

EXECUTIVE SUMMARY

This document provides an overview of the status of Bermuda's biota, identifies the most critical issues facing the conservation of the Island's biodiversity and attempts to place these in the context of the social and economic needs of our highly sophisticated and densely populated island community. It is intended that this document provide the framework for discussion, establish a baseline and identify issues requiring resolution in the creation of a Biodiversity Strategy and Action Plan for Bermuda.

As human use or intrusion into natural habitats drives the primary issues relating to biodiversity conservation, societal factors are described to provide context for analysis.

- The Island's human population demographics, cultural origin and system of governance are described highlighting the fact that, with 1,145 people per km², Bermuda is one of the most densely populated islands in the world.
- Bermuda's highly developed infrastructure is described along with comments on some of the inevitable stresses placed on natural systems when providing such sophisticated support systems on such a small land base.
- The effects of the Island's limited space on development opportunities, property prices and housing issues are discussed.

- The Island's principal industries and trends are briefly described.
- Statistics addressing the socio-economic situation including income, employment and issues of racial equity are provided along with a description of Government policies to address these issues and the Island's health services.

A major portion of this document describes the current status of Bermuda's biodiversity placing it in the biogeographical context, and describing the Island's diversity of habitats along with their current status and key threats. Particular focus is given to the Island's endemic species.

- The combined effects of Bermuda's isolation, climate, geological evolution and proximity to the Gulf Stream on the development of a uniquely Bermudian biological assemblage are reviewed.
- The effect of sea level change in shaping the pre-colonial biota of Bermuda along with the impact of the early colonists on this unique system is briefly explained.
- Of the 21 habitat categories described, the marine habitats have fared the best as, with the dramatic exception of Castle Harbour, they are buffered from the impacts of development. However, it is noted that the open ocean is becoming increasingly fouled with plastic debris, coral reefs are threatened by global warming and seagrass habitats are being

eroded by the proliferation of moorings in protected bays.

- On land the impacts of development and invasive species have been severe. Remarkably, a full 13.7% of the Island is covered in concrete (the area of Devonshire and 1/3 of Smiths Parish). There are very few remaining pristine habitats and these occur in small isolated patches. Development and invasive species are identified as the key threats to Bermuda's terrestrial native and endemic species.
- A review of Bermuda's marine and terrestrial biodiversity is provided noting that over 8,000 species occur locally of which 3% are endemic. The majority of the Island's endemic species are found in the caves, which are, in many instances threatened by development and pollution.
- Identified threats to biodiversity include: a) habitat destruction through hurricanes, shipwreck, development and dumping, b) pollution through dumping, improper use of pesticides, waste disposal, c) invasive species especially introduced plants, insect pests and feral animals, d) over-harvesting particularly of fisheries resources, e) and climate change.

The status of biological resources is reviewed with particular attention to the existing and future economic activities based on those resources such as tourism and fishing. A framework for the valuation of these resources is provided.

The values of biodiversity section deals with ecosystem services and provides examples of

particular components of the Island's ecosystems and the services that they provide. Mention is also made of the non-monetary traditional, cultural and aesthetic values of these resources.

The Island has several conservation agencies, both Government and NGO, which fortunately display a high level of co-operative spirit. These agencies are listed along with their primary areas of focus. The potential of a restructured environment section of the Ministry of the Environment, Development and Opportunity to build on this spirit of co-operation in order to promote effective conservation is noted.

Existing conservation programmes and the agencies involved are described. The legislative protection afforded to species and habitats are reviewed along with contingency plans, information management systems and education programmes. Although there is evidence of a highly organised system of programmes to promote conservation, an outstanding lack of protection for Bermuda's terrestrial endemic species is uncovered.

The final section of this report deals with an analysis of the underlying issues affecting the conservation of Bermuda's biodiversity.

INTRODUCTION

Since its discovery in 1503, humans have viewed Bermuda from a series of divergent perspectives: a treacherous island to be avoided, a land of plenty, a strategic outpost, a beautiful place to vacation, a secure place to do business. Today, like many island communities, Bermuda's economy, through tourism, recreational activities and international business, is intrinsically dependent on the health of its natural habitats. But Bermuda is perhaps unique amongst island communities in that its affluence coupled with an educated populace have created an environment in which nature's intrinsic value can indeed be appreciated.

Given its geographical isolation, Bermuda supports a surprisingly rich assemblage of plant and animal species, over 8,000 of which have been documented. In addition to its intrinsic value, this natural heritage is of ecological, social, economic, scientific, cultural and aesthetic importance. Many of the species found in Bermuda are at the extreme limits of their geographical distribution, and as such, the status of the Island's biodiversity is not only critical to the well-being of Bermuda and its people, but also serves as an important barometer of climate-driven global trends.

However, with a resident population of 60,000 inhabiting a total land mass of 50 km², and entertaining 500,000 visitors a year, the pressure for further development poses a rapidly escalating threat to the Island's fragile ecology, and to its underlying economy.

In an effort to promote more effective management of the Island's natural resources the Bermuda Zoological Society in partnership with the Bermuda Aquarium, Museum and Zoo, launched the Bermuda Biodiversity Project (BBP) in 1997. The BBP represents the first attempt to create a comprehensive information management system for Bermuda's natural resources. With this underlying goal, the project has focussed on the collation and dissemination of information, promotion of its importance and encouragement of its use. Information gaps identified during this process are being addressed in a collaborative effort by BBP staff and visiting scientists. Particular emphasis is being given to the detailed mapping of coral reefs, as well as to an island-wide vegetation survey, to provide a valuable baseline of information. A primary focus of the BBP has also been to target 'high priority' conservation issues and threatened endemic species.

In 2000, the BBP launched an initiative to develop a biodiversity strategy and action plan (BSAP) for Bermuda. Many Bermudians now recognise that there is an urgent need for a co-ordinated, community-based plan for the conservation of the Islands' unique natural heritage. The intent of the BSAP, is to develop a well-defined framework for conservation action, which sets realistic conservation targets, and establishes a series of prioritised, practical options for achieving these.

The success of this initiative will be entirely dependent on the extent to which the wider community has input into the plan. By engaging the whole community it is hoped that there will be a broader understanding of how environmental, social and economic issues are inter-related. This in turn should encourage more widespread

support for the development of an effective conservation strategy.

A necessary first step in the development of such a plan, is an assessment of the current status of the Island's biodiversity resources and their value. The Biodiversity Country Study has been compiled over the past four months, and follows general guidelines developed by the United Nations Environment Programme, and guidelines produced by Fauna and Flora International. Contributions from many organisations and individuals have been incorporated.

It is difficult to conceive of adequately assessing the importance of biodiversity to the Island. All life is contingent upon other life forms, and it is the very complexity of biological systems with their myriad species, that creates our stable life-support system. This document attempts to place Bermuda's unique biodiversity in context with the realities of a heavily developed urban landscape, and to highlight some of the services that nature provides for us. It aims to summarise existing information by drawing on the many valuable manuscripts that describe the Island's natural history; and through the work of the Bermuda Biodiversity Project, provide new data on the status and trends of Bermuda's species and habitats as well as the status of current conservation and use mechanisms. The Study identifies many of the potential threats to our natural communities as well as critical issues confronting their effective conservation.

This document is not intended to be conclusive, but rather to serve as a first iteration, identifying the opportunities and problems that we face in effectively

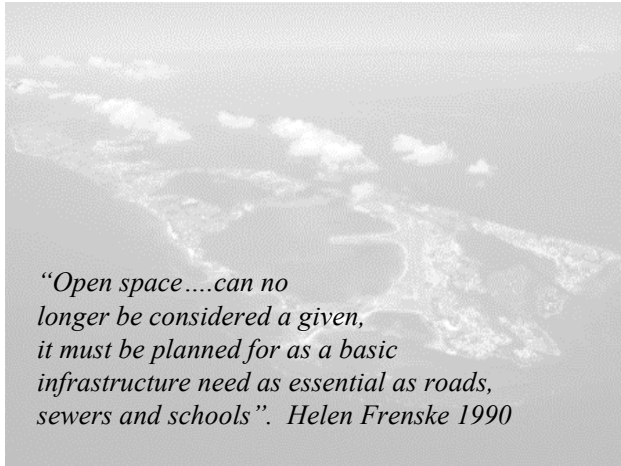
managing our resources, and serving to initiate a process of biodiversity planning. The Country Study should evolve through the acquisition of additional data. It should also serve:

- To provide a basis of determining priorities for the conservation and sustainable use of Bermuda's biological diversity
- As a benchmark to monitor the effectiveness of the BSAP
- To identify activities likely to have an adverse impact on the conservation and sustainable use of Bermuda's biological diversity
- To identify the economic benefits resulting from the conservation and sustainable use of Bermuda's biological diversity
- To identify appropriate measures for achieving effective conservation and sustainable use of Bermuda's biological diversity.

Although the intent in launching this initiative is to satisfy a recognised need within Bermuda, the development of this BSAP will be a major step for Bermuda towards committing to the principles of the 1992 Convention on Biological Diversity, which the UK has already signed on behalf of its Overseas Territories. This convention represents an agreement between nations to act co-operatively to protect habitats, species and genes, to adopt sustainable patterns of resource use, and to ensure that the benefits of natural resources are equitably shared across local regional, national and global societies.

For clarification, an important distinction needs to be made between “biological resources” and “biodiversity”. The latter refers to the variability among living organisms from all sources, and the ecological complexes of which they are a part; this includes diversity within species (at the genetic level), between species, and of ecosystems. Biological resources include organisms or parts thereof, populations or any other biotic component of an ecosystem which is harvestable or potentially harvestable or has some value or use for humanity.

COUNTRY CONTEXT



Geographical Location and Borders

Bermuda is an oasis of life in an oceanic desert. The Bermuda chain, comprising over 150 islands and islets, lies isolated in the middle of the Atlantic Ocean at latitude 32° 19' N and longitude 64° 46' W. The closest continental point of land is Cape Hatteras, North Carolina, which is 965 km (570 miles) to the west. Often mistaken as a Caribbean Island, Bermuda lies over 1200 km (746 miles) to the north of its nearest Caribbean neighbour.

Physical Geography

Unique in that it forms the most northerly coral reef system in the world, Bermuda lies on the southern rim of the largest of three steep-sided sea-mounts. The two other sea-mounts, Challenger Bank and Argus Bank, lie submerged between 19 and 32 km

(12 and 20 miles) to the south west of Bermuda. Originating through two periods of volcanic activity approximately 110 million years ago and 33 million years ago, these mounts rise from a depth of 4,270 m (14,000 ft) from the floor of the Atlantic Ocean.

On top of the volcanic pedestal the shallow-water Bermuda platform comprises a limestone cap which is up to 100 m (300 ft) thick, and encompasses an area of approximately 1000 km² (386 miles²). The extremely porous nature of the limestone means that there are no rivers, streams and freshwater lakes; all drainage is underground.

Topographically the Island consists of a series of low-rolling hills with a maximum height of only 70 m (260 ft) at Town Hill in Smiths. Bermuda's seven principal islands are connected by a series of causeways and bridges to produce a fish-hook shape with a total area of 55 km² (21 miles²). The Island is divided into 9 parishes which are, from west to east, Sandys, Southampton, Warwick, Paget, Pembroke, Devonshire, Smith's, Hamilton, and St. George's.

Climate

Of great biological interest is the fact that Bermuda's climate is sub-tropical, despite its northerly latitude. This is largely explained by the transport of warm waters in the Gulf Stream current from the Caribbean. Although Bermuda lies to the east of this northerly flowing current, spin-offs bring warm water to the Island. Another underlying factor of the sub-tropical climate is the Bermuda-Azores high-

pressure system, which sets up in the summer months and deflects summer storms.

Despite this sub-tropical climate, Bermuda is far enough north to be influenced by the westerlies, so winds show much more seasonal variability than in the truly sub-tropical islands of the North Atlantic. However, the prevailing winds are from the south west. Hurricanes strike the Island every few years, often with devastating effects to the local flora and fauna.

Substantially moderated by the surrounding ocean, Bermuda’s mean monthly air temperatures range from 18.5°C (65.3°F) in February to 29.6°C (85.3°F) in August, whilst sea surface temperatures range from 18°C to 28°C (64.4°F to 82.4°F).

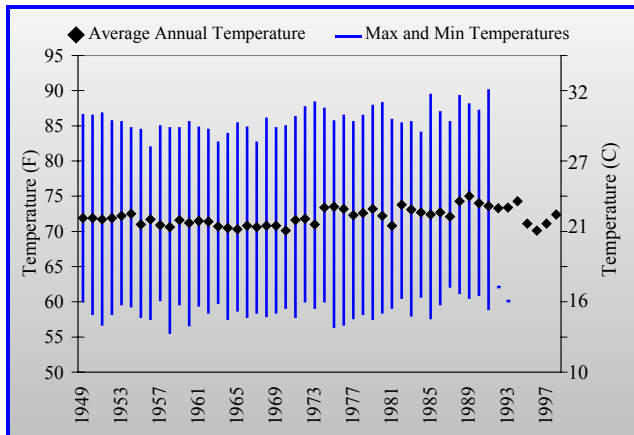


Figure 1. Average annual temperature with average minimum and maximum air temperatures recorded in Bermuda between 1949 and 1998¹.

Annual rainfall is highly variable, and periods of drought present a very real threat, as rainfall is the principal source of freshwater. Rainfall patterns

reveal a definite “Island effect”². The prevailing westerly winds coupled with convection over the land mass bring greater rainfall over the eastern end of Bermuda.

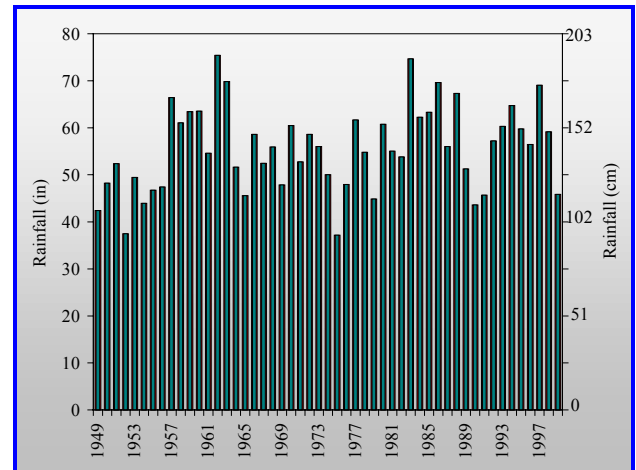


Figure 2. Annual rainfall in Bermuda between 1949 and 1999¹.

Humidity is uniformly high at 70-82% year round, whilst the solar energy reaching the surface of Bermuda has a marked seasonality averaging 240 gcal/cm²/day in July and 640 gcal/cm²/day in December³.

Oceanography

Lying on the western margin of the Sargasso Sea, Bermuda is under the influence of the North Atlantic Gyre, and is dominated by the northerly flowing Antilles Current in the summer and autumn, and the

² Glasspool, A. Pers. Comm. Bermuda Zoological Society. From data collected for the Air Ocean Chemistry Experiment 1988-1995.

³ U.S. Naval Weather Service Detachment. 1974. Bermuda Environmental Scenarios. Ashville, North Carolina.

¹ From data collected by the Bermuda Weather Service.

Gulf Stream in winter and spring. Whilst some of the marine species found in Bermuda are globally distributed, most of the Island's marine life originated from source populations in the Caribbean, and were transported to Bermuda in the Gulf Stream as eggs, larvae or adults. Periodic recruitment from the Caribbean probably occurs for most species⁴, but from a management perspective Bermuda's non-migratory marine species are considered to be self-replenishing⁵. Bermuda's relative isolation coupled with the wide temperature range experienced locally does mean that the diversity of marine organisms found here is considerably less than in the Caribbean.

Surface waters around Bermuda are generally nutrient-poor; however, there are increased levels of nutrients in the inshore waters due to the combined effects of terrestrial run-off, waste water input, mixing of the water column, as well as the increased biological activity of the coral reef system.

Whilst mean tidal range is just 75 cm (2.5 feet), the Island is exposed to large waves from any direction. The extensive rim reefs surrounding the shallow waters of the North Lagoon shelter the Island's north shore. However, on the southern side of the Island the reefline is never more than 1 km (0.6 miles) from the shore, so wave action has a much greater impact.

⁴ Glasspool, A. 1994. Population structure and gene flow in Bermuda's reef fish. Proceedings of the 47th Gulf and Caribbean Fisheries Institute. 47. In press.

⁵ Farmer, M.W., J.A. Ward and B.E. Luckhurst. 1988. Development of spiny lobster (*Panulirus argus*) phyllosoma larvae in the plankton near Bermuda. Proceedings of the 39th Gulf and Caribbean Fisheries Institute. 39, 289-301.

Human Population and Demography

Bermuda is one of the most densely populated isolated islands in the world! As of the last census conducted in 1991, the population was numbered at 58,460 (civilian non-institutional population), with a ratio of 48% male to 52% female⁶. Current estimates put the population closer to 62,000. Whilst 61% of the population is black, they comprise 71% of the voting population. This is because 44% of the white population are non-Bermudian residents without voting privileges⁷.

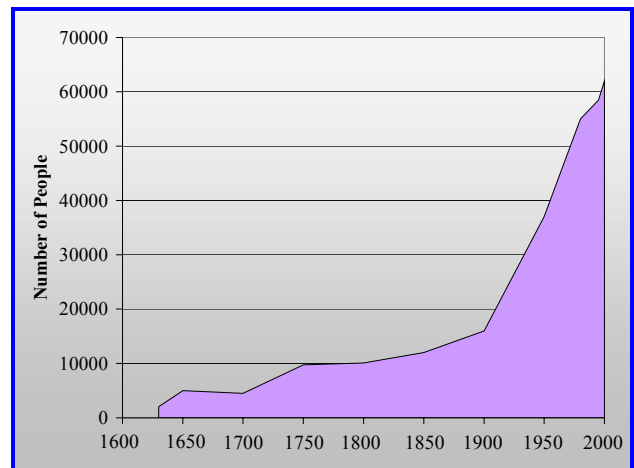


Figure 3. Population growth in Bermuda from ~1626 to 2000⁸.

Bermuda, like all other developed countries, has an increasingly dependent, ageing population and due to declining birth rates, a decrease in the number of young people entering the workforce.

⁶ Department of Statistics, Ministry of Finance, Government of Bermuda. 1991. Census of Population and Housing Executive Report. p. 7.

⁷ Newman, D.K., 1994. Bermuda's Stride Toward The Twenty-First Century. Department of Statistics, Ministry of Finance, Government of Bermuda. p. 3.

⁸ Frazer, S. 1981. Population. In: Bermuda's Delicate Balance. S.J. Hayward, V. Holt Gomez, W. Sterrer (Eds). Bermuda National Trust, Hamilton Bermuda. pp. 10-18.

The population density is a staggering 1,145 people per km² (2,818 people per mile²). However, this is unevenly distributed with 47% of the population concentrated in just three parishes, Pembroke (20%), Warwick (14%) and Devonshire (13%). Less concentrated are; Sandys (11%), Southampton (10%), Smith's (9%), Paget (8%), Hamilton (8%) and St. George's (8%)⁹. Over the last four decades, there has been a steady migration of people away from the City of Hamilton and Pembroke Parish. Southampton and Hamilton parishes account for the largest influxes. External factors influencing residential issues in Bermuda include zoning laws (restricting density per hectare), educational opportunities, and family or neighbourhood associations. Whilst the residential environment is for the most part relatively integrated, small enclaves do exist that are poorly integrated from a racial perspective. Most areas of higher density housing tend to support predominantly black communities.

As of the 1991 census, 79% of the population was Bermudian (by birth and/or status). This represented a 6% increase in the Bermudian population between 1980 and 1991, whilst the non-Bermudian population grew 17% during the same time frame.

Unfortunately there is no record of the number of residents, both Bermudian and non-Bermudian, emigrating to other countries or of Bermudians returning to the Island after living abroad.

⁹ Department of Statistics, Ministry of Finance, Government of Bermuda. 1991. Census of Population and Housing. p. 9.

People and Culture

There are no indigenous Bermudian people. Juan de Bermudez is generally recognised as having 'discovered' the island in 1503, but it was only after a British expedition to Virginia foundered on the eastern reefs in 1609 that a permanent settlement was established. Nowadays the inhabitants comprise a mixed ancestry.

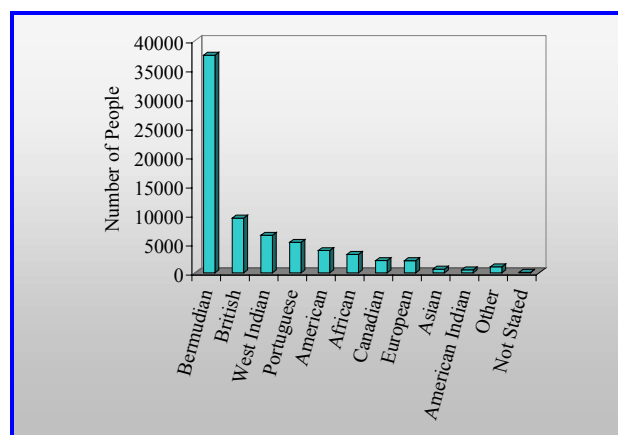


Figure 4. Results of the 1991 Census showing the make-up of the population by ancestry¹⁰.

Legislative And Political Structure

Bermuda is the oldest self-governing British colony (now referred to as a British Overseas Territory) with its government dating back to 1620. The legislature is organised with the Governor at the head (a representative of the Crown), followed by the Deputy Governor, the Senate and the House of Assembly. The House of Assembly is the principal legislating body, currently consisting of 40 members of parliament who meet weekly to debate or initiate

¹⁰ Department of Statistics, Ministry of Finance, Government of Bermuda. 1991. Census of Population and Housing. p. 21.

bills. Although the Senate may also initiate bills, it is usually responsible for approving and forwarding bills for signing by the Governor to be made into law. The Senate consists of 11 members appointed by the Governor with the advice of the Premier and Opposition Leader.

In August 2000, the Government tabled a proposal in the House of Assembly to make changes to the Bermuda Constitution. The most significant of these involves the removal of parish boundaries as the guideline upon which electoral constituencies are based, and the establishment of single seat constituencies representing, as far as possible, an equal number of registered voters. There has been public resistance to these changes and the proposals remain unresolved.

There are 2 main political parties, the Progressive Labour Party (PLP) and the United Bermuda Party (UBP), with a third minor party, the National Liberal Party (NLP). The party that wins the most seats in a general election, or has the support of the majority of members in the House of Assembly, forms the government, with its leader as the Premier. The largest minority party forms the Opposition.

Infrastructure

Roads

Bermuda has approximately 225 km (140 miles) of public roadway and about the same length of private roads. The road network is well developed with

very little room for expansion, and well maintained by the Ministry of Works and Engineering to enhance safety and efficient traffic flow. However, there are issues relating to traffic congestion, especially during rush hours. The Island has a very high number of vehicles per capita, despite the fact that each household is limited to one car.

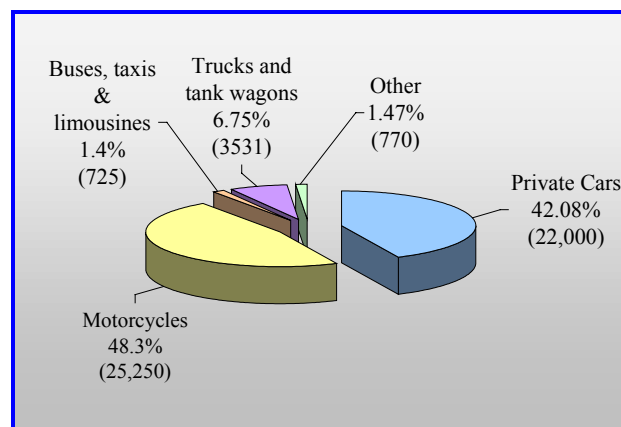


Figure 5. Number of registered road vehicles in 1998¹¹.

A National Transportation Strategy is currently being prepared to identify ways of increasing the efficiency of transportation as well as to encourage the use of public transportation. A reform of the ferry service is underway which includes new, faster ferries as well as additional ferry stops with designated car parking facilities. It is hoped that this will reduce traffic congestion by encouraging people to park and commute via ferry to Hamilton. However, it will involve the construction of new docks and the need for parking facilities at these locations.

¹¹ Department of Statistics, Ministry of Finance, Government of Bermuda. 1999. Facts and Figures. p. 11.

Bridges

Several bridges link the main islands. For the most part these are kept in good repair. However, in the last few years mechanical failures with the two ageing bridges in St. George's have impacted both marine and road traffic.

Sewers

All public roads are maintained to ensure efficient drainage of storm water run-off, although flooding can be a significant problem during heavy rainfall, especially in low-lying areas such as the Mills Creek industrial area in Pembroke. There is no Island-wide sewer system and the majority of domestic wastewater is disposed through cesspits. Some major hotel developments have sewage treatment plants, and there are plans for the construction of a tertiary treatment sewage plant to service the Islands' largest sewer, managed by the Corporation of Hamilton. However, at present, sewage from the City receives only primary treatment before being pumped into the ocean through the Sea Bright outfall off of Hungry Bay. A small but increasing proportion of the Island's sewage waste is discharged into deep-sealed boreholes.

Solid Waste Management¹²

Domestic and commercial non-bulk waste is handled at the Government mass burn incinerator at Tynes Bay. The ash residue from the incinerator is mixed

with concrete to form blocks 1m³ (35 ft³) in size. These are placed into Castle Harbour as part of the land reclamation scheme at the airport. Based on figures from the 1990's, it is estimated that there is an annual increase of 2,000 metric tonnes of waste burnt each year. There is non-mandatory recycling of glass bottles and aluminium cans.

Inert waste, comprising building debris, rubble and metal objects such as cars and refrigerators, is taken to the Airport Waste and Land Reclamation facility. Oils, gasoline and refrigerants are removed before the waste is flattened and then deposited into Castle Harbour.

Hazardous waste including batteries, asbestos, fluorescent tubes, paint, waste oil and chemicals are taken to the Hazardous Waste Facility in Dockyard. From there, they are shipped to hazardous waste processing plants in North America at a cost of about \$450,00 per year¹³. The waste oil is sent abroad for recycling or fuel blending.

The Compost Facility at Marsh folly, the site of the former Pembroke Dump handles horticultural waste, food waste, and carcasses. It will need to be relocated due to the planned restoration of the area as a park.

A bio-oxidiser or special incinerator at the King Edward Memorial Hospital handles biomedical waste from the hospital, and other medical and veterinary practices.

¹² Brett, J. Pers. Comm. Waste Management Section, Ministry of Works and Engineering.

¹³ Trott, C. Pers. Comm. Waste Management Section, Ministry of Works and Engineering.

<i>Type of Hazardous Waste</i>	<i>Amount Collected Annually</i>
Vehicle Batteries	11,000
Household Batteries	4,536 kg
Fluorescent Lamps	40,000 tubes
Waste Paint	45,460 litres
Waste Oil	272,760 litres
Asbestos	1,814,400 kg
Household Waste	67,000 tonnes
Ash Blocks	7,200
Inert Waste	33,800-36,400 loads
Horticultural / Food Waste	18,000 tonnes

Table 1. Most recent figures of the amount and type of waste collected annually in Bermuda¹⁴.

Fresh Water Supply¹⁵

The main source of the Island's freshwater is rainwater, which is caught on the whitewashed roofs of most residences, and directed into storage tanks on each property.

Groundwater is extracted for use by large institutions such as hospitals, businesses and large hotels. There are four fresh groundwater lenses, the largest being the Central Lens in Pembroke and

¹⁴ Brett, J. Pers. Comm. Waste Management Section, Ministry of Works and Engineering.

¹⁵ Rowe, M. Pers. Comm. Hydrogeology Section, Ministry of the Environment, Development and Opportunity.

Devonshire. Up to 10 m (30 ft) deep, the freshwater lens sits on top of brackish groundwater, which in turn floats on salt water. The limestone, through which rainwater percolates to recharge the groundwater supply, acts as a natural filtration system that reduces impurities in the groundwater. Since disposal of most domestic wastewater and sewage occurs through cesspits, testing of well water by the Health Department is carried out before it can be approved for drinking. Of the 3,100 households that have a domestic well, most use the water for washing and toilet flushing, whilst relying on rain water for drinking. There are 850 commercial wells, and 4 groundwater suppliers in addition to the Government are licensed to sell water.

The average daily rate of extraction of groundwater was between 5.5 and 6.8 million litres (1.2 and 1.5 million imperial gallons) per day in 2000. This rate increases in times of drought. An extraction limit of 9.73 million litres (2.14 million imperial gallons) per day has been set in order to ensure sustainable use of this important natural resource. A seawater reverse osmosis plant, operated by Watlington Water Works, converts 2.275 million litres (0.5 million imperial gallons) of seawater per day to fresh water.

Energy Sources

A private company, the Bermuda Electric Light Company Ltd., generates and distributes electric power using fuel shipped to Bermuda, and energy generated by the Government's mass burn

incinerator (23,000 megawatts generated annually)¹⁶. Energy consumption has increased from 480,142 megawatt hours in 1996 to 552,470 megawatt hours in 1999. Half of all energy consumption is attributed to commercial properties.

Diesel fuel and gasoline are imported for use in motor vehicles and propane is imported for cooking. The viability of electric-powered cars is currently being assessed, and solar energy, although not widely collected, is utilised by some hotels and a few private homes for heating water. Solar panels and electric vehicles are imported duty free.

The feasibility of using offshore wind turbines is currently under investigation by the Bermuda Electric Light Company Ltd., the Government and the Bermuda Biological Station for Research.

Communications

Bermuda has excellent cable and satellite communications and service links. It received its first underwater telecom cables in the 1890's and has since kept pace with technological developments. It now has a highly developed communications infrastructure which, according to "Wired Magazine" was ranked third amongst 197 countries surveyed in the late 1990's for their relative "Techwealth"¹⁷. All external communications are provided by Cable and Wireless Ltd. and operated in conjunction with the Bermuda Telephone Co. Ltd.

and several other long-distance telephone service providers. The Island's sophisticated infrastructure has supported an explosive growth in electronic commerce. There are several internet service providers.

Property Rights And Tenure

Land Registry

Bermuda does not have a land title registry so land ownership is often hard to trace. The issue of developing a land title registry has proven contentious, but is still being considered. The Ministry of Works and Engineering and the Planning Department are currently preparing a land parcel map; this will provide more detailed information but will not define ownership, only approximate boundaries¹⁸. The Crown owns all areas below the high water mark.

High Property Prices

Given the scarcity of land and the high population density, the pressure to develop land for profit is great, and consequently land is expensive. Inherent in these high land prices is the high cost of rental housing. This is further compounded by the international business sector which provides rent subsidies for many of its expatriate workforce, thereby driving rents higher and encouraging locals to build with the intent to rent.

¹⁶ Brett, J. Pers. Comm. Waste Management Section, Ministry of Works and Engineering.

¹⁷ Bermuda International Business Association. Bermuda: International Solutions for Digital Business (leaflet).

¹⁸ Viney, T. Pers. Comm. Survey Division, Ministry of Works and Engineering.

<i>Property</i>	<i>Area</i>	<i>Price</i>
Vacant building lot	0.05 ha/ 0.124 acres	\$150,000
Vacant building lot	0.25 ha/ 0.628 acres	\$325,000
3 Bedroom House (Waterfront)	0.56 ha/ 0.775 acres	\$1,400,000
3 Bedroom House (High Density Area)	0.06 ha/ 0.148 acres	\$350,000

Table 2. Examples of property prices in January 2001¹⁹.

Control of Land Sale to Foreigners

Property is available for sale to non-Bermudians but is strictly regulated according to the Annual Rental Value (ARV) of the property. The policy on the acquisition of residential property by non-Bermudians is “to preserve the majority of housing stock and residential land for Bermudian ownership. It is recognised that there is only a small market for the highest-priced houses and these may be acquired by non-Bermudians for private residential use”²⁰.

Housing Stock

The 1991 Population Census reports that the owner-occupier ratio for Bermudians increased to 51% in 1991 from 47% in 1980²¹. About 45% of the housing stock has been built since 1960. By May

2000 the total number of dwelling units was 27,612²².

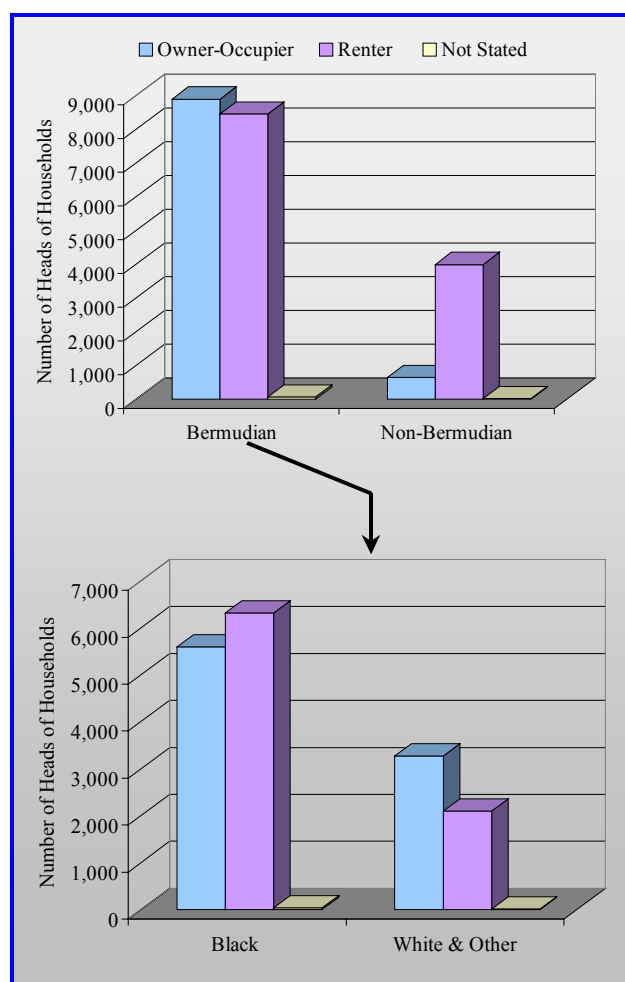


Figure 6. The distribution of home-owners by status and by race²³.

¹⁹ The Royal Gazette, January 2001.

²⁰ Ministry of Labour, Home Affairs & Public Safety, Department of Immigration, Bermuda Government. 2000. Policy Statement and Notes for the Acquisition of Residential Property by Non-Bermudians.

²¹ Department of Statistics, Ministry of Finance, Government of Bermuda. 1991. Census of Population and Housing Executive Report. p. 6.

²² Ball. S. Pers. Comm. Land Valuation Office, Ministry of the Environment, Development and Opportunity.

²³ Newman, D.K. 1994. Bermuda’s Stride Toward the Twenty-First Century. Department of Statistics, Ministry of Finance, Government of Bermuda. p. 70.

Land Use

There is no precise data on the use of Bermuda’s 5,369 ha (13,267 acres) of land. However, zoning designations from the 1992 Bermuda Plan, give a close approximation and show that 43% of the Island is zoned as “Residential”²⁴. Some land zoned as Rural also supports a significant amount of housing, though at a lower density. In the 1992 Bermuda Plan, 33% of Bermuda (just over 1800 ha or 4448 acres) was designated “Open Space”. The former foreign military bases have added another 514 ha (1,270 acres) or 10% of Bermuda’s total land area (219 ha (540 acres) of which, comprise the Bermuda International Airport).

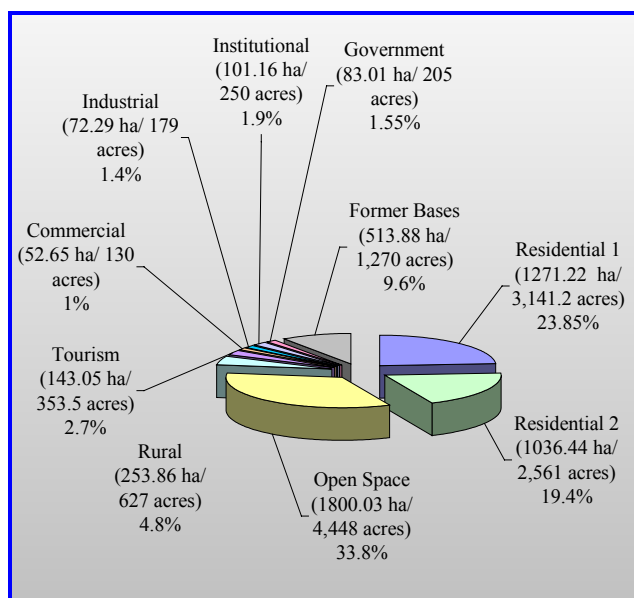


Figure 7. Percentage of land use in 1992, excluding the City of Hamilton²⁴.

²⁴ Department of Planning, Ministry of the Environment, Government of Bermuda. 1992. Bermuda Plan.

* Some land for historical properties not available.

** Calculations of Bermuda Housing Corporation land not yet available.

	PROPERTIES	HECTARES
Government Owned Land	Parks	330
	Airport	219
	Gov. Golf Courses	121.31
	Railway Trail	40.47
	Schools	27.88
	Prisons	17.97
	Industrial (Gov. quarry, bus garage)	16.48
	Tourism (former Club Med)	14.41
	TOTAL	787.57
Quasi-Gov. Organisations	WEDCo	80
	BLDC	298
	Bermuda Hospital’s Board	9.5
	TOTAL	387.5
Municipal Authorities	Corporation of Hamilton	71
	Corporation of St. George’s	135
	TOTAL	206
NGOs	Bermuda National Trust	89*
	Bermuda Audubon Society	15
	TOTAL	104
GRAND TOTAL		1485.02

Table 3. Area of land held by major land owners in 2001.**

Industry

Bermuda has two main industries, tourism and international business. International business, attracted by Bermuda’s absence of restrictive regulations, low tax liability, stable governance and good infrastructure and communications, surpassed tourism in becoming the main foreign exchange earner in 1995²⁵. In 1999, international companies spent \$912.1 million in Bermuda, a 20% increase

²⁵ Holberton, R. Pers. Comm. Ministry of Finance.

from 1998. In comparison, visitors spent \$476.4 million in Bermuda in 1999, down \$10 million or 2% from the 1998 level²⁶.

International Business

The first Bermuda-based international company was established in 1935. By September 2000, 12,261 international companies were locally registered, of which only 456 actually had a physical presence on the Island. These comprise companies engaged in insurance, transport, trading, financial activities, communications and business services. In 1999, the international business sector employed 3,355 people²⁷; 53% of these were Bermudian.

Tourism

Tourism became the mainstay of Bermuda's economy in the early 20th Century and peaked in 1980 with 491,000 visitor arrivals by air, and 118,000 by cruise ship. Since then, declining air arrivals, especially from Bermuda's largest market, the United States, has offset a general trend of increasing cruise ship arrivals. In 2000, there were 332,000 air arrivals and 210,000 cruise ship visitors. Visitor expenditures per capita fell by 21% between 1990/91 and 1997/98.

Farming and Fishing

Bermuda's primary industries are restricted to small-scale agricultural and fishing interests, and along with quarrying, employed only 566 people in 1999²⁵. There is no export market; indeed over 80% of agricultural food products are imported²⁸.

Socio-Economic Situation

Bermuda has experienced tremendous economic growth over the last quarter of a century. This growth means that the Island now enjoys one of the highest per capita incomes in the world. In 1998, the Gross Domestic Product per capita was \$34,600²⁹.

Employment

This wealth is not evenly distributed. Figures from 1991 indicate that at each educational level, wages for black people in every major occupation were less than for white people, and those for women were less than for men³⁰. Furthermore, in 1990, whilst 60% of the professional positions and 75% of the management positions were held by Bermudians, only 20% of these were held by black Bermudians. Again, in 1991 of the 6% unemployed, 84% were black, and the unemployment rate amongst black

²⁶ Ministry of Finance, Government of Bermuda. 2001. 2000 Economic Review. p. 17.

²⁷ Ministry of Finance, Government of Bermuda. 2001. 2000 Economic Review. p. 41.

²⁸ Department of Agriculture, Fisheries and Parks, Ministry of the Environment, Government of Bermuda. 1995. Agriculture in Bermuda. p. 3.

²⁹ Department of Statistics, Ministry of Finance, Government of Bermuda. 1999. Facts & Figures. p. 7.

³⁰ Newman, D.K. 1994. Bermuda's Stride Toward the Twenty-First Century. Department of Statistics, Ministry of Finance, Government of Bermuda. p. 5.

males was 11%. Women by contrast have fared better, and unlike many countries, have a consistent long-term attachment to the labour force³¹.

<i>Economic Activity Group</i>	<i>Number of Filled Jobs</i>
Public Administration	4054
Retail Trade, Repair	4004
Hotels	3794
Business	3355
International Business	3255
Finance	2907
Education, Health, Social Services	2890
Transport, Communications	2868
Construction	2508
Community, Social, Personnel Services	2372
Restaurants, Bars	1863
Wholesale Trade, Motor Vehicles	1283
Manufacturing	1208
Agriculture, Fishing, Quarrying	566
Electricity, Gas, Water	466
Real Estate, Rentals	456
TOTAL	37,849

Table 4. Jobs held by the population in 1999³².

In response to pressure to develop more equitable hiring practices, the Government has responded by adopting policies that invest in social and educational development and maintain Bermudian enterprise chiefly for Bermudians. In 1994, the Commission for Racial Unity and Equality (CURE) Act was passed. A CURE Office was set up and CURE Regulations came into effect in 2000 to monitor racial distributions in the workplace. College bursaries have increased in number and immigration policies have tightened to ensure that Bermudians are hired and trained. Of a total

workforce of 37,849 in 1999³³ 80% were Bermudian and 7,412 work permits were held³⁴. It should be noted that whilst the increase in international business has largely offset the recession in tourism, hiring is from a totally different skills pool. Concern has recently been expressed that over the next decade of over 6,000 new jobs predicted by the Department of Statistics, overseas workers will fill half³⁵. Whilst overseas workers in the hotel industry are predominantly single, most of these new jobs are expected to be created in the international companies sector. Expatriate staff in this sector, tend to bring their families with them.

Government economic priorities remain focussed on revitalising the tourist industry in terms of providing greater incentives and on the further strengthening of the international financial and e-commerce sectors.

The level of consumer spending in Bermuda generally highlights the relative affluence of its people, despite markedly higher housing costs than in other jurisdictions. The Bermuda Housing Corporation was established in 1973 to provide adequate, affordable housing for Bermudians. It has adopted a multi-pronged strategy of both building low-cost housing for rent (there is also provision for rent subsidy allowance) and for purchase, and has made a very large and valuable contribution to the supply of housing for Bermudians.

³¹ Newman, D.K. 1994. Bermuda's Stride Toward the Twenty-First Century. Department of Statistics, Ministry of Finance, Government of Bermuda. p. 6.

³² Ministry of Finance. Government of Bermuda. 2001. 2000 Economic Review. p. 41.

³³ Ministry of Finance. Government of Bermuda. 2001. 2000 Economic Review. p. 40.

³⁴ Taylor, M. 7 Feb 2001. Work permits on the rise. The Royal Gazette. p. 1-3.

³⁵ Burgess, D. 2001. "Jobs Explosion". The Bermuda Sun, April 27th 2001. p. 1.

The 1991 Census reported that 13% of all households with children were single parent households³⁶. Seventeen percent of all black households were single parent households in comparison to only 5% of all white households. During the 1990's, the proportion of children born outside of wedlock averaged 38% annually³⁷. Concern is regularly expressed about the consequences of the lack of paternal responsibility, as well as teenage pregnancy. This, combined with the high cost of living, are thought to be factors that impact negatively on development in children, especially young black males, leading to social problems such as drug addiction and crime. Black males comprise ninety-three percent of the total prison population of 342³⁸.

Health Services³⁹

In the recently released Adult Wellness Report it was found that of 1,056 locals surveyed in 1999⁴⁰, the most frequent health problems experienced were allergies, asthma, migraine headaches, tension headaches, depression, and anaemia. One in three people were considered obese, and one in four experienced "stress overload".

³⁶ Department of Statistics, Ministry of Finance, Government of Bermuda. 1991. Census of Population and Housing. p. 5.

³⁷ Department of Statistics, Ministry of Finance, Government of Bermuda. 1998. Bermuda Digest of Statistics 1998. p. 8.

³⁸ E. Dyer. Pers. Comm. H.M.S. Prisons, Ministry of Labour, Home Affairs and Public Safety.

³⁹ Department of Information Services, Government of Bermuda. Bermuda Report 1985-1988. pp 86-99.

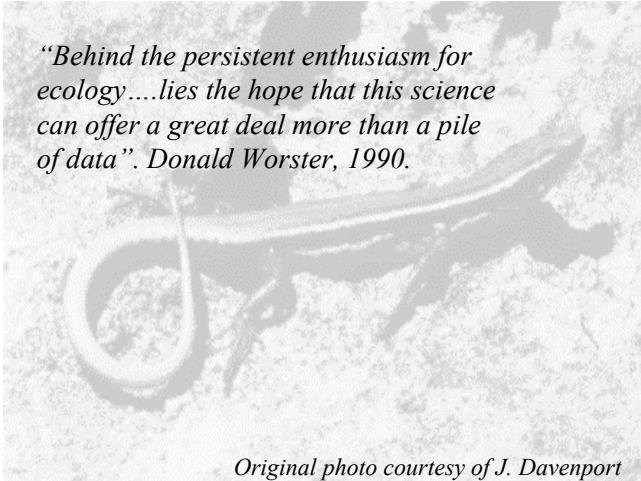
⁴⁰ Regan, N. 16 March 2001. Living large and paying the price. The Bermuda Sun Weekend. p. 1.

Bermuda enjoys a very high standard of health care and a wide range of medical and social services provided by government as well as private practitioners. In 1998, there were 15 physicians, 7 dentists and 70 nurses for every 10,000 residents⁴¹. The general hospital, King Edward Memorial Hospital, and the psychiatric hospital, St. Brendan's Hospital, are accredited by the Canadian Council on Hospital Accreditation and administered by the Bermuda Hospitals Board. The Department of Health supports a variety of programmes that include dental health, child health, adult and geriatric care, disease monitoring and environmental health. The Department of Social Services provides day care services, residential care for young people, child welfare services, including adoption and foster care, financial assistance for low income and handicapped people as well as care for the elderly.

Most private businesses have contributory health schemes provided by private health insurance companies. Government's Hospital Insurance Plan is available to all employed and self-employed people. Government employees are covered under the mandatory Government Employees Health Insurance Scheme. The Contributory Pensions Act 1968 provides for contributory and non-contributory old age pensions, disability benefits and a widow's allowance. On 1st January 2000, the National Pension Scheme Amendment Act came into effect requiring every Bermudian and spouse of a Bermudian to have a personal pension plan.

⁴¹ Department of Statistics, Ministry of Finance, Government of Bermuda. 1999. Facts and Figures. p. 10.

STATUS OF BERMUDA'S BIODIVERSITY



Bermuda is probably one of the best-known oceanic islands in the world. Studies began in 1609, when the first settlers arrived and described an abundance of birds and marine life.

There are now over 3,500 documents describing the Island's natural history, reviewed by Sterrer in 1998⁴². The literature consists of historical references, books, journal articles, graduate theses, unpublished student reports and informal notes in local news media. The searchable Bermuda Natural History Bibliography provides the most comprehensive compilation of these references⁴³. As yet unpublished data from baseline surveys conducted through the Bermuda Biodiversity Project also serve as an important resource.

⁴² Sterrer, W. 1998. How many species are there in Bermuda? *Bulletin of Marine Science* 62, 809-840.

⁴³ <http://www.bamz.org>

Biogeography⁴²

By the beginning of the Pleistocene Ice Age (about 1.6 million years ago), the Bermuda Seamount was gradually eroded by waves to a more or less flat surface below sea level. During subsequent warm periods (e.g. 400,000 years ago), sea level rose to as much as 20 m above the present level⁴⁴, coral reefs flourished and Bermuda would have comprised just a few scattered islands and islets. As the corals and other marine organisms growing on this submerged platform died, their skeletons began accumulating as sediment, which was washed onto beaches to form sand dunes. During cold periods (e.g., 20,000 years ago) when the sea-level dropped as much as 125 m below the present level, reef growth halted, and the dunes became cemented by wind and rain to create the fossilised limestone landscape that forms Bermuda's rolling hills of today.

Further rain helped to break down the limestone on top of the dunes to form a soil cover. The soil oxidised into a whitish soil called a palaeosol. (The red-coloured soil found in Bermuda is also derived from wind-blown material, but it has blown from distant continental deserts such as the Sahara). The formation of caves also occurred during glacial periods. As the rainwater percolated through the soil layer, it combined with carbon dioxide, forming a weak acid. The acid dissolved the underlying limestone, forming cavities underground.

⁴⁴ Hearty, P.J., P. Kindler, H. Cheng, R.L. Edwards. 1999. A +20 m middle Pleistocene sea-level highstand (Bermuda and the Bahamas) due to partial collapse of Antarctic ice. *Geology* 27 (4), 375-378.

This “yo-yo” of alternating high and low sea level explains Bermuda's "layer cake" stratigraphy of alternating limestone and soil horizons, with the youngest, barely cemented sand stones overlapping older, harder rocks riddled with partially drowned caves.

Evidence exists that during the last interglacial flooding about 125,000 years ago, when sea levels were raised by as much as 5–8 m above today's, much of the Island's terrestrial biota (including birds, a tortoise and land snails) was decimated. Earlier and higher sea-level stands were presumably just as destructive. Low sea-level would have restricted shallow-water marine species to a narrow band, which coupled with the accompanying drop in temperature may explain the low rate of marine endemism.

The history of Bermuda's pre-colonial flora and fauna was thus driven by the alternating opportunities/hazards for terrestrial/marine organisms presented by the rising and falling sea levels. (There are no data regarding Bermuda's pre-Pleistocene biota).


Like most island ecosystems, Bermuda's terrestrial habitats supported a limited diversity of plant


species prior to human settlement. The Island's early floral biodiversity comprised a dense forest, largely dominated by the endemic Bermuda Cedar and Bermuda Palmetto. The early forest probably also included natives such as Yellowwood and Hackberry. Emerging under the sheltered canopy of these forests were Bermuda's endemic understorey species including the Bermuda Sedge, Bermuda Maidenhair Fern and Bermuda Snowberry, as well as a variety of native species.


Bermuda's isolation prohibited colonisation by amphibians and mammals (except bats) and most reptiles. However, birds and insects would have been abundant.


Human colonisation resulted in an immediate and dramatic change to Bermuda's flora and fauna. Hogs were perhaps the earliest introduced animal species, but rats, cats and dogs quickly followed. The accidental introduction of a scale insect, which resulted in the loss of 96% of the endemic cedars in the 1940's, highlighted the threat of introduced pests, and was followed by a wave of further introductions, some accidental and some intentional. Coupled with the impact of other human activities, the Island's natural history has changed dramatically since its colonisation in the early 1600's.


Definitions:

 **Endemic** – Species found only in Bermuda and nowhere else, and which arrived here naturally without the aid of humans. Most of the species extinctions in the world have occurred to island endemics because, having evolved in relative isolation, they are more vulnerable to mainland diseases and predators and cannot compete with faster growing invasive species. They are also often tame, and easily harvested by humans.

 **Native** – Species which also arrived at Bermuda without the aid of humans, but which are found in other areas too.

 **Introduced** – Species which would not have made it to Bermuda on their own, but have been brought here by humans. These species may have been introduced accidentally, or brought here for economic or ornamental reasons, or to serve as a biological control.

 **Invasive** – Introduced species which adapt so well to the local conditions that they become a threat to the natives species by preying on them, taking over their nests, or just over-growing them.

 **Naturalised** – Introduced species that are not presently considered to be invasive, but are able to reproduce naturally in the wild.

Diversity Of Habitats

Open Ocean

Located on the northwestern edge of the Sargasso Sea and greatly influenced by the warming effects of the Gulf Stream, Bermuda is far removed from any continental watershed. As a result the waters surrounding the Island are virtually pristine, some of the clearest, most nutrient starved waters of the Atlantic. The extreme clarity of the ocean surrounding Bermuda betrays the low abundance of life that these waters support. Despite the scarcity of nutrients for phytoplankton and the rarity of food for higher life forms, a large number of highly adapted organisms thrive in this habitat, ranging from jellyfish and crustaceans to tuna such as the Yellowfin and whales including the Humpback which migrates past Bermuda each year. In fact, due to the highly migratory habits of many of these species, their management requires international co-operation.

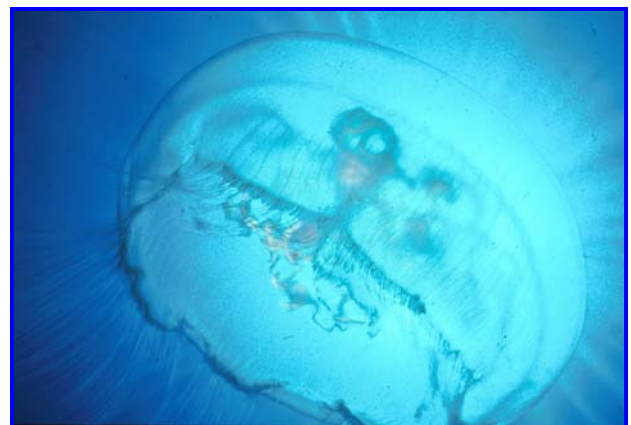


Plate 1. Moon Jellyfish, one of many species of jellyfish found in the open ocean. (Photo courtesy of I. Murdoch).

Threats

Although the environmental quality of the open ocean remains high, the impact of humans is being increasingly felt, not only at Bermuda but even in the remotest parts of the Sargasso Sea. The large amounts of oil that fouled Bermuda's coastlines in the 1970's and 1980's are virtually gone thanks to better cleaning practices on passing oil tankers. However, the presence of large quantities of plastics in this mid-oceanic gyre is a cause for considerable concern. The effect of this oceanic circulation in concentrating plastic flotsam in the same area where for millennia rafts of *Sargassum* have provided critical habitat for numerous marine species poses a serious threat. Despite being on the fringe of this gyre, Bermuda commonly receives large amounts of plastic debris on the shoreline and many of the juvenile turtles taken in by the Bermuda Aquarium Museum and Zoo for rehabilitation show signs of having ingested plastic.

Shallow Water Habitats

The truncated top of the massive seamount that is Bermuda supports a thriving quasi-tropical marine community, often dubbed an oasis in this oceanic desert. Like most tropical marine ecosystems, coral reefs, seagrass beds and mangrove swamps are the three critical habitats comprising this ecosystem. Of these, both the coral reef and mangroves carry the distinction of being the northern-most examples in the world. Although these three distinct habitats form the most important centres of biological diversity, a large proportion of the Bermuda platform is covered by soft sediments. Whilst these

are home to a reduced species assemblage, these organisms are important none-the-less, primarily for the role that they play in recycling the organic matter that sinks to the seafloor.

Coral Reefs

The northerly extension of coral reefs to Bermuda is made possible by the Gulf Stream, which transports warm seawater, and associated organisms, eggs and larvae to the area of Bermuda.

Bermuda's reefs are typical of high latitude reefs, with a low level of live coral coverage (typically 50% or less), lower coral growth rates⁴⁵ and coral growth which does not extend into depths as great as it does on warmer reefs closer to the equator. For example, Bermuda has only about one third of the shallow-water coral species recorded for Jamaica⁴⁶.

There are several types of reef found in Bermuda. Extending from a depth of approximately 75 m to 20 m (250 ft to 65 ft) is the Fore Reef Slope. Average coral cover is only about 25% on these reefs, which are dominated by brain corals (*Diploria* species) great star corals (*Montastrea* species) and mustard corals (*Porites* species).

The Main Terrace reefs are found at depths of 25 m to 15 m (75 ft to 45 ft). This is the area of highest

⁴⁵ Logan, A. and T. Tomascik. 1991. Extension growth rates in two coral species from high-latitude reefs of Bermuda. *Coral Reefs*. 10, 155-160.

⁴⁶ Thomas, M.L.H. and A. Logan. 1992. *A Guide to the Ecology of Shoreline and Shallow-water Marine Communities of Bermuda*. Wm. C. Brown Publ., Iowa. 346 pp.

coral coverage (over 50%), again dominated by brain and great star corals.

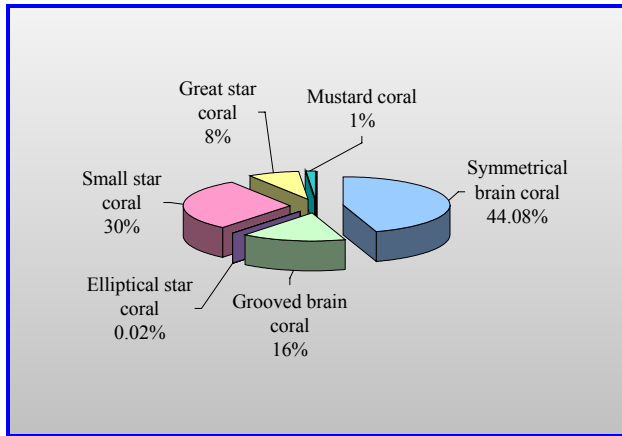


Figure 8. Coral species typically found on main terrace reefs⁴⁷.

With a coral coverage of just over 20%, the Rim reefs encircle the North Lagoon and are the most visible, lying at depths of 15 m to 1 m (45 ft to 3 ft). The corals comprising the Rim reefs are more diverse than those in deeper water, although the main reef building corals mentioned above are still dominant. Sea fans and sea rods are also common.

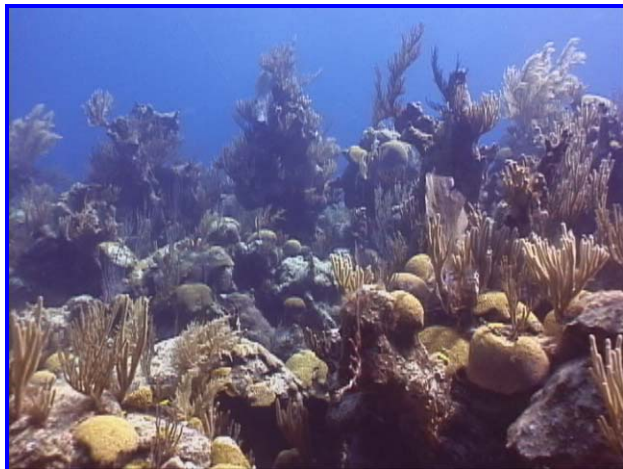


Plate 2. Rim reefs (Photo courtesy of W. Mitchell).

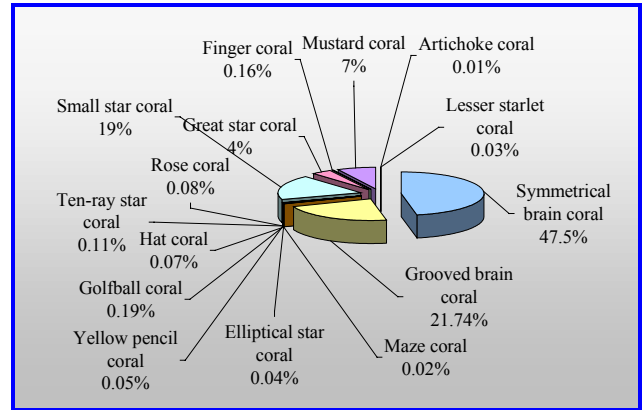


Figure 9. Coral species typically found on Rim reefs⁴⁷.

Landward of the rim reefs lies the North Lagoon, within which lie a variety of Lagoonal reef types. These range from small patches of coral (Knob reefs) to larger Pinnacle reefs up to 50 m wide. A few even larger structures exist, forming Mini-atolls and Faro reefs. The Lagoonal reefs are characterised by lower coral cover (about 14%) and smaller, branching corals such as Ivory Bush Coral, the Finger Corals, and Fire Corals. Within the sounds and harbours, the coral coverage drops to below 10% on the Inshore reefs.

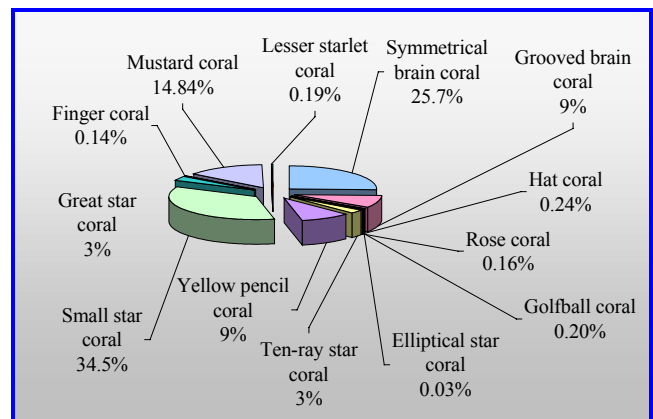


Figure 10. Coral species typically found on Lagoonal patch reefs⁴⁷.

⁴⁷ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

The reefs to the south of Bermuda are significantly different. Most obvious are the wine glass shaped cup reefs, or “boilers”, which are constructed of hard coralline algae and a marine snail, and have almost no coral in their structure. Some cup reefs are to be found to the north of the Island too.

Bermuda’s thriving reef communities provide a habitat for a colourful array of reef fish and invertebrates. The populations of herbivorous parrotfishes and surgeonfishes graze on the fleshy seaweeds on the reefs, effectively controlling their growth and preventing them from smothering the corals. However, some algae species can become abundant seasonally⁴⁸.

Threats

In 1966, long before the global community expressed concern for the future of coral reefs, Bermuda passed the Coral Reef Preserves Act. Then in 1978, the Bermuda Government responded to the increasing popularity of bleached corals as curios with a protected species order that completely banned the harvest of any coral, stony or soft. With this action Bermuda became, in effect, a coral preserve.

On the whole, the Bermudian reefs are in excellent condition compared to those in other locations. In large measure this may reflect Bermuda’s isolated, high latitude position along with the success of conservative fisheries management in maintaining healthy populations of reef grazers. However, there

are instances in which local reef communities have come under stress. These include the dredging of Castle Harbour for the airport construction, ship groundings, the deployment of anchors, pollution, and sedimentation in shipping channels⁴⁹. Some corals show signs of disease, and there are occasional episodes of bleaching, although this is usually not fatal. This has been attributed to elevated water temperatures from global warming.

It is interesting to note that in a recent report of the current condition and potential threats to the world’s coral reefs, Bermuda’s reefs are ranked in the “high risk” category⁵⁰. Although not specified, this appears to be attributed to the Island’s high population density within 20 km of the coral reefs and the volume of shipping traffic and potential pollution threats from these vessels.

The Bermuda Biodiversity Project is currently mapping Bermuda’s reefs in detail. Such maps will greatly assist in the environmental management of this critically important resource. Every effort should be made to ensure that reef condition is monitored as closely as possible. Ongoing monitoring studies such as those being conducted by the Bermuda Biological Station for Research Inc. and the Bermuda Biodiversity Project are essential. Measures to protect reefs against physical damage

⁴⁸ Smith, S.R. Pers. Comm. Bermuda Biological Station for Research Inc.

⁴⁹ Cook, C.B., R.E. Dodge, and S.R. Smith. 1993. Fifty years of impact on coral reefs in Bermuda. Proceedings of the Colloquium on Global Aspects of Coral Reefs: Health Hazards and History, R.S.M.A.S., Miami. 160-166.

⁵⁰ Bryant, D. L. Burke, J. McManus and M. Spalding. 1998. Reefs at risk: A map-based indicator of threats to the world’s coral reefs. World Resources Institute. Washington DC, U.S.A. p. 31.

should be increased, as there is no current legislation to levy fines or recover costs for damage to reefs.

Seagrasses

Bermuda has four species of seagrasses, Turtle Grass, Manatee Grass, Shoal Grass and Dwarf Grass. Seagrasses are marine flowering plants, which form large underwater meadows in some of Bermuda's marine ponds, inshore waters and coastal bays. The area of Bermuda's nearshore seagrasses, was believed to cover approximately 500 ha (1235.6 acres) in 1981⁵¹. Widely recognised as one of the most productive ecological systems, seagrasses also support a rich community of marine organisms that includes worms, crustaceans and molluscs, as well serving as an important refuge for many species of juvenile fish, and a feeding ground for immature Green Turtles. In a recent survey of three coastal seagrass bed sites, 44 species of fish were observed (excluding gobies)⁵¹.

Fish species observed in seagrass surveys:

Endemic: Bermuda Anchovy, Bermuda Bream, Garfish

Native: Pilchard, Blue Fry, Anchovy or Spanish Sardine, Sliver Jenny, Bigeye Mojarra, Tomtate or White Grunt, Blue-striped Grunt, Yellow Grunt, Slippery Dick, Bucktooth Parrotfish, Slender Filefish, Fringed Filefish, Imperial Blackfish, Bandtail Puffer, Sand Diver, Dusky Squirrelfish, Pugnose Pipefish, Longsnout Seahorse, Horse-eye Jack, Grey Snapper, Lane Snapper, Yellowtail Snapper, Mottled Mojarra, Pigfish, Whitebone Porgy, Pinfish, Spotted Goatfish, Four-eye Butterflyfish, Spotfin Butterflyfish, Hogfish, Princess Parrotfish, Rredtail Parrotfish, Redfin Parrotfish, Liza, Great Barracuda, Doctorfish, Surgeonfish.

Additionally, the root system of the seagrasses serves to stabilise the sediment whilst their leaves trap particles suspended in the water which would otherwise smother neighbouring reefs.

Threats

Studies have shown that there have been substantial changes in the extent of the seagrass meadows around Bermuda, with some dramatic declines in the seagrasses in the North Lagoon⁵². However, in the coastal seagrass beds losses in some areas appear to have largely been compensated for by expansion in others⁵¹. The cause of these changes remains uncertain, and warrants further investigation. It is clear though, that the constant sweep of boat mooring chains is resulting in halos of bare sand in many inshore seagrass beds.

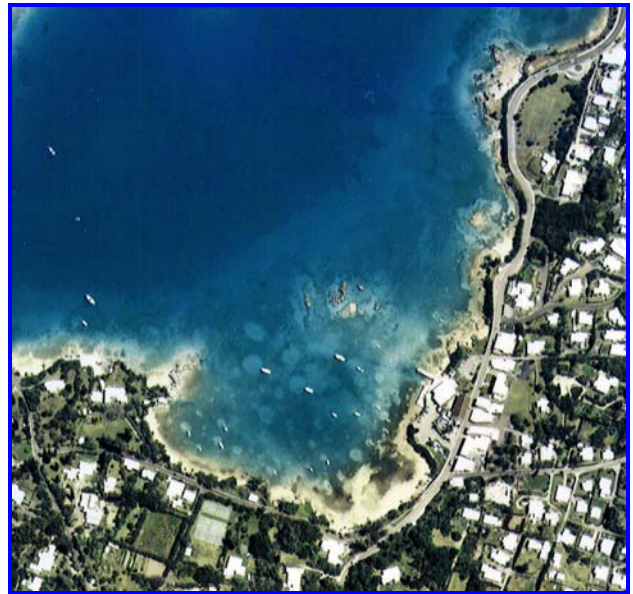


Plate 3. A 1997 aerial photograph showing the halos made in seagrass beds by boat moorings. (Photo courtesy of the Ministry of Works and Engineering).

⁵¹ Ward, J.A.D. 1999. Bermuda's Coastal Seagrass Beds as Habitats for Fish. Unpublished M.Sc. Thesis. University of Glasgow. 103 pp.

⁵² Smith, S.R. Pers. Comm. Bermuda Biological Station for Research Inc.

Mangroves

Bermuda's mangroves, unique in that they are the most northerly in the world, have been heavily impacted by human activities. Once occupying perhaps as much as 25 ha (61.8 acres) in pre-settlement times, mangroves are now reduced to a total area of 18 ha (44.48 acres)⁵³, distributed between about 30 swamps. These swamps can be classified into three types; pond mangrove swamps, (relics of periods of higher sea level), bay mangrove swamps, and fringing communities⁵⁴. The largest is the Hungry Bay mangrove swamp, which covers an area of 2.9 ha (7.2 acres).

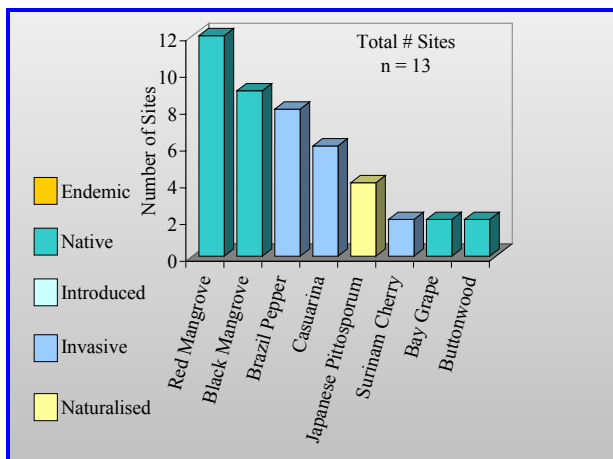


Figure 11. The most commonly observed trees in mangroves and the number of survey sites at which they were observed⁵³.

Mangroves occupy the intertidal zone in areas where wave action is low enough to allow sediment to accumulate. Their submerged root system provides an extensive substratum for many organisms, and an

⁵³ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

⁵⁴ Thomas, M.L.H. 1998. Marine and Island Ecology of Bermuda. Bermuda Aquarium, Museum and Zoo. p. 64.

important nursery for juvenile reef fish. Their canopy supports many bird species, including the Yellow-crowned Night Heron, Belted Kingfisher, Osprey, Great Blue Heron, Great Egret, Northern Waterthrush, American Redstart. In addition to providing protection from erosion, mangroves are also areas of very high productivity, having an importance far beyond their borders as a result of this. In 1989, the International Union for the Conservation of Nature (IUCN) declared that mangroves were the most threatened habitat in the world⁵⁵.

Because Bermuda's mangroves are at the northerly extent of their range, the species diversity is less than further south. The two species found in Bermuda are the Red Mangrove and the Black Mangrove; Buttonwood often lives at the landward edge of the mangrove swamps.

Threats

Tolerant of small amounts of pollution, (which explains why they can survive in Mills Creek) mangroves are threatened by floating debris such as plastics, and destruction due the development of docks and jetties. Whilst most mangroves are now protected under the Development and Planning Act 1974, failure to rigorously enforce this has led to occasional losses. Coastal erosion is a persistent threat, particularly with rising sea levels, and has caused the seaward edge of Bermuda's largest mangrove at Hungry Bay to recede. In addition, the landward edge of many mangroves is now being

⁵⁵ Ministry of Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda: A Discussion Paper. p. 72.

invaded by aggressive plant species such as Surinam Cherry, Allspice, Brazil Pepper, Jumbie Bean and Fiddlewood, whilst Asparagus Fern is encroaching upon the understorey.



Plate 4. The roots of mangroves above and below the water showing the diversity of attached organisms. (Photo courtesy of C. Clark).

Inland Bays and Sounds

The stresses imposed by human development have a significant effect on Bermuda's inshore harbours and sounds. These semi-enclosed bodies are generally deeper than the entrances through which water exchange occurs, resulting in limited flushing which promotes the settlement of fine particles. Seepage of nutrient rich groundwater, discharges of coolant water and surface runoff enrich these bodies while massive resuspension of fine particles occurs regularly in St. Georges and Hamilton Harbours and the Great Sound whenever large ships transit these areas. Substantive ecological changes have been

documented in these basins. During the 1970's a mass bloom of the alga *Cladophora* formed mats that, in areas, exceeded 1 m (3 ft) in thickness and smothered the sandy bottom animals in many coastal bays. Concern that this bloom reflected declining water quality prompted extensive research of the benthic communities and nutrient cycling in inshore waters but failed to establish a definitive link between nutrient levels and the growth of this alga⁵⁶. However, it was determined that the system is phosphate limited with this nutrient being rapidly bound in the presence of Bermuda's calcium carbonate rock. Although the *Cladophora* bloom has abated, it still occurs in some places.

Salt Marshes

Like mangroves, salt marshes are found along sheltered coastlines where they offer protection to the shoreline. In Bermuda, there are few remaining salt marshes, and these comprise just 1.0 ha (2.47 acres)⁵⁷. The largest is at the eastern end of Spittal Pond. The salt marsh to the east of the Hungry Bay outlet has been almost obliterated through intense storm activity over the last few years. Perhaps the best remaining salt marsh lies on the former U.S. Naval Base in St. Davids. There is evidence that before human colonisation there were extensive salt marshes at Pembroke Marsh West.

⁵⁶ Morris, B., J. Barnes, F. Brown, and J. Markham. 1977. The Bermuda Marine Environment: A Report of the Bermuda Inshore Waters Investigation 1976-1977. Bermuda Biological Station Special Publication No. 15. 120 pp.

⁵⁷ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.



Plate 5. A view of the salt marsh at Spittal Pond through Sea Rush, *Juncus maritimus* (Photo courtesy of L. Rodrigues).

Salt marshes are important in that they support a number of rare and endangered plants and animals, including the Land Hermit Crab, which appears to be limited to less than a hundred individuals at Hungry Bay⁵⁸.

Most commonly observed Salt Marsh plants:

Native: Sheathed Paspalum, Sea Rush, Switch Grass, Morning Glory, Marsh Samphire, Salt Marsh Sand Spurrey, Salt Marsh Ox-eye, Seaside Heliotrope.

Introduced: Para Grass

Invasive: Wedelia

Threatened Natives: Marsh Samphire, Seaside Heliotrope

Threats

The main threat to Bermuda's salt marshes is coastal erosion from storm activity.

⁵⁸ Godsall, B. 2000, Unpublished report. Survey of the Population of the Land Hermit Crab, *Coenobita clypeatus*, in Hungry Bay. Bermuda Biodiversity Project, Bermuda Zoological Society. 13 pp.

Marine Ponds

Described as one of Bermuda's national treasures, the Island has a wealth of marine ponds supporting a high diversity of marine and brackish water organisms⁵⁹. Largely surrounded by mangroves, these ponds form rich feeding grounds with the extensive mangrove root system providing an area for settlement for marine animals from tube worms, sponges and sea squirts to oysters. DeLaubenfels described Walsingham Pond as "The Sponge metropolis of the World"⁶⁰! The endemic Bermuda Killifish thrive in most of the ponds, whilst the endemic Bermuda Sargassum Weed can be found in Walsingham Pond. Migratory warblers join toads, whistling frogs, many species of waterfowl and countless insect species living around the edges of the ponds.

Threats

Run-off, groundwater enrichment and trash are probably the main threats to Bermuda's ponds. Anecdotal reports of mass mortalities of fish in Trotts Pond and Mangrove Lake have been received⁶¹. Given their rich biodiversity, some measure of protection should be extended to those ponds not already in nature reserves or parks.

⁵⁹ Ministry of Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda: A Discussion Paper. p. 75.

⁶⁰ Thomas, M.L.H. 1998. Marine and Island Ecology of Bermuda. Bermuda Aquarium, Museum and Zoo. p. 40.

⁶¹ Thomas, M. Pers. Comm. University of New Brunswick.

Caves⁶²

Bermuda has one of the highest concentrations of caves in the world (150 are known). However, these are perhaps the least appreciated of the Island's habitats, despite a number of caves having been operated as commercial tourist attractions. Above sea level, the caves are characterised by extensive collapse and are therefore fairly short in section. By contrast, primarily at depths of 17 m to 20 m below sea level there is an integrated network of submerged passageways, which connect otherwise isolated cave pools. For example, Green Bay forms a large and extensive flooded labyrinth nearly two miles long. It is in the dark interiors of these caves that over 60 of Bermuda's endemic species live⁶³. Recently, a team of scientists discovered one of the best and most complete Pleistocene deposits in the world in Admiral's Cave at Grotto Bay, in which they discovered a complete sequence of fossil birds dating back several hundred thousand years.

Threats

Many caves are inaccessible to the general public, and are thus fairly well protected. However, there are four main threats to Bermuda's caves. These are; construction and quarrying activities, water pollution, dumping and littering and vandalism. Bassett's Cave on the former U.S. Naval Base in Southampton, which is severely polluted with oil and sewage, exemplifies just how vulnerable the caves systems are, whilst the continued blasting in

Wilkinson's Quarry adjacent to Admiral's Cave is posing a serious threat.



Plate 6. SCUBA divers in a submerged cave with impressive limestone column formations. (Photo courtesy of C. Lascu).

Beaches and Dunes

One of Bermuda's most attractive features are the spectacular sandy beaches, particularly those of the south shore, famous for their pink hue derived from the crushed skeletal remains of the single-celled foraminiferan *Homotrema rubrum*. The sand itself supports a wealth of organisms. Some are burrowing whilst others are largely invisible to the naked eye, as they live between the sand grains. More easily visible are the Ghost Crab and Land Crab, shorebirds such as Ruddy Turnstone and various plovers and sandpipers, as well as the Tiger Beetle, Rove Beetle and Sand Flea. The Bermuda Skink and Jamaican Anole may also scavenge on the beaches. The strandline that forms along the beach from organisms that have washed ashore is an important microhabitat.

⁶² Iliffe, T. Pers. Comm. Texas A & M University.

⁶³http://www.tamug.tamu.edu/cavebiology/fauna/bermuda_faunalist.html

Forming behind the beaches, above the strand line, are the sand dunes, which support a number of specially adapted plants. Behind the fore dunes, the vegetation becomes more continuous, giving way to mature dunes that support both endemic and native species. In total, Bermuda’s beaches and dunes cover an area of 77 ha (190 acres)⁶⁴.

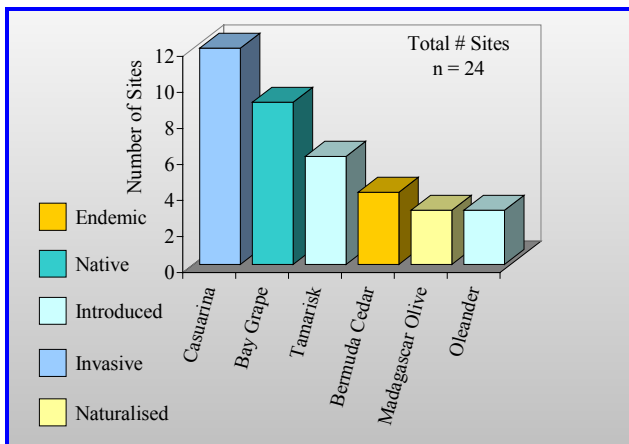


Figure 12. The most commonly observed trees in beach and dune habitat and the number of survey sites at which they were observed⁶⁴.

Most commonly observed understorey species on Beaches and Dunes are:

Endemic: Bermudiana

Native: Crab Grass, Seaside Goldenrod, Spanish Bayonet, Bay Grape, Seaside Morning Glory, Bay Bean, Tassel Plant, Scurvy Grass, Sea Ox-eye, Sheathed Paspalum, Cape Weed, Beach Croton, Prickly Pear, Coast Spurge, Morning Glory, Seaside Evening Primrose, West Indian Grass

Naturalised: Fennel, Star of the Veldt, Common Sage Bush

Invasive: Wedelia

Threatened Endemics and Natives: Beach Alternanthera, Beach Lobelia, Seaside Heliotrope, Bay Lavender, Darrell’s Fleabane, Diffuse Starwort.

Threats

The major threat to the beaches and dunes is coastal erosion from storm surge. Intense storms may temporarily, but significantly reduce the beaches and dunes around the Island. Trash is another major problem, and the raking of beaches for tourism also impacts upon the associated flora and fauna making the continued preservation of the few protected beaches a priority. Invasive species present another threat. Authorised and unauthorised camping may cause considerable damage to the south shore dunes in the summer.



Plate 7. The beach at Nonsuch Island fringed by rocky coastal habitat. (Photo from BAMZ slide collection).

Rocky Coastal

With breaks for beaches and dunes, the rocky coastal habitat extends around most of Bermuda’s shoreline from the high water tide mark inland up to 15 m, an area of approximately 149 ha (368 acres)⁶⁴. Only the most salt-tolerant species flourish in this habitat. Prior to human settlement, these would have

⁶⁴ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

included Buttonwood and Bay Grape⁶⁵. Despite perhaps being the most resistant of all Bermuda's terrestrial habitats to invasive species, the native and endemic species of the rocky coast are nevertheless threatened by Casuarina and Brazil Pepper.

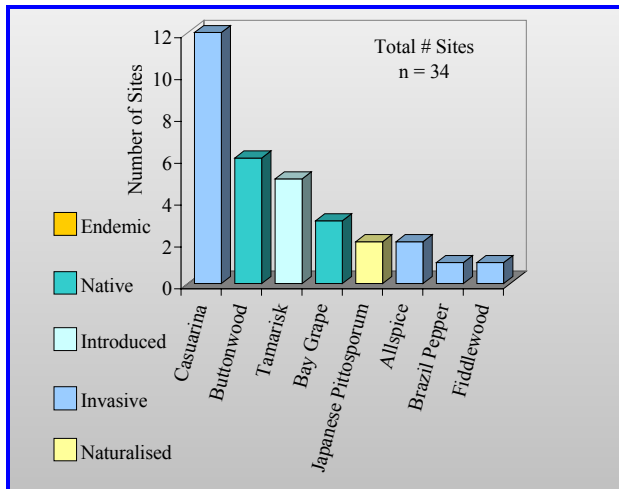


Figure 13. The most commonly observed trees in rocky coastal habitats and the number of survey sites at which they were observed⁶⁶.

The most commonly observed understorey species in Rocky Coastal areas are:

Endemic: *Bermudiana*

Native: *Sea Ox-eye, Seaside Goldenrod, Coast Spurge, Crab Grass, Sheathed Paspalum, Prostrate Spurge, Buttonwood, Cape Weed, Prickly Pear, Joseph's Coat, Seaside Purslane, West Indian Grass*

Invasive: *Asparagus Fern*

Threatened Endemics and Natives: *Beach Alteranthera, Beach Lobelia, Seaside Heliotrope, Bay Lavender, Darrell's Fleabane, Diffuse Starwort*

A good example of Rocky Coastal habitat with a high native biodiversity is Spittal Pond and the area north of the Railway Trail, west of Shelly Bay.

Sightings of the Sally Lightfoot Crab as well as several heron species, Longtails, Common Terns, Cranes, Cormorants and Kingfishers are common. A patient observer may also be rewarded with a glimpse of a skink.

Threats

The major threat to this habitat is pollution, particularly from oil, and destruction for development of boathouses and docks. Given the porous nature of the rock, coastal erosion is also a problem.

Upland Coastal

Extending inland from the rocky coastal to the top of the old foredune, (an area of about 346 ha or 855 acres)⁶⁶, the upland coastal habitat also supports vegetation well adapted to salt spray, and capable of rooting in shallow soil. There are some differences between sheltered and exposed habitats: The flora of sheltered upland coastal areas such as Lovers Lake in St. George's more closely resembles that of upland hillsides with salt-intolerant species such as *Forestiera* present.

Pre-settlement species would have included endemics such as Bermuda Cedar and Bermuda Palmetto, as well as natives such as Bay Grape, *Forestiera*, and Buttonwood. Many of the same

⁶⁵ Wingate, D.B. 1971. Bermuda's Prehistoric Flora. In: The Bermuda Jubilee Garden. E.L. Wardman (Ed.). pp. 131-149.

⁶⁶ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

understorey species would have been present as in the rocky coastal, with the addition of Darrell’s Fleabane, Spanish Bayonet, Poison Ivy, Cape Weed, Common Sage, Ink Berry, and Seven Year Apple. One of the best examples of the upland coastal habitat with a high endemic and native biodiversity is High Point in Southampton Parish. Unfortunately, the Brazil Pepper and Casuarina tree have taken hold in most areas, and of increasing concern are the presence of Surinam Cherry and Allspice seedlings, both of which threaten the endemic Bermuda Palmetto and Darrell’s Fleabane, and native Forestiera, Coast Sophora and Inkberry.

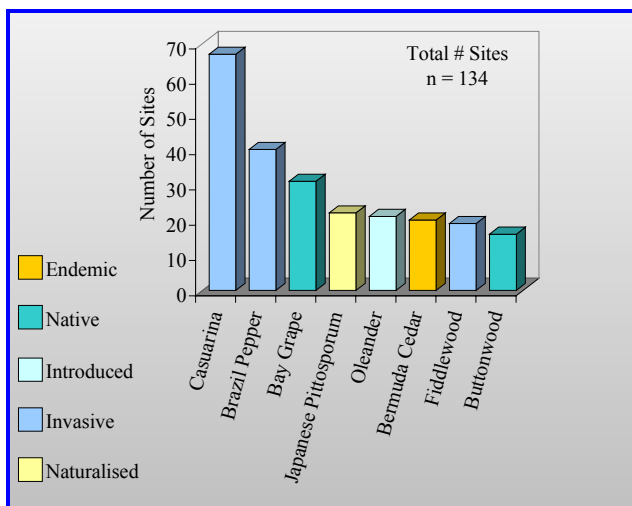


Figure 14. The most commonly observed trees in upland coastal areas and the number of survey sites at which they were observed⁶⁷.

Animals such as the Land Crab, Yellow-crowned Night Heron, the endangered native Land Hermit Crab, and endemic Skink, as well as Orb Web Spiders, Leaf-Scarring Beetles, and Leaf-Cutting Bee are often associated with the upland coastal habitat.

⁶⁷ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

The most commonly observed understorey species in Upland Coastal areas are:

Endemic: Bermudiana

Native: Crab Grass, Seaside Goldenrod, Cape Weed, Joseph’s Coat, Sea Ox-eye, Prickly Pear, Morning Glory, Sheathed Paspalum, Jamaica Dogwood, West Indian Grass

Invasive: Wedelia, Asparagus Fern

Naturalised: White Beggar’s Tick, Fennel, Beard Grass, Common Sage Bush

Threatened Endemics and Natives: Coast Sophora, Seven Year Apple, Darrell’s Fleabane, Ink Berry

Threats

Ongoing development, invasive species, and hurricanes threaten coastal hillsides.

Upland Hillside

Occupying a total area of 908 ha (2,244 acres)⁶⁷, only a few pristine upland hillside habitats still survive, the best example being Abbott’s Cliff. Most have been cleared for agricultural or residential use. Characterised by deeper soil and fairly sheltered locations, pre-settlement species would have included trees such as the endemic Bermuda Cedar, Bermuda Palmetto, Bermuda Olivewood, as well as Forestiera, White Stopper, and Jamaica Dogwood. Whilst understorey species such as endemic Bermuda Snowberry, Shrubby Fleabane, Doc-bush, Bermuda Bedstraw, Poison Ivy, Virginia Creeper, Turnera, St. Andrew’s Cross, Sword Fern and Paspalum grasses would have prevailed.



Plate 8. Upland Hillside habitat at Abbott's Cliff. (Photo courtesy of H. De Silva).

The deep soil and protection from wind and salt spray in these areas has nowadays enabled faster, taller growing introduced, invasive plants such as Brazil Pepper, Allspice and Surinam Cherry to take a foothold, displacing the existing native and endemic species.

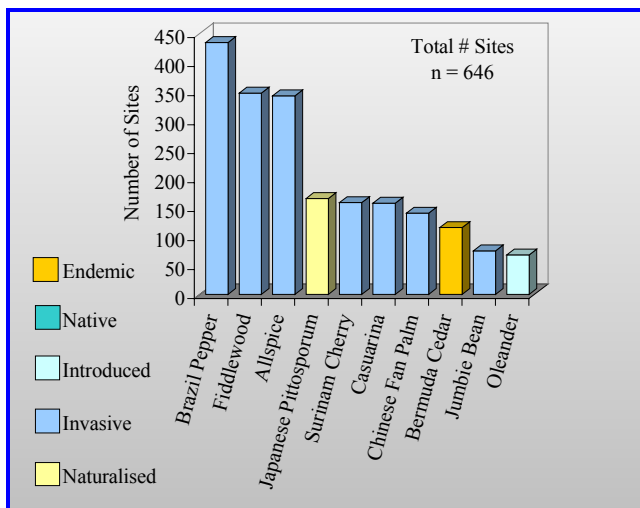


Figure 15. The most commonly observed trees in upland hillside habitats and the number of survey sites at which they were observed⁶⁸.

Birds, including the Grey Catbird, White-eyed Vireo, European Goldfinch, and Northern Cardinal can regularly be observed in the upland hillside, along with pests such as Sparrows and Kiskadees. The introduced lizards, the Barbados Anole, Antigua Anole (Warwick Lizard), and Jamaican Anole are also common. Dead cedars are hosts to termites, whilst other commonly observed insects include the Argentine Ant, Big Head Ant and the Paper Nest Wasp. The Golden Silk Spider and Spiny-Bellied Orb Weaver are also common.

Most commonly observed understorey species in the Upland Hillside are:

Native: Morning Glory, Crab Grass, Poison Ivy, Cape Weed, Virginia Creeper, Seaside Goldenrod, White Stopper

Invasive: Asparagus Fern, Wedding Fern

Naturalised: Flopper, Mock Orange, Fennel, Common Sage Bush

Threatened Endemics and Natives: Bermuda Bedstraw, Ink Berry, Doc-bush, St. Andrew's Cross, Brier Bush, Rhacoma, Turkey Berry, Wood Grass

Much of the remaining upland hillside is found in Smith's and Hamilton parishes, as well as Devonshire and the western part of Southampton.

Threats

One of Bermuda's most threatened habitats, the upland hillside is heavily impacted by habitat loss through development, as well as being particularly susceptible to invasive species.

⁶⁸ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

Upland Valley

These areas comprise the sheltered valleys and depressions with deep soil along the central axis of the Island. They have become completely developed for arable, residential and garden use. There are no undisturbed upland valleys, but the former Chief Conservation Officer, David Wingate, has restored an area of upland valley on Nonsuch Island. In pre-colonial times, the endemic Bermuda Cedar, Olivewood and Palmetto, and trees like Yellowwood and Southern Hackberry would have dominated this habitat. The dense canopy would have supported native and endemic ferns and mosses.

The upland valley in Somerset which is now the National Trust's Gilbert Nature Reserve, might be a suitable site for another upland valley habitat restoration project.

Limestone Sink

A limestone sink is a depression, sometimes with a steep-sided rock face, that is the site of a collapsed cave. This is a very localised habitat, and most are found in the areas of oldest limestone, the Walsingham Formation, in Hamilton Parish. Because of their rugged topography, which historically has been difficult to develop, many sink holes have served as a refuge for endemic and native species that have disappeared from other locations. Coupled with their moist environment, they provide ideal conditions for ferns, including the endemic Bermuda Shield Fern, mosses and liverworts such as Long Spleenwort and Toothed Spleenwort, as well

as the endemic Wild Bermuda Bean and Bermuda Wild Pepper.



Plate 9. Sear's Cave, a limestone sink with native and endemic fern species (Photo courtesy of H. De Silva).

Threats

The major threats to these sink holes are dumping of trash and development.

Peat-Filled Marshes

Peat marshes, which are confined to low lying inland areas, form the most extensive freshwater habitat in Bermuda. Their area has declined dramatically since colonisation. In 1900 there were about 121 ha (298 acres) of peat marsh, which by 1997 had been reduced to approximately 67 ha (165.5 acres)⁶⁹. Of

⁶⁹ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

these, Paget Marsh, is the largest at 9.25 ha (22.8 acres).



Plate 10. A view of Paget Marsh showing Bermuda Palmettos and various fern species. (Photo from BAMZ slide collection).

Marshes were historically used as areas to dump garbage, which provided an efficient way to eliminate mosquito breeding grounds. They were also cleared for lowland agricultural areas. Some marshes (or parts thereof), such as Mills Creek, have been filled to allow development, whilst others such as The Pampas, Smith’s Parish and The Lagoon Estate in Paget have been grassed over after being filled with waste and rubble to form lawns or wayside habitats.

Peat Marshes have a high diversity of native and endemic species. Dominating the canopy in areas above the water-table are the Bermuda Palmetto, Bermuda Cedar, and Wax Myrtle. The invasive

Brazil Pepper, and in some areas Surinam Cherry and Guava must also be added to the current list of dominant species.

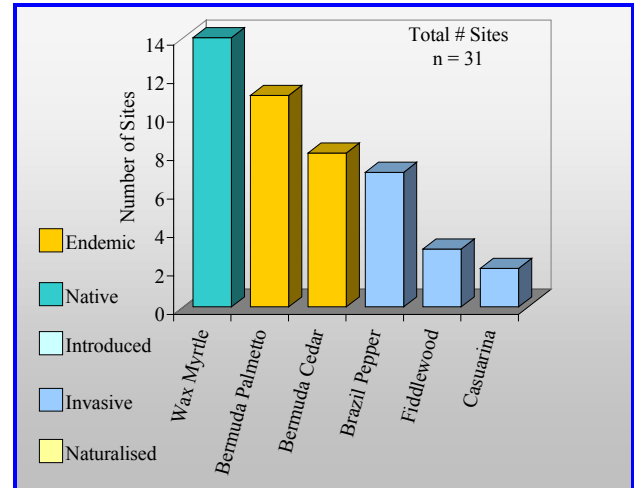


Figure 16. The most commonly observed trees in peat marshes and the number of survey sites at which they were observed⁷⁰.

The most commonly observed understorey species in the Peat Marshes are:
Native: Cinnamon Fern, Wax Myrtle, Morning Glory, Southern Bracken Fern, Virginia Chain Fern, Creeping Day Flower, West Indian Cissus, Giant Fern, Royal Fern, False Nettle, Saw Grass
Invasive: Ardisia, Asparagus Fern, Wedelia
Threatened Endemics and Natives: Bermuda Sedge, Ten Day Fern, Virginia Chain Fern, St. Andrew’s Cross, Psilotum

Wildlife supported in the peat marshes includes the Barn Owl, Migratory Bats, the Yellow-rumped Warbler and other migratory warblers, Cane Toad, one species of whistling frog, the Grey Catbird, Chick-of-the-Village, Great Blue Heron, as well as ducks, herons, egrets, rails and other waterfowl, and a wide variety of insects.

⁷⁰ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

Threats

Expanded industrial development poses a potential threat to Devonshire Marsh, whilst the impact of various introduced animals such as the Ram's Horn Snail and Red Eared Slider Turtles, discarded by local pet owners, warrants study.

Fresh-Brackish Pond

There are about a dozen freshwater ponds in Bermuda, totalling an area of 7 ha (17 acres)⁷¹; Warwick Pond is the largest. Natural fresh water ponds have thick peat deposits on the bottom and around the edges, which prevent water from draining away. Several, such as David's Pond at Paget Marsh, Bartrum's Pond at Stokes Point Nature Reserve, and one at Nonsuch Island have been artificially created. There are also ponds on golf courses and many residential properties.

The most commonly observed species found in Fresh/Brackish Ponds are:

Native: *Narrow Leaved Cattail, Sheathed Paspalum, Olney's Bulrush, Knotted Spike Rush, Creeping Day Flower, Morning Glory, Valdivia Duckweed, Mermaid Weed*

Invasive: *Water Fern*

Naturalised: *Para Grass, Umbrella Sedge*

Threatened Endemics and Natives: *Valdivia Duckweed, Mermaid Weed*

Freshwater ponds are important for a diversity of resident and migrant waterfowl, as well as Mosquito Fish, Giant toads, tree frogs, and aquatic insects such as dragonflies, midges and water snails.

Threats

Pollution from run-off of animal wastes from livestock/ dairy farming and fertilisers and pesticides from vegetable farming all threaten the freshwater pond habitat.

In addition to those described above, there are a number of habitats created by humans that warrant mention.

Hedgerow

Comprising the hedges bordered by roads or footpaths, hedgerows are dominated by attractive ornamental plants. Many of these are self-seeding invasives (Surinam Cherry, Chinese Fan Palm, Allspice, Fiddlewood, Brazil Pepper, Elephant's Ear and Asparagus Fern) which threaten endemics such as the Bermuda Cedar and Palmetto, and natives including Joseph's Coat, Morning Glory and Cape Weed. Other introduced species in the hedgerows, include Wire Weed, Sow Thistle, Fumitory, Mock Orange, Nasturtium and Flopper Plant. Hedgerows provide an important habitat for many species of birds (including the European Goldfinch, Chick-of-the-village and Northern Cardinal, as well as Crows, European Starlings and Kiskadees) and numerous insect species.

⁷¹ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

The most commonly observed understorey species in Hedgerows are:
Native: Crab Grass, Cape Weed, Bull Grass, Morning Glory, Poison Ivy
Invasive: Asparagus Fern, Elephant’s Ear
Naturalised: English Plantain, Rye Grass, Bermuda Grass, Sow Thistle, Toothed Medic, Flopper, Fumitory, Hairy Horse-weed

Garden

Terrestrial habitat surveys conducted at 127 sites in residential gardens, playing fields and public parks, documented the dominance of invasive trees⁷². However, it is worth noting that the planting of ornamentals in gardens has actually helped increase the numbers of native and endemic species, by providing more space for them to grow.

Gardens provide an important habitat for many animals, including the Bluebird (threatened by the Kiskadee, Sparrow and Starling), European Goldfinch, Ground Dove, Mourning Dove, as well as a wide variety of migratory warblers and other songbirds. Common insects include the Field Cricket, Long-Horn Grasshopper, Short-Horn Grasshopper, Surinam and American Roaches, Monarch Butterfly, Buckeye Butterfly, Cloudless Sulphur Butterfly and Cabbage White Moth. Wolf spiders, toads and whistling frogs are also common.

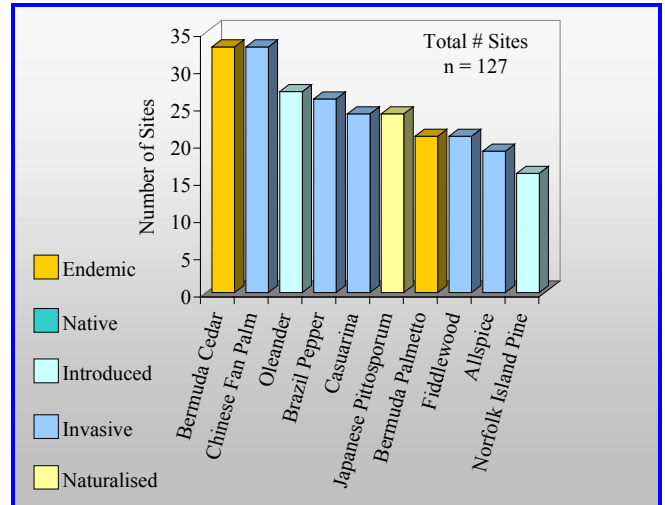


Figure 27. The most commonly observed trees in gardens, and the number of survey sites at which they were observed⁷².

Golf Courses

Golf courses cover an extensive area (243 ha or 600 acres⁷¹) and serve as important habitats for many bird species including migratory warblers and swallows, Bluebirds, the European Goldfinch, Common Ground-dove and Mourning Dove and other song birds. Water hazards often support waterfowl and shorebirds.

The most commonly observed understorey species on Golf Courses are:
Native: Crab Grass, Cape Weed
Invasive: Asparagus Fern, Wedding Fern
Naturalised: Bermuda Grass, Rye Grass, Annual Meadow Grass, Wire Weed, Dandelion, Japanese Hawksbeard, Wood Sorrel, Toothed Medic

Threats

The liberal use of fertilisers and pesticides is probably the major threat to the wildlife supported on Bermuda’s golf courses. Integrated pest

⁷² Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

management techniques should be encouraged. Adoption of principles such as those outlined in the “Environmental Principles for Golf Courses in the United States” and following the U.S. Audubon Cooperative Sanctuary Program and the Audubon Signature Program should be considered.

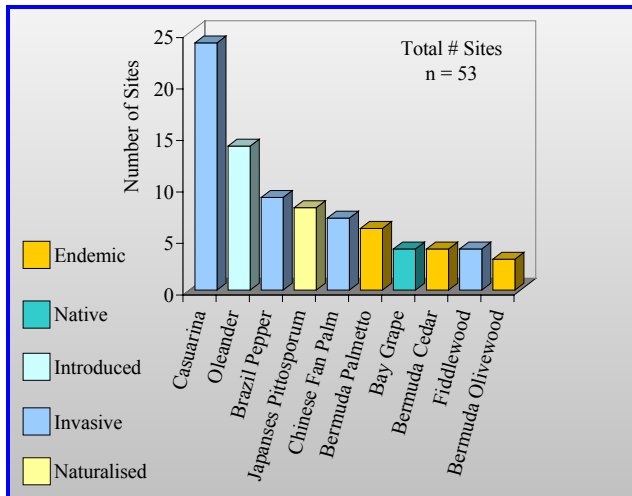


Figure 18. The most commonly observed trees on golf courses and the number of survey sites at which they were observed⁷³.

Field and Wayside

Areas of land at the edges of main roads, unmown grassed areas and sites where building demolition has occurred as well as land formerly used as a dump (amounting to about 34 ha or 84 acres⁷²), can be classified as wayside. They provide a surprisingly diverse species assemblage with over 120 species in total recorded in the understory; however, 75% of these are self-propagating introduced species, which threaten the few natives and endemics found in this habitat. They are important areas nevertheless, as they often serve as corridors for various animals.

⁷³ Bermuda Biodiversity Project. 2001, Unpublished data. Bermuda Zoological Society.

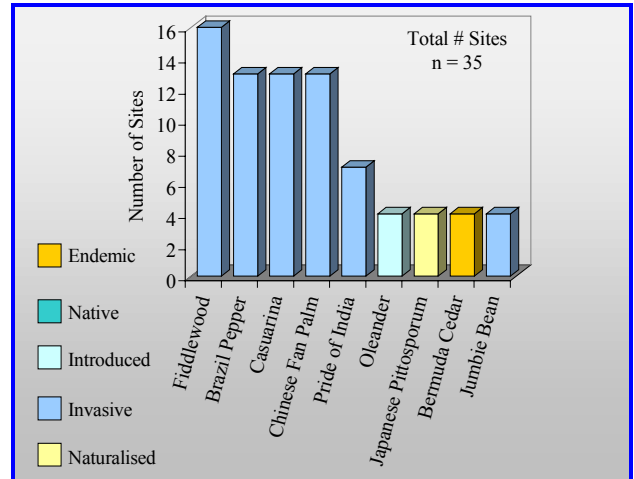


Figure 19. The most commonly observed trees in the wayside canopy and the number of survey sites at which they were observed⁷³.

Species Diversity⁷⁴

Sterrer (1998) undertook a comprehensive review of the literature, concluding that at least 8,301 species have been recorded from Bermuda, of which 3.0% are endemic. Of these, 4,597 are marine and 3,702 are terrestrial.

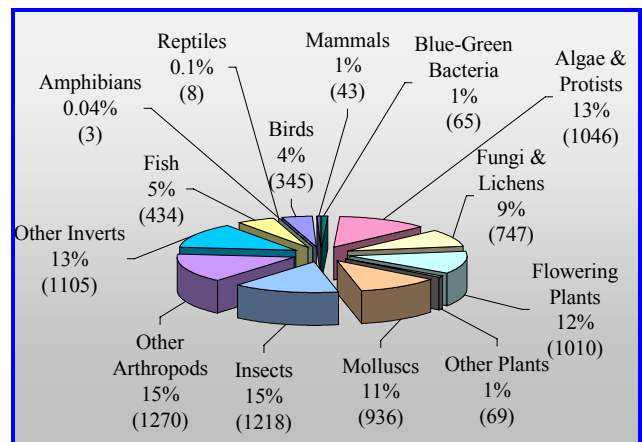


Figure 20. Composition of Bermuda's marine and terrestrial flora and fauna.

⁷⁴ Sterrer, W. 1998. How many species are there in Bermuda? Bulletin of Marine Science. 62, 809-840.

Cyanobacteria (Blue-Green Bacteria)

Cyanobacteria are well represented in Bermuda with 65 species having been reported, largely from rocky intertidal and sub-tidal surfaces, but also from sandy substrates and mangrove roots.

Marine Algae

Nine of the 473 species of macro-algae reported from Bermuda are endemic. An estimated 269 species of marine micro-algae have been reported.

Protozoa

There are 269 protozoan species known locally; 200 of these are the predominately benthic foraminiferans, of which *Homotrema rubrum* is perhaps best known for the pink hue its skeleton gives to Bermuda's sand.

Myxomycota, Fungi And Lichens

Of 783 species recorded 50 are endemic. The marine mycota of Bermuda is reported to be almost identical with that of other tropical and subtropical areas, such as Florida, the Caribbean, and the tropical part of the Pacific Ocean.

Terrestrial Plants

In spite of major changes in Bermuda's terrestrial ecology, especially since 1942, very little botanical work has been done since Britton in 1918, and the numbers reported below need revising.

Bryophytes (mosses and liverworts)

Fifty species have been recorded, of which 2 are endemic.

Ferns

Four of Bermuda's 19 species of fern were thought to be endemic, but one (*Dryopteris speluncaea*), is now considered to be only a native population of the more widely distributed *Ctenitis sloanei*. Another endemic, Governor Laffan's Fern is locally extinct in the wild; there are just five remaining at the Bermuda Botanical Gardens.

Gymnosperms and Angiosperms (Flowering plants)

Of 1010 species of flowering plants recorded by Britton, 11 are endemic. In 1976, it was estimated that more than 1500 species of plants have been introduced to Bermuda, of which about 800 have become naturalised.

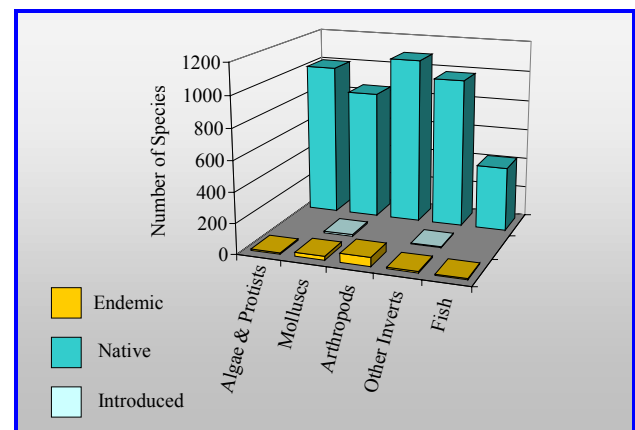


Figure 21. The number of marine plants and animals that are endemic, native, or introduced. Introduced includes invasive and naturalised species.

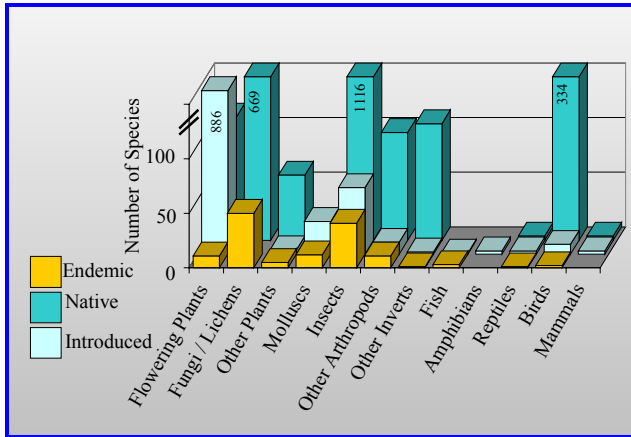


Figure 22. The number of terrestrial and freshwater plants and animals that are endemic, native, or introduced. Introduced includes invasive and naturalised species.

Porifera (Sponges)

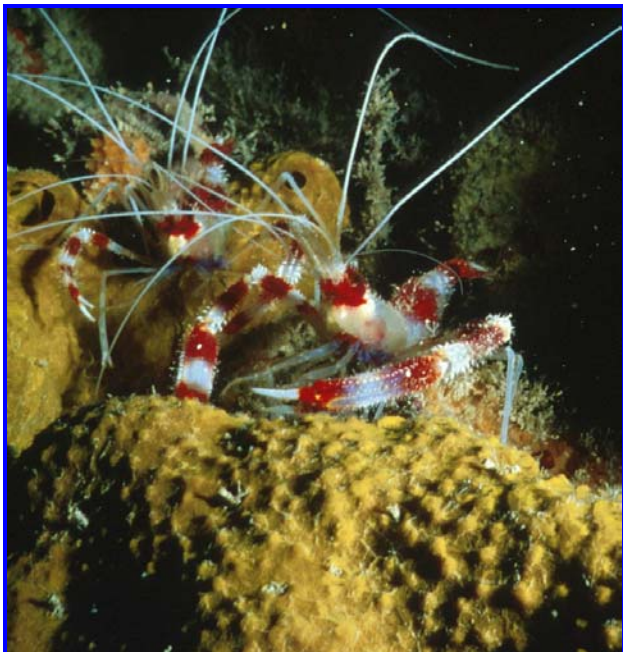


Plate 11. Pair of Banded Coral shrimp on one of Bermuda’s many sponges. (Photo courtesy of I. Murdoch).

Bermuda’s sponge fauna is relatively well known. At least 70 shallow-water species have been recorded, although recent studies suggest that actual number

may be in excess of 100 species⁷⁵. Commercially usable sponges of the keratose family Spongiidae were apparently common in Bermuda in the late 1800’s. However, all of these seem to have disappeared.

Cnidaria

Hydrozoa (Hydroids)

Commonly occurring on rocks, rubble, turtle grass, pilings as well as other invertebrates, 90 shallow-water hydroid species have been recorded of which 79 are also known from the Caribbean and West Indian regions. Three species are considered endemic to Bermuda. There are 45 species of the colonial, planktonic Siphonophora known from local waters as well as 2 species of Chondrophora one of which, *Physalia physalis*, is commonly seen stranded on Bermuda’s beaches in the Spring.

Scyphozoa (Jellyfish)

None of the 10 species recorded from Bermuda are endemic.

Anthozoa (Sea Anemones, Corals)

Soft corals and sea fans (Alcyonaria) are a visually dominant component of most Bermuda’s reefs and 25 species have been reported. There are 38 species of stony corals (Scleractinia). This includes 13 ahermatypes, which lack zooxanthellae and inhabit

⁷⁵ Ritter, J. Pers. Comm. Bermuda Biological Station for Research Inc.

the caves and deep water. Nine zoanthid and 21 Zoantharia species are also known locally. Of the 5 species of black coral recorded from Bermuda, 3 were collected in a single deep dive to 60 m, which suggests that even shallow-water Antipatharia are still insufficiently known.

Ctenophora (Comb-Jellies)

Only 5 species are known from Bermuda.

Simple Worms (Flatworms, flukes, roundworms)

There are 253 simple worms known from Bermuda. Of the flatworms, 67 are parasitic (50 having been recorded from Bermudian fishes), whilst 12 of the 78 species of round worm are also parasitic. One of the jaw worms is endemic.

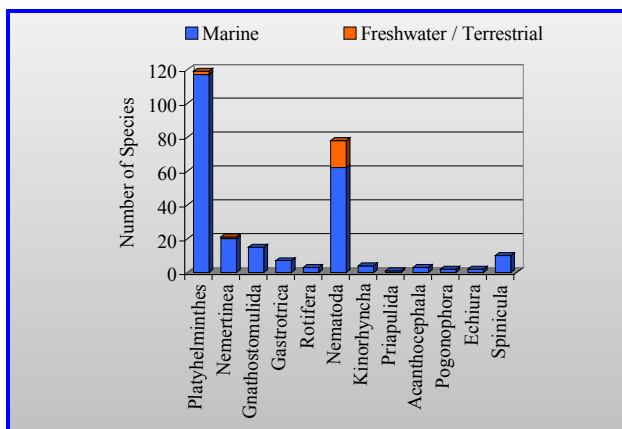


Figure 23. Marine and freshwater simple worms from Bermuda (by class).

Bermuda's tree frogs and toads are hosts to 11 helminth parasites. One species is a parasite of lizards, and one of land crabs. Four intestinal helminths have been found in dogs and cats, whilst

Ascaris lumbricoides, *Trichuris trichura* and *Enterobius vermicularis* are the most commonly seen nematodes in humans.

Annelida (Bristle worms, leeches)

A total of 211 annelids have been reported primarily from the marine environment. The marine bristle worms Oligochaeta (40 species) and Polychaeta (over 250 species⁷⁶) are reasonably well known. Six species of Archiannelida (of which 1, the “marine earthworm” *Pontodrilus bermudensis* Beddard is the only endemic macro-oligochaete), and 1 species of marine leech have also been reported. A survey of terrestrial Oligochaeta in 1996 added 6 species to the 8 recorded previously.

Arthropoda

Crustacea

Of the 130 marine ostracods, 14 are cave-dwelling endemics. Other endemics include one barnacle, six marine amphipods, one marine isopod, and six endemic decapods. Of these, the caridean shrimp *Periclimenes anthophilus* is possibly synonymous with the Caribbean *P. pedersoni*. Three other caridean species from marine caves are endemic as is one deepwater crab. The sixth endemic decapod is the astacid *Eunephrops luckhursti*.

⁷⁶ Pocklington, P. Pers. Comm. Bermuda Biological Station for Research Inc.

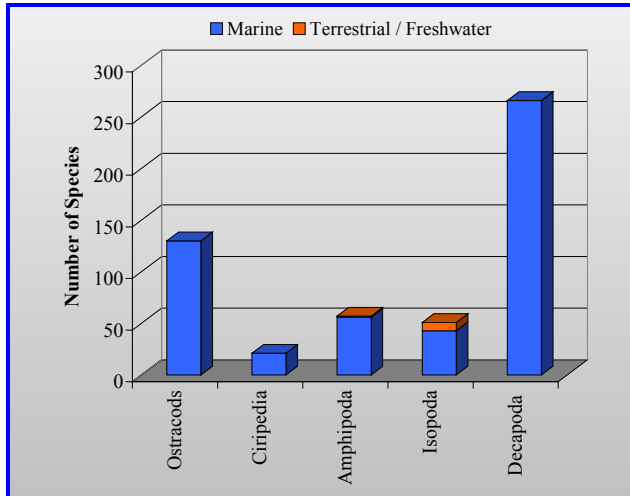


Figure 24. Marine and terrestrial/ freshwater Crustacea from Bermuda (by class).

Araneae (Spiders)

Of the 59 known species of spiders, one is a new species (*Anyphaena bermudensis*) and therefore a potential endemic. We know that several species were already residents at the time of Bermuda's colonisation.

Insecta

Of the 183 species of Lepidoptera (Butterflies), about 125 are thought to be established residents, while the remainder are assumed to be vagrants. Eleven species and three subspecies are endemic, and one of these, *Semiothisa ochrifascia* is believed to be extinct. This moth was dependent on the endemic Bermuda cedar. There are 228 species of Coleoptera (beetles), none of which are endemic, and 258 species of Diptera (flies), including 17 endemics of which 7 are possibly extinct. Of about 44 endemic insect species, 16 (36.4%) seem to have become extinct in this century, the most conspicuous being the Bermuda Singer or Cicada, and the

Bermuda Flightless Grasshopper. There are 7 dragon- and 3 damselflies known locally.



Plate 12. This grasshopper is one of over 1,000 insects known from Bermuda. (Photo courtesy of R. Ground).

Mollusca (Snails, bivalves, squid, etc.)

Bermuda's marine molluscs, including those from deeper waters as well as micro-gastropods, are well known. Of 88 species of marine Pleistocene molluscs (48 Gastropoda, 40 Bivalvia) recorded, 6 no longer survive in Bermuda. Of 594 marine gastropods, 22 are endemic and of 205 marine bivalves, 4 are endemic. Nine chitons (Polyplacophora), 4 tusk shells (Scaphopoda), 69 Cephalopoda and 2 worm molluscs (Aplacophora) have also been documented.

The 47 species of terrestrial slugs and snails known to occur here are from 20 families. Of these, 11 are endemic, 7 are native, and there have been at least 25 accidental introductions, while 4 were deliberately introduced. Several endemics, including the last two extant species of *Poecilozonites*, are feared to be extinct, probably fallen victim to

Euglandina rosea and other introduced carnivorous snails.

Of 6 freshwater molluscs described from Bermuda, two (the gastropod *Ancylus bermudensis* and the bivalve *Pisidium volutabundum*) reported from Pembroke Marsh were probably endemic but are now extinct.

Echinodermata (Sea urchins, sea cucumbers, sea stars)

None of the 72 species of Echinoderms known from Bermuda are endemic. Of four species of starfish (Asteroidea) recorded in the early 1900's, two (*Asterina folium* and *Luidia clathrata*) have disappeared. Several other seastars, including the conspicuous *Oreaster reticulatus*, only turn up occasionally as isolated waifs giving a total of 12 recorded species. There are 21 species of brittle star (Ophiuroidea), and 20 species of sea urchin (Echinoidea), of which *Lytechinus variegatus* is by far the most conspicuous in Bermuda's inshore waters. The Spiny Sea Urchin, *Diadema antillarum*, never particularly abundant in Bermuda, was decimated in 1983 by a pathogen that spread rapidly throughout the northwestern Atlantic; it seems to be slowly recovering. There are 18 species of sea cucumber (Holothuroidea) known, ranging from the intertidal to deep water.

Hemichordata

Of 6 species of Hemichordates documented from local waters, 4 are acorn worms (Enteropneusta),

and the other 2 are Pterobranchia. The latter, *Cephalodiscus gracilis* and *Rhabdopleura normani*, are interesting in that most species from this class are known from colder, deeper habitats; few have been reported from shallow tropical areas.

Chordata

Tunicates (Sea squirts, salps)

Of the 96 species of tunicates (Thaliacea, 29; Larvacea, 20; Ascidiacea, 47) recorded from Bermuda, 5 are endemic sea squirts (Ascidiacea). Interestingly, of approximately 70 species of Larvacea known globally, more than 20 have been reported from the Sargasso Sea.

Cephalochordata (Lancelets)

Three species of this fish-like chordate have been reported from Bermuda.

Fishes

As many as 433 species (9 endemic) in 107 families of mostly inshore fishes have been listed for Bermuda, the majority from depths above 200 m. Of these, three endemic species of *Fundulus*, and the introduced *Gambusia affinis* are found in the Island's brackish ponds and marshes. The Bermudian ichthyofauna consists almost exclusively of species found elsewhere in the tropical western Atlantic. It is relatively depauperate in comparison, with only about 50-55% of the number of resident species found in the Florida Keys or Bahamas.

Amphibia

All three established species of amphibians (the Giant Toad and the two species of West Indian whistling frogs) have been introduced. One species of whistling frog has not been seen since the mid-1990's.

Reptilia

Four species of marine turtles are recorded from Bermuda: the Green Turtle, the Hawksbill, the Loggerhead and the occasional Leatherback. The Green Turtle is by far the most abundant, but Bermuda's breeding population was decimated decades ago, and the Island now serves as an important nursery for juvenile turtles from other regions.

Bermuda boasts only one native land reptile, the endemic Skink, which is believed to be most closely related to a species in Florida. The description of a recently excavated fossil land tortoise adds an extinct endemic. Three introduced species of West Indian *Anolis* are well established.



Plate 13. Bermuda Rock Lizard or Skink (Photo courtesy of R. Ground).

Birds

Only 2 of the 360 birds⁷⁷ recorded from Bermuda, are endemic; these are the Bermuda Petrel or Cahow, and a subspecies of the White-Eyed Vireo, locally called Chick-of-the-Village. Fossil records exist for several species that no longer breed here including the Audubon Shearwater, and an albatross, probably the Short-Tailed Albatross, which survives in the Pacific. A few more species, probably all endemic, are now extinct: a crane (*Baeopteryx latipes*), a duck (*Anas pachyscelus*), 4 species of rail (Rallidae), as well as a woodpecker, a hawk, a heavy-billed passerine, and a small owl - the latter two having been noticed by the first settlers.

Mammalia

There are no native, resident land mammals. The list comprises 4 visiting bats and the introduced rodents: the House Mouse, the Black Rat, and the Norwegian Rat; but excludes domestic mammals of which some (e.g., cats and rabbits) are considered feral.

There have been 36 species of whales, porpoises and dolphins (Cetacea) reported from Bermuda's waters. The most frequently sighted are the Common Dolphin, the Pilot Whale, the Sperm Whale, Cuvier's Beaked Whale, the Minke Whale and the Humpback Whale.

⁷⁷ Dobson, A. Pers. Comm. Current bird list at <http://www.audubon.bm>

Threatened Species

The International Union for the Conservation of Nature (IUCN) has developed categories and criteria for the classification of threatened species⁷⁸. The categories provide a way of highlighting those species that are under higher extinction risk so as to prioritise conservation measures. These categories are “extinct”, “extinct in the wild”, “critically endangered”, “endangered”, “vulnerable”, and “lower risk”. One criterion for the classification of “critically endangered” is that a species has an estimated occurrence of less than 100 km² (38.6 miles²). In effect, this means that all of Bermuda’s terrestrial and freshwater endemics should be considered “critically endangered”.

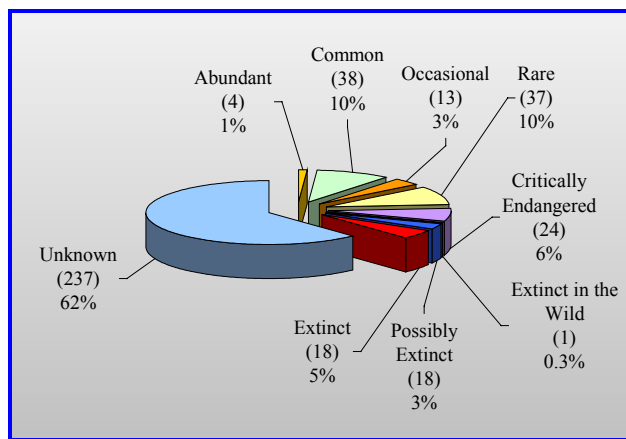


Figure 25. Status of Bermuda’s endemic species.

Marine Species

A number of Bermuda’s native marine species including turtles, all mammals, corals, and many molluscs are considered threatened both locally and internationally. They are all locally protected from

⁷⁸ http://www.redlist.org/categories_criteria.html

harvesting. Some, such as the Green Turtle, have been over-harvested to the extent that there is no longer a Bermuda breeding population. All of the Green turtles found locally today are the juveniles of another breeding population.

Of particular concern are the local Bermuda Scallop and Queen Conch populations. The latter, although not endemic, have shown some evidence of genetic variation from the Caribbean stock.

The native West Indian Top Shell is another species that was locally extirpated, but has recently been re-introduced. The population is still considered vulnerable.

Common Name	Species Name	Origin	IUCN Red List 2000 Status
Green Turtle	<i>Chelonia mydas</i>	Native	<ul style="list-style-type: none"> Endangered Population reduced by 50% over three generations
Northern Right Whale	<i>Eubalaena glacialis</i>	Native	<ul style="list-style-type: none"> Endangered Population < 2500 individuals Expected decline of 20% within 2 generations Population < 250 mature individuals
Pilot Whale	<i>Globicephala macrorhynchus</i>	Native	<ul style="list-style-type: none"> Lower Risk Conservation dependent survival
Lined Seahorse	<i>Hippocampus erectus</i>	Native	<ul style="list-style-type: none"> Vulnerable Expected decline of 20% in next 10 years Decline in area of occurrence
Humpback Whale	<i>Megaptera novaeangliae</i>	Native	<ul style="list-style-type: none"> Vulnerable Expected decline of 20% over 3 generations
Marine Shrimp	<i>Somersiella sterreri</i>	Native	<ul style="list-style-type: none"> Critically Endangered Known only at a single location Decline due to area / quality of habitat

Table 5. Bermuda’s marine species found on the 2000 IUCN Red List⁷⁹.

Terrestrial Species

In comparison with Bermuda’s marine flora and fauna, the Island’s terrestrial species are under significantly greater threat. A number of endemics, including a woodpecker, a hawk and a small owl, have already become extinct, whilst one, Governor

⁷⁹ <http://www.redlist.org>

Laffan’s Fern, is extinct in the wild. Some, such as the Bermuda Cicada, the Flightless Grasshopper and several *Poecilozonites* snail species are also feared to be extinct⁸⁰. Many more, such as the Cahow and the Bermuda Rock Lizard as well as plants including, Bermuda Spike Rush, and Bermuda Sedge are now threatened. The threat to all of Bermuda’s terrestrial and freshwater endemics is likely escalating given the continued loss of habitat and increasing number of introductions. Native species are not immune from these threats either.

Common Name	Species Name	Origin	IUCN Red List 2000 Status
Piping Plover	<i>Charadrius melodus</i>	Native	<ul style="list-style-type: none"> • Vulnerable • Population est. < 10,000 individuals • Continuing decline in numbers due to severe fragmentation
Bermuda Olivewood	<i>Elaeodendron laneanum</i>	Endemic	<ul style="list-style-type: none"> • Vulnerable • Population is very small and occupies a small area
Bermuda Rock Skink	<i>Eumeces longirostris</i>	Endemic	<ul style="list-style-type: none"> • Critically Endangered • Severely fragmented habitat • Decline in area, habitat, mature individuals
Bermuda Cedar	<i>Juniperus bermudiana</i>	Endemic	<ul style="list-style-type: none"> • Critically Endangered • Small area and extent of habitat
Bermuda Land Nemertean	<i>Pantionemertes agricola</i>	Endemic	<ul style="list-style-type: none"> • Possibly Extinct • Data Deficient • More research is required
Bermuda Petrel	<i>Pterodroma cahow</i>	Endemic	<ul style="list-style-type: none"> • Endangered • Population < 250 mature individuals
Bermuda Palmetto	<i>Sabal bermudana</i>	Endemic	<ul style="list-style-type: none"> • Endangered • Severely fragmented habitat • Continuing decline in area and population
Yellowwood Tree	<i>Zanthoxylum flavum</i>	Native	<ul style="list-style-type: none"> • Vulnerable • Observed decline of 20% over 3 generations • Decline in extent of occurrence

Table 6. Bermuda’s terrestrial species found on the 2000 IUCN Red List⁸¹.

Cave Species

Bermuda’s cave systems harbour a wealth of endemic species, which are under increasing threat from development and pollution. Of these, 25 are currently listed as critically endangered because of

their restricted range, many having only been found in a single cave or cave system.

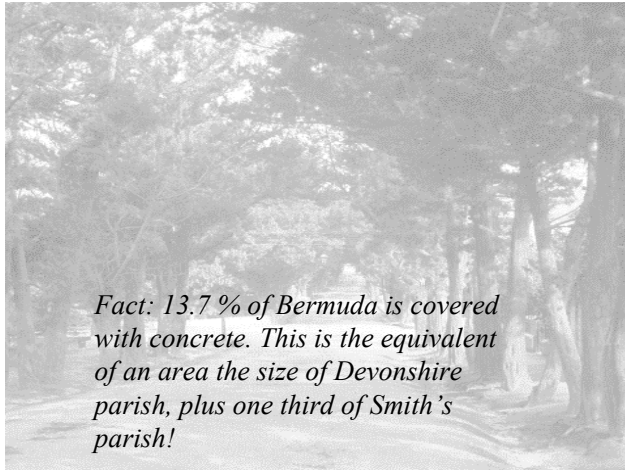
Common Name	Species Name	Origin	IUCN Red List 2000 Status
Cave Copepods	<i>Antriscopia prehensilis</i>	Endemic	<ul style="list-style-type: none"> • Critically Endangered • Known only at a single location • Decline due to area / quality of habitat
	<i>Nanocopia minuta</i>	Endemic	
	<i>Paracyclops naessi</i>	Endemic	
	<i>Speleoithona bermudensis</i>	Endemic	
	<i>Speleophria bivexilla</i>	Endemic	
	<i>Speleophria scottodicarloi</i>	Endemic	
Cave Isopods	<i>Eroboneces nesioicus</i>	Endemic	<ul style="list-style-type: none"> • Critically Endangered • Known only at a single location • Decline due to area / quality of habitat
	<i>Atlantaselus cavernicolus</i>	Endemic	
	<i>Bermudalana aruboides</i>	Endemic	
Cave Shrimp	<i>Currassanthura bermudensis</i>	Endemic	<ul style="list-style-type: none"> • Critically Endangered • Known only at a single location • Decline due to area / quality of habitat
	<i>Barbouria cubensis</i>	Native	
	<i>Mictocaris halope</i>	Endemic	
	<i>Platyops sterreri</i>	Endemic	
	<i>Procaris chacei</i>	Endemic	
Cave Amphipods	<i>Typhlatya iliffei</i>	Endemic	<ul style="list-style-type: none"> • Critically Endangered • Known only at a single location • Decline due to area / quality of habitat
	<i>Bogidiella bermudensis</i>	Endemic	
	<i>Idunella sketi</i>	Endemic	
	<i>Ingolfiella longipes</i>	Endemic	
	<i>Cocoharpinia iliffei</i>	Endemic	
	<i>Pseudoniphargus grandimanus</i>	Endemic	
Cave Worm	<i>Mesonerilla prospera</i>	Endemic	<ul style="list-style-type: none"> • Critically Endangered • Known only at a single location • Decline due to area / quality of habitat
	<i>Phallogrillus macmasterae</i>	Endemic	
Cave Ostracod	<i>Spelaeoecia bermudensis</i>	Endemic	<ul style="list-style-type: none"> • Critically Endangered • Known only at a single location • Decline due to area / quality of habitat

Table 7. Bermuda’s cave species found on the 2000 IUCN Red List⁸¹.

⁸⁰ Thomas, M. Pers. Comm. University of New Brunswick, Canada

⁸¹ <http://www.redlist.org>

THREATS TO BERMUDA'S BIODIVERSITY



Habitat Destruction

Habitat degradation is one of the most significant threats to Bermuda's biodiversity and occurs both through human impacts, and from natural processes.

Storms and Hurricanes

Storm-induced coastal erosion along Bermuda's south shore is a significant threat to Bermuda's shoreline. The porous nature of the rocky coast means that large pieces of rock periodically give way during, or in the aftermath of high winds and seas. This poses a tremendous threat particularly to the integrity of the exposed Cahow breeding islands around Nonsuch Island, to the Longtail nest sites around the coast, as well as to the shoreline protecting Bermuda's largest remaining mangrove stand at Hungry Bay. Beaches are also affected by storm surge, and the practice of cleaning some

public beaches often results in the removal of stabilising components such as seaweed.



Plate 14. The surf hitting the rocky coast results in shoreline erosion. (Photo from BAMZ slide collection).

Further inland, it is usually the less wind-resistant, introduced tree species such as Casuarina and Fiddlewood that topple and leave conspicuous gaps in wooded areas.

Ship Groundings

The vulnerability of Bermuda's coral reef system was dramatically demonstrated in 1984, with the grounding of the fully laden super tanker *Aguila Azteca* on the reefs to the north of Bermuda. Carrying 196,000 tons of heavy Maya crude oil, this tanker could easily have created the largest oil spill in history, were it not for the unseasonably mild weather. However, it is not only the ships themselves, which damage the reefs when grounding but also the blasting that is often employed to

salvage them. About 70 ha (173 acres) of shallow outer reef (less than 10 m (33 ft) in depth) have been severely disturbed by groundings, representing about 1% of that reef zone⁸². Long-term monitoring of the Mari Boeing grounding scar, created in 1978, has shown that recovery of the reef is very slow, on the order of 100 years or more.



Plate 15. Cruise ships stir up the sediment of shallow harbours and bays, smothering the corals with silt and greatly reducing the amount of light available to them. (Photo from BAMZ slide collection).

⁸² Cook, C.B., R.E. Dodge, S.R. Smith. 1993. Fifty years of impact on coral reefs in Bermuda. Proceedings of the Colloquium on Global Aspects of Coral Reefs: Health Hazards and History, R.S.M.A.S., Miami. pp. 160-166.

Dredging^{83,84}

The construction of Kindley Air Force Base (the present-day airport) during the 1940's necessitated extensive dredging in Castle Harbour. This resulted in the destruction of once thriving seagrass beds, mangroves, and coral reefs. The construction required the bulldozing of a dozen islands and the dredging of sediments and near shore coral reefs to generate landfill. In all, approximately 24.4 ha (60 acres) of coral reef, 18.2 ha (45 acres) of seagrass beds⁸⁵ and 5.7 ha (14 acres) of mangrove habitats were destroyed. The dredging, rock crushing and filling activity produced a tremendous quantity of fine silt material that spread over the entirety of St. George's and Castle Harbours choking the coral and permanently altering the marine environment. The new land restricted tidal flow and was insufficient in removing the silt that remains trapped and continually re-suspends to this day. The siltation is the primary reason why the reefs in Castle Harbour may never grow back to their pre-1940 condition. (Sedimentation resulting from daily boating traffic in the shipping channels Island-wide is also a significant problem for the adjacent reefs).

A dredging permit is compulsory for any dredging activity, but illegal dredging is a problem, and is of particular concern in seagrass beds.

⁸³ Sterrer, W. and D.B. Wingate. 1981. Wetlands and Marine Environments. In: Bermuda's Delicate Balance. S.J. Hayward, V. Holt Gomez, W. Sterrer (Eds.). Bermuda National Trust, Hamilton, Bermuda. 402 pp.

⁸⁴ Sleeter, T. Pers. Comm. Ministry of the Environment, Opportunity, and Development.

⁸⁵ Smith, S.R. 1999. Impact of the construction of Kindley Field Airbase on the marine environment of Castle Harbour, Bermuda. Ministry of the Environment.

Moorings and Anchor Damage

The damage caused by boat mooring chains as they rotate to the surrounding seagrass has already been mentioned. Evidence of anchor and/or propeller damage can also be observed in many seagrass beds, whilst the destruction caused by anchors deployed on coral reefs has long been a cause for concern.

Dumping

Due to the association of mosquitoes with marshes, a policy of complete marsh reclamation was initiated by the Government that began around 1900 when there was a total of 121 ha (298 acres) of marshland⁸⁶. By the 1930's garbage was being used as a cheap and easy solution to marsh reclamation. The edges of inland peat marshes were also cleared and filled to extend arable land.

Development

At present, development is the biggest overall threat to the Island's biodiversity. Over the last 10 years, 91.9 ha (227 acres) of land has been developed⁸⁷, which equates to an area the size of Ferry Reach Park being lost to housing development every three years. Approximately, 13.7% of Bermuda is covered with concrete, of which 7.96% is accounted for by

buildings and 5.74% by roads⁸⁸. This is the equivalent of an area the size of Devonshire Parish plus one third of Smith's Parish being solid concrete! Continuing at this rate, and given the current footprint of the average house on a building lot, an area the size of Ferry Reach Park will be covered in concrete approximately every 9 years. This does not take into account any industrial and commercial development.

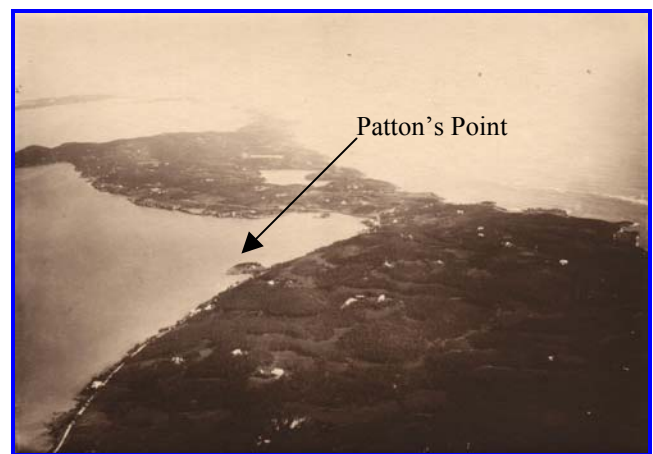


Plate 16. An aerial photograph circa 1920 of the Knapton Hill area. (Photo courtesy of B. Hollis).



Plate 17. A 1997 aerial photograph of the Knapton Hill area. (Photo courtesy of the Ministry of Works and Engineering).

⁸⁶ Sterrer, W. and D.B. Wingate. 1981. Wetlands and Marine Environments. In: Bermuda's Delicate Balance. S.J. Hayward, V. Holt Gomez, W. Sterrer (Eds.). Bermuda National Trust, Hamilton, Bermuda. 402 pp.

⁸⁷ Department of Planning, Ministry of the Environment, Opportunity, and Development.

⁸⁸ Viney, T. Pers. Comm. Ministry of Works and Engineering.

Noise, traffic, and lighting are by-products of development that disturb wildlife and reduce the value of an area to support wildlife.

Pollutants

Trash

Illegal dumping is a major problem in Bermuda. Wooded areas, marshes, caves and wayside fields tend to have significant amounts of garbage. In the marine environment, plastics, ranging in size from large sheets to microscopic pieces, and helium balloons are a major problem. A number of marine turtles and seabirds are killed each year from ingesting plastics or becoming entangled in fishing gear. A Humpback Whale recently entangled in fishing gear off the south shore, had to be cut free by divers.



Plate 18. This juvenile Hawksbill Turtle with a massively bloated gut, died as a result of ingesting the plastics shown in the jar in Plate 19. (Photo courtesy of J. Gray).



Plate 19. Plastics removed from the gut of a dead Hawksbill Turtle (Photo courtesy of J. Furbert).

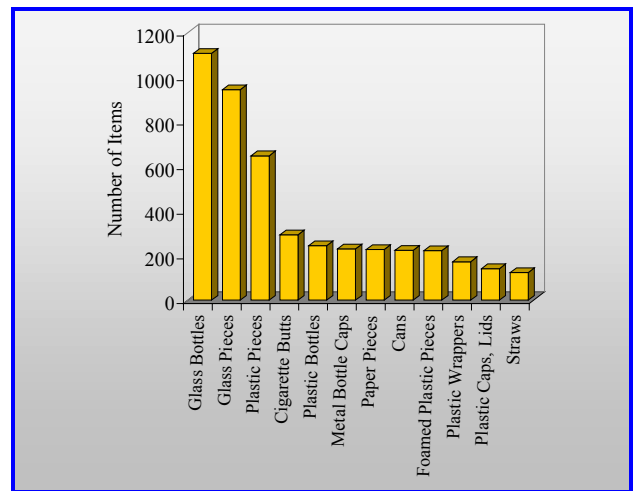


Figure 26. Items collected during the 1999 Keep Bermuda Beautiful (KBB) terrestrial clean-up⁸⁹.

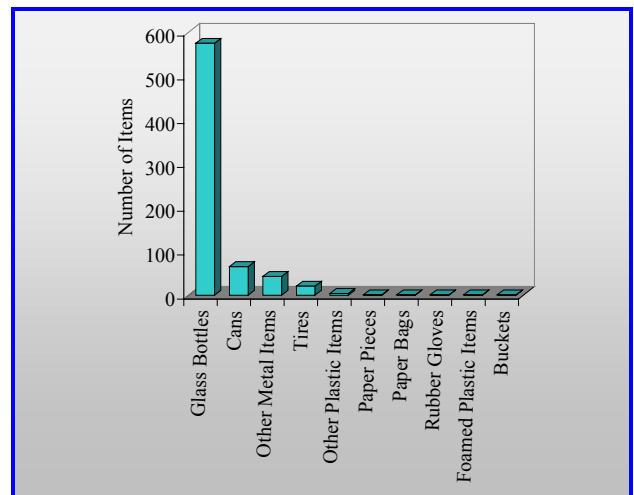


Figure 27. Items collected during the 1999 Keep Bermuda Beautiful (KBB) marine clean-up⁸⁹.

⁸⁹ Boodram, L. Pers. Comm. Keep Bermuda Beautiful.

Pesticides

Pesticide use in Bermuda is quite liberal, and licensing of operators is not required. Historically there was widespread use of DDT and related pesticides to control mosquitoes and agricultural pests. DDT is especially known for its effects on birds, whose eggshells become brittle upon exposure, reducing reproductive success. DDT is no longer in use, although it is still present in the environment due to its persistent properties⁹⁰.

Recent research has shown that Bermuda's toad populations experience unusually high rates of deformities⁹¹. Whilst the cause of these deformities is still unknown, the asymmetrical and unilateral nature of the deformities suggests that chemicals may be responsible. Pesticides that are known to cause such deformities in amphibians are used heavily on the Island, and research into any correlation is ongoing. DDE, heavy metals and evidence of immune system suppression in dead specimens of Bermuda's amphibians have been documented.



Plate 20. Deformed hand of a Giant Toad with only three (fused) digits. (Photo courtesy of J. Bacon).

Emissions

Despite being spared the polluting impacts of heavy industries, Bermuda is not immune from the problem of emissions. The main sources are the local electricity supply company BELCO, as well as the 51,258 road vehicles and approximately 5,500 powered marine vessels. As of 2002, all vehicles imported into Bermuda will be required to meet European, Japanese, or U.S. domestic emission standards. Testing of all road vehicles as a condition of licensing is in the feasibility stage with a pilot project being conducted in 2001⁹².

Sewage and waste water⁹³

Sewage disposal in Bermuda is accomplished for the most part by discharge into household soakaways or cesspits, there being no public sewer system other than in the Town of St. George's and the City of Hamilton. For the last 20 years, high-density

⁹⁰ Ministry of the Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda: A Discussion Paper. 495 pp.

⁹¹ Bacon, J. Pers. Comm. Bermuda Zoological Society.

⁹² Sleeter, T. Pers. Comm. Ministry of the Environment, Development and Opportunity.

⁹³ Rowe, M. Pers. Comm. Ministry of the Environment, Development and Opportunity.

developments such as condominiums have been required to install septic tank treatment systems and deep sealed boreholes (“vertical leaching fields”) for effluent disposal. Meanwhile, the largest new housing and hotel developments, or re-developments are now required to implement secondary or tertiary sewage treatment.

Typical Bermuda limestone is a porous sandstone and, as such, is efficient at physically filtering and chemically absorbing many contaminants in any effluent, which percolates through it. Such “slow sand filtration” is recognised in the water industry as one of the most effective means of “polishing” wastewater.

Analyses of ground water in Bermuda indicate that some contaminants, notably nitrates, are attributable to cesspit seepage. However, the amount and rate of contamination has been low enough that we have been able to live with it safely. Nitrate levels over the past five years have stabilised and even decreased in some areas due to lower population growth and increased annual rainfalls.

Some of the larger hotels and the urban developments of Hamilton and St. George’s dispose of sewage effluent through ocean outfalls, which do not extend beyond the outer reef-line. Whilst studies have shown no alarming alteration of the reef ecology, probably due to the high levels of dilution and mixing, improved levels of treatment and re-use of this effluent are an ultimate objective.

Heated water from the incinerator and hyper-saline water from reverse osmosis plants is also pumped into the ocean. Monitoring has shown that such inputs have had little or no effect on the marine environment^{94,95}.

Oil spills⁹⁶

Oil spills from ships are a major threat to Bermuda’s marine habitats. Since 1976 and the spilling of oil from the passenger liner *Statendam*, Bermuda’s oil spill response has been very effective. More than 135 oil spills have occurred in local waters since then, and of these 22 have been pursued in court, all of them leading to convictions. Bermuda was ahead of the U.S.A in employing oil “fingerprinting” techniques to trace offenders in the mid-1970’s⁹⁷. On land, both oil companies (Esso and Shell) are in the process of installing state of the art equipment at all their service stations to help minimise the risk of spills or leaks. Keep Bermuda Beautiful is developing a campaign to encourage marine service stations and the boating public to adopt more careful fuelling practices.

⁹⁴ Smith, S.R. 1999. Bermuda. In: Kjerve, B. (Ed.) CARICOMP: Caribbean coral reef, seagrass, and mangrove sites. UNESCO Coastal Region and Small Island Papers. 3, 247-257.

⁹⁵ Smith, S.R., D.C. Hellin, S.A. McKenna. 1998. Environmental impacts of the effluent released from the Tynes Bay incinerator and disposal of ash blocks in Castle Harbour. BBSR Special Publ. No. 35.

⁹⁶ Sleeter, T.D., Knap A.H., Hughes, I.W. 1983. Oil spill contingency planning and scientific support coordination in Bermuda: A successful model. 1983 Oil Spill Conference. pp. 149-153.

⁹⁷ Sleeter, T. Pers. Comm. Ministry of the Environment, Development and Opportunity.

Once a significant problem on the Island, the amount of tar washing onto beaches has decreased in recent years as a result of greater vigilance on board shipping vessels.

Anti-fouling Paints⁹⁸

Metal-based anti-fouling paints used on boat bottoms are one of the main sources of metal contamination in the marine environment. Many of these paints contain TBT (Tri-butyl tin) which is highly effective as an anti-fouling agent. It is responsible for a condition termed “imposex” in gastropods, in which the female develops a penis and becomes infertile. There is evidence of imposex in older Harbour Conch in Bermuda⁹⁹. This condition may pre-date the local ban on the importation and use of TBT-based paints in 1988. However, TBT is still used on cruise ships and most large ships. Concentrations of TBT in Bermuda’s inshore waters are still elevated despite the ban of anti-fouling paints and additives, as paint chips scraped off boats are often washed into the water and become buried in the sediment¹⁰⁰.

⁹⁸ Ministry of the Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda: A Discussion Paper. 495 pp.

⁹⁹ Outerbridge, M. 1999. Unpublished report. Population Studies and Imposex of the Harbour Conch (*Strombus costatus*) in Harrington Sound. Bermuda Biodiversity Project, Bermuda Zoological Society.

¹⁰⁰ Sleeter, T. Pers. Comm. Ministry of the Environment, Development and Opportunity.



Plate 21. A female Harbour Conch showing abnormal development of a penis. (Photo courtesy of M. Outerbridge).

The Bermuda Biological Station for Research Inc. is investigating the effects of Irgarol, a chemical that leaches from new bottom paints¹⁰¹. It is used on large vessels and is at detectable levels in Hamilton Harbour. The chemical is persistent and is known to inhibit photosynthesis in plankton and corals.

Invasive Species

According to the United Nations, the biggest single threat to island biodiversity is from invasive species. Invasive species are organisms that (largely through human transport) successfully establish themselves in, and then overcome pre-existing native ecosystems. The impact is often catastrophic for the native species, whilst the costs to the local economies may be enormous. Invasive species can change light levels, decrease oxygen in water, change soil chemistry and increase surface run-off and erosion. They can affect nutrient cycling and

¹⁰¹ Smith, S.R. Pers. Comm. Bermuda Biological Station for Research Inc.

pollination cycles, and displace native species, even causing the extinction of local populations.

A review of Bermuda’s flora and fauna reveals a long history of invasions. Most have probably been introduced accidentally, but there have also been numerous intentional introductions, either for ornamental purposes, or as biological controls.

Terrestrial Invasives

Nowhere is the impact of invasive species more apparent than amongst the flora of the Island. Being better competitors for habitat space and more efficient seeders, invasives such as Brazil Pepper, Casuarina, Chinese Fan Palm, Allspice, Fiddlewood, and Surinam Cherry dominate Bermuda’s landscape.



Plate 22. The invasive Indian Laurel tree growing out of the side of a building. (Photo courtesy of H. De Silva).

Another species not yet widely recognised by residents as a problem is the Indian Laurel. Not only does this species threaten the endemic and native

flora, but its aggressive root system undermines the integrity of many of Bermuda’s man-made structures, including walls, pavements and roads. A recent survey noted that of 736 locations where individual Indian Laurels were found along Bermuda’s main roads, 133 were considered as hazardous in terms of the potential for structural damage caused by the tree¹⁰².

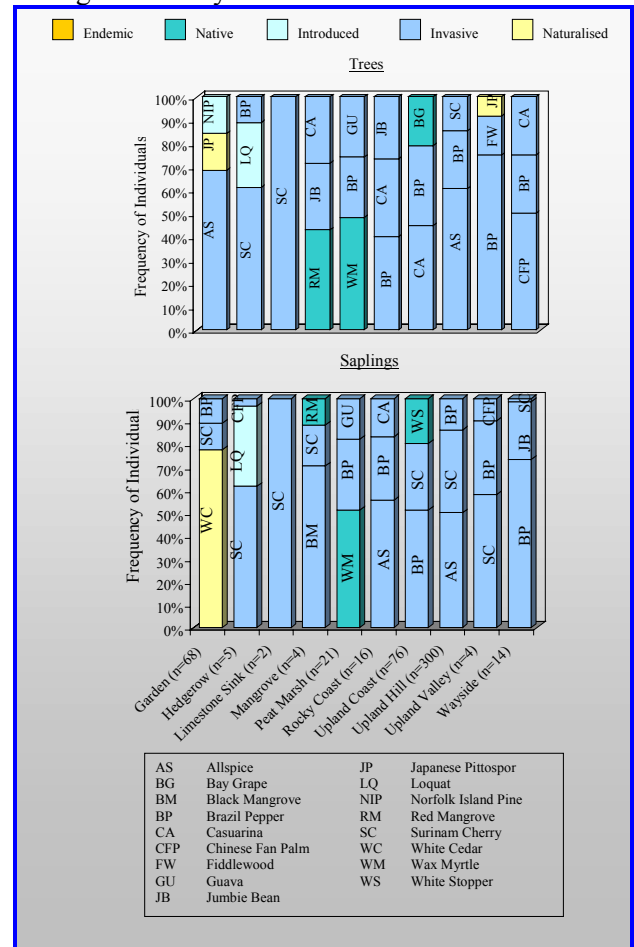


Figure 28. The dominant tree and sapling species in 10 different habitats, highlighting the prevalence of invasives¹⁰³.

¹⁰² Anderson, C. 2000, Unpublished report. Survey of *F. microcarpa* (Indian Laurel) populations along Bermuda’s major roadways. Bermuda Biodiversity Project, Bermuda Zoological Society. 28 pp.

¹⁰³ Bermuda Biodiversity Project. 2001. Unpublished data. Bermuda Zoological Society.

Of the resident birds in Bermuda the three most common, the European Starling, House Sparrow and Great Kiskadee, are all considered invasive pests. The latter were introduced in 1957 to reduce the populations of *Anolis* lizards, which were themselves introduced to control the Mediterranean Fruit Fly¹⁰⁴. The Giant Toad, was also intentionally introduced to control insect species, especially the cockroach. The two whistling frog species known locally were most likely accidental introductions.

The cedar blight in the 1940's triggered a rash of intentional introductions in a futile effort to try and control the scale insects responsible for the disease. Their failure was compounded by the loss of at least one endemic insect as a direct result of the introductions. Nowadays, species introduced as biological controls are usually host specific; however, once released, monitoring their subsequent ecological impact is difficult¹⁰⁵.

The Black Rat was accidentally introduced to Bermuda from a grain ship in 1613 and the Norwegian Rat was later introduced in the 18th century¹⁰⁶. They eat farm crops and take the eggs and chicks of nesting birds, including the Longtail. To control the rat problem, cats were released in Bermuda.

Feral Species

A feral species is an animal that was once domesticated, but was released and lives in the wild. Feral species present a significant threat to Bermuda's native and endemic species. Dog control was initiated in 1971 and is no longer a major problem¹⁰⁷. Cats first introduced by the settlers in the 1600's to control rat populations have since become feral, preying on bird populations as well as threatening domesticated cats through transmission of infectious diseases such as feline leukaemia and various viruses¹⁰⁸. Populations of feral chickens have increased and can decimate large areas of habitat very quickly¹⁰⁹. More recently, pigeons have become a problem in Bermuda as they are taking over nesting areas from Longtails and can be found all over the City of Hamilton. The number of feral ducks is also on the rise, and even guinea pigs have been released at Spittal Pond¹¹⁰.

Of potential concern are species brought in for the local aquarium trade. These include the Red Eared Slider Turtles, which often become too large for their owners who then release them into the wild (often into the ponds on local golf courses). Research is needed to determine whether these

¹⁰⁴ Wingate, D.B. 1995. Breeding Birds of Bermuda. Bermuda Zoological Society, Project Nature Eco File. 10 pp.

¹⁰⁵ Jessey, C. Pers. Comm. Department of Agriculture and Fisheries.

¹⁰⁶ Wingate, D.B. 1994. Bermuda Rats. Bermuda Zoological Society, Project Nature Eco File. 2 pp.

¹⁰⁷ Benevides, J. 1993. Dog control in Bermuda. Monthly Bulletin Department of Agriculture and Fisheries. 64 (2), 9-14.

¹⁰⁸ Burnie, N. 1991. Feral cats. Monthly Bulletin Department of Agriculture and Fisheries. (4), 26-27.

¹⁰⁹ Burnie, N. 1990. The problem with chickens. Monthly Bulletin Department of Agriculture and Fisheries. 61 (6), 49-50.

¹¹⁰ Daniels, S. 1990. Guinea pigs on the run! Monthly Bulletin Department of Agriculture and Fisheries. 61 (6), 45-48.

imported species pose a threat to native and endemic species such as the Bermuda Killifish.

The issue of feral animals, particularly cats, is highly volatile within the local community.

Marine Invasives¹¹¹

The marine environment has had far fewer introductions generally, and is therefore less plagued by invasive species. Invasive marine species could potentially come in with ballast water used to stabilise ships when they have no cargo. However, in Bermuda, merchant ships typically arrive fully laden and leave empty, thereby minimising the threat.

The predatory snail, *Trunculariopsis trunculus*, introduced in the 1960's from the Mediterranean became locally established and may have contributed to the decline of the Calico Clam in Harrington Sound.

In 1924, there was an unsuccessful attempt to establish populations of commercially viable marine fish species¹¹². However, one introduced freshwater species, the Mosquito Fish was successfully established in the inland marshes and ponds to control the mosquito population. The failure of most local marine introductions suggests that the marine

environment is more resilient to exotic and invasive species than the terrestrial environment.

Knock-On Effects (Chains Of Extinction)¹¹³

In 1983 and 1984, a water-borne pathogen decimated the Caribbean and Bermudian populations of the Long-spined Sea Urchin, as it was transported throughout the region by ocean currents. On a healthy reef, sea urchins function as important grazers of algae, but their sudden disappearance reduced the number of available grazers throughout the region. In Jamaica, where overfishing had already dramatically reduced the numbers of grazing parrotfish, the loss of 98% of the urchin population resulted in a decline in coral cover from 52% to just 3% and an increase in algal cover from 4% to 92%! Bermuda was more fortunate in that there were sufficient grazing fish to prevent algal over-growth on the reef, but Jamaica's tragedy provided a sharp reminder of the precarious balance of nature.

Over-Harvesting

Since colonisation in the 1600's, the Island's fauna and flora, both terrestrial and marine, has been subject to intense harvesting, although this is less of a problem nowadays.

For example, the endemic Cahow was so dramatically reduced in number that it was thought

¹¹¹ Ministry of the Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda: A Discussion Paper. 495 pp.

¹¹² Smith-Vaniz W. F., B. B. Collette, B. E. Luckhurst. 2000. Fishes of Bermuda: History, Zoogeography, Annotated Checklist, and Identification Keys. American Society of Ichthyologists and Herpetologists, Kansas. 424 pp.

¹¹³ Lessios, H.A., D.R. Robertson, T.D. Cubit. 1984. Spread of *Diadema* mass mortality through the Caribbean. Science. 226, 335-337.

to be extinct for nearly 300 years until it was rediscovered in 1951¹¹⁴! Numerous other species have been extirpated through overharvesting. By the 19th century, the West Indian Top Shell could no longer be found and initial attempts to re-introduce the mollusc in 1901 failed. A recent reintroduction appears to have been much more successful¹¹⁵; however, reports of illegal harvesting reveal that many residents are unaware that this shellfish is protected.

The Bermuda Cedar was extensively utilised by colonists for housing furniture, shipbuilding, and export. Laws were made to protect cedars as early as 1622¹¹⁶. Nowadays, demand for cedar products results in occasional illegal harvesting of cedars from nature reserves and national parks. Another endemic tree, the Bermuda Palmetto, was also extensively utilised by colonists for roof thatch, basketry, food and drink.

Turtles, which once nested abundantly in Bermuda, were over-harvested by the early colonists with records showing catches in excess of forty turtles per day. The first conservation act was passed in 1620 against the killing of young turtles but the population continued to suffer until 1973 when the

turtle fishery finally closed. There is no breeding population left.

Groupers (mainly the Nassau Grouper) were the major targets of fish pots. Large numbers of groupers could be easily captured at their spawning sites, which were usually fished from May until mid-July. Through the 1960's groupers remained the dominant fish in fish pots, but by the late 1980's, the fishery had collapsed. A number of grouper species are now believed to be locally extinct.

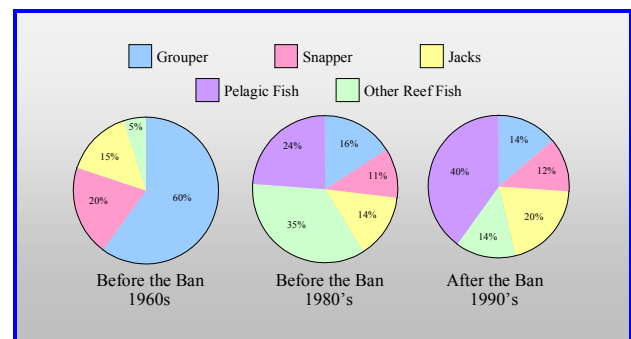


Figure 29. Percentage of fish caught locally before and after the fish pot ban¹¹⁷.

Climate Change

There is convincing evidence that suggests that the global climate is changing at an alarming rate. The addition of gases such as carbon dioxide to the atmosphere trap heat and cause the earth to warm¹¹⁸. This can have long term effects, such as melting of glacier ice caps and rising sea levels. There has been an estimated sea level rise of about 10-12 mm

¹¹⁴ Wingate, D.B. 1995. Breeding birds of Bermuda. Bermuda Zoological Society. Project Nature Eco File. 10 pp.

¹¹⁵ Cattell, N. 2000. Population survey of the geographical and age distribution of the West Indian Topshell, *Cittarium pica*, in Bermuda. Unpublished report. Bermuda Biodiversity Project, Bermuda Zoological Society.

¹¹⁶ Durham G. 1996. Trees of Bermuda. Bermuda Zoological Society. Project Nature Eco File. 13 pp.

¹¹⁷ Data derived from information at the North Rock Exhibit, Bermuda Aquarium, Museum, and Zoo.

¹¹⁸ Anon. 1989. The earth as a greenhouse. *Oceanus*. 32 (2), 35.

over the past 100 years¹¹⁹. The consequences for the low-lying islands of Bermuda are obvious. Whilst the sea surface temperature has not shown any obvious increase locally, the relative sea level has risen.

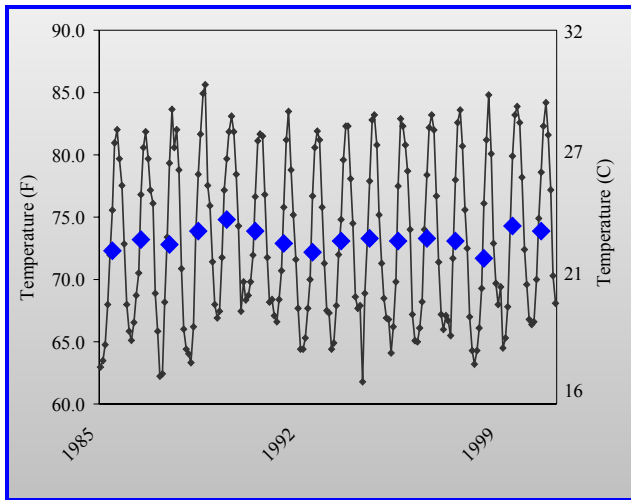


Figure 30. Monthly mean change and yearly mean change (blue diamonds) in sea surface temperature over the last 15 years¹²⁰.

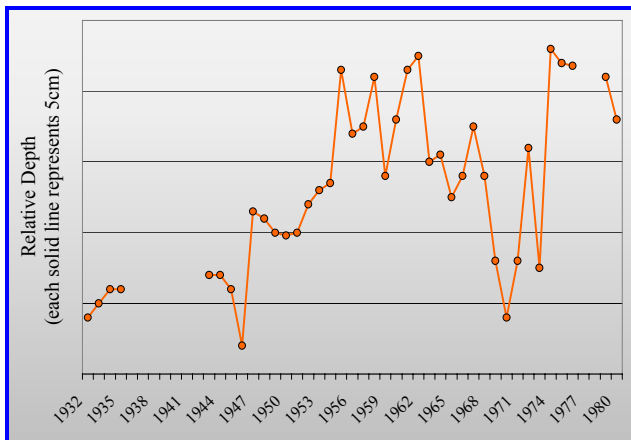


Figure 31. Relative changes in sea level from 1932 to 1980¹²¹.

In addition to rising sea levels, global climate change could also affect rainfall patterns, causing periods of severe drought, as well as increased storm activity, which would also present an enormous threat to the Island’s biodiversity.

The increased reports of coral disease and bleaching in many parts of the world have also been linked to climate change. Coral diseases, such as the black band disease (BBD), white band disease (WBD)¹²², and yellow band disease¹²³ can be observed in corals on Bermuda’s reefs. BBD is caused by the blue-green alga *Oscillatoria submembranacea* in association with bacteria and primarily infects brain coral, whilst WBD seems to be the physiological response of the coral tissue to certain trauma. Yellow band disease is prevalent in Bermuda on Small Star Coral. Sea fans and other soft corals can be affected by the fungus *Aspergillois sp.*¹²³.

To date, Bermuda has largely escaped the massive coral bleaching events observed in many parts of the world, including the Caribbean. Short-term, localised bleaching has been reported, but the corals appear to have recovered.

Natural Pathogens

In the 1940s, two scale insects, the Juniper Scale and the Oyster-shell Scale, were accidentally introduced

¹¹⁹ Ellison, J.C. 1993. Mangrove retreat with rising sea-level, Bermuda. *Estuarine, Coastal, and Shelf Science*. 37, 75-87.

¹²⁰ From data collected by the Bermuda Weather Service.

¹²¹ Wanless, H.R. 1982. Sea level is rising – So what? *Journal of Sedimentary Petrology*. 52 (4), 1051-1054.

¹²² Rützler, K, D.L. Santavy. 1983. The black band disease of Atlantic reef corals. *Marine Ecology*. 4 (4), 301-319.

¹²³ Weil, E. and S.R. Smith. Pers. Comm. Bermuda Biological Station for Research Inc.

on shipments of ornamental junipers from the US. In the absence of biological controls, the scale insects quickly destroyed 95% of the remaining Bermuda Cedar population, leaving only the hardiest to survive. More than 25 species of ladybird beetles were introduced to try to stop the decimation. Naturally resistant individuals were subsequently nurtured and their progeny are being successfully replanted around Bermuda today. Natural pathogens remain a persistent threat to Bermuda’s biodiversity.

Lack of Awareness

Potentially the biggest threat to Bermuda’s biodiversity is a lack of environmental awareness. In the 2000 Bermuda Omnibus Survey, only 2 out of 400 people surveyed considered the environment to be the single most important issue facing Bermuda today!

On a more encouraging note, in a recent survey conducted of over 2,000 local students aged 5 to 14+, 33% said that the environment was what they would most like to change in the world¹²⁴. However, whilst 80% of the students felt that people were to blame for the problems, only 56% indicated that people could help solve the problems. Only 7% suggested that they themselves could do something! Most of the children (63%) said they learnt about the environment at school, 20% through the media, and 13% at home.

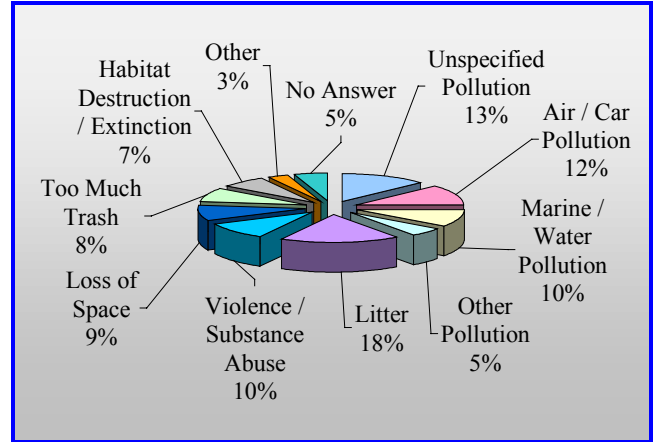
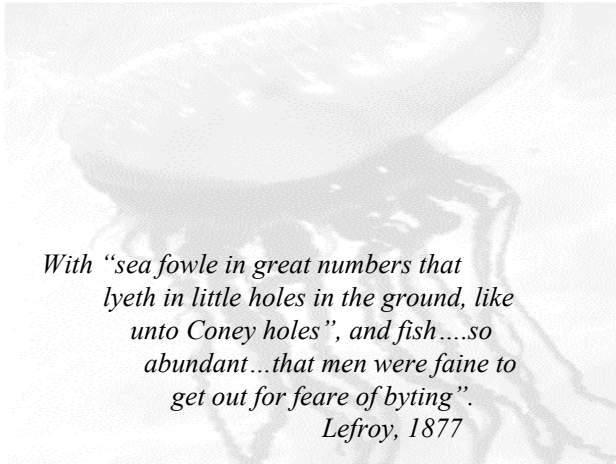


Figure 32. Results of a survey highlighting the top environmental concerns of local school children¹²⁴.

There is a need for studies to investigate the effect of ethnicity, wealth and level of education on environmental attitudes. This would enable the design of effective programmes that promote community-wide appreciation of environmental issues.

¹²⁴ Youth Environmental Conference. 2000, Unpublished Report. Bermuda Zoological Society.

STATUS OF BIOLOGICAL RESOURCES



Users Of Biological Resources And Extent of Use

Agriculture¹²⁵

Agriculture was once the main industry in Bermuda, but has long been displaced by tourism and international business. In 1989, agriculture (including both commercial and hobby production of food and ornamental plant material) still satisfied 29% of Bermuda’s demand for fresh and frozen agricultural products, and employed just over 100 people. Products include the production of eggs, honey, a variety of vegetables, fruit, and flowers, meat, forage crops as well as 100% of the fresh milk Bermudians consume. Moreover, agricultural land and the associated open spaces provide a buffer to the rapidly developing urban Bermuda.

¹²⁵ Ministry of the Environment, Department of Agriculture, Fisheries, and Parks, Government of Bermuda. 1995. Agriculture in Bermuda. 17 pp.

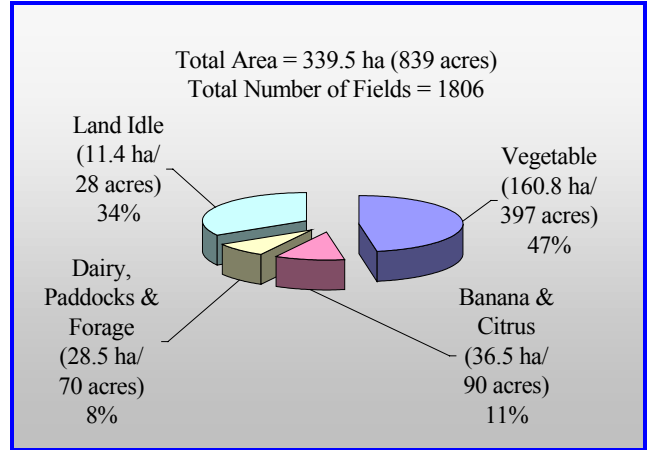


Figure 33. Agricultural land use in 1989¹²¹.

The most recent island-wide survey of Bermuda’s remaining arable land in 1989 documented 340 ha (838.93 acres) of land (1,806 parcels) set aside for agricultural purposes, with 90% of the fields less than 0.4 ha (1 acre) in size. Only 67% of the total agricultural land was being actively farmed in 1989. The extremely high real estate value of property in Bermuda creates a huge incentive for owners to develop their land, tempting many to stop production in the hope that this will lead to their property being re-zoned for development. Between 1981 and 1989 approximately 36 ha (90 acres) of agricultural land was lost to development, whilst the 1992 Development Plan reduced the zoned agricultural land from 327 ha (809 acres) to 281 ha (695 acres).

Fisheries¹²⁶

By the beginning of the 20th Century, Bermuda’s growing population exerted a huge demand for local

¹²⁶ Ministry of the Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda: A Discussion Paper. 495 pp.

fish. In the 1950's, having received an optimistic report on local fish resources, the Bermuda Government began to actively promote the fishery, and incentives were offered to encourage investment in fishing¹²⁷. Unfortunately the projected annual catch far exceeded that which was realised, and by the 1980's landings of choice grouper species crashed. The fishermen began targeting the reef grazers such as parrotfish, and despite a series of increasingly restrictive management practices the decline continued. In 1990, the trap fishery was closed.

In 1999, there were 300 registered fishermen in Bermuda, 213 licensed fishing vessels, 23 charter fishing vessels, and 485 recreational lobster divers. The mainstays of the fishery today are the offshore pelagic species; Yellowfin and Blackfin tunas and Wahoo.

Prior to the fish pot ban Caribbean Spiny Lobster landings were consistent. However, with the fish pot ban, the commercial harvesting of lobsters was also curtailed. To address this, a lobster-specific trap was developed for use by commercial fishermen. The commercial harvest of Guinea Chick Lobsters was re-introduced in 1998.

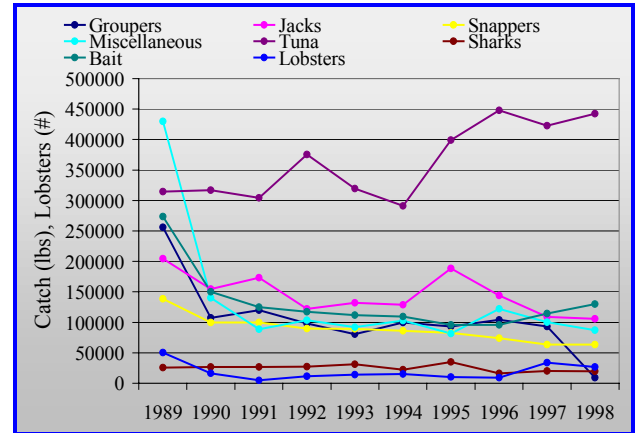


Figure 34. Annual fish and lobster landings between 1989 and 1998¹²⁸.

An experimental pelagic fishery to target shark and tuna species began in June 1981 and has continued on and off. There are 3 vessels currently licensed and suitably geared for this activity. However, there is some concern that this fishery may deplete local shark stocks, which are considered ecologically important.

There was a commercial Turkey Wing Mussel fishery in Harrington Sound up until 1994 when the policy of not allowing new participants to enter led to closure of the fishery by attrition. This closure is supported by the results of an ecological survey of the benthos of Harrington Sound, which uncovered a massive loss of branching corals, presumably the result of long-term dredging for mussels¹²⁹. Small quantities of mussels continue to be harvested by swimmers and skin divers.

¹²⁷ Ward, J. A. 1996. Coral Reef Conservation at Bermuda: A Case Study. Regional Proceedings of the American Zoo and Aquarium Association Conference, Hawaii, September 1996. 370-375.

¹²⁸ Ministry of the Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda: A Discussion Paper. 495 pp.

¹²⁹ Thomas, M. L. H. 1996. The Marine Ecology of Harrington Sound, Bermuda. Unpublished report. 46 pp.

A deep-water fishery for snappers and Wreckfish was conducted during the 1980's using vertical longlines. Although initial landings were high the fishery soon crashed and interest declined. It is now clear that the relatively narrow band of productive habitat that rings the Island cannot sustain heavy fishing pressure.

Seine nets have traditionally been used inshore for taking bait, jacks and Little Tunny. Offshore netting is not presently in use, although some research has demonstrated that it can be an effective method for taking flying fish.

Sportfishing¹³⁰

Sportfishing is popular with both Bermudians and tourists alike. This activity rarely targets the vulnerable reef species but is mainly directed to offshore pelagic fish. There are 24 charter fishing vessels licensed, which provide crew, gear, and bait for an average fee of \$650-\$1100 per person per day. A study conducted in 1999 estimated that recreational pelagic fisheries accounted for 17% of the overall extraction of pelagic stocks, although this varied significantly by species, with up to 42% for yellow fin tuna¹³¹.

Lobster diving is a popular recreational activity, with licences issued from September to April. Restrictions limit both catch and gear, and prevent

the sale or barter of the catch. For the past few years the number of licences issued has levelled at just under 500, although there is currently no limit.

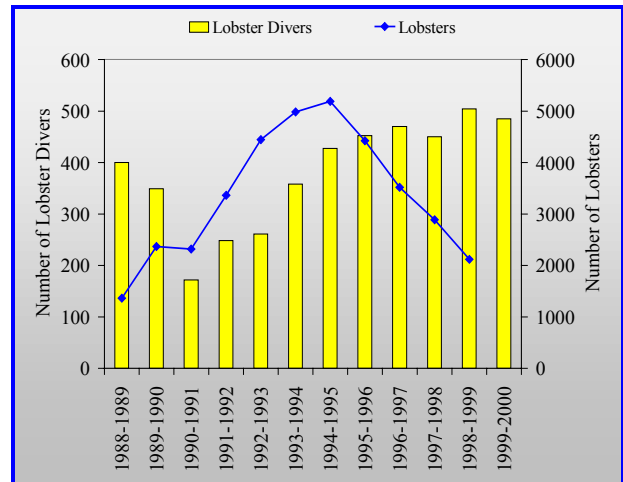


Figure 35. The number of licensed lobster divers and the number of lobsters caught between 1988-2000¹²⁶.

There is little data regarding the effects of recreational fishing on Bermuda's marine environment, although some concern has been expressed for party boat fishing, where fishing pressure is intensified due to the number of people participating from one boat.

Small-scale harvesting of ornamental fish and invertebrates for display in personal aquaria does occur and is not regulated. Fisheries regulations allow for the collection of fish for private aquarium displays; use of SCUBA gear for collecting is not permitted and a special permit is required for hand nets or barrier nets.

¹³⁰ Ministry of the Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda: A Discussion Paper. 495 pp.

¹³¹ Hellin, D.C. 1999. An assessment of recreational fishing in Bermuda. Unpublished M.Sc. Thesis. University of Newcastle.

Ecotourism¹³²

Ecotourism is a relatively new industry for Bermuda and one that is hindered by the limited availability of undisturbed natural areas. With the specific objective of studying, admiring, and enjoying the scenery and wild plants and animals, ecotourism is largely restricted to the parks system on land but has room to expand in the marine environment.

In Bermuda, there are several marine operations including dive and snorkel boats, glass-bottom boat tours and cruises, and a few terrestrial ecotourism guides. However, the philosophy of ecotourism is poorly integrated into local operations. Few of the tour operators truly focus on the impact and responsibilities of both the tourist and the tourism industry on the environment. They do not subscribe to any consistent code of practice and, at present, there are no regulations governing ecotour operators in Bermuda.

The development of the Daniel's Head Village with an ecotourism theme represents the first major formal effort to establish ecotourism locally. However, it is widely feared that the intensive development of this site and the lack of significant undisturbed natural habitats nearby will greatly limit the success of this venture.

¹³² Ministry of the Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda: A Discussion Paper. 495 pp.

Recreation¹³²

In addition to sportfishing, Bermuda's waters are used for a variety of recreational purposes, including swimming, boating (for pleasure as well as competition), sailing, SCUBA and skin diving, water-skiing, para-sailing and jet skiing. There are over 9,500 locally registered pleasure craft.



Plate 23. Snorkelers enjoying a trip to a shallow reef. (Photo from BAMZ slide collection).

Use Of Bio-Technology And Genetic Extraction

In October 1999, the Bermuda Biological Station for Research Inc. (BBSR), a U.S. not-for-profit, Bermuda-based institution began a three-year collaborative bioprospecting effort with Diversa Corp. Genetic extraction techniques are being used to isolate microbial nucleic acids from symbiotic bacteria living within a variety of marine invertebrates (such as sponges and tunicates) collected from local waters. The research is directed towards the development of improved drugs for

cancer, arthritis and osteoporosis, as well as for the development of anti-fouling for boats.

Access To Genetic Resources

At present, there is unrestricted access to genetic resources in Bermuda, although access to species that are locally or internationally protected does require a collecting permit. To date, access has been limited to scientific research by local and overseas researchers, and to the bio-prospecting effort between the Bermuda Biological Station for Research Inc, (BBSR) and Diversa Corp. There is currently no legislation governing such activity, but the Ministry of the Environment, Development and Opportunity has expressed some concern over this effort, as one of the objectives of the Convention on Biological Diversity is the “equitable sharing of benefits arising out of the utilisation of genetic resources,”...“taking into account all rights over those resources”¹³³.

Assessments Of Sustainability

By any reasonable measure of production, Bermuda’s standard of living is not sustainable. Bermuda’s population has grown so large and affluent that we are totally dependent upon outside imports for all manufactured goods and even such basic commodities as food. There is no integrated economic plan for the Island that defines target

population levels, identifies sectors for expansion that build on the skills of the resident population, or that charts a course for necessary skill development in order to minimise the need to import specialised labour. In short, private enterprise continues to define the levels of immigration into Bermuda despite the fact that the population currently exceeds the carrying capacity of the environment.

A simple and extremely conservative assessment serves to highlight the degree to which the local population exceeds the carrying capacity of the Island. It has been estimated that approximately 0.4 ha (1 acre) of productive land is required to provide a high meat diet for one human. In Bermuda we have a population density of 11.45 people/ha (4.6 people/acre). Thus assuming that all of Bermuda’s land is highly productive farm land (which it is not), and that all Bermudians eat a high meat diet (which in general is probably not far from true) we have exceeded our carrying capacity for food production alone, by a factor of more than 4.5. In other words, we would have to reduce our population from approximately 62,000 to less than 14,000 in order to feed ourselves without imports.

Without defined population targets it appears inevitable that overseas labour will continue to be recruited to work on the Island and, in order to make immigration sufficiently appealing to attract qualified personnel, many of these people will require high quality housing. The clear results of this trend are the ongoing political pressure to develop affordable housing for Bermudians, the continued

¹³³ Earth Summit. 1992. The Convention on Biological Diversity. Rio de Janeiro, Brazil.

destruction of Bermuda’s limited open spaces, and the displacement of native species.

On a species level, with the exception of limited modelling of fisheries yields, there have been few attempts to assess population sustainability. Those species for which accurate population information exists are generally limited to critically endangered organisms with such small populations that it is clear that their survival is in peril. Ironically the clear exceptions to this rule are those invasive species that are in no danger and which will sustain or increase their present population unless dramatic action is taken to control their numbers.

Economic Value of Biological Resources

Economic valuation is measured from the perspective of humans and inherently misses much of the value that closely evolved interactions between species bring to natural systems. This value includes the products and services provided by natural systems along with any income derived from activities that rely on natural environmental amenities, such as tourism. Although it is relatively easy to provide a value for fisheries landings, to adequately measure the economic value of all of Bermuda’s biological resources will demand a great deal of information and sophisticated techniques. Although such a valuation is beyond the scope of this report, the following information is presented to provoke consideration of the issues and provide a framework for discussion.

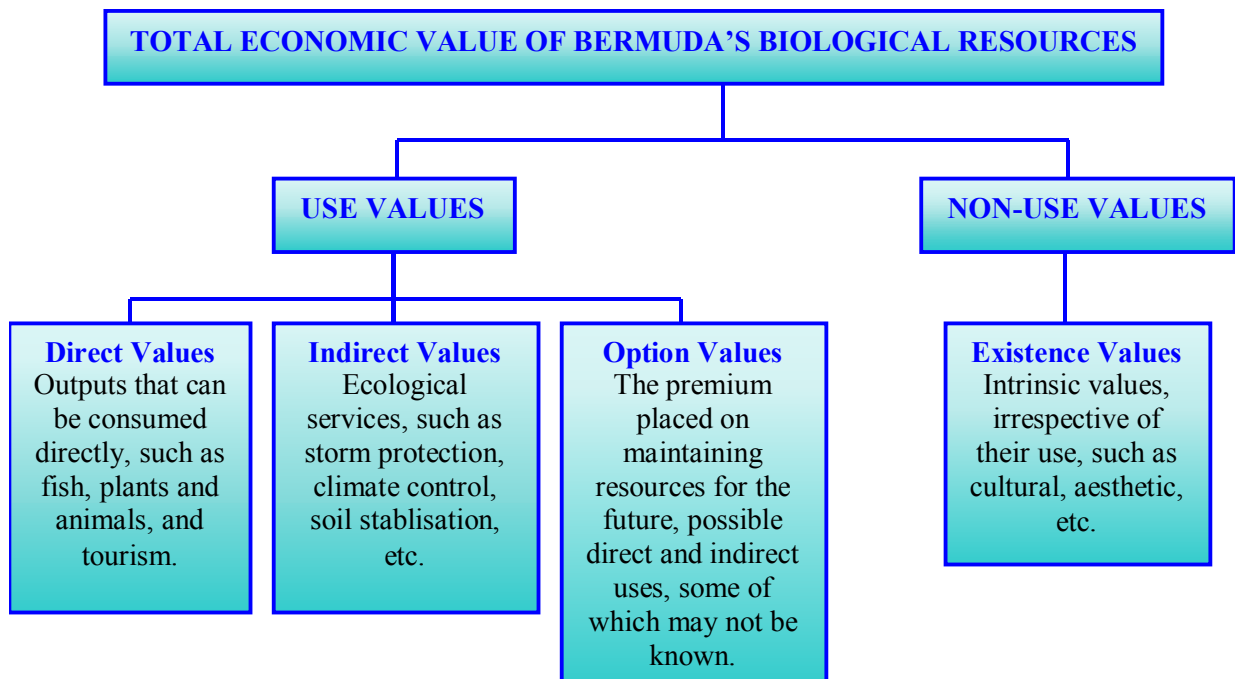


Figure 36. Adapted from Seychelles Biodiversity Strategy and Action Plan, 1997.

Biological Resource	Direct Use		Indirect Use	Option Value	Existence Value
	Extractive	Non-Extractive			
Coral Reef System	- Fishing - Bioprospecting	- Recreation - Scientific - Tourism - Education	- Shoreline protection - Sand production - Habitat	- Bioprospecting - Potential future supply of goods and services	- Intrinsic (northernmost) - Aesthetic - Cultural
Mangrove System	- Bioprospecting	- Education - Scientific	- Fish and invert production - Erosion protection - Bird sanctuary - Runoff mitigation - Habitat	- Bioprospecting	- Intrinsic (northernmost) - Aesthetic
Cedar Tree	- Timber	- Education - Scientific	- Bird habitat - Nitrogen-fixing - Soil conservation	- Seed production - Future furniture products	- Cultural - Aesthetic
Upland Hillside		- Scientific - Recreation (birdwatching)	- Climate control - Soil production - Habitat	- Bioprospecting - Timber - Medicinal uses - Ecotourism	- Cultural - Spiritual regeneration

Table 8. Examples of the economic value of Bermuda’s biological resources and biodiversity.

Fisheries¹³⁴

In 1988, the capture fishery (including lobster and offshore pelagic fish) generated a gross earning of around \$6 million. Despite the closure of the trap fishery in 1990, this value rose to more than \$6.5 million in 1998. A survey of restaurants, hotels, and grocery stores found that local fish accounted for 20-25% of fish utilised. However, despite the dominance of imported fish and perhaps because of price and seasonal availability, these outlets handled only approximately 30% of the catch.

Marine Tourism¹³⁴

A survey of the marine tourist-related industry conducted in 1989 revealed that this sector of the economy grossed in excess of \$9 million per

annum. Despite significant investment in this industry since then, the decline in tourism has had a negative affect on income levels. It is worthy of note that, unlike the capture fishery, properly executed marine tourism does not damage the resource.

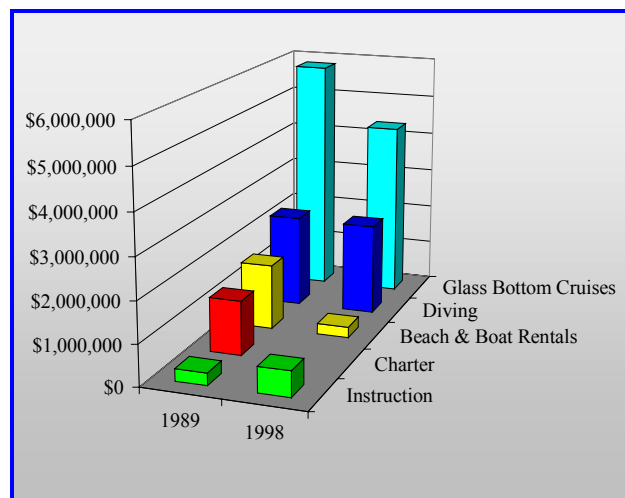
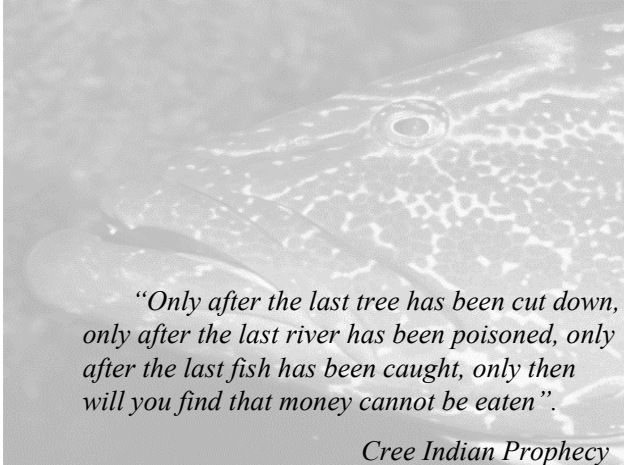


Figure 37. The total gross income of commercial marine operations in 1989 and 1998 (minus charter data in 1998)¹³⁴.

¹³⁴ Ministry of the Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda: A Discussion Paper. 495 pp.

VALUES OF BIODIVERSITY



Economic Values

From the perspective of economic valuation there is an important distinction to be made between the value of biological resources and the diversity of those resources. For instance in the case of fisheries harvest, there may be no difference in the unit price of two species of fish. However, if one species is rare, and potentially useful for mariculture, or important ecologically or even aesthetically, the genetic value of that species may far outweigh its utility as a harvestable resource.

In Bermuda there has been virtually no research aimed at valuing biodiversity. However, it is clear that there is potentially great economic value to be realised through the use of our unique life forms. In addition to the financial benefit of such things as the successful extraction of pharmaceutically active compounds from marine organism, there is also

remarkable intrinsic values of such endemic species as the Cahow which could be marketed to promote tourism. Indeed given the fact that the Cahow was believed extinct for 300 years, and with 20% of all North Americans reportedly involved in bird watching, this one species alone might hold great value for ecotourism.

Non-economic Valuations of the Resources

Biological Services^{135, 136}

Nature provides many services that are essential to human life and, in many cases, are impossible to reproduce artificially. They occur as simple side effects or by-products of the normal activities of the organisms involved. There is absolutely no cost incurred by our use of these services; they are free and available to everyone. To illustrate this point, several of the more significant groups of organisms found in Bermuda and some of the services that they provide are described here.

Plants

Plants provide the most essential of services to all animal life, by using the energy of the sun to bind carbon dioxide with water to create carbohydrates and to liberate oxygen through the process of photosynthesis. In this way plants provide two essential resources for animal life, food and oxygen.

¹³⁵ Baskin, Y. 1997. *The Work of Nature: How the Diversity of Life Sustains Us*. Island Press, Washington D.C. 263 pp.

¹³⁶ Daily, G.C. (Ed.) 1997. *Nature's Services*. Island Press, Washington D.C. 392 pp.

Without this service virtually all animal life would cease (the only likely exceptions are the deep-ocean thermal vent communities). Plants also bind air and water-borne pollutants and affect the atmosphere, as they directly and indirectly alter the concentrations of some greenhouse gases (carbon dioxide, methane, nitrous oxide), which have been shown to cause climate change.

Plants provide humus to build, aerate and bind soil to increase production and reduce erosion and nutrient run-off. Trees create windbreaks, protecting animals and more delicate plants from severe storms. Plants create structure, providing homes of different sizes for a host of animals. Whole forests are needed for large animals whilst individual trees serve as habitats for smaller creatures. Plants influence the exchange of heat and moisture between the earth's surface and the atmosphere thereby affecting global climate or on a local scale, providing shade – an essential service for many creatures including humans, in the heat of summer!

Mangroves

At the junction between land and sea, mangroves and mangrove swamps provide some specific and critically important plant services. They absorb nutrients and trap sediments from land run-off thereby protecting adjacent seagrass and coral reef communities. Mangrove forests stabilise shorelines protecting them against severe storm damage, and creating complex 3-dimensional habitats that provide shelter to nurture aquatic organisms. The leaf litter of mangroves supports a complex web of

life that is critical to a host of marine and terrestrial organisms. Indeed the juveniles of many commercially important marine fish and crustaceans depend upon the food and shelter provided by coastal mangroves. In Bermuda, with the incredible monetary value placed on coastal property, mangroves are under threat of clearing to make way for marine access. Unfortunately, there is limited understanding of the unique biological value of Bermuda's remaining mangrove stands.

Decomposers and Soil

Soil biology is a vast and growing mystery. There is a huge diversity of microbes living in the soil, providing services that we know nothing about. Their work has been summarised as “the basis of planetary metabolism...the soil micro-organisms that turn back into nutrient flows everything that falls on or grows within the ground”¹³⁷. Unfortunately we rarely treat soil as a thriving and critical ecosystem but rather view the soil as simply a growth medium containing the nutrients needed for plant growth. This ignorance leads to harmful practices, with excessive pesticides, herbicides and fertilisers used with little regard for the profound and long-lasting effect such activities can have on the health of the soil community. Indeed, anecdotal reports indicate that one established farmer actually uses diesel oil as a herbicide when growing carrots.

¹³⁷ Hawkin, P., A. Lovins, L.H. Lovins. 1999. *Natural Capitalism*. Little Brown & Co., Boston. 396 pp.

Insects

Insects provide a host of important ecological services from pollination of both cultivated food crops and wild plants (bees, flies, butterflies, and moths) to degrading dead animals (flies), controlling agricultural pests (mites and ladybugs) and providing high quality Bermuda honey (bees, of course). Despite the obvious value of these services to humans, insects have received a bad reputation. Popular opinion holds an abiotic environment as the ultimate in good housekeeping and, in this regard, insects in a house represent failure. Commonly Bermudian housekeepers use excessive quantities of pesticides killing both the beneficial and “harmful” insects and disrupting the natural controls that formerly existed.



Plate 24. Ladybug, a natural pest control. (Photo courtesy of R. Ground).

Corals

Viewed in light of the extremely low nutrient environment in which they thrive, coral reef systems are amazingly productive. Capturing planktonic organisms from the water column, the coral colony

efficiently recycles the nutritive value of its prey with the help of symbiotic algae living within its tissues. Laying down a calcium skeleton, the corals build a living barrier to waves and create numerous crevices that form habitats of various sizes for a great variety of fish and marine invertebrates. With the coral colonies as the basic building block, a complex community of highly specialised creatures live together forming an extremely efficient team for recycling the scarce nutrients that occur over the reef. This vibrant community has great aesthetic and intrinsic value and produces food while protecting the land from erosion. Bermuda’s reefs are a recognised treasure that is, to date, in remarkably good health.

Aesthetic Qualities

Bermuda is beautiful. It is largely the multicoloured landscape of trees and flowers, the vast deep blue ocean, pink beaches, and vibrant coral reefs that, along with a benign climate, form the compelling draw that encourages tourists to visit Bermuda. Whilst lying on a beach in the shade of a swaying palm tree the visitor generally fails to realise that the warm sand is formed of the skeletons of numerous minute marine organisms whilst the beautiful coconut palm didn’t even originate in the Atlantic. The sounds of nature are also of great intrinsic value. The songs of birds, crickets, bees, and whistling frogs form a fantastic backdrop for the soothing sound of breezes in the trees. Biological resources both local and introduced are critical to the aesthetic charm of Bermuda and, to a great degree, it is that

charm that created and sustains the Island's remarkable quality of life.

An increasingly popular local recreational activity, is birdwatching, for example. Although Bermuda has only 20 resident bird species, over 350 migrant species have been recorded on the Island. Beginning in late August the fall migrants arrive, while late February brings the arrival of the spring migrants¹³⁸. An increasingly popular event is the Bermuda Audubon Society annual Christmas Bird Count.



Plate 25. Whistling Frog. (Photo courtesy of R. Ground).

Although Bermuda's aesthetic qualities are critical to our economy, the nature that surrounds us is also essential for maintaining our physical and mental health, and spiritual regeneration. In fact, clinical studies have demonstrated that people surrounded by nature exhibit lower levels of stress, less violence, and heal faster from illness. Nature is also a great motivator for physical exercise and has for generations inspired our creativity through art, literature, music, and cuisine. To a very large degree

the quality of our lives is so deeply entwined with biodiversity that most of us never notice. Humans are a product of nature and, although we have the capacity to alter our surroundings, we remain dependent upon nature to sustain us. Nature has intrinsic importance, that is, an importance in and of itself, and we have a custodial responsibility to conserve it.

Scientific Value

Bermuda is one of the best-studied islands in the world. Since the shipwreck of the *Sea Venture* in 1609, people have been documenting the Island's natural history. In 1903 the Bermuda Aquarium Museum and Zoo (BAMZ) and the Bermuda Biological Station for Research Inc. (BBSR) were founded to provide accommodation, laboratory space, boats and logistic support for scientists, as well as to exhibit the Islands' marine life. Their establishment dramatically promoted the conduct of science in Bermuda, which was readily recognised to be an outstanding site from which to stage deep ocean research. Largely because of BBSR, Bermuda's marine environment has been the primary focus of study, with far less emphasis placed on terrestrial research. However, several local institutions now support marine and/or terrestrial research conducted by local and visiting scientists.

¹³⁸ Dobson, A. 1997. Birdwatching in Bermuda. Bermuda Zoological Society, Project Nature Ecofile. 9 pp.

Cultural and Traditional Values of Biodiversity

Throughout Bermuda's history, the Island's natural resources have been utilised and valued by locals. From the beginning, with the shipwreck of the *Sea Venture*, fish, birds, sea turtles, palmetto and cedar berries have been valued as sources of food. Many familiar plants in our landscape were once recognised for their medicinal value and were used against everything from coughs and colds (Calamint) to kidney ailments (Cape Weed)¹³⁹. Plants also served more functional uses; the Century Plant was cut in half and used as a scrubbing brush that self-lathered, and the branches of the Allspice were tied together to make fish pots. The Bermuda Cedar has long been used in all facets of Bermudian life, including ship and house building, and in the making of furniture and souvenirs. It was recognised as a symbol of life and often planted by the bride after a wedding. Another important endemic, the Bermuda Palmetto, was used to thatch roofs, whilst the leaves were made into ladies hats and fans, and the heart of the palm was eaten.

Although the flora and fauna of Bermuda had important uses in the past, most are no longer employed today and, in many cases, their utility has been forgotten. Virtually all of the commodities traded in Bermuda are produced overseas and few Bermudians work in businesses that are directly related to the Island's biological resources. Even fishing and farming are in decline and our

¹³⁹ Waterston, J.M. 1939. Bermuda herbs and their uses. Monthly Bulletin Department of Agriculture and Fisheries. 18 (6), 42-45.

historically strong cultural ties to natural products are being progressively weakened with urbanisation. Although the demand and appreciation for cedar products remains strong, the supply is extremely limited.

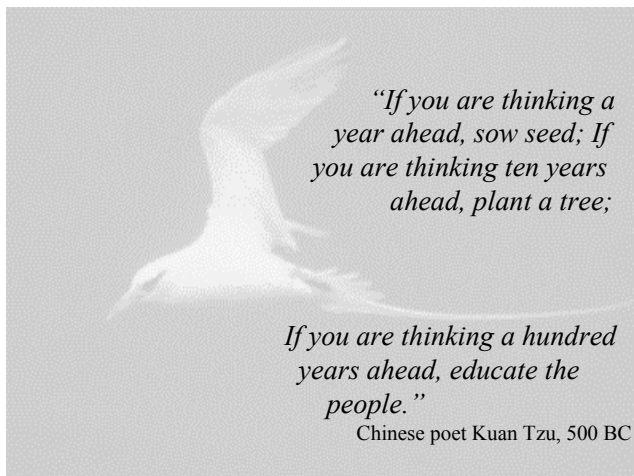


Plate 26. A Bermuda Palmetto leaf hat (Photo from BAMZ slide collection).

Our dependence upon biodiversity and biological resources for our long-term well-being is not yet fully appreciated in decision-making. Biodiversity conservation is still largely viewed as a cost to society rather than as an investment. There is a need to develop appropriate methods to evaluate the benefits of biodiversity and effect their incorporation into the Island's accounting system.

Some form of biodiversity is used by everyone everyday. Food, whether plant or animal, paper, medicines, pharmaceuticals, perfume, gum, plastic, oils, dyes, and detergents can all be derived from living organisms.

EXISTING AGENCIES FOR BIODIVERSITY CONSERVATION AND THEIR ROLES



Despite its geographical isolation, the small size of the Island, and a population of just 60,000, Bermuda’s current capacity to satisfy the components needed for promoting effective biodiversity conservation is significant. Particularly encouraging is the increasing spirit of collaboration between so many sectors of the community.

Government Agencies

As would be expected of a sophisticated community, the Government infrastructure in Bermuda is highly developed. Various bodies have been established to manage the Island’s natural resources. Under the Ministry of the Environment, Development and Opportunity these include: The Department of Agriculture and Fisheries, which supports and regulates these primary industries, and also has a Plant Protection Unit and an Animal Husbandry unit to guard against invasions by disease-causing

organisms; the Department of Planning, which includes a building control section, a development control section and a forward planning section; and the Department of Parks, which has responsibility for terrestrial conservation, (marine conservation falling under the Department of Agriculture and Fisheries). Additionally, under other Ministries, the Department of Health addresses environmental health, whilst the Department of Works and Engineering assumes responsibility for waste management.

In a very promising move, a review of the then Ministry of the Environment was initiated in 1998, at the request of senior civil servants who felt that the department “lacked relevance and stature in comparison to other government departments; that certain constituencies within the community were not being well served; and that the development of adequate environmental protection legislation was lacking”¹⁴⁰. A stakeholder survey identified the following as areas where the Ministry should be more active:

- Educating and communicating with the public
- Conserving Bermuda’s natural resources
- Leading in the ‘greening’ of Bermuda
- Institutionalising environmental consciousness
- Establishing and supporting an integrated planning process
- Building on and strengthening existing NGO relationships
- Maintaining envirometrics and conducting relevant research

¹⁴⁰ Department of Management Services, Bermuda Government. 2000. Review of the Ministry of the Environment.

- Strengthening the enforcement of environmental regulations.

The result is a proposed re-structuring with two new departments; one, the Department of Environmental Protection brings together setting standards, monitoring and enforcement activities. The second, the Department of Conservation Services, “would assume responsibility for promoting the safeguarding of Bermuda’s environmental heritage and would be a proactive, public facing unit”.

Non-Governmental Organisations

The Non-Governmental Organisations (NGO’s) in Bermuda play a vital role in promoting local biodiversity conservation. Some are purely voluntary while others have full time paid staff co-ordinating activities and programmes. The largest, the Bermuda Zoological Society has a membership of just over 4,000, representing approximately 15.5% of the population. Many individuals in the community enjoy membership in several of the NGO’s, which helps foster open communication between them. However, there is still a need for greater co-operation in order to make more efficient use of limited resources.

<i>Organisation</i>	<i>Focus</i>
Bermuda Audubon Society	Established in 1954 to lobby against the policy of filling marshes with waste; incorporated in 1960 to hold land as nature reserves. Promotes education and in-situ conservation. http://www.audubon.bm
Bermuda Biological Station	Established in 1903, to carry out marine and atmospheric research and education in science. http://www.bbsr.edu
Bermuda Botanical Society	Began in mid-1980’s to encourage and support the botanical sciences and promote further development of the Botanical Gardens and Arboretum
Bermuda Eden Project	Formed in 1998, to raise awareness of environmental issues by holding an annual exposition.
Bermuda Feline Assistance Bureau	Established as a charity in 1992 to control and reduce, through humane means, the feral cat population of Bermuda.
Bermuda Garden Club	Established in 1921 to promote horticulture through courses and to improve the environment through gardening.
Bermuda Zoological Society	Established in 1978 to support BAMZ and develop community participation in, and support for programmes in education, conservation and research through membership and donation. http://www.bamz.org
Bermuda National Trust	Restructured from the Historical Monuments Trust; incorporated in 1969 as a membership organisation. Engages in environmental advocacy work to prevent loss of open space and buildings of historical character. http://www.bnt.bm
Bermuda Underwater Exploration Institute	Established in 1992, opened in 1997 to advance the understanding, appreciation and knowledge of the ocean and to encourage the protection of the marine environment. http://www.buei.bm
Friends of the Bermuda Aquarium	Incorporated in 1993 as a U.S. not-for-profit organisation to promote education, conservation and research through BAMZ. http://www.bamz.org/foba/friends.html
Friends of Fish	Formed in the late 1980’s and dedicated to ensuring Bermuda’s reef fish are protected and preserved for future generations. Instrumental in the 1990 fish pot ban.
Keep Bermuda Beautiful	Originally part of the Bermuda Garden Club, established as a separate organisation in 1964. Emphasises programmes to reduce litter and promote appropriate disposal and recycling of waste. http://www.kbb.bm
Save Open Spaces	Formed in the early 1980’s out of concern for the rapid pace of development, resulting in the loss of open space.

Table 9. Principal local environmental non-governmental organisations.

Educational/Research Institutions

The absence of a degree granting institution on the Island is, on the one hand beneficial in that it forces young Bermudians to continue their education overseas. On the down side, finances preclude many young people from furthering their education abroad, and Bermuda does not benefit from the research component associated with such institutions. Having said that, the Bermuda College offers first and second year college courses in preparation for higher degree courses overseas, including the sciences, and is supported by a keen faculty.

The principal scientific research body on the Island is the Bermuda Biological Station for Research. This U.S. not-for-profit facility has established itself as a global leader in the fields of physical and chemical oceanography, attracting multinational research projects. It currently has 11 resident faculty, comprising U.S., Canadian, British, and Bermudian scientists. There is currently limited research at the taxonomic level, but ongoing monitoring of Bermuda's coral reef ecosystem is an important component of the facility's activities. Educational opportunities are provided for overseas and Bermudian students.

The natural history museum at the Bermuda Aquarium, Museum and Zoo (BAMZ) is the principal organisation for promoting research of the Island's terrestrial and shallow water flora and fauna. With a long history of supporting overseas scientists conducting research aimed mainly at the

taxonomic level, the launch of the Bermuda Biodiversity Project in 1997 (a joint initiative of BAMZ, the Bermuda Zoological Society and the Friends of the Bermuda Aquarium) has provided the necessary framework for a more integrated approach to research into the Island's biodiversity.

Research at the Division of Fisheries is focussed on studies of fisheries-related issues. There is also a plant biology laboratory at the Department of Agriculture and Fisheries which focuses primarily on plant pest species.

Business Involvement

The local and international business community makes a significant contribution to biodiversity conservation, although this is largely limited to a small number of dedicated supporters. Most of this support is through corporate sponsorship of NGO initiatives. This may be either through membership, or directly for specific projects such as the Keep Bermuda Beautiful "Adopt-a-Park" and the Learning Through Landscapes programmes. A number of businesses also provide significant "in kind" support (such as the printing and/or distribution of information/flyers). Many also serve as volunteer representatives on various advisory committees.

International Co-operation/ Exchange Projects

<i>Organisation</i>	<i>Relevant Activities</i>
Bermuda Aquarium, Museum & Zoo/ Bermuda Zoological Society	<ul style="list-style-type: none"> • Associate member of U.K.O.T. Conservation Forum • Collaboration with Fauna and Flora International to develop BSAP • Collaboration with Marine Mammal Stranding, WIDECAST, Caribbean Conservation Corporation • Support visiting scientists • Funding from overseas agencies • Participation in REEF fish and AGRRA coral surveys
Bermuda Audubon Society	<ul style="list-style-type: none"> • Support for Cahow conservation (BirdLife)
Bermuda Biological Station for Research	<ul style="list-style-type: none"> • Member of the CARICOMP Caribbean-wide monitoring project on corals, seagrasses and mangroves • Cooperative studies with University of the Azores on systematics and molecular genetics • Current graduate research (Snell, SUNY, Buffalo) on genetic similarity of Bermuda's corals to Caribbean conspecifics
Bermuda Garden Club	<ul style="list-style-type: none"> • Affiliated with Royal Horticultural Society, National Association of Floral Artists • Hosts gardening enthusiasts from abroad
Bermuda National Trust	<ul style="list-style-type: none"> • Associate membership of U.K. O.T Conservation Forum
Department of Agriculture and Fisheries	<ul style="list-style-type: none"> • CITES • Member CCA, GCFI, ICAAT
Department of Health	<ul style="list-style-type: none"> • Affiliated with Center for Disease Control • Liase with Environmental Protection Agency
Department of Parks	<ul style="list-style-type: none"> • Collaboration with NSW Parks and Wildlife Service (Australia) in sharing information & techniques in Petrel management • Collaboration with U.S. Fish and Wildlife Service and National Audubon Society in sharing migratory bird and banding data
Department of Planning	<ul style="list-style-type: none"> • Member of the UK Institute of Environmental Assessment and Management
Keep Bermuda Beautiful	<ul style="list-style-type: none"> • Collaboration with the Centre for Marine Conservation (CMC) for International Coastal Cleanup • New information and resource sharing partnership with Keep America Beautiful • Partner with ITW Hi-Cone to collect and return over 10,000 six-pack holders to their factory

Table 10. Current co-operative programmes with international agencies.

Most of the NGO's and government departments have forged strong working relationships with international bodies.

Community Groups

A recent survey of local community groups and churches revealed that many promote biodiversity conservation by raising awareness¹⁴¹. A number also actively participate in clean-up and enhancement programmes, and some encourage the propagation of native and endemic plants. Some expressed their receptiveness to undertake more ambitious projects given some guidance.

Training for Biodiversity Conservation

Despite limited formal training programmes in Bermuda, many of the environmentally-related Government departments encourage young Bermudians enrolled in undergraduate degree programmes overseas, to undertake a period of internship. This applies to the Departments of Parks (including the Division of Conservation), the Department of Agriculture and Fisheries and the Department of Environmental Health. These programmes are designed to provide hands-on field experience but also allow the students an opportunity to gain exposure to potential employers. Most departments also support overseas training for resident staff. The Department of Parks is currently

¹⁴¹ Bermuda Biodiversity Project. 2000, Unpublished survey. Bermuda Zoological Society.

developing an in-house training programme in conjunction with the Bermuda College for accredited courses in all horticultural practices.

Many of the NGO's also provide training opportunities, either through scholarships for overseas training (Bermuda Botanical Society, Bermuda Garden Club, Bermuda Underwater Exploration Institute, Friends of the Bermuda Aquarium), or through their own internship programmes (Bermuda Aquarium Museum and Zoo/Bermuda Zoological Society, Bermuda Biological Station for Research). It is widely felt that locals would benefit from more overseas training opportunities.

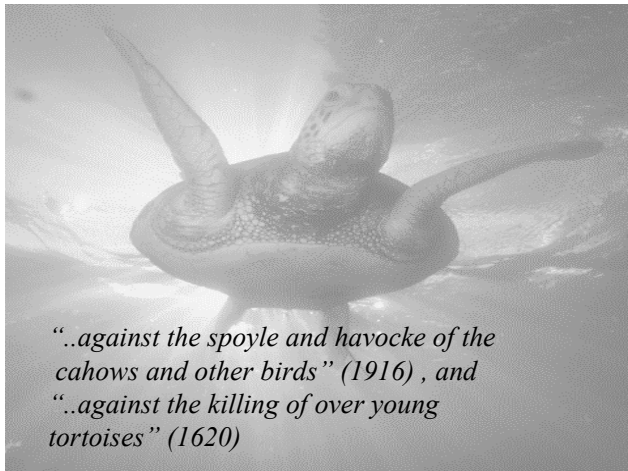
Existing Financial Resources for Biodiversity Conservation

Conservation funding is derived from both local and overseas sources. The Environment component of the Ministry of the Environment, Development and Opportunity secures only about 2% of the Island's annual budget, which is perhaps indicative of the current lack of cross-sectoral awareness of the value of Bermuda's natural resources. Most of the remaining support comes from private donations through the local NGO's. Their achievements reflect the extent and generosity of the local community (including the international business sector) in supporting local conservation.

Financial support from overseas has been harder to secure. As a U.K. Overseas Territory, Bermuda is

excluded from many funding sources available to other small island states. Adding to this frustration is the fact that its relative affluence has often been an obstacle to accessing funding available through the U.K. There has been a failure to communicate that the cost of conserving Bermuda's biodiversity is directly proportional to the high cost of living! However, the U.K. Government has recently demonstrated its commitment to conserving the Island's biodiversity through various grants to support habitat mapping, a marine moorings initiative, and the development of a Biodiversity Strategy and Action Plan. A number of local initiatives have also benefited from generous support from overseas NGO's, both in the U.K. and in the U.S.A.

EXISTING BIODIVERSITY CONSERVATION PROGRAMMES



*"..against the spoyle and havocke of the cahows and other birds" (1916) , and
 "..against the killing of over young tortoises" (1620)*

Research

Bermuda's attractiveness as a natural laboratory explains the wealth of scientific research conducted on the island, particularly over the last century. This work is conducted by local and visiting scientists. The establishment of the Bermuda Biological Station for Research Contribution Series for scientific publications in 1903 has been instrumental in ensuring that the research findings of many of these visiting scientists are made available locally. The increasing number of visiting scientists working at the Bermuda Aquarium, Museum and Zoo has also prompted the establishment of a Bermuda Biodiversity Project Contribution Series. Every effort should be made in the future to encourage visiting scientists to provide copies of their publications in return for being given access to study Bermuda's unique environment.

<i>Organisation</i>	<i>Relevant Activities</i>
Bermuda Aquarium, Museum & Zoo/ Bermuda Zoological Society	<ul style="list-style-type: none"> • Baseline habitat surveys • Investigation of incidence and cause of deformities of Bermuda's amphibian population • Population studies of various native and endemic species (turtles, skinks, longtail, seahorses, land hermit crabs, West Indian Topshells) • Distribution of selected invasive pest species • Various collaborative research with visiting scientists • Paleobiology
Bermuda Audubon Society	<ul style="list-style-type: none"> • Support for Cahow conservation, including fund for use on burrow construction, etc • Common Tern banding programme • Ruddy Turnstone colour banding programme • Annual Christmas Bird Count (since 1975) with data to National Audubon Society
Bermuda Biological Station for Research	<ul style="list-style-type: none"> • Coral reef, sea grass and mangrove monitoring • No-take fisheries study • Molecular biology and genetic studies of marine species and stress responses • Mariculture of bivalves, stock enhancement, small-scale commercial aquaculture assessment • Air, water and terrestrial pollution assessment • Health of marine organisms
Bermuda National Trust	<ul style="list-style-type: none"> • Research on the rate of coastal erosion • The Cruise Ship Report
Bermuda Underwater Exploration Institute	<ul style="list-style-type: none"> • Sea Level study
Department of Agriculture and Fisheries	<ul style="list-style-type: none"> • Library research, consultation with local and abroad scientists and/or field research • Studies of the basic biology of Black Grouper, Lane Snapper, Red Hind, Wreckfish, Blue Marlin • Pop-up tag pilot study on Blue Marlin • Mariculture of Bermuda Scallop and Calico Scallop
Department of Parks	<ul style="list-style-type: none"> • Management regime for pruning trees • Management of various native reforestation projects • Management programmes for threatened and/or endangered flora and fauna (Bermuda Petrel, Tropicbird, Common Tern, Bermuda Skink) • Reintroduction projects to bring back species extirpated from Bermuda (Yellow-crowned Night Heron, Turkey-berry)
Department of Planning	<ul style="list-style-type: none"> • Analysis of impact of development on existing protected woodland areas for review of development plan • Coastal erosion study • Review of Bermuda Plan 1992 • Preparation of State of the Environment report

Table 11. Current Island-wide research initiatives.

In-Situ Measures For Species And Habitats

<i>Organisation</i>	<i>Relevant Activities</i>
Bermuda Aquarium, Museum & Zoo/ Bermuda Zoological Society	<ul style="list-style-type: none"> • Learning Through Landscapes schools programme • Growing with Trees • Bermuda Moorings Initiative • Installation of signs in turtle habitats • Construction & distribution of bluebird boxes
Bermuda Audubon Society	<ul style="list-style-type: none"> • Construction and placement of bluebirds boxes • Construction and placement of nesting burrows for longtails • Restoration of wetland habitats • Management of nature reserves • Planned extension of Seymour’s Pond nature reserve • Planned creation of new nature reserve west of Coral Beach
Bermuda Biological Station for Research	<ul style="list-style-type: none"> • Nesting boxes for Bluebirds • Construction of pond at BBSR • Maintenance of native plant species garden • Instruction for scientists and students to conserve & replace organisms collected for research • Scallop seed production for stock enhancement and aquaculture development
Bermuda Botanical Society	<ul style="list-style-type: none"> • Support Learning Through Landscapes • Encourage planting of Milkweed for Monarch Butterfly
Bermuda Garden Club	<ul style="list-style-type: none"> • Support Learning Through Landscapes
Bermuda National Trust	<ul style="list-style-type: none"> • Improvement of Warwick Pond Nature Reserve • Improvement of Spittal Pond Nature Reserve
Department of Agriculture and Fisheries	<ul style="list-style-type: none"> • Fisheries regulations enforcement
Department of Health	<ul style="list-style-type: none"> • Cleaning of marshes to protect mosquito fish
Department of Parks	<ul style="list-style-type: none"> • Site specific plantings of endemics • Management of all Government Nature Reserves and other areas of protectively zoned land • Specialised species/ habitat management for NGO Groups • Provision of nesting boxes/burrows for Bluebirds, Longtails and Cahows
Department of Planning	<ul style="list-style-type: none"> • Woodland management schemes • Landscaping conditions on planning permissions

Table 12. Locally driven in-situ conservation projects

Protected Marine Areas³³

200 Mile Exclusive Economic Zone

The E.E.Z. around Bermuda was declared in 1996. This gives Bermuda jurisdiction over an area of about 125,000 square nautical miles. This area was declared a marine mammal preserve in 2000.

“Area To Be Avoided”

Alarmed at the near disaster of the grounding of the *Aguila Azteca* in 1984, the Bermuda Government petitioned the International Maritime Organisation which declared a 30 mile “Area to be Avoided” by all commercial shipping not calling at Bermuda. Additionally, the Bermuda Government invested several million dollars in RACON (Active radar responding) beacons on the fringing reef to mark navigational hazards.

Coral Reef Preserves

In the mid-1960’s various schemes were proposed for the reclamation of land on the shallow reefs to the west and north of Bermuda. Earlier experiences with dredge and fill operations during the construction of the airport demonstrated that such land reclamation projects would cause widespread damage to Bermuda’s coral reefs. These schemes prompted wide debate, which ultimately led to the passing of the Coral Reef Preserve Act 1966. This Act prevented these land reclamation plans by providing for complete protection of all attached organisms within two substantial areas of Bermuda’s

shallow waters; the North Shore Coral Reef Preserve and the South Shore Coral Reef Preserve.

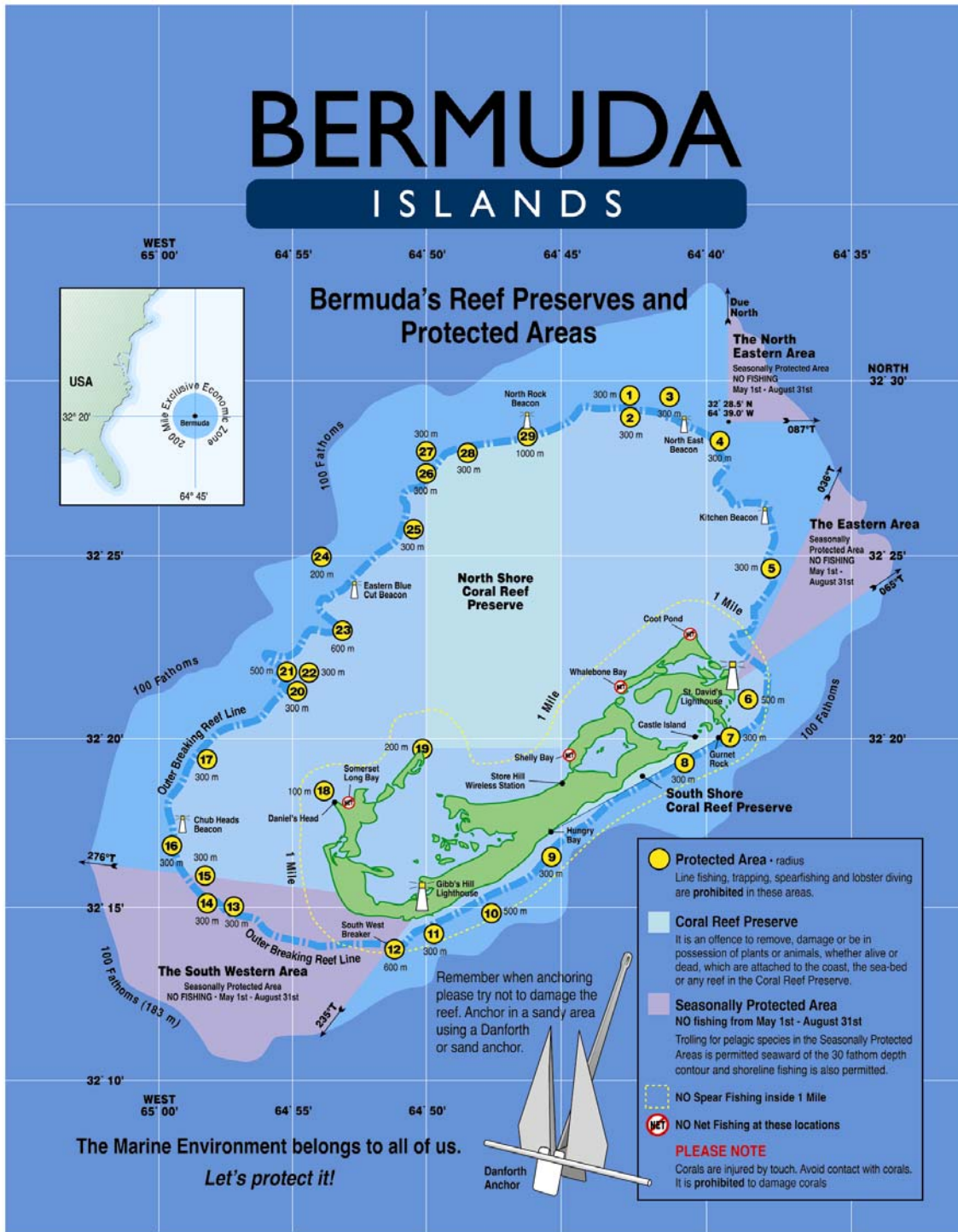


Figure 38. Marine Protected Areas. (Courtesy of Terry Madeiros).

Protected Areas

Through a collaborative venture between local SCUBA divers and dive operators, the Bermuda Zoological Society, the Ministry of the Environment, Development and Opportunity and the U.K. Foreign and Commonwealth Office, 29 Protected Areas have been established around the fringing reef and the western end of Bermuda. These have a radius of between 300 m and 1000 m. Permanent mooring buoys are deployed at these locations for recreational and commercial boat operators to pick up. Line fishing, spear fishing and lobster diving are all prohibited.

The Bermuda Biological Station for Research Inc. is conducting a two-year assessment comparing fish stocks in marine protected areas with those on fished reefs to determine the effectiveness of the marine protected areas¹⁴².

Marine Parks

Currently there is only one established Marine Park, the Walsingham Marine Reserve. Mooring and anchoring in this area is prohibited (except for authorised scientific research or educational projects), as is fishing. The Reserve was established to safe guard and maintain the fringing reefs and their attendant flora and fauna, the seagrasses and the mangroves in the area.

The Department of Parks is currently considering a proposal to establish a further 8 Marine Reserves adjacent to Bermuda's shoreline.

No Spear Fishing Limit

Spear fishing is prohibited within one mile of the Bermuda shoreline.

No Net Fishing

Four inshore bays, Somerset Long Bay, Shelly Bay, Whalebone Bay and Coot Pond are protected from all net fishing, whilst only cast and bait nets are permitted in Harrington Sound and Flatts Inlet. As all reef fish are also protected from netting, there is in effect no net fishing on the reefs.

Seasonally Protected Areas

There are three seasonally protected areas, one to the south west of the Island, and the other two, to the north east. These areas were established largely to protect grouper species in their spawning grounds. The taking of any fish in these areas is prohibited between 1st May and 15th August each year.

Seagrasses

Although no specific legislation exists protecting seagrass beds, this important habitat is afforded protection under the Fourth Schedule of Department of Planning Act 1974, under Habitat Protection. Planning applications for developments such as

¹⁴² Smith, S.R. Pers. Comm. Bermuda Biological Station for Research Inc.

docks and marinas located in seagrass beds are strongly discouraged.

Protected Marine Species¹⁴³

In 1978 Bermuda's growing tourist trade provided a threat to corals, as the popularity of bleached corals as souvenirs increased. In response, a Protected Species Order was passed under the Fisheries Act of 1972, banning the harvest of any coral, and in effect making Bermuda the first coral reef preserve in the world.

Under the Fisheries (Protected Species) Order 1976, it is also illegal to remove any of the following marine invertebrates, whether *alive or dead*: Atlantic Pearl Oyster, Atlantic Calico Scallop, Bermuda Scallop, Calico Clam, West Indian Top Shell, Queen Conch, Harbour Conch, Bermuda Cone, Netted Olive, and all species of helmets and bonnets. All marine mammals and turtles are protected locally.

An annual licence is required to participate in recreational diving for Caribbean Spiny Lobsters; any lobsters taken may not be sold. There is a bag limit of two lobsters per person per day during the season (1st September to 31st March); the taking of lobsters is prohibited from 1st April to 31st August. The minimum carapace length is 92 mm (3 5/8 in) and only a noose or a snare may be used to take lobsters; spearing is prohibited. Any lobster whether

alive or dead with eggs is protected at all times of the year.

There is a year round bag limit of two fish per species per boat per day for the following species of grouper: Nassau Grouper, Deer Hamlet, Mutton Hamlet, Yellowfin Rockfish, Monkey Rockfish, Black Rockfish, Finescale Rockfish, and Tiger Rockfish. Parrotfish of all species are protected year round, whilst a seasonal limit of ten fish per boat per day from 1st May to 30th September is in place for Red Hind. Bonefish and Pompano can only be removed on a hook and line. Recreational fishermen are prohibited from taking more than thirty Lane Snappers per vessel per day.

Minimum catch sizes and/or weight for many of the groupers, snapper, tunas and swordfish apply.

It should be noted that a ministerial permit may be obtained to take any of the above fish for scientific purposes, for local or overseas museums or aquaria, or for protection or conservation of the fish.

International Protection for Marine Species

All sea turtles found in Bermuda are protected locally and along with most of the marine mammals, are internationally protected. There is growing momentum internationally for controlling the trade in corals. Despite protecting its own corals, Bermuda does import corals for sale as souvenirs.

¹⁴³ Ministry of the Environment, Bermuda Government. 2000. Marine Resources and the Fishing Industry in Bermuda. A discussion Paper. 495 pp.

Species	Local Status	Threats
Green Turtle (<i>Chelonia mydas</i>)	Abundant as juveniles; local breeding population extirpated	
Loggerhead Turtle (<i>Caretta caretta</i>)	Rare; juveniles strand on shoreline	- Pollution (esp. plastics) - Entanglement in fishing gear
Hawksbill Turtle (<i>Eretmochelys imbricata</i>)	Rare	- Boat collisions
Leatherback Turtle (<i>Dermochelys coriacea</i>)	Rarely seen, pelagic	
All marine mammal species	Rare	- Pollution - Entanglement in fishing gear
All coral species	Abundant and healthy	- Global warming - Disease - Sedimentation - Coastal development
Queen Conch (<i>Strombus gigas</i>)	Uncommon; 4 known surviving populations	- Illegal harvesting - Small population size
Harbour Conch (<i>Strombus costatus</i>)	Very abundant inshore	- Anti-fouling paint (esp. TBT)
Bermuda Cone (<i>Conus bermudensis</i>)	Rare	- Illegal harvesting
Netted Olive (<i>Oliva reticularis</i>)	Fairly common inshore	- Illegal harvesting
Bermuda Scallop (<i>Eivola ziczac</i>)	Rare	- Illegal harvesting
Calico Scallop (<i>Argopecten gibbus</i>)	Uncommon	- Unknown
Atlantic Pearl Oyster (<i>Pinctada imbricata</i>)	Very abundant	- Unknown
All helmets and bonnets species	Rare	- Unknown
Calico Clam (<i>Macrocallista maculata</i>)	In Harrington Sound only, where numbers fluctuate	- Illegal harvesting
West Indian Topshell (<i>Cittarium pica</i>)	Uncommon; but multiplying along south shore	- Illegal harvesting
All parrot fish species	Abundant	- Illegal harvesting
Groupers (<i>Mycteroperca</i> and <i>Epinephelus</i> spp.)	Rare	- Harvesting

Table 13. The local status of and major threats to Bermuda’s marine species¹⁴⁴.

Protected Terrestrial Areas¹⁴⁵

Only about 9%, a total of about 500 ha (1,236 acres), of Bermuda’s land area is set aside as parks and nature reserves. Over half of this land is used for passive recreation and so cannot be considered as a refuge for plants and animals

¹⁴⁴ Ministry of the Environmen, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda. A Discussion Paper. 495 pp.

¹⁴⁵ Department of Planning, Ministry of the Environment, Government of Bermuda. 1992. Bermuda Plan.

Open Space

The designation of Open Space in the 1992 Bermuda Plan creates continuous green belts throughout the Island. These are meant to protect land that is linked together, in particular by the Railway Trail and Tribe Roads, from development. This designation is included in the planning statement to preserve and protect the scenic and aesthetic qualities of Bermuda. The zone designated Open Space includes a number of Conservation area designations. Additionally, some Conservation areas fall under development zones, such as Residential, Industrial or Tourism. These Conservation areas are described as follows:

Woodland Reserve and Woodland

The two protected categories of Woodland Reserve and Woodland recognise that trees are an important resource for aesthetic and functional reasons. As habitats for wildlife, windbreaks and protection and for their scenic beauty, woodlands serve many functions, most of which are only effective with dense, mature stands.

Woodland Reserves are protected for their ecological and/or amenity value. They include extensive stands of mature trees and dense vegetation, as well as smaller areas of trees and shrubs in prominent locations. All forms of development are prohibited and any access through the area requires approval, especially for vehicles.

Woodlands are a mixture of trees, shrubs and vegetation that are less uniform in quality than the

Woodland Reserve, but are nevertheless important. Development is not normally allowed in these areas, but can be approved by the Planning Board.

Section 27 of the Development and Planning Act with its accompanying Tree Preservation Order (TPO) regulations provides for the preservation of individual trees, groups of trees and woodlands. A total of thirty-two tree preservation orders, presently in effect, cover mature endemic (eg. Cedars) and native trees (Yellowwood, Southern Hackberry) as well as exotic trees and trees related to historic events. Fourteen tree preservation orders concern protection of woodland areas or a hedgerow. Two additional orders have been revoked. Of some concern is the apparent lack of enforcement regarding these TPO's. Some 28 ha (69 acres) of woodland and hedgerows are protected in perpetuity through planning agreements.

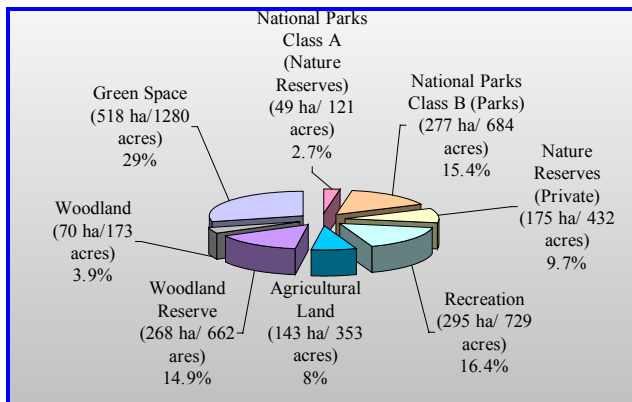


Figure 39. Conservation designations with Open Space overlay in the 1992 Bermuda Plan, excluding the City of Hamilton.

Green Space

Green Space is designated as land that is important because of its natural appearance and scenic

qualities that, contributes to the establishment of the network of linked open spaces. This area is especially designed to protect coastline, cliffs, beaches, dunes, rock formations and undeveloped islands. Minor development for improvements to public facilities and safety are possible.

National Parks

National Parks are areas that have been protected under the National Parks Act, 1986, for the enjoyment of present and future generations. Additional land can be added to the parks system. There are two classes of protected areas under this act; Nature Reserves, which comprise some 49 ha (121 acres) and Parks, which total some 281 ha (694 acres). The 1988 National Parks regulations prohibit the destruction and collection of plants and animals in both classes of protected areas. Under the 1992 Bermuda Plan, all these lands are protected from any building development that may compromise the quality, character and function of the park.

Nature Reserve

These are areas in addition to the National Park Nature Reserves. There are 177 ha (437 acres) of privately owned Nature Reserves, of which the Bermuda National Trust and the Bermuda Audubon Society own about 50%. Nature Reserves under the 1992 Plan are areas of special environmental significance and ecological, biological or scientific value, including mangroves, marshlands, bird sanctuaries, cave and rock formations, islands and other wildlife habitats. All forms of development

<i>Habitat</i>	<i>Conservation Designations</i>								<i>Total Area of Habitat with Conservation Designations (Areas Zoned as Open Space)</i>	<i>% of Habitat with Conservation Designations</i>
	<i>Total Area of Habitat</i>	<i>Woodland Reserve</i>	<i>Woodland</i>	<i>Agricultural Land</i>	<i>Green Space</i>	<i>National Park</i>	<i>Recreation</i>	<i>Nature Reserve</i>		
Beach and Dune	77.4	1.4	0.2	-	26.9	24.1	-	3.2	55.9 (54.9)	72.2
Fresh/ Brackish Pond	23.3	-	-	-	0.4	1.0	0.6	21.3	23.3 (22.8)	100
Golf Course	242.8	6.2	5.4	1.2	6.2	0.7	216.5	1.5	237.7 (237.6)	97.9
Mangrove	17.5	0.1	0.3	0.1	1.0	4.7	0.2	9.4	15.8 (15.8)	90.4
Marine Ponds	17	-	-	-	-	0.9	-	16.3	17 (17)	100
Peat Marsh	67.5	7.4	0.7	4.3	18.7	5.7	0.7	26.9	64.3 (63.9)	95.2
Rocky Coastal	148.8	2.2	2.6	-	75.6	29.3	2.3	23.8	135.9 (135.2)	91.4
Salt Marsh	0.6	-	-	-	-	0.2	-	0.1	0.4 (0.4)	66.7
Upland Coastal	345.6	43.7	19.3	5.4	100.7	79.0	6.3	35.1	289.5 (252.0)	83.8
Upland Hillside	907.7	283.3	80.2	36.8	94.2	75.0	19.0	45.0	633.4 (448.5)	69.8

Table 14. The area (in hectares) of each conservation designation within the various terrestrial habitats.

are prohibited and encouragement is given to management initiatives that successfully conserve and enhance the special qualities of these sites. However, these sites are not necessarily supported by the same restrictions regarding the destruction and collection of animals and plants, as the National Park Nature Reserves.

Recreation

The Recreation designation is land set aside for recreational activities, including playing fields, sports facilities, and golf courses. Priority is given to retain the land in its open state, whilst protecting natural features. Only recreational forms of development are permitted.

Caves

The Cave Protected Areas identify the extent of the sensitive cavernous areas around Harrington Sound and the location of known caves. Any development that has a detrimental effect on a cave entrance or an underlying cave will not be permitted. However, to date very few of the cave systems have been mapped and therefore the effectiveness of such protection is limited.

Wetlands

These areas are presently covered under the National Parks and Nature Reserve designations under the 1992 Plan. For the first time, the 1983 Development Plan designated all remaining wetlands as Nature Reserves. However, since 1970 the area of wetland habitat has increased as a result of deliberate restoration projects initiated by the Bermuda Audubon Society and the Bermuda National Trust. Seven sites in Bermuda are recognised under the Ramsar Convention.



Plate 27. Yellow Crowned Night Heron, a frequent sight in Bermuda's wetland habitats. (Photo courtesy of R. Ground).

Ground Water

The Ground Water Protection area recognises the approximate extent of Bermuda's four underground water lenses, the St. George's Lens, Central Lens, Port Royal Lens, and Somerset Lens. All development must be designed to dispose of sewage and other effluent in a satisfactory manner without harm to any ground water lens.

Protected Terrestrial Species¹⁴⁶

Unlike the marine environment, Bermuda's terrestrial plants and animals are afforded little protection locally. The exception are the birds; protection is afforded all birds and their eggs in Bermuda, under the Protection of Birds Act 1975 (excluding farmyard or domesticated birds, birds kept in captivity, the Common Crow, European Starling, Great Kiskadee, and House Sparrow).

Islands and unnamed islets in Harrington Sound, Great Sound, and Hamilton Harbour that are used as breeding and nesting areas by the Common Tern were declared nature reserves in 1976. Spittal Pond, Castle Harbour in 1979, and land at Evans Bay in Southampton in 1981 were also declared nature reserves to protect the feeding and nesting areas of protected bird species.

¹⁴⁶ Department of Agriculture, Ministry of the Environment, Development and Opportunity, Government of Bermuda. Legislation.

International Protection for Terrestrial Species

The Bermuda Rock Lizard is listed as critically endangered under CITES (Convention on International Trade in Endangered Species), thereby prohibiting its trade overseas. The Cahow is also listed as endangered. This species, and the White-eyed Vireo (Chick-of-the-Village) are the only terrestrial Bermuda endemics, protected locally.

Ex-Situ Measures for Species

Ex-situ measures for biodiversity conservation include the propagation of native and endemic plants by the NGO Save Open Spaces, as well as by the Department of Agriculture at their Tulo Valley Nursery and at the Botanical Gardens and by the Department of Parks. Programs such as “Growing with Trees” also promote community participation in propagation, whilst the Bermuda Botanical Society and Bermuda Garden Club hold plant sales to encourage plantings of endemics. Many private individuals also actively propagate these species.

The Department of Parks and the Bermuda Aquarium, Museum and Zoo undertake rehabilitation of injured birds and marine turtles.

The establishment of a private mariculture company, Sea Venture Farm, which utilises facilities at the Bermuda Biological Station for Research Inc., demonstrates the potential for restocking the Bermuda and Atlantic Calico Scallops populations.

Contingency Plans

Oil Spill Contingency Plan¹⁴⁷

A Marine Pollution Contingency Plan exists to provide a formal response procedure in the event of spills of oil and other toxic substances in coastal waters. The plan includes environmental sensitivity maps, damage and risk assessment, and scientific support co-ordination. Details on the mobilisation of key personnel and equipment, their course of action (depending upon the magnitude of the incident), and the communication networks required are all described in the plan. Maps of coastal areas give information on water depth, current velocities and distances across inlets for the deployment of containment booms. The coastal areas are also ranked on a 1 to 10 scale, reflecting the expected persistence of oil spills in the environment. The maps allow for the identification of priority areas that may require a maximum effort. The co-ordination of scientific activity, both on land and at sea is also outlined, including the complete documentation of all data collected during the incident. Pre-approved areas have been designated for the use of chemical dispersants in the event of a spill.

¹⁴⁷ Ministry of the Environment, Government of Bermuda. 2000. Marine Resources and the Fishing Industry in Bermuda. A Discussion Paper. 495 pp.

Invasive Species Prevention

Like any isolated island, Bermuda has been plagued by the problem of invasive species. The Plant Protection Laboratory working in partnership with the Customs Department closely inspects imported vegetables and plants for disease and pests. Imported plants must be free of all sand, soil, and earth. Contaminated material is destroyed. Regular awareness campaigns are aired on local television stations and through flyers. The Animal Control Section is responsible for inspecting all animals brought to the Island. Despite tight controls, illegal importation of plants and animal does occur.



Plate 28. Illegally imported snake recently confiscated from a private residence. (Photo courtesy of L. Rodrigues).

The issue of feral animals in Bermuda is an emotional one. A local NGO, the Bermuda Feline Assistance Bureau has implemented a campaign to trap, spay, neuter, and subsequently release feral cats across the Island. Over 8,000 cats have reportedly been trapped, an effort that is estimated to prevent about 16,000 kittens from being born each year.

The prevention of invasive plant species has been much harder to implement. In part, this is often because species considered invasive in one country may not adapt so well to conditions in another and may therefore pose no threat. A growing number of plant species are considered invasive locally, and this is clearly an issue that needs to be addressed. Most local NGO's and relevant government departments have resorted to invasive species management through culling programmes, but these are extremely labour-intensive.

Permits are required for the importation of freshwater species for local aquaria. A number of species formerly imported are now prohibited; this includes the Red Eared Slider Turtle which can, however, be bred locally.

The marine environment has, to date, been less susceptible to invasive species. The importation of any living marine organism to Bermuda is strictly prohibited. This applies both to exotic species for the Aquarium trade, as well as to food items such as lobsters from the U.S.A. A catastrophic problem in many parts of the world has been the introduction of invasive marine species through the dumping of ballast water carried by ships from one location to another. Currently there is no local legislation regarding the dumping of ballast water from ships arriving in Bermuda. The Ministry of the Environment, Development and Opportunity is reviewing this¹⁴⁸.

¹⁴⁸ Begeman, P. Pers. Comm. Ministry of the Environment, Development and Opportunity.

The Consumer Affairs Bureau makes daily checks with the U.S. Environmental Protection Agency for any potential environmental health threats from food recalls and alerts the Department of Environmental Health, which itself is in regular contact with the Center for Disease Control¹⁴⁹.

Biodiversity Information Systems

The absence of an integrated biodiversity information system inspired the launching of the Bermuda Biodiversity Project in 1997. The project is focussed on the collation and dissemination of information, promotion of its importance and encouragement of its use. The backbone of the BBP is the development of a GIS-interactive, relational, event-centred database, pooling information on Bermuda's flora and fauna. The primary function of the database is to record the occurrence in time and distribution of species (and higher taxa) in Bermuda. The secondary function of the database is to manage four "collections", which themselves serve as the data sources for biodiversity events. These are: Museum lots (biological and geological specimens and artefacts); the Bermuda Natural History Bibliography (a collection of over 3,400 scientific documents describing the Islands' natural history); Images (comprising over 12,000 slides and photographic images); and Field Logs (data collected but not published).

The Field Logs incorporate valuable data provided by local and overseas scientists and naturalists. For example, local bird experts have provided thousands of records of birds sightings in Bermuda.

This database is being designed to link with the Government's Geographic Information System (GIS), which allows spatial analysis of the data, and serves to greatly facilitate decision-making. A recent workshop organised by the Survey Section of the Ministry of Works and Engineering to discuss the value of a Spatial Data Infrastructure for Bermuda was a promising step towards promoting more co-ordinated and efficient information sharing¹⁵⁰.

Many Government departments are in the process of implementing new database systems, with links to the Bermuda Land and Property Addressing database managed by the Ministry of Works and Engineering. These include the Department of Planning's Bermuda Environmental Management Information System (BEMIS), and the Environmental Health Department's Bermuda Environmental Health Data System (BEHDS).

The U.K. Overseas Territories Conservation Forum has recently launched a web-based database, which should prove to be a valuable vehicle for biodiversity information sharing between the Overseas Territories.

¹⁴⁹ Harvey, E. Pers. Comm. Department of Environmental Health.

¹⁵⁰ Survey Section, Ministry of Works and Engineering, Government of Bermuda. 16 Feb 2001. A National Spatial Data Infrastructure for Bermuda? Ocean View Golf Course, Devonshire, Bermuda.

<i>Organisation</i>	<i>Relevant Activities</i>
Bermuda Aquarium, Museum & Zoo/Bermuda Zoological Society	<ul style="list-style-type: none"> • Vacation camps for local children; Organised field trips; Open days; Learning Through Landscapes; Growing With Trees; Friends Teacher Training Course; Nonsuch Natural History Camp; Public lectures; Tour operator training • Internship programmes for entry level scientists • School visitations for classroom presentations & teacher workshops; Involvement in development of schools curriculum • T.V./radio broadcasts; Web site; Quarterly newsletter to members, mailed flyers, production of field guides; Publication series; Ecofiles; Project Nature; Public exhibits
Bermuda Audubon Society	<ul style="list-style-type: none"> • Natural history summer camp; Organised field trips • Public lectures; Introduction to Birdwatching Course • Quarterly newsletter; Web site • Public education regarding recycling, helium balloons, feral cats
Bermuda Biological Station for Research	<ul style="list-style-type: none"> • Graduate and undergraduate courses in marine biology • Distance learning curriculum on coral reefs • Organised field trips to Nonsuch Island; Field guide production • JASON education project; Summer camp for local children • Media releases, annual reports, newsletters • Maintain research library open to public; Facility open days
Bermuda Botanical Society	<ul style="list-style-type: none"> • Summer Botany Camps; Organised field trips; Lectures and workshops; Quarterly newsletter to members
Bermuda Garden Club	<ul style="list-style-type: none"> • Scholarships for horticulture and landscape design studies; • Courses offered on gardening topics; Publisher of “The Bermuda Jubilee Garden”
Bermuda National Trust	<ul style="list-style-type: none"> • Spittal Pond Children’s Walk; Palm Sunday Walk • Paget Marsh Educational Signage (past); Warwick Pond Educational Signage (present) • Incorporation of Warwick Pond into middle school curriculum as an “outdoor classroom” • Consult with developers on developments that may negatively impact the environment
Bermuda Underwater Exploration Institute	<ul style="list-style-type: none"> • Educational Explorer’s Camps; Ocean Discovery Centre, roving exhibits; TV broadcast, newsletters • Tours and activities, field trips; Open days; Lecture Series • Government after-school programme; Middle school teacher workshop
Department of Agriculture and Fisheries	<ul style="list-style-type: none"> • School camps; Visitation to schools for classroom presentation
Department of Health	<ul style="list-style-type: none"> • Fliers, media campaign • Exhibitions and workshops; Courses at Bermuda College
Department of Parks	<ul style="list-style-type: none"> • Park Ranger Service – Winter walks (Oct-May); Railway trail walking tours; Field guides; Learning Through Landscapes • Organised environmental education tours for schools and other interested groups in Nature Reserves and other areas • School classroom presentations; Media stories and broadcasts (T.V., radio, newspapers) • Production of management plans and field guides • Liaison with Planning Dept. to give property owners advice on management of woodland reserve / woodland areas
Department of Planning	<ul style="list-style-type: none"> • Co-ordinating the Ministry of Environment’s first State of the Environment Report
Bermuda Eden Project	<ul style="list-style-type: none"> • Annual exposition
Keep Bermuda Beautiful	<ul style="list-style-type: none"> • Web site; NewsLitter (Royal Gazette Supplement); T.V. broadcasts and news; School visitations for classroom presentation; Special School Projects

Table 14. Current environmental education programmes

Education and Public Awareness

The need to raise the level of environmental awareness is widely recognised by local conservation bodies. With this aim, most of the local NGO's as well as the various Government departments incorporate an educational component into their activities. This may take the form of information brochures and flyers, or it may involve field trips, school visits, workshops and courses. Table 14 summarises this. In support of relevant environmental education for Bermudian children, the Ministry of Education has adopted the theme of oceanic islands as the science model in the Middle Schools, and the coral reef is the focus of science education in M3.

Advocacy

The role of environmental advocacy in triggering positive conservation action in Bermuda should not be ignored. In the 1970's a concerned group of citizens formed a group called Save Our Sound, to petition the Government regarding the water quality of Harrington Sound, a virtually enclosed body of water. As a result, the Bermuda Government provided a grant to support the Bermuda Inshore Waters Investigation, a survey conducted through the Bermuda Biological Station for Research Inc., to establish baseline parameters, and to assess possible detrimental changes, in the marine environment.

Concerned at the rapid pace at which development was occurring on the Island, a group called Save

Open Spaces pressured the Government into placing a moratorium on land subdivision in the early 1980's.

In the late 1980's when fears were raised that the decline in reef fish abundance through fishing pressure might threaten the health of the coral reef system, several outspoken divers joined with the action group Friends of Fish, and successfully petitioned the Government for a ban on fish traps.

Monitoring Systems

<i>Organisation</i>	<i>Relevant Activities</i>
Bermuda Aquarium, Museum & Zoo/Bermuda Zoological Society	<ul style="list-style-type: none"> • REEF fish monitoring • AGRRR coral and fish surveys
Bermuda Audubon Society	<ul style="list-style-type: none"> • Recording of bird sightings
Bermuda Biological Station for Research	<ul style="list-style-type: none"> • Coral reef, sea grass and mangrove monitoring • Juvenile and adult reef fish surveys • Air, water and terrestrial pollution assessment
Bermuda Feline Assistance Bureau	<ul style="list-style-type: none"> • Number of feral cats, rate of reproduction, distribution
Bermuda National Trust	<ul style="list-style-type: none"> • Review planning applications for encroachments onto conservation zonings and environmentally sensitive areas • Review of the next Development Plan
Bermuda Underwater Exploration Institute	<ul style="list-style-type: none"> • Sea Level Rise
Department of Agriculture and Fisheries	<ul style="list-style-type: none"> • Controlling the importation of animal species that may threaten local species • Agricultural land survey • Catch and effort statistics from registered fishermen • Recreational fishery landings • ICCAT requirements to document landings of pelagic species • Reef fish census • Reproductive seasonality of reef fishes • Spiny lobster monitoring of adults and post-larvae
Department of Environmental Health	<ul style="list-style-type: none"> • Drinking water supply
Department of Marine and Ports	<ul style="list-style-type: none"> • Shipping
Department of Parks	<ul style="list-style-type: none"> • Park Rangers issue permits for any infringements and use of parks • Uses of pesticides and fertilisers • Yearly monitoring of native planting areas and various Nature Reserves and Woodland Areas • Population studies of seabirds • Banding program for Common Tern chicks
Department of Planning	<ul style="list-style-type: none"> • Environmental conditions during and post construction phases of a development • Annual report documenting development and conservation efforts • Review of development plan and zonings
Keep Bermuda Beautiful	<ul style="list-style-type: none"> • Data oriented litter pickups: marine, KBB assisted, Adopt-A-Park

Table 15. Range of monitoring programmes currently underway which promote biodiversity conservation

Incentive Systems

The use of incentive schemes to encourage conservation has not really been promoted locally. However, two schemes do exist which fall under this heading. Home owners with a newly completed property development are entitled to a voucher for 50 plants (at a cost of just \$3 per plant) from the Government nursery at Tulo valley. It would appear that not everyone takes advantage of this; only 15 claims were made in 1999 and 18 in 2000¹⁵¹.

The recent changes in the tax laws, which encourage homeowners to divide their homes into two residential units might also be viewed as an incentive scheme. However, the down-side to this is that by gaining another assessment number, many homeowners may be using this policy to acquire a second vehicle for their household.

Legislation and Policy

The legal framework in Bermuda is based on English Common Law, Principles of Equity and all English Acts of General Application in force in 1612, but these laws are subject to acts of amendment passed by the Bermuda Legislature since that date. New Acts and amendments do not necessarily model themselves on British precedents.

As far back as 1616, the then Governor issued a proclamation for an article against “the spoyle and

¹⁵¹ Northcot, S. Pers. Comm. Department of Agriculture and Fisheries.

havocke of the cahows”, whilst in 1620 the Bermuda Assembly passed an Act “against the killing of over young tortoises” (turtles). This is believed to represent the first conservation legislation passed in the western hemisphere, and is sadly a reflection of the extent to which the early settlers, in just a few short years, had decimated the environment. Trees were not spared either, and in the 1630’s an Act was passed against the waste of cedar, and later, in 1659, against the exportation of cedar.

Present environmental legislation is embodied in various acts published in the Laws and Statutes of Bermuda, and administered through a number of Government departments.

The establishment of a new unit, the Central Policy Unit (CPU), is currently underway, with the “aim of improving the co-ordination of policies across Government. The CPU reports through the Cabinet Secretary to the Premier. In addition to co-ordinating policy, the CPU will work with Ministries to improve the quality of policy proposals, ensuring that they are based on research and analysis and that they will take account of stakeholders’ views. The CPU will also run projects in cross-cutting policy areas to define the appropriate approaches to long-term policy issues”.

Legislation For Protected Areas and Species

A number of Acts cover the protection of species and habitats. It is clear however that the legislation protecting local species and habitats, particularly

those on land, is inadequate. With the exception of the birds, which are protected, and a few Tree Preservation Orders, Bermuda’s terrestrial species are afforded no specific protection, unless they are to be found within a National Park. It is ironic that the Bermuda Skink, for example, which is recognised internationally as “critically endangered,” is protected through the Convention on International Trade in Endangered Species but has no local protection. The same is true of the endemic cave species, as well as Bermuda’s endemic flora.

With the exception of the coral reef, legislation protecting specific habitats is also lacking. Some, such as mangroves, are given protection because they fall under certain Planning designations, but critically important habitats such as seagrasses are currently unprotected. The Bermuda National Trust is spearheading an effort to generate legislation to protect this important habitat.

A proposed law, *The Prevention of Physical Damage to Reef Act*, has been drafted to prohibit types of reef-damaging conduct, establish a penalty system with fines that will be used to restore damaged reefs, and establish mechanisms to aid in enforcement and administration. This act is currently under review by the Ministry of the Environment.

The following acts are administered by the Department of Agriculture and Fisheries:

The Agriculture Act 1930 which provides for;

- the control of introduced plant diseases and pests through local licensing, and through the prohibition, inspection, treatment or destruction of imports,
- the control of animal diseases through local licensing and through the prohibition of imported animals without health certificates, and the quarantine or slaughter of animals suspected of carrying a communicable disease,
- the control of soil erosion by limiting the density of grazing cattle,
- and the prohibition of import of certain pesticides.

The Care and Protection of Animals Act 1975 which provides for;

- the control of imported animals through the need for permits, and their subsequent care,
- and the prohibition of animals likely to become a hazard to human or animal health or to the ecology of Bermuda.

The Protection of Birds Act 1975 which provides for;

- the protection of all birds and their eggs (with the exception of farmyard or domesticated birds, birds kept in captivity, the Common Crow, Starling, Kiskadee and House Sparrow)
- the control by an officer of the department of protected species that become pests,
- the establishment as nature reserves, areas that are important to rare, breeding bird species.
- and the establishment of a scientific advisory body to determine whether certain imports or exports are endangered.

The Endangered Animals and Plants Act 1976 which provides for;

- the prohibition of importation or exportation of any plant or animals protected under the Convention of International Trade of Endangered Species (CITES) 1973, unless a permit is issued,
- the establishment of a local scientific advisory authority to decide whether a plant or animal is endangered.

The Dogs Act 1978 which provides for;

- the compulsory licensing of all dogs,
- the conditions of ownership (including number of dogs allowed),
- the leashing of dogs on paved public places,
- the seizure and disposal of stray and abandoned dogs,

The following is administered by the Department of Parks:

The Bermuda National Parks Act 1986, is administered by the Department of Parks, and provides for;

- the establishment, administration, management, regulation and enforcement of a National Parks System comprising areas (owned by Government and privately owned) of both land and water, which are protected,
- and a management plan to be prepared and to be in effect for each protected area within five years.

Certain conflicts have arisen with regard to the Parks system in Bermuda. For instance, in addition to safeguarding the natural features, Parks also serve as a means to ‘protect and maintain historic monuments and buildings (including forts) and sites of particular historic, archaeological or aesthetic value.’ In some nature reserves, these objectives have conflicted. The need for significant archaeological work to be conducted to reinforce the fort on Southampton Island Nature Reserve, for example, was deemed to pose a threat to the thriving population of Bermuda Skink (*Eumeces longirostris*) on the Island, with the result that the dig was suspended. As another example, the use of Coney Island National Park as a motorcross scrambling track appears to be a direct contradiction of the very philosophy behind the parks system.

The following legislation administered by the Ministry of Works and Engineering serves the marine environment:

The Minor Dredging Works Act 1945, administered by the Department of Works and Engineering provides for the prohibition of dredging below the high water mark and the deposit of any object on the seashore or seabed unless consent from the Minister has been granted.

The following legislation is administered by the Department of Agriculture and Fisheries:

The Coral Reef Preserves Act, 1966, administered by the Department of Agriculture and Fisheries, provides for the designation of Bermuda’s two coral reef preserves and the protection of all marine flora and fauna within them.

The Fisheries Act 1972 provides for;

- the establishment of the Marine Resources Board to advise the Minister,
- the declaration of protected areas within the Bermuda’s 200 mile Exclusive Fishing Zone,
- the licensing of fishermen and compulsory record keeping by the fishermen,
- the provision for regulating catch and the methods employed to fish,
- the provision of fines, vessel seizure and arrest for fisheries violations,
- and the provision to make orders and regulations

Private Acts

Several private Acts provide for the holding of land in trust as nature reserves. These include: the *Walsingham Trust Act 1937*; *The Bermuda Audubon Society Act 1960*; *The Heydon Trust Act 1964* and the *National Trust Act 1969*.

Legislation Regulating Land Development

Development & Planning Act, 1974, is administered by the Department of Planning. It controls and directs development by providing regulatory mechanisms that strive to use land resources wisely in order to maintain quality of life and safeguard the environment. It allows for the preparation of development plans with the designation of land into development areas with accompanying regulations.

The Development and Planning Act was amended in 1983 (Section 28 and Fourth Schedule) to strengthen protection for arable land, woodlands, nature reserves, caves and coastal areas. This provides for the review by the Government Conservation Officer of planning applications that impinge on conservation areas.

Planning legislation in existence since 1965 has, for the most part, been tremendously successful in striking a balance between the need for development and the need for land designated for conservation. One ongoing point of contention is the lack of compensation for the loss of development rights due to environmental protection designations on private land.

A Development Applications Board, which comprises twelve laypersons selected by the Minister of the Environment, Development and Opportunity, grants permission for development either unconditionally or subject to conditions, or refuses permission. The Board cannot grant permission which would result in a development that

is contrary to the Act, a development plan and its accompanying regulations, a zoning order, municipal by-law or other statutory provision. After planning permission is granted, a building permit is required which initiates an inspection process throughout the construction of a property to ensure the structural soundness and safety of buildings. There is an appeals process that allows for third party appeals against the Board's decision. The Minister decides appeals; however, the appellant has the choice of having an independent planning inspector hearing the appeal who recommends a decision to the Minister.

Section 34 of the Act gives the Minister of the Environment power to enter into a planning agreement with a developer for the purpose of restricting or regulating the development or use of the land. The use of planning agreements in Bermuda is focussed on protecting parts of properties from development while allowing development on other parts of the application site. Of 114 planning agreements signed since the introduction of planning agreements in 1983, 89 relate to protecting a total of approximately 70 ha (173 acres) of arable land, woodland, nature reserve areas and open space/amenity areas. These agreements over-ride the development plan and are transferred when the land changes ownership and last *in perpetuity* unless the Minister allows the agreement to be amended. Only one agreement has been revoked.

The Crown owns all areas below the high water mark. A foreshore encroachment licence from the

Ministry of Works and Engineering is required for all developments over the seabed such as docks, jetties, and floating berths. Applications for such developments are vetted by the Marine Resources Board, which advises the Minister responsible for the environment, so as to ensure that environmental damage is minimised.

Legislation For Environmental Impact and Liability

Although the United Kingdom has environmental assessment legislation and related regulations, there is no such legislation in Bermuda. In an effort to keep abreast with legislation in the UK and other countries, environmental analysis was included for the first time in Section 4 of the 1992 Bermuda Plan Planning Statement. It requires developers to provide a site analysis report for small development proposals including details concerning the boundaries of conservation designations, existing vegetation, geological conditions, details of restrictive covenants and planning agreements. For larger projects, such as major hotel developments, sewage treatment and disposal systems, power plants and water supply systems, quarrying operations, reclamation projects and marinas, and large scale residential or industrial development, an environmental impact statement (EIS) may be required. The Statement must include a description and quantification of the likely significant effects, direct and indirect, on the environment of the development, as well as a description of the

measures to be implemented to avoid, reduce or remedy any adverse effects.

EIS's have been submitted for several development projects, including the mass burn incinerator at Tynes Bay, the ash block disposal in Castle Harbour, the former Castle Harbour Hotel property at Ship's Hill and the Daniels' Head Ecotourist resort. All EIS's are evaluated by the Institute for Environmental Assessment in the UK. This evaluation process is helpful as it points out weaknesses and omissions in statements.

In 1998, the requirement for the submission of an EIS was provided for under the Development and Planning Act 1974, Development and Planning (Application Procedure) Rules 1997, Additional Information (7) which states: "The Board may, in addition to the information referred to in these Rules, require an applicant to provide further specified drawings. Plans or other information, including a model, architectural renderings and such information relating to the environmental effects of the proposed development as it considers appropriate, to enable it to determine an application.

Whilst EIS's are becoming increasingly popular in many countries, there are two inherent flaws with them. Firstly, the onus is on the developer to ensure an EIS is performed, which means very often the EIS is subject to bias. Secondly, even if required, an EIS is usually just a procedural formality because the legislation does not require any follow up once the EIS has been submitted.

Legislation For Pollution and Waste Disposal

The Amenities Act 1950, administered by the Department of Works and Engineering, provides for the enforcement of the removal from private land, of material or structures that are considered unsightly.

The Marine Board Act 1962, administered by the Department of Marine and Ports, provides for the establishment of a Ports Authority and addresses navigational safety in Bermuda's waters as well as the issue of dumping waste into local waters.

The Prevention of Oil Pollution Act 1971, addresses measures which may be taken, in accordance with International Conventions for the Prevention of Pollution of the Sea by Oil, and from Ships, to prevent oil pollution both in Bermuda's waters and outside her territorial waters if there is a need to protect the coastline.

The Waste and Litter Control Act 1987, administered by the Department of Works and Engineering, provides for regulations of the public collection of waste, the prohibition of depositing waste on land and public areas, and the conditions of waste collection licences.

The Clean Air Act 1991, administered by the Ministry of the Environment provides for regulations governing issuance of permits for the construction of a controlled plant and acceptable limits for air contaminants.

Work on legislation for a Bottle Bill for Bermuda is being actively pursued, in large measure through the efforts of the local NGO, Keep Bermuda Beautiful.

Legislation For Public Health and Human Disease

The following Acts are all administered by the Department of Health:

The Quarantine Act 1946, deals with people with communicable diseases.

The Public Health Act 1949, provides for regulations regarding sewage disposal, as well as the removal of solid waste (administered by the Department of Works and Engineering), protection from contamination of water supplies, control of communicable diseases, vermin, and insect disease vectors, and the inspection and licensing of food preparation establishments and dairy products.

The Water Resources Act 1975, administered by the Ministry of Environment, provides protection for Bermuda's fresh ground water resources and seawater. The pollution of public water due to the discharge of marine vessels is an offence under this act.

The Pharmacy and Poisons Act 1979, addresses the sale and control of pharmaceuticals and poisons, including pesticides.

International Treaties And Conventions

International Treaties and Conventions are important for establishing standards and tend to focus on procedures for encouraging countries to adopt widely agreed and accepted practices. Non compliance by a signatory may result in significant international embarrassment. In terms of the environment, such treaties have increasingly been used for promoting new ideas such as sustainable development, and for promoting precautionary principles when a particular impact may be unknown but is banned as a precaution.

All relevant international treaties and conventions are signed and ratified on behalf of the Overseas Territories by the U.K. Government. U.K. Overseas Territories cannot enter into treaties by themselves. However, Overseas Territories are sometimes given the authority to conclude particular treaties, or categories of treaties, in their own right.¹⁵²

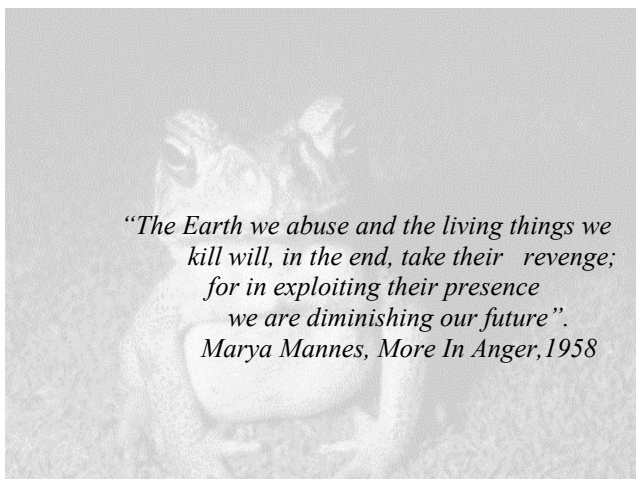
International treaties have little use unless they are integrated into national laws. Those treaties of relevance to biodiversity conservation in Bermuda are listed.

1. The 1973 Convention On International Trade in Endangered Species of Wild Fauna and Flora (CITES/1973). This provides for the regulation of trade in whole plants and animals, dead or alive, and their parts and derivatives.
2. The Convention on the Prevention of Marine Pollution from Ships (MARPOL 1973/78).
3. Convention On the Law of the Sea (1982). A convention concerned with the management and conservation of minerals and food supplies, giving Bermuda the rights to all living resources within a 200 mile Exclusive Economic Zone.
4. Montreal Protocol on Substances that Deplete the Ozone layer (1987) and all its Amendments.
5. Ramsar Convention (1971). An agreement by the parties to take action to create reserves and protect wetlands that are internationally important for their habitat for rare or migratory birds. Bermuda has seven designated Ramsar sites. These are Spittal Pond, Hungry Bay, Walsingham Pond, Warwick Pond, Lovers Lake, Somerset Long Bay and Mangrove Lake.
6. Convention for the Protection of World Cultural and Natural Heritage (1975). The Historic Town of St. George and the fortifications of St. George's Parish were declared a World Heritage Site in 2000. This includes the islands of Castle Harbour, which are recognised for their importance as breeding grounds for the Cahow, and as an important refuge for Skinks.
7. International Convention on the Conservation of Atlantic Tunas (ICCAT). Concerns the management of tuna stocks in the Atlantic.

Table 16. International treaties of direct relevance to biodiversity conservation in Bermuda.

¹⁵² Gurney, T. Pers.Comm. Deputy Governor.

PROBLEM ANALYSIS



Socio-economic and Development Context

There is no doubt that the major threat to conservation of nature in Bermuda is ongoing habitat destruction. Natural habitats in Bermuda have become so fragmented and reduced in extent that very few large tracts of virgin land remain. There are huge financial incentives to subdivide and sell real estate for development purposes, with property values approximating \$2.4 million/ha (\$1million/acre). Dwindling open spaces have prompted restrictive planning legislation, which has in turn instilled a sense of urgency in many landowners of their need to secure development rights. This is a key point amongst those who preserved their virgin land for environmental reasons only to find that their potential wealth has been denied by planning restrictions. To date no adequate system exists for compensation for landowners that have been denied development rights.

In general, home ownership is perceived to be a right of all Bermudians. However, with the high value placed on land and the high cost of construction it is extremely difficult for first-time owners to purchase a home. Historically, much of the Island’s wealth and power has been concentrated in the hands of a small group of white merchants. As a result there is a racial-based inequity in home ownership. These factors have created a strong political push for the creation of affordable housing developments with the potential for additional loss of habitat.



Plate 29. Aerial photograph showing the Island-wide spread of development across Bermuda. (Photo courtesy of Department of Works and Engineering).

The availability of affordable housing has been further compounded by the growth of the international business sector. In order to attract highly qualified people to Bermuda, international businesses often provide large housing allowances to ensure high quality housing for their executives. Many Bermudians have upgraded their houses, moved to less luxurious accommodations and placed their homes for rent in this lucrative market. This has served to create more demand for modest housing and has caused rents in this sector to rise dramatically.

It has been argued that actually Bermuda doesn't have a housing problem, we have social problems that create a housing shortage. The basis of this argument is two-fold: i) there are many large houses owned by both Bermudians and foreigners that are rarely fully occupied and, ii) a full 15% of all households with children are single parent families with, in many cases, the father occupying a separate dwelling. Both of these factors have created a demand for housing that far exceeds the number of dwellings that would be required if our culture promoted better utilisation of existing resources.

Probably as a direct result of the historical inequity in wealth, white people have to date dominated the local conservation community. While there does appear to be a growing awareness and concern for environmental health amongst the black community, conservation activists are commonly viewed as rich white people. It appears likely that, as much of the community lives in heavily developed areas that are largely devoid of environmental amenities, there is a widespread lack of appreciation of nature. This is compounded by the fact that only a small and declining number of Bermudians work in sectors that are closely associated with biological resources. There is a need for studies to assess the effect of ethnicity, wealth and level of education on environmental attitudes so as to design effective programmes to promote community-wide appreciation of environmental issues.

Many Bermudian homeowners strive to maintain their grounds in a highly manicured state. With the high value of land, little effort is made to recreate

native habitat and showy exotic species are commonly planted. In many other cases of newly developed sites, little effort is directed to plantings despite a Government programme, which subsidises plants for landscaping new dwellings. Probably as a result of the extreme cost of construction, landscaping plans that are required to secure permission to develop are often disregarded without penalty. These factors create residential districts with limited ability to support diverse natural communities. Recognising the need for more effective enforcement of planning conditions, the Department of Planning is presently considering creating a landscape plan/ condition enforcement system.



Plate 30. Two years after completion, the planters in the 15 ft. high boundary wall on this residential property remain bare. (Photo from Bermuda Biodiversity Project).

Human Pressure On The Environment

With a population density of 1,145 people per km² (2,818 people per mile²), Bermuda is one of the most heavily developed isolated islands in the world. As the residential development of the Island has not been clustered but spread over the Island, there are virtually no remaining natural refugia from man's impact.



Plate 31. Traffic congestion, as seen in this view of Front Street, is an escalating problem. (Photo from BAMZ slide collection).

Bermuda supports an affluent community with a highly consumption-oriented lifestyle. Virtually all products are imported creating a massive input of wastes. Solid waste disposal has heavily impacted on the island's marshlands, and more recently, the inshore waters. To date no real commitment to recycling has been displayed, as it has not been deemed viable from an economic perspective.



Plate 32. Airport dump. (Photo from BAMZ slide collection).

Sewage disposal on Bermuda has been via septic pit, ocean outfall, and most recently through deep-sealed boreholes that inject waste into the rock beneath the fresh-water lenses. Very little substantive evidence of sewage impacts on natural communities has been gathered. Surveys of reef health adjacent to the Sea Bright outfall have indicated that the rapid dilution of sewage prevents adverse impacts, and studies of the inshore waters have revealed that phosphate is bound in Bermuda's calcium carbonate rock thereby largely protecting the environment from the effects of septic pit leachate. As nitrate is not similarly bound, sewage inputs have led to enrichment with this nutrient. In cave areas, which are characterised by very hard, impervious rock, the effectiveness of septic pits is dramatically reduced resulting in declining water quality in drowned caves. This is a critical point as many of Bermuda's critically endangered endemic species are confined to these caves. The long-term effect of deep-sealed boreholes has not been studied.

Through the widespread introduction of plants and animals man has created intense competitive

pressure on the Island's native flora and fauna. Ranging from ornamental plants to agents of biological control, many of these species have thrived, displacing native organisms. Efforts to control these nuisance species have proven to be very expensive and ineffective.

Key Sectors Affecting Biodiversity

It is probable that the fishing industry, the only sector of the economy currently involved in the exploitation of biological resources, has had a significant effect on Bermuda's marine biodiversity. The most remarkable change in the species composition of Bermuda's reef fish is the virtual absence of the formerly abundant grouper species. Rare today are: the Red Grouper, Nassau, Gag, Yellowfin and Yellowmouth. The Tiger Grouper and Mutton Hamlet are extremely rare and may be extinct locally. The virtual elimination of these species may have allowed the increased abundance of omnivorous species such as the Grey Trigger, and Bermuda Chub.

The fishing industry has been subject to extensive legislation aimed at curbing fishing pressure. Despite this the industry remains subsidised with tax relief and restricted entry to favour profitability. Enforcement has generally been ineffective and the judiciary has often failed to adequately deal with those offenders that are brought to court. This has led to contempt for the fisheries legislation, loss of morale amongst the Fisheries wardens and widespread poaching. Recent collaborative

enforcement efforts involving wardens and Marine Police have been effective and may herald renewed respect for the law.



Plate 33. Confiscated fish pots. (Photo from BAMZ slide collection).

As previously mentioned, real-estate development is the primary cause of terrestrial habitat loss and, as such, is the sector of the economy with the most dramatic, albeit indirect, effect on local biodiversity. The Planning Act, like most Bermudian legislation, gives great power to the Minister. The Minister can override the decisions of the Development Application Board through the appeals process and alter zoning designations through issuing a Special Development Order to allow development that would otherwise not be permitted. Whilst strict planning regulations exist to control development, the economic incentives are high and political pressure can lead to decisions favouring development. This is particularly true where arguments favouring development include the revitalisation of failing sectors of the economy, notably tourism.

Historically, as land was cleared and ploughed to make way for introduced crops, farming had a substantive negative impact on local biological communities. The native forests were displaced from the prime valleys with deep soil but were left to thrive on the upland hillsides.

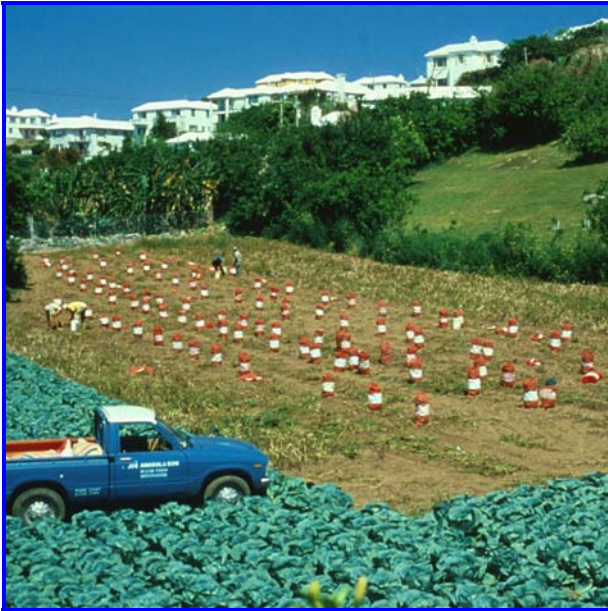


Plate 34. Farm land - A precious land bank (Photo from BAMZ slide collection).

Today, as the available open spaces dwindle, farmland is considered to be a precious land bank upon which future biodiversity restoration initiatives could be based. However, this primary industry receives the support of the Government with plans to ensure its continuity. Farming is now considered to be ecofriendly, at least relative to the generally accepted logical alternative, development. Government support to farming provides duty relief for supplies including pesticides. To date there has been no licensing of pesticide applicators and there is wide concern that improper use is the norm. The emerging trend amongst cutting edge farmers is the use of integrated pest management to minimise

pesticide usage. This involves the importation of beneficial insects to control pests. Whilst historically this approach has resulted in adverse affects on non target species, recent efforts have shown promise.

Bermuda's economy is largely dependent upon the Island's beauty, which in turn is dependent upon attractive landscaping. Without the extensive horticultural amenities that we enjoy, the landscape would appear to be excessively urbanised and our quality of life would undoubtedly suffer. Whilst extremely important to our wellbeing, horticulture, as the prime agent for the introduction of potentially invasive plants and insect pests, also poses great threats to the Island's native and endemic plants. Careful inspection of imported plant material has limited the introduction of insect pests. However, despite this relatively effective model, no similar process has been applied to screening plant species for their potential to become invasive.

Key Threats To Biodiversity

In a few notable cases, habitat destruction has been directly linked with the loss of species. In the 1940's the creation of the airbase in Castle Harbour led to widespread destruction of critical marine habitats including mangroves, seagrass beds and coral reefs. Following this massive environmental disruption, ten species of fish that had been recorded from this area were no longer seen in Bermuda¹⁵³.

¹⁵³ Smith-Vaniz, W. F., B. Collette, B.L. Luckhurst. 1999. Fishes of Bermuda: History, Zoogeography, Annotated Checklist, and Identification Keys. American Society of Ichthyologists and Herpetologists, Kansas. 424 pp.

The long-term use of Pembroke Marsh as a dumpsite led to a substantive reduction in the extent and environmental health of this wetland. Recent ecological surveys of this area have found the marsh to support very few organisms, and two endemic species that were only recorded from this habitat are now believed to be extinct¹⁵⁴.



Plate 35. An aerial view of the former Pembroke Dump. Photo courtesy of Department of Works and Engineering).

The hard rock of the Walsingham formation made traditional construction difficult thereby limiting the development on that portion of the Island bounded by Harrington Sound and Castle Harbour. Fortuitously, this acted to protect the underlying caves, which harbour unique and endangered life forms and, having been left largely undisturbed, this area supports some of the most extensive remnants of Bermuda's pre-colonial forests. However, with

modern construction methods and the declining availability of land, the incentive for building in this area has risen dramatically. Current projects continue to erode this important habitat and threaten the survival of Bermuda's unique cave fauna.

Since man first visited the Island and left hogs for future voyagers, invasive species have created havoc with Bermuda's endemic species. Rats, cats and dogs joined with man and hogs to decimate the vast rookeries of seabirds and turtles. Later an introduced scale insect destroyed most of the Island's cedar forests. More recently still, the remarkable success of many introduced plants has caused the widespread displacement of Bermuda's native flora such that today, invasive plants heavily dominate throughout the Island's woodlands.

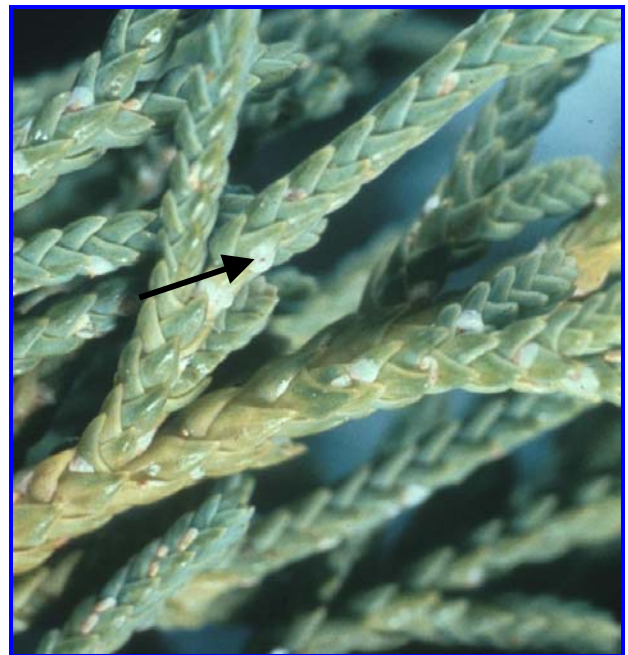


Plate 36. Cedar scale on Bermuda Cedar. (Photo from BAMZ slide collection).

¹⁵⁴ Thomas, M. L. H. 1996, Report on the ecological conditions of Pembroke Canal and the inner part of Mills Creek. Unpublished report. 26 pp.

The grounding of large ships on the Island's fringing reefs also poses a very real threat to Bermuda's biodiversity. This was dramatically demonstrated when the fully laden supertanker, *Aquila Azteca* ran aground on the reefs to the north. Whilst this ship was successfully re-floated with no spillage of its cargo, visions of the disaster that was so narrowly averted left no doubt of the severity of the threat posed by passing ships. Whilst moves have been taken to ensure that similar accidents do not occur in the future, the threat remains.

No discussion of the key threats to Bermuda's biodiversity can ignore the potential impacts of climate change. With no streams or lakes, Bermuda's biota is dependent upon a consistent pattern of rainfall distributed throughout the year. Disruptions of wind patterns could produce a protracted period of drought with catastrophic effects. Additionally, the increased incidence and severity of hurricanes not only threatens human dwellings, but also heavily impacts the coastal habitat of the endemic Cahow and Skink. Perhaps most disturbing of all, periods of elevated sea surface temperatures have already stressed Bermuda's corals causing temporary bleaching and the predicted rise in temperature in the coming century will cause much greater stress potentially dooming the Island's coral reefs. As this living barrier is critical to preventing excessive erosion of the Island's coasts and as the rising temperature also brings higher sea levels, this warming trend actually threatens the very existence of Bermuda.

Underlying Causes of Biodiversity Loss

Throughout history it has been repeatedly demonstrated that island species are poorly adapted to competing with introduced organisms. The losses of Bermudian species can be largely attributed to the inability of the Island's endemics to withstand the competitive pressure of the many species introduced by man. Moreover, this progressive displacement of endemic species has been exacerbated by the ongoing encroachment on natural habitats and fouling of natural waters by man. Particularly on land, the sheer magnitude of the human population has forced the remaining natural communities to occupy small and, in many cases, marginally productive habitats. Man's dramatic impact on Bermuda's biota is further heightened by both ignorance and a lack of care for the consequences of the ongoing urbanisation of the Island. With such a large portion of the community working in sectors that are not directly linked to natural resources, there is limited appreciation or passion for the intrinsic value of the Island's biota. Short-term profit consistently takes precedence over long-term environmental health. Plans that serve to protect against the degradation of natural communities by limiting development and do not offer substantive financial reward during a Government's term of office are rarely supported.

Current Constraints To Biodiversity Conservation

Despite a rich history of biological research in Bermuda, for many of the endemic species there is a little information available on their current population status or, where relevant, the threats to their survival.



Plate 37. *Mictocaris halope*, an endemic cave shrimp that is listed as critically endangered. (Photo courtesy of W. Sterrer).

This is true even for those species that have recently been listed as critically endangered as, in large part, they have received this designation simply because of their obviously small and fragmented populations and their proximity to dense human habitations. For many endemic species there is very little substantive information to direct effective conservation action.

Whilst there are a number of conservation-oriented organisations in Bermuda, many of which have cordial relations with like-minded agencies, to date

there has been poor co-ordination of resources and occasional duplication of effort. There is need for enhanced communication amongst environmental NGOs and Government to improve efficient use of the limited available resources.

Bermuda lacks a clearly communicated, long-term vision. The need to plan the economic development of the Island with due regard to conservation is not widely recognised. Despite the best efforts of the Forward Planning Section of the Ministry of the Environment, the lack of such a big-picture approach to Bermuda's future is likely to lead to ongoing erosion of the Island's natural amenities and the loss of rare and unique life forms.

Bermudians seem largely apathetic to the ongoing destruction of their natural surroundings. This apparent lack of awareness of the implications of failing to advocate for responsible environmental management may in part reflect a sense of impotence to affect the outcomes of controversial development proposals. One example is the Catchment Hill development, which received Approval in Principle despite an unprecedented barrage of objections from the general public. This disregard for public opinion and subsequent lack of substantive political fallout may, largely explain the perceived historical indifference with which many local politicians have treated the Island's conservation legislation.

Enforcement of environmental legislation is not a Bermudian strong point. There is a great need to strengthen the effectiveness of enforcement of

conditions of development approvals and monitor and enforce Tree Preservation Orders. Also, the perception that illegal developments frequently receive retroactive approval, needs to be addressed. When the limited enforcement staff does effectively prosecute offenders, the Judiciary rarely considers environmental infractions to be of a serious nature. Often it literally pays to ignore the regulations and pay the fine if one is so unlucky as to be caught. Indeed the 1990 Commission of Inquiry into the Fishing Industry and the Future of the Marine Environment cited the failure of the Judiciary to adequately penalise offenders as a major factor promoting illegal fishing in Bermuda.

Current Opportunities For Biodiversity Conservation

The planned restructuring of the Ministry of the Environment presents an excellent opportunity for raising the profile of, and commitment to conservation initiatives. This organisation is blessed with both committed and competent scientists and policy makers. With a renewed emphasis on environmental protection and education it may effectively combat community apathy to environmental issues, improve monitoring and enforcement of environmental legislation, and raise the level of appreciation for the value of biodiversity.

Equally encouraging is the fact that during meetings leading up to the production of this report it became apparent that there is a general willingness amongst

Bermuda's environmental NGOs to collaborate and perhaps to form a local conservation forum. Coupled with the Ministry of the Environment's commitment to foster collaborative work with these organisations, the stage is set for effective inter-agency team development.

Education is key to promoting conservation and Bermuda is fortunate to have many excellent vehicles for disseminating information. It is very easy to share a message with the entire community through the local media. Additionally, the schools are very receptive to environmental messages.



Plate 38. Participants in the Youth 2000 Environmental Conference. (Photo courtesy of T. Hasselbring).

Appropriately designed training packages could serve to heighten the awareness of the judiciary to the environmental costs and profit motives attendant to crimes against environmental protection legislation. Armed with a greater understanding of the issues involved, it is anticipated that they would act as a more effective deterrent to violators.

As many of Bermuda's critically endangered species are not currently protected under any act, an Endangered Species Act written specifically to

provide local protection for endemic species would greatly improve the ability to conserve our unique biota.

Opportunities exist for community involvement in habitat restoration projects, which can both raise awareness of the issues facing Bermuda's natural communities and empower residents by demonstrating the ability to reverse environmental degradation. Such projects could be coupled with the Learning Through Landscapes programme which serves to develop school grounds as outdoor educational facilities.

There is great potential to diminish Bermuda's environmental problems through incentive programmes aimed at rewarding appropriate behaviour. These could include such things as:

- a bottle bill providing refunds on all returned bottles,
- rewards for information leading to the arrest of violators of environmental legislation,
- rewards for information leading to the detection of illegal fishing gear,
- low interest loans and tax relief to promote environmentally responsible practices.

The Bermuda Government's move to develop a Central Policy Unit to co-ordinate the activities of various Ministries brings with it a potential for a more holistic approach to managing Bermuda's natural resources. By reconciling the potentially conflicting goals of the economic sector with the need to protect nature for the greater community

well-being, a common vision may emerge and efficiency of resource allocation may be facilitated.