacians medium	10	
Cetacians low	5	
Mangroves	20	
Estuaries	20	
Beaches	20	

Rocky Shores	20	
Blue Holes	30	
Manatees	30	
Coastal Lagoons/Salt Ponds	30	
Channels	30	
Deep Reef Wall	20	
Reef flat	30	

Terrestrial

Target	Goal Ha	Selection Criteria & Comments
Bahamian_Dry_Broadleaf_Evergreen_Limestone	86229.94	
Bahamian_Pine_Mosaic_Limestone	79567.29	30% of Current Extent
Bahamian_Shrublands_Limestone	57813.40	
Caribbean_Shrublands_ExtrIntrSedAllu	8148.54	
Caribbean_Shrublands_Limestone	12854.69	
Cuban cactus scrub_ExtrIntrSedAllu	16127.42	
Cuban cactus scrub_Limestone	12840.96	
Cuban cactus scrub_Ultramafic	289.44	
Cuban dry forests_ExtrIntrSedAllu	346041.00	
Cuban dry forests_Limestone	273305.66	
Cuban dry forests_Ultramafic	28280.58	
Cuban moist forests_ExtrIntrSedAllu	108680.22	
Cuban moist forests_Limestone	75516.35	
Cuban moist forests_Ultramafic	10723.26	
Cuban pine forests_ExtrIntrSedAllu	48038.25	
Cuban pine forests_Limestone	5736.25	
Cuban pine forests_Ultramafic	8383.47	
Cuban wet forests_ExtrIntrSedAllu	7670.34	
Cuban wet forests_Limestone	909.55	
Cuban wet forests_Ultramafic	5016.80	
Hispaniolan dry forests_ExtrIntrSedAllu	81553.26	
Hispaniolan dry forests_Limestone	71425.17	
Hispaniolan dry forests_Ultramafic	4.54	
Hispaniolan moist forests_ExtrIntrSedAllu	179683.66	
Hispaniolan moist forests_Limestone	167671.00	10% of Potential Extent
Hispaniolan moist forests_Ultramafic	2550.06	
Hispaniolan pine forests_ExtrIntrSedAllu	80386.33	
Hispaniolan pine forests_Limestone	35249.55	
Hispaniolan pine forests_Ultramafic	325.02	
Hispaniolan wet forests_ExtrIntrSedAllu	55527.75	
Hispaniolan wet forests_Limestone	47118.31	
Hispaniolan wet forests_Ultramafic	2532.38	
Jamaican dry forests_ExtrIntrSedAllu	6670.37	
Jamaican dry forests_Limestone	15188.79	
Jamaican moist forests_ExtrIntrSedAllu	19914.42	
Jamaican moist forests_Limestone	45543.47	
Jamaican moist forests_Ultramafic	37.53	
Jamaican wet forests_ExtrIntrSedAllu	7081.94	
Jamaican wet forests_Limestone	9372.74	
Jamaican wet forests_Ultramafic	28.37	
Leeward_Islands_Moist_Forests_ExtrIntrSedAllu	8726.35	
Leeward_Islands_Moist_Forests_Limestone	109.44	
Lesser_Antillean_Dry_Forests_ExtrIntrSedAllu	4350.64	
Lesser_Antillean_Dry_Forests_Limestone	595.08	
Puerto Rican dry forests_ExtrIntrSedAllu	8154.71	
Puerto Rican dry forests_Limestone	4002.02	
Puerto Rican moist forests_ExtrIntrSedAllu	40873.99	
Puerto Rican dry forests_Ultramafic	12.72	
Puerto Rican moist forests_Limestone	128.62	30% of Current Extent

Puerto Rican moist forests_Ultramafic	554.67	10% of Potential Extent
Puerto Rican wet forests_ExtrIntrSedAllu	20104.65	
Puerto Rican wet forests_Limestone	652.61	
Puerto Rican wet forests_Ultramafic	518.29	
Windward_Islands_Moist_Forests_ExtrIntrSedAllu	20811.86	
Windward_Islands_Moist_Forests_Limestone	20.40	

Appendix C

STRATIFICATION AND PLANNING UNITS

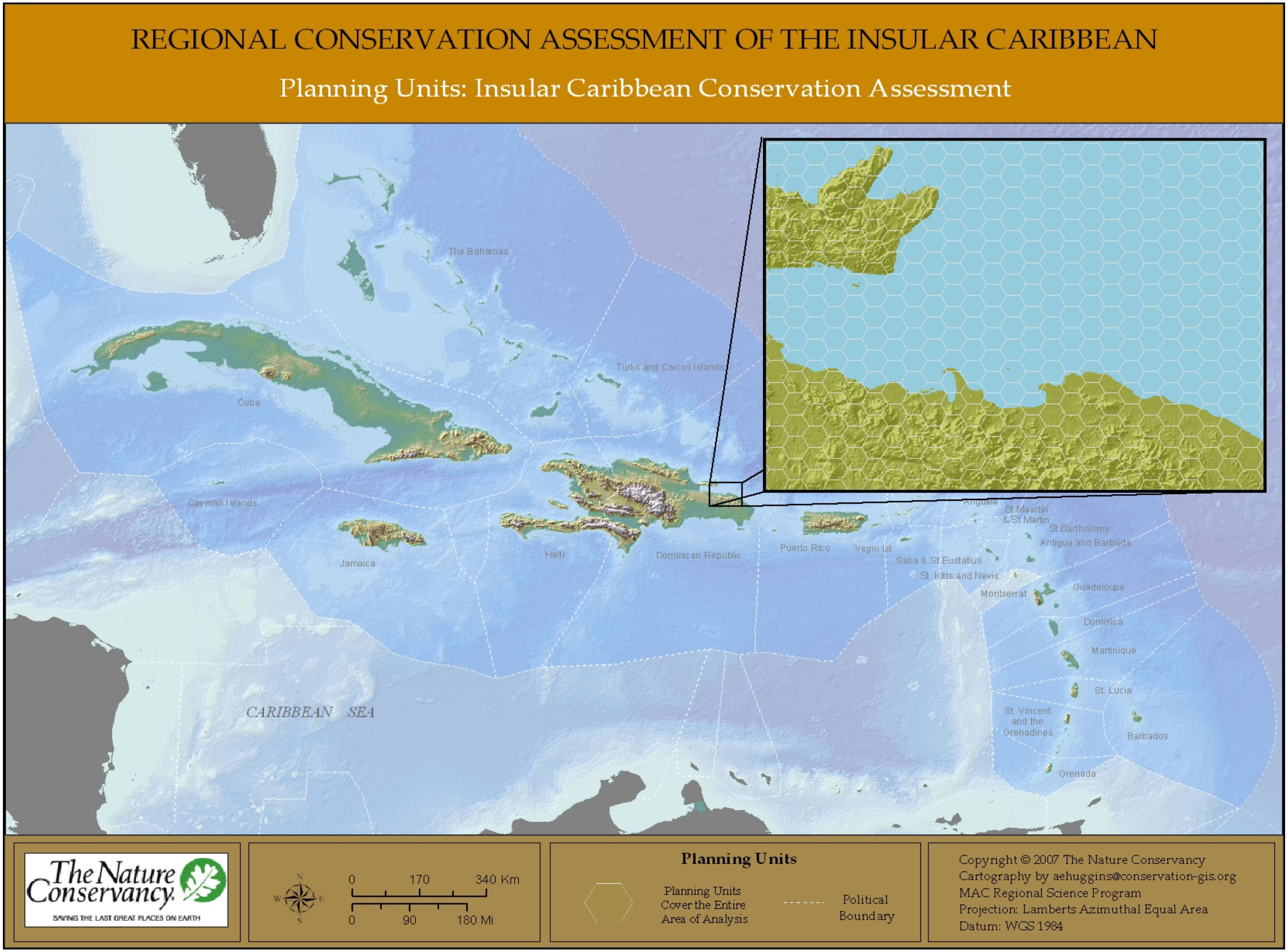

Figure 7; Planning Units

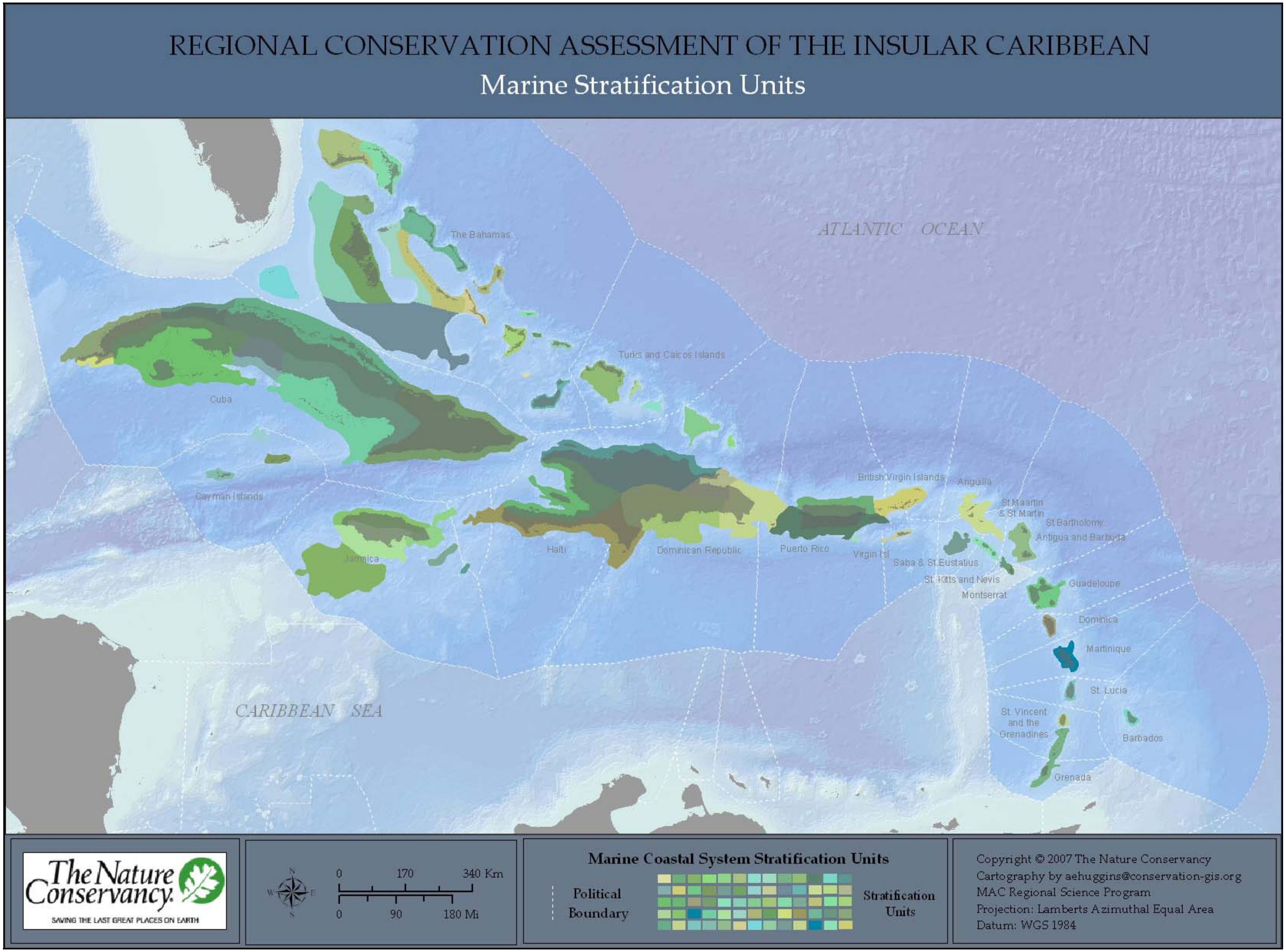

Figure 8; Marine Stratification Units

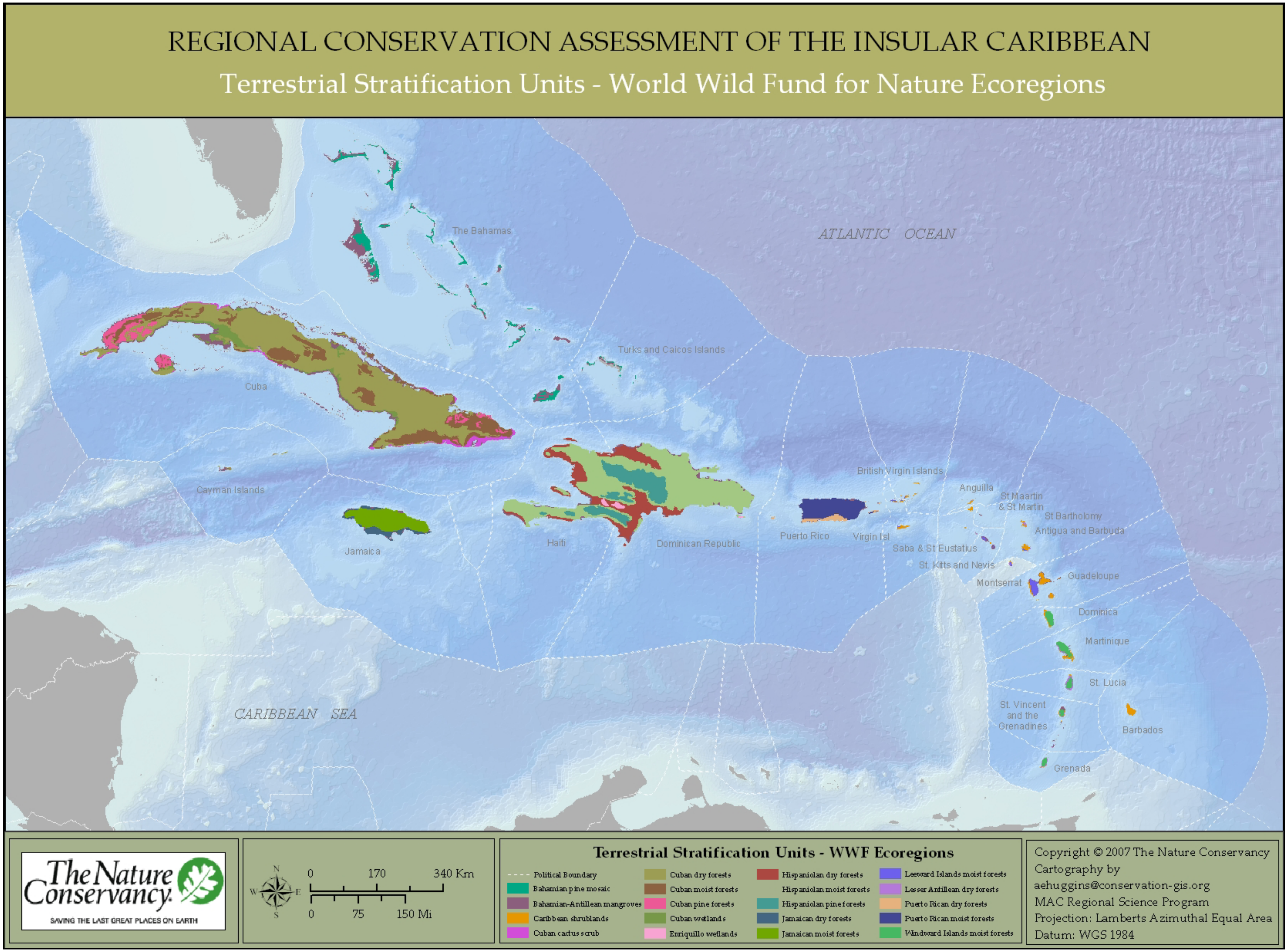

Figure 9; Terrestrial Stratification Units

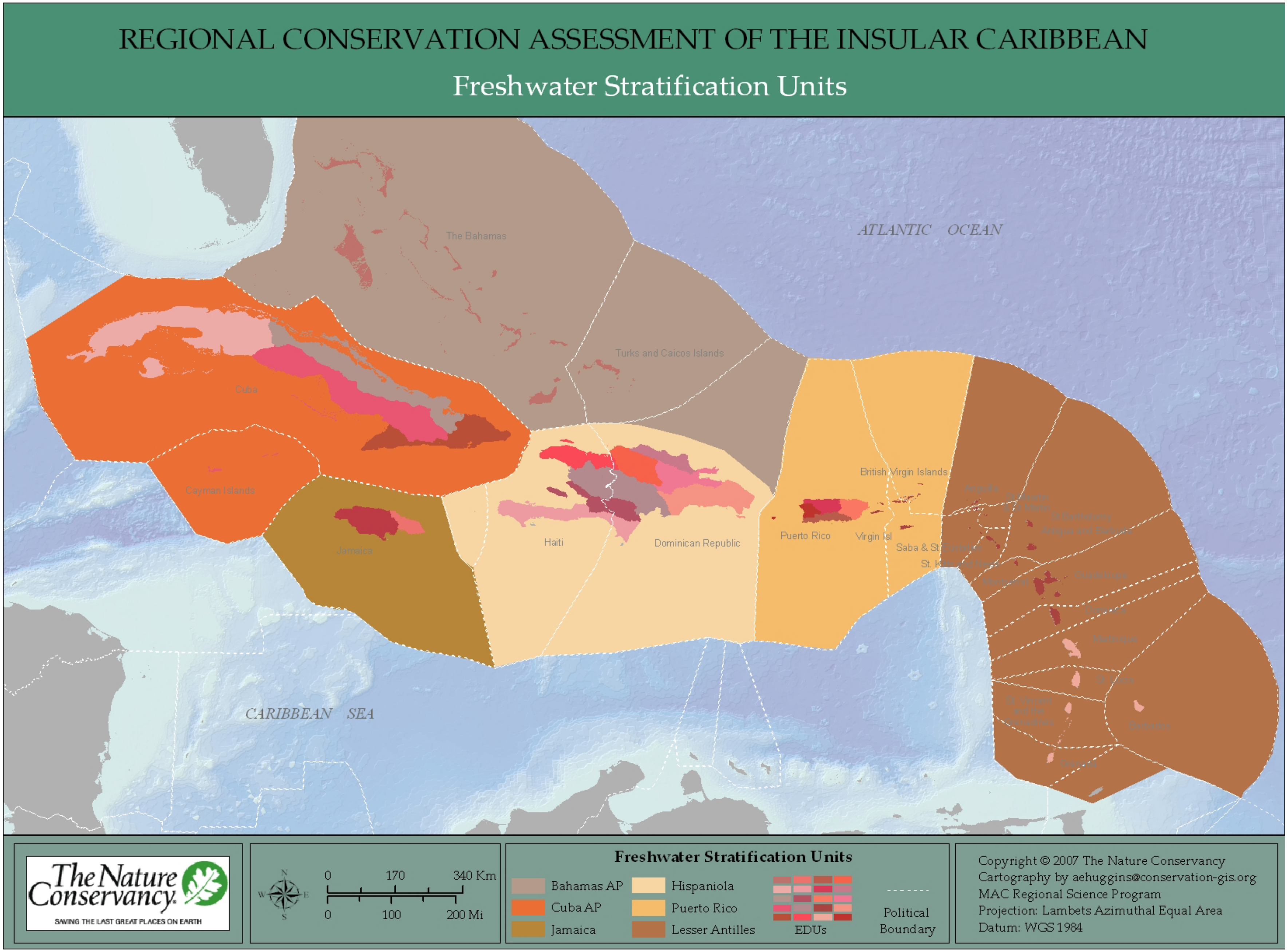

Figure 10; Freshwater Stratification Units

Appendix D

ENVIRONMENTAL RISK SURFACES used as SUITABILITY MAPS

Terrestrial

It was assumed that relative human activity intensity is a surrogate for alteration of key ecological attributes, and for increased conservation cost and likelihood of conservation success; therefore affecting the suitability of impacted areas as candidates for conservation areas. Human activities considered in the suitability surface were tourism, agriculture, roads and urban areas. It was assumed that impact on biodiversity was not linearly related to intensity of the human activity factor. Some factors only begin to have an effect at a certain threshold, whilst others have a large impact at a low level but their effect reaches a plateau with increasing intensity. A logistical function was therefore used to classify the impact of human activities relative to the intensity of each factor into categories (Table 1) with the classes being relative to other threats in the analysis.

The influence of the factors is assumed to decay with distance away from the source, so a distance grid methodology was developed (Huggins, 2004) and the CDSS module 'environmental risk surface' created to carry out the GIS procedures to create the maps. A distance of influence for each threat is calculated. Each class of threat can be assigned a different distance of influence, or one distance can be used for all classes. The procedure carried out by the CDSS module to create an environmental risk surface used here as a suitability map is as follows: grids for each activity are created, and from these the distance away from each activity of every pixel in the map is calculated in a 'distance map'. The grid cell size is dependant on study area size and resolution of threat mapping but independent of planning unit size, except that it should be smaller. Different grids are calculated for each class of intensity of each of the activities. The parts of the grid that are over the distance of influence for each activity are removed. The distance numbers are then inversed to make the maximum score be positioned within the activity and the score tailing down with increasing distance from the site of the activity, to zero at the maximum distance of influence assigned to each activity. Different intensity levels of one threat can be assigned different distances of influences. The distance grids for each activity are then multiplied by the intensity level. These are then combined for each threat (to allow the individual threats to be identified during portfolio investigation) using the maximum value at each point on the map for each activity, and then different activities combined in the same manner. The maximum value method for combining the grids is used to prevent a build up of cost or lowering or suitability in areas where two parts of the same activity that had different distances of influence overlap. For example, shipping lanes and harbours. The reduced suitability for a protected area is provided by the same threat i.e. shipping activity, but the distance of influence is different for the two parts. It also prevents the build up of scores in an area outside an activity to a level higher than inside an activity by the overlap of two circles of influence.

Figure 11 shows examples of polygon, line, and point features that represent human activities with varying intensity values and influence distances. The dark red areas represent higher combined risk and the lighter blue areas, lower risk. Some features may have high risk activities that extend a long distance from the center, while others have a lower risk with more constricted boundaries.

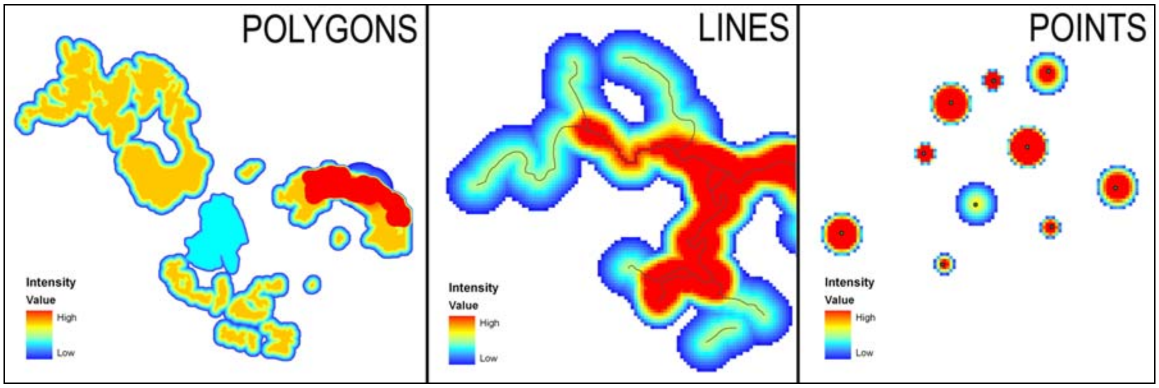

Figure 11; Examples of the components of a suitability index map from polygon, line, and point features. Each feature has an intensity and influence distance assigned. Red represents high risk or lower suitability as a conservation area, with the color fading to lighter blue as a result of distance decay.

Following portfolio selection, during portfolio analysis, the individual activity surfaces can be analyzed within each planning unit and, as they have a finer resolution than the planning unit, the position of a threat within a planning unit can be identified.

Threat Factors Entered into the Terrestrial Suitability Map:

Agriculture

In modern history, Caribbean economies have evolved as primarily agricultural, characterized by monoculture crops, beginning with sugar cane. These have been dominated by large-scale plantation agricultural activities, co-existing with peasant agriculture, which emerged in the post-emancipation period. Most of the land-based agricultural sector activities in the Caribbean are in primary production with the major crops being sugar cane, bananas and rice. Other crops include coffee, citrus, coconuts, cocoa and nutmeg. In addition, a sizeable amount of vegetables and fruits are produced.

Agriculture has many inputs, including capital, labor, machinery, land, water, nutrients, pesticides, and energy. The clearing and preparation of new land, in addition to land maintenance, requires large amounts of energy and the provision of drainage, irrigation, and soil conservation measures. Any inefficiencies in the process particularly with regard to nutrients and pesticides, can impose environmental and social costs, such as reduced water quality and impacts on biodiversity. The identification of crop type within the mapped agriculture allowed a measure of agricultural intensity to be used in the suitability index.

It was important the agriculture data be consistent across the region. Consequently, all agricultural areas were mapped using Geocover LC product from the year 2000. This is a consistent global product at a 30m cell resolution that is derived from satellite classification of Landsat ETM+ scenes (see http://www.geocover.com). The classification of "agriculture" only captures a select portion of the region's agriculture. This is mostly large scale, industrial operations such as sugarcane production, tilled areas used for vegetable or tuber production, mixed cultivation, and some pasture or abandoned agricultural lands.

Urban Areas

Population growth over the next thirty years is expected to be concentrated in urban areas. The smaller urban settlements of less developed regions, such as the Caribbean, are likely to absorb a substantial part of this growth. The spatial extent of urban areas was mapped throughout the region using the year 2000 Geocover Land Cover. USGS population density for year 2000 was used, defined as persons per square kilometer, as a surrogate for urban intensity.

Tourism

Over the past two decades, the Caribbean was become highly dependent on tourism, accounting for a third of all trade, a quarter of foreign exchange earnings, and a fifth of all jobs (de Albuquerque and McElroy, 1995). As such, the tourism sector in the Caribbean has a strong influence on terrestrial, marine and freshwater resources. Negative impacts from tourism occur when the level of visitor use is greater than the environment's ability to cope with the use of natural resources within the acceptable limits of change. More specifically, tourism development and activities can lead to impacts such as soil erosion, increased pollution, discharges into the sea, natural habitat loss, increased pressure on endangered species and heightened vulnerability to forest fires. It also puts a strain on water resources.

Tourism is clearly a driving economic force throughout the Caribbean and likely to shape the human and ecological landscapes and seascapes in the upcoming decades. Assessing and tracking tourism patterns and impacts is a first step towards developing strategies to mitigate them and to promoting compatible and sustainable tourism. To identify general areas of tourism influence, tourism zones were mapped. They represent concentrations of tourism activity and identify where predominant consumption and waste disposal takes place by tourists and include the major hotel and restaurant districts and major tourism activity areas such as beaches, dive centers, golf courses, etc. The Tourism zones were created either from hard copy official "tourism zone" maps provided by the country, or a generalized assessment of natural concentrations of hotels and tourism activities. Numbers of hotel rooms, combined with visitation data and other information (taken from the Caribbean Tourism Organization's annual report, years 2000 and 2001), was used to calculate relative intensity for each zone according to the following formulas (visitation is expressed as density per km^2, daily rates expressed per 24 hour time period):

1. Daily overnight visitors =
(number of rooms) * (average number of visitors per room) * (% occupation for 1 year)

Average number of visitors per day per room (national average) =
((Number of overnight visitors x average stay) /365)/Number of Rooms)

2. Daily non-overnight visitors (e.g. cruise ship visitors) =
i) (Number of visitors per year) x (length of stay in hours) = Number of visitor hours per year
ii) (Number of visitor hours per year) / 24 = Number of visitor days per year
iii) (Number of visitor days per year) / 365 = daily non-overnight visitors

3. Visitation density =
(daily overnight visitors) + (daily non-overnight visitors) / tourism zone area (km^2)

To calculate overall human influence in a tourism zone, tourism intensity value (tourist population per km^2) was combined with urban intensity.

To acquire hotel location information, country tourist boards were contacted by phone or via email. A list of tourist accommodations by island and the number of rooms at each hotel and maps containing hotel locations was gathered. Most countries sent promotional packages with the names of hotels and the number of rooms; while some tourist boards sent direct lists of hotels in word or excel form via email. If additional information was needed, for example, if the lists of hotels sent were not complete or if further information on a hotel location or number of rooms was missing, freely accessible online sources that list hotel information were consulted. Primary sources for this information were found online (http://www.tripadvisor.com and http://www.caribbean-on-line.com/). As supplemental information sources, standard tourist guides and books were used (e.g. Lonely Planet, Rough Guide etc.) and in many cases, verified information by telephone contact directly with individual hotels.

Hotel locations were digitized against the background of the world vector shoreline. For hotels that did not have a location on a map, it was ensured that they were located in the appropriate bay (as most hotels are located along the coastline) or near the closest named town. The digitizing precision located the hotel point in a particular bay, watershed or town, but did not necessarily reflect the exact order or location of hotels within that area. A map of major roads and cities gave context for finding more precise hotel locations.

Roads

Roads have a profound and well-studied negative influence on biodiversity. Roads are defined as linear human disturbances that can accommodate a motorized vehicle, but also include rights-of-way, powerlines, fencelines, pipelines and other similar developments. A number of studies have described the direct and indirect impacts on biodiversity due to the presence of roads including patterns of landscape fragmentation (for a review see Trombulak & Frissell, 2000). A direct impact is traffic caused mortality (Fraser & Thomas 1982). Road construction increases the rates of landslides from 30 to 350 fold (Sidle *et al.,* 1985), and similarly. Roads influence sedimentation, invasive species introduction and chemical contaminant rates in forest ecosystems, measured from a range of 25 meters to over 200 meters (Quarles *et al.* 1974; Dale and Freedman 1982; Greenberg *et al.* 1997; also see Trombulak & Frissell 2000). The USGS road map used, acknowledging that although more roads exist on the landscape than are mapped in this data set, the spatial configuration is likely to be similar, so can represent relative densities.

Activity Scales and Influence Distances

Factor	Intensity Indicator	Intensity	Distance
Agriculture	Crop Type Intensity Score 1	0.05	1000m
	4	0.11	1000m
	8	0.17	1000m
	12	0.25	1000m
	18	0.5	1000m
	22	0.75	1000m
	33	0.87	1000m
	40	0.95	1000m
Urban areas	Population Density 1-9	5	250m
	10-29	11	250m
	30-49	17	250m
	50-99	25	250m
	100-199	5	250m
	200-499	75	250m
	500-999	87	250m
	1000-19999	95	250m
	20000+	100	250m
Tourism Zones	0-100 rooms	5	1000m
	100-200 rooms	11	1000m
	200-500 room	25	1000m
	500+ rooms	50	1000m
Roads	Divided Highways	50	500m
	Primary/Secondary	25	500m
	Path/Trails	11	500m

Table 1: Intensities and influence distances

Freshwater

A flow accumulation model was used to calculate relative freshwater conservation area suitability map. For each point on the map, the total area and intensity of upstream human activities was calculated and used as a surrogate for relative impact or suitability for inclusion in a portfolio of conservation areas. First, flow direction is calculated using the FLOWDIRECTION command in the ARC/INFO GRID module, which shows the direction of flow out of each cell. In order to define a drainage network, the FLOWDIRECTION command identifies the steepest down-slope flow path between each cell of a raster DEM and its eight neighbor cells. The path is the flow path leaving each raster cell. This technique uses the D-8 method where each cell can flow in one of eight cardinal directions based on the slope within the given cell.

Once the flow direction is established, the flow accumulation was calculated using the ARC/INFO GRID command FLOWACCUMULATION. This process identifies the total number of upstream cells flowing into a given cell or the sum of the upstream grid cell values that flow into a given cell. If a cell has an undefined flow direction (or zero slope), these cells will only receive flow and will not contribute to any downstream flow. The accumulated flow is based upon the number of cells flowing into each cell in the output grid (Figure 12). The current processing cell is not considered in this accumulation. Output cells with a high flow accumulation are areas of concentrated flow and may be used to identify stream channels. Output cells with a flow accumulation of zero are local topographic highs and may be used to identify ridges.

Agriculture and urban grids were used as weight grids to calculate the total number of agriculture or urban cells that flow into any given cell in a watershed. The maximum value per planning unit was calculated and used as a suitability map for analysis of candidate areas using MARXAN to select a freshwater conservation areas portfolio.

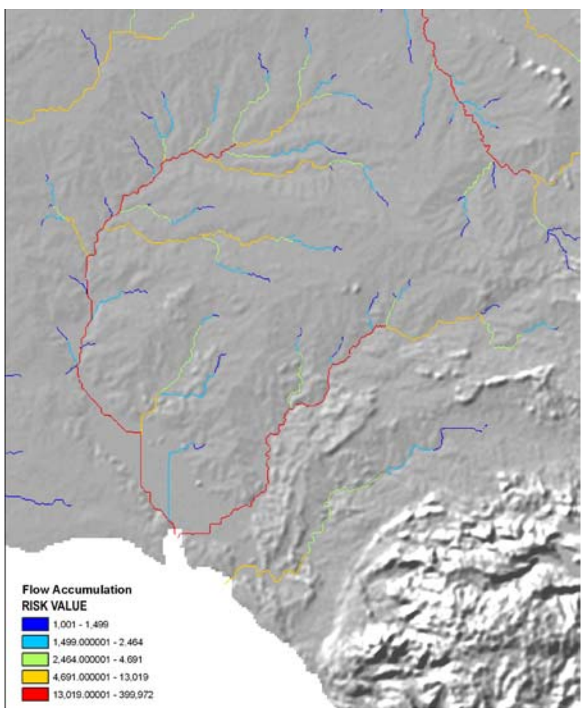

Figure 12; Flow accumulation model detail

Marine

The World Resource Institute's Reefs at Risk models (Burke & Maidens, 2004) were used as a suitability map for assessing candidate areas for a portfolio of conservation areas. Four marine impact models describing coastal development, sediment and pollution from inland sources, marine-based sources of threat and over-fishing, were combined into a single suitability map.
See http://www.reefsatrisk.wri.org for additional model details.

Coastal Development

● Threats to reefs were evaluated based on distance from cities, ports, airports, and dive tourism centers. Cities and ports were stratified by size.
● Coastal population density (2000), coastal population growth (1990–2000), and annual tourism growth were combined into indicator of "population pressure" treated as an additional 'stressor'.
● Thresholds selected for each stressor based on guidance from project collaborators and observations of local damage from coastal development (including sewage discharge). Stressors aggregated into single map layer.
● Management effectiveness included as mitigating factor for threats to reefs inside marine protected areas.
● Data sets used are the best available, but limitations regarding accuracy and completeness are inevitable.
● In particular, rapid growth of tourism sector makes it difficult to capture the most recent developments.

Sediment and Pollution from Inland Sources

● Watershed-based analysis links land-based sources of threat with point of discharge to the sea.
● Analysis of sediment and pollution threat to coral reefs implemented for more than 3,000 watersheds discharging to the Caribbean.
● Relative erosion rates estimated across the landscape, based on slope, land cover type, precipitation (during the month of maximum rainfall), and soil type.
● Erosion rates summarized by watershed (adjusting for watershed size) to estimate resulting sediment delivery at river mouths.
● Sediment plume dispersion estimated using a function in which sediment diminishes as distance from the river mouth increases. Estimated sediment plumes calibrated against observed sediment impacts on selected coral reefs
● Nutrient delivery to coastal waters probably underestimated due to lack of spatial data on crop cultivation and fertilizer application and resulting use of a proxy (sediment delivery) for indirect estimation
● Sediment and nutrient delivery from flat agricultural lands probably underestimated because slope is a very influential variable in estimating relative erosion rates.

Marine-Based Sources of Threat

● Threats to coral reefs from marine-based sources evaluated based on distance to ports, stratified by size; intensity of cruise ship visitation; and distance to oil and gas infrastructure, processing, and pipelines.
● Estimates focus on ships in or near port. Threat associated with marine travel lanes probably underestimated due to lack of sufficiently detailed database on Caribbean shipping lanes.

Overfishing

● Threats to coral reefs evaluated based on coastal population density and shelf area (up to 30 m depth) within 30 km of reef. Analysis calibrated using survey observations of coral reef fish abundance.
● Management effectiveness included as mitigating factor for threats to reefs inside marine protected areas (MPAs).

● Destructive fishing practices not evaluated, as these are rare in the Caribbean region.
● Local over fishing pressure captured in proxy indicator (based on human population per unit of coastal shelf area), due to lack of spatially-specific data on numbers of fishers, landing sites, fishing method/effort, or fish catch from reef fisheries.
● Indicator reflects fishing within 30 km of shore. Impacts of larger-scale commercial fishing pressure, illegal fishing, or movement of fleets are not included in this analysis.

Appendix E

MARXAN SOFTWARE

Early conservation assessments depended on manual mapping to delineate sites and were often reliant on expert opinion to prioritize conservation areas. The large number, size and diverse types of datasets describing the targets in this analysis required the use of a more systematic and efficient site selection procedure. The software MARXAN provides decision support for teams of experts choosing between hundreds of biodiversity targets and thousands of candidate areas (planning units). It identifies efficient portfolios of planning units and has a measure of flexibility that allows the teams to adapt efficient solutions to real world situations. Using a transparent process that is driven by quantitative goals, the analysis is repeatable and objective. MARXAN results can illustrate a pattern of priority sites of low political or social pressure that can still satisfy the explicit biodiversity goals. It can also identify a network of sites where resources necessary to implement conservation strategies or threat abatement are forecast to be lower due to threat or other factors.

Planning units are parts of the land and seascape that are analyzed as the potential building blocks of an expanded system of reserves or areas of conservation priority. They allow a comparison between candidate areas. Planning units can be natural, administrative or arbitrary sub divisions of the landscape. They differ widely in size between studies and within regions, dependant mostly on scale of analysis and data resolution. Two MARXAN tutorials, that also contain guidelines for running MARXAN, are available on the accompanying DVD, one designed for use by GIS beginners and one designer for GIS users.

MAARXAN Algorithm

MARXAN implements a 'simulated annealing' site optimization algorithm. In order to design an optimal reserve network, each planning unit is examined for the values it contains. The features within one planning unit may be valuable alone but may not be the best choice overall, depending on the distribution and replication of those features in the wider planning area.

During the procedure, an initial portfolio of planning units is selected. Planning units are then added and removed in an attempt to improve the efficiency of the portfolio. Early in the procedure, changes in the portfolio that do not improve efficiency can be made in order to allow the possibility of finding a more efficient overall portfolio. The requirement to accept only those changes that improve efficiency becomes stricter as the algorithm progresses through a set of iterations. Note that for any set of conservation targets and goals, there may be many efficient and representative portfolios that meet all conservation goals – but most of these networks would have a number of planning units in common. Many runs of the algorithm are used to find the most efficient portfolio and to calculate a measure of *irreplaceability* or flexibility (used here to indicate the number of times a particular unit is chosen). In some cases, conservation targets are only found in limited sites – areas of low flexibility or high irreplaceability that are always chosen in any representative portfolio. Additionally, areas of low flexibility (or high irreplaceability) also include planning units whose exclusion would require a proportionally larger conservation area network to achieve the same level of representation, resulting in a loss of portfolio efficiency.

The algorithm attempts to minimize portfolio total 'cost' whilst meeting conservation goals in a spatially compact network of sites. This set of objectives constitutes the 'objective cost function':

Total Cost = Unit Cost (or suitability score) + Species Penalties + Boundary Length

where 'Total Cost' is the objective (to be minimized), 'Unit Cost' is a cost assigned to each planning unit (a measure of suitability due to human activities is used in the current analysis), 'Species Penalties' are costs imposed for failing to meet biodiversity target goals, and 'Boundary Length' is a cost determined by the total outer boundary length of the portfolio.

Attempts are made to minimize the total portfolio cost by selecting the fewest planning units with the lowest total unit cost needed to meet all biodiversity goals, and by selecting planning units that are clustered together rather than dispersed (thus reducing outer boundary length). This task is accomplished by changing the planning units selected and re-evaluating the cost function, through multiple iterations. Alternative scenarios were evaluated by varying the inputs to the total cost function. The boundary length cost factor, for example, can be increased or decreased depending on the assumed importance of a spatially cohesive portfolio of sites.

Portfolios are identified that meet stated goals for representation of the biodiversity targets. The ultimate objective is to find the portfolio that meets stated goals for all target groups in an efficient manner, whilst also meeting the general criteria of reserve design (e.g., connectivity, minimal fragmentation). MARXAN allows many design scenarios to be compared by the planning team, all of which meet all the stated goals and objectives.

Following MARXAN analysis, flexible units can be swapped with other flexible units to build a more practical portfolio of conservation areas that is accepted by the local communities, where conservation strategies have the possibility of succeeding.

Appendix F

PORTFOLIO ANALYSIS

TERRESTRIAL

Conservation Target	Target ID	Total Target Area (Ha)	Goal Area (proportion)	Goal Met
Bahamian Dry Broadleaf Evergreen Limestone	12900	287433.15	10% Potential	yes
Bahamian Pine Mosaic Limestone	13000	265224.29	10% Potential	yes
Bahamian Shrublands Limestone	13100	192711.32	10% Potential	yes
Caribbean Shrublands ExtrIntrSedAllu	13200	86645.54	10% Potential	yes
Caribbean Shrublands Limestone	13300	75308.45	10% Potential	yes
Cuban cactus scrub ExtrIntrSedAllu	16900	150666.12	10% Potential	yes
Cuban cactus scrub Limestone	17000	123928.47	10% Potential	yes
Cuban cactus scrub Ultramafic	17100	2894.42	10% Potential	yes
Cuban dry forests ExtrIntrSedAllu	17200	1964389.98	10% Potential	yes
Cuban dry forests Limestone	17300	1600634.93	10% Potential	yes
Cuban dry forests Ultramafic	17400	210058.00	10% Potential	yes
Cuban moist forests ExtrIntrSedAllu	17500	910561.79	10% Potential	yes
Cuban moist forests Limestone	17600	559468.08	10% Potential	yes
Cuban moist forests Ultramafic	17700	101290.39	10% Potential	yes
Cuban pine forests ExtrIntrSedAllu	17800	341612.75	10% Potential	yes
Cuban pine forests Limestone	17900	35851.28	10% Potential	yes
Cuban pine forests Ultramafic	18000	82062.47	10% Potential	yes
Cuban wet forests ExtrIntrSedAllu	18100	75778.80	10% Potential	yes
Cuban wet forests Limestone	18200	8648.14	10% Potential	yes
Cuban wet forests Ultramafic	18300	49886.03	10% Potential	yes
Hispaniolan dry forests ExtrIntrSedAllu	15800	345648.63	10% Potential	yes
Hispaniolan dry forests Limestone	15900	504064.88	10% Potential	yes
Hispaniolan dry forests Ultramafic	16000	41.28	10% Potential	yes
Hispaniolan moist forests ExtrIntrSedAllu	16100	541356.07	10% Potential	yes
Hispaniolan moist forests Limestone	16200	744041.22	10% Potential	yes
Hispaniolan moist forests Ultramafic	16300	15045.25	10% Potential	yes
Hispaniolan pine forests ExtrIntrSedAllu	15700	502725.40	10% Potential	yes
Hispaniolan pine forests Limestone	16400	187768.68	10% Potential	yes
Hispaniolan pine forests Ultramafic	16500	2361.81	10% Potential	yes
Hispaniolan wet forests ExtrIntrSedAllu	16600	196624.51	10% Potential	yes
Hispaniolan wet forests Limestone	16700	198408.75	10% Potential	yes
Hispaniolan wet forests Ultramafic	16800	16351.83	10% Potential	yes
Jamaican dry forests ExtrIntrSedAllu	14900	10435.46	10% Potential	yes
Jamaican dry forests Limestone	15000	68829.34	10% Potential	yes
Jamaican moist forests ExtrIntrSedAllu	15100	51050.52	10% Potential	yes
Jamaican moist forests Limestone	15200	248336.75	10% Potential	yes
Jamaican moist forests Ultramafic	15300	57.48	10% Potential	yes
Jamaican wet forests ExtrIntrSedAllu	15400	41346.15	10% Potential	yes
Jamaican wet forests Limestone	15500	57528.44	10% Potential	yes
Jamaican wet forests Ultramafic	15600	114.48	10% Potential	yes

Leeward Islands Moist Forests ExtrIntrSedAllu	13400	69601.58	10% Potential	yes
Leeward Islands Moist Forests Limestone	13500	25833.37	10% Potential	yes
Lesser Antillean Dry Forests ExtrIntrSedAllu	13700	21929.69	10% Potential	yes
Lesser Antillean Dry Forests Limestone	13600	4861.33	10% Potential	yes
Puerto Rican dry forests ExtrIntrSedAllu	14000	14722.85	10% Potential	yes
Puerto Rican dry forests Limestone	14100	17504.75	10% Potential	yes
Puerto Rican dry forests Ultramafic	14200	42.39	10% Potential	yes
Puerto Rican moist forests ExtrIntrSedAllu	14300	154866.73	10% Potential	yes
Puerto Rican moist forests Limestone	14400	428.74	10% Potential	yes
Puerto Rican moist forests Ultramafic	14500	3942.21	10% Potential	yes
Puerto Rican wet forests ExtrIntrSedAllu	14600	75731.39	10% Potential	yes
Puerto Rican wet forests Limestone	14700	4765.00	10% Potential	yes
Puerto Rican wet forests Ultramafic	14800	5172.69	10% Potential	yes
Windward Islands Moist Forests ExtrIntrSedAllu	13800	165123.24	10% Potential	yes
Windward Islands Moist Forests Limestone	13900	2826.70	10% Potential	yes

MARINE					
Conservation Target	**Target ID**	**Total Target Area (Ha)**	**Goal Area (%)**	**Area Neecesary to Meet Goal (Ha)**	**Goal Met**
Non reef flat	7573	236888.4800	30	71066.54	Yes
Non reef flat	7572	47891.8300	30	14367.55	Yes
Non reef flat	7571	141993.6900	30	42598.11	Yes
Reef flat	7533	170801.2100	30	51240.36	Yes
Reef flat	7532	22403.6000	30	6721.08	Yes
Reef flat	7531	81663.5300	30	24499.06	Yes
Deep Reef Wall	6703	128334.0400	20	25666.81	No
Deep Reef Wall	6702	16563.2700	20	3312.65	No
Deep Reef Wall	6701	77619.7000	20	15523.94	No
Channels	253	30687.0000	30	9206.10	Yes
Channels	252	815.9400	30	244.78	Yes
Channels	251	100393.4100	30	30118.02	Yes
Coastal Lagoons/Salt Ponds	243	81146.7500	30	24344.03	Yes
Coastal Lagoons/Salt Ponds	242	2045.6100	30	613.68	Yes
Coastal Lagoons/Salt Ponds	241	125844.4100	30	37753.32	Yes
Manatees	233	123.7800	30	37.13	Yes
Manatees	231	6.7500	30	2.03	Yes
Blue Holes	221	40.8200	30	12.25	Yes
Reef Top Lands	213	26427.4200	20	5285.48	Yes
Reef Top Lands	212	9.3900	20	1.88	Yes
Rocky Shores	203	11409.7700	20	2281.95	No
Rocky Shores	202	15640.9200	20	3128.18	Yes
Rocky Shores	201	183.5200	20	36.70	Yes
Beaches	193	32437.9500	20	6487.59	Yes
Beaches	192	3575.7600	20	715.15	Yes
Beaches	191	19661.9700	20	3932.39	Yes
Estuaries	173	1547415.650	20	309483.13	Yes
Estuaries	172	17212.1900	20	3442.44	Yes
Estuaries	171	215210.8300	20	43042.17	Yes
Mangroves	163	1071485.410	20	214297.08	Yes
Mangroves	162	11556.5500	20	2311.31	Yes
Mangroves	161	234486.3100	20	46897.26	Yes
Cetacians	153	11976262.89	5	598813.14	Yes
Cetacians	152	39957.5400	5	1997.88	Yes
Cetacians	151	7614146.770	5	380707.34	Yes
Cetacians	143	5726944.850	10	572694.49	Yes
Cetacians	142	712847.510	10	71284.75	Yes
Cetacians	141	1931627.810	10	193162.78	Yes
Cetacians	133	3664266.580	15	549639.99	Yes
Cetacians	132	2235695.080	15	335354.26	Yes
Cetacians	131	3785229.400	15	567784.41	Yes
Birds high	123	1.6800	40	0.67	Yes
Birds high	122	5.0900	40	2.04	No
Birds high	121	0.7200	40	0.29	No
Birds med	113	1.6500	30	0.50	Yes

Birds med	112	0.9900	30	0.30	Yes
Birds med	111	3.0300	30	0.91	Yes
Birds low	103	2.8300	30	0.85	Yes
Birds low	102	0.2100	30	0.06	Yes
Birds low	101	4.6800	30	1.40	Yes
Seagrass	83	2558251.170	20	511650.23	Yes
Seagrass	82	241475.0600	20	48295.01	Yes
Seagrass	81	3835144.200	20	767028.84	Yes
Sea turtle nesting	73	115.7600	40	46.30	No
Sea turtle nesting	72	190.4100	40	76.16	No
Sea turtle nesting	71	29.2500	40	11.70	Yes
Sea turtle nesting	63	20.2600	30	6.08	Yes
Sea turtle nesting	62	165.4100	30	49.62	Yes
Sea turtle nesting	52	5.6300	20	1.13	Yes
SPAGS	43	944.6700	30	283.40	No
SPAGS	42	170.6300	30	51.19	No
SPAGS	41	516.2300	30	154.87	No
SPAGS	33	6.7800	40	2.71	No
SPAGS	32	0.0000	40	0.00	No
SPAGS	31	3.3900	40	1.36	No
SPAGS	23	30.5100	30	9.15	No
SPAGS	22	14.6900	30	4.41	No
SPAGS	21	1.1300	30	0.34	No
SPAGS	13	7.9100	20	1.58	Yes
SPAGS	12	5.6500	20	1.13	Yes
SPAGS	11	23.5700	20	4.71	Yes

FRESHWATER

Conservation Target	Target ID	Total Target Area (Ha)	Goal Area/ Length (%)	Area/Length Neecesary to meet Goal (Ha)	Area in Portfolio (Ha)	Goal Met
Coastal Lagoons Cuba 2	100	14690.5150	99	14543.60985	13659.656	no
Coastal Lagoons Cuba 3	200	3321.0000	99	3287.79	3225.854	no
Coastal Lagoons Cuba 4	300	5663.7920	99	5607.15408	5620.886	yes
Coastal Lagoons Cuba 5	400	530.0890	99	524.78811	396.76	no
Coastal Lagoons Hispaniola 10	500	70.4960	99	69.79104	69.816	yes
Coastal Lagoons Hispaniola 11	600	443.8430	99	439.40457	443.843	yes
Coastal Lagoons Hispaniola 12	700	933.1540	99	923.82246	929.019	yes
Coastal Lagoons Hispaniola 13	800	426.1740	99	421.91226	426.174	yes
Coastal Lagoons Hispaniola 15	900	1221.8570	99	1209.63843	1221.857	yes
Coastal Lagoons Hispaniola 8	1000	640.3040	99	633.90096	555.493	no
Coastal Lagoons Hispaniola 9	1100	36.9400	99	36.5706	36.94	yes
Coastal Lagoons Jamaica 6	1200	1928.6030	99	1909.31697	1910.638	yes
Coastal Lagoons Lesser Antilles 20	1300	569.9060	99	564.20694	565.533	yes
Coastal Lagoons Lesser Antilles 21	1400	141.2140	99	139.80186	140.73	yes
Coastal Lagoons Puerto Rico 17	1500	290.6370	99	287.73063	290.044	yes
Coastal Lagoons Puerto Rico 18	1600	236.6410	99	234.27459	236.641	yes
Coastal Lagoons Puerto Rico 19	1700	719.4070	99	712.21293	719.407	yes
Lakes Bahamas 1	1800	214.7114434	99	212.564329	0	no
Natural Lakes Cuba 2	1900	3333	99	3300.13332	2893.61	no
Natural Lakes Cuba 3	2000	7464	99	7389.64314	3770.07	no
Natural Lakes Hispaniola 11	2100	592	99	586.08693	570.256	no
Natural Lakes Hispaniola 9	2200	38643	99	38256.65118	38643.081	yes
Natural Lakes Jamaica 6	2300	576	99	570.65877	331.54	no
Natural Lakes Jamaica 7	2400	9	99	8.76546	5.056	no
Natural Lakes Lesser Antilles 20	2500	1250	99	1237.84353	843.047	no
Natural Lakes Lesser Antilles 21	2600	479	99	474.44463	256.797	no
Natural Lakes Puerto Rico 17	2700	6	99	5.46381	5.519	yes
Medium Rivers Cuba 2	2800	2576337.8870	25	644084.4718	695139.359	yes
Medium Rivers Cuba 3	2900	1576788.6330	25	394197.1583	451150.664	yes
Medium Rivers Cuba 4	3000	2506073.6140	25	626518.4035	638155.892	yes
Medium Rivers Cuba 5	3100	1010145.0050	25	252536.2513	403268.706	yes
Medium Rivers Hispaniola 10	3200	1131281.6310	25	282820.4078	367556.516	yes
Medium Rivers Hispaniola 11	3300	537727.3650	25	134431.8413	162402.438	yes
Medium Rivers Hispaniola 12	3400	393550.7500	25	98387.6875	225938.687	yes
Medium Rivers Hispaniola 13	3500	330637.7690	25	82659.44225	95716.551	yes
Medium Rivers Hispaniola 14	3600	455658.6700	25	113914.6675	219852.219	yes
Medium Rivers Hispaniola 15	3700	845427.6900	25	211356.9225	267927.812	yes
Medium Rivers Hispaniola 8	3800	638908.1690	25	159727.0423	178132.181	yes
Medium Rivers Hispaniola 9	3900	306514.1570	25	76628.53925	154906.663	yes

Medium Rivers Jamaica 6	4000	274575.7080	25	68643.927	94979.099	yes
Medium Rivers Jamaica 7	4100	122057.6440	25	30514.411	51045.269	yes
Medium Rivers Lesser Antilles 20	4200	51129.3880	25	12782.347	16804.722	yes
Medium Rivers Lesser Antilles 21	4300	31391.3480	25	7847.837	15074.628	yes
Medium Rivers Puerto Rico 16	4400	80801.6300	25	20200.4075	21031.156	yes
Medium Rivers Puerto Rico 17	4500	137369.1460	25	34342.2865	37125.387	yes
Medium Rivers Puerto Rico 18	4600	176837.0950	25	44209.27375	66323.697	yes
Medium Rivers Puerto Rico 19	4700	163270.9810	25	40817.74525	44118.413	yes
Estuaries Bahamian 1	4800	1.0000	25	0.25	0	no
Estuaries Cuba 2	4900	19.0000	25	4.75	9	yes
Estuaries Cuba 3	5000	15.0000	25	3.75	7	yes
Estuaries Cuba 4	5100	16.0000	25	4	12	yes
Estuaries Cuba 5	5200	4.0000	25	1	3	yes
Estuaries Hispaniola 10	5300	3.0000	25	0.75	3	yes
Estuaries Hispaniola 11	5400	4.0000	25	1	1	yes
Estuaries Hispaniola 12	5500	2.0000	25	0.5	2	yes
Estuaries Hispaniola 13	5600	2.0000	25	0.5	1	yes
Estuaries Hispaniola 14	5700	2.0000	25	0.5	2	yes
Estuaries Hispaniola 15	5800	9.0000	25	2.25	7	yes
Estuaries Hispaniola 8	5900	8.0000	25	2	3	yes
Estuaries Hispaniola 9	6000	2.0000	25	0.5	1	yes
Estuaries Jamaica 6	6100	9.0000	25	2.25	5	yes
Estuaries Jamaica 7	6200	3.0000	25	0.75	2	yes
Estuaries Lesser Antilles 20	6300	3.0000	25	0.75	1	yes
Estuaries Lesser Antilles 21	6400	2.0000	25	0.5	1	yes
Estuaries Puerto Rico 16	6500	3.0000	25	0.75	2	yes
Estuaries Puerto Rico 17	6600	3.0000	25	0.75	1	yes
Estuaries Puerto Rico 18	6700	3.0000	25	0.75	1	yes
Estuaries Puerto Rico 19	6800	2.0000	25	0.5	1	yes
Large Rivers Cuba 2	6900	1289983.6220	25	322495.9055	293258.903	no
Large Rivers Cuba 3	7000	747091.6690	25	186772.9173	192575.825	yes
Large Rivers Cuba 4	7100	1667500.6310	25	416875.1578	411748.863	no
Large Rivers Cuba 5	7200	379434.6350	25	94858.65875	203377.974	yes
Large Rivers Hispaniola 10	7300	927884.2410	25	231971.0603	285619.968	yes
Large Rivers Hispaniola 11	7400	165346.3390	25	41336.58475	30199.617	no
Large Rivers Hispaniola 12	7500	514491.8100	25	128622.9525	278570.348	yes
Large Rivers Hispaniola 13	7600	85624.3590	25	21406.08975	31736.455	yes
Large Rivers Hispaniola 14	7700	330113.5890	25	82528.39725	168643.315	yes
Large Rivers Hispaniola 15	7800	515377.5370	25	128844.3843	257336.9	yes
Large Rivers Hispaniola 8	7900	205743.7820	25	51435.9455	53133.237	yes
Large Rivers Hispaniola 9	8000	201376.3980	25	50344.0995	116145.688	yes
Large Rivers Jamaica 6	8100	259600.2400	25	64900.06	99891.732	yes
Large Rivers Jamaica 7	8200	27602.4120	25	6900.603	19417.801	yes
Large Rivers Lesser Antilles 20	8300	1726.9560	25	431.739	1726.956	yes
Large Rivers Puerto Rico 16	8400	56649.3250	25	14162.33125	14397.86	yes
Large Rivers Puerto Rico 18	8500	79356.6720	25	19839.168	31755.218	yes
Large Rivers Puerto Rico 19	8600	49961.7970	25	12490.44925	16002.028	yes

Small Rivers Cuba 2	8700	4196965.2600	25	1049241.315	1206486.894	yes
Small Rivers Cuba 3 Small Rivers	8800	3327583.9200	25	831895.98	884150.035	yes
Small Rivers Cuba 4 Small Rivers	8900	4145861.1950	25	1036465.299	1141629.43	yes
Small Rivers Cuba 5	9000	1721682.0520	25	430420.513	736878.089	yes
Small Rivers Hispaniola 10	9100	1937482.0990	25	484370.5248	762487.176	yes
Small Rivers Hispaniola 11	9200	669943.4960	25	167485.874	177106.22	yes
Small Rivers Hispaniola 12	9300	825576.2340	25	206394.0585	458640.473	yes
Small Rivers Hispaniola 13	9400	384144.1240	25	96036.031	143622.663	yes
Small Rivers Hispaniola 14	9500	888368.0550	25	222092.0138	399841.419	yes
Small Rivers Hispaniola 15	9600	1130806.5290	25	282701.6323	423722.884	yes
Small Rivers Hispaniola 8	9700	1140812.1090	25	285203.0273	343781.736	yes
Small Rivers Hispaniola 9	9800	521230.1790	25	130307.5448	264873.354	yes
Small Rivers Jamaica 6	9900	596965.4920	25	149241.373	216711.798	yes
Small Rivers Jamaica 7	10000	310338.1780	25	77584.5445	174551.223	yes
Small Rivers Lesser Antilles 20	10100	265375.9700	25	66343.9925	0	no
Small Rivers Lesser Antilles 21	10200	214932.4050	25	53733.10125	109609.376	yes
Small Rivers Puerto Rico 16	10300	158664.1980	25	39666.0495	46157.89	yes
Small Rivers Puerto Rico 17	10400	272482.8890	25	68120.72225	91472.652	yes
Small Rivers Puerto Rico 18	10500	281079.7380	25	70269.9345	121407.097	yes
Small Rivers Puerto Rico 19	10600	396539.8840	25	99134.971	0	no
Wetlands Bahamian 1	10700	9340.3970	75	7005.29775	4747.99	no
Wetlands Cuba 2	10800	7764.2890	50	3882.1445	5289.739	yes
Wetlands Cuba 3	10900	7168.8250	50	3584.4125	4244.561	yes
Wetlands Cuba 4	11000	10511.8380	50	5255.919	8069.618	yes
Wetlands Cuba 5	11100	649.3980	50	324.699	448.783	yes
Wetlands Hispaniola 10	11200	5466.4920	50	2733.246	4925.653	yes
Wetlands Hispaniola 11	11300	703.1060	50	351.553	551.873	yes
Wetlands Hispaniola 12	11400	217.4640	50	108.732	147.933	yes
Wetlands Hispaniola 13	11500	147.6670	50	73.8335	96.428	yes
Wetlands Hispaniola 14	11600	35.9240	50	17.962	35.924	yes
Wetlands Hispaniola 15	11700	133.3840	50	66.692	101.682	yes
Wetlands Hispaniola 8	11800	774.0310	50	387.0155	562.422	yes
Wetlands Hispaniola 9	11900	105.8800	50	52.94	93.955	yes
Wetlands Jamaica 6	12000	11676.2270	50	5838.1135	11563.741	yes
Wetlands Jamaica 7	12100	191.2030	50	95.6015	204.343	yes
Wetlands Lesser Antilles 20	12200	643.7720	75	482.829	238.439	no
Wetlands Lesser Antilles 21	12300	123.2730	75	92.45475	98.261	yes
Wetlands Puerto Rico 16	12400	136.7470	75	102.56025	0	no
Wetlands Puerto Rico 17	12500	200.5750	75	150.43125	75.496	no
Wetlands Puerto Rico 18	12600	12.1070	75	9.08025	0	no
Wetlands Puerto Rico 19	12700	234.5190	75	175.88925	131.191	no
Wetlands Puerto Rico 20	12800	675.0000	75	506.25	88.415	no

Appendix G

CONSERVATION AREAS

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Terrestrial Highlighted areas are those outside the existing designated protected area network

Country	Conservation Area	Principle Ecoregion
Puerto Rico	N of Cordillera Jaicoa	Puerto Rican Moist Forests Ecoregion
Puerto Rico	Rio Abajo Forest Reserve	Puerto Rican Moist Forests Ecoregion
Puerto Rico	Vega Forest Reserve	Puerto Rican Moist Forests Ecoregion
Puerto Rico	Caribbean National Forest extending W to Aguas Buenas and S to Carite Forest Reserve	Puerto Rican Moist Forests Ecoregion
Puerto Rico	Canal Luis Pena Nature Reserve and Wildlife Refuge	Puerto Rican Dry Forests Ecoregion
Puerto Rico	Mona y Monito Nature Reserve	Puerto Rican Dry Forests Ecoregion
Puerto Rico	Maricao Forest Reserve	Puerto Rican Moist Forests Ecoregion
Puerto Rico	Toro Negro Forest Reserve, Tres Picachos Forest Reserve, and Cerillos Forest Reserve	Puerto Rican Moist Forests Ecoregion
Puerto Rico	Cabo Rojo Wildlife Refuge, Boqueron Wildlife Refuge and Guanica Forest Reserve	Puerto Rican Dry Forests Ecoregion
Puerto Rico	Punta Petrona Nature Reserve	Puerto Rican Dry Forests Ecoregion
Puerto Rico	Vieques Nature Reserve	Puerto Rican Dry Forests Ecoregion
Jamaica	Negril Wildlife Refuge	Jamaican Moist Forests Ecoregion
Jamaica	Cockpit Country Forest Reserve	Jamaican Moist Forests Ecoregion
Jamaica	Mt. Diablo Block "A" West	Jamaican Moist Forests Ecoregion
Jamaica	3 forest reserves--Stephney John'S Vale, Kellets-Camperdown, and Mt. Diablo Block "A" East extending to Ocho Rios Marine Park on the north	Jamaican Moist Forests Ecoregion
Jamaica	Blue and John Crow Mountain National Park, Port Antonio Wildlfe Refuge on the NE and Citron Valley Forest Reserve	Jamaican Moist Forests Ecoregion
Jamaica	Black River Wildlife Refuge	Jamaican Moist Forests Ecoregion
Jamaica	Long Bay Wildlife Refuge,Brazilletto Mountains Forest Reserve, Portland Bight Marine Park and Kinston Harbor Marine Park	Jamaican Dry Forests Ecoregion
Hispaniola	Pic Macaya National Park	Hispaniolan Moist Forests Ecoregion
Hispaniola	Moist forests E of Jereme including Grande Cayemite	Hispaniolan Moist Forests Ecoregion
Hispaniola	Forested areas west of Soucé Blanch extending to Duverge and peninsula	Hispaniolan Dry Forests Ecoregion
Hispaniola	Forested areas between Montagnes Noires and Plateau Central	Hispaniolan Moist Forests Ecoregion

Hispaniola	Four protected areas--Foret Des Pins Forest Reserve in Haiti and adjacent Donald Dog National Park in DR, Jaragua National Park and Juan U. Garcia National Park and in-between forested areas	Hispaniolan Dry Forests Ecoregion, Hispaniolan Pine Forests Ecoregion
Hispaniola	Sierra Martin Garcia National Park	Hispaniolan Dry Forests Ecoregion
Hispaniola	Monte Cristi National Park	Hispaniolan Dry Forests Ecoregion
Hispaniola	Madre de las Aguas Conservation areas (5 national parks) extending to Litoral Sur de Santo Domingo National Park	Hispaniolan Pine Forests Ecoregion, Hispaniolan Moist Forests Ecoregion
Hispaniola	Los Haitises National Park, Ideliza Bonnelli de Calventi Nature Reserve	Hispaniolan Moist Forests Ecoregion
Hispaniola	Parque de Este Natioan Park	Hispaniolan Moist Forests Ecoregion
Cuba	Guanahacabibes National Park	Cuban Dry Forests Ecoregion
Cuba	Vinales National Park and some 14 other reserves along the Cordillera de Guaniguanico	Cuban Moist Forests Ecoregion, Cuban Pine Forests Ecoregion
Cuba	Sierra del Rosario Managed Resources, Las peladas Nature Reserve	Cuban Moist Forests Ecoregion, Cuban Dry Forests Ecoregion
Cuba	San Felipe National Park	Not included in the Ecoregion Map
Cuba	Sur de La Isla de La Juventus Managed Resources	Cuban Dry Forests Ecoregion
Cuba	Valle del Yumuri Managed Reserve and adjacent reserves	Cuban Dry Forests Ecoregion
Cuba	Dry forests in Cienaga de Zapata Marine Park	Cuban Dry Forests Ecoregion
Cuba	Topes de Collantes Managed Resources	Cuban Moist Forests Ecoregion
Cuba	Buena Vista Biosphere Reserve and adjacent wetland reserves and wildlife refuge	Cuban Dry Forests Ecoregion
Cuba	Jardines de La Reina National Park	Not included in the Ecoregion Map
Cuba	Forests E of Sierra de Maragúan Flora and Faunal Reserve	Cuban Dry Forests Ecoregion
Cuba	Forests NE of Las Tunas	Cuban Dry Forests Ecoregion
Cuba	Caletones Ecological Reserve	Cuban Dry Forests Ecoregion
Cuba	Desembarco del Grama National Park	Cuban Dry Forests Ecoregion, Cuban Cactus Scrub Ecoregion
Cuba	La Bayamesa National Park	Cuban Moist Forests Ecoregion
Cuba	Baconao Managed Resources	Cuban Moist Forests Ecoregion, Cuban Cactus Scrub Ecoregion
Cuba	Baitiquirí Nature Reserve, Boquerón Ecological Reserve	Cuban Cactus Scrub Ecoregion
Cuba	Cuchillas del Toa Managed Resources connecting with some 14 reserves in the SE	Cuban Moist Forests Ecoregion, Cuban Pine Forests Ecoregion, Cuban Cactus Scrub Ecoregion
Bahamas	Gran Bahama pine forest	Bahamian Pine Mosaic Ecoregion
Bahamas	Abaco National Park	Bahamian Pine Mosaic Ecoregion
Bahamas	Central Andros National Park	Bahamian Pine Mosaic Ecoregion
Bahamas	Exuma Cay Land And Sea Park	Bahamian Dry Forests Ecoregion, Bahamian Shrublands Ecoregion
Bahamas	Great Exuma forests, Moriah Harbour Cay Wildlife Refuge	Bahamian Dry Forests Ecoregion
Bahamas	Cat Island forests nr. New Bight	Bahamian Dry Forests Ecoregion
Bahamas	Inagua National Park	Bahamian Dry Forests Ecoregion, Bahamian Shrublands Ecoregion
Bahamas	Little Inagua National Park	Bahamian Shrublands Ecoregion

Bahamas	North, Middle and East Caicos Island Protected Land and Seascape	Bahamian Dry Forests Ecoregion
Lesser Antilles	Anegada Nature Reserve	Caribbean Shrublands Ecoregion
Lesser Antilles	Virgin Islands National Park	Leeward Islands Moist Forests Ecoregion, Caribbean Shrublands Ecoregion
Lesser Antilles	Land areas of East End Marine Park	Caribbean Shrublands Ecoregion
Lesser Antilles	Guadeloupe National Park	Leeward Islands Moist Forests Ecoregion
Lesser Antilles	Morne Diablotin National Park and Northern Forest Reserve in Dominica	Windward Islands Moist Forests Ecoregion
Lesser Antilles	Morne Trois Pitons National Park in Dominica	Windward Islands Moist Forests Ecoregion
Lesser Antilles	Martinique National Park	Windward Islands Moist Forests Ecoregion
Lesser Antilles	Central Forest Reserve connecting with 3 national Parks--Qualibou, Grande Anse, and Canaries and 4 other protected areas in St. Lucia	Windward Islands Moist Forests Ecoregion, Lesser Antillean Dry Forests Ecoregion
Lesser Antilles	Forests in Central North of Saint Vincent	Windward Islands Moist Forests Ecoregion

Marine

Country/Territory	Conservation Area	Portfolio ID	Stratification shelf ID	Hectares
Bahamas	Western Little Bahama Bank	1	16	118616
Bahamas	Sweetings Cay	2	16	66844
Bahamas	Northern Abaco	3	15	228197
Bahamas	Southern Abaco	4	15	12175
Bahamas	Bimini	5	22	137219
Bahamas	Berry Islands	6	22	60044
Bahamas	West Andros	7	17	513634
Bahamas	High Cay	8	17	5613
Bahamas	South Andros	9	17	252616
Bahamas	Southern Great Bahama Bank	10	14	168375
Bahamas	Central Great Bahama Bank	11	18	313216
Bahamas	Damas Cays	12	2	35909
Bahamas	Anguilla Cays	13	2	13794
Bahamas	West Cay Sal Bank	14	2	58600
Bahamas	New Providence	15	19	5369
Bahamas	Yellow Banks	16	19	2441
Bahamas	Egg Island	17	19	26459
Bahamas	Eluthera Island	18	20	162388
Bahamas	Eastern Great Bahama Bank	19	19	63347
Bahamas	Exumas Land & Seas Park	20	20	78497
Bahamas	Southern Exumas	21	20	126209
Bahamas	Northern Cat Island	22	20	24869
Bahamas	Southern Cat Island	23	20	32481
Bahamas	Northern San Salvador	24	1	14153

Bahamas	Eastern Rum Cay	25	1	11734
Bahamas	Northern Long Island	26	21	14638
Bahamas	Southern Great Exuma Island	27	20	3622
Bahamas	Central Long Island	28	21	12431
Bahamas	Southern Long Island	29	21	6319
Bahamas	Southern Tongue of the Ocean	30	19	11031
Bahamas	Ragged Island Range	31	14	311197
Bahamas	Southern Ragged Islands	32	14	20200
Bahamas	Northern Crooked Island	33	6	18172
Bahamas	Western Samana Cay	34	3	5719
Bahamas	Central Crooked Island	35	6	22075
Bahamas	Acklins Island	36	6	22509
Bahamas	Northern Mayaguana Island	37	5	3275
Bahamas	Southern Mayaguana Island	38	5	3447
Bahamas	Eastern Great Inagua Island	39	10	54428
Turks and Caicos Islands	Northern Caicos Bank	40	9	167075
Turks and Caicos Islands	Turks Bank	41	8	25475
Cuba	Cabo Corrientes	42	24	113722
Cuba	Archipielago de los Colorados-1	43	24	12419
Cuba	Archipielago de los Calorados-2	44	24	35250
Cuba	Matanzas	45	23	5075
Cuba	Jibacoa Bacunayagua	46	23	6913
Cuba	Archipielago de Sabana	47	28	160894
Cuba	Archipielago de Camaguey	48	28	417847
Cuba	Rio Maximo-Laguna Sabinal	49	28	62650
Cuba	La Iseta-Nuevas Grandes	50	31	10741
Cuba	Bahia de Naranjo	51	31	11675
Cuba	Cayo Saetia	52	31	96153
Cuba	Eastern Cuba-1	53	31	5084
Cuba	Eastern Cuba 2	54	31	3775
Cuba	Guantanamo Bay	55	31	37344
Cuba	Baconoa-1	56	31	2375
Cuba	Baconoa-2	57	31	8053
Cuba	Gulf of Guacanabo	58	32	161859
Cuba	Jardines de la Reina	59	32	306922
Cuba	Gulfo de Ana Maria	60	32	222656
Cuba	Cayo Blanco de Casillida	61	32	53503
Cuba	Cienfuegos coast	62	26	3853
Cuba	Eastern Gulf of Batabano.Cazones/Gulf	63	27	585872
Cuba	Inner Gulf of Batabano-2	64	27	3897
Cuba	Inner Gulf of Batabano-1	65	27	4788
Cuba	Gulfo de Batabano -center	66	27	34941
Cuba	Los Indios San Felipe	67	27	106769
Cayman Islands	Offshore Bank- Cayman	68	29	2584
Cayman Islands	Little Cayman	69	30	3844
Cayman Islands	Eastern Grand Cayman	70	33	4822
Cayman Islands	Head of the Barkers-Flats	71	33	7575
Jamaica	Nigril/Western Jamaica	72	39	4819
Jamaica	Pedro Point area	73	39	3588
Jamaica	Fallmouth	74	39	3556
Jamaica	Discovery Bay/Ocho Rios	75	39	3388
Jamaica	Galina Point area	76	39	9109
Jamaica	Port Antonio	77	39	8056
Jamaica	Eastern Jamaica	78	44	17519
Jamaica	Portland Bight	79	45	88097
Jamaica	SW Jamaican Shelf	80	45	3781
Jamaica	South Jamaica shelf- offshore	81	49	12194
Haiti	Western Hispaniola	82	49	5906

Jamaica	Southern Pedro Bank	82	49	196922
Jamaica	Morant Bank	83	46	8459
Haiti	Jacmel area	84	47	2559
Haiti	Ile a Vache	85	47	37563
Haiti	SW Hispaniola	86	47	2475
Haiti	Navassa Area	87	47	23134
Haiti	Les Iles Cayemites	88	38	35031
Haiti	Ile de la Gonave (SE)	90	38	6694
Haiti	Ile de la Gonave (S)	91	38	3169
Haiti	Ile de la Gonave (N)	92	38	4647
Haiti	Gonaives coast	93	38	20853
Haiti	Ile de la Tortue	94	34	24775
Dominican Republic	Montecristi	95	34	96691
Dominican Republic	Luperon coastal area	96	34	41709
Dominican Republic	Mouchoir Bank	97	11	3847
Dominican Republic	Banco de la Plata	98	12	102191
Dominican Republic	Puerto Plata coast	99	34	30034
Dominican Republic	Cabo Frances Viejo	100	34	2466
Dominican Republic	Los Haitises/Samana Bay	101	35	36769
Dominican Republic	Lagunas Redonda Y Limon	102	35	52684
Dominican Republic	Mona Island	103	40	49784
Dominican Republic	Park del Este	104	40	87591
Dominican Republic	La Romana	105	43	6059
Dominican Republic	San Pedro de Macoris	106	43	5788
Dominican Republic	Santo Domingo area	107	43	20125
Dominican Republic	Bahia de Ocoa	108	43	5225
Dominican Republic	Bahia de Neiba	109	43	9738
Dominican Republic	Park Jaragua	110	47	139469
Puerto Rico	Western Puerto Rico	111	41	45400
Puerto Rico	NW Puerto Rico	112	36	4494
Puerto Rico	Laguna Tortuguero/N. Puerto Rico	113	36	14894
Puerto Rico	Eastern Puerto Rico Islands	114	36	130806
Puerto Rico	Isla Caja de Muerto/South PR	115	41	21869
Puerto Rico	La Parguera/SE Puerto Rico	116	41	28100
British Virgin Islands	Anegada/Horshoe Reef	117	37	81869
Virgin Islands	Eastern St. Croix	118	51	10584
Anguilla	Anguilla	119	50	36972
St. Martin	St. Martin	120	50	54078
St. Kitts and Nevis	Saba Bank (W)	121	52	24200
St. Kitts and Nevis	Saba Bank (E)	122	52	4588
St. Kitts and Nevis	NW St. Eustatius	123	53	4647
St. Kitts and Nevis	SE Peninsula	124	53	10019
Antigua and Barbuda	Western Barbuda	125	54	39391
Antigua and Barbuda	NE Antigua	126	54	9969
Montserrat	NW Monserrat	127	55	5653
Guadeloupe	Grand Cul-de-Sac	128	56	15925
Guadeloupe	Southern Grande Terre	129	56	27816
Guadeloupe	Iles des Saintes	130	56	10809
Dominica	Northern Dominica	131	57	10788
Martinique	Caravelle	132	58	2584
Martinique	Village de la Poterie	133	58	5666
Martinique	Grand Macabou	134	58	17106
St. Lucia	Grand Anse Beach	135	59	3478
St. Lucia	Maira Islands/SE St. Lucia	136	59	3156
St. Vincent and the Grenadines	Southern St. Vincent	137	61	3831
Barbados	NE Barbados	138	60	5441
Barbados	SE Coast Barbados	139	60	2531

Grenada/St. Vincent	Grenadines Bank	140	62	56975
Grenada	SE Grenada Bays	141	62	3559

Freshwater

Ecoregion	Site	No	Main Conservation Targets
Bahamas	Andros, Grand Bahama, Eleuthera, Mayaguana, and Caicos	1	Natural Lakes, Blue Holes, Wetlands
Cuba	Sierra Maestra / Humboldt National Park	2	Small rivers, Medium rivers, Large rivers
Cuba	Humedal Rio Maximo – Caguey	3	Small rivers, Medium rivers, Wetlands, Estuary
Cuba	Sierra Maestra / Turquino National Park	4	Small rivers, Medium rivers, Large rivers
Cuba	Cauto River Delta	5	Wetlands, Large river, Estuary
Cuba	Sierra del Escambray	6	Small rivers, Medium rivers, Large rivers
Cuba	Zapata Peninsula	7	Wetlands
Cuba	Pinar del Rio	8	Small rivers, Medium rivers, Wetlands, Estuary
Cuba	Cienaga de Lanier	9	Small rivers, Wetlands
Jamaica	Blue and John Crow Mountains	10	Small rivers, Medium Rivers, Large Rivers, Estuaries
Jamaica	Cockpit Country	11	Small Rivers, Medium Rivers, Large Rivers, Wetlands
Jamaica	Negril Great Morass	12	Small rivers, Wetlands
Jamaica	Black River Lower Morasss	13	Small rivers, Medium rivers, Wetlands, Estuary
Jamaica	Portland Bight	14	Wetlands, Estuary
Jamaica	Ocho Rios	15	Small rivers, Medium rivers
Hispaniola	Massif de la Hotte	16	Small rivers, medium rivers
Hispaniola	Massif de La Selle extended to Tiburon Peninsula	17	Small rivers, Medium rivers, Wetlands, Natural Lakes
Hispaniola	Bahoruco / Enriquillo Complex	18	Small rivers, Medium rivers, Wetlands, Natural Lakes, Coastal Lagoon
Hispaniola	Artibonite River Delta	19	Large river, Estuary, Wetlands
Hispaniola	Artibonite River Highlands	20	Small rivers, Medium rivers
Hispaniola	Yaque del Norte / Masacre Rivers Complex	21	Small rivers, Medium rivers, Large rivers, Coastal lagoons, Natural Lakes, Wetlands, Estuaries
Hispaniola	Cordillera Central River System (Madre de las Aguas)	22	Small rivers, Medium rivers, Highland Wetlands, Natural Lakes
Hispaniola	Yuna River / Samana Bay Complex	23	Small rivers, Medium rivers, Large river, Wetlands, Coastal Lagoons, Estuaries
Hispaniola	Lagunas Redonda y Limon	24	Wetlands, Coastal Lagoons
Hispaniola	Soco / Cumayasa / Chavon Rivers Complex	25	Small rivers, Medium rivers, Wetlands, Coastal Lagoons, Estuaries
Puerto Rico	El Yunque and Close River Systems	26	Small rivers, Medium rivers, Large rivers, Wetlands, Estuaries
Puerto Rico	Mandri and Santa Teresa Lagoons	27	Wetlands, Coastal Lagoons
Puerto Rico	Isla Verde / Grande de Loiza River Complex	28	Wetlands, Coastal Lagoons, Estuarios, Medium River
Puerto Rico	Caño Tiburones / Tortugero Lagoon Complex	29	Wetlans, Estuaries, Coastal Lagoon,
Puerto Rico	Karstic River system Tanamá / Camuy	30	Small rivers, Medium rivers
Puerto Rico	South Central Mountain Range River System	31	Small rivers, Medium rivers, Wetlands, Estuaries
Puerto Rico	Western Aquatic System / Grande de Añasco River	32	Small rivers, Medium rivers, Wetlands, Estuaries, Coastal Lagoons
Lesser	Guadeloupe / Basse - Terre	33	Small rivers, Medium rivers, Wetlands,

Antilles			Estuaries, Coastal Lagoons
Lesser Antilles	Dominica / Morne Trois Pitons	34	Small rivers, Medium rivers, Wetlands, Estuaries, Coastal Lagoons, Natural Lakes
Lesser Antilles	Martinique / Carbet Mountains	35	Small rivers, Medium rivers, Wetlands, Estuaries, Coastal Lagoons
Lesser Antilles	St. Lucia / Mount Gimie – The Pitons	36	Small rivers, Medium rivers, Wetlands, Estuaries, Coastal Lagoons
Lesser Antilles	St. Vincent / La Soufriere - Richmond Peak	37	Small rivers, Medium rivers, Wetlands, Estuaries, Coastal Lagoons
Lesser Antilles	Grenada / Mount St. Catherine	38	Small rivers, Medium rivers, Wetlands, Estuaries, Coastal Lagoons, Natural Lakes

Appendix H

CDSS SPATIAL DATABASE

Introduction

Finding and accessing geospatial data for mapping and modeling purposes can be very problematic within data-poor regions of the world such as the Caribbean. One of the biggest stumbling blocks facing the conservation community is knowing what spatial data is available and where the data resides. The Nature Conservancy worked with key partners in the Caribbean Region to collect, standardize, and centralize vast amounts of conservation-related geospatial data. These data represent a comprehensive biological and socio-economic spatial database for the Caribbean that took over three years to gather, organize and compile and are provided to those who wish and need to understand spatial relationships for balancing economic and environmental interests. The information has been archived in a standardized structure on a freely accessible spatial warehouse using simple, robust systems that are easily accessible to partners, stakeholders and the wider public. The open access data standardization model is designed to facilitate updates of new information that is easily integrated and compared with existing information. It is hoped that this data management structure will provide the ability to respond quickly to external opportunities, leverage funding and facilitate collaboration with other conservation partners.

The following sections provide an overview of the data formats used as well as a discussion on how the data directory structure is organized and defined. Explanations on file naming conventions, projections, metadata content and data gaps/limitations are provided. The last section is a discussion on how to access the data using SERVIR, a free online visualization and monitoring system that provides interactive maps, geospatial data, and thematic decision-support tools. SERVIR takes advantage of internet technology and provides user-friendly, interactive tools geared towards scientists, educators, policy makers, and the general public. This online system was put in place to integrate data across multiple scales, permit searching of metadata records, and improve free and public access and dissemination of a variety of conservation information. With help from partners, it is hoped that these datasets will be improved and updated in the years to come. It is the intent of the Mesoamerica and Caribbean Region Program of The Nature Conservancy to continue to develop a modular conservation information system over time that integrates data across multiple scales, standardizes metadata, provides free and public access to the information, and increases GIS capacity within the region.

It is suggested that the best way for the data to remain current and relevant is for it to be used for multiple strategic planning purposes, so that existing information is utilized, and critical new data sets are identified, created and incorporated. Caution should be taken, however, as some of the data gathered had little metadata and documentation, and has not been verified for accuracy or limitations.

Data Formats

Geodatabase

All geospatial data for the Caribbean Decision Support System have been compiled in an ESRI (Environmental Systems Research Institute) *geodatabase* format. These data are stored in both a *personal geodatabase* (Microsoft Access) format and in a *multi-user geodatabase* format in Oracle SDE (Spatial Database Engine) on SERVIR. The geodatabase format provides a common data access and management framework for ArcGIS that enables users to deploy GIS functionality and logic wherever it is needed; in desktops, servers (including the Web), or mobile devices. Unlike shapefile formats, geodatabases contain topology, explicit spatial relationships between geographic features which help to ensure data quality.

Topology enables GIS software to answer questions such as adjacency, connectivity, proximity, and coincidence. By providing the data in geodatabase format, users have the tools to assemble intelligent geographic information systems where rules and relationships can be applied and where large volumes of data can be efficiently handled.

All feature classes (vector) and raster catalogs (raster) in each geodatabase has been represented in a series of thematic layers and common spatial representations that will explained in the Data Directory section below. Each spatial record in each geodatabase has been standardized through the creation of FGDC-compliant metadata with keywords and abstracts; pre-defined *layer* files; projection information checked and assigned, and all feature geometry has been checked and repaired when needed.

Shapefile/Grid

In addition to the geodatabase format, all datasets have been provided in ESRI shapefile format (for vector files) and GRID format (for raster datasets). This is due to the wide adoption of ArcView 3.x across the Caribbean region and for users who do not have access to ArcGIS 9.x. Each shapefile and GRID contains well-defined metadata and projection information that is included in the metadata .XML file and the .PRJ (projection definition). Outside of the geodatabase format, all raster data have been supplied as either ArcInfo GRID or TIFF format (with associated world file .TFW) compatible with the current version of ArcView or ArcGIS. In general, all digital imagery, such as scanned aerial photographs, has been supplied as tagged image file format (.TIFF) files with the proper world file (.TFW) for georeferencing purposes. Other formats may include ERDAS Imagine files with associated pyramid files (.RRD) and other compressed spatial data formats such as MrSID with world file (.SDW).

File Names

The purpose of employing a layer naming standard is to promote consistency and clear understanding of the information the layers contain. Naming standards can also help to avoid pitfalls such as placing volatile information constantly subject to change, like organization, in layer names. Every attempt was made to provide clear and meaningful file names to convey the nature of the data, subject, and feature represented. All data and related file names adhere to ArcSDE 9.1 naming standards which restricts file names to 30 characters long:

- Layer names must start with a letter, and may contain only letters, digits, and '_' (underbar).
- Names cannot contain blanks, so words within the name will be separated by '_' (underbar).
- Oracle table names are case-insensitive. Although names can be entered and queried in upper or lower case, they will be stored and compared in UPPER CASE only.
- SDE includes a layer description field, which is limited to 63 characters. This is a free text field which may contain blanks and other punctuation.

The geodatabase naming convention for SDE layers (total of 30 characters max):

SDEUSER_NAME (2) EXTENT (5) THEME (5) TOPIC (12) DATE (8)

SDEUSER NAME:	SDE User Group Name (i.e. NC for The Nature Conservancy)
EXTENT:	Geographic extent of dataset (e.g. MACR for MAC Region, JM for Jamaica) For countries it is the ISO Alpha-2 country code.
THEME:	Thematic name of the data feature, usually referring to the thematic directory structure
TOPIC:	Addition space to further define the feature beyond the theme
DATE:	7 space format: 16JAN06

Examples: *NC_MACR_FW_MAJORRIVERS_12DEC06*
CA_DO_MAR_CORALREEFS_03JAN06

This naming format also applies to all shapefiles that are exported from the geodatabase. Examples of shapefile names include "NC_JM_Lndcv_1998_22Mar04.shp" and "NC_PR_ Hydr0_smallstrms_10Nov05.shp". This naming convention helps to quickly identify and describe the data. Microsoft Word or ASCII text readme documents may use long file names for clarity of data content. See data listing in Table 2 for a complete listing of data layers available in the regional geodatabase.

Data Directory

A systemic layer (.lyr) files has been assigned to each feature class/raster catalog in the geodatabase and is housed in the following directory structure:

a. Bathymetry
b. Climate
c. Connectivity
d. Freshwater
e. Geology
f. Imagery
g. Infrastructure
h. Landcover
i. Marine
j. Models
k. Political
l. Protected_Areas
m. Socioeconomic
n. Targets
o. Terrestrial
p. Topography

Projections

All geospatial data have been assigned the most-widely adopted projection within each respective country or region. Each spatial record has a description of the projection information within the metadata. A listing of projections for each individual country and for the region is listed in Table X.

Table 2: Regional and country projections used in the Caribbean region.

Bahamas Projection UTM Units METERS Datum WGS84 Zone 18 Parameters	**Cuba** Projection UTM Units METERS Datum NAD27 Zone 17 Parameters
Dominican Republic and Hispaniola-Wide Projection UTM Units METERS Datum WGS84 Zone 19 Parameters	**Grenadine Bank (SVG/Grenada)** Projection UTM Units Meters Spheroid WGS84 Zone 21 Parameters
Haiti Projection UTM Units METERS Datum NAD27 Zone 18 Parameters	**Lesser Antilles** Projection UTM Units Meters Spheroid WGS84 Zone 21 Parameters

Jamaica (JAD2001)	**Caribbean Regional**
Projection LAMBERT Units METERS Datum NAD83 Spheroid GRS1980 Parameters 18.000000 /* 1st standard parallel 0.000000 /* 2nd standard parallel -77.000000 /* central meridian 18.000000 /* latitude of projection's origin 750000.000000 /* false easting (meters) 650000.000000 /* false northing (meters)	Projection LAMBERT_AZIMUTHAL Zunits NO Units METERS Xshift 0.0000000000 Yshift 0.0000000000 Parameters 6370997.00000 /* radius of the sphere of reference -76 0 0.000 /* longitude of center of projection 16 0 0.000 /* latitude of center of projection 0.00000 /* false easting (meters) 0.00000 /* false northing (meters)
Puerto Rico Projection STATEPLANE FipsZone 5200 Units METERS Zunits NO Datum NAD83 Spheroid GRS80 Xshift 0.0000000000 Yshift 0.0000000000 /* PRSP27 = fipszone 5201/datum NAD27/spheroid Clarke1866	

Metadata

Metadata is "data about data" and attempts to address the following questions:

- What does this dataset describe?
- What geographic area does the dataset cover?
- What coordinate system is used to represent geographic features?
- Who are the originators of the dataset and who contributed to the dataset?
- To whom should users address questions about the data?
- How was the dataset created, generated, processed, or modified?
- How reliable are the data; what problems remain in the dataset?
- How can someone get a copy of the dataset?
- Are there legal restrictions on access or use of the data?
- Who wrote the metadata and contact information?

The goal was for all geospatial data was to include metadata for each spatial record that meets the minimum content standard for Federal Geographic Data Committee (FGDC) digital geospatial metadata (http://geology.usgs.gov /tools/metadata/). Efforts to incorporate comprehensive metadata are on-going but basic metadata that complies with FGDC-standard is currently in place. The metadata has been parsed with no errors prior to submission using the Metadata Parser (MP) provided by the FGDC. The metadata is delivered as an FGDC-standard formatted .XML file.

Data gaps and Limitations

Although the data described here likely represents the most comprehensive collection of spatial region-wide information ever assembled, the data gathering effort is by no means complete. The focus was primarily on ecoregional-scale data, in particular, on data sets that had uniform region-wide coverage. The need to understand the appropriate scale of use and limitations associated with the assembled data are emphasized. Many of the data are regional scale and should only be used for regional scale analyses.

Decisions at national and site scales require higher resolution data. There are some such data products in existence available at national scales, but often covering only one or a subset of sub regions. In many cases, separate assessment processes are underway to assemble national scale data and some may eventually be available for the whole region. In addition, there is a lack of region-wide species information for some groups. This information is needed to systematically assess the status and representation of species throughout the Caribbean and to validate the use of coarse-filter, predictive spatial models for planning.

Free Access to Data

The data, tools and results are freely available to any non-commercial interest. Currently, there are two ways to obtain the data: SERVIR web site and FTP access. Users may also access many of the CDSS products at www.conserveonline.org under the Caribbean Decision Support System workspace.

SERVIR

SERVIR (Environmental Monitoring and Decision Support System for Mesoamerica) was originally conceptualized by NASA in 2002 and developed as a test bed facility at Marshall Space Flight Center. The basic idea was to provide the Mesoamerican region with an on-line distribution center for map, geospatial data, thematic decision-support tools, and 3D visualization of data. SERVIR takes advantage of internet technology and provides user-friendly, interactive tools geared towards students and the general public. The system can be used by scientists, educators, and policy makers to monitor and forecast ecological changes, respond to disasters such as forest fires, tropical storms, floods, drought, and volcanic eruptions. SERVIR serves as the "regional thematic node" of SIAM (Mesoamerican Environmental Information System) for organizations such as CCAD and IABIN. It is a partnership between several agencies and gets direct funding from NASA, USAID, World Bank, and CATHALAC (Water Center for the Humid Tropics of Latin America and the Caribbean).

The spatial data warehouse at SERVIR contains vector and raster data in an Oracle (LINUX) Spatial Database Engine (SDE) database. ArcSDE is an efficient way to store and access GIS data and will be used to catalog and distribute all regional vector and raster datasets. The system work load is divided between two PowerEdge 6650 servers, one server manages the Oracle database and a custom web based user interface and the second server will process the data requests. The system has minimum disk storage of 2TB, expandable to 16TB, configured as a SAN system accessible by both servers. The system also has a tape library system and backup software. The hardware is designed for easy expandability and conversion to a grid based configuration if required.

The MAC region has been collaborating with USGS to host several regional ArcIMS (Internet Map Services) sites on their data server at EROS data center (Sioux Falls, SD). These map services are currently being moved to SERVIR where they will benefit from the faster data accessibility of ArcSDE technology and will be accessible via a web browser (http://maps.cathalac.org/Portal/). SERVIR has recently launched a Geoportal Toolkit which permits searching of metadata and spatial data using keywords or geographic queries. These web services have a variety of tools for browsing, querying and performing simple spatial analysis on GIS data. One key design of the IMS is a feedback mechanism where local experts can provide spatial-specific comments when reviewing conservation target occurrences and model results. It is also planned to implement a zip-and-ship feature where users will be able to specify data they are interested in and would like to download. The three IMS sites currently hosted at USGS EROS include:

http://edcw2ks42.cr.usgs.gov/website/tnc_cerp (Caribbean Basin ERP)
http://edcw2ks42.cr.usgs.gov/website/tnc_dr (Dominican Republic)
http://igskmncngs061.cr.usgs.gov/website/tnc_ja (Jamaica)

Once ArcSDE and ArcIMS is fully deployed on SERVIR, the regional GIS team will begin to implement ArcGIS Server to centrally manage information and data, support multiple users, and build an enterprise GIS that includes advanced GIS functionality. The system will enable users throughout the enterprise, at the main office or regional offices, at home or in the field, to access data and GIS capabilities via a single shared system. With this centralized approach to data management and application support, the organization can build one solution and deploy it to a host of users. ArcGIS Server can be used for mapping, geocoding, spatial queries, editing, tracing, and high-end analysis. Because this functionality is server based, it can readily be served to end users who do not have a desktop GIS. Examples of applications that developers can build for end users who do not have a desktop GIS include protected area gap assessments, land change analysis, querying the conservation value of a property in regards to The Nature Conservancy's 2015 goal, habitat connectivity/corridor modeling, and MARXAN irreplaceability (flexibility) analysis. Many of these scripts have been developed as Visual Basic applications and can be easily deployed in an ArcGIS Server environment. The applications developed using ArcGIS Server will provide the opportunity to create and serve up an entire class of advanced GIS server applications that go beyond simple mapping.

FTP

A backup site for downloading both the geodatabases and shapefiles/grids can be found on an FTP site in the Nature Conservancy's Worldwide Office in Arlington, USA. The data can be accessed using standard file-transfer protocol (FTP) client software at the following site:

ftp.tnc.org
username: cerp
password: cerppassword

Table X. Geodatabase data listing by theme for the Greater Caribbean Basin

Theme	*File Name*	*Description*
Bathymetry		
	nc_gcea_TaTe_200mDpthCon	Polygon feature class showing the oceanic surface area around each country up to 200m oceanic depth.
	nc_gcea_TaTe_200mDpthIns	Polygon feature class showing the oceanic surface area around each Island up to 200m oceanic depth
Bathymetry_Raster		
	gcea_etopolz1	Bathymetry Sea Floor Map
	gcea_wriBhym	Bathymetry for the Caribbean Sea and Gulf of Mexico (1 km grid cells) in meters
Freshwater		
	nc_gcea_fw_medRivers	Line Feature Class Showing all Medium Rivers in the Caribbean Region
	nc_gcea_fw_medRivSum	Line Feature Class Showing all Medium River Sums for the caribbean
	nc_gcea_fw_rt1kbasin4	Caribbean 4th order Watershed Basins. Derived using River Tools with a 1km minimum mapping unit
	nc_gcea_fw_rt1kbasin5	Caribbean 5th order Watershed Basins. Derived using River Tools with a 1km minimum mapping unit
	nc_gcea_fw_rt1kbasin6	Caribbean 6th order Watershed Basins. Derived using River Tools with a 1km minimum mapping unit
	nc_gcea_fw_rt1kbasins	Caribbean Watershed Basins derived using River Tools with a 1km minimum mapping unit.
	nc_gcea_fw_rt1kBsnDivd	Caribbean Watershed Basins created using River Tools with a 1km minimum mapping unit
	nc_gcea_fw_rt1kCWtshd	Polygon Feature Class showing the Caribbean Continental Watershed.
	nc_gcea_fw_rt1kOutlets	Caribbean River Outlets. Created using River Tools with a 1km minimum mapping unit
	nc_gcea_fw_rt1kRiver3	3rd order rivers of the Caribbean. Derived using River Tools with a 1k minimum mapping unit
	nc_gcea_fw_rt1kRiver4	4th order rivers of the Caribbean. Derived using River Tools with a 1k minimum mapping unit
	nc_gcea_fw_rt1kRiver5	5th order rivers of the Caribbean. Derived using River Tools with a 1k minimum mapping unit
	nc_gcea_fw_rt1kStrata	Caribbean Freshwater Regions. Created using River Tools with a 1km minimum mapping unit
	nc_gcea_fw_rt1kStrtaLN	Caribbean Freshwater Regions. Created using River Tools with a 1km minimum mapping unit
	nc_gcea_fw_rt1k3WSa600m	Polygon Feature Class showing all of the watersheds in the Caribbean above 600m elevation. 1km MMU
	nc_gcea_fw_rt1k3WSb600m	Polygon Feature Class showing all of the watersheds in the Caribbean below 600m elevation. 1km MMU

	nc_gcea_fw_rt1kWSgulf	Polygon Feature Class showing Gulf of Mexico watershed. Created using River Tools with a 1km MMU
	nc_gcea_fw_rt1kWSsouth	Polygon Feature Class showing the mainland southern watershed of the Caribbean Region. 1km MMU
	nc_gcea_fw_rt1kWSswest	Polygon Feature Class showing the mainland southwest watershed of the Caribbean Region. 1km MMU
	nc_gcea_fw_rt1kWSwest	Polygon Feature Class showing the mainland western watershed of the Caribbean Region. 1km MMU
	nc_gcea_fw_rt90mEduPOP	Population Density classified according to Ecological Drainage Units. 90m MMU
	nc_gcea_fw_rt90mEdus04	Ecological Drainage Units. Created using River Tools with a 90 meter minimum mapping unit.
	nc_gcea_fw_rt90mEduURB	Urban areas classified according to Ecological Drainage Units. 90 meter minimum mapping unit.
	nc_gcea_fw_rt90mEg600	Caribbean sums of small rivers above 600m elevation. 90 meter minimum mapping unit.
	nc_gcea_fw_rt90mEl600	Caribbean sums of small rivers below 600m elevation. 90 meter minimum mapping unit.
	nc_gcea_fw_rt90mLRGriv	All Caribbean large Rivers. Created using River Tools with a 90 meter minimum mapping unit
	nc_gcea_fw_rt90mLrvCON	All Caribbean large Rivers classified by country. 90 meter minimum mapping unit.
	nc_gcea_fw_rt90mLrvSum	Sums of the Caribbean large rivers. Created using River Tools with a 90 meter minimum mapping unit
	nc_gcea_fw_rt90mWSag	Caribbean Agriculture classified according to watersheds. 90 meter minimum mapping unit.
	nc_gcea_fw_rt90mWSpopD	Population Density classified according to watersheds. 90 meter minimum mapping unit.
	nc_gcea_fw_rt90mWSurbn	Urbanization classified according to watersheds. 90 meter minimum mapping unit.
	nc_gcea_fw_rt90mWtshd	Caribbean watersheds created using Shuttle Radar Topography Mission applications. 90 meter MMU
	nc_gcea_fw_smRvOvr600m	Caribbean small rivers over 600 meters elevation
	nc_gcea_fw_smRVUdr600m	Caribbean small rivers under 600 meters elevation
	nc_gcea_fw_usgsDAMS	USGS Point Feature class showing all Dams in the Caribbean
	nc_gcea_fw_usgsIntmRIV	USGS Polygon Feature class showing areas containing the intermittent rivers of the Caribbean
	nc_gcea_fw_usgsPrnlRIV	USGS Polygon Feature class showing areas containing the perennial rivers of the Caribbean
	nc_gcea_fw_usgsSmRiver	USGS Small Rivers of the caribbean
	nc_gcea_fw_usgsWtrbody	USGS perennial waterbodies of the caribbean.
	nc_gcea_fw_usgsWtrfall	USGS waterfalls of the Caribbean.
	nc_gcea_fw_usgsWtrshed	USGS watersheds of the Caribbean Region
	nc_gcea_fw_wri1kbsnRiv	World Resources Institute basin rivers
	nc_gcea_fw_wri1kBsnShd	World Resources Intitute Basin Watersheds
	nc_gcea_fw_wri1kRiv1mi	Rivers, Caribbean, 1:1,000,000 scale
	nc_gcea_fw_wri1kRiv3mi	Rivers, Caribbean, 1:3,000,000 scale
Geoclimate		
	nc_gcea_gecl_3classes	Polygon Feature Class containing three seperate geologic types: Limestone, Serpentine, and Other
	nc_gcea_gecl_GeoBndrTNC	Polygon Feature class containing the four seperate TNC geologic codes
	nc_gcea_gecl_geoTNCcode	Polygon Feature class containing the four seperate TNC geologic codes
	nc_gcea_gecl_grtrAntiles	Geologic Types for the Greater Antilles
	nc_gcea_gecl_hurricanes	Hurricane and Tropical Storm paths and data for the Caribbean
	nc_gcea_gecl_usgsErthqak	Earthquake data for the Caribbean Region
	nc_gcea_gecl_usgsGeoAge	Polygon Feature Class illustrating Geologic Age classes for the Caribbean Region
	nc_gcea_gecl_usgsGeoPvnc	Geologic provinces of the Caribbean Region along with petroleum, oil, and gas data
	nc_gcea_gecl_usgsSrfcGEO	This dataset includes polygons that describe geologic age of outcrops of bedrock in Caribbean region
	nc_gcea_gecl_usgsVolcano	Volcano Data for the Caribbean Region
Geoclimate_Raster		
	carib_hurricanes	Raster Dataset illustrating Hurricane Paths in the Caribbean Region
Imagery		
	nc_gcea_imag_lndstPthRow	Polygon Feature Class showing Landsat Imagery Paths and Rows
Imagery_Raster		
	baseimage	Map composition of the 1km bathymetry and 1km elevation data of the caribbean.
	earth1km	BMNG image using NASA Terra MODerate resolution Imaging Spectroradiometer (MODIS) science data collected in 2004
	modis	14 day MODIS composite
Geocover_Raster		
	gcov1990	10 class (unsupervised) land cover Landsat data from 1990 (www.geocover.com)
	gcov2000	10 class (unsupervised) land cover Landsat data from 2000 (www.geocover.com)

Infrastructure		
	nc_gcea_infr_usgsAirFlds	Airfields in the Caribbean Region
	nc_gcea_infr_usgsRlRoads	Railroads of the Caribbean Region
	nc_gcea_infr_usgsRoads	Roads of the Caribbean Region
	nc_gcea_infr_wriAirports	Airports of the Caribbean Region. Developed by the World Recourses Institute
	nc_gcea_infr_wriOilGasVM	Oil and Gas Plant data for the Caribbean Region. Developed by the World Resources Institute
	nc_gcea_infr_wriPipelnVM	Pipeline networks for the Caribbean Region. Developed by the World Resources Institute
	nc_gcea_infr_wriPortWPI	Ports of the Caribbean Region. Developed by the World Resources Institute
	nc_gcea_infr_wriPrtCruse	Cruise Ports of the Caribbean Region. Developed by the World Resouces Institute
Landcover_raster		
	usgsLandcovr	Derived from the early to mid-1990s Landsat TM and mapped in the Albers Conic Equal Area projection
	wriGlcb1k	This datset provides a 1-km classification of land cover.
	wriGLCCrer	This datset provides a 1-km classification of land cover.
Political		
	nc_gcea_poli_boundary	Greater Caribbean Ecological Assessment Boundary
	nc_gcea_poli_capitals	Country Capitals in the Caribbean Region
	nc_gcea_poli_cities	Cities of the Caribbean Region
	nc_gcea_poli_cntryinsulr	Insular Countries of the Caribbean Region
	nc_gcea_poli_cntryMaster	All countries of the Caribbean Region
	nc_gcea_poli_coast250k	Coastlines for the Caribbean Region.
	nc_gcea_poli_EEZboundary	Exclusive Economic Zone boundaries of all countries in the Caribbean Region
	nc_gcea_poli_features	Caribbean Features: This Point Feature Class contains small island names and individual island features
	nc_gcea_poli_regnalBndry	Regional Boundary of the Greater Caribbean Region showing all of the countries and islands
	nc_gcea_poli_regnlBndr	Mainland Boundary for the TNC Caribbean Region
	nc_gcea_poli_usgsCtyLabl	Mainland Boundary for the TNC Caribbean Region
	nc_gcea_poli_usgsGaztter	Both island features and oceanic features for the Caribbean Region
	nc_gcea_poli_usgsMJRcity	Major cities and their associated population data for the Caribbean Region
	nc_gcea_poli_usgsPOLbndr	Political Boundaries for each country in the Caribbean Region
	nc_gcea_poli_usgsVillage	Villages and Features of the Caribbean Region
Protected_Areas		
	nc_gcea_prot_prtArea010906_14jul06	This Feature Class includes all of the latest Protected Areas of the Caribbean Region
Socioeconomic		
	nc_gcea_soec_cnssGDP1980	Gross Domestic Product and census data for each country in the Caribbean Region: 1980
	nc_gcea_soec_cnssGDP1990	Gross Domestic Product and census data for each country in the Caribbean Region: 1990
	nc_gcea_soec_cnssGDP1999	Gross Domestic Product and census data for each country in the Caribbean Region: 1990
	nc_gcea_soec_cnssHDI1980	Human Development Index data for the Caribbean Region: 1980
	nc_gcea_soec_cnssHDI1990	Human Development Index data for the Caribbean Region: 1990
	nc_gcea_soec_cnssHDI1999	Human Development Index data for the Caribbean Region: 1990
	nc_gcea_soec_damsDcw	Dams of the Caribbean Region
	nc_gcea_soec_InslarHotel	Hotels and Resorts of the Caribbean Region
	nc_gcea_soec_landcoverAG	Agricultural Data for the Caribbean Region
	nc_gcea_soec_landcverUrb	Urban Areas of the Caribbean Region
	nc_gcea_soec_marinas	Eastern Caribbean Marina Data
	nc_gcea_soec_tourismZnes	Tourism Zones and associated data for the Caribbean Region
	nc_gcea_soec_usgsMines	Mine data for the Caribbean Region
	nc_gcea_soec_usgsOilGas	Oil and Gas Field Data for the Caribbean Region. Developed by the USGS
	nc_gcea_soec_usgsOreDpst	Ore Deposit data for the entire Caribbean Region. Developed by the USGS
	nc_gcea_soec_usgsUbnArea	Urban Areas of the Caribbean Region. Developed by the USGS.
	nc_gcea_soec_wriDiveCntr	Dive Centers of the Caribbean Region
Socioeconomic_Raster		
	1kmpop	This Raster Dataset includes population data from the Global Landcover dataset
	1kmurban	This Raster Dataset includes the Urban Areas from the Global Landcover dataset
	90murban	This Raster Dataset includes the Urban Areas from the Global Landcover dataset.

	hfootdd	Nine global data layers were used to create this global "human footprint" map.
	mthrcd	Coastal development in the Caribbean Region
	mthrmbp	Marine-based pollution in the Caribbean Region
	mthrovf	Over fishing zones in the Caribbean Region
	mthrsed	Sedimentation in the Caribbean Region
	usgspop	Human population distribution in Mesoamerica, the Caribbean and South America
Soils		
	nc_gcea_soil_FAOsoilsExtc	Soils Extract of the Caribbean Region. Developed by the Food and Agriculture Organization
	nc_gcea_soil_wriRivSedmt	River sediment and precipitation data for the Caribbean Region. Developed by WRI
Soils_Raster		
	glccdb	1km Global Landcover data
	repint	Relative erosion potencial in the CERP-extented
Terrestrial		
	nc_gcea_TaTe_tncEcorgn04	Terrestrial/Ecological data for the Caribbean Region
Topography_Raster		
	gtopo	GTOPO30 is a global digital elevation model (DEM) resulting from a collaborative effort led by the staff at the U.S. Geological Survey's EROS Data Center in Sioux Falls, South Dakota
	srtm90m	The Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale in Feb 2000.
Models_Basin		
	nc_gcea_CoOt_bndryInclGom	Carribean Region Extent
	nc_gcea_CoOt_BndryMainlnd	Mainland extent of the Carribean Region
	nc_gcea_CoOt_CountryLine	Layer identifying each country of the Carribean Region
	nc_gcea_CoOt_ecoregnLine	Line Layer Identifying the different ecoregions within the Caribbean
	nc_gcea_CoOt_land	Countries of the Carribean Region
	nc_gcea_CoOt_MainlndBndry	Mainland Boudaries of the Caribbean Region
	nc_gcea_CoTe_InslrHotels	Insular Hotels of the Caribbean Region
	nc_gcea_CoTe_URBNwiPOPdensty	Urban Population Density Layer
	nc_gcea_CoTe_usgsRoads	Roads layer developed by the USGS
	nc_gcea_MoOt_Pumaster	Master Planning Unit Layer for June 2004
Models_Insular		
	nc_gcea_MoOt_EDUshape	Insular Caribbean Ecological Drainage Units
	nc_gcea_MoOt_hexShape	Insular Caribbean hexagons
	nc_gcea_MoOt_MarxnCombind	Insular Caribbean combined marxan results
	nc_gcea_MoOt_MarxnFW	Insular Caribbean freshwater marxan results
	nc_gcea_MoOt_MarxnTerrstrl	Insular Caribbean terrestrial marxan results
	nc_gcea_MoOt_rbiCntryMarTotls	Insular Caribbean marine relative biodiversity index results by country
	nc_gcea_MoOt_rbiCntrySummryMastr	Insular Caribbean relative biodiversity index summary master
	nc_gcea_MoOt_rbiCntryTerrTotls	Insular Caribbean terrestrial relative biodiversity index totals
	nc_gcea_MoOt_rbiEDUfw	Insular Caribbean freshwater relative biodiversity index results
	nc_gcea_MoOt_rbiEDUfwTotls	Insular Caribbean freshwater relative biodiversity index totals
	nc_gcea_MoOt_rbiEDUsummryMastr	Insular Caribbean relative biodiversity index summaries by ecological drainage units
	nc_gcea_MoOt_rbiEDUTerrTotls	Insular Caribbean terrestrial relative biodiversity index totals
	nc_gcea_MoOt_rbiFWCntry	Insular Caribbean freshwater relative biodiversity index results by country
	nc_gcea_MoOt_rbiFWtotals	Insular Caribbean freshwater relative biodiversity index totals
	nc_gcea_MoOt_rbiHex	Insular Caribbean hexagons used for RBI
	nc_gcea_MoOt_rbiHexFW	Insular Caribbean freshwater relative biodiversity index results by hexagon
	nc_gcea_MoOt_rbiHexFWtotls	Insular Caribbean freshwater relative biodiversity index totals by hexagon
	nc_gcea_MoOt_rbiHexMar	Insular Caribbean marine relative biodiversity index results by hexagon
	nc_gcea_MoOt_rbiHexMarTotls	Insular Caribbean marine relative biodiversity index totals by hexagon
	nc_gcea_MoOt_rbiHexSumryMastr	Insular Caribbean relative biodiversity index summary master by hexagon
	nc_gcea_MoOt_rbiMar	Insular Caribbean marine relative biodiversity index results by country
	nc_gcea_MoOt_rbiMarine	Insular Caribbean marine relative biodiversity index results in July 05
	nc_gcea_MoOt_rbiShlf200mSummryMastr	Insular Caribbean marine relative biodiversity index results using 200 m shelf
	nc_gcea_MoOt_roiCountry	Insular Caribbean Return on Investment model

Models_Insular_Raster		
	ins_fw_cost	Insular Caribbean Freshwater Environmental Risk Surface (COST)
	ins_ma_cost	Insular Caribbean Marine Environmental Risk Surface (COST)
	ins_terr_cost	Insular Caribbean Terrestrial Environmental Risk Surface (COST)
Targets_Insular		
Freshwater	nc_gcea_TaFW_cstalLagoon	Coastal Lagoons of the Caribbean Region
	nc_gcea_TaFW_cstalSprings5kbuff	Coastal Springs with a 5 kilometer buffer.
	nc_gcea_TaFW_EDUs_10sep06	Insular Ecological Drainage Units
	nc_gcea_TaFW_lakes	Lakes
	nc_gcea_TaFW_largeRivers	Large Rivers
	nc_gcea_TaFW_medmRivers	Medium Rivers
	nc_gcea_TaFW_nonMangrveEstuary	Non Mangrove Estuaries
	nc_gcea_TaFW_smRivOvr600	Small Rivers over 600 ft. elevation
	nc_gcea_TaFW_strataEDU	Strata Ecological Drainage Units
	nc_gcea_TaFW_wetlands_10sep06	Wetlands
	nc_gcea_TaFW_smRivers_10sep06	Small Rivers
	nc_gcea_TaFW_estuaries_10sep06	Estuaries
	nc_gcea_TaFW_uplndWetlnd	Upland Wetlands
Marine	nc_gcea_TaMa_beaches_16sep06	Beaches
	nc_gcea_TaMa_blue_16sep06	Blue holes
	nc_gcea_TaMa_cetaceans_16sep06	Cetaceans
	nc_gcea_TaMa_channels_16sep06	Channels
	nc_gcea_TaMa_estuaries_16sep06	Estuaries
	nc_gcea_TaMa_lagoons_16sep06	Coastal Lagoons (Marine)
	nc_gcea_TaMa_manatee_16sep06	Manatee areas
	nc_gcea_TaMa_mangroves_16sep06	Mangroves
	nc_gcea_TaMa_nonReefFlat_16sep06	Coral reef (non reef flat)
	nc_gcea_TaMa_reefFlat_16sep06	Coral reef (reef top)
	nc_gcea_TaMa_reefTop_16sep06	Coral reef (reef top)
	nc_gcea_TaMa_rocky_16sep06	Rocky shores
	nc_gcea_TaMa_seabirds_16sep06	Seabird nesting sites
	nc_gcea_TaMa_seagrass_16sep06	Seagrass
	nc_gcea_TaMa_spags_16sep06	Spawning aggreagation sites
	nc_gcea_TaMa_turtles_16sep06	Turtle nesting sites
	nc_gcea_TaMa_wall_16sep06	Coral Walls
Terrestrial	nc_gcea_TaTe_unscreen_recode_2_24_05	Unscreened areas
	nc_gcea_TaTe_TrgetsFine_15aug06	Fine Targets
	nc_gcea_TaTe_TrgtsCoarse_15aug06	Coarse Targets