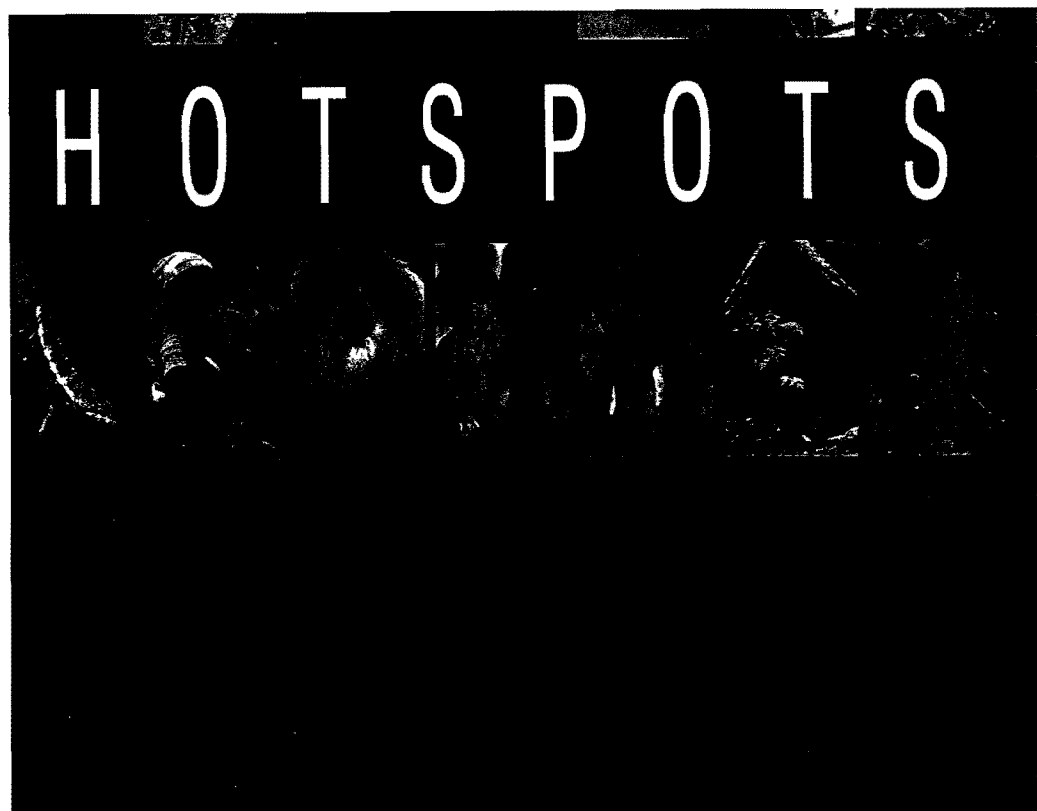


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H O T S P O

EARTH'S BIOLOGICALLY RICHEST AND MOST ENDANGERED TER

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FOREWORD
HARRISON FORD

CEMEX

CARIBBEAN

The Caribbean Hotspot, as we define it, consists of all the islands of the Greater Antilles and the Lesser Antilles, the Bahamas, the Turks and Caicos Islands, and also subtropical Florida from Lake Okeechobee south through the Everglades and into the Florida Keys. However, it does not include the continental islands of Trinidad and Tobago and Isla Margarita, which are not considered part of the Antillean chain and which have basically a mainland South American biodiversity that is covered elsewhere. The hotspot also excludes the many cays off the Caribbean coast of Mesoamerica, which are covered in the Mesoamerican Forests Hotspot. The islands of the Greater and Lesser Antilles form a "reverse-L-shaped" chain that stretches from Florida to Venezuela, and separates the Caribbean Sea from the Atlantic Ocean; together with the Bahamas and the Turk and Caicos Islands, they extend over an ocean area of some 4.31 million km², but with a terrestrial surface of only 229 865 km². Add to this the 33 670 km² represented by that portion of southern Florida south of Lake Okeechobee (Carr, 1973), and the total for this hotspot reaches 263 535 km². Although this land area is only about the size of the American state of Colorado, slightly smaller than the Philippines, and about the same as the Chocó-Darien-Western Ecuador and New Zealand hotspots, its exceptional biodiversity ranks it among the top 4 hotspots on Earth.

Like the Polynesia/Micronesia Hotspot, this region is also very diverse in political terms, being composed of 12 independent nations (Antigua and Barbuda, the Bahamas, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines), two overseas territories of France (Guadeloupe and Martinique), five independent British territories (Anguilla, the Cayman Islands, the British Virgin Islands, Montserrat, and the Turks and Caicos Islands), five autonomous Dutch territories (Curaçao, Bonaire, Saba, St. Eustatius, and St. Maarten, the latter of which is shared with France as St. Martin), one separate Dutch territory in transition to independence (Aruba), one U.S. territory (the U.S. Virgin Islands), one self-governing commonwealth associated with the U.S. (Puerto Rico), and part of one American state (Florida).

Geologically, the focal point of the region centers on the large islands of the Greater Antilles (Cuba, Hispaniola, Jamaica, and Puerto Rico), which are



the remnants of a subcontinent formed 120 million years ago. Situated on the Caribbean tectonic plate, these islands have been moving against the westward-flowing Atlantic plate, creating an area of geological convergence on which the Lesser Antilles have formed. Lesser Antillean volcanism began in the Cretaceous period some 70-80 million years ago, creating the smaller, outlying islands in the northeast corner of the Antillean chain. This group, which is also called the "Limestone Caribbees," has since been submerged, supported coral growth, and reemerged only within the last 2 million years (Harris, 1965). The main volcanic arc of the Lesser Antilles began to appear some 14 million years ago (Beard, 1949), and includes the majority of the Lesser Antilles stretching to the south and northwest. The islands of the main volcanic arc are, by contrast, younger, more mountainous, and volcanically active. This active volcanism is evident on Martinique, St. Vincent, and especially on Montserrat, where the eruptions of the Soufriere Hills have drawn international attention since they began in July, 1995. Islands like the Bahamas and the Caymans are similar to the "Limestone Caribbees" in that they are primarily flat, limestone-based masses which have also undergone periods of submergence. The three Dutch islands off the northern coast of Venezuela — Aruba, Bonaire, and Curaçao — are remnants of a Cretaceous extension of

On the opposite page, the iguanoid lizard genus Anolis is represented by many species in the Caribbean and accounts for a high percentage of the reptile diversity of this hotspot. The species depicted here, Anolis hemaculatus, is one of several anoles in the region. It is endemic to some of the small islands in the northern part of the Lesser Antilles, including Antigua, Barbuda, St. Eustatius, and Nevis.
John Cancalosi



A female Antigua racer
(*Alsophis antiguae*) eating a lizard.
This is one of the world's rarest
snake species, and a member
of a genus of snakes endemic
to the Caribbean.
• John Cancalosi

mainland South America known as the Parian Borderland, which extended as far north as 14°N, where present-day Martinique now sits, and are also mainly limestone-based. The alluvial plain of southern Florida was formed on a submerged, shallow continental shelf, with the original foundation being continental in structure, rather than basaltic.

The climate of the Caribbean Basin is very variable. Rainfall can range from 300 mm to 3 000 mm per year in different localities of Cuba alone (Harcourt and Sayer, 1996), but typically averages between 1 500-2 000 mm per year in inland areas (Davis et al., 1997). The latitude of the region places most of the area within the Inter-Tropical Convergence Zone, which is subject to continual northeasterly trade winds. This latitude, the same as both the Sahara and Sonora deserts, is naturally dry, and flat islands, which have very little physical interaction with the trade winds, may receive only 890-1 020 mm of rain per year and are frequently plagued by drought. The habitat types on these islands are dominated by dry evergreen bushland and dry evergreen thicket, with savanna occurring on parts of Barbuda, Jamaica, and Puerto Rico, where the average rainfall is only 300-600 mm of rain per year. Coastal communities on dry rocky or sandy substrates support cactus scrub and spiny shrub vegetation. Sand dunes occur only in Florida, the Dominican Republic, southern Jamaica, and on Barbados, Aruba, and Barbuda. Previously extensive coastal forests have all been destroyed. Remnants of marsh forest near Negril, Jamaica, which were destroyed for tourism development in the 1960s, showed that this type of coastal forest was dominated by buttonwood (*Conocarpus erectus*) and *Tabebuia angustata* trees up to 25 m in height; buttonwood in other areas only grows to 7 m (Davis et al., 1997). In moister areas, around lagoons and river mouths, and in protected still waters such as in the Florida Keys, permanent brackish and freshwater swamps give way to extensive mangrove forests.

The high altitudes found on more mountainous islands such as the younger volcanic islands and the majority of the Greater Antilles have quite different weather patterns and vegetation types, with the highest points in the region being Pico Duarte (3 174 m) and La Pelona (3 087 m) in the Dominican Republic. A common feature of Caribbean mountain peaks is the "trade wind cloud," which only disappears during extremely dry or still weather (Beard, 1949). In the younger Lesser Antilles it is common to have clear skies over the coast and the sea, while the interior of these islands maintains a consistently dense cloud cover. This altering of weather patterns can produce up to 10 times the normal regional rainfall in the high-altitude regions of such small islands as Dominica, whose montane region boasts 8 340 mm of rain per year. The wetter environment created by Caribbean mountains gives rise to a variety of moist tropical forest types, including marsh forest, various types of seasonal forest, montane forest, and elfin woodland (Beard, 1955), although typical lowland tropical rain forest of the kind found throughout

Mesoamerica and Amazonian South America does not occur in this region due to the high degree of seasonality. Rivers abound on the high, moist islands (360 on Dominica alone), but most of them are small. The four major rivers of the Caribbean Islands are the Cañoabo of Cuba, the Artibonite of Haiti, and the Yaque del Norte and Yaque del Sur of the Dominican Republic. These, and additional smaller river systems, support freshwater swamps, gallery forests, and marsh forests.

The southern portion of Florida, from Lake Okechobee south, is included in this hotspot because of its flora and fauna, and although it obviously includes some North American elements, it has strong affinities with the Caribbean. In terms of weather patterns, winds passing over the warm Gulf Stream pick up extreme moisture as they head towards Florida, creating high humidity throughout the region. Historically, there has been a distinct rainy and dry season with an annual total of 1 000-1 650 mm of rain per year. This has given rise to a unique hydrological system that has evolved over the last 5 000 years. The rains of the wet season falling on the Kissimmee River Basin from May to October, flow southward into Lake Okechobee. These waters then overflow their banks and form an immense shallow "river" which flows south towards Florida Bay. Often called the "River of Grass" because of saw grass (*Cladium jamaicense*), the dominant species in this ecosystem, this region is better known as the Everglades. It once covered 1 million hectares (SFWMD, 1992) and reached 80 km in width, but rarely exceeded 0.3 m in depth.

This subtropical wilderness is the most extensive and unique wetland in the United States. Slight variations in sea level, soil composition, and salinity result in a wide variety of microhabitats within the Everglades, including sand pine scrub, pine flatwood, coastal prairie, freshwater marl prairie, freshwater slough, oak hammock, tropical hardwood hammock, salt marsh, and single-species dominated tree "islands" (bayheads, willowheads, cabbage palm hammock, saw palmetto rings, pond and swamps, pop ash domes, and cypress domes).

The single most important island within the Caribbean Hotspot is without question Cuba. The largest island in the Antillean chain at 110 861 km², it occupies about 42% of the land area in the hotspot. Its flora is particularly rich, with an estimated 6 505 vascular plant species, of which 3 224 (50%) are endemic (Davis et al., 1997); this represents 46% of the endemic plants for the hotspot as a whole. In contrast, Hispaniola, Jamaica, and Puerto Rico together account for 3 004 plant endemics and the Lesser Antilles only 327 endemic species (Davis et al., 1997). Although less than 15% of Cuba's original forests remain intact, they still represent the largest forest areas remaining in the Antilles.

The original dominant forest type is believed to have been a mixture of evergreen and semideciduous forest combined with cloud forest, swamp, gallery forest, pine forest, and rain forest that still exists today (Capote et al., 1989). Cuba also harbors the world's ninth largest

large mangrove forests, which at 5 300 km² constitute nearly one third of the island's remaining forest cover (Harcourt and Sayer, 1996). Four regions of Cuba, the Sierra del Río, Cajáibana Tableland and Preluda Mountain region in the Oriente; and the coast from Juragoa to Casilda in the Trinidad Mountains, and Sierra del Escambray, comprise a total of 21 950 km² and represent four of the 11 centers of Plant Endemism identified by WWF/IUCN (Davis et al., 1997). The 100-km² Cajáibana Tableland and Preluda Mountain region alone boasts 40 species of endemic plants, and is also known for its extensive stands of Caribbean pine (*Pinus caribaea*).

The vertebrate fauna of Cuba contributes 133 species of reptiles (79 of them endemic), 46 species of amphibians (31 of them endemic), and 42 mammals to the hotspot total (WCMC, 1992). In addition, the island has 10 species of freshwater fish in 14 different families, including 21 endemics (Harcourt and Sayer 1996; UNEP, 1996). An estimated 15 000 species of insects (33% of them coleopteran beetles), 1 800 arachnid species, 15 annelid worms, and 1 405 species of terrestrial mollusks, of which 1 350 (96.1%) are endemic to the island (UNEP, 1996).

The island of Hispaniola is the second largest island in the chain and is composed of the countries of Haiti and the Dominican Republic. Although there are fewer species recorded from Hispaniola than from Cuba, Hispaniola has greater ecosystem diversity, and total diversity is likely to increase when more field research is done there.

Plant diversity and endemism in the Caribbean Hotspot are both very high. Although it is difficult to come up with precise figures given the variability in quality of data for different islands, we do have enough information to make a rough estimate of vascular plant diversity and endemism for this hotspot. Davis et al. (1997) estimate 13 000 species for the Caribbean as a whole, that is including Trinidad and Tobago, and the southern part of Florida. They give a figure of 2 568 species (1 982 phanerogams and 277 ferns), of which 236 (10%) are endemic. Since it is reasonable to assume that Trinidad and Tobago share far more species with the South American mainland than with the rest of the Caribbean, we believe that the estimate of 13 000 species for the Caribbean minus Trinidad and Tobago is reduced by 1 000-1 500 species, bringing that figure down to 11 500-12 000 species. However, if we add the species from southern Florida (Wunderlin, 1996), the total diversity figure increases once again. Apparently, there are no endemics in southern Florida. If it is reasonable to assume that the majority of southern Florida's species are shared with the Caribbean, then the remainder would be shared with other southern portions of the southeastern U.S. If we assume that two thirds of southern Florida's 1 340 species of approximately 893 species, overlap with those of the Caribbean Islands and are already counted in the total of 11 500-12 000, then only one third, approximately 447 species, can be added to the total for

the Caribbean Hotspot as we define it. This would give us a total estimate of 12 000-12 500 species, and for purposes of this analysis we use the lower, more conservative figure of 12 000.

To arrive at a figure for plant endemism, we use single-island totals for each of the islands of the Caribbean, as derived from Davis et al. (1997) and T. Zanoni (New York Botanical Garden, pers. comm.). Using this approach, we arrive at a total of 6 632 single-island endemics. Yet since a number of species are certain to be found on more than one island but are still endemic to the region as a whole, we believe that actual vascular plant endemism for the Caribbean Hotspot as we define it, will be on the order of 7 000-9 000 species. However, once again, we take the more conservative approach and use the lower estimate of 7 000 endemic species, or 58% of the total of 12 000, in our global analysis.

Plant endemism at the generic level is also high in this region. Of an estimated 2 500 genera of seed plants in the Caribbean, 204 angiosperm genera and one gymnosperm genus (*Microcya*) are endemic to the region, all of them being confined to the Greater Antilles. Of these, fully 118 are restricted to single islands. On top of this, there is also an endemic plant family, the Goetzeaceae (Davis et al., 1997).

These figures for total plant diversity and endemism compare favorably with those for the Madagascar and Indian Ocean Islands Hotspot, which has received much more attention than the Caribbean as a terrestrial conservation priority. The figures for total plant diversity are identical, while those for species endemism are slightly lower, which is not surprising given the fact that the Caribbean Hotspot is less than half the size. While it is true that Madagascar is far more impressive in terms of endemic families (it has 11), the data on Caribbean plants is noteworthy nonetheless — and is reinforced by the findings on vertebrates discussed below.

Vertebrate diversity is also high for such a small land area, and endemism is extremely high. Mammals are represented by 164 species, of which 49 (29.9%) are endemic, including some very unusual forms like the solenodons (*Solenodon* spp.), the hutias, represented by five genera, and the fruit-eating bats of the genus *Brachyphylla* that are endemic at the generic level. Fifteen of the endemic mammals are found on Cuba, five on Jamaica, and three on Hispaniola. Although the southern Florida portion of the hotspot contributes only a few strictly endemic mammal species like the Florida mouse (*Peromyscus floridanus*), it is home to over 75 species of mammals, many of them represented by endemic subspecies like the Florida panther (*Felis concolor coryi*), the Key deer (*Odocoileus virginianus clavium*), the Key Largo cotton mouse (*Peromyscus gossypinus allapaticola*), and the Big Cypress fox squirrel (*Sciurus niger avicennia*).

Birds are represented by 668 species, of which 148 (22.2%) are endemic. BirdLife International also recognizes the importance of this region for bird conservation, identifying six primary Endemic Bird Areas



The narrow-billed tody (*Todus angustirostris*) lives in dense, damp jungle and mountain shrubbery and is found only in the mountains of Haiti and the Dominican Republic.

• Doug Wechale: Vito



The adult male of the streamertail (*Trochilus polytmus*) is the most spectacular West Indian hummingbird, often with long, black tail feathers that produce a whirring sound in flight. Its range is restricted to Jamaica.

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Oxford Scientific Films

(EBAs) and an additional two secondary areas in its recent global analysis (Stattersfield et al., 1998). The six primary EBAs, which cover almost all of the Caribbean islands portion of this hotspot, include Cuba, with 10 restricted-range species, six of them confined to the EBA, two of which, the Zapata rail (*Cyanolimnas cerverai*) and the Zapata wren (*Ferminia cerverai*), are critically endangered and one of which, the Cuban macaw (*Ara tricolor*) is already extinct (ca. 1855); the Bahamas, with seven restricted-range species, four of them confined to this EBA, and one of them, Brace's emerald (*Chlorostilbon bracei*) already extinct (1877); Jamaica, with 35 restricted-range species, 28 of them confined to this EBA, and two of them, the ring-tailed pigeon (*Columba caribea*) and the Jamaican parakeet (*Siphonoris americana*) critically endangered; Hispaniola, with 34 restricted-range species, 23 of them confined to this EBA; Puerto Rico and the Virgin Islands, with 24 restricted-range species, 14 of them confined to this EBA, and two of them, the Puerto Rican Amazon (*Amazona vittata*) and the Puerto Rican nightjar (*Caprimulgus noctitherus*), critically endangered; and the Lesser Antilles, with 33 restricted-range species, 24 of them confined to this EBA, and two of them, the Grenada dove (*Leptotila wellsi*) and Semper's warbler (*Leucopoea semperi*), critically endangered (Stattersfield et al., 1998).

The Caribbean Hotspot is also rich in reptiles with 497 species, of which a very high 418 (84.1%) are endemic. This ranks the Caribbean second in the world in reptile diversity, an especially striking ranking given the small size of the region; indeed, the Caribbean has about 50% more reptiles than the Madagascar and Indian Ocean Islands Hotspot in an area less than half the size. South Florida contributes 23 species (no endemics). In addition to the endemic reptile species, eight genera are also endemic, six of them snakes (*Antillophis*, *Arrhyton*, *Darlingtonia*, *Hypsirhynchus*, *Ialtris*, and *Tretanorhinus*) and two of them lizards (*Cricosaura*, *Leiocephalus*). Among the more interesting Caribbean radiations are the large land iguanas of the genus *Cyclura*, which are endemic to the region; the *Anolis* lizards, which reach their highest diversity in the Caribbean with 138 species, 137 of them endemic; the boas of the genus *Epicrates*; and the wood snakes of the genus *Tropidophis*. *Tropidophis* is in its own family and includes 16 species, 3 of which are found in mainland South America while the other 13 (81%) are endemic to the West Indies.

Amphibians are also quite diverse and unique, with 189 species and 164 endemics (86.8%), one of the reasons why the Caribbean is considered among the world's epicenters of amphibian diversity (Glaw and Kohler, 1988). The total diversity figure is equal to that of Madagascar, but endemism is slightly less—again in an area less than half the size. South Florida contributes at least 24 species to this total, of which four overlap with the Antilles. Among the more interesting endemics are the "mountain chicken" (*Leptodactylus fallax*), an edible species from the Lesser Antilles that can

reach a snout-vent length of 210 mm and is the second largest frog in the hemisphere after the American bullfrog (*Rana catesbeiana*); its name derives from the fact that it is a favored dish on Dominica and Montserrat. Another is a newly-described frog from Cuba (*Eleutherodactylus iberia*), which at 10 mm rivals the Brazilian frog *Psyllophryne didactyla* for title of the smallest tetrapod in the hemisphere (Hedges, 1996).

In total, there are 1 518 non-fish vertebrate species in this hotspot, of which an astounding 779 (51.3%) are endemic. This ranks the Caribbean Hotspot third on the global list in non-fish vertebrate endemism. Furthermore, since it is by far the smallest of the top five hotspots for endemic vertebrates, it comes out near the top of the list in terms of endemics per unit area. Taken together with the plant data discussed above, it becomes clear that the Caribbean is a major priority for terrestrial biodiversity conservation, and that it has been largely overlooked.

A number of organizations identify parts of the Caribbean Hotspot in their priority-setting exercises. The WWF/IUCN study of Centers of Plant Diversity and Endemism (Davis et al., 1997) recognizes 11 critical areas in the Caribbean islands, including three totaling 21 850 km² in Cuba (the south-central coast, the Trinidad Mountains and Sierra del Escambray; the Oriente; and Pinar del Río), the 70-km² Morne Trois Pitons National Park in Dominica, three areas totaling at least 2 845 km² in the Dominican Republic (Cordillera Central, Los Haitises, and Sierra de Neiba), two areas totaling 75 km² in Haiti (Pic Macaya and Morne la Vista), and two areas totaling approximately 700 km² in Jamaica (the Blue and John Crow Mountains and Cockpit Country). In addition, WWF's (1997) list of Global 200 priority ecoregions includes the "Greater Antillean Moist Forests — Haiti, Cuba, the Dominican Republic, Jamaica, and Puerto Rico" (5), the "Greater Antillean Pine Forests — Haiti, Cuba, and the Dominican Republic" (65), and the "Everglades Flooded Grasslands of Florida" (110), all of which are considered critically endangered. Also included on the WWF list of priorities are the "Greater Antillean Streams — Cuba, Jamaica, Haiti, and the Dominican Republic" (142).

Within the United States, a recent study (Dobson et al., 1997) examined the distribution of endangered species by county and identified the most significant concentrations in Hawaii, southern California, southern Appalachia, and the southeastern coastal states, including Florida. One of the priority counties, Monroe County in extreme southern Florida, lies within this hotspot, and was identified as being noteworthy for its unusually high numbers of bird and mammal species.

Flagship Species

The Caribbean Hotspot has a number of interesting flagship species, of which the solenodons, the hutia, the Caribbean monk seal, the three Amazon parrots of

Lucia, and Dominica, the bee hummingbird (*Mellisuga helenae*), the possibly extinct Cuban oropendola (*Campephilus principalis*), the crocodile (*Crocodylus rhombifer*), the Aruba Island lizard (*Crotalus unicolor*), the West Indian iguana (*Cyclura* spp.), the galliwasps, and the boas are most notable. Southern Florida has several interesting endemic flagships as well as the Florida panther (*Felis concolor coryi*) and the Florida scrub jay (*Odocoileus virginianus clavium*) are also. The widespread American alligator (*Alligator mississippiensis*), which occurs throughout the United States, is also a conspicuous element of the wetlands ecosystems and reaches high densities there.

Snakes are among the most unusual of the island's and represent a genus endemic to the islands. There are two species, both of which are endangered, the Cuban solenodon (*Solenodon cubanus*), which is found only on the island of Cuba, and the Hispaniolan solenodon (*Solenodon paradoxus*), which is endemic to Hispaniola. Both are terrestrial creatures that are apparently adapted to humid montane forests for their survival. Originally, solenodons were probably among the mammalian predators on Cuba and Hispaniola. The arrival of Europeans and the subsequent introduction of mongooses and feral cats and, eventually, these alien species, along with significant loss of primary forest cover on both islands, have reduced solenodon populations to tiny remnants, and they hang in the balance.

Medium-sized rodents of the family Capromyidae, *Capromys*, has been split into five genera, *Isolobodon*, *Mesocapromys*, *Mysanthes*, and a dozen species, all of which are listed on the 1996 IUCN Red List of Threatened Animals. The Cuban hutia is highly prized, which means that it is a serious threat, while introduced feral dogs also prey upon hutias and are a threat to population declines in parts of Cuba. Five of the six hutia species listed as endangered are endemic to Cuba, making that island a priority for conservation of these little mammals. Wildlife Preservation Trusts, founded by the author and naturalist Gerald Durrell, took the Cuban hutias to flagship species status and has established a captive-breeding program for the Cuban hutia in 1972.

The Caribbean monk seal (*Monachus tropicalis*), the Caribbean monk seals in the world (the other being the Mediterranean). This pinniped is widespread in the Caribbean, but was extirpated from Cayo Albuquerque in the San Andrés Islands of Colombia in 1965 (J. A. Schoenherr, pers. comm.). The disappearance of the Caribbean monk seal is principally a victim of hunting, rep-

resents one of the more significant mammal extinctions in this century.

The Caribbean is also home to a number of important bird flagships, of which the Amazon parrots — the St. Vincent parrot (*Amazona guildingii*) from the island of St. Vincent, the St. Lucia parrot (*Amazona versicolor*) from St. Lucia, and the imperial parrot (*Amazona imperialis*) from Dominica — are probably the best examples. All three of these species are strikingly beautiful, well known to the local people, and dependent on undisturbed forest for their survival, making them excellent symbols for conservation awareness campaigns on their respective islands. The St. Lucia parrot, despite legal protection for over a century, fell to only about 150 birds in the wild by 1975 as a result of excessive habitat destruction (which reduced their habitat to 38 km²), hunting and, to a lesser extent, capture for the local and international bird trade (Abramson et al., 1995). The St. Vincent parrot suffered similar declines. Due to successful captive-breeding and reintroduction programs, populations of both of these species have now stabilized (Abramson et al., 1995). Conservation education campaigns, initiated in the 1970s by the Wildlife Preservation Trusts and several other organizations, helped generate much-needed field research, training programs for wildlife and forestry personnel, local captive-breeding projects, and a region-wide workshop several years ago that focused on expanding the use of prominent parrots as flagships for conservation in other parts of the Caribbean.

The bee hummingbird (*Mellisuga helenae*) from Cuba is a mini-flagship species, with males reaching only 5.5 cm and weighing just 1.95 grams. Not only is this species the world's smallest bird, it is also the smallest warm-blooded animal overall. In spite of their tiny size, the males are fiercely territorial. Unfortunately, this wonderful little creature is now considered threatened by loss of its forest habitat.

The ivory-billed woodpecker (*Campephilus principalis*), largest and most spectacular of the woodpeckers, once occurred in Cuba and the southeastern United States, but is now presumed extinct in the U.S. and probably in Cuba as well. The last reported sightings in the U.S. were in the 1960s and early 1970s, and it was last seen in Cuba in 1987 or 1988, and possibly as late as 1991; however, more recent searches in remote forests of Cuba were unsuccessful in locating the animal. A specialist on wood-boring beetle larvae found only in dead and dying trees characteristic of old virgin forest, this species was heavily impacted by timber extraction and clearing of forested land for agriculture. Although some hope remains that it might still be located in Cuba, the likelihood that it has already gone extinct there as well is unfortunately quite high. The reported existence of this species led to the protection of tens of thousands of hectares of the Big Thicket Forest Wilderness in southeastern Texas, one of its last known haunts on the continent.

The Cuban crocodile (*Crocodylus rhombifer*) is a very



The Cuban crocodile (*Priotelus temminckii*) is an endemic species, found only in the forested mountains of Cuba and the Isle of I.

• Doug Wechsler

unusual crocodile species that once preyed on giant ground sloths and still shows adaptations to a more terrestrial life-style, including a "high walk" and a propensity for leaping. Formerly found over much more extensive areas of Cuba and also in the Cayman Islands and the Bahamas, it is now confined to the 300-km² Zapata Swamp in Cuba. According to the IUCN/SSC Crocodile Specialist Group's Action Plan (Thorbjarnarson et al., 1992), "the Cuban crocodile is without a doubt the most threatened species of New World crocodilians." Among the pressures that it has faced are hunting and widespread habitat degradation associated with agriculture and the charcoal production industry. Another serious problem comes from increased hybridization with the now sympatric American crocodile (*Crocodylus acutus*) and competition from the introduced spectacled caiman (*Caiman crocodilus fuscus*).

As difficult as it is to generate enthusiasm for protecting large, potentially dangerous reptiles such as crocodiles, building local support for conservation projects focused on venomous snakes can be an even greater challenge. The challenge, however, appears to have been met in the case of the Aruba Island rattlesnake (*Crotalus unicolor*). This endangered endemic is found only on the island of Aruba in the Netherlands Antilles, where it inhabits rocky slopes and xeric habitats. With fewer than 250 individuals left in the wild, it is possibly the most endangered rattlesnake in the world. Considered critically endangered by many researchers and listed as threatened by the U.S. Fish and Wildlife Service and on CITES, for a number of years this smaller relative of the more widespread cascabel rattlesnake of South America has been the focus of a Species Survival Plan (SSP) established by the American Zoo and Aquarium Association (AZA). This program has successfully combined captive breeding in U.S. zoos with public awareness, field research, and habitat protection efforts on the island of Aruba. As a result, residents of Aruba are now aware of and take pride in their unique rattlesnake, significant areas of its arid habitat have now been officially protected, and the snake's image has even appeared on stamps and currency.

An important group of flagship reptiles are the West Indian rock iguanas of the genus *Cyclura*. These large (up to 2 m), robust, terrestrial lizards are found only in the Caribbean, and are represented by eight species and 16 subspecies. They are mainly herbivorous, and are important seed dispersers of some of the endemic plants on the islands that they inhabit. Unfortunately, as is the case with many other Caribbean species, the rock iguanas have been heavily impacted by introduced species such as feral cats, feral pigs, Norway and black rats, and the Indian mongoose. Several species are critically endangered, with three listed as endangered and 13 as threatened by the U.S. Fish and Wildlife Service. One of the rock iguanas, the Jamaican iguana (*Cyclura collei*), was presumed extinct for nearly half a century (Mittermeier, 1972). However, in 1990, it was

suddenly rediscovered in the Hellshire Hills of Jamaica when a pig hunter's dog cornered an adult. Shortly thereafter, two active nesting sites were discovered, and it has now been documented that there is a remnant population of some 50-200 animals. Since its rediscovery, the Jamaican iguana has been the focus of intensive conservation efforts in the Hellshire Hills, Jamaican zoos, and U.S. zoos. More than 100 iguanas now reside at the new iguana management/head-start facility at the Hope Zoo in Kingston, Jamaica, and 36 captive-raised iguanas have been established at several U.S. zoos. Since 1996, at least 20 Jamaican iguanas have been released back into the remote Hellshire Hills region of Jamaica. It is hoped that these efforts will lead to the recovery of this species, and make it one of the real success stories of Caribbean biodiversity conservation (Alberts, 1997). Other positive developments include the creation of a West Indian Rock Iguana Species Survival Plan by the AZA, the establishment of an IUCN Species Survival Commission Specialist Group for West Indian Iguanas, and the production of an IUCN/SSC Action Plan on their behalf.

Another flagship group of reptiles are the galliwasp, an unusual group of lizards of the family Anguillidae that includes both entirely legless species and species with only vestigial limbs. "Galliwasps" is a Creole patois name that refers to the native belief that these animals are poisonous. Twenty-two species of the genera *Celestus* and *Diploglossus* are endemic to the Caribbean islands, and these include several giant forms on Hispaniola and Jamaica that can exceed 25 cm in length. Some of the larger species feed on venomous *Scolopendra* centipedes that may exceed 15 cm in length, while a few smaller species have been considered millipede mimics. Most of the galliwasp are threatened by habitat destruction and exotic predators. Several may already be extinct, with the species on Jamaica having been heavily impacted by the introduction of the mongoose and not having been seen since 1872 (Mittermeier, 1972).

Yet another group of reptile flagships are the boas of the genus *Epicrates*. These small to medium-sized boas are divided into ten species, nine of which are endemic to the Caribbean, and they range in size from the vine boa (*Epicrates gracilis*) at less than 1 m to the 3-4 m Cuban boa (*Epicrates angulifer*). The one mainland species, the rainbow boa (*Epicrates cenchria*) is thought to represent the basal lineage, suggesting that the other species radiated out into the Antilles. Several of these boas prey on bats by capturing them in mid-flight as they leave their limestone cave roosts in the evening. Two species, the Puerto Rican boa (*Epicrates inornatus*) and the Mona Island boa (*Epicrates monensis*) are critically endangered due to predation of young snakes by introduced predators like feral cats, feral pigs, Norway and black rats, and the Indian mongoose.

Looking at flagships from southern Florida, we have the Florida panther, a subspecies of the wide-ranging puma or cougar that is now restricted to the Everglades

On the opposite page,
aerial view of landscape near
Puerto Principe, Haiti,
one of the most devastated places
on Earth.

© Patricio Robles Gil/Sierra Madre

Above, a male rhinoceros iguana
(*Cyclura cornuta*)
from Hispaniola, Mona,
and Navassa. This species is the
best-known member of this genus
of large iguanas that is endemic
to the Caribbean. There are seven
species in all, and they represent
one of the most important flagship
groups in the region.

© Phillip Coffey



The hutias are a group of large guinea pig-like rodents endemic to the Caribbean.

Here, the Jamaican hutia (*Geocapromys brownii*) has been greatly decimated by humans, dogs, and the imported mongoose, and now is being bred by the Jersey Wildlife Preservation Trust.

• Phillip Coffey

On the opposite page, close-up of the Florida panther (*Felis concolor coryi*).

• Art Wolfe

region of southern Florida. Officially recognized as Florida's state animal in 1982, this large cat once ranged throughout the entire southeastern United States from eastern Texas and the lower Mississippi River Valley east to the southern coastal states and Florida. As a result of widespread hunting and habitat destruction and alteration since the early 1900s, the wild population of this subspecies is now down to only 30-50 individuals. Despite its status as a fully protected species and its inclusion on the first Endangered Species List in 1976, the animal is now found only in the Everglades. Although the newly-established Florida Panther National Wildlife Refuge provides some degree of protection, this panther's future hangs in the balance, with inbreeding in this very small population perhaps being one of the most serious issues.

Decades ago, another Florida endemic was in similar straits, but seems to have dodged the proverbial bullet. A wildlife survey undertaken shortly after World War II indicated that the number of Key deer, a dwarf subspecies of the white-tailed deer and the smallest deer in North America, had plummeted to perhaps two to three dozen animals on only a handful of islands within the Florida Keys. Loss of habitat in the rapidly developing island chain was the primary cause of the Key deer's decline, but this was certainly compounded by losses suffered from hunting, feral dogs, automobile accidents, hurricanes, and fires. In response to the surveys, several thousand hectares were ultimately set aside in the Key Deer National Wildlife Refuge, which was eventually combined with the Great White Heron and Key West Refuges to create a contiguous and more substantial protected area for deer and other wildlife.

The American alligator, the largest of North America's reptiles, received its name from early Spanish explorers of the New World, who called it *el lagarto*—"the lizard." Widely abundant for centuries in the marshes, swamps, ponds, and drainage canals of the southeastern United States, alligator populations began to decline as the value of hides (and secondarily of meat) spawned a multimillion dollar industry and decades of illegal poaching (1940s through the 1960s) that ultimately threatened the species with extinction. Thanks to protection received under the Endangered Species Act and the Lacey Act (which made interstate shipping of illegally-taken animals or their products a federal violation), wild alligator populations rebounded in the 1970s and are today at the point that the species status has been downgraded from endangered to threatened.

A number of plant species also qualify as flagships in the Caribbean Hotspot, especially some that are of economic value. The regionally endemic West Indian mahogany (*Swietenia mahogany*) has now vanished in parts of its range, and most stands of old-growth forest have been severely depleted through excessive harvesting. Other endemic species of economic value are walnut (*Juglans jamaicensis*), West Indian ebony (*Brya ebenus*), and poui (*Tabebuia heterophylla*). Endemic fruit species

include the star apple (*Chrysophyllum icaco*) and wild mamee (*Garcinia humilis*).

Threats

The islands of the Caribbean have been inhabited by humans for only a few thousand years, with the first Amerindians arriving on the Antillean islands about 3 700 years ago (Steadman et al., 1984). Little is known about them except that, like the groups that followed them, they most likely worked their way north through the Lesser Antilles from South America. They were later followed by other groups, among them the Island Caribs in the Lesser Antilles, the Taino Indians in the Greater Antilles, and the Lucayans in the Bahamas, which were the groups present in these islands at the time of European arrival. The Island Caribs were part of a widespread linguistic group that is still well-represented in northern South America, and it is from them that the name "Caribbean" is derived. A warlike group that sometimes practiced cannibalism, they are also the origin of the word "cannibal."

When Europeans reached the New World, their first point of contact was in the Caribbean, with Columbus arriving on Hispaniola in 1492. As in most other parts of the world, the European settlement that followed shortly thereafter brought with it serious alteration and destruction of natural landscapes. The forests were first cleared to grow sugarcane (*Saccharum officinarum*), which was introduced to the Caribbean around 1520. The introduction of African slaves made the sugar trade a very lucrative business, and nearly every bit of suitable land was utilized for its production (Schwartz and Henderson, 1991). The sugar industry declined after the Napoleonic wars and the abolition of slavery, but the environmental damage to the region had already been irreversible in many areas.

Europeans also introduced a number of alien species, notably the Indian mongoose (*Herpestes auropunctatus*), which was brought in as a form of biological control against rodents and poisonous snakes. First introduced to Jamaica on February 13, 1872, the mongoose was subsequently released onto 29 other West Indian islands (Hoagland et al., 1989). This adaptable, voracious species had devastating effects on the native vertebrates, especially reptiles and amphibians, and caused the extinction of dozens of endemic species. Other introduced species such as rats, cats, goats, donkeys, and even monkeys have impacted the Caribbean islands as well. At least three African monkey species are now established on several Caribbean islands, including the vervet (*Cercopithecus aethiops sabaeus*) on Barbados and St. Kitts, the mona monkey (*Cercopithecus mona*) on Grenada, and the rhesus monkey (*Macaca mulatta*) on the island of Cayo Santiago off the coast of Puerto Rico.

Today, the Caribbean continues to be impacted by expanding human population, with Haiti being the

most extreme example. As of 1996, Haiti had a population density of 270 people/km², which ranks it among the most densely populated nations on Earth. Not surprisingly, its natural ecosystems have been devastated, with very little now remaining. The population of the Caribbean as a whole was estimated at 35 million in 1991, and is projected to reach 40 million by the year 2000 and nearly 60 million by 2025.

The development of the tourist industry, the major foreign exchange earner for most of the region, is also a major factor, particularly in the coastal regions. This has usually meant total alteration of the local landscape, planting of ornamental trees, shrubs, and grasses for lawns and golf courses, extensive road construction, and the building of tourist facilities and vacation homes (Davis et al., 1997). Tourism has grown at different rates on the islands, varying from 2% per year on St. Vincent to 81% in Cuba in 1994 (Potter, 1996). One example of the impact of tourism on biodiversity is exemplified by several small offshore islets of the Lesser Antillean island of Antigua. The fifty or so rocks and islands which lie off the northeast corner of Antigua had long been refuges for a number of endangered species, since they had escaped the introduction of the mongoose and had not been utilized for agriculture. They are home to an endemic snake (*Alsophis antiguae*), the tropical mockingbird (*Mimus gilvus*), and the endangered West Indian whistling duck (*Dendrocygna arborea*); in addition, the islet known as Long Island also harbors one of the greatest concentrations of nesting hawksbill sea turtles (*Eretmochelys imbricata*) in the Caribbean. In spite of their importance, the government of Antigua and Barbuda signed an agreement with a Malaysian developer in February 1997 to build an Asian-style village resort on these offshore islets. The project involves the building of hotels with 2 000-room capacity and two 18-hole golf courses on the last vestige of pristine evergreen bushland in the northeast Antilles.

In the Greater Antilles, agricultural expansion is still a serious threat. On Cuba, for instance, the expansion of cacao, coffee, and tobacco plantations is rapidly invading the last 15% of the island that remains in a natural state (Perera and Rosabal, 1986). This loss of forest habitat is responsible for the threatened status of the bee hummingbird and the likely extinction of the ivory-billed woodpecker (Lammertink and Estrada, 1995).

Mining has also had a major impact, with bauxite mining being particularly important on islands like Jamaica. Riversides and beaches are also mined for building material such as sand and gravel, and can have serious impacts in terms of erosion, flooding, and pollution (Davis et al., 1997).

In contrast to the Caribbean islands, southern Florida has been inhabited for nearly 11 000 years (Robinson et al., 1996). The Calusa and Tequesta Indians were the two main groups that historically occupied the Everglades and the Florida Keys. In the wake of European invasion, the Seminole Indians of Georgia and the Caro-

linas moved into this territory and wiped out these people to become the dominant indigenous group of southern Florida. Key West, the popular tourist destination in the Florida Keys, takes its name not from its geographical location, but rather is an English corruption of the Spanish "Cayo Hueso," which means "Island of Bones," a name given by the first Spanish to set foot on this island to the graveyard of scattered human remains—the vestiges of battles between the Seminole and the earlier indigenous inhabitants (K. Leckler, pers. comm.). The Seminole and their kin, the Miccosukee, still live in the Everglades region today.

Europeans did not really begin to impact the natural habitats of southern Florida until the late 1800s, at which time colonists and land developers began to see the wetlands of the Everglades as useless swampland in need of "reclamation." This led to the installment of an elaborate system of dikes, drainage canals, and landfills through to about 1910, which in turn dramatically impacted and altered the hydrography, ecology, seasonal climate, and vegetation of the region. Today, only about 50% of southern Florida's original wetlands exist, with the result that wading bird populations have dropped by about 90% (NPS, 1998), and flagship species such as the Florida manatee (*Trichechus manatus*), the indigo snake (*Drymarchon corais couperi*), and the snowy egret (*Egretta thula*) are endangered.

Human population growth in the region has been dramatic as well. In Dade County, Florida, for example, which today is known best for the Miami metropolitan area, there were only 861 inhabitants in 1890 (Hollingsworth, 1949). With the completion of the Henry Flagler railroad to Key West in 1912, however, the population soared, to the point that there were 2 057 000 residents in the city of Miami alone by April 1995. This growth continues, as 900 people per day move to Florida, creating the need for an extra 200 000 gallons of water each day.

Alien species introductions have also been large-scale in southern Florida, resulting in all kinds of ecological impacts, many of them likely irreversible. Animals ranging from the Central American coati (*Nasua narica*) to Bahamian curly-tailed lizards (*Leiocephalus carinatus mouri*) to Asian macaque monkeys (*Macaca* spp.) and South American squirrel monkeys (*Saimiri* spp.) have been able to establish breeding populations in many parts of the region. Even more serious are invasive plants. Some 272 exotic species, 25% of Florida's current flora, exist in Everglades National Park alone (Whiteaker and Doren, 1989), many of them originally introduced either as ornamentals or as biological "tools" to help drain the swamps. Among the most problematic of these are Brazilian pepper (*Schinus terebinthifolius*), melaleuca (*Melaleuca quinquenervia*) and Australian pine (*Casuarina* spp.), water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata*).

As a result of changes that have taken place since European arrival, only a small portion of what once existed still remains in more or less pristine condition. Looking



Waterfall in El Yunque rain forest, one of the last patches of this habitat in Puerto Rico.
© Wolfgang Kaehler

on the Caribbean islands, it is estimated that once was 227 910 km², or almost the entire Caribbean portion of the hotspot. As estimated that only 37 860 km², or 16.6% forest cover remained (UNEP, 1996). Analysis by Conservation International that was left was 14 912 km² of tropical 11 840 km² of dry forest formations, 52 km², or 11.6% of the 230 000-km² defined by the Caribbean island portion of the hotspot that the estimate of 16.6% derives from a decade old and that the more recent estimate includes at least some secondary vegetation impacted by invasive species, we estimating pristine vegetation occupies only 10% of the original extent of this portion of the hotspot — and that quite likely it is considerably less than that.

Florida south of Lake Okeechobee, habitat in more or less pristine condition lies within the Everglades National Park, the national Wildlife Refuge, and a handful of wildlife refuges, and totals approximately 10% of this portion of the hotspot. Combining these, we arrive at a total of 29 840 km², Caribbean Hotspot remaining in more or less pristine condition.

Protected areas exist in the Caribbean Basin as of this point in time. Available data indicate that 100 000 km², or 15.6% of the original extent, is officially protected in a variety of management units (IUCN, 1992; Davis et al., 1998). This is larger than our estimate of remaining primary vegetation, indicating that a number of protected areas are no longer entirely pristine, and it appears to be the case.

For example, some 12% of the total land area of the Caribbean Basin consists of so-called conservation units (including the national parks, but excluding the Cuban crocodile), but few of these units have strict protection as logging occurs in many of the reserves appear to be too small to provide protection over the long term (Statistical Yearbook, 1998). As less than 15% of Cuba's land area is under strict protection, ensuring the effective management of already existing protected areas is clearly a conservation priority.

The Caribbean protected area network of some 40 units, including the recently established John Crow National Parks, but many of which are unmanaged and unmonitored, and many of which have habitat encroachment are effective (Statistical Yearbook et al., 1998). Since only a small percentage of the region's forests remain, improved management of protected areas should once again be a high priority.

In the Dominican Republic, there were 22 protected areas in 1993. This was increased to 52 through a 1996 decree, then reduced to 44 by another decree in 1997 which down-listed a number of areas. The current total of 44 amounts to roughly 18% of the land surface of the country. However, only 10 of the national parks in the Dominican Republic have management plans, and many of them in both the Dominican Republic and Haiti, as in Cuba, are small (under 75 km²). Furthermore, as is the case in many other hotspots, certain key ecosystems in the Dominican Republic are either underrepresented or entirely absent from the protected area network, montane forest being a particularly significant example (Statistical Yearbook et al., 1998).

A number of conservation organizations are active in biodiversity conservation within this hotspot. The Island Resources Foundation (IRF), for example, specializes in providing development and environmental planning assistance to governments and private, nonprofit environmental organizations of small tropical islands, and currently has a biodiversity program in the eastern Caribbean. Through partnerships with the U.S.-based Nature Conservancy and with Caribbean governmental and nongovernmental agencies, this initiative has expanded to include field research, public awareness, information networking, and local capacity building to St. Kitts, Nevis, Antigua, Montserrat, and Dominica. IRF also engages in species conservation programs. In conjunction with the U.K.-based Fauna and Flora International (FFI), it has developed a joint initiative on Great Bird Island, a tiny island off Antigua, to conserve the highly endangered Antigua racer (*Alsophis antiguae*). This program includes public education, eradication of the introduced black rat, and a captive-breeding program.

WIDECAST, the only region-wide organization devoted to the conservation and recovery of sea turtles, is another nongovernmental organization that is engaged in species conservation activities. WIDECAST aims mainly at promoting a regional capability to implement scientifically-sound sea turtle conservation programs through better understanding of sea turtle biology and management by local people and institutions. It also assists Caribbean governments in fulfilling their obligations under the SPAW Protocol, a UNEP initiative signed by Caribbean governments in 1991 and intended to provide protection for the region's endangered species, including all six species of sea turtle.

The Caribbean Conservation Association (CCA) facilitates the development of policies, programs, and practices that contribute to the sustainable management of Caribbean resources. Now in its thirtieth year, CCA represents the interests of over 120 different Caribbean government and nongovernmental institutions and hundreds more individual members. It focuses its efforts on an array of activities such as conserving the region's cultural heritage, environmental education, information management, and sustainable resource management. Included in the latter are a variety



Checking plants
as a part of reforestation
in Quisqueya Verde
in the Dominican Republic
which CEMEX helps
• Patricio Robles Gil



Sugarcane, which is still harvested by labor-intensive, back-breaking traditional methods, remains the Caribbean region's most important agricultural crop.

• Steve Raymer/

National Geographic Society

On the opposite page, destruction of the natural vegetation for charcoal production continues to be a problem, as is seen in this image from Viñales, Cuba.

Given the tremendous importance of biodiversity in this hotspot, major efforts are needed to introduce more efficient technologies such as solar power to meet the fuel requirements of local people.

• Mark Edwards/Still Pictures

of programs to create and protect marine parks, manage fisheries, and promote the preparation of national conservation strategies and regional environmental impact assessments.

The Caribbean Conservation Corporation (CCC) is another region-wide organization, the goal of which is conservation of sea turtles and other marine life. It was originally founded in response to renowned ecologist Archie Carr's award-winning book, *The Windward Road*, an account of his years of field studies on sea turtles in the wider Caribbean. The CCC began its work on the sea turtle nesting beaches of Caribbean Costa Rica in 1959, where it maintains an active presence to this day, and has also undertaken work in a variety of other Caribbean and Western Atlantic nations. In addition to the CCC's nearly four decades of effective research, training, advocacy, education, and protection activities in Costa Rica's Tortuguero National Park, it has also played an active role in the establishment of the Archie Carr National Wildlife Refuge, declared by Congress in 1989 and the first sea turtle refuge in the United States. The Carr Refuge offers hope for saving the most important global nesting and foraging habitat for the Atlantic loggerhead turtle (*Caretta caretta*) in the Western Hemisphere, as well as the most significant populations of nesting green turtles (*Chelonia mydas*) in the United States.

In the United States, the U.S. National Park Service and other governmental bodies maintain several protected areas, the most important of which is the 609 675-ha Everglades National Park, one of only three areas in the world designated as a World Heritage Site, an International Biosphere Reserve, and a Wetland of International Significance. Although this region continues to suffer many different threats, extensive monitoring and evaluation projects linked to governmental, nongovernmental, and university research groups contribute to the maintenance of the existing protected areas. Legislative support, including the 1987 Surface Water Improvement and Management Act (SWIM), the 1992 Everglades Protection Act, and the 1994 Everglades Forever Act passed by the Florida State Legislature, all help in improving surface water management. This positive legislative and public support for protection of the Everglades system has been very encouraging, but the tremendous habitat alteration of the early twentieth century remains difficult to reverse. Nonetheless, restoration of the original water flow and seasonal cycles of inundation should continue to be the long-term objective for this region.

Although much has been lost in the Caribbean, there is still an opportunity to protect the vast majority of the region's biodiversity. Among the major measures needed over the next few decades are the following:

- Maintenance and improved management of the existing network of protected areas;
- Establishment of new protected areas, where necessary, to provide maximum representation of species and ecosystems unique to this hotspot;
- Development of additional legislation and national

policies promoting biodiversity conservation, particularly in the highly diverse Greater Antillean lands of Cuba, Hispaniola, and Jamaica;

- Increased emphasis on research in existing and potential protected areas through both rapid assessment programs and long-term field stations;
- Establishment of more programs for conservation education and public awareness to highlight the region's biological importance in a global context, stimulate further conservation action, and promote local pride in the natural heritage of these islands and
- Initiation of more species conservation activities including both region-wide programs like the Action Plan for *Cyclura* iguanas and projects focusing on specific endangered species such as those carried out for the Jamaican iguana and the hutia.

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