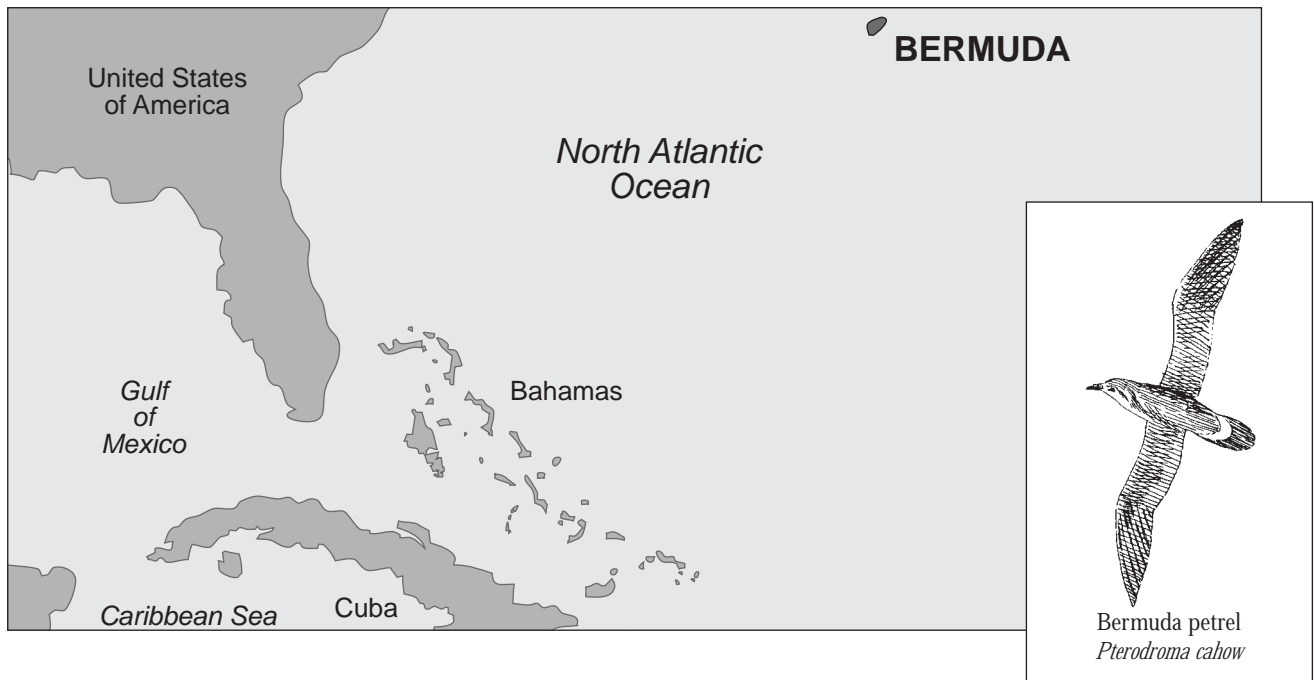


4: Bermuda



Introduction

Bermuda is situated in the western Atlantic Ocean (32°N, 64°W) approximately 917 km from the coast of North Carolina in the USA. Bermuda consists of around 150 coral limestone islands and islets extending along the edge of an extinct submarine volcano. The ten main islands are connected by bridges or causeways to form a chain about 35.4 km long. The total land area of Bermuda is 55 km². It has an estimated population of 61,000. Tourism and international business are the main sectors of the economy.

International obligations relevant to nature conservation

Bermuda is included in the UK's ratification of the following international agreements:

- Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention)

- Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
- International Convention on the Regulation of Whaling

Implementation

Ramsar: the implementation of the Ramsar Convention in Bermuda is considered in detail by Pritchard (1992). Nine sites are considered to meet the criteria for listing under the Ramsar Convention, and six sites have been put forward for formal designation in 1999.

CITES: this Convention is implemented through the Endangered Animals and Plants Act 1976 (as amended).

Protected areas

Bermuda has a comprehensive system for protection of remnant areas of natural habitat, with various legal measures in place.

- **The Bermuda National Parks Act 1986.** This is the enabling legislation for the designation of national parks and reserves, which may be areas of land or water. The Act also requires the preparation of a strategic plan for the management and development of the national parks system as a whole. The main purpose of protected areas declared under the legislation is informal recreation. There are two designations:

Class A Protected Areas— Nature Reserves: to be managed to protect special or fragile natural features and provide limited public access;

Class B Protected Areas—Parks: to be managed to encourage conservation and enjoyment of natural and historic features with the minimum of commercial activity.

Reserves further divide into Government reserves and private (or 'agreement') nature reserves. Private reserves enter the system by agreement and can be withdrawn by agreement. None of these has yet been gazetted, although it is the intention to do so with Audubon Society reserves. Each protected area is meant to have a management plan in place within five years of declaration, but plans have not yet been completed for all sites. Any activity undertaken within a protected area must be consistent with the purposes of the area and its management plan. Ministers can make regulations to ensure this, and can provide for permit arrangements. Infringement of the terms of a permit is an offence, and strict enforcement is provided for. Construction or alteration of roads, buildings, alteration of land and other activities requires written approval of the

Minister: proposals must be published and there is a period for public comment.

Currently, 12 nature reserves covering some 48 ha, and 63 parks ranging in size from 0.04 ha to 38 ha are listed under the Act. The nature reserves listed include a number of those already declared under statutory instruments arising from the Protection of Birds Act.

- **Protection of Birds Act 1975.** The first legislation to provide for nature reserves was the 1949 Protection of Birds Act, under which the first reserve was declared at Castle Harbour Islands following the rediscovery of the cahow in 1951. This Act was superseded by the Protection of Birds Act 1975, which similarly provided for reserves to be declared by the Minister on land appearing to be "especially suited for the feeding and nesting of protected birds, or otherwise important for their preservation." Reserves are declared only on Government-owned land, or with the consent of the private landowner(s). Enforceable restrictions in reserves relate to access control by permits or to designated access areas. A number of sites have been declared by Statutory Instrument under this Act: The Nature Reserves (Tern Nesting Areas) Order 1976; The Nature Reserves (Spittal Pond) Order 1979; The Nature Reserves (Castle Harbour) Order 1979; and The Nature Reserves (Evans Bay) Order 1981.
- **Tree Preservation Orders.** Section 27 of the Development and Planning Act 1974 provides for the making of Tree Preservation Orders that can be applied to individual trees, groups of trees or woodlands. Several are currently in force.
- **Coral Reef Reserve Act 1966.** This is the enabling legislation for the designation of coral reef reserve areas. Two coral reef areas, North Shore Coral Reef Preserve and South Shore Coral Reef Preserve, are protected under the Coral Reef Reserve Act.

- **Fisheries Act 1972.** This is the enabling legislation for the designation of exclusive fishing zones. Section 4 gives the Minister of the Environment authority to declare any area of the waters within the exclusive fishing zone to be a protected area, prohibiting or restricting the taking of fish (although this does not affect use of boats within designated areas).

In addition to the protected areas established under the above legislation, ten sites (c. 15 ha) are managed by the Bermuda Audubon Society, 15 sites (c. 40 ha) by the Bermuda National Trust, and there are two other private protected areas (25 ha) administered under the Walsingham Trust Act and the Heydon Trust Act. The Bermuda National Trust Act 1969 (amended 1970) is the legal means by which the Trust can purchase or receive land for management as nature reserves to be managed according to the Bermuda National Trust (Open Spaces and Property) Regulations. Nature reserves acquired and owned by the Bermuda National Trust are managed by the Gardens and Nature Reserves Committee, with the advice and assistance of the Government Conservation Division. Reserves owned by the Bermuda Audubon Society are managed by the Society's Executive Committee with advice from the Conservation Division. The Bermuda Audubon Society Act 1960 provides for the purchase and holding in trust of land managed as a nature reserve.

Planning legislation in Bermuda also has provisions giving precedence to the conservation of natural areas.

- **The Development and Planning Act 1974.** Legislation enacted in 1965 made provision for a Planning Department and for various categories of land zoning, including public and private open space. A 1983 amendment to the 1974 Development and Planning Act included an additional provision for "overlay zoning" of "Environmental Conservation Areas", within which the preservation of open space and the natural environment takes precedence over other planning considerations.

- **"Bermuda 2000": The Bermuda Plan 1992.** The Bermuda Plan 1992 was preceded by island-wide development plans prepared in 1968, 1974 and 1983. The 1983 development plan introduced a wide range of zonings and provisions designed to identify and protect areas of environmental importance. The Bermuda Plan 1992 is based on the concept of sustainable development. The plan identifies sufficient land to meet the community's development needs during the plan period and places greater emphasis on the conservation of open land and natural resources.

Three goals of the plan are to:

- conservate open space and promote a high quality environment;
- provide sufficient development potential to meet the community's needs; and
- encourage a more efficient use and development of land.

The 1992 plan maps identify for protection areas of open space, agricultural land, woodland, parkland, nature reserves, caves and groundwater resources. 'Nature reserves' are defined as "areas of special environmental significance and ecological, biological, geological or scientific value." They include mangrove swamps, marshlands, bird sanctuaries, cave and rock formations, islands and other wildlife habitats.

The section on nature reserves states: "There is an urgent need to safeguard those special places which sustain wildlife in Bermuda. Some of these places are already protected as nature reserves under the National Parks Act or under the stewardship of the Audubon Society or National Trust. Many areas do not enjoy such protection and it will fall on planning policy to ensure their continued existence." Nature reserves designated by the plan itself or run by the National Trust or Audubon Society are identified by a nature reserve zoning on the plan's maps.

Woodland reserves are defined as areas of mature trees and dense vegetation to be protected because of their ecological or amenity value. They may be important as natural habitats, buffer zones or windbreaks, or for their scenic value.

Habitats of major significance

Bermuda is densely populated and only small areas of natural habitat survive, for example at Paget and Devonshire marsh, and the upland hills of Castle Harbour and Walsingham. In total, the inland peat marshes cover about 48 ha and are sites of great botanical interest. Approximately 10% of the total land area of Bermuda is forest or woodland. Bermuda is the most northerly site of mangrove distribution in the world, and small, scattered areas of mangrove swamp amounted to a total of 16.7 ha in 1980.

Nine sites have been put forward to the UK authorities as proposed Ramsar sites. It is expected that the Bermuda Government will declare the following six areas in time for the 7th Conference of Ramsar Parties in May 1999:

Hungry Bay Mangrove Swamp
Lovers Lake
Paget Marsh
Pembroke Marsh East
Spittal Pond
Warwick Pond

The three other identified candidate sites are: Devonshire Marsh east and west basins, Trott's Pond and Mangrove lake, and Somerset Long Bay Pond.

The Bermudian coral reefs are of scientific importance, forming the most northerly coral reef system in the world. An extensive programme of marine environmental research is carried out by the Bermuda Biological Station for Research, and the Bermuda Aquarium, Natural History Museum and Zoo (BAMZ) and its supporting arm, the Bermuda Zoological Society (BZS).

Bermuda's limestone caves are of international

biological significance. They are described in various publications by Iliffe and co-authors (Iliffe 1979 *et seq.*). More than 150 caves are known. Over 100 of these, including many of Bermuda's largest and longest caves, are located in the 2 km² area of the Walsingham Tract, between Harrington Sound and Castle Harbour. Most of the island's more extensive dry caves, notably Admiral's, Sibley's and Jane's Caves, are located here.

The sea-level, brackish pools located in the interior of Bermuda's caves, as well as similar pools of collapse origin located outside caves, are classified as 'anchialine' habitats (i.e. subterranean, brackish water bodies with limited connection to the sea). A rich and diverse biota inhabits the submarine passageways and anchialine pools. Two of the most important caves in Bermuda are Church and Bitumen Caves, situated beneath Ship's Hill. Church Cave contains the largest underground lake in Bermuda. The saltwater lakes of these caves contain at least 11 species of endemic troglobitic invertebrates (Iliffe 1997).

Species of major significance

Biodiversity assessment

The biodiversity of Bermuda is relatively well known, with over 3,450 publications relating to the fauna and flora of the island. A recent assessment of biodiversity at a species level, indicates that Bermuda has at least 8,299 species of which 4,597 are marine and 3,702 are terrestrial (Sterrer 1998).

In February 1997 the BAMZ and BZS launched the Bermuda Biodiversity Project which aims to promote informed management of the island's natural resources. Through this ongoing project published and unpublished information on all species is being collated and entered into a database which is linked to the GIS database being developed by the Department of Planning. Information gaps are being addressed through fieldwork with particular emphasis on detailed mapping of fragile ecosystems. The data will be used directly by local planners, resource managers

and conservationists to provide a rational basis for conservation activities and sustainable resource use.

Plants

The flora of Bermuda is well studied although most of the published accounts were produced early in this century. There are 165 native vascular plant species, 15 of which are endemic. The conservation status of flowering plants and ferns has been studied and measures are being taken to propagate rare species in the Botanical Gardens and to enhance wild populations. Endemic flowering plants and ferns are as follows.

Non-woody plants

Adiantum bellum. a fern found in deep road cuttings and on rough stone boundary walls, it is quite widespread and apparently not threatened. This species may also occur in Guyana.

Carex bermudiana (R): rare sedge which is found in the Paget Marsh Nature and at five upland sites.

Bermuda snowberry *Chiococca bermudiana* (R): a sprawling bush or vine, it is generally found on hillsides and woody areas. It is uncommon but still widespread.

Bermuda cave fern *Ctenitis sloanei*. rare, it survives in Walsingham.

Diplazium laffanianum (EX): now extinct in the wild, this fern was formerly found in the caves of Paynter's Vale and Walsingham districts, and last found in Walsingham at the turn of the century. A few specimens survive in the Bermuda Botanical Gardens.

Bermuda spike rush *Eleocharis bermudiana* (EX): believed extinct, it formerly occurred in peat marshes of lowland valley areas.

A fleabane *Erigeron darrellianus*. fairly common and widespread throughout Bermuda in sandy or rocky coastal situations.

Goniopteris bermudiana (E): an endangered fern, it survives only in rocky holes and sinks in the Walsingham area.

Hypericum macrosepalum (Guttiferae): an endangered shrub that was once frequent on hillsides and marshes. Land development and competition from introduced plants have reduced the species to a few isolated localities.

A wild pepper *Peperomia septentrionalis* (R): a rare species of 'wild pepper', this succulent herb is mainly on pinnacle rock and in sink-holes of the Walsingham geological formation between Harrington Sound and Castle Harbour at the east end of Bermuda.

A vine *Phaseolus lignosus* (E): an endangered climbing vine, known only from one small hillside site.

Blue-eyed grass *Sisyrinchium bermudiana*. common and widespread in Bermuda it thrives in any open sunny site, mainly in coastal areas. It is not certain that this species is endemic: it may also occur naturally in south-west Ireland.

Trees

Bermuda olivewood *Elaeodendron laneanum* (VU): a rare evergreen tree which survives naturally on rocky hillsides in the Eastern End, Harrington Sound, Walsingham and Abbotts Cliff areas. Propagation as an ornamental tree has greatly increased its distribution parks and gardens since 1960.

Bermuda cedar *Juniperus bermudiana* (CR): over 95% of the trees of this valuable timber species have been lost through infestation by a scale insect accidentally introduced in the 1940s. Since then a scale resistant strain has evolved with the aid of biological controls. Although the population has recovered to 10% of its former abundance, competition from a host of introduced and invasive broad-leaved trees is preventing a full recovery.

Bermuda palm *Sabal bermudana* (EN): restricted to

small areas of natural vegetation, it is an ornamental species, well established in cultivation.

The bryophyte flora consists of 51 species with two endemic species of moss recorded. These are *Campylopus bermudiana* and *Trichostomum bermudianum*.

Invertebrates

The following information on insects is taken from Sterrer (1998). Records for Lepidoptera cover 183 species of which 50 resident species are identified as probably indigenous and 11 species and three subspecies are endemic. One of these, a geometrid moth *Semiothisa ochrifascia* is believed to be extinct. This species was dependent on the endemic Bermuda cedar *Juniperus bermudiana*. There are 228 recorded species of Coleoptera with no endemics (Hilburn and Gordon 1989) and 258 species of Diptera, including 17 endemic species (Woodley & Hilburn 1994). In total there are about 44 endemic insect species of which 16 are thought to have become extinct this century. These include a cicada *Tibicen bermudiana* and the Bermuda flightless grasshopper *Paroxya bermudensis*. Seven dragonflies and three damselflies are recorded for Bermuda (Wingate 1996).

The caves of Bermuda have a rich and diverse marine biota. More than 250 species of macro-marine invertebrates have been identified from the caves including 42 new species, 14 new genera, one new family (of Isopoda) and two new orders (of Peracarida and Copepoda). Sixty of these taxa are endemic. Twenty-five species of invertebrates are considered to be critically endangered (IUCN, 1996; Iliffe 1997).

A copepod *Antriscopia prehensilis* (CR): known only from five mature specimens collected in Roadside Cave (Walsingham Tract).

An isopod *Atlantasellus cavernicolus* (CR): a small, unpigmented, eyeless isopod known only from Walsingham Sink Cave (Walsingham Tract).

A shrimp *Barbouria cubensis* (CR): the Bermuda

population is known only from Tucker's Town, Chalk, and Admiral's Caves (Walsingham Tract). This cave-limited shrimp species is also known from Cuba, the Bahamas, Cayman Islands, Jamaica and Yucatan (Mexico).

An isopod *Bermudalana aruboides* (CR): known only from Church, Bitumen and Wonderland Caves (Walsingham Tract), Bermuda.

A mysid *Bermudamysis speluncola* (CR): a monotypic genus known from Green Bay Cave (Shelly Bay) and Castle Grotto, Cherry Pit, Palm, Walsingham, Leamington Caves and Grenadier Pool Bermudian caves.

An amphipod *Bogidiella (Antillogiella) bermudensis* (CR): blind and unpigmented, it is known from six specimens collected from Walsingham and Roadside Caves (Walsingham Tract).

An amphipod *Cocoharpinia iliffei* (CR): known only from Walsingham Cave (Walsingham Tract).

An isopod *Currassanthura bermudensis* (CR): known only from a single specimen washed from coarse sediments on the shore of Church Cave. The other two species of the genus occur in subterranean habitats in the Canary Islands and Curacao (Netherlands Antillies).

A copepod *Erebonectes nesioticus* (CR): known only from Christie's, Church, and Bitumen Caves (Walsingham Tract) and Devonshire Cave (Devonshire). The Bermuda Government is confident that strict environmental controls, monitoring and mitigation measures will protect the species from the threat posed by the resort housing development in the vicinity of Christie's, Church and Bitumen caves.

An amphipod *Idunella sketi* (CR): known only from Walsingham Cave (Walsingham Tract).

An amphipod *Ingolfiella longipes* (CR): known only from a single specimen collected in 1978 at Walsingham Sink Cave (Walsingham Tract),

Bermuda. Despite repeated collection efforts, no additional specimens have ever been collected.

A polychaete *Mesonerilla prospera* (CR): known only from Walsingham, Cripplegate, Deep Blue, Emerald Sink, Cherry Pit, Myrtle Bank, Church and Bitumen Caves (all in the Walsingham Tract).

A peracarid crustacean *Mictocaris halope* (CR): a blind and unpigmented troglobitic species of known only from Green Bay Cave (Shelly Bay) and Crystal, Roadside and Tucker's Town Caves (Walsingham Tract).

A copepod *Nanocopia minuta* (CR): known only from two specimens collected in Roadside Cave (Walsingham Tract).

A copepod *Paracyclopia naessi* (CR): known only from Chalk Cave (Devil's Hole); Christie's, Southdown and Tucker's Town Caves (Walsingham Tract); and Devonshire Cave (Devonshire). The monotypic genus *Paracyclopia* is the only representative of the calanoid family *Pseudocyclopiidae* in Bermuda. Previous records of this family included only specimens from a single genus inhabiting waters around the British Isles and Norway.

A tubificid *Phalldrilus macmasterae* (CR): a transparent tubificid known only three specimens collected from Prospero's Cave (Walsingham Tract), Bermuda.

A mysid *Platyops sterreri* (CR): known only from five specimens collected in Castle Grotto (Walsingham Tract) and Green Bay Cave (Shelly Bay).

A shrimp *Procaris chacei* (CR): known only from two specimens collected in Green Bay Cave (Shelly Bay), Bermuda.

An amphipod *Pseudoniphargus grandimanus* (CR): this troglobitic amphipod is common in the groundwater lenses of Bermuda, most frequently in the moderately saline sections, including the anchialine cave waters of Roadside, Wonderland, Church, Bitumen, Admiral's, Shop and Bat Caves

(all in the Walsingham Tract). Before its discovery in Bermuda, this genus had been known from inland groundwaters around the Mediterranean basin, in Atlantic drainage systems of Portugal and Spain, and in the Azores.

A shrimp *Somersiella sterreri* (CR): the Bermudan population is known from only two specimens collected from Tucker's Town Cave (Walsingham Tract) and Chalk Cave (Devil's Hole). The shrimp also inhabits caves in the Bahamas, Yucatan Peninsula (Mexico) and Cuba.

An ostracod *Spelaeoecia bermudensis* (CR): this species has been reported from Jane's, Bitumen, Christie's, Church, Crystal, Fern Sink, Green Bay, Roadside, Tucker's Town, Walsingham Sink, and Wonderland Caves (all in the Walsingham Tract).

A copepod *Speleoithona bermudensis* (CR): a minute diaphanous cyclopid known only from Walsingham, Bee Pit, Church and Bitumen Caves (Walsingham Tract).

A copepod *Speleophria bivexilla* (CR): known only from Roadside Cave (Walsingham Tract).

A copepod *Speleophria scottodicarloi* (CR): known only from a single specimen collected in Chalk Cave (Devil's Hole).

A shrimp *Typhlatya iliffei* (CR): known only from Tucker's Town and Bitumen Caves (Walsingham Tract), the closest relative of this shrimp is *T. rogersi* from Ascension.

Fish

The list of fish recorded for Bermuda consists of 430 species in 107 families. These are mostly inshore species recorded from depths above 200 m. Three endemic species of *Fundulus* are found in brackish ponds and marshes.

Reptiles

Bermuda has one indigenous terrestrial lizard

Eumeces longirostris, an endemic skink which is declining and now rare on the main islands. Healthy populations remain on a few smaller islets. The skink is the subject of an intensive study as part of the Bermuda Biodiversity Project (Davenport *et al.* 1997; Raine 1998).

Four sea turtle species forage in Bermuda waters. Foraging turtles are reported to be moderately abundant.

Loggerhead turtle *Caretta caretta* (EN). Breeding and foraging have been reported (UNEP/IUCN 1988). The last breeding attempt was in 1991.

Green turtle *Chelonia mydas* (EN): formerly nesting on Bermuda, green turtles became extinct as a nesting species by 1934 (Groombridge & Luxmoore 1989). An experiment to restore this species as a breeder was carried out between 1968 and 1978 by transportation, and hatching of egg clutches; 16,000 hatchlings were released on Bermuda beaches. Bermuda supports an abundant population of juvenile turtles which are the subject of a lengthy tag and recapture study through the BAMZ (Meylan *et al.* 1992).

Leatherback turtle *Dermodochelys coriacea* (EN): no nesting has been reported. They may be observed foraging around Bermuda (UNEP/IUCN 1988).

Hawksbill turtle *Eretmodochelys imbricata* (CR): no nesting has been reported. Low numbers of hawksbills are known to forage on the reefs of the Bermudan platform (Groombridge & Luxmoore 1989).

Birds

A checklist of the birds of Bermuda is provided by Wingate (1973) and Amos (1991) and includes over 350 species. Resident and breeding species are relatively few, with nine surviving indigenous species, one reintroduced, three recent colonisations and six introductions. The Bermuda petrel *Pterodroma cahow*, and the Bermuda white-eyed vireo *Vireo griseus bermudianus* are endemic to Bermuda.

Bermuda petrel *Pterodroma cahow* (EN). This species was once an abundant nesting seabird throughout Bermuda. The introduction of mammal predators before and during early European settlement (1560–1620) caused rapid extermination from the main and largest inhabited islands. It was lost to science for three and a half centuries until 18 pairs were found breeding on tiny rocky islets (total area 1 ha) in Castle Harbour during 1951. Since 1961, intensive management, including the creation of artificial burrows and the elimination of nest-site competition by the white-tailed tropicbird *Phaethon lepturus*, has resulted in an increase to 55 pairs (Wingate 1998) with 30 young fledged.

Bermuda white-eyed vireo *Vireo griseus bermudianus*. This species is known in Bermuda as the chick-of-the-village. Numbers declined as a result of the loss of Bermuda's extensive cedar forests (*Juniperus bermudiana*), although they continue to thrive in parks and larger remaining woodlands.

Marine mammals

Bermuda is an important area for migrating humpback whales *Megaptera novaeangliae* (VU). Sperm whales *Physeter catodon* (VU), blue whales *Balaenoptera musculus* and northern right whales *Eubalaena glacialis* (EN) may occasionally occur in Bermudan waters. Also known from Bermuda are Cuvier's beaked whale *Ziphius cavirostris*, short-finned pilot whale *Globicephala macrorhynchus* and minke whale *Balaenoptera acutorostrata*.

Species protection

- **Protection of Birds Act 1975:** 'Protected birds' include all non-captive-bred species, except four pest species (viz. American crow *Corvus brachyrhynchus*, house sparrow *Passer domesticus*, starling *Sturnus vulgaris* and kiskadee *Pitangus sulphuratus*) (see Protected areas above).
- **Tree Preservation Orders:** (see Protected areas above).

- **Protected Species Order 1978:** includes all corals, sea turtles, marine mammals and threatened species of molluscs and fish.

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